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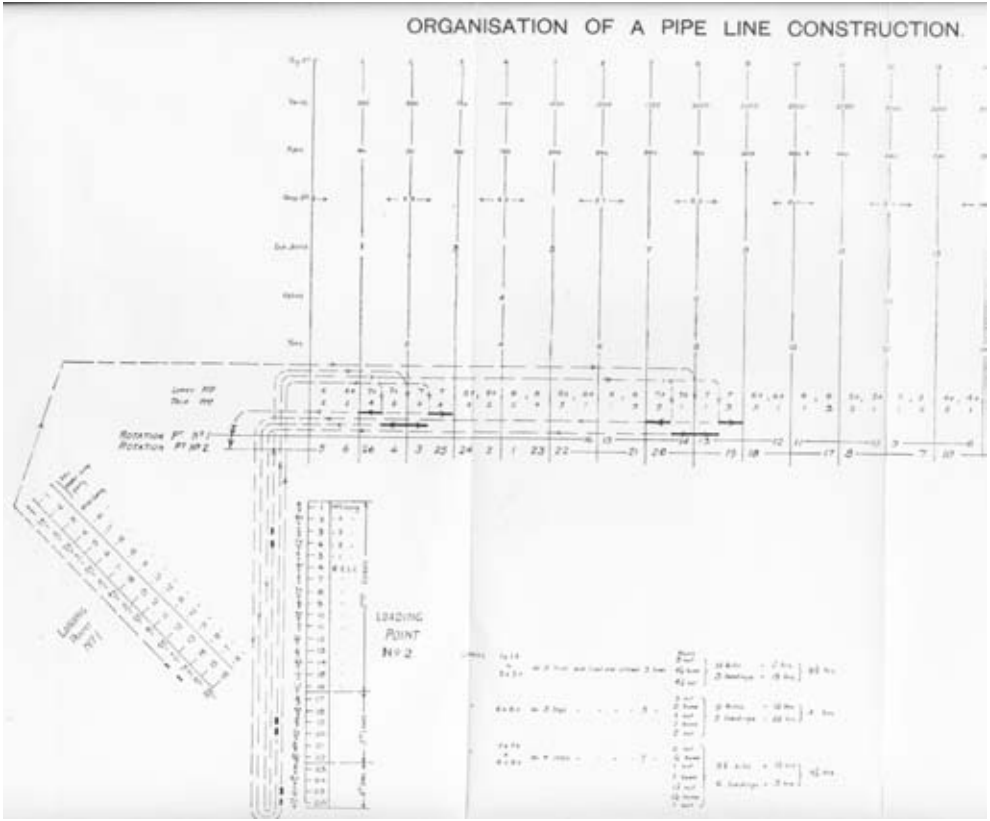
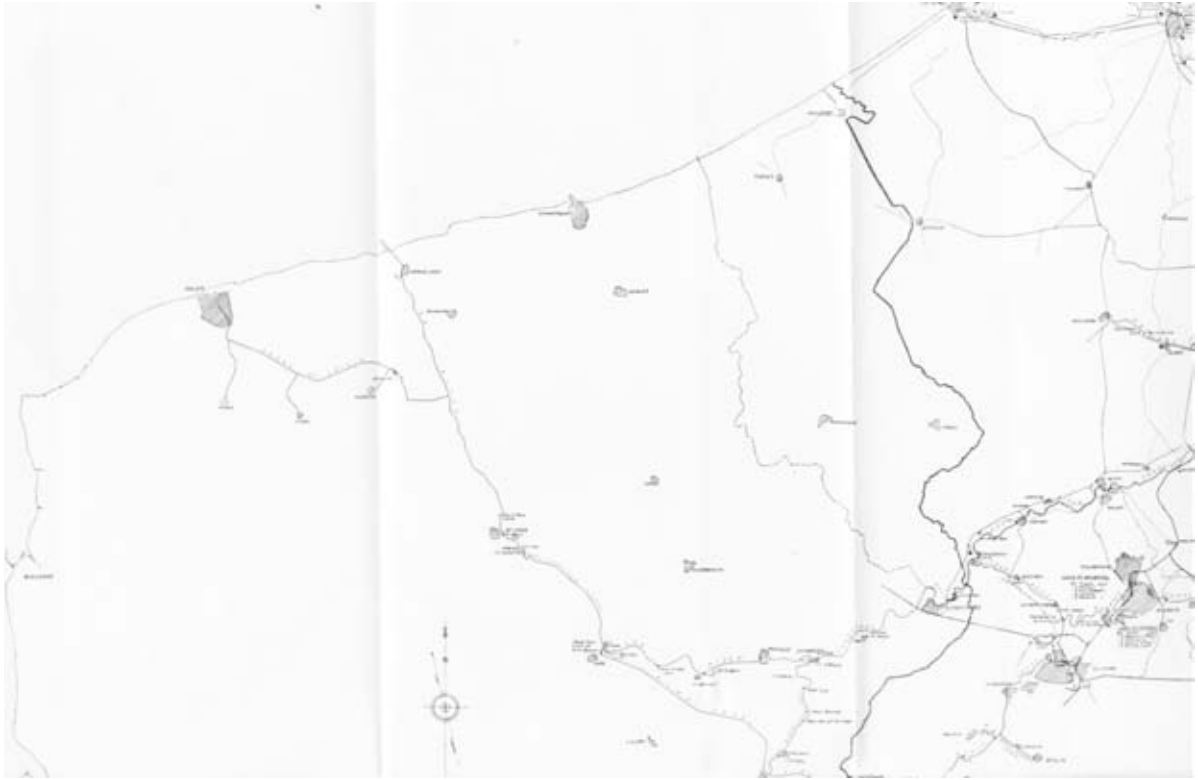
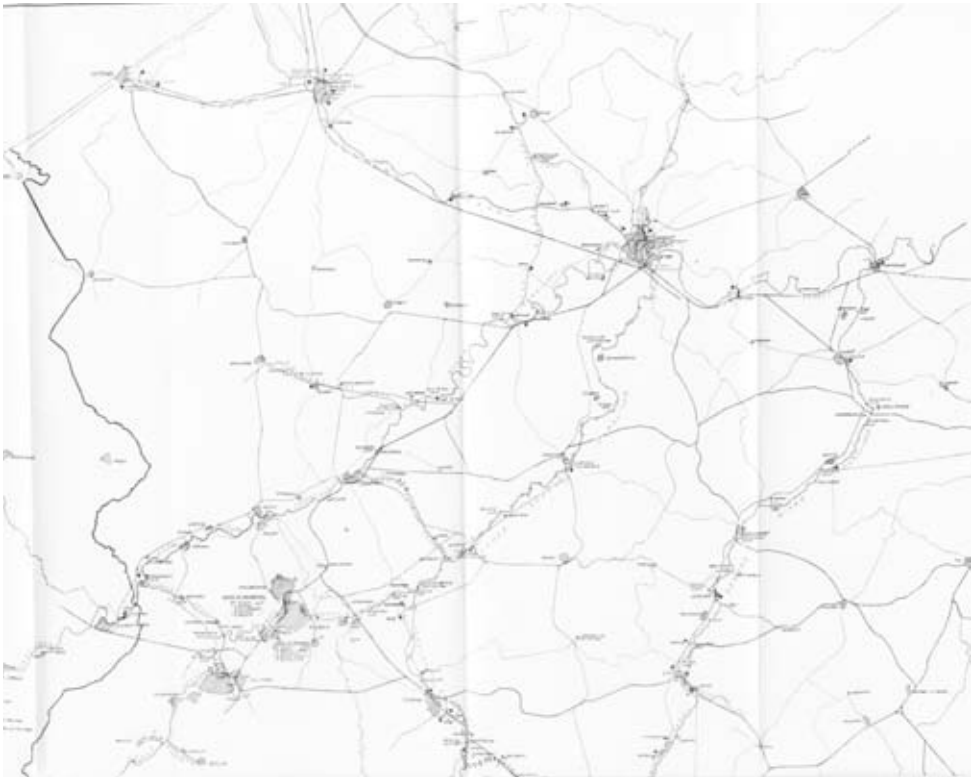


PIPE LINE CONSTRUCTION



MAP 1



MAP 2


MAP SHEWING PART OF THE SYSTEM
OF
NAVIGABLE WATERWAYS
OF
BELGIUM AND NORTH-EAST FRANCE
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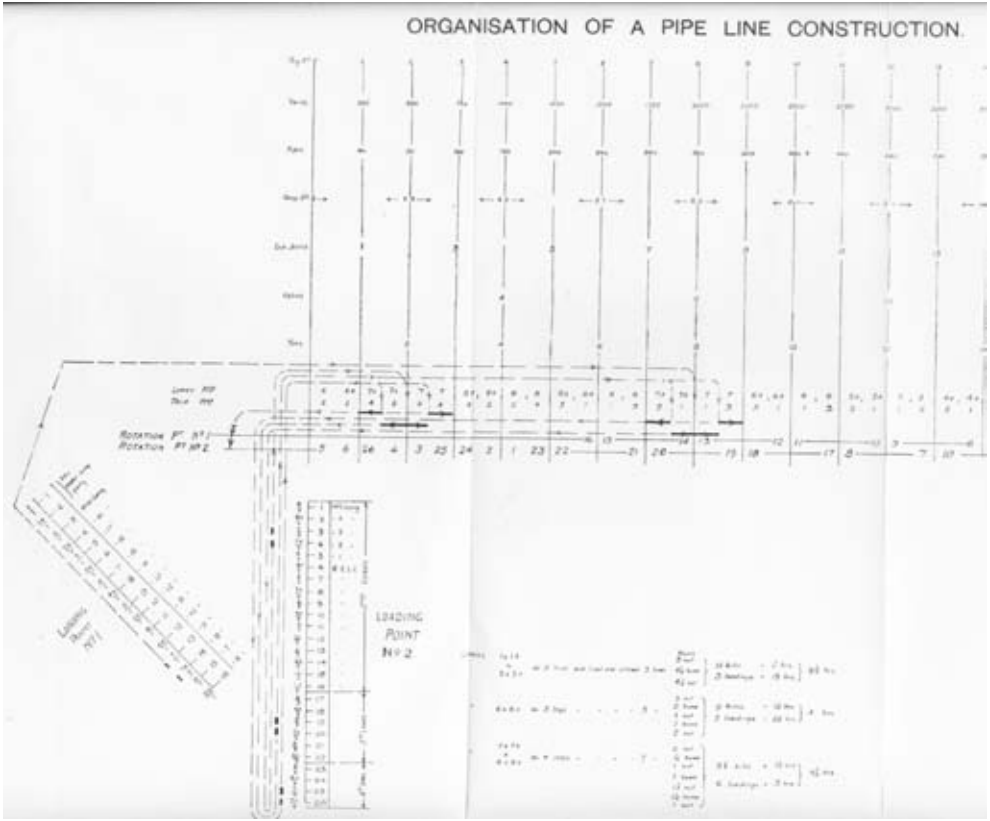
MAP 4



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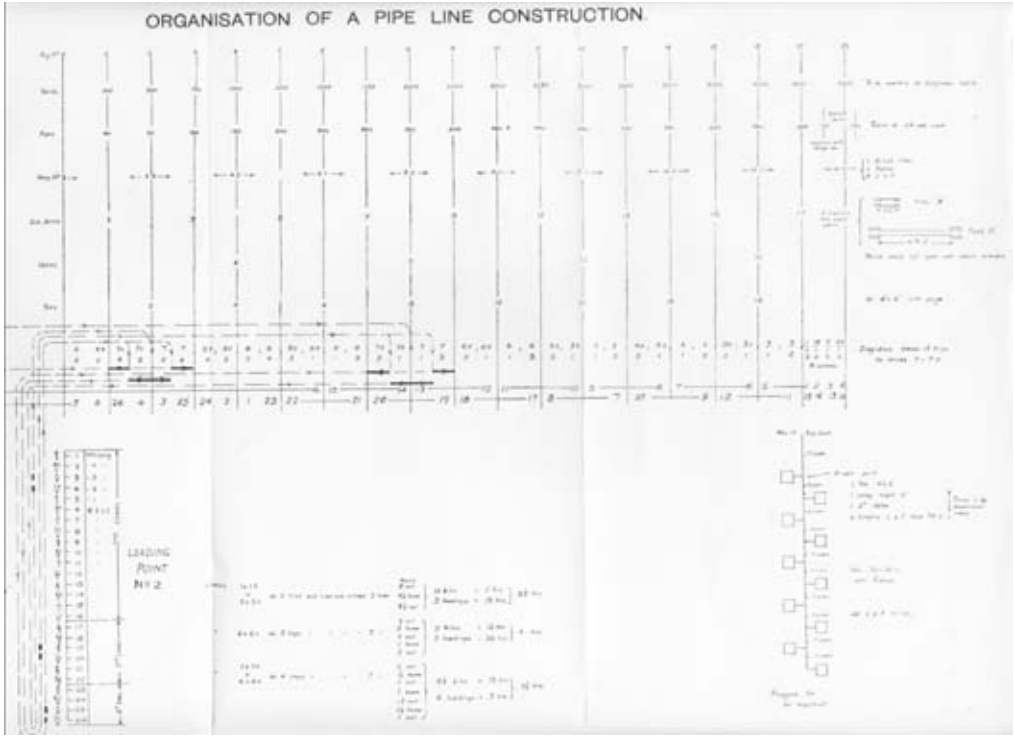


PIPE LINE CONSTRUCTION

CONTENTS.

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

WATER SUPPLY OF TROOPS IN THE FIELD.

By BRIG.-GENERAL R. P. T. HAWKSLEY, C.M.G., D.S.O.,
CHIEF ENGINEER, 21ST CORPS.

Water Supply for troops in the Field divides itself into three categories :—

(*a*) When at rest.
(*b*) Tactical, or in preparation for concentrations or offensives.
(*c*) When on the move.

The two former categories merge into one another, and the requirements for (*b*) should, as far as possible, be foreseen in making the provisions necessary for (*a*).

2. The allowance per head is :—per man—1 gallon per day ; per horse or mule—10 gallons per day ; per camel—20 gallons every third day, and these amounts should be calculated for in (*b*) and (*c*).

The allowance per man and horse may, for certain definite purposes and over very short periods of a day or two, be reduced to half a gallon and five gallons respectively, but as a rule both should be provided with as much water as they require, within reason.

The theory that men and horses can be trained to use a very small amount of water is not a sound one. It is better to start an operation with men and horses in the pink of condition than in a half-starved state. Therefore, in arranging for (*a*) the amounts should be considerably increased. But when this is analysed, the increase, except in very hot weather, when a horse may drink some 12 gallons, or even more, is due to the requirements of men only as regards washing, disinfection of clothing, and similar purposes.

3. The Division is divided for water purposes into four groups, viz :—

			Gallons per day.		
	Men.	Horses.	Men.	Horses.	Total.
Divl. H.Q. Group.	3,900	3,120	3,900	31,200	35,100
3 Brigade Groups (each)	5,000	1,530	5,000	15,300	20,300

The total requirements of a Division, on this scale, are therefore 95,400 or (say) 100,000 gallons per day.

The above figures are approximate for an Indian Division, but are near enough to facts for water purposes. A British Division requires somewhat less. Corps Troops vary in number, but may be taken at 10,000 men and 5,000 horses.

4. Where open water and flowing streams exist, and the red, white and blue flags can be used, no particular difficulty need be anticipated, but where every drop of water has to be dug for, or lifted from

wells 100 ft. to 200 ft. deep, quite a different proposition presents itself.

5. The water distribution unit for animals is :—

1 L. & F. pump, complete with hose.
1 trough, canvas, 600 gallons * (nominal, but really some 350 gallons).

This unit, provided too great a duty is not put on the pump, can water, with good management, some 180 horses, or 54 camels, per hour. It should be noted that only 18 camels can use a trough at one and the same time, and each relay takes 20 minutes to water.

Each watering should be calculated as for 2 hours. Therefore each Brigade Group requires a minimum of 5 units, and the Divl. H.Q. Group requires 9 units, where it is essential to water entirely from troughs. As the watering is very often widely distributed, and as sometimes, where the source of supply is insufficient for a unit supply, a Division should carry no less than 36 units, or 12 per Field Company, of which some must be applied to mens' water.

For men the tank, canvas, 2,300* gallon (nominal, but really about 1,500 gallon) is required, for collection and chlorinating purposes, and some 10 of these are required per Division. The actual number depends greatly on how many water carts or other receptacles, in which chlorinating can be done equally well, are carried.

6. For storage, while at rest, large canvas bucksails, 30 ft. by 30 ft., specially proofed, and holding, when mounted on timber frames, or dug into ground, some 7,000 gallons, are often used. It is, however, highly desirable, in order to economise in these and in the 2,300-gallon tanks, and also in 600-gallon troughs, also if the duration of a halt is likely to justify this course, to construct masonry reservoirs, and wooden or even masonry troughs, in order to save the canvas reservoirs and troughs for mobile use.

7. Similarly, while at rest, it is extremely desirable to withdraw from use equipment pumps, and replace them by other pumps, in order that when a move occurs, all equipment shall be in first-class order.

8. Where water has to be dug for, it is not a practical proposition to expect a Division to be watered the night of arrival at its destination, where water occurs at more than 6 ft. underground. Where this state of affairs occurs in sandy soil, a great strain is thrown on the Royal Engineers, and it may be necessary to carry specially designed well linings, of corrugated iron on timber framings, making a well of 6 ft. by 6 ft.

Where the soil consists of coarse sand, perforated driving heads, known sometimes as spear points, sunk by means of the Norton Tube monkey, may be used in conjunction with the L. & F. pumps, but

* The method under which this gallonage was arrived at is not known.

these are disappointing in fine sand or in clay or ordinary soil. They are specially useful for obtaining drinking water for men, as the risk of pollution is decreased by their use.

The Norton Tube sets are especially valuable in such cases in testing the depth of the water, but as means of supply, their yield being only some 200 gallons per hour, they are not of much use.

Shallow wells may be expected to yield from 300 to 500 g.p.h. and therefore some 20 wells per Division are necessary.

9. Where water is at depth below the reach of a L. & F. pump, there are two possible means of lifting, during operations, with great speed from open wells: (*a*) L. & F. pumps in series, or stages; (*b*) Water bags (with valve in base).

(*a*) is placed out of court at once, where the necessary stagings are not in existence;

(*b*) is always possible, and is the best and quickest. With a good depth of water in the well, water at 100 ft. may be drawn up at the rate of upwards of 1,000 gallons per hour, with a 20 gallon bag, by man or horse power.

The last six inches of a well always give the greatest yield. The valve in the bottom of the bag can deal with this, but more slowly. This means of lifting water from depth is, on the whole, the most efficient when speed of erection is considered.

The yield of a deep well may be anything from 500 to 3,000 gallons per hour, or even more. A Division must, however, with such sources of supply, be considerably dispersed where yields are not great.

Where more time is available, a Chain Helice pump, driven by a 5 h.p. engine, yielding, at 150 ft. depth, 1,200 gallons per hour, is most useful, and takes only some 2 hours to erect. Where still more time is available, a deep well pump (preferably with a ball valve), driven by a 5 h.p. engine, yielding at 150 ft. depth, 1,000 gallons per hour, may be used, but this takes 9 hours to erect, and is therefore not of much use in rapid operations.

10. Where bore-holes are met with, it is often the case that the pump is either in working order or can be quickly repaired, but the engine is destroyed. The Lister type engine, of which each Division should carry two, can be used in such cases. An Isler pump is useful for bore-holes of 5 in. or upwards, but for smaller bores an Isler pump fitted with ball valves might be found suitable. Clack valves are unsuitable.

11. Where native-owned engines and pumps are found, it is often the case that the owners will have removed the magneto, and other essential parts. A little peaceful persuasion, with the promise of water for the owners' use will, as a rule, produce the missing parts, when all will be well.

12. Engines and pumps erected by the enemy cannot be relied

upon. They are found, as a rule, in a wrecked condition, except where an advance has been so rapid as to upset all arrangements for destruction. It is unsafe to rely upon them for supply.

13. In preparing for a concentration, the supply from a well or bore-hole should be arranged at per Brigade Group or Divl. H.Q. Group, provided always the well or bore is of sufficient yield, and should be piped to the site of distribution. Each Brigade Group should be provided with 6 water points for troughs, and 1 water point for men. The former may consist of 3 standpipes with T head, not less than 30 ft. apart, to deliver into equipment or other troughs, and the latter should be a stand pipe to deliver into water carts, or it may deliver into a canvas tank, from which the water is pumped by hand into water carts, fanatis or other receptacles. (Fanatis are boxes of galvanised iron or copper, of 10 to 15 gallons capacity, for camel pack transport). The distribution for the Divl. H.Q. Group is larger in proportion.

Water prepared for concentrations in offensives must be so sited as to comply with tactical requirements.

As a rule, a Division in the attack is distributed in depth. The extent of front and depth depends entirely on the conditions of the campaign. An average distribution is by Brigade Groups, the leading water point being about one mile in rear of the front line, and succeeding Brigade Groups and Divl. H.Q. Group water points being at intervals, towards the rear, of as much as one or two miles. Where very large masses of troops are engaged these intervals must, doubtless, be reduced very considerably.

In the event of an offensive being directed towards a country devoid of water, except such as can be easily destroyed by the enemy, it may be necessary to allow for two or even three Brigade Groups per Division at the most advanced water point, in order that, if new water is not taken beyond the front line, it may be possible to send back to the most advanced prepared water point. These water points may be wells or bores, either existing and developed, or specially sunk, or pipe lines may be specially laid.

When laying pipes for tactical purposes (*b*) or domestic purposes as in (*a*) the general rule is to establish the pumping installation at a suitable source of supply as far back as possible within reason. Such distance will, of course, depend on the pumps or head available, as well as on the supply of pipes and specials.

Anyway, by adopting this rule, the headworks or pumps are placed in the safest situation, and as free as possible from shell fire or capture. When laying a pipe line it is as well to look forward to the possibility of extending it in the event of an advance, and to leave T's for use in the event of a retirement. Where wells or bores are used, they should be specially chosen for the suitability as regards invisibility, both of the site itself and the approaches.

These remarks apply similarly to the domestic supply for a Division in the line.

14. Pipe lines may be laid from a source of supply behind the front line, to provide a supply to troops who have gained their objective. Where accurate contoured maps exist the matter does not present any great difficulties, but where heads have to be guessed at it may be necessary to erect relay sets at intermediate points.

The actual laying and screwing up of the pipes does not present any great difficulties. The success of the enterprise depends on the speed at which pipes can be transported to site and the extent to which the enterprise has been organised beforehand.

An example of the organisation of a pipe line construction is appended (see accompanying *Plan*). The source of supply was a large river, and a triple ram pump and 12 h.p. Robson engine were used. The delivery was 4,000 g.p.h. against a head of 200 ft. The line was laid and bucksails of 70,000 gallons capacity erected in 8½ hours. The work was carried out within full view of the enemy, but no interference was attempted. Labour used was almost entirely Native Egyptian.

15. It has been found necessary, where troops are expected to move through an absolutely waterless country, to provide Water Convoys. A Division, at the rate of ½ gallon per man and 5 gallons per horse, would require 4,400 fanatis of 12 gallons each, carried on 2,200 camels. The filling of these at speed must be arranged for, and can only be done with the use of reliable pumps and perfect organization. In addition to the filling of fanatis, the camels which carry them have to be watered.

16. In some countries, especially those possessed of an ancient civilization, most of the old native wells will be found to have very small yields. Where time admits, these should be cleaned out. As an example, no less than 24 ft. of sludge has been removed from a well 150 ft. deep, with the result that the yield was increased from 300 to 3,000 gallons per hour. To effect this clearing out, pumps with ball valves, and tripods with buckets, are essential. A boring outfit is most useful for this purpose.

17. Reports on water, when found, should be sent to H.Q. of formation without delay. The yield of a well cannot be accurately gauged without observing its behaviour over a period. It would suffice in the first instance if the number of troops watered at the well be stated and the opinion of the reporting officer. If the opportunity occurs, this report can be amplified later.

18. Where a country of springs is occupied, and information is indifferent as to the minimum yields, they should be gauged from the commencement of occupation, in order that an estimate of their minimum yields may be made. The yield of a spring sometimes reduces violently down to a minimum about half way through the

dry season, at which level it remains constant. The behaviour of springs varies, of course, in different formations and different countries, so that no known rule applies.

19. The essential conditions of a water distribution area are :—

(*a*). Fairly level site.

(*b*). Sufficient room for barracking a certain number of animals in preparation for watering.

(*c*). Easy ingress and egress.

(*d*). Lines of troughs not less than 30 ft. apart in the clear.

(*e*). Animals should enter troughs at one end, and leave at the other.

(*f*). The supply to any trough must be sufficient for maximum number of animals watering at that trough.

If, for instance, a trough is 100 ft. long, and will water, therefore, 68 horses, using both sides, at one time, the supply to this trough should be not less than 68×4 gallons $= 272$ gallons in ten minutes, or at a rate of $272 \times 6 = 1{,}632$ gallons per hour.

(*g*). In some soils the standings must be hardened.

(*h*). Overflow water must be drained off.

20. The general conditions of water "tactics" or "strategy" (for want of a better word) seem to be as follows :—

(i). In a native country, where water exists at depth, and deep wells exist :—

(*a*). With fast moving troops—which implies fast retirement of the enemy, and that they have not destroyed the wells—water bags must be used ;

(*b*). Where the enemy retires more slowly, water bags may still be used, but to save the endless wear and tear on ropes and bags, power-driven Chain Helice pumps may be used.

(ii). Where water exists at depth, in a native country partly exploited by Europeans, it will be found that open wells, both native and European, and bore-holes exist.

(The European open wells and the bore-holes will be found fitted out with power pumps, some ready for use, and some in a worn-out condition) :—

(*a*). With fast moving troops, the open wells can be worked with water bags, the power pumps must be put in order quickly, and where necessary engines must be provided to work them. The engine will be more often found not fit for use than the pump. Hence 5 h.p. engines at the rate of two per Division should be carried.

(*b*). Where the advance is slower, a considerable amount of labour may be saved by carrying one Chain Helice and one Isler, or similar pump, per Division.

It may be necessary to carry some spare parts of engines and pumps most likely to be met with.

21. Where water is met with at 200 ft. or less with moderate certainty and conditions are generally suitable for quick boring, a properly organized and equipped Boring Company or Section is essential, where troops do not move too fast, and usual long halts are made, and for L. of C. purposes.

Where a Boring Section only is provided, it should be attached to the most suitable A.T. Coy. R.E. at the head of the L. of C. The Boring Company or Section should have access to the machinery shops, and should have a special agent stationed in these shops.

22. On a new line formations must be followed up for consolidation purposes by A.T. Coys. R.E. equipped with pumps of from 1,000 to 3,000 g.p.h. capacity.

23. When an Army has to use power pumps, and other machinery, a well organized repair shop is an essential. This shop may be located at an advanced base on L. of C. All pumps which are issued to the troops must be thoroughly overhauled by these shops before issue, and all engines must be given trial runs on testing blocks.

It is often the case that a tactical operation depends on the success of a water pumping operation. Hence any deficiency in machinery may easily upset the calculations in connection with the military operation.

As an Army advances, enemy shops which are worth while taking over should be brought into use. For such purposes, efficient workshop officers and staffs should follow the Army at the head of L. of C. whether attached, or posted, to A.T. Coys. R.E. or not.

24. The Hayward Tyler land set can be utilized for pipe lines, or may be used for filling six troughs or tanks at one and the same time. For the latter purpose an arrangement of canvas hose, fitted with W.I. Tee pieces, and provided with six water points, can be easily constructed and should be part of the outfit of the set. The Hayward Tyler set may be connected to six spear points connected together where suitable soil exists.

25. Where water is scarce, more appliances for lifting are required.

Where new countries are exploited by Europeans, and especially where German influence is felt, much machinery will be found. This was found to be the case in German S.W. Africa and Palestine. It is essential in such countries that units shall have on their Establishments many more engine drivers, especially in oil and petrol, than are authorized. A Division may have to work upwards of ten sets,

entailing 3 engine drivers each. A Field Company should therefore contain from ten to fifteen of such engine drivers.

26. The oriental methods of raising water are often extremely efficient, and are useful when an Army is at rest. The Shadouf (Arabic), Dhingly (Hindustani) consists of a bucket hung by a rope to a swinging pole weighted at the end opposite to that to which the bucket is attached. This is capable of an average of upwards of 1,500 g.p.h. from a depth of some 6 ft.—the capacity entirely depends on the skill of the operators, and natives are far more adept than Europeans can ever become.

Sakkieh (Arabic), Arrat (Hindustani) is capable of some 3,000 g.p.h. at 40 ft. depth. It may be operated by men, oxen, camels, horses, mules, etc. This is the "Persian Wheel."

Chursa, used in India and Mesopotamia, capable of upwards of 1,500 g.p.h. at 40 ft.

27. Air lift pumps cannot be relied upon during operations, as wells with sufficient depth of water are very unusual. If, however, such a well is met with while the Army is at rest, an air lift pump could be brought up for the special purpose, and would doubtless be found most useful.

28. Among other suitable types of pumps and engines for service purposes are :—

Engines.	Pumps.
5 h.p. Lister.	Isler, deep well. 1,000 g.p.h. at 150 ft.
do.	Dando, deep well. 1,000 g.p.h. at 200 ft.
8 h.p. Lister. / 7 h.p. Blackstone.	Dando, deep well. 3,000 g.p.h. at 200 ft.

For cleaning out wells the Dando with its ball valve pump is most suitable.

5 h.p. Lister.	Chain Helice. 1,200 g.p.h. at 120 ft. (requires 18 in. depth of water.)
Hayward Tyler Land Set.	(4 h.p. Blackstone.) 3,600 g.p.h. against 100 ft. head.

Notes.—

Petrol or oil driven engines are, as a rule, essential on service. Native producer gas, steam, etc., and even Diesel engines are often found, and units must be capable of using them.

A peculiarity about the supply of water to troops in the field, is that the more they are supplied with, the greater are their demands.

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

(Continued.)

BRIDGING.

CHAPTER II.

BRIDGING OPERATIONS PRIOR TO AUGUST, 1918.

Introduction.—Prior to 1917.—During 1917.—January to March, 1918.—April to July, 1918.

1. INTRODUCTION.

Actual Bridging operations during the War may be divided into five distinct periods :—

(1st). *Prior to* 1917, which was a period of strenuous preparation and training, but during which Bridging operations were of minor importance ;

(2nd). *During* 1917. Operations following the withdrawal of the German Army to the Hindenburg Line ;

(3rd). *January to March*, 1918. Preparations made in anticipation of a general German offensive ;

(4th). *April to July*, 1918. Bridges necessitated by the withdrawal of the British Line ; and—

(5th). *August to November*, 1918. Bridges erected during the final advance (described in detail in succeeding Chapter.)

These periods will now be described in detail.

Map B. shows the principal waterways referred to.

2. PRIOR TO 1917.

In the first months of the War a few timber Bridges of ordinary type were built.

During the Battle of the Aisne a heavy timber braced trestle bridge built by the 20th Fortress Company at Bourg was the principal means of communication to the British I Corps, and, when the front was taken over by a French Corps, the entire relief took place across this bridge during one night.

Pending the arrival from England of the bridge work which had been ordered, a few steel spans (R.S.J. and Girder) were made up locally at Lillers and Armentiéres; some of these were utilised for the repair of low level bridges on the Lys between La Gorgue and Armentières, and on the River Lawe.

A wooden Girder Bridge (Central Span about 65 ft.) was also erected at Le Bizet, North of Armentiéres; this was replaced later by a steel Girder Bridge consisting of one 60ft. Class B. and four rolled steel joist spans on braced timber trestles.

Some of the earliest bridges were illustrated in the first Edition of "Memo. on Construction and Repair of Road Bridges."

The 20th, 25th, 31st, and 42nd Fortress Companies were all employed on this work during the end of 1914 and beginning of 1915. They also assisted in fitting out the Barge Depôts and Bridges,and in working out various details and designs.

The need for heavy bridging equipment, which Fortress Companies lacked, was one of the main causes of the conversion of these Units into Army Troops Companies, in whose equipment provision was made for special tackle, pile drivers, etc., and mechanical transport, as well as increased *personnel*.

3. DURING 1917. THE SOMME.

On the 17th March the Germans commenced to withdraw across the Somme in front of the British Fourth Army. On the following day the crossings came completely into our possession, and reconnaissances showed that the whole of the bridges had been destroyed. Work was at once commenced by the Field Companies of the 1st Division on temporary crossings, and Infantry were enabled to cross the same night.

Medium Bridges to carry first line transport were commenced the following morning, and a crossing was completed at 5 a.m. at Brie. There were six gaps in the original crossing over the Somme River and Canal, one across the Canal about 35 ft. broad, and five others 28 ft., 93 ft., 24 ft., 78 ft. and 61 ft. respectively.

On the 18th of March an interview took place between the Army and Corps Bridging Officers, and an Officer specially sent from the Bridging School, at which schemes for the erection of steel bridges were decided on. The required spans were at once despatched from the Base, and two train loads arrived at the Army Depôt on the 21st, and two more on the 22nd. From this Depôt all material had to be taken by horse transport a distance of about 10 miles, as the roads were unfit for M.T.

Before heavy bridging could be commenced a second set of medium bridges had to be erected, and the original ones which for the

sake of rapidity had been built on the site of the old bridges, dismantled.

Some delay was also caused owing to a single truck being cut off *en route*, in which were packed the bolts for all the steel spans. The erection of the heavy bridges was carried out by the 23rd and 409th (Lowland) Field Companies, of the 1st Division, assisted by a detachment of an Army Troops Company, and working parties from two complete Infantry Battalions.

The entire crossing was ready for all heavy traffic at 4 p.m. on the 28th March.

The estimated date for the completion was the 30th, and a special message of congratulation to the Engineers of the Fourth Army was received from the Commander-in-Chief.

The details of Bridges were as follows :—

No. 1. Gap	...	...	30 ft. Span on crib piers.
No. 2. Gap	...	...	21 ft. 6 in. Span on crib piers.
No. 3. Gap	...	...	60 ft. Span on crib piers.
No. 4. Gap	...	...	16 ft. Span on crib piers.
No. 5. Gap	...	...	Filled in by means of a cofferdam.
No. 6. Gap	...	...	60 ft. Span on crib piers.

No particular difficulty seems to have been found in launching the girders, though none of the troops employed had had much previous training. The actual time taken in the erection of the five heavy bridges was a week.

When this same crossing had to be bridged in 1918, the work was completed within four days, which shows the advantage of previous experience, and of further opportunities for training.

This was the first heavy bridging operation of any importance carried out during the War, and it is interesting to notice the chief lessons which were reported by the C.E. of the Army.

They were as follows :—

(*a*). Spans used are generally longer than what had been calculated from the available information, owing to the destruction of abutments and approaches.

(*b*). Special arrangements are necessary for artificial lighting at night, so as to allow of continuous shifts. A.A. Searchlights were borrowed and were quite suitable. (Note—At this time night bombing was practically unknown).

(*c*). It is most essential to have a skilled Officer in general charge whose authority, irrespective of rank, must be paramount, and who must have a whole time Assistant.

(*d*). No trouble was found in assembling any of the spans. The workmanship of the steel was excellent.

(*e*). An ample number of plans is required with each bridge, and they should be mounted on cloth to resist the weather.
(*f*). Transport of material needs most careful organising, and should be arranged for by the Army Chief Engineer.

The Engineer-in-Chief circulated these notes, and drew special attention to the necessity for the most careful preliminary reconnaissances and organisation of *personnel*, material, and transport, so that no time shall be wasted when work becomes possible.

Subsequently a number of other bridges were erected over the Somme and its tributaries, including four 60 ft. Spans, one 30 ft., and one 13 ft. in Peronne.

Arras. A few bridges were built by the Third Army during the Arras battle in April. The most important of these carried the main Cambrai road across the railway just north of Arras Station. This crossing had been completely destroyed by the explosion of an ammunition dump on Easter Sunday.

The 557th (Glamorgan) Army Troops Company started work a few days later, and spent a week clearing the débris under constant shelling, which continued during most of the work of erection.

At one time work was stopped by order of G.H.Q. for 2 days, and was resumed again. The entire crossing was finished in a fortnight more. Two bridges were built side by side, each consisting of a 60 ft. span, 21 ft. 6 in. span, and a 14 ft. span carried on steel tube piers, which rested on concrete foundations. About 30 casualties were suffered during this work, mostly by the carrying parties.

The same Company next repaired a damaged girder bridge over the railway at Achicourt—wooden trestles were first inserted underneath, and the steel girders subsequently repaired.

Another important road bridge over a railway cutting near Arras was repaired under heavy fire by the 289th Army Troops Company, holes in the arches being filled with reinforced concrete, which required the erection of false work to a height of between 30 and 40 feet. Orders for this work were issued on the 16th April, and the bridge was re-opened for all traffic on the 11th May, during which period 14 R.E. and 83 others engaged in the work were killed or wounded.

Ypres—Poperinghe. During the Summer of 1917 a certain number of bridges were erected in Flanders, in which no special points of interest are to be found.

Preparations for Crossing the River Lys in 1917. In July, 1917, preparations were made for a possible crossing of the River Lys by the Second Army. Exact sites for proposed crossings could not be determined, but it was decided to provide, and have ready at accessible dumps, sufficient bridging material, stores and launching equipment

to allow of the erection of two steel bridges at any two points on the river, also to provide the necessary pontoons and special superstructure to enable 2 R.S.J. Heavy Pontoon Bridges for A. Loads to be quickly constructed at the selected sites, pending the completion of the steel bridges. Material for the steel bridges was collected partly from the Base, and partly from the Army Barge Depôt, into an advanced Depôt at Steenwerck. All material for the Heavy Pontoon Bridges was also assembled here. A subsidiary dump of heavy bridging stores and material was also formed on the right bank of the Canal at Merville. Materials for each separate bridge were carefully laid out and marked, and all material and stores made up into lorry loads for transport.

The projected operations were ultimately abandoned.

When the German advance in April, 1918, took place, these Depôts were overrun, and practically all the material lost, but during the subsequent advance of the British Army later in the year, the steelwork of the bridges was recovered intact together with most of the bridging stores, and was all used during the Second Army Advance.

4. January to March, 1918.

A general attack by the German forces was expected during the early part of 1918, against the Southern British Armies.

With a view to possible eventualities, a considerable amount of additional bridging was carried out on the Somme front during February and March. Existing bridges were doubled on the main routes, others strengthened to carry Tanks, and new ones erected. This work was organised by the C.E. Fifth Army, and was all carried out under the general supervision of the G.H.Q. Bridging Officer by the 216th A.T. Company, and two Companies of American Engineers. The 216th Company was specially picked out for this work on account of the O.C. and senior Subaltern of the Company having both passed specially good courses at the Bridging School. The American Army had asked to be supplied with various type spans for instructional purposes, and willingly agreed to a suggestion that they should instead send Units to assist in practical work on the Somme.

The complete scheme which was drawn up embraced 62 bridges, and of these 51 had to be completed before the 21st March. Nearly all types were represented, including a Hopkins 90 ft. span, several 60 ft., 30ft., 21ft. 6 in., and 16 ft. type AA. bridges, 6 Pont Levis, and 1 Portal Lifting Bridge. Work proceeded smoothly and rapidly, and the opportunity that it offered for progressive training to the Units engaged was most valuable. The very high standard of efficiency attained by these Companies in a comparatively short time showed clearly the results that could be obtained by training

and practice, and this was fully borne out by the work of the 216th A.T. Company in the intensive bridging operations during the Autumn of 1918.

At the end of March all these Units became involved in the retirement of the Fifth and Third Armies, and became part of the so-called Carey's Force. As soon as they had been relieved they commenced the next stage of bridging on the Somme under the Fourth Army, and later in the Aire district.

5. APRIL TO JULY, 1918.

The success of the great enemy attacks on the British fronts during March and April not only involved the loss of a number of bridges and bridging stores, but also created the necessity for a large number of additional bridges behind the re-constituted front.

This work was carried out by the Second Army in the St. Omer area, by the First Army near Bethune, by the Fourth Army on the Somme east and west of Amiens, by the Director of Works in the Abbeville district, and under the G.H.Q. Bridging Officer in the neighbourhood of Montreuil. *Photographs* XVIII., XIX. and XX. show a 2-span 85 ft. bridge in course of construction at Beutin. The two spans were bolted together and launched by the cantilever method.

The Second Army work included a large number of Rolled Steel Joist spans over the mass of small streams in the low-lying Country north-west of St. Omer, as well as a considerable amount of pile work.

The troops engaged included the 216th A.T. Company, Canadian Railway Troops, and I.W.T. Units, the latter of whom did most of the pile driving, and also erected a 120 ft. Hopkins Bridge at Arques. This is shown in *Photograph* XXI.

The most important work done during this period was probably that of the Fourth Army east of Amiens, which was carried out under considerable difficulties immediately the line stabilised.

Troops engaged were the 216th and 574th Army Troops Companies, the 353rd E and M Company, and two Companies of American Engineers.

Much use was made during this period of the Inglis rectangular type bridge, which could be erected very rapidly, and dismantled and moved to a fresh site as soon as a permanent bridge was completed.

At Blangy the canalised Somme was first bridged by an 84 ft. length of Inglis, which was replaced by a continuous R.S.J bridge made up of 21 ft. 6 in. and 16 ft. stock spans on four 2 pile bents. A

feature of the construction of this bridge was that the spans were assembled on pontoons, floated into position, and the piles driven from the bridge, the pile drivers being so arranged that piles could be driven simultaneously on each side of the bridge.

At the conclusion of these operations the Chief Engineer reported the most important lesson learnt to be that the success of heavy bridging operations on a large scale must depend very greatly on :—

1. The loading of the trains at the base.
2. The organisation at railhead and dumps.
3. The organisation of road transport.
4. The liaison between base, railhead, dumps and receiving unit.

In no case was there difficulty or delay in assembling and launching spans at the bridge sites. A good deal of difficulty was experienced with approach roads at the new sites, and in several cases long lengths of new plank road had to be made across the marshy ground in the Somme Valley. A typical example is shown in *Photograph* XXII.

Additional crossings were next made between Amiens and Abbeville. This work was delayed by frequent changes in the Units engaged, the 574th A.T. Company finally being left to complete the work alone.

A Hopkins 105 ft. span erected at Hangest-sur-Somme gave some trouble owing to the proximity of the main railway line, which was an obstacle to the launching arrangements. The back guys of the launching derricks had to cross the line at a sufficient height to allow trains to pass underneath. An overhanging spar on one of the trucks of the fifth train to pass struck the guys during launching operations, which fouled the train, causing a delay of 24 hours.

At Long a series of spans was erected on pile bents. The piles provided were 27 ft. long, and it was found necessary to splice on the top of each a lengthening piece of 13—15 feet, in order to obtain sufficient bearing stability.

A mechanical pile-driver was used here for the first time in the Fourth Army. It consisted of an 8 horse-power Lister petrol engine driving a small friction winch, and an ordinary derrick. This was found an improvement on hand piling, but the apparatus was not altogether satisfactory.

Several lifting bridges were erected, and the light lifting gear of the Portal type gave a good deal of trouble.

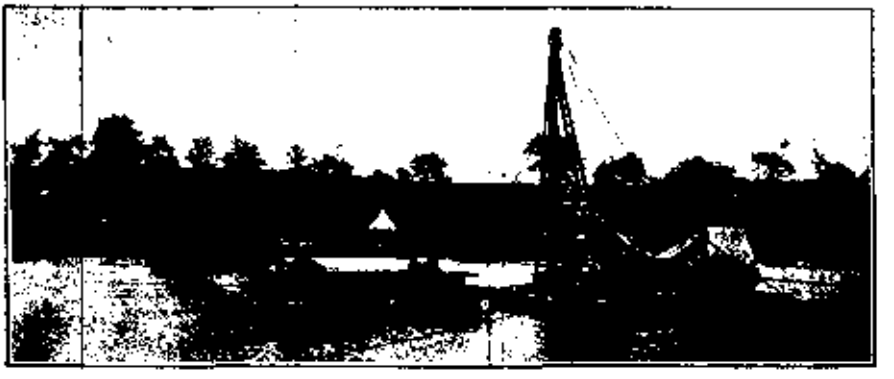
Special attention was again given to the receipt of material at railheads, and the transportation to, and unloading at, sites, all

the arrangements being carried out without a hitch, and without any single deficiency in stores occurring.

Photograph XXIII. shows a standard 21 ft. 6 in. span, and *Photograph* XXIV. an 84 ft. length of Inglis Rectangular with a replacement bridge alongside consisting of two 21 ft. 6 in. and two 16 ft. spans.

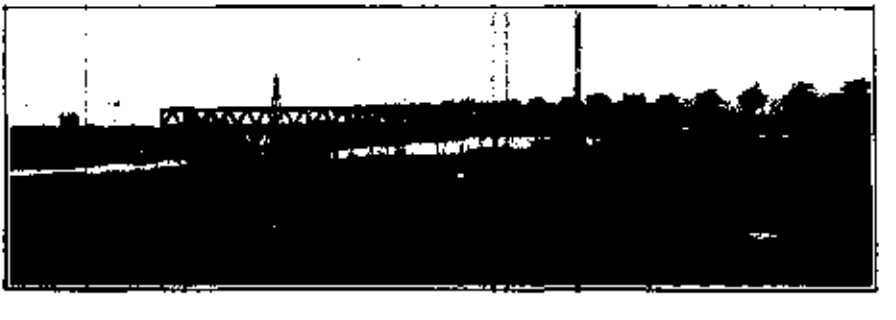
(*To be continued.*)

[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) and October (Bridging, Chapter I. p. 162). Copies of these Journals may be obtained through the usual channels.]



Photograph XVIII.

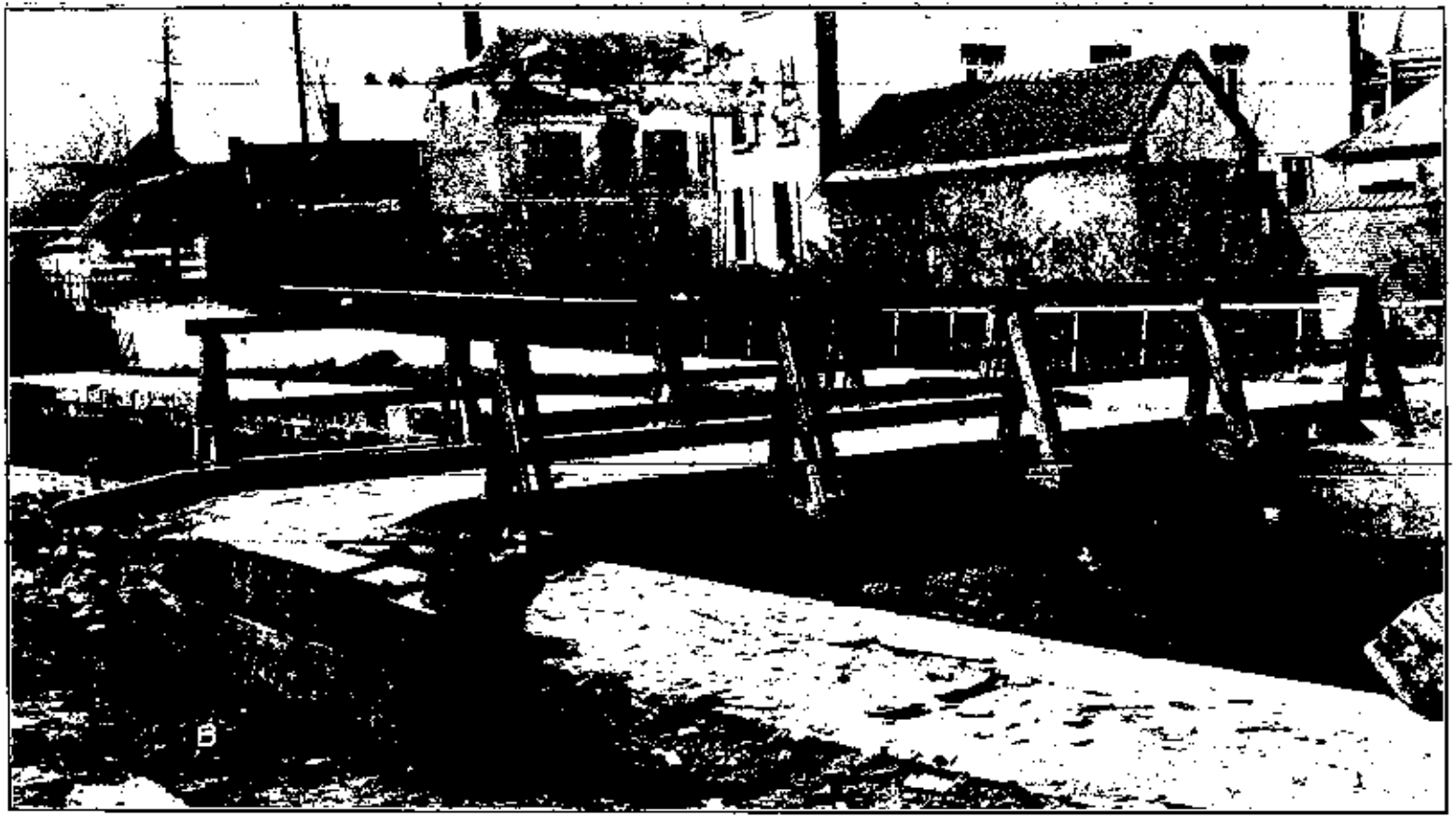
Photograph XIX.



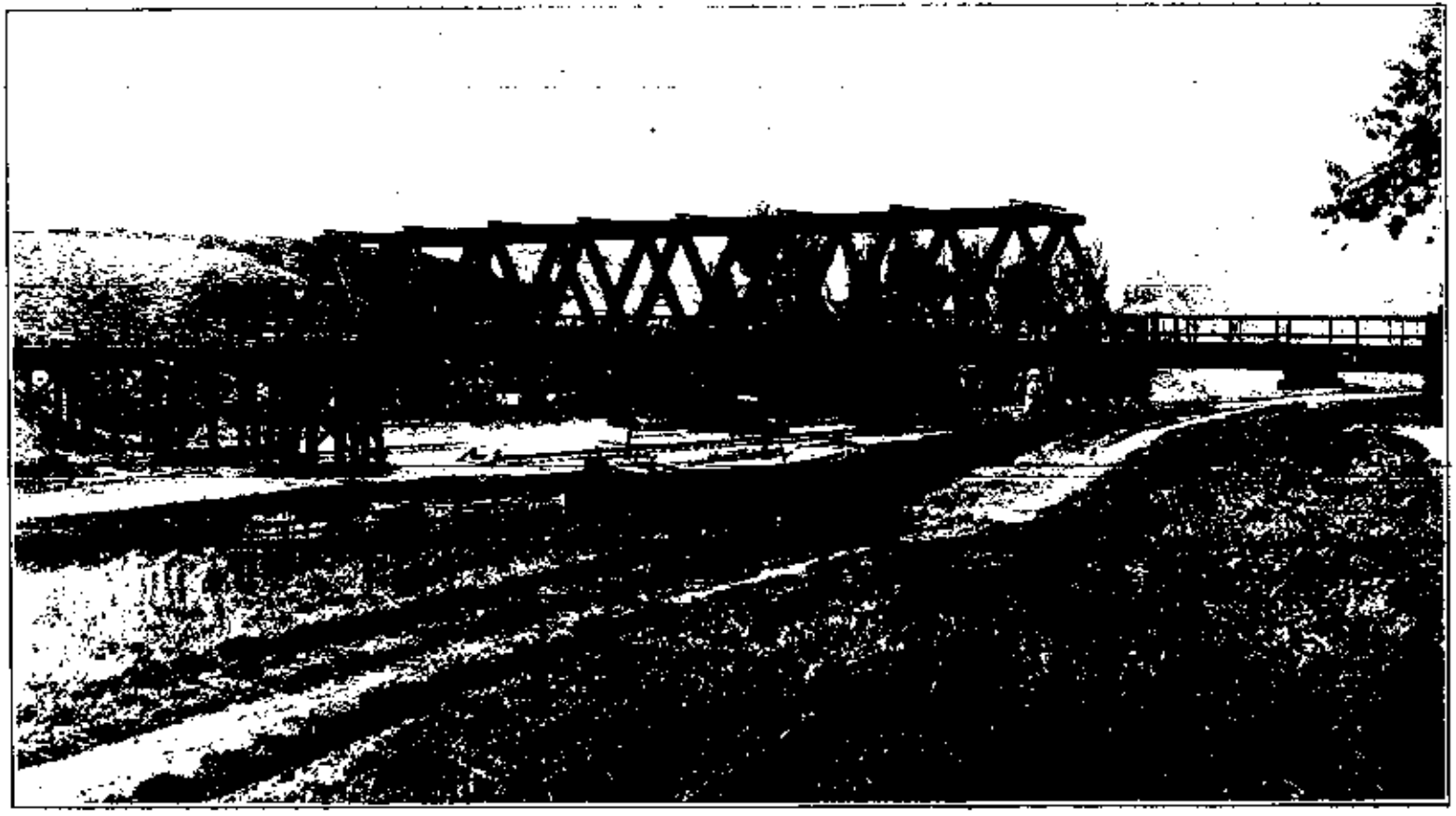
Photograph XX. -Erection of a Two-Span 85ft. Bridge at Beutin.

Photograph XXIV.—K. 84-ft. 0-in. length of Inglis Rectangular Type at La Motte, April, 1918; also to the right is shown Kt. Replacement Bridge, consisting of 2 21-ft. 6-in. and 2 16-ft. 0-in. Spans, Mark II. N.14.d 1.3. View shows Inglis Bridge being dismantled. 4th Army.

Photograph XXII.- Timber Approach to Bridge at Tronville Chateau, April 1918. 4th Army.



Photograph XXIII.—N2. 21-ft. 6-in. Span, Mark II., at Fouilloy (Corbie), April, 1918. 4th Army.



Photograph XXI.—120ft. Hopkins Bridge at Arques.

THE DESIGN OF ROOFS.

By LIEUT.-COL. H. L. LEWIS, D.S.O., R.E.

EVEN before the war it occurred to many officers that recognized methods of designing roofs gave results that erred very much on the side of safety, not to say extravagance.

During the war, and especially in its later stages, the shortage of material enforced a reduction in the size of members, and it was found that roof structures cut down to a fraction of the strength that would have been considered normal in peace time, were able to fulfil their purpose, and, in exposed situations, to survive repeated storms.

It became evident that the theory of roof construction required investigation and drastic revision to bring it into line with the experience recently gained.

2. It is for the purpose of propounding some ideas and of inviting a discussion that this short article has been written.

Essentially, a roof consists of a "covering" and of a structure whose function it is to maintain that covering in place under all conditions except the most abnormal.

It is now suggested that past practice resulted in some, if not all, of these members being made very considerably stronger than safety demanded.

That the pure theory of roof design was at fault, may be ruled out at once, for this theory is the same as is applied to other engineering structures, and is based on very numerous experiments.

We may attribute any errors that may have arisen to one of two causes :—

(1). A faulty arrangement of the members.
(2). An excessive estimate of the load that might be imposed.

As regards the first of these, it must be admitted that a very large number of roof structures are imperfect. The spacing of the trusses, the number of the points at which the principal rafters are supported by struts, the spacing of rafters, are considerations which all have their effect on the economy of design, and in the aggregate may easily make a difference in cost of ten or fifteen per cent.

Such questions rarely receive sufficient attention. Joints are often designed so as to bring about large and avoidable secondary

stresses, and to meet these members must be made heavier than would otherwise be necessary. These secondary stresses are never calculated, or directly provided for, but as a sufficient factor of safety must be obtained, theory is made to square with practice by allowing for a roof load greatly in excess of whatever actually occurs.

3. Let us consider how the roof load is estimated and whether the customary allowances are in fact justified.

The permanent loads allowed for are actual existing loads, and it is only a question of estimating or measuring them correctly. This can always be done with sufficient accuracy, if not at the first, then at the second or third attempts.

There remain to be considered the allowances which should be made for the various temporary loads which may be imposed, whether due to the weight of workmen, weight of snow, or to wind pressure.

4. Firstly as regards weight of workmen.

A very usual allowance in this case is 25 lbs. a foot super., which is considered applied to battens, to common rafters, to purlins, and to trusses. In order to appreciate what this means, let us apply this allowance to a roof with a clear span of 40 ft., with trusses 10 ft. apart. The length of principal rafters will be about 24 ft., and we may assume that the purlins are spaced 6 ft. apart. Assume that the common rafters are 2 ft. apart, centre to centre, and that battens are spaced at 1 ft.

A load of 25 lbs. dead load per foot super means on each common rafter, a dead load of 300 lbs.; on each purlin, a dead load of 1,500 lbs.; on each truss, a dead load of 12,000 lbs. So that, so far as workmen are concerned, the assumed load is equivalent to about :—

1¾ workmen on each common rafter,
9 workmen on each purlin,
70 workmen on each truss,

taking the weight of one workman at about 170 lbs.

Stated in this way, it is evident that, whereas 25 lbs. a foot super. is not an unreasonable allowance for workmen in considering the load that may come on a common rafter, it is a wholly absurd allowance as applied to a purlin or to a truss.

A common rafter may have to bear the bulk of the weight of a single workman, being live load and not too well distributed.

A purlin is most unlikely to have to bear more than four workmen at one time, at the very outside, or a total load of 680 lbs.

If any of the overlaying structure is in place, this load will be fairly well distributed, and as the men will have to move cautiously it may be considered a very nearly dead load. If, on the other hand, the superstructure has not been placed, the load is less well distributed

and is more suddenly applied, but on the other hand, the permanent load is absent.

We may assume here that, for four workmen, a total load allowance of 680 lbs. or at the rate of 11½ lbs. a foot super is well up to the mark.

Were the purlins spaced closer together, there would be proportionately fewer workmen on each, and the same allowance, say 12 lbs. a foot super would be ample.

The truss will never have to support 70 workmen at one time. We may put the maximum number conceivable for a roof of this span at 10 on each side, which works out to an allowance of 7¼ lbs. a foot super. of roof slope. Such loads can always be considered dead and distributed.

It should be noted with regard to rafters, purlins, and trusses that a factor of safety will be applied to both permanent and temporary loads and that the former being invariable, the actual margin available to meet unusual variations of the latter is greater than is apparent at first sight.

It would appear therefore, that for the roof which is being considered, and for all similar roofs, the following would be a fair and sufficient allowance for workmen, provided the ordinary rules for good construction are followed :—

On battens and common rafters	25 lbs. per foot super.
On purlins	12 „ „ „
On trusses	7½ „ „ „

5. *Allowance for Snow.*—In England, it is rare for any considerable quantity of snow to lodge on a sloping roof. If the slope of the roof exceeds 45°, no allowance need be made. On flatter roofs, and in the absence of strong wind, a considerable thickness of snow may collect and may remain for several days.

The average weight of fresh snow is about 8 lbs. a cubic foot, and on a roof of very flat pitch this might accumulate to a depth of two or even three feet. On the average slate or tiled roof a depth of one foot is about the maximum, and an allowance of 8 lbs. a foot super is sufficient. This allowance applies equally to battens, rafters, purlins and trusses.

6. *Allowance for Wind Pressure.*—The pressure which can be exerted by wind has given rise to much discussion in the past, and fantastic allowances, some even as high as 56 lbs. to the square foot, have been applied to structures.

Over a period of seven years, the highest wind pressures recorded at the Firth of Forth bridge, on two surfaces, one of 1½ square feet, the other of 300 square feet, were 41 lbs. a square foot and 27 lbs. a square foot respectively. The surfaces experimented on were

placed high above the ground, in most exposed situations, and the locality is liable to very severe gales.

More recent experiments give results which agree closely with one another and which are expressed by the formula :—

$$P = \cdot 0032 \times V^2, \text{ when}$$

P is the pressure in lbs per square foot,
V is the velocity in miles per hour.

What in Beaumont's scale is known as a "fresh gale" corresponds to a wind velocity of 48 miles per hour, whilst a "full gale" has a velocity of 67 miles per hour.

These would exert a pressure on a surface normal to the direction to the wind of 7·36 lbs. a square foot and 14·4 lbs. a square foot respectively, whilst a hurricane of 100 miles an hour would exert a pressure of 32 lbs. a square foot.

Now in England, buildings are rarely placed in very exposed sites; the force of the wind is much broken by the unevenness of the ground, by trees, and by the proximity of other houses.

In very exposed sites, special allowances should be made, but there is no reason why these allowances should be also applied to buildings in ordinary situations.

For a moderately exposed site it is suggested that a wind velocity of 48 miles an hour, with a pressure of 7½ lbs. a square foot, and for an exposed site a velocity of 60 miles an hour, with a corresponding pressure of 11½ lbs. a square foot will be enough.

For a tall chimney, or other high and isolated structures, a velocity of 80 miles an hour, and a wind pressure of 20½ lbs. a square foot might be provided for.

All of the foregoing pressures refer to a surface normal to the wind.

For a roof sloping at 1 in 2, the pressure would be ·7 of the above, and for a roof of 1 in 1, ·95 of the above. For the ordinary pitch of 4 in 7, we may assume that the actual pressure, in an exposed site will not exceed ·87 × 11½ lbs. or 10 lbs. a square foot.

7. Summing the foregoing results, and remembering that with a strong wind, there can be neither snow nor workmen on the roof; and that when there is snow, at most one or two workmen will get on the roof to clear it, and that they will not proceed beyond the eaves until they have cleared as far as they can reach, we arrive in the last column at the maximum allowances that appear necessary.

Member.	Workmen.	Weight of Snow.	Wind Pressure.	Maximum Temporary load.
Battens and Common Rafters.	25	8	10	25
Purlins	12	8	10	12
Trusses	7½	8	10	10

In the case of an ordinary site, not exposed to the full force of the wind, the allowance for a truss might be further reduced to 8 lbs.

8. Our load for purposes of calculation, in the case of a roof consisting of slates resting on battens, will then work out as under :—

For Battens and Rafters.

Weight of slates	6	lbs.	per ft.	super.
,, ,, battens	1	,,	,,	,,
,, ,, C rafters	1	,,	,,	,,
Occasional load	25	,,	,,	,,
Total	33	,,	,,	,,

For Purlins.

Weight of slates, battens, and common rafters	8	lbs.	per ft.	super.
Weight of purlin	1	,,	,,	,,
Occasional load	12	,,	,,	,,
Total	21	,,	,,	,,

For Trusses.

Weight of slates, battens, common rafters, and purlins	9	lbs.	per ft.	super.
Weight of truss	6	,,	,,	,,
Occasional load	10	,,	,,	,,
Total	25	,,	,,	,,

9. As the strength of a roof is the strength of its weakest part, it is believed that a roof design based on the foregoing allowances will be no less safe than if the under portion of the structure were calculated with a higher load allowance, or what comes to the same thing, with a higher factor of safety. That such structures can be reduced much below their ordinary strength without undue risk has been proved during the war. The present cost and shortage of materials make it necessary that every possible economy should be effected, and it appears well worth considering whether some considerable economy may not be effected by adopting the system that has been explained at some length in the foregoing pages.

One warning is however necessary.

If roof trusses are to be calculated strictly in accordance with the loading that will be imposed, and not for a loading greatly in excess, it is imperative that the design should be a sound one, and that it should not involve stresses for which no allowance has been made.

Reference is especially made to a very common fault in design, viz., failure to ensure that the stresses brought to a joint by two or more members, together with any load whether upward or downward, that is applied at that joint, should actually meet at a point. Only too frequently, the stresses are brought together so eccentrically, that surprisingly large bending moments are superimposed on direct thrusts and tensions, with the result that stresses are often two or three times as great as they are intended to be, or need be. With very little care, such secondary stresses can be almost completely eliminated and the truss can therefore sustain a much greater *properly* applied load than if this point were neglected.

THE 11th (FIELD) COMPANY, R.E., AT THE BRICKSTACKS CUINCHY, ON 6th FEBRUARY, 1915.

EXTRACT FROM REPORT OF O.C. 11TH (FIELD) COMPANY, R.E.

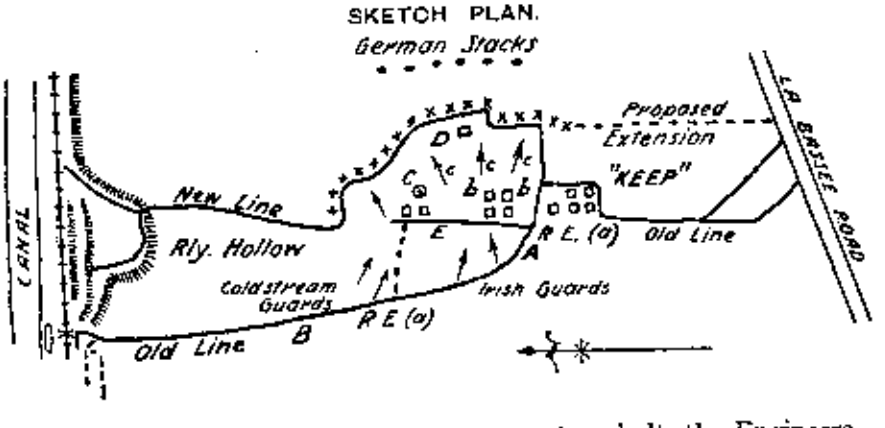
IN compliance with the Brigade Order that "the O.C., 11th Company, will detail two parties to follow the assaulting columns, strength being left to his discretion," the company paraded at 11.15 a.m. on the 6th February, 1915, in the neighbourhood of the Keep at Cuinchy Brickstacks, 50 rounds extra ammunition having been issued to each man. Total strength—4 officers and 90 Other Ranks. Each man carried one pick and shovel and 20 empty sandbags.

The interval before the assault was occupied in accumulating a stock of sandbags in the Keep.

One section (1 officer and 25 O.R.) was detailed to report to the Officer Commanding Coldstream Guards in the Railway Hollow, and the remainder, under the O.C., assembled at Point A in the keep, at a sandbag barricade blocking the German trench E.

After the artillery bombardment, as soon as the Irish Guards had reached the point E, the barricade just referred to was torn down, and, when the assaulting party vacated the trench E and moved eastwards, the O.C. Company entered the trench, followed by two sections and gained the two stacks *b b*; one officer with the 4th Section was left in reserve at A.

SKETCH PLAN.



Immediately the assaulting troops came to a halt, the Engineers were distributed along their line and half-an-hour's hard digging

followed, fire being kept up along the line. An advanced Keep was also established in the stack C and the communications throughout were improved.

The section in reserve was meanwhile brought up, making several journeys, carrying and distributing sandbags to the infantry. By this time it was possible to move about freely, and the O.C. was able to adjust the line, taking advantage of all natural features, connecting up scattered parties, joining together the two battalions and finally effecting a good junction with the Railway Hollow.

Close rifle fire had now ceased and it was possible to walk out to the front almost up to the German stacks (see *Plan*). The O.C. reconnoitred the German communications running into the British line, and got parties to work, blocking some half-dozen of them with sandbag barricades, and shaving down the sides of trenches to the front, so as to allow as long a straight field of fire down them as possible.

The fire trench was now sufficiently established, and the whole of the company was withdrawn (leaving their tools to the infantry) and sent to the R.E. depôt at Cuinchy for wire. Here a stock had been accumulated some days previously in anticipation of this attack. It was about 4 p.m. when wiring commenced, but it soon had to be discontinued, as a small group of the enemy opened fire from the stacks which were only about eighty yards off.

The wiring party got back to cover, only one sapper having been hit out at the entanglements.

At dusk the wiring was continued and the whole of the front between the lines of brickstacks was completed. This was the most important portion of the line, as a counter-attack could have been massed behind the German stacks unseen.

About 500 yards of front was wired, two rows of French roseaux Brun wire (in places, three rows), reinforced with strands of barbed wire, being laid and picketed down. The following night the remainder of the line was wired.

The new brigade line was excellently adapted to the ground and included the solitary stack D, thus denying the enemy a likely base for mining operations and sniping.

The report of Brigadier-General Lord Cavan, Commanding the 4th Brigade, stated that 340 yards of wire entanglement, 10 yards deep, were erected by the 11th Field Company, under Major Foulkes, in broad daylight, between 2.30 and 4.30 p.m., and the Divisional Commander, Major-General Sir H. S. Horne, warmly commended the devoted skill of all ranks of the Company in Division Orders.

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

Pre-War Unit	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
West Riding Div. H.Q.			
No. 1 Field Co.	1 1 455th Field Co., 230th Div., France.	2 1 458th Field Co., 49th Div., France.	3 1 461st Field Co., 62nd Div., France.
,, 2 ,, ...	1 2 456th Field Co., 49th Div., France.	2 2 459th Field Co., 6th Div., France.	See also note below.
,, 3 ,, ... (Not pre-war).	1 3 457th Field Co., 62nd Div., France. (Not pre-war.)	2 3 460th Field Co., 62nd Div., France.	See note below.
		Note.—The 4 1, 3 2 and 3 3 became 464th Reserve Field Co., Northern Group, which was reorganized later.	See note against 3rd line of Northumbrian R.E.
Signal Co., West Riding Divl. Signal Co.	1 1 49th Div. Sig. Co., France.	2 1 62nd Divl. Signal Co., France.	3 1 W. Riding Signal Co. was merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.
North Midland. H.Q.			
1st Field Co.	1 1 465th Field Co., 46th Div., France.	2 1 468th Field Co., 15th Div., France.	3 1 470th Field Co., 59th Div., France. See also note below.
2nd ,, ...	1 2 466th Field Co. 46th Div., France.	2 2 469th Field Co., 59th Div., France.	See note below.
3rd ,, ... (Not pre-war.)	1 3 467th Field Co., 59th Div., France. (Not pre-war.)	2 3 . See note against 3rd Line.	No 3 3 formed. See note below.
		Note.—The 4 1, 3 2 and 2 3 became the 473rd Reserve Field Co., Northern Group, which was reorganized later.	See note against 3rd line of Northumbrian R.E.
Signal Co., North Midland Divl. Signal Co.	1 1 46th Divl. Signal Co., France	2 1 59th Div. Signal Co., France.	3 1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.

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

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
South Midland. H.Q.			
No. 1 Field Co.	1/1 474th Field Co., 48th Div., Italy.	2/1 477th Field Co., 46th Div., Italy.	3/1 479th Field Co., 61st Div., Italy. See also note below.
„ 2 „	1/2 475th Field Co., 48th Div., Italy.	2/2 478th Field Co., 61st Div., France.	See note below.
„ 3 „ ... ... (Not pre-war.)	1/3 476th Field Co., 61st Div., France. (Not pre-war.)	2/3. See 3rd Line.	See note below.
		Note.—The 1/1, 1/2 and 1/3 Field Cos. became the 482nd Reserve Field Co., R.E. (Engrs. 7611, d. S. 1. 17, which, with the 508th Wessex Reserve Field Co., formed the Southern Group Reserve Field Cos., A.C.I. 2420 of 1916. The Southern Group Reserve Field Cos. became the 5th Reserve Battn., R.E. (which also absorbed the Reserve Depot of the Royal Naval Div., R.E.) on reorganization by 20 Engrs. 3214 (A.G.7.) of 12. 1. 18. The 5th Reserve Battn. was subsequently reorganized (some *personnel* going to 2nd Reserve Battn., etc.) into a Tank Bridging, T.C., consisting of a Headquarters Tank Bridging, T.C., and three Tank Bdg. Battns. R.E., 20 Engrs. 5325 5326 5327. The Headquarters Tank Bdg., T.C., and the three Tank Bdg. Battns., R.E., are being broken up and only an Experimental Tank Bdg. Co. is proposed for retention at present. See 20 Engrs. 5345.	
Signal Co., South Midland Divl. Signal Co.	1/1 48th Div. Sig. Co. Italy ...	2/1 61st Div. Signal Co., France.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 613 of 1917.
Wessex Div. H.Q.			
No. 1 Field Co.	1/1 500th Field Co., 27th Div., Salonika.	2/1 503rd Field Co., 58th Div., France.	3/1 Became with the 2/5th Hants converted Field Co., the 508th Wessex Reserve Field Co.
„ 2 „	1/2 501st Field Co., 27th Div., Salonika.	2/2 504th Field Co., 58th Div., France.	3/2 For subsequent reorganizations see Note against 3rd line of S. Midland R.E., T.F.
„ 3 „ ... ... (Not pre-war.)	1/3 502nd Field Co., 57th Div., France. Not pre-war.	2/3 505th Field Co., 57th Div., France.	3/3.
Signal Co., Wessex Divl. Signal Co.	1/1 27th Div. Signal Co., Salonika.	2/1 58th Div. Signal Co.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 613 of 1917.

Note.—It will be observed that units of the 43rd and 45th (Wessex) Divs. were transferred to the 27th Div.

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

Pre-War Unit.	Present 1st Line.	Present 2nd Line.		Present 3rd Line.
Divisional Field Cos., R.E. [T.F.] E. Anglian Div. H.Q.				
No. 1 Field Co.	1/1 483rd Field Co., 2nd Div., France.	2/1 486th Field Co., 54th Div., Egypt.		3/1 488th, being disbanded since 24. 10. 18. 20 Engrs. 5334 (A.G.7 B) 24. 10. 18.
,, 2 ,, ...	1/2 484th Field Co., 54th Div., Egypt.	2/2 487th Field Co. Being disbanded since 24. 10. 18. 20 Engrs. 5334. Completed disbandment 22. 1. 19.		
,, 3 ,, ... (Not pre-war.)	1/3 485th Field Co. Being disbanded since 24. 10. 18. 20 Engrs. 5334. Not pre-war.	Amalgamated with Reserve Field Co. See note against 3rd line.		
		The 4/1, 3/2 and 2/3 became the 489th Reserve Field Co. 19 Engrs. 7611 (A.G.7) d. 8. 1. 17), which, with the 490th (Home Counties) Reserve Field Co. formed the Eastern Command Group Reserve Field Cos. A.C.I. 2320 of 1916. This group was broken up "*for personnel*" to the 5th Reserve Batn., R.E., Christchurch. 20 Engrs. 5314 (A.G.7), d. 22. 1. 18. For further reorganization of 5th Reserve Batn., R.E., see South Midland R.E., T.F.		
Signal Co. East Anglian Div. Signal Co.	1/1 54th Div. Signal Co., Egypt.	Disbanded was the 2/1 56th Divl. Signal Co. Disbandment in progress since 24. 10. 18. 20 Engrs. 5334.		3/1 merged into S.S.T.C. See A.C.I. 1438 of 1916 and 913 of 1917.
Home Counties Div. H.Q.				
No. 1 Field Co.	1/1 490th Field Co., 8th Div., France.	2/1 493rd Field Co.	Being disbanded since 24. 10. 18 under W.O. letter 20 Engrs. 5333 (A.G.7 b.1.	The 3/1, 3/2 and 2/3 Home Counties and 2/1, 2/2 and 2/3 Kent "Converted" Field Cos. became the 490th "Home Counties" Reserve Field Co. (see 9 Engrs. 7611 (A.G.7) of 8. 1. 17), which, with the 489th E. Anglian formed the E. Cd. Group Reserve Field Cos. A.C.I. 2320, 1916. The Eastern Group Reserve Field Cos. reorganized by 20 Engrs. 5314 (A.G.7 b.) d. 22. 1. 18. See 3rd line of East Anglian R.E., T.F.
,, 2 ,, ...	1/2 491st Field Co., 5th Div., France.	2/2 494th Field Co.		

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

Pre-War Title.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
No. 3 Field Co. ... ... (Not pre-war.)	1/3 49th Field Co., North Russian E.F. 6194/5151. (Not pre-war.)	Amalgamated with Reserve Field Co.	No. 3/3 Field Co. formed. See above.
Signal Co. Home Counties Div. Signal Co.	1/1 28th Div. Signal Co.	2/1 Signal Co. was for some time the 67th Div. Signal Co., but on the break up of the 71st, 72nd and 73rd Home Service Divs., the 71st Div. Signal Co. was re-numbered 67th, and the 2/1 Home Counties Signal Co. was broken up. 20 Engrs./5329.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1435 of 1916 and 615 of 1917.
1st London Div. H.Q.			
No. 1 Field Co.	1/1 369th Field Co., 6th Div., France.	2/1 512th Field Co., 56th Div., France.	The 3/1, 3/2 and 2/5 First London Field Cos. formed the 516 (1st London) Reserve Field Co. 9 Engrs./7615., which, with the 525th (2nd London) Reserve Field Co., formed the London Group Reserve Field Cos., T.F., Esher. A.C.I. 2420, 1916. The London Group was broken up and *personnel* distributed to the 1st and 2nd Reserve Batts., R.E., at Chatham and Chattenden. See 20 Engrs./5214. (A.G.7.) d. 12. 1. 18. For further reorganization of the 2nd Reserve Batts. see 20 Engrs./5333.
" 2 "	1/2 510th Field Co., 29th Div., France.	2/2 513th Field Co., 56th Div., France.	
" 5 " ... ... (Not pre-war.)	1/5 (Not pre-war. 511th Field Co., 58th Div., France.	Amalgamated with Reserve Field Co. See 3rd line.	
Signal Co. 1st London Divl. Signal Co.	1/1 29th Div. Sig. Co., France.	2/1 56th Div. Signal Co., France.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1435 of 1916 and 615 of 1917.
2nd London Div. H.Q.			
3rd Field Co.	1/3 517th Field Co., 47th Div., France.	2/3 520th Field Co., 47th Div., France.	3/3 522nd Field Co., 7th Indian Div., Egypt.

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

Pre-War Units.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
4th Field Co.	1/4 518th Field Co., 47th Div., France.	2/4 521st Field Co. 60th Div., Egypt.	The 4/3, 3/4 and 2/6 2nd London Field Cos. formed the 525th (2nd London) Reserve Field Co., 9 Engrs. (1911), which, with the 516th formed the London Group Reserve Field Cos. For details of further reorganization see 3rd line of 1st London R.E., T.F.
6th ,, ... (Not pre-war.)	1/6 519th Field Co., 9th Div., Egypt.	Amalgamated with Reserve Field Co. See 3rd line.	
Signal Co. 2nd London Div. Signal Co.	1/2 47th Div. Signal Co. France.	2/2 60th Div. Signal Co., Egypt.	3/2 merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.
Mixed Brigade Signal Sections. Not pre-war Units. When first formed during war they were the Signal Sections of the Provisional Field Cos.	Nos. 221, 222, 223, 224, 225, 226, 227 being disbanded by 20 Engrs. 5334 (A.G.7.b.) of 24. 10. 18.		

PROVISIONAL FIELD COS.—Later known as Mixed Brigade Field Cos.:—

1st 2nd 3rd 4th 5th 6th 7th 8th	These Units were formed under authority of W.O. file No. 79/7269. (See A.G.I. letter d. 24. 4. 15 and "Instructions issued by W.O." Nos. 55 of June, 1915, and 31 of July, 1915.) The units consisted of 2 Field Sections and 1 Signal Section each.	Re-numbered	640th	(London)	Field Co. by 9 Engrs. (1911) (A.G.7) of 8. 1. 17				Disbandment of 640th to 646th ordered by 20 Engrs. 5334 (A.G.7.b.) of 24 10 1918.
		,,	641st	(Northumbrian)	,,	,,	,,	,,	,,	
		,,	642nd	(London)	,,	,,	,,	,,	,,	
		,,	643rd	(E. Anglian)	,,	,,	,,	,,	,,	
		,,	644th	(N. Midland)	,,	,,	,,	,,	,,	
		,,	645th	(W. Lancs.)	,,	,,	,,	,,	,,	
		,,	646th	(London)	,,	,,	,,	,,	,,	
		,,	647th	(S. Midland)	,,	,,	,,	,,	,,	Disbanded 30. 5. 18. 114 G.N. 5753. G.B 4681 A.G.7.
9th		,,	648th	(Home Counties)	,,	,,	,,	,,	,,	France 22. 8. 18 with new 73rd Div.
10th		,,	649th	(W. Riding.	,,	,,	,,	,,	,,	Disbandment ordered by 20 Engrs 5334. (A.G.7.b.) of 24. 10. 18.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Fortress R.E. (T.F.)			
City of Aberdeen W. Co.	1 1 552 Aberdeen A.T. Co.	2 1 553 Aberdeen Works Co. Disbandment ordered on 20. Engrs., 5382 (A.G.7.b.) 6. 2. 4. 19.	No 3rd line formed
City of Dundee No. 1 W. Co. ...	1 1 554th A.T. Co.	2 1 554th Dundee was converted from a Fort Co. to a Field Co. for the 51st Home Service Div., later the 51st (H.S.) Div. was broken up, but the 554th embarked for N. Russia (Siven Force) 20. 10. 6. 18. No 3rd line formed for 1 2.	No 3rd line formed.
,, ,, No. 2 E.L. ...	1 2 (Not pre-war Dundee E.L. Co. Auth. for formation 20 Engrs. 5018. (Absorbed 30th 1 Sec. of 553rd Works Co., R.E., T.F.) into 590th (Tay and Aberdeen) Fortress Co., R.E. 20 Engrs., 5215 (A.G. 7.b.) 10. 6. 18.)		No 3rd line formed.
,, ,, (Not pre-war).			
Renfrew No. 1 Co. (W.)	1 1 468th (Renfrew) Field Co. (Auth. for conversion to Field Co. 79/7634 (A.G.1.) of 22. 6. 15.)	2 1 raised to establ. of 3rd line Depot of a Field Co. on higher establ. as in table "A" of 79/5958 (A.G.1.) of 25. 3. 15. Auth. 79/7634 (A.G.1.) of 22. 6. 15. Later it was merged with 3 1, 4 2 and 1 3 Highland Field Cos. into Scottish Group Reserve Field Cos. A.C.I. 1420 of 1916 and designated 408th Highland Reserve Field Co. by 9 Engrs., 7511 (A.G.7.) of 5. 1. 17. On reorganization of R.E. Reserves the 408th Field Co. was merged into 6th Reserve Battn., R.E. Irvine. 20 Engrs., 5214 (A.G.7.) of 12. 1. 18. The 6th Reserve Battn. has since been reduced to Cadre. 9 Engrs., 1311 (A.G.7.b.) of 1. 2. 19 and 18. 2. 19.	No 3rd line formed.
Renfrew No. 2 (E.L.)	1 2 and 2 2 612th Clyde Fortress Co. 20 Engrs. 5215 A.G.7.b. of 10. 6. 18. (Prior to reorganization into the 612th Co. the 1 2 and 2 2 were amalgamated with a combined establ. of 14 officers, 200 other ranks. Auth. 79/8344.)	2 2 612th (Clyde) Fortress Co. 20 Engrs., 5215 (A.G.7.b.) of 10. 6. 18. See note against 1 2.	No 3rd line formed.
City of Edinburgh No. 1 Co. (W.)	1 1 416 Field Co. converted from a Works Co. Auth. 79/7634 (A.G.1.) d. 22. 6. 15.	2 1 raised with Imperial Service *personnel* to the establ. of a 3rd line depot of a Field Co. on higher establ. shown in Table A of 79/5958 (A.G.1.) of 29. 3. 15 79/7634 (A.G.1.) of 22. 6. 15. Subsequently absorbed into 416th Lowland Reserve Field	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.
City of Edinburgh No. 2 (E.L.) ...	The 1/2, 2/2, 1/3, 2/3, 1/4, 2/4, 2/5 and 2/5 were absorbed into the 591st and 592nd (Forth) Fortress Cos., R.E. Authority 20/Engrs./3215 (A.G.7.b.) of 10. 6. 18.	See 1st line.	No 3rd line formed.
,, ,, No. 3 (E.L.) ... Not pre-war.			
,, ,, No. 4 (E.L.) ... Not pre-war.			
,, ,, No. 5 (E.L.) ... Not pre-war.			
Lancashire No. 1 Co. (E.L.) ...	1/1 and 2/1 611th Mersey Fortress Co. Lancs. R.E. 20/Engrs./3215 (A.G.7.b.) of 10. 6. 18.	2/1 611th (Mersey) Fort. Co. See 1/1.	No 3rd line formed.
,, ,, 2 ,, (E.L.) ...	1/2 and 2/2 614th (Queenstown) Fort. Co. Lancs. R.E. 20/Engrs./3215 (A.G.7.b.) of 10. 6. 18. *Note*:—The 613th (Belfast and Lough Swilly) Fortress Co. was also formed from 1/1, 2/1, 1/2 and 2/2 Lancs. Fort. Cos. R.E., which were reorganised as Nos. 1, 2, and 3 Cos., prior to being numbered 611th, 614th, and 613th Cos.	2/2 614th (Queenstown) Fort. Co. See 1/2.	No 3rd line formed.
,, ,, 3 ,, (W.) ...	1/3 555th Lancs. A.T. Co.	2/3 549th Field Co., converted into a Field Co. for 73rd (E.S.) Div. Auth. 79/9368. Later, when the 73rd Div. was broken up, this Co. was re-mobilized for the new 73rd Div., and went to France 22. 6. 18.	No 3rd line formed.
Glamorgan No. 1 Co. (W.) ...	1/1 556th A.T. Co.	2/1 550th Field Co. Was converted to a Field Co. for 72nd (H.S.) Div., was known as 72 (Glam.) Field Co., 2nd designated 550th by 9/Engrs./7611 (A.G.7.) of 8. 1. 17. The 72nd (H.S.) Div. was broken up (114 G.N. 5/6/18), but the 550th Co. was re-mobilized for new 73rd Div., and went to France 22. 6. 18.	No 3rd line formed.
,, ,, 2 ,, (W.) ...	1/2 557th A.T. Co.	2/2 551st Field Co. was converted to a Field Co. for 72nd (H.S.) Div., which was broken up. The 551st Co. was disbanded 3. 6. 18 (R.O. Returns 273 (A.G.7.b.)).	No 3rd line formed.

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

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Glamorgan No. 3 .. (E.L.) ...	1/3 and 2/3 60th (Milford Haven) Fort Co. 20 Engrs. 5215 (A.G.7.b) of 10. 6. 18.	2/3 merged with 1/3 into 60th (Milford Haven) Fort. Co. See 1/3.	No 3rd line formed.
.. .. 4 .. (Not pre-war.)	1/4 and 2/4 Not pre-war 609th (Cardiff and Barry) Fort. Co.	2/4 merged with 1/4 into 609th Cardiff and Barry Fort. Co. See 1/4.	No 3rd line formed.
.. .. 5 .. .. (Not pre-war.)	1/5 Not pre-war 350th Works Co. was formed from portions of 2/1 and 2/2 for Gibraltar 9 Engrs. 6139. Went to Gibraltar 29. 10. 16 in replacement of 1/2 Devon 1566th A.T. Co.)	No 2/5 formed.	No 3rd line formed.
Tyne Electrical Engrs., R.E., T.F.			
No. 1 Co. (E.L.)	No. 1 Co. was absorbed into 594th (Tyne) Fort. Co., R.E. 20 Engrs. 5215 (A.G.7.b) of 10. 6. 18.	The pre-war establishment of the Tyne E.E. is laid down in Peace Establishments Part II. 1914-15. War Establishments Part II., 1911, provided for a Four-Company organization.	
No. 2 Co. (E.L.)	No. 2 Co. became No. 2 Tyne Searchlight Co., R.E. 9 Engrs. 4442 (A.G.7) of 22. 4. 16. On reorganisation of Anti-Aircraft S.L. Cos. it was absorbed into No. 42 A.A.S.L. Co., R.E., which was formed 8. 7. 16 and disbanded 21. 4. 18, the *personnel* being distributed to A.A. Cos., R.G. Artillery. 20 Engrs. 5256.	W.O. letter 79/1634 (A.G.1), d. 22. 6. 15, authorized the raising of 2nd line units, but no action had been taken to form 2nd line units, and the raising of 2nd line units for the Cos at Portsmouth was prohibited by 9 Engrs. 1784 (A.G.7) of 14. 9. 15. An increase of 4 officers, 100 other ranks to establishment of Tyne E.E. was approved by 121 6571 (T.F.1), d. 23. 10. 15, to provide reinforcements for London and Tyne E. and M. Cos. In November, 1915, in view of a proposal to form Field Searchlight detachments for employment in England, a total Establishment for 1st and 2nd lines at Tyne, Forth, Portsmouth and Isle of Wight, of 64 officers, 1,047 other ranks, was approved by 9 Engrs. 1784 (A.G.7) of 27. 11. 15. In addition to its functions in Garrisons the Tyne E.E. formed various Anti-Aircraft Searchlight Cos. The A.A.S.L. Cos. have since been reorganized as separate units, but the Tyne E.E. and London E.E. are parent units of all R.E. *personnel* attached to A.A. Cos., R.G.A. The establishment of the Tyne E.E. is under consideration on 9 Engrs. 6199. The re-formation of T.F. Headquarters has been dealt with on 9 Engrs. 5392.	
No. 3 Co. (E.L.)	No. 3 Co. was absorbed into 594th Tyne Fort. Co., R.E. 20 Engrs. 5215 (A.G.7.b) of 10. 6. 18.		
No. 4 Co. (E.L.)	No. 4 Co. became No. 4 Special Tyne Searchlight Co., R.E. 9 Engrs. 4442 (A.G.7) of 22. 4. 16. On reorganization of A.A.S.L. Cos. it was absorbed into No. 34 A.A.S.L. Co., R.E., which was formed 29. 7. 15, and disbanded 26. 1. 18, *personnel* used to form new No. 1 A.A.S.L. Co.		

(To be continued).

PLANE TABLES AND FIELD SHEETS.

By Bt. Lt.-Col. H. St. J. L. Winterbotham, c.m.g., d.s.o., R.E.

In August, 1914, there appeared in the *R.E. Journal* an interesting paper on the subject of mounting drawing paper on plane tables, by Lieut.-Colonel (then Captain) R. H. Phillimore, D.S.O., R.E. The distortion of the "field section" or "field sheet" due to changes of humidity and temperature, has been a thorn in the side of the topographer for many years, neither does there appear to be any means of eliminating it as long as the field sheet is of paper, or Bristol board, mounted upon a wooden board. Some papers give much better results than others. Messrs. Mallandain & Co., King's House, King Street, London, E.C., supplied, before the war, a linen backed paper which has been found to give fairly satisfactory results. Distortion is due, however, not only to the paper, but to the unequal absorption of moisture by the paste, and to differences of expansion in the wood, with and against the grain.

The solution of the problem given by Lieut.-Colonel R. H. Phillimore, is ingenious, and the results of his experience will be most interesting.

An adaptation of the same idea was tried during a topographical training on the Ordnance Survey in 1913. Bristol boards slightly smaller in area than the plane table were attached by corner clips which were kept loose enough to allow free play for expansion except when the plane tabler was actually at work. This system was found to answer fairly well, despite a few cases of "cockling," and made possible the transfer of the Bristol board from the topographers' board to that of the reviser.

In a systematic topographical survey the possibility of transferring a field sheet from one board to another is a great advantage, for it renders unnecessary the number of boards which must otherwise be carried, and enables the plotting of the trig. points to be done as long before the detail as may be expedient.

Bristol boards, however, although they generally show no distortion, if they are free to move, yet do expand. For reproduction this would not be serious, but for the comparison of mutual edges it remains a drawback. Moreover a Bristol board increases the weight. In view of these two objections, experiments were made in

1913 with linen backed paper mounted on aluminium or zinc. The co-efficients of expansion of both these metals are so small as to be negligible for any ordinary range of temperature.

The points which were aimed at in the production of a mounted field sheet were :—

1. Elimination of distortion.
2. Permanency—so that the finished field sheet should constitute a reliable record of the work done.
3. Adaptability to any of the special plane tables designed for it.
4. Lightness.

The two metals have about equal claims under 1, 2, and 3, but aluminium is much the lighter and its slightly larger cost is negligible in comparison to the value of the finished field sheet. Aluminium was therefore chosen. It was at first thought that the actual field work could be done upon a grained aluminium plate, and the experiment was tried. Although not altogether unsuccessful the experiment proved that an aluminium surface is undesirable for the following reasons :—

1. It is too easily destroyed by dirt and by friction, and will not stand much erasure.
2. It becomes unpleasantly hot in warm weather.
3. It is not easily secured to the table.

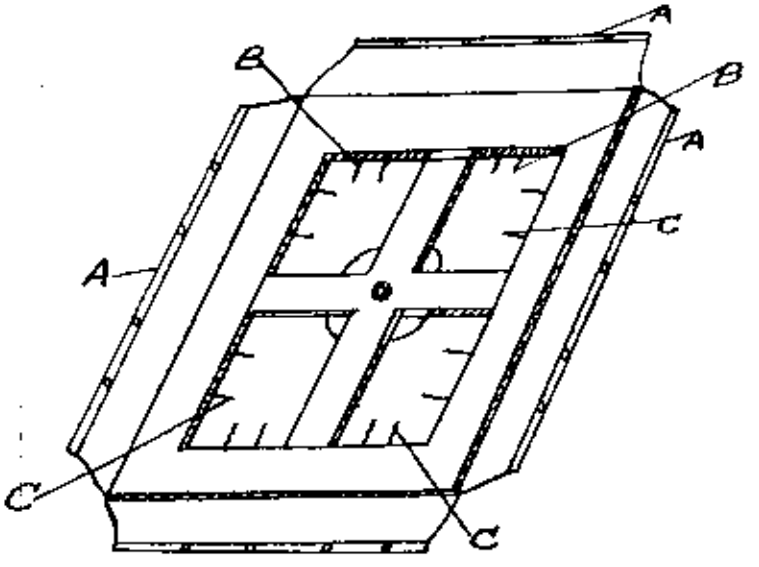
Paper can be secured firmly to grained aluminium and the combination remains sensibly constant for normal ranges of temperature. The next experimental field sheet was therefore made of paper pasted or glued to aluminium, but it was found that the edges curled up enough to interfere with the sight rule.

It became necessary, therefore, to strain the field sheet down upon the table by springs, or lashings, and this was simplified by fixing linen on the aluminium with overlaps projecting beyond all four edges. The paper was then mounted on the top of the linen. Field sheets so constructed have proved satisfactory.

The weight of this field sheet is about 1 lb. more than that of linen-backed paper of sufficient size to mount the board. In some surveys this extra 1 lb. would be a handicap, and it seemed possible to save it in the weight of the board. Aluminium (of 30 gauge) supported at small intervals on wooden battens, is sufficiently stiff to bear the weights of the alidade and Indian clinometer, and the pressure of hand and pencil. A skeleton board was therefore made, and proved to answer very well. It is described on page 116 of the "Text Book of Topographical Surveying."

The first design was somewhat too elaborate, however, and during

the first trainings of 1914 experiments were made to find a simpler pattern. That which proved most satisfactory is described below.



The field sheet is laid on the board ready for fixing and the board is viewed from below.

A.A. Strips of aluminium mounted in the edge of the overlaps of linen and with holes at intervals to fit.

B.B. Fixed hooks
C.C. Spring hooks } fixed in the depth of the scantling of the skeleton top.

The weight of this board mounted with an aluminium field sheet is compared with those of a board mounted with linen-backed paper, and a Bristol board, respectively, in the following table :—

Description, size 24 in. by 18 in.	Total Weight.
New board and aluminium field sheet	4 lb. 7½ ozs.
Plane table, R.E.—board with linen-backed paper	4 lb. 12½ ozs.
Plane table, R.E.—board with Bristol board ..	5 lb. 0½ oz.

At the outbreak of war there were only two boards fitted for the new field sheets. Six more of a much larger size (36 in. by 24 in.) were ordered at once, and the whole eight were taken to France by the 1st Ranging Section, R.E.

They proved exceedingly valuable. The original field sheets were used again and again, each successive task, finished in pencil, being rubbed out as soon as it had been traced or photographed.

During the war it was my good fortune to see something of American methods of plane tabling. They differ a good deal from our own, and we had much to learn from each other.

Their field sheets were of a species of grained celluloid, which was

evidently a first-class surface to work upon. The celluloid was clamped to the board by six saucer-shaped screws which forced the celluloid into corresponding cups in the wooden table. The screw is popularly known as the "blow and be damned" and well deserves its name, for it holds the celluloid securely in any wind, whilst offering no obstacle to the sight rule.

We made some experiments on similar lines and secured fair results, but we found that celluloid expands and contracts and "cockles" a good deal in changeable weather. There is little doubt that the aluminium and paper field sheet is preferable.

The pattern of board described above can be fitted to the legs now in use for the "plane table, R.E."

There are, however, no arrangements for a slow motion in azimuth on these legs. Indeed the feeling of many topographers is averse to the introduction of anything in the nature of a "gadget." In those countries where most of our plane table work is done breakdowns may be fatal. Experiment has proved, however, that a simple but ingenious arrangement can be fitted to the existing pattern of legs which provides a slow motion, thrown in or out of action by a cam, and detachable at will. It was tried in 1914 and unanimously approved of.

Another small modification which proved valuable was the introduction of one collapsible leg for each table. They are quite stiff when clamped, add little to the weight, and enable the table to be levelled on steep ground without undue splay of the legs. As each leg is detachable and is generally packed separate from the "top" the inclusion of a small number of legs of this pattern in the survey outfit will not necessitate their use if found undesirable, but will provide for a probable want.

It occasionally happens that topographical work is based upon a graphic triangulation, or that the two are done concurrently. The importance for graphic triangulation of a field sheet which will maintain its size, not only relatively, but also absolutely, is self-evident. For work of this nature a special plane table has been tried with a board of 24 in. square. The field sheet and board are designed on the same principle as described above, but made stronger to support the additional weight of the telescopic alidade. The board is levelled by a ball and socket joint made of aeromin.

There has been little opportunity, so far, of testing the merits of this board. It has been used for one training only, but was very favourably reported on at that time.

In the following table the 18 in. by 24 in. board designed for a paper-covered aluminium field sheet is called Type "A." The tripod with slow motion in azimuth and one collapsible leg is called Type "A" tripod.

The larger plane table, 24 in. by 24 in., with ball and socket joint is called Type "B."

Table of Relative Weights and Prices.

N.B.—The prices quoted herein are pre-war prices, and will not apply now.

Description of Table, etc.	Weight. lbs.	Weight. ozs.	Price.	Remarks.
Plane table, R.E.—complete (without cover).	10	12½	£2 8 10	Priced vocabulary of stores, Part I.
Type "A" board with tripod of plane table, R.E.	9	7½	£3 0 0 £2 17 6	According to quantity quoted, by Messrs. Watts & Co., 123, Camberwell Road, London.
Type "A" board and Type "A" tripod legs.	11	2½	£3 15 0 £3 12 6	
Type "B" board and tripod.	12	8½	£5 12 9 £5 7 6	

REVIEW.

PERMANENT WAY HANDBOOK. By Capt. S. C. Clayton, C.E. (late R.E.). (Spon, Ltd.).

One is somewhat misled by the title of this handbook which deals almost exclusively with the practice on Indian Railways and reflects the views of Indian Railway Engineers rather than a general consensus of opinion. To illustrate this one need only quote one example:—The author states that "crossings built of steel rail are superior to any form of cast or box crossing," a view that the vast majority of American railways, and not a few British railways, would contest, if they did not refute. A number of useful formulæ are given for special work, junctions, etc., and some short notes on temporary bridges, painting, brickwork and water supplies.

In the Preface the author suggests that the book should be useful to Permanent Way Engineers and Inspectors—but in order to make it suitable for use by the former, a particular point should be made of distinctly labelling *approximate* formulæ as such. The formula given on pp. 34—35 is an example, where under certain circumstances a very considerable accumulated error will be produced on a long curve. Incidentally the diagram illustrating this method should be re-drawn in accordance with the letter-press. There is some discrepancy in the figures given for expansion gaps at rail ends for 30-ft. rails—*vide* ⅜in. on page 10, and ½in. on page 23.

If the book is to be of general utility it would be advisable to add a glossary of terms, for the engineer who works with flanged rail might be puzzled at the note that "the nose of the switch rails should be neatly housed under the flange (*sic*) of the stock-rail."

Speaking broadly, the book should be of value to P.W. Inspectors in the country where the practice quoted in it obtains, but very considerable revision and widening of its views would be necessary before it could be claimed to be of general utility.

H. N. Cotterill, *Capt., R.E.*

BOOKS ON ENGINEERING.

THE following is a list of books which are recommended to officers who wish to improve their knowledge in various branches of engineering.

The list is not complete, but will be republished with additions and amendments from time to time.

Should an officer require information on any subject not included in these lists, he should write direct to the Chief Instructor in Construction, S.M.E., Chatham, stating as fully as necessary what his requirements are, and every endeavour will be made to supply or procure the information.

1. APPLIED MECHANICS.

NOTES ON APPLIED MECHANICS. (Printed at the S.M.E.).

THE STRENGTH AND ELASTICITY OF STRUCTURAL MEMBERS.—By R. J. Woods, M.Inst.C.E. Published by Edward Arnold, London. 2nd edition; 1 vol.; 8vo. 1906. 10/6.

Chapter I.—Graphic Statics. II.—Stress and Strain. III.—Stress-Strain Diagrams, Working Stress, Resilience. IV.—Compound Stresses. V.—Bending Moments and Shearing Forces. VI.—Moments of Inertia. VII.—Girders. VIII.—Deflections. IX.—Combined Stress, Non-Axial Stress, Stress at a Plane Joint, Masonry Structures. X.—Columns and Struts. XI.—Riveted Joints. XII.—Continuous Girders. XIII.—Cantilever Bridges, Suspension Bridges, Arched Ribs. XIV.—Torsion.

This book was originally written as a series of lectures for students at the Royal Indian Engineering College, Cooper's Hill. It is a clearly written elementary text book.

THE THEORY OF STRUCTURES.—By R. J. Woods, M.Inst.C.E. Published by Edward Arnold, London. 1 vol.; 8 vo.; 1909. 10/6.

Chapter I.—Compound and Principal Stresses. II.—Earth Pressure. III.—Stresses due to Eccentric Loads. IV.—Working Stresses, Stresses in Girders with Parallel Chords by Method of Co-efficients. V.—Girders with Parallel Chords, General Method. VI.—Parabolic Girders. VII.—Curved Girders, not Parabolic. VIII.—Wind Pressure, Portal Bracing, High Steel Trestles. IX.—Continuous Girders. X.—Cantilever Girders, Suspension and Stiffening Girders. XI.—Riveted Joints. XII.—Plate Girders. XIII.—Columns and Struts. XIV.—Arched Ribs and Braced Arches. XV.—Reinforced Concrete.

This volume is a continuation of "The Strength and Elasticity of Structural Members," by the same author. It contains several worked out examples but no drawings of actual work.

THE THEORY AND DESIGN OF STRUCTURES.—By E. S. Andrews, Lecturer at the Goldsmiths' College, New Cross. Published by Chapman & Hall, London. 1 vol.; 8 vo.; 1908. 9/-

Chapter I.—Stress, Strain, and Elasticity. II.—Principles of Design. Working Stress, Wind Pressure. III.—Forces, Areas, Moments. IV.—Riveted Joints. V.—Bending Moments and Shearing Forces. VI.—Stresses in Beams. VII.—Rolling Loads. VIII.—Deflection. IX.—Fixed and Continuous Beams. X.—Shearing Stress in Beams. XI.—Framed Structures. XII.—Columns and Struts. XIII.—Suspension Bridges and Arches. XIV.—Masonry Structures. XV.—Reinforced Concrete. XVI.—Design of Steelwork in Buildings. XVII.—Design of Roofs. XVIII.—Design of Bridges and Girders.

This book covers the usual college course, and is good of its kind, but only touches lightly on questions of design. The diagrams and general presentation are good.

APPLIED MECHANICS.—Embracing the Strength and Elasticity of Materials, Theory and Design of Structures, Theory of Machines and Hydraulics. By D. A. Low, M.I. Mech. E., Professor of Engineering, East London College. Published by Longmans, Green & Co., London. 1 vol.; 8 vo.; 1913. 7/6.

Chapter I.—Preliminary. II.—Motion and Force. III.—Work and Energy. IV.—Polygon of Forces. V.—Moments and Centroids. VI.—Simple Strains and Stresses. VII.—Beams and Bending. VIII.—Deflection. IX. Compound Strains and Stresses. X. Columns and Struts. XI.—Behaviour of Materials in the Testing Machine. XII.—Stress Diagrams. XIII.—Design of Roofs. XIV.—Design of Plate Girders. XV.—Design of Braced Girders. XVI.-XXVI.—Theory of Machines. XXVII.—Hydrostatics. XXVIII.-XXXI. Hydraulics.

Only a portion of this book is devoted to structural mechanics. This covers the ordinary college course. There are three chapters on design, including worked out examples of plate and braced girders, with detailed drawings. The book makes a feature of exercises, of which there are 780 in all.

Graphics and Structural Design.—By H. D. Hess, M. Amer. S.C.E., Professor of Machine Design, Cornell University; formerly Designer and Compiler with the American Bridge Company. Published by Wiley & Sons, New York (Chapman & Hall, London). 1 vol.; 8 vo. 2nd edition, 1910. $3.00.

Chapter I.—Materials. II.—Graphics. III.—Stresses in Structures. IV.—Algebraic Determination of Stresses. V.—Influence Diagrams. VI.—Tension Pieces, Compression Pieces, and Beams. VII.—Columns. VIII.—Girders for Conveyors. IX.—Trusses, Bents, and Towers. X.—Design of Steel Mill Buildings. XI.—Design of a Plate Girder Railway Bridge. XII.—Crane Frames. XIII.—Girders for Overhead Electric Travelling Cranes. XIV.—Reinforced Concrete. XV.—Foundations. XVI.—Chimneys. XVII.—Retaining Walls. XVIII.—Bins. XIX.—Shop Floors. XX.—Walls and Roofs. XXI. Specifications. XXII.—Problems.

2. MATHEMATICS.

Calculus for Engineers.—By Prof. Perry. Published by Edward Arnold. 7/6.

A most useful and interesting book, giving progressive examples of the practical application of the Calculus to Engineering and Electrical problems.

Unlike most other treatises on the Calculus, this book is essentially practical from beginning to end.

STRENGTH OF MATERIALS.

The Strength of Materials.—By J. A. Ewing, F.R.S., M.Inst.C.E., etc. Cambridge University Press.

Chapter I.—Stress and Strain. II.—Relation between the Elastic Constants. III.—Ultimate Strength and Non-elastic Strain. IV.—Testing of Materials. V.—Uniform and Uniformly Varying Distributions of Stress. VI.—Stress in Beams. VII.—Deflection of Beams. VIII.—Frames. IX.—Struts and Columns. X.—Torsion of Shafts. XI.—Shells and Thick Cylinders. XII.—Hanging Chains and Arched Ribs.

Strength of Materials.—By Arthur Morley, M.I. Mech. E., formerly Professor of Mechanical Engineering in University College, Nottingham. Published by Longmans, Green & Co., London. 1 vol.; 8 vo.; 3rd edition; 1913. 7/6.

Chapter I.—Elastic Stress and Strain. II.—Mechanical Properties of Metals. III.—Resilience and Fluctuating Stress. IV.—Theory of Bending. V.—Stresses in Beams. VI.—Deflection of Beams. VII.—Built-in and Continuous Beams. VIII.—Secondary Effects of Bending. IX.—Direct and Bending Stresses. X.—Twisting. XI.—Pipes, Cylinders, and Discs. XII.—Bending of Curved Bars. XIII.—Flat Plates. XIV.—Vibrations and Critical Speeds. XV.—Testing Machines, Apparatus, and Methods. XVI.—Special Tests. XVII.—Special Materials.

The Elasticity and Resistance of the Materials of Engineering.—By W. H. Burr, C.E., Professor of Civil Engineering, Columbia University, New York. Published by Wiley & Sons, New York (Chapman & Hall, London). 1 vol.; 8 vo.; 7th edition, 1916. $5·50.

Part I.—Analytical. Elementary Theory of Elasticity in Amorphous; Solid Bodies; Flexure; Torsion; Hollow Cylinders and Spheres; Resilience; Combined Stress Conditions.

Part II.—Technical. Tension, Compression; Riveted Joints and Pin Connections; Long Columns; Shearing and Torsion; Bending or Flexure; Concrete—Steel Members; Rolled and Cast-Flanged Beams; Plate Girders; Miscellaneous Subjects; The Fatigue of Metals; The Flow of Solids.

Appendix I.—General Equations; Thick Hollow Cylinders and Spheres; and Torsion; Theory of Flexure.

Appendix II.—Clavareno's Formulæ.

Appendix III.—Resisting Capacity of Natural and Artificial Ice.

3. STRUCTURAL STEEL.

ENGINEERING CONSTRUCTION IN STEEL AND TIMBER.—By W. H. Warren, M.Inst.C.E., Challis Professor of Engineering, University of Sydney. Published by Longmans Green & Co. Price 18/-.

Chapter I.—Stress, Strain, Working Stresses: Properties of Steel. II.—Timber and its Properties. III.—Determination of the Stresses in Structures. IV.—Bending Moments and Shearing Stresses. Influence Lines. V.—Moments of Resistance and Intensity of Shearing Stresses in Beams. VI.—Bridges and Viaducts of Small Span. VII.—Examples of Graphical Statics. VIII.—Braced Girders with Parallel Chords. IX.—Bowstring and other Trusses. X.—Slope and Deflection of Beams. XI.—Continuous and Cantilever Bridges. XII.—Strength of Columns. XIII.—Riveted Joints. Pins and Eye-Bars in Bridges. Timber Joints. XIV.—Wind Pressures, etc. XV.—Stresses in Braced Piers. XVI.—Approximate Weights of Girders and Trusses. Live Loads. Concentrated Wheel Loads. XVII.—Plate Web Girder Bridges. XVIII.—Pratt Truss Bridges. XIX.—Design of a Parker Truss Bridge for a Single Line of Railway. XX.—Swing Bridges. XXI.—Arched and Suspension Bridges.

THE DESIGN OF STEEL MILL BUILDINGS AND THE CALCULATION OF STRESSES IN FRAMED STRUCTURES.—By M. L. Ketchum, C.E., Professor of Civil Engineering, Colorado University, Consulting Engineer. Published by Engineering News Publishing Co. New York. 1 vol., 8 vo.; 3rd edition; 1913. $4·00.

Part I.—Loads. Chapters I.-IV.—Dead, Snow, Wind, and Miscellaneous Loads.

Part II.—Stresses. Chapter V.—Graphic Statics. VI.—Stresses in Framed Structures. VII.—Stresses in Simple Roof Trusses. VIII.-IX.—Beams. X.—Stresses in Bridge Trusses. XI.—Stresses in a Transverse Bent. XII.—Stresses in Portals. XIII.—Stresses in a Three-Hinged Arch. XIV.—Stresses in a Two-Hinged Arch. XV.—Combined and Eccentric Stresses. XVI.—Graphic Calculation of Deflection in Beams.

Part III.—Design of Mill Buildings. Chapter XVI.—General Design. XVII.—Framework. XVIII.—Corrugated Steel. XIX.—Roof Coverings. XX.—Side Walls and Masonry Walls. XXI.—Foundations. XXII.—Floors. XXIII.—Windows and Skylights. XXIV.—Ventilators. XXV.—Doors. XXVI.—Shop Drawings and Rules. XXVII.—Paints and Painting. XXVIII.—Estimates of Weight and Cost.

Part IV.—Miscellaneous Structures. Description of various Buildings, Specifications, Problems in Graphic Statics and Calculations of Stresses.

"The book is intended to provide a short course in the calculation of stresses in framed structures and to give a brief discussion of steel mill construction. It is meant to supplement the elementary books on stresses on the one hand and the more elaborate treatises on bridge design on the other. Much of the matter will apply equally well to all classes of steel frame construction." The author has a large consulting practice and considerable teaching experience. The book is well illustrated and there are several worked out examples.

STRUCTURAL ENGINEERS' HANDBOOK. Data for the Design and Construction of Steel Bridges and Buildings.—By M. L. Ketchum, C.E., Professor of Civil Engineering, University of Colorado, Consulting Engineer. Published by McGraw Hill Book Co., New York (Hill Publishing Co., London). 1 vol.; 8 vo.; 1914. $5·00.

Part I.—Data and Details for Design and Construction. Chapter I.—Steel Roof Trusses and Mill Buildings. II.—Steel Office Buildings. III. Steel Highway Bridges. IV.—Steel Railway Bridges. V.—Retaining Walls. VI.—Bridge Abutments and Piers. VII.—Timber Bridges and Trestles. VIII.—Steel Pins. IX.—Steel Grain Elevators. X.—Steel Head Frames and Coal Tipples. XI.—Steel Stand Pipes and Elevated Tanks. XII.—Structural Drafting. XIII.—Estimates of Structural Steel. XIV.—Erection of Structural Steel. XV.—Engineering Materials. XVI.—Structural Mechanics. XVII.—The Design of Steel Details.

Part II.—Structural Tables.—This part consists of 105 tables under the following headings:—Bars and Plates, I Beams, Channels, Angles, Miscellaneous Sections, Columns and Struts, Top Chord Sections, Plate Girders, Details for Bars, Pins, Bolts and Nuts, Rivets and Riveting, Beam and Lateral Connections, Miscellaneous, Bethlehem Sections, Mathematical, and Miscellaneous.

"This book"—to quote the preface—"is for the student or engineer who has had a thorough course in applied mechanics and the calculations of stresses in structures. Great care has been used to give examples that represent standard practice. The drawings have been prepared from actual working plans. The book is a source book, not a treatise, intended to furnish data that are available to only a few engineers, and specifications that are available only in transactions of societies or special treatises." Though dealing with American practice this is a very useful up-to-date book. Part I., 600 pp., contains a mass of information on practical calculations, specifications, structural details, materials, etc., and is profusely illustrated.

4. STRUCTURAL TIMBER.

STRUCTURAL DETAILS: ELEMENTS OF DESIGN OF TIMBER FRAMING.—By H. S. Jacoby, Professor of Bridge Engineering, Cornell University. Published by Wiley & Sons, New York. 1 vol.; 8 vo.; 1914. 9/6.

Chapter I.—Fastenings. II.—Joints. III.—Wooden Beams and Columns. IV.—Wooden Roof Trusses. V.—Examples of Framing in Practice. VI.—Timber Tests and Working Stresses.

A very useful book on the designing of timber work, with much information on the strength of nails and bolts and the strength of joints. Well illustrated with dimensioned drawings. The book is frequently quoted in the United States.

TIMBER FRAMING.—By H. D. Dewell, Assoc. M. Amer. S.C.E., Chief Structural Engineer for the Panama-Pacific International Exposition. Published by Dewey Publishing Co., San Francisco (D. Van Nostrand & Co., New York). 1 vol.; 8 vo.; 1917. 10/-.

Chapter I.—Introduction. II.—Mill and Yard Specifications, Grading Rules. III.—Working Stresses. IV.—Washers and Pins; Compression on Surfaces Inclined to the Direction of the Fibres; Resistance of Wood to Metal Pins; Sheer Pin Joints. V.—Spiked, Screwed, and Bolted Joints; Lateral Resistance of Spikes and Nails, Common Wood Screws, Lag Screws, and Bolts. VI.—End Joints. VII.—Intermediate Joints. VIII.—Tension and Compression Splices. IX.—Main Members of Trusses, Compression Chords and Struts, Laminated Truss Chords, Timber Tension Members, Tension Rods. X.—Bracing Trusses; Details of Howe Roof Truss, Lattice Trusses, Truss Connections to Posts. XI.—Theory of Columns; Tests of Timber Columns. XII.—Column Splices and Girder Connections; Floors; Joists; Joist Hangers; Mill Construction. XIII.—Foundations. XIV.—Miscellaneous Structures. XV.—Wind Pressure; Working Drawings. XVI.—Specifications for Timber Framing.

An up-to-date book treating fully and practically a subject which is hardly discussed at all in other books, with the exception of the previous one by H. S. Jacoby. The author has had eleven years' experience of timber work on a large scale.

5. STEEL BRIDGES.

DESIGN OF STEEL BRIDGES.—By F. C. Kunz, C.E., formerly Designer for the Bridge and Construction Department of the American Bridge Company and Chief Engineer of the Bridge and Construction Department of the Pennsylvania Steel Company. Published by McGraw Hill & Co., New York (Hill Publishing Co., London). 1 vol.; 8 vo.; 1915. 21/-.

Chaper I.—External Forces. II.—Reactions and Influence Lines. III.—Moments and Shears in Simple Spans. IV.—Stresses in Simple Trusses. V.—Stresses in Bracing of Simple Spans. VI.—Types of Bridges and Principal Dimensions. VII.—Design of Bridge Floors. VIII.—Beam and Plate Girder Bridges. IX.—Simple Truss Bridges. X.—Skew Bridges and Bridges on Curves. XI.—Weights of Simple Span Bridges. XII.—Viaducts. XIII.—Elevated Railroads. XIV.—Movable Bridges and Turntables. XV.—Arch Bridges. XVI.—Long Span Bridges in General and Examples. XVII.—Cantilever Bridges

Appendix A.—Actual Pressure of Foundations in Bridge Work. B.—Actual Pressure of Foundations in Structural Work. C.—Properties of Materials. D.—Tables. E.—Properties of Sections. F.—Riveting. G.—Tables. H.—Specifications.

This book was to form the second volume of a series all by the same author, but so far it is the only one published. The first, third, and fourth volumes were to deal with General Theory, Steel Buildings, and Masonry, Concrete, and Reinforced Concrete, respectively.

The book is written in a somewhat condensed style. Its aim is not to be a text book, but to give the engineer numerical examples and results of the best modern practice in designing and estimating of steel bridges, and to serve him as a guide and aid in the calculation of stresses, sections, and weights. A feature is the set of 52 good plates at the end of the book, "which are expected to guide the designer from dead and live load assumptions to the last rivet spacing without reference to the text."

BRIDGE ENGINEERING.—By J. A. L. Waddell, C.E., D.Sc. Published by Wiley & Sons, New York (Chapman & Hall, London). 2 vols.; 8 vo.; 1916. $10·00.

Volume I.—Chapter I.—Evolution of Bridge Engineering. II.—The Bridge Specialist. III.—Ordinary Materials of Bridge Construction. IV.—Alloy Steels in Bridge Work. V.—Dead Loads. VI.—Live Loads. VII.—Impact Loads. VIII.—Centrifugal Force and Other Effects of Track Curvature. IX.—Wind, Vibration,

and Traction Loads. X.—Methods of Stress Computation. XI.—Secondary Temperature and Indeterminate Stresses. XII.—Deflections. XIII.—Combination of Stresses. XIV.—Intensities of Working Stresses. XV.—First Principles of Designing. XVI.—Detailing in General. XVII.—Shopwork as Affecting Bridge Design. XVIII.—Classes of Traffic and Provision Therefor. XIX.—Floors and Floor Systems. XX.—Laterals and Sway Bracing. XXI.—Plate Girder and Rolled I Beam Bridges. XXII.—Simple Truss Bridges. XXIII.—Trestles, Viaduct, and Bridge Approaches. XXIV.—Elevated Railroads. XXV.—Cantilever Bridges. XXVI.—Arch Bridges. XXVII.—Suspension Bridges. XXVIII.—Movable Bridges in General. XXIX.—Swing Bridges. XXX.—Bascule Bridges. XXXI.—Vertical Lift Bridges. XXXII.—Riveted *versus* Pin-Connected Trusses. XXXIII.—Dimensioning for Camber. XXXIV.—Protection of Metal Work. XXXV.—Wooden Bridges and Trestles. XXXVI.—Draw Bridges and Protection. XXXVII.—Reinforced Concrete Bridges. XXXVIII.—Foundations in General. XXXIX.—Cofferdams. XL.—Open Dredging Process. XLI.—Pneumatic Process. XLII.—Piles and Pile Driving. XLIII.—Piers, Pedestals, Abutments, Retaining Walls, and Culverts. XLIV.—Shore Protection and Mattress Work.

Volume II.—Chapter XLV.—Expedients in Design and Construction. XLVI.—Data Required for Designing Bridges, Trestles, and Viaducts. XLVII.—Locating of Bridges and Preliminary Surveys. XLVIII.—Borings. XLIX.—Determination of Waterways. L.—Requirements of the U.S. Government for Bridging Navigable Waters. LI.—Hydrographic Surveys for the Bridging of Navigable Waters. LII.—Æsthetics in Design. LIII.—True Economy in Design. LIV.—Determination of Lay-Outs. LV.—Weights of Steel Superstructures. LVI.—Quantities for Piers, Pedestals, Abutments, Retaining Walls, and Reinforced Concrete Bridges. LVII.—Estimates. LVIII.—Office Practice. LIX.—Inspection of Materials and Workmanship LX.—Triangulation. LXI.—Engineering of Construction. LXII.—Erection and Falsework. LXIII.—Maintenance of Traffic. LXIV.—Bridge Examination. LXV.—Reconstruction, Maintenance, and Repair of Existing Bridges. LXVI.—Status of Highway Bridge Building. LXVII.—Bridge Failures and Their Lessons. LXVIII.—Specifications in General. LXIX.—Contracts. LXX.—Reports. LXXI.—Administration of Construction. LXXII.—Arbitration. LXXIII.—Promotion of Bridge Projects. LXXIV.—Bridge Engineering Fees. LXXV.—Some Business Features of Bridge Engineering. LXXVI.—Responsibility of the Bridge Engineer. LXXVII.—Ethics of Bridge Engineering. LXXVIII.—General Specifications Governing the Design of Superstructure of Bridges, Trestles, Viaducts, and Elevated Railroads. LXXIX.—General Specifications for Manufacture and Erection of Superstructure, Substructure, and Approaches, etc. LXXX.—Glossary of Terms (243 pp.). Index (224 pp.).

This is a very valuable book, and well worth reading even by other than bridge engineers, for many of the chapters are interesting essays in themselves. The book is written in an almost conversational style, with many touches of personal experience which make it very readable. The author, who is a well-known American consulting engineer, states his aim to be "to give to his readers, concerning every branch of bridge work, all the information he has been able to accumulate during a practice of 40 years. Nothing of any value has been omitted, except such matter as can readily be obtained from other books, because he has never been a believer in the pseudo-economic idea that what has cost so much labour and money to discover and record should be utilised only for one's personal gain. On that account there appear for the first time in print all the diagrams of weights of metals, quantities of masonry, costs of construction, economic functions, etc., that this book contains."

The book has been very favourably received. It contains 2,200 pages, including a useful glossary of 243 pages, a full index, and very many plans, diagrams, and tables.

6. CONCRETE AND REINFORCED CONCRETE.

Reinforced Concrete.—By Capt. J. G. Fleming, R.E. Published by the R.E. Institute. Price 3/6. (Out of Print).

A revised and enlarged edition will be issued early next year.

Reinforced Concrete Construction, Part I.—By M. T. Cantell (Spon & Co.). A somewhat elementary, but excellent little book, giving a full table of formulæ, and 30 worked out examples of columns, singly and doubly reinforced beams and Tee Beams.

Concrete Engineers' Handbook.—Data for the Design and Construction of Plain and Reinforced Concrete Structures.—By G. A. Hool, N. C. Johnson, and S. C. Hollister. Published by MacGraw, Hill Book Co., New York (Hill Publishing Co., London). 1 vol.; 8 vo.; 1918. 25/-.

NOTICES OF MAGAZINES.

THE MILITÄR-WOCHENBLATT.

July—August, 1919.

The paper seems to be drifting more and more into being the organ of the ex-officer; much of its contents is taken up with articles on the economic position of officers and ex-officers, regimental unions, notices of civil posts open to officers (mostly in police and municipal services). The translation of Lord French's "1914" is continued in each number, as are also "Reviews of the Press," wholly from English papers, and "Short Notices," paragraphs of military news from the Entente Press. "The Rolls of Honour" still form an interesting feature: noticeable are the small losses of the cavalry. (A few numbers of the paper during the period July—August, 1919, were not received).

No. 10.

The Officers' Compensation Law.—A complaint that the War Ministry has not listened to the demands of the D.O.B., the German Officers' Union.

Remarks on the Military Political Situation in Russia.

Provision for the Military who are to be retired from the Army.—As the Army has to be reduced to 100,000 by the 1st April, 1920, the officers, who before the war numbered 36,000, will be cut down to 4,000, and jobs must be found for the N.C.O.'s, 76,000 strong before the war. In the present state of unemployment and credit, their prospects are poor and the State must provide for them. (In the advertisements three situations only for ex-officers appear.)

Roll of Honour.—Infantry Regiment No. 146: officers 85, N.C.O.'s 232 and 1,960 men killed. Infantry Regiment No. 149: officers 122, other ranks 3,446 killed. Pioneer Battalion No. 5: officers 56, N.C.O.'s 167, men 1,045 killed. Hussar Regiment No. 8: 35 officers and many other ranks killed.

Advertisements.—Announce the formation of a number of Regimental Clubs.

No. 11.

The Officers' Compensation Law.—A bitter complaint at the treatment of officers under the peace terms. What would happen it is asked if 16,000 railway or post office employés were suddenly turned out into the street. The terms of compensation proposed for officers removed on reduction of establishment are:—(*a*) Officers under 10 years' service, one year's pay without allowances. (*b*) All other officers up to Brigade-

Commanders exclusive, if married, 5 years' pay; if unmarried, 2 years' pay. (c) Brigade-Commanders and upwards will receive pensions.

"*Long-continued Laughter from the Whole House.*"—A complaint that the above appears in an account of a sitting of the Reichstag. "There ought" the writer says, "to be tears and gnashing of teeth."

Officers' Settlement Union.—This Union has taken a piece of ground to teach ex-officers and officials agriculture and gardening.

Rolls of Honour.—Infantry Regiment No. 97: 120 officers and about 3,000 other ranks killed. Infantry Regiment No. 98: 90 officers and 2,245 other ranks killed.

Advertisements.—A Union to protect the personal freedom and life of Wilhelm II has been formed. Warning against migrating to Cassel, as there is a lack of houses there.

No. 12.

Misleading Generalizations.—A signed article by the well-known military historian General von Freytag-Loringhoven denouncing two books:—"The Death Path of the German Army" and "The Marne Drama" (reviewed in the *Times Literary Supplement* of 4th September), in which the truth about the condition of the German Army in the latter part of 1918 is told.

Bonus for Retired Officers on Account of Dearness of Living.—Complaints that the instructions are not clear and smell of the Finance Branch—A poor War Ministry defence follows.

Roll of Honour.—Uhlan Regt. No. 14: 20 officers and many other ranks killed.

Advertisements.—The Mess furniture, etc., of the Military Technical Academy (where Engineer and Artillery officers received higher technical training), and of the Non-Commissioned Officers' School at Treptow are being sold off. So the schools are no doubt being closed down. Five posts in municipal offices and police are offered to ex-officers.

No. 14.

Transfer of Officers in the Active Army.—In selecting officers for the Defence Force, their confidential reports, their behaviour in war and since the armistice, age, size of family and private means will be taken in account.

The Officers' Compensation Law.—A complete draft of the bill, the important points of which were given in No. 13, is printed.

Our South Russian Troops.—A bitter complaint of the treatment by the Allies of the German Forces cut off in South Russia. They could not march home, the Allies promised ships, but only took the troops as far as Salonika, where they were interned. The senior officer who made complaints was given 15 days' arrest by the French Commander.

The War Minister to General Otto von Below.—A letter of official thanks for services. It is quite a good imitation of the ex-Kaiser's best style.

Regimental Unions of the Old Army.—A further list of unions formed.

Roll of Honour.—The Guard Corps Train: 18 officers and many other ranks killed.

No. 15.

Proposals for State Assistance to Pensioners remaining in Ceded Territory.—Apparently pensioners who remain in Alsace and Lorraine, etc., at present are deprived of their pensions.

Not Black-red-gold, rather Black-white.—The proposed democratic national colours are jeered at. If black-red-white will not do, then it is better to adopt the Prussian colours, black and white.

Posts for ex-Officers.—Seven police and municipal jobs are offered. The pay varies from 2,400 to 6,000 marks.

Rolls of Honour.—Foot Artillery Regiment No. 7: 64 officers and over 1,000 other ranks killed. Fusilier Regiment No. 33: 101 officers and 3,000 other ranks killed. Infantry Regiment No. 143: 121 officers, 324 N.C.O.'s and 2,619 men killed.

No. 16.

Ludendorff's Memorandum of September, 1917.—A violently worded article denying that the chance of peace in 1917 was spoilt by Ludendorff demanding enormous annexions. Far from it, the published documents show that he only wanted the Briey plateau, a more favourable frontier on the Meuse, and a commercial connection with Belgium that would ensure the necessary facilities for expansion to German trade!

The Officers' Compensation Law.—A later complete text of the bill. The amounts proposed are slighrly less than before published, and officers must have done 12 years' service instead of 10 before they receive any compensation for being compulsorily retired.

Rolls of Honour.—Infantry Regiment No. 29: 143 officers and about 3,500 other ranks killed. Infantry Regiment No. 74: 101 officers, 310 N.C.O.'s and 2,236 men killed.

No. 17.

The Strength and Worth of our Future Peace Army.—By the peace conditions Germany is allowed a maximum of 100,000 men, insufficient, the writer says, to maintain internal order. He disapproves of the proposed organization of the 100,000 allowed, viz., Stafis 1,696, Infantry 53,046, Cavalry 16,212, Artillery 10,955, Pioneers 2,884, etc., on the ground that over one-sixth are Cavalry; before the war, in which Cavalry did nothing, the proportion was one-tenth. He suggests cutting down the Cavalry by half and doubling the Artillery, and increasing the Pioneers to 3,200 and adding a Flying Corps.

The Fate of our Fortresses.—Twenty are to be ceded or destroyed, and there will only remain Borkum, Cüstrin, Cuxhaven, Geestemünde, Glatz, Glogau, Ingolstadt, Königsberg, Königstein, Neisse, Pillau, Spandau, Swindemünde, Ulm, Wilhelmshafen.

Rolls of Honour.—Infantry Regiment No. 141: 120 officers killed,

Infantry Regiment No. 96: 114 officers killed; in 1914, 26; in 1915, 26; in 1916, 12; in 1917, 16; and in 1918, 31, and 3 unknown. Infantry Regiment No. 112: 87 officers, 281 N.C.O.'s and 2,462 men.

No. 18.

Should Articles 227 and 228 of the Peace Treaty be Carried Out?—These articles refer to the surrender of the ex-Kaiser and certain officers. The letter of Prince Henry of Prussia to H.M. the King offering to take his brother's place, and ex-Crown Prince Rupprecht of Bavaria's offer to be tried by the Bavarian Parliament are praised.

Churchill's Speech on Intervention in Russia.—A translation of the speech, which must from its publication in the *M.W.B.* be pleasing to monarchical Germany.

The Situation at Archangel.—A summary of information from *The Times*.

Step in Rank on Retirement.—Officers whose total service in a rank is within a year of that of the most recently promoted officer above them may claim a step in rank. It appears that promotion in war in the higher ranks was slower than in peace, *e.g.*, to Lieutenant-General from Major-General 3¾ years during the war, 2½ years in peace!

Order of Merit.—Owing to so many unauthorized persons wearing this Order, it has been found necessary to issue a list of recipients. A total of 680 officers received it, viz., Generals (excluding General Staff), 228; General Staff Officers, 72; Regimental Commanders, 145; Other Officers exclusive of flyers, 92; Flying Officers, 75; Naval Officers, 52; Allied Generals, 16.

Rolls of Honour.—Field Artillery Regiment No. 60: 44 officers and over 300 other ranks killed. Field Artillery Regiment No. 2: 28 officers, 53 N.C.O.'s and 256 men killed. Infantry Regiment No. 6: 106 officers killed. Infantry Regiment No. 93: 104 officers and 3,320 other ranks killed.

No. 20 (19 not received).

Joffre's Explanations.—A summary of Marshal Joffre's evidence before the Parliamentary Committee as regards the evacuation of the Briey Basin and his failure to cover the Belgian frontier. That Briey could not be held because it was too close to Metz is accepted as conclusive; but it is insinuated that the French strategists should have appreciated that the German Army could not have left its right flank exposed to Belgian attack.

Regimental Unions.—Thirty-four have now been formed. The notice is tactfully dated 18th June, 1919, "Waterloo Day." Before the war the Germans called the battle "Belle Alliance."

Rolls of Honour.—German South West African troops: 19 Officers and 218 other ranks killed. Infantry Regiment No. 58: 112 officers killed.

No. 21.

The Military-political World Situation.—A survey of what is going on as regards Armies and Navies. "England, the great, mighty wire-

puller" is dealt with first The writer considers that we can afford the luxury of a small army, but will be involved in a Naval Armaments' Competition with America. America has now a huge Army devised by President Wilson, not to fight the Germans but the Japanese!, etc.

A Review in the Occupied Territory.—An eye-witness's account of a review by General Mangin at Coblence. The Editor regrets that Germans were present as spectators.

Rolls of Honour.—Field Artillery Regiment No. 39: 39 officers and 296 other ranks killed. Infantry Regiment No. 60: 104 officers and 4,130 other ranks killed, 13 officers missing.

No. 23.

General Ludendorff's Life-work.—The commencement of a long review of his book. (Reviewed in *The Times*).

The Reckoning of Private Earnings against Pensions.—A protest against the proposal to take private means and earnings into account in awarding pensions.

Private Property of Members of the Army in Alsace and Lorraine.—It is asserted that this has been seized and sold by the French.

Rolls of Honour.—Infantry Regiment No. 88: 90 officers, 3,377 other ranks. Infantry Regiment No. 113: 93 officers, 2,200 other ranks.

No. 25.

The Fifth Anniversary of the Battle of Tannenberg.—By Major Giehrl who was on the General Staff of a Brigade and the 1st Reserve Corps during the battle. A review of the operations. Like Ludendorff in his memoirs he says "that thousands and thousands of Russians with horses, guns, and colours found death in the Masurian Lakes," is a popular fable (*Märchen*); equally so, that Hindenburg as a General Staff Officer had studied the Lake district, and that Ludendorff was there as a Major. He was first there in 1914.

Ludendorff's Life-work.—Review of his book continued from No. 23.

The Future of the Officers.—On 1st August there were still 20,000 officers. The number must be reduced by the peace conditions to 8,000. A number of posts at present held by retired officers must be vacated to find jobs for ex-active officers.

Rolls of Honour.—Mounted Jäger Regiment No. 6: 21 officers killed, three died at home of disease contracted in the field. Infantry Regiment No. 69: 134 officers and over 3,000 other ranks killed. Field Artillery Regiment No. 25: 38 officers killed, 2 missing; about 500 other ranks killed. Foot Artillery Regiment No. 5: 53 officers, 155 N.C.O.'s and 1,033 men killed.

No. 26.

The Officers' Compensation Law.—The latest news is that officers with 10 years' service who are removed from the Army on reduction, will be pensioned whether wounded or not. War service will count double. Officers below the rank of General will receive in addition a "transition" allowance, and if in proved need "war assistance."

The "transition" allowance will be paid for 3 years to married officers and 2 years to unmarried. Officers with less than 10 years' service will receive what amounts to half-pay, if under 5 years' service for 1 year, if between 5 and 8 years for 2 years, if between 8 and 10 years for 3 years.

The Fifth Anniversary of the Battle of Tannenberg (continued).—A sketch with the usual assertion that the Russians were three times the strength of the Germans: this forgotten battle is compared to Cannae and we are assured that posterity will recognise its enormous importance.

German War Calendar.—This has not been noticed before. It deals with 1918 and is only remarkable that even in August, 1918, German victories are recorded daily. The following are specimens: They are translated verbatim:—28th—29th August.—The German line on either side of Bapaume and southwards to the Somme is withdrawn according to plan. Heavy defeat of the French between Pont St. Mard and Chavigny. 30th August.—The English continued their attack between Arras—Cambrai and S.E. of Bapaume. The battle ended in the disconfiture of the enemy. 31st August.—The Salient in front of Hazebrouck was abandoned to the enemy; thus Kemmel comes in possession of the English. Between Arras—Cambrai and Peronne the attacks of the enemy collapsed.

Rolls of Honour.—Foot Artillery Regt. No. 14: 75 officers and about 1,500 other ranks killed. Pioneer Battalion No. 18: 31 officers and about 1,000 other ranks killed.

Advertisement.—A General Staff Officer who has entered a printing business begs his former comrades to give him custom.

No. 27.

The Belgian Army before and after the War.—Among other matter it is stated that before the war the Belgian Army suffered from the small number of men with the Colours and short service. Now the Army is popular with all classes and all parties will support it on account of its victories (with the word spitefully in inverted commas).

The Officers' Compensation Law.—Remarks on the speech of a Centre Deputy, who said that 3,500 marks pension for an officer of 17 years' service was too much. Even a workman could not support a family on this sum. (This seems true in Berlin now food for a family of four costs 600 marks a month).

On Subjective Writing.—Reply of Lieut. Hesse, the writer of a book on the war entitled "The Marne Drama," which contains unpleasant truths and deductions therefrom, to General Freytag-Loringhoven's criticisms, who desires only objective truth. He says the truth has been so long concealed that the young of Germany are asking "Is there still truth?" and only naturally demand what was wrong and what can be improved!

Rolls of Honour.—Foot Artillery Regiment No. 45: 31 officers, 81 N.C.O.'s and 237 men killed. Foot Artillery Regiment No. 43: 28 officers, 53 N.C.O.'s and 178 men killed.

J. E. EDMONDS.

REVUE MILITAIRE SUISSE.

No. 8.—August, 1919.

THE GERMAN AND FRENCH CAVALRIES IN THE GREAT WAR.

The article on the above subject by Colonel Poudret, begun in the number of the *Revue* for May, 1919 (*vide R.E. Journal* for July, 1919, *et seq.*) is continued in the number under notice. The "exploitation of success" by large cavalry formations is touched upon. The opportunity which the French cavalry had been looking forward to for four years to undertake one of the greatest of tasks that can fall to that arm, namely, the completion of the discomfiture of a defeated enemy, did not come to pass: the acceptance by the German High Command of the armistice terms imposed by the Entente and Associated Powers put an end to the high hopes of thousands of gallant cavalrymen. The part played by the French 2nd Cavalry Corps, and particularly the 6th Cavalry Division, in Flanders during the last three months of active hostilities in 1918, however, provide some indication of the nature of the difficulties which large cavalry formations have to contend with in the case of operations falling under the denomination, "the exploitation of success."

The operations of the 6th Cavalry Division in Flanders and in Belgium during the period, September 18th to November 11th, 1918, are briefly described with the aid of a sketch map, which accompanies the text of the original article. As a result of the six Franco-British offensives of August and September, the Germans had been definitely forced back to the "Hindenburg Line"; and this "Line" was broken, towards the end of the latter month, in the Argonnes and in Artois. The Franco-Belgian attack on the left wing against Sixt von Armin's Army, was launched on September 28th. The French 2nd Cavalry Corps had, since August 19th, been in rest quarters at Beauvais, in rear of the positions from which the attacking troops advanced.

The 6th Cavalry Division moved forward from Chapelle-aux-Pots on September 18th and reached the neighbourhood of Steenwoorde on the 26th *idem.*: it was directed to operate in the direction of Deynze and Ghent, *via* Roulers and Thielt. The division had followed the infantry during the attacks in this region. When the Franco-Belgians had reached the line Staden—Westroosebeke, owing to the turn in affairs, the 6th Cavalry Division, then at Boesinghe, was, on the 30th *idem.*, ordered to push ahead of the infantry at all costs, and to move towards Melle (S. of Ghent) and Brussels. Advancing in two columns, it reached Langemarck and Westroosebeke at 4 p.m. on the same day, leaving the Belgian infantry behind. It was now that difficulties were met with. The Division came up against the Germans holding the ridge which covers Hooglede and Roulers. The enemy was strongly entrenched and amply provided with machine-guns. The French guns were, unfortunately, unable to move forward beyond Langemarck owing to the nature of the ground and, without the assistance of artillery, it was found impossible to make progress. The Division consequently went into bivouacs at Westroosebeke and Oost Nieuw Kerke.

The guns had been got out of the mire by October 1st, and the Cavalry Division was, in consequence, ready to act in the direction of Hooglede

for the purpose of exploiting any success gained by Massenet's troops. However, the enemy held on to his positions tenaciously, and the cavalry could not be usefully employed in the region. This Cavalry Division was, in consequence, withdrawn and sent into rest quarters at Wylder-Bambecke.

On October 12th, the 6th Cavalry Division was attached to the Flanders Army Group, and on the night of the 13—14th *idem.*, it went into bivouacs N. of the Houthulst Forest. The Franco-Belgian success at Dixmude on the 13th *idem.* uncovered the German right flank, and the later successes of the infantry again afforded an opportunity for making use of this cavalry force. On the 15th *idem.*, one of its brigades, reinforced by artillery and machine-guns, was therefore sent forward towards Thourout.

The Germans began now to retire slowly eastwards, and were pressed by the Franco-Belgians during their retreat: the cavalry being used to outflank the German rear-guards. By November 10th, the main body of the 6th Cavalry Division had reached the neighbourhood of Cruyshautem, between the Lys and the Scheldt. The infantry crossed the Scheldt between Nederswalm and Audenarde, and drove the Germans back, whereupon the 6th Cavalry Division also began to cross the river, in order to make an attempt to break the enemy's front at Segelsem. One of its brigades had, between 2 and 4 p.m. on the 10th *idem.*, reached the neighbourhood of St. Denis and St. Blaise; another of the brigades was not able to cross the river owing to the insufficiency of bridges. All preparations had been made by the 6th Cavalry Division to take part in the pursuit on the 11th *idem.*, but at 11 a.m. news arrived that the armistice terms had been accepted by the enemy.

A short account is given of the operations in which the Divisional Cavalry took part. It is pointed out that the Divisional Cavalry had a very great variety of duties to perform; it filled gaps in the line at critical moments and also took its share in the trench warfare. Owing to the smaller size of the bodies that had to be handled the Divisional Cavalry was employed with greater success in the pursuit than was the case with the larger cavalry formations. The patrols sent out by the Divisional Cavalry often penetrated deep into the gaps formed by the retreating enemy and constantly harassed the Germans. These patrols on many occasions rendered most valuable services, some of which are recounted in the original article. A copy is published of General Order No. 681, issued by the Commander of the French 121st Infantry Division, in which references occur to the part played by his Divisional Cavalry during the period, August 27th to September 7th, 1918; his thanks and congratulations are conveyed to the cavalry leaders in this Order.—(*To be continued*)

THE DEFEAT OF THE GERMAN ARMY.

The original article is by Colonel Feyler: he draws attention to the article which appeared in the number of the *Revue* for February last (*vide R.E. Journal*, May, 1919), wherein mention was made of the distinction which certain persons desired to make in the character of the defeat sustained by the German Army on the Western Front; the suggestion being that this army was defeated *morally*, but not *technically*.

It is stated that recently two important publications have been issued, which form an interesting study on the subject of the above controversy. One of these documents is German and the other French.

The German document is a "White Book," and consequently an official publication. In it are reproduced the correspondence and the telegraphic and telephonic communications which passed between the French G.H.Q. and the Berlin Government during the period August, 1914—November 11th, 1918. The French document is a pamphlet issued by the military authorities entitled: *Pourquoi l'Allemagne a Capitulé le 11 Novembre*, 1918, and gives a brief account of the military operations during the period, July to November, 1918.

The account given of the operations on the Western Front in the publications in question show that surprise remains as important a factor in war to-day as ever it was, in spite of the greatly altered conditions introduced by trench warfare. The results produced by surprise are widened by the events connected with the Cambrai Battle in the autumn of 1917; the affair of the Chemin des Dames on May 27th, 1918; the breach of the Debropolie on the Balkans Front on September 15th, 1918; and the failure of the German Crown Prince's attack in the Champagne on July 15th, 1918.

At the date last mentioned the German forces on the Western Front consisted of 207 divisions, of which 81 were in reserve; 62 of the latter were "fresh" divisions. The French G.H.Q. had been expecting a new offensive to be launched in July, probably on the 15th; there were reasons for supposing that the next German move would take place in the Champagne in the region of Rheims: thirty of the German divisions in reserve had been located in rear of the sector Chateau-Thierry—the Argonnes. It is now known that these divisions took part with the normal garrison of this sector in the attack against the French positions.

The attack being foreseen, the German offensive was rapidly brought to a halt after a partial success: a few German troops had succeeded in getting across the Marne between Jaulgonne and Dormans, where they found themselves in a dangerous "pocket."

When the French 10th and 6th Armies delivered their counter-attack from the Forest of Villers-Cotterets on July 18th, the German General Staff should have appreciated that it was too late for their plan to succeed. At this date, there were 40 German divisions in the bend of the river, and there was only one railway line to supply them; a line which, in the neighbourhood of Soissons, passed within less than nine miles of the French front. Foreseeing the possibility of a French attack from the direction of the Forest of Villers-Cotterets, the Germans had placed eight divisions in their second line "in the pocket" formed in this part of the Western Front during the mid-July offensive. The provisions made by the Germans in this region proved insufficient: the counter-attack by the French 10th Army took them by surprise and they were at a single stroke driven back beyond the Soissons—Chateau-Thierry road, which fell into French hands. At the same time, the French 5th Army advanced on the east of the "pocket." Three French Armies, reinforced by the Americans and an Italian Corps, now made a

converging attack on the Germans holding the "pocket," and the latter were obliged to fall back, slowly it is true, but suffering heavy casualties in order to save their supplies. The Germans had planned a second offensive to take place, about the same time, in the region of Lille against the British lines, but this they were obliged to abandon.

Having thus secured the initiative, the French G.H.Q. next planned operations with the object of reducing the "pocket" N. of Montdidier. The task of doing so was allotted to the British 4th Army and the French 1st Army; these armies were set in motion on August 8th on the front Albert—Moreiul along the Amiens—Roye Road: the Germans began to withdraw on the 15th *idem*.

The German White Book mentioned earlier in this article begins with the description of the events taking place on the Western Front on August 14th. On this date, a conference took place at Hindenburg's Headquarters, then at Spa. The German Commander-in-Chief was at this time of opinion that his army could still hold out. On the other hand, Burian, the Austro-Hungarian Foreign Minister, was at this time proposing that an attempt should be made to secure a peace by compromise: he had suggested that a meeting should be arranged in some neutral State between representatives of the belligerent Powers.

Marshal Foch's message of August 12th to the armies operating under his supreme command is recalled; he therein stated: "One hundred and twenty German Divisions have been heavily engaged against us since July 15th; we have to meet a situation which will not recur and which requires us to put forth all our strength and power." It was in connection with the Battle in Picardy, which began on August 8th, and consisted of four distinct phases, that Foch's troops were called upon to make their great effort finally to wrest the victory of the campaign.

The result of the operations that followed is summed up in the Summary prepared by the French 2nd Bureau on September 26th:—Of the 207 divisions which the Germans had in July on the Western Front, 163 had taken part in the fighting—75 of the latter had engaged twice or even three times. The German General Staff had been able to reconstitute 68 divisions as a reserve, but of these only 21 were "fresh." Although the German front had been reduced by 125 miles, they had still to employ the same number of divisions in their first line positions as on July 15th, owing to the strength of the units and their *morale* having been so reduced—15 divisions had been entirely wiped out, and in 50 of the remaining divisions the battalions were reduced to three companies apiece.

The seriousness of the situation, as can be seen by the account given in the German White Book, was at last brought home to the authorities in Berlin, and this it was that led to the desire on Hertling's part to re-open peace negotiations with President Wilson: the Germans were now prepared to renounce many of their pretensions.

At the same time, Marshal Foch fully realized that the German Armies were in a sufficiently tired out and disorganized state to justify one last great effort to break them up finally. Three great converging attacks were, in consequence, planned and resulted in the Battles of the Champagne and the Meuse, of Cambrésis and of Flanders.

It is recorded that Hintze arrived at the German Headquarters on September 29th; and the order was given on that day to hoist the white flag. A telegram was sent to Berlin at 9.40 p.m. wherein directions were sent to the Wilhelmstrasse to break the news confidentially to Vienna and Constantinople that Wilhelm II. intended to approach President Wilson to seek peace on the basis of the latter's 14 points.

The telegrams sent at this period from the German Headquarters to Berlin indicate that the German High Command had begun to lose confidence in its troops and on October 1st Ludendorff is found urging that the peace offer must be sent off immediately to Washington, as the troops could not be trusted to hold out for longer than another 48 hours. However, Prince Max of Baden, who had become Imperial Chancellor, was not to be hurried: he enquired whether the military authorities appreciated the consequences that might follow on a demand for peace owing to the weakness of the German military situation. However, Hindenburg and his Chief-of-Staff were fully aware of the extreme dangers that the German Army now ran, and, whatever the consequences might be, they were insistent in their demands for peace.

The statements compiled from the intelligence collected at Marshal Foch's G.H.Q. show that, between September 26th and October 20th, out of 191 German Divisions remaining on the Western Front 139 had been engaged in the fighting. It had been ascertained, as early as October 11th, that 44 German Divisions in the line had suffered so heavily as to be unfit to take further part in any serious fighting. Therefore, from a practical point of view, the German reserves were used up.

On the other hand, Marshal Foch had a large number of "fresh" troops in hand, and was able to plan operations for the invasion of Germany.

President Wilson had, on October 5th, replied to the Central Empires' messages and informed them that he did not feel justified in intervening in the military situation. Telegraphic correspondence ensued, but Berlin got no satisfaction. Finally, on October 27th, Germany realised the complete hopelessness of her position and asked to be informed the terms on which an Armistice could be concluded. The terms were made known to the *parlementaires* sent to Marshal Foch from Hindenburg's Headquarters. Berlin considered the terms extremely severe, and whilst instructing the *parlementaires* to endeavour to obtain some relaxation, informed them that if they were unsuccessful in obtaining a modification of the terms, they must agree to them "in any case."

The reason for this decision is apparent when the state of the German Army is realized. By November 10th, the German divisions on the Western Front had been reduced from 207 to 187; of the latter only 17 were in reserve, two alone being "fresh." At the date of the offensive in March, 1918, the strength of a German infantry company was about 120 men, by July 15th this strength had been reduced to between 70 and 90 men, and by the beginning of November to 50 men.

The loss in artillery had also been very great. On July 15th the Germans had on the Western Front 3,100 field batteries—say 12,500 guns—and 2,150 heavy batteries—say 7,860 guns of all calibres—comprising a total of some 20,360 guns. At the beginning of November

there remained of these but 2,600 field batteries and 1,605 heavy batteries: the loss in guns totalled 6,860 pieces of all calibres.

Colonel Feyler, in conclusion, states that although no soldier will refuse a word of praise to the German Army for the stubbornness with which it fought, on the other hand, no one can any longer assert that it was not completely defeated.

OFFICIAL DINNERS.

The original article contains a criticism of a practice which has come into existence during the period of the "War Mobilization" of holding "official dinners." It would appear that the C.O.'s of certain units have been in the habit of issuing *orders* to their subordinates to dine together: the intention has been to promote good fellowship, but the result appears to have been far otherwise. Complaint is made that these entertainments impose a heavy financial burden on the junior officers, a burden which they are not in a position to bear.

NOTES AND NEWS.

Switzerland.—Two matters are occupying a considerable amount of attention in military and civilian circles in Switzerland: the proposed entry of Switzerland into the League of Nations and that of the Vorarlberg into the Helvetian Confederation. The first question was referred to the Commission on National Defence, which has reported favourably on the proposal; the German-Swiss officers are, however, opposed to the scheme on strategic grounds.

The Vorarlberg question is still under discussion in the Press, a certain section of which seems to be extremely hostile to the incorporation of this region into Switzerland. The chief reason for this hostility arises from a desire not to increase the proportion of the German element in the Swiss nation and the number of Roman Catholics in the Republic. It is pointed out that Switzerland has in the past always been ready to accept within its fold those who have asked to be admitted to membership of the Confederation.

The *Revue* is in favour of the Vorarlberg being admitted to membership, as the 23rd Canton of the Confederation, provided suitable measures can be made for dealing with the war debt of this region incurred by Austria.

The death is announced of Colonel Paul Ktier, of the Swiss Engineers. He was better known in Switzerland as a politician than as a soldier, being President of the Vaudois Government at the time of his decease.

W. A. J. O'MEARA.