WORK OF R.E.

IN THE

EUROPEAN WAR, 1914-19

BRIDGING

THE

WORK OF THE ROYAL ENGINEERS

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I. INTRODUCTION.

At the beginning of the war the British Army not only was unprovided with special material for heavy bridging, but technical intelligence on which to base possible requirements was almost entirely lacking.

The need for heavy bridges was first experienced on the Aisne.

Some heavy timber girder and trestle bridges were built, but took too long to make and to erect, and the B.G., R.E. at General Headquarters promptly sent home a demand for steel spans.

At the end of November, 1914, Lieutenant Colonel W. A. Liddell (now Major-General Sir W. A. Liddell, K.C.M.G., C.B.) was appointed to the B.G., R.E.'s office for executive charge of roads and bridges in rear of Divisional R.E.

At that time there was only one army—later when a second was formed, the executive functions in respect of roads passed to Chief Engineers of Armies.

Compilation of Road and Bridge Maps.—The investigation of information regarding roads and bridges was at once commenced, and the work was done entirely in the B.G., R.E.'s office until the spring of 1916, when it was taken over by the Intelligence Section of the General Staff. The information was obtained with great difficulty, because most of the French departmental records of the area were left in Lille, and those of Belgium in Antwerp or Brussels—however, by the time the work was handed over to the Intelligence Section road and bridge maps as far south as the Somme, and as far east as the Escaut were practically completed.*

Details of the waterways in the area traversed by the Lys and its

*Further information on this subject will be found in a separate report on Engineer Intelligence.

tributaries and the adjoining canals (Aire-La-Bassee, Ypres-Menin, etc.) were first obtained, and before the battle of Loos in September, 1916, maps and books for the immediate British front had been issued—a portion of one of the earlier sheets is reproduced (*Map* A.).

Diagrams of Loads, etc.—The next step was to work out technical details for the transport, assembling, and launching of the steel spans under order from England.

Great progress had already been made before the end of 1914, and many details were sent to England together with a diagram of loads, all of which were elaborated by the Inspector of Iron Structures, and incorporated in a book termed *Portable Road Bridges, and Diagrams of Roads and Bridges* issued from that office. A second volume was issued later to show the A.A. type bridges, and a complete new edition was in preparation at the time of the Armistice.

Plate I. is the original diagram of loads, and *Plate* IA. a diagram of tank loads.

Base Depôt, Havre.—Steel spans began to arrive early in 1915, and by the end of that year bridges of all types had been received, and were erected at the Base Park, Havre. Work of the very greatest value was done at this park, where not only were experiments of every kind carried out which led to many improvements in methods of erection, etc., but instruction was also given to a large number of R.E. officers and other ranks.

During practically the whole of 1915 and 1916 classes were continually held under the supervision of the O.C. Base Park in addition to his normal duties. The work ultimately became far too heavy, and the formation of a proper bridging school was finally approved. This is fully described in the Appendix.

Memo. on Road Bridges.—During the summer of 1915 the first edition of *Memo. on Construction and Repair of Road Bridges* was issued from the Engineer-in-Chief's office. This was mainly compiled from the results of experience obtained by the O.C. Base Park, to whose foresight, zeal, and unremitting work much of the later success of the organisation for heavy bridging operations is due.

At the end of 1917, a pamphlet on *The Organisation of Bridging Work* was issued based on the practical experience gained in the crossing of the Somme at the beginning of that year.

During the summer of 1918 a completely new edition of *The Memo. on Road Bridges* was brought out in which the contents of all the previous publications were embodied and brought up to date.

A regular series of drawings and publications dealing with stock spans and bridging appurtenances was issued from time to time during the war from the Engineer-in-Chief's office.

A complete list of these is given on *Plate* II.

Development of Organisation.—It will be easily understood that an enormous amount of work was involved in developing the details of what was comparatively a new subject in field military engineering; of course there had been a great deal of rapid railway bridge work in the South African War, but the conditions in France were different, and it was seen that the rate of advance of an army fed and supplied mainly by motor transport, and with a very large proportion of heavy artillery, would depend in a measure on the rapidity with which heavy bridges could be constructed.

The width of the front demanded a large number of bridges to be constructed simultaneously, with labour which could only be partly skilled, consequently the organisation of supply of materials, namely—storage, sorting, loading and despatch, reception near site, and transport, had to be perfected, and full instructions for erection had to be formulated, based on local conditions. Types of bridges had to be standardised after experiment, and also methods of erection to compensate for the lack of fully skilled labour and superintendence.

Field Engineers.—The appointment of field engineers (civil engineers of good technical experience) made early in 1915 was partly designed with a view to the superintendence of heavy bridging work. At the time the amount of bridging work in progress did not require specially appointed officers, but as demands for bridges increased, the field engineers gradually were taken on to the staff of C.E.'s of corps and armies as bridging officers; similarly in the E. in C.'s office a succession of temporary field engineers and the staff of the bridging school all contributed to the gradual development of the organisation.

Engineering Stores Directorate.—On the formation of the Directorate of Engineering Stores in the summer of 1918, the whole supply of heavy bridging materials and stores was taken over by the new director, who was also responsible after the Armistice for the disposal of all surplus material and stores, as well as for the sale of bridges *in situ* to the French and Belgians. The compilation of exact records of all the bridges erected was a long and difficult job. This was done in the office of the Engineer-in-Chief, as well as the valuation of all bridges, the statistics being finally handed over to the D.E.S. for completion of the business part of the sales.

Steel bridges were valued solely on the weight of metal at an agreed price per ton, all timber and fittings being thrown in gratis.

French, Belgian and American Organisation.—The French had six heavy bridging specialist companies in 1915—16, but their bridge spans were largely improvised from ships' plate, and the companies were manned by dockyard *personnel.*

The types of bridges were not satisfactory; they would not carry our heaviest ordnance nor their own, and the roadway and clearances were also insufficient; these were revised later on.

The Belgians depended mainly on wooden girder bridges on wooden piles, but their material and stock were very scanty.

The French bridging on the Yser Canal during the Passchendaele attack in 1917 was done almost entirely with material supplied to them by the British Army.

The Americans fully recognised the necessity for large supplies of steel bridges, and decided to adopt the British types generally. After careful investigation they decided to produce a modified pattern of the 60-ft. span, in which the cross girders and flooring were raised so as to allow the sponsons of tanks to ride over the girders.

An agreement was made under which a number of these new spans were to be supplied to us by the American Army in return for an equivalent weight of Hopkins', 30-ft., and 21-ft. 6-in. bridges—none of the new type had been actually delivered before hostilities ceased.

2. First Orders for Steel Spans.

At the beginning of Oct. 1914, a letter was drafted by the Brig.-Gen., R.E., at G.H.Q., and sent to the War Office under the signature of the C. in C., asking for the provision of material for 16 steel girder bridges, together with an adequate supply of pile drivers and monkeys. These bridges were to be capable of carrying the heaviest loads then in the country (8-in. howitzer—13 tons on one axle). The actual designs were made at the office of the Inspector of Iron Structures, with the following limitations laid down by the B.G., R.E., France :—

(*a*) Maximum length of one piece not to exceed 25 ft.
(*b*) Width of one piece not to exceed 7 ft. 6 in.
(*c*) Weight of one piece not to exceed $3\frac{1}{2}$ tons.

The first order was actually placed at the beginning of December for 4,140 ft. run in 13-ft., 30-ft. and 60-ft. lengths, and deliveries were promised to begin by the end of December. Before many of these were received, the introduction of the 6-in. Mark VII gun on Naval Carriage had increased the maximum axle load to 17 tons, and in March, 1915, another order was given for bridges to carry this load in lengths of 16 ft., 21 ft. 6 in., 30 ft., 60 ft. and 85 ft. ; also in January, 1915, the first order was given for Lifting Bridges for use on navigable canals. The design for these was got out in the office of the B.G., R.E., France.

The bridges to carry 13 tons axle load were termed B type bridges. Those to carry 17 tons axle load A type bridges.

Manufacture of these first two orders was pressed on with the greatest possible speed.

At the beginning of 1915 the military situation made it clear that there would be no immediate use for these bridges, and considerable difficulty was found in providing storage space for them at the base as they arrived.

The War Office pointed out that extraordinary exertions had been made by all concerned in the bridge production, and that it was very desirable that there should be no delay in accepting delivery.

With some difficulty yard room was arranged at Havre, and this developed into the permanent heavy bridging depôt, and remained as such throughout the whole of the war.

3. Heavy Pontoon Bridging Material.

In the early days of the war the War Office took up the question of heavy floating bridges that might be required for the passage of the Rhine in the event of operations being carried into the enemy's country.

The design was got out for a heavy pontoon to carry the maximum load of a 14 tons traction engine across a river 500 yards broad, with a minimum current of five miles an hour. A special steel pontoon was designed 45 ft. long, 4 ft. deep, and 8 ft. beam, weight of each pontoon approximately 5 tons, weight of super-structure of each pontoon $3\frac{1}{2}$ tons, clear waterway 12 ft. The earliest date of delivery quoted was the end of July, 1915.

At the beginning of March, 1915, the War Office wrote to the C.-in-C., B.E.F., France, asking :—

(i) Whether it was desirable to arrange for supply of this material.
(ii) Whether the design was considered suitable.
(iii) Whether two bridges, each of 500 yards length, should be provided for, or one only.
(iv) Whether the date of earliest delivery was considered suitable.

The higher authorities in France were unanimous in expressing the opinion that the British Army was unlikely to be called on to bridge the river Rhine in the course of active operations.

The Chief of the General Staff considered that material should be provided for not less than 20 bridges, capable of carrying the heaviest loads over the Upper Scheldt, the Dendre, and the Meuse, and 10 over the river Lys.

The B.G., R.E., insisted on the advantages of steel girders resting on fixed foundations over any form of floating bridge, and a reply was accordingly sent to the War Office deprecating the expenditure of valuable time and material on floating bridge equipment.

Owing to the enormous pressure of other work at home, the additional steel bridges required by the C.G.S. were not ordered for the moment.

Meanwhile experiments were continued by the Deputy Director of Works attached to the office of the B.G., R.E., in the fitting out of standard French 280 ton barges so as to form road bridges with cuts for canal traffic.

4. Subsequent Orders for Steel Spans.

At the beginning of October, 1915, the Engineer-in-Chief obtained authority to order approximately 10,000 ft. run additional steel bridging in spans varying from 16 ft. to 85 ft. The reasons given for the necessity of this order were, first, that the size of the British Army had been more than doubled, secondly, that we had a liability to provide the French Army with material for 12 heavy bridges in case of an advance as far as Valenciennes, and that we should probably also have to supply the Belgian Army. The total amount now on order was calculated to allow about 10 bridges per Army Corps, which was thought to be the minimum that was likely to be wanted, allowing for 20 Corps British and French in line.

The situation was next reviewed by the E. in C. in January, 1916, in a letter to the Q.M.G., giving details of material received up to date. He also reported that three fleets of equipment barges were completed, and a fourth nearly ready. A certain number of Inglis type bridges had also been ordered. The E. in C. pointed out that there was no alteration in the military situation, and recommended that no further orders for bridging material should be given at present.

In April, 1917, the E. in C. wrote to the C.G.S., and to Q.M.G., again reviewing the situation in the light of the experience gained by the Fourth Army in crossing the Somme, and also of the much fuller information that had become available as to bridges in the country in front of us. He also pointed out that neither the French nor Belgians appeared to have made any serious provision for heavy bridging, and also drew attention to the extra requirements of light railways. A table was drawn up showing the number of bridges that might be required for an advance of 50 miles beyond the present line, and numbers of spans actually available.

Authority was asked to order 50 each of the following Class A spans—85-ft., 60-ft., 21-ft. 6-in., and 16-ft.

Changes due to Introduction of Tanks.—During 1917 considerable modifications had to be made to practically all the type spans owing to the introduction of tanks, which increased the maximum load to be carried from 17 tons to 30 tons. Certain of the stock spans could not be converted to carry this increased load, and consequently fell into disuse later on. The question of roadway clearance and head room was carefully investigated, and the G.O.C. Tank Corps decided that no alteration of design was required in these respects.

The stock spans generally gave a clear roadway of 10 ft., which, although insufficient for tanks with sponsons out, was ample when sponsons were turned in, and no difficulty was anticipated in doing this when necessary. In actual experience this view was not confirmed, and during the first half of 1918 a certain number of tanks were probably lost owing to the impossibility of turning in sponsons in emergency.

The new and converted bridges were termed A.A. type.

The retreat in March and April, 1918, also cost the loss or destruction of a quantity of heavy bridging material, estimated to amount to about 17,000 ft. run.

These points were brought forward in a letter from the E. in C., to the C.G.S. in May, 1918. For these and other reasons it was considered that the material still in hand or under order would only provide for a 30-mile advance, instead of 50 miles, and a further large order was recommended calculated on an additional 50-mile advance.

It was also recommended that 25 per cent. of the new bridges should be of an increased width to allow of the passage of tanks with sponsons out.

During the year 1918 the situation was constantly reviewed, and every effort made to hasten deliveries, though this was found to be almost impossible owing to the very full programme of work at home, and difficulties in the supply of raw material.

Only a portion of the spans ordered were received before the Armistice, when outstanding orders were at once cancelled.

In October, 1918, a further extensive order was made out to be spread over most of the following year, but this was cancelled after the Armistice.

The following is a summary of the quantities of heavy bridging material ordered during the war :—

October, 1914.—4,140 ft. run (B type span). Length of spans—13 ft., 30 ft., 60 ft.

March, 1915.—7,473 ft. run (A type span). Length of spans—16 ft., 21 ft. 6 in., 30 ft., 60 ft., 85 ft.

October, 1915.—10,425 ft. run (A type span). Length of spans—16 ft., 21 ft, 6 in., 30 ft., 60 ft., 85 ft.

April, 1917.—9,130 ft. run (A type span). 16 ft., 21 ft. 6 in., 60 ft., 85 ft.

May, 1918.—21,250 ft. run (A and A.A. type spans). 21 ft. 6 in., 30 ft., 75 ft., 120 ft.

Supplies of heavy baulk and other timber for piles, seatings, roadway, etc., in proportion in each case.

5. Characteristics and Development of Types.

B Type Bridges.—The 13-ft. bridge consisted of four 12 in. × 6 in. rolled steel joists.

The 30-ft. and 60-ft. types each consisted of two light Warren girders.

The earliest of these sent to France were all deck spans, but modifications were introduced to make them capable of being used as either deck or through spans, as it was found that in many cases the deck span did not allow sufficient head room on navigable canals.

A Type Bridges.—The 16-ft., 21-ft. 6-in. and 30-ft. were all manufactured rolled steel joist spans.

The 60-ft. and 85-ft. consisted of heavy Warren girders. The 21-ft. 6-in., 30-ft. and 60-ft. types are illustrated in *Plates* III. to IX.

A.A. Type Bridges.—Modifications were made in the 16-ft., 21-ft. 6-in., 30-ft. and 60-ft. bridges, to carry the extra load. In the case of the 60-ft. all that was found necessary was an increase in the size of the bolts.

The 30-ft. A span was weak, and to use up the existing spans, the 30-ft. reinforced bridge was designed, in which four existing girders were used instead of three as in the A span. In the A span the rolled steel joist girders are jointed, but when new spans were ordered the girders were made in a single piece 33 ft. long. This extra length had been made feasible by the introduction of Berna lorries, fitted with a special arrangement of rollers for carrying long timbers or girders.

The 85-ft. type had never been popular owing to the great weight (66 cwt.) of a single section, so the opportunity was taken to design a new bridge. *Photograph* I. shows an 85-ft. span.

Hopkins' 120-ft. Type Span.—The following specification was laid down :—

(*a*) The bridge should carry tanks.
(*b*) The total weight of the bridge should not be more than the weight of the old 85-ft. span.
(*c*) The heaviest single piece should not weigh more than 30 cwt.
(*d*) The number of bolts should not be unduly increased.

These conditions were completely satisfied by the Hopkins' bridge. The bridge can be made up in any multiples of 15-ft. spans, and carries tanks over a 150-ft. span, and a 17-ton axle load up to 195-ft. span. The total weight of the steel work is 43 tons for a 90-ft. length, as compared to 53 tons for the original 85-ft. span. The heaviest section only weighs 10½ cwt., and the number of bolts for a 90-ft. length is the same as that in the 85-ft. class A span.

The main feature of this bridge is the depth of the lattice girders, which are 16 ft. 3 in. over all, with overhead bracing.

The general arrangement of this bridge is shown on *Plate* X. *Photographs* II. to IV. illustrate erecting and launching at the bridging school.

Hopkins 75-ft. Type.—The Hopkins' 120-ft. type was found so satisfactory, that at the beginning of 1918 a similar bridge of slightly lighter design was ordered in 75-ft. span, and would have ultimately replaced the 60-ft. type bridge.

This 75-ft. Hopkins carries tanks up to 90-ft. span, and 17-ton axle load up to 105-ft. span. It weighs a few tons less for a 60-ft. length than the 60-ft. class A bridge. See *Photographs* V. and VI.

Hopkins Lorry Bridge.—In the autumn of 1918 a very light lattice girder bridge was designed to carry loads up to 5-ton lorries over a 75-ft. span. This bridge was still in the experimental stage at the time of the Armistice. The only one that was actually received in France was erected at the bridging school during the last class held there. Both instructors and students were unacquainted with the bridge, but a 60-ft. length was built, launched, decked, and approach ramps fitted ready for traffic in five hours. This is illustrated in *Photographs* VII. and VIII.

Lifting Bridges.—Belgium and Northern France are cut up by a network of canals, along which a great quantity of war material was conveyed, and which it was consequently necessary to keep open for traffic. These canals could often be bridged by erecting high level bridges, but in very many cases the same result was more easily attained by using lifting bridges.

The maximum width of locks is 6·50 metres (21 ft. 4 in.), so 21 ft. 6 in. was made the standard span for British lifting bridges.

The first types supplied were 21-ft. 6-in. class A spans, with the addition of lifting gear. These were made in three patterns, the Davit Bridge, the Portal Bridge, and the *Pont Levis*. Of these the first two were supplied by the War Office, and the third was manufactured in France, from designs got out at the Base Park, Havre, and modelled on the local French 16-ft. span *pont levis*.

The Davit Bridge consisted of four lattice davits, with a lifting gear of differential blocks, by means of which the four corners of the bridge could be raised.

There was no counter-weight of any kind, and if the four corners were not lifted evenly the bridge was apt to jamb.

It was difficult to erect accurately, and required four men to raise or lower it, and not being found satisfactory, was soon given up for field use.

This type was originally intended for improvised low level bridges on canals where the footings of formerly existing bridges had been damaged by explosion.

The Portal Bridge consisted of four columns braced together with shallow lattice bracing girders at the top, both across the roadway and across the canal, and the lifting gear consisted of a worm gear arrangement with a hand chain for working it, and there was also a counter-weight equal to the weight of the bridge. The lifting arrangement was weak, and trouble was also caused by the fact that bridges were supplied by four different makers, each to their own detailed drawings, so that spares were not interchangeable. It was an easy bridge to erect, and failing a better pattern a good many were used.

The Pont Levis consists of two independent towers with overhead arms carrying a counter-weight between them at one end, the bridge being suspended by wire ropes at the other end. The lifting apparatus consisted of a wire rope attached to the bridge, and led through a pulley at the top of the tower, thence being taken on to a 1-ton winch by means of which the bridge was lifted. This bridge was rather difficult to erect because it required very accurate setting out. *Photograph* IX. shows a bridge that had just been erected at the school. The derrick on the left was used for erection purposes only.

Pont Levis Mark II.—Later a new design was got out, in which the bridge proper consisted of two special plate girders with cross girders and longitudinals in place of the standard 21-ft. 6-in. class A span. The two columns were erected on a pier of rolled steel joists, which tied them together; the hinges of the bridges were carried on the column bases, so that no setting out was required once the base joists were laid. This bridge was heavier than the others, but was the most satisfactory type produced, and the weight of each individual piece was actually less than in the Pont Levis Mark I. The general arrangement of this bridge is shown on *Plate* XI.

The Emergency Portal.—This was an emergency design to carry 12-ton axle loads. It was only erected in places where it could normally remain either up or down, and would only be moved in cases of emergency.

The bridge consisted of four uprights braced together at the top as in the ordinary Portal, but with standard rolled steel joists instead of lattice bracing. For lifting apparatus the differential tackles from the discarded Davit Bridges were used.

Rolled Steel Joist Spans.—A type of bridge that was extensively used during the last months of the war was built up of stock rolled steel joists from the base. A large number of 12 in. × 5 in. × 22 ft., and 10 in. × 5 in. × 20 ft. joists were ordered specially for bridge work, and in addition use was freely made of supplies imported for gun emplacements and other defensive work.

Designs were prepared in the Engineer-in-Chief's office for standard field spans to carry various loads. They consisted of rolled steel joists laid side by side in the number necessary for the traffic that the bridge was to carry, *e.g.*, 6 joists for a 12-ton axle load, 8 for a 16-ton axle load, and 12 for a 30-ton tank. The decking of these bridges consisted of local timber, generally 2 to 3 in. layers, which was normally supplied ready cut from the base. These bridges were very easily and quickly erected. They were economical for light loads, but rather extravagant for heavy loads. The 22-ft. patterns for tanks and 12-ton axle load are shown on *Plates* XII. and XIII.

Inglis Bridges.—The Inglis pattern portable bridge consists of a series of identical bays formed of weldless steel tubes. In the original or light type, the bays were pyramidical, each 8 ft. long, 8 ft. wide, and 8 ft. high, and the bridge was designed to carry infantry in single file over a span of 120 ft.

At the first demonstration with this bridge in France, a 108-ft. span was thrown across a canal in 13 minutes by an untrained party of Army Service Corps.

The second pattern was similar to the first, but the bays were 12 ft. long, 12 ft. wide, and 12 ft. high. This was designed to carry all arms, with their first line transport, up to not exceeding 7 tons in weight, over a span of 96 ft. The triangular section of this bridge made it unsuitable for the passage of mechanical transport, and in practice it was never used. (See *Photograph* X.)

Both types were also designed to be used in pairs with a central suspended decking. (See *Photograph* XI.)

Early in 1917 a rectangular pattern Inglis bridge began to arrive in France capable of carrying A loads over a span of 96 ft. or B loads over 108 ft. This bridge was easily erected or dismantled, and was in great request during the final advance. It was not strong enough to carry tanks over any span, and also had the disadvantage of being just too low for the passage of motor buses. *Photograph* XII. shows one bay under test, and *Photograph* XIII. a completed bridge.

A drawback to all bridges of this type is the expense and also slowness of manufacture.

At the end of the war a strengthened type was under experiment to carry tanks—this is shown in *Photographs* XIV. and XV.

Barge Bridges.—For each of the Army Barge Bridge Depôts two specially fitted up turn-table barges were provided, each equipped with double roadway and cut span for floating bridges, one 60-ft. class B through span erected on turn-table, one set of shore trestles complete with roadway and cut.

When it was required to bridge a gap, the 60-ft. span could be swivelled round, and water pumped into the barge to lower it until the bridge came to bear on the abutments. In addition, each of the six store barges in each Army Depôt was fitted with trestles and superstructure calculated to carry an axle load of 16 tons, and could be used as a pier for a floating bridge, with double roadway. It was calculated that with three such barges and shore trestles, a bridge could be made across most of the French or Belgian canals. In actual practice these bridges were never utilised owing to the destruction of canals and great difficulty and length of time experienced in re-opening them for traffic.

Special Barge Bridge.—In July, 1917, a special floating bridge was designed for the passage of the Yser River, to be used in connection with a proposed landing from the sea. This bridge was to consist of four 60-ft. A spans, carried each on two sea-going Thames lighters (60—70 tons). The barges were to be lashed together for conveyance of the bridges to the site, and there spread apart so as to be one under each end of the span. In this case the spans were fixed at right-angles to the barges, and not along them as in the case of the turn-table bridges. Owing to the cancellation of the military operations for which the design was made, these bridges were never used, and the barges were dismantled during the summer of 1918.

Sankey Bridge.—The piers of this floating bridge were formed by the standard pontoons, and the roadway was carried by stock rolled steel joists. The bridge was designed to carry loads up to 14-ton caterpillars. It was made use of several times during the advance in the autumn of 1918, and was found quite satisfactory for sluggish currents, for which clear waterway between pontoon piers need not be considerable.

The three types are illustrated on *Plates* XIV. to XVII.

Types B and C require steel joists and certain other special stores.

Type D requires nothing except pontoon equipment and stores, to be obtained from any Corps dump.

Bridge B will carry all B loads, and with proper precautions, is capable of taking A loads in emergency.

Bridge C will carry the heavy commercial lorry, and bridge D loaded 3-ton lorries. (See *Photographs* XVI. and XVII.)

6. Bridging Depôts and Stores.

Base Depôts.—Reference has been made in Para. 2 to the formation of a heavy bridging depôt at Havre.

As the size of the forces increased a general division of supply was made between the northern and southern lines of communication. The Northern Armies were based on Calais and Boulogne, the Southern ones on Havre and Rouen. A second heavy bridging base depôt was therefore formed early in 1917, at Les Attaques, near Calais.

The D.E.S. automatically took over both these depôts in the summer of 1918.

Barge Depôts.—As soon as steel spans began to arrive in France arrangements were started to provide each army with a heavy bridging depôt. These were at first designed to be barge depôts for canal traffic and were formed mainly to provide mobile storage of bridging plant at a time when the wholesale destruction of canals seemed unlikely; we had then full power of movement by canal up to Armentières, beyond Bethune and on the Somme.

Each army was provided with a fleet of 280-ton barges consisting of one fully equipped workshop barge; two store depôt barges, each carrying two 60 ft. spans, two 30 ft. spans, and two 13 ft. spans, with launching gear, roadway, and erection stores; two timber depôt barges, each carrying pile drivers and 30 ft. lattice steel derricks, in addition to timber; two turn-table barges.

By the end of 1915 three fleets were completed, and a fourth nearly so.

Early in 1917 these barge depôts were dismantled, and the barges handed over to the Inland Water Transport Department. This was primarily due to the urgent demand for transport barges by the I.W.T., but by this time it was realised that canal transport was not likely to prove feasible for bridging material during an advance.

As a subsidiary matter the barges were fitted for use as floating bridges; details are given in para. 5; they were intended for use as such behind our lines, and might have proved of great value in the first half of 1918 if they had not been already dismantled.

Army Bridging Store Depôts.—The absence of canals over a large portion of the front at the beginning of 1917 necessitated the formation of bridging store depôts in army areas.

These were first started on a small scale by the Fourth Army when the Germans withdrew across the Somme after blocking the canal, and by the Third Army for the battle of Arras.

More information will be found on this subject in the introduction to Chapter 3.

From the very first the great importance of the supply of all accessory stores required in the execution of heavy bridging was fully realised, and a complete list for each type of bridge was carefully worked out and published in the original *Memo on Construction and Repair of Road Bridges.* Of these stores the larger and more expensive were kept only at the base park, whilst the lighter stores, timber, etc., were kept in the army barge depôts. The original lists remained unaltered until the spring of 1917, when they were revised, and published on a special form.

Early in 1918 a revised list of stores was got out for an army bridging store depôt, the stores being divided into sets which were calculated to be sufficient for the erection of any three bridges; three such sets forming a complete army bridge store depôt. (See *Plate* XVIII., Copy of Form H.B., 23A.).

Considerable difficulty was always found both in the storing and the transport of these stores, as they were supplied from various sources.

The ideal was that every bridge sent up from the base, for erection by the army during operations, should be accompanied by all the stores required in the erection of the bridge. This was not practicable, and would also have been wasteful of transport, as many of the stores already existed in army and corps advanced parks.

To the end of the war no completely satisfactory solution had been arrived at, and each army made the arrangements that seemed best for the provision of such stores.

Special Bridging Stores.—In addition to the stock spans stored, full new details were worked out of suitable cribs, piles and trestles for bridges across the normal waterways. Materials for such were kept both at the base parks, and at the army barge depôts. *Plate* XIX. gives details of a standard trestle as adapted for use with R.S.J. field spans.

Steel Cube Piers.—Mild steel cubes 3 ft. high were stocked at the base depôts for the erection of cube piers. This type is economical and light, and will stand a weight of 40 tons on each cube. They were very suitable for quick erection on land, but difficult to place in water.

Pile Drivers.—The standard hand pile driver was 24 ft. high, with 15-cwt. monkey. Although this was extensively used, no two units ever agreed as to its merits or demerits, and demands for a mechanical driver were general. It was noticeable that when mechanical drivers were supplied, units generally went back in a short time to the hand machines.

Petrol Pile Driver.—A standard petrol driven pile driver winch was provided, but although received at first with acclamation, was actually very seldom used. This may have been due to the absence of special heavy bridging units with *personnel* trained in the use of such appliances.

Such machines required a permanent crew, and were seldom made full use of if transferred from one unit to another without *personnel* accustomed to work them.

They must also be provided with spare parts and repair materials.

For 9-in. to 12-in. piles a petrol driven driver with a 15-cwt. monkey and a 24-ft. frame would appear to be generally suitable.

Steam Pile Drivers.—Eight steam pile drivers with monkeys from 20 to 30 cwt. were obtained, but were never actually used, and in only a few cases were there sufficient piles to be driven at one site to warrant the erection of such a driver. Similar pile drivers erected on rafts were used very successfully by the Inland Water Transport, but in their case they always had a large number of piles to drive at a given place, also all the work was carried out on navigable waterways.

One very heavy steam pile driver with an overhang of 30 ft., capable of driving two piles simultaneously, was obtained for the construction of viaducts across a waterway or flooded country, but was never actually used.

Air Compressor Plant.—During the final advance it was often found possible to salve damaged girders of the destroyed bridges, and to re-erect them *in situ*. For this type of work and also in drilling existing girders for reinforcement to carry tanks, a portable air compressor plant was found most valuable. Each plant weighed about three tons, and could be conveniently mounted on and worked from a 3-ton lorry, or a 7-ton trailer. One of these plants, with a complete set of tools, was being supplied to each army, but did not arrive in time to be of much use.

Storekeeping and Issuing.—One of the most technical, and certainly among the most important branches of bridging organisation was the care and issue of stores. As the amount of bridging material increased, a very great strain was brought on the *personnel* at the base, whilst formations had to make use of any skilled *personnel* that they could find, and which was at any time liable to be moved.

The earliest practical bridging operations, *i.e.*, the crossing of the Somme in March, 1917, made very clear the primary importance of skilled organisation in the supply of material. This was improvised, and during the intensive operations of 1918, and in spite of the greatest difficulties, there is hardly a case on record of any breakdown in the organisation.

One of the great difficulties that had to be faced during the greater part of the war was the storage and care of the steadily increasing accumulation of bridging material at the bases.

During 1916 there was a feeling in some quarters that shipping and ports were being blocked by the large quantities of material for which the actual need was still open to question.

As a result, the Director of Fortifications and Works came to France as President of a Committee, which investigated the whole question of R.E. stores. This committee entirely concurred in the demands that had been made and were being made, and the supply of bridging and other stores proceeded unchecked.

When the great final advance began there were many anxious moments, during which it seemed impossible to keep pace with the requirements of heavy bridging, but although at times reserves of all stock spans fell to a dangerous point, there was never any actual failure to supply what was required.

7. Special Bridging Staff and Units.

It has been already mentioned that for the greater part of the war there was no special bridging *personnel*. In 1915 a qualified officer was attached to the office of the Engineer-in-Chief as acting Bridging Officer.

He made reconnaissances of various routes behind our lines and calculation of the strength of the bridges on these routes, with a view to the passage of heavy guns or tanks.

He also worked on the classification and collation of bridging stores, and also on details of the application of various stock spans to certain canal and river crossings. This officer remained about a year.

In March, 1917, another specially qualified officer came to G.H.Q. and remained as bridging officer until the end of the war. His first work was the design of the new bridge to replace the 85-ft. A span.

Subsequently he worked out details of all the various rolled steel joist bridges, as well as the revised lists of stores, and various technical details connected with the erection of the various spans. In addition to these duties a lot of practical work was carried out in the field, including at times the direct superintendence of the erection and dismantling of bridges, as well as regular liaison with the Bridging Officers of Armies and Corps. This officer came on the authorised staff of the Engineer-in-Chief in July, 1917.

During 1918 the work increased enormously, and two officers, Instructors at the Bridging School, were brought into G.H.Q. to assist. During times of special stress one or more of these officers were attached to the Chief Engineer of the army most busily employed, to give assistance in the heavy bridging work. It was very noticeable that in such cases Chief Engineers almost invariably chose to put these officers in charge of the supply and issuing of bridging spans and stores, rather than employ them in superintendence of actual bridging operations.

The training given at the bridging school had by this time been sufficient to ensure a fairly general acquaintance with the erection of all stock spans among the R.E. field units, but the preparatory work in assembling both bridge sections and stores needed very special technical qualifications. This is dealt with more fully in Chapter II.

In every operation which entailed bridging on any considerable scale, both Army and Corps concerned found it essential to detail a special officer for this work alone.

It was not until the autumn of 1918, when the increased scale of field engineers on the staff of C.E.'s of Armies and Corps came in, that a permanent bridging officer could be appointed in each formation. The training of complete units was always a problem of the greatest difficulty, and was never really solved.

The advantages to be gained if such training had been possible were forcibly illustrated by the very high degree of skill attained by one Army Troops company that had the opportunity of practical training. (See Section II, Chapter II, page 27.)

When the final advance began, and it was obvious that heavy bridging was becoming one of the most important duties, if not the most important, of the Royal Engineers, a scheme was worked out in the Engineer-in-Chief's office for the formation of special bridging companies. These companies were to be formed from a certain number of existing Army Troops companies with special equipment and transport. The idea was that one such company should be allotted to the Chief Engineer of each army, and would be divisible into small sections, which would form the nucleus round which other R.E. units could work on the erection of bridges.

This proposal was not generally concurred in by Chief Engineers of armies, and was finally dropped.

8. Transport of Stock Spans.

The most useful transport which could normally be obtained by Chief Engineers of armies were the pontoon wagons of the M.T. Pontoon Parks. These vehicles would carry practically any of the standard sections—the only ones that gave difficulty were those of the 85-ft. span, and long rolled steel joists, or long timbers for piles.

After 1916 the Engineer-in-Chief had at his disposal twelve 5-ton Berna lorries, and twelve 7-ton trailers. The Berna lorry has a frame with top transom fitted behind the cab, and another frame carrying a roller and winch fitted on the rear of the chassis. They will take girders, long timber or piles up to 32 ft. in length. The 7-ton trailer hauled by a F.W.D. lorry was the most suitable type of all vehicles for heavy bridging material. They could be loaded up to 6 tons, and could be fitted with planks so that small stores as well as large sections could be carried. Twelve additional trailers were on order when hostilities ceased.

Other types of transport that were sometimes used are :—

(1) 5-ton steam Foden—
This was suitable for all loads up to 24 ft. in length.

(2) 5-ton Clayton steam lorries—
These are similar to the Foden, but have shorter bodies. They will take loads up to 18 ft. in length.

(3) 3-ton petrol lorries—
These are suitable for all loads except for girders or girder sections over 20 ft. in length.

CHAPTER II.

BRIDGING OPERATIONS PRIOR TO AUGUST, 1918.

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

9. 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.

These periods will now be described in detail.

Map B. shows the principal waterways referred to.

10 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 Armentières ; 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 Armentières ; 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*.

11. 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 cube 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.

12. 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 been 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.

13. 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 rialheads, 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.

Chapter III.

BRIDGING OPERATIONS—AUGUST TO NOVEMBER, 1918.

Introduction.—Army Organisation.—The Ancre River.—Somme River and Canal and Tributaries.—Canal-du-Nord.—Haute-Deule Canal.—Lys River and Canal.—St. Quentin Canal, Escaut (Scheldt) River and Canal.—Selle River.—Canal de la Sambre.—Summary.

14. Introduction.

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

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

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

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

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

During the bare three months that elapsed between the beginning of the Fourth Army advance and the conclusion of the Armistice, approximately 330 Stock Span or Rolled Steel Joist bridges were erected, or nearly double the number that had been used during the whole of the preceding four years. A complete account of all the bridging work done during these three months would fill many volumes. All that can be attempted here is to describe generally the work done in crossing the main rivers and canals, with a few of the more important and interesting operations in detail. A short account of the hasty bridging by divisional troops will be found in the next chapter.

15. Army Organisation.

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

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

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

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

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

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

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

16. The Ancre River.

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

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

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

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

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

17. Somme River and Canal, and Tributaries.

The first crossings were all constructed by the Australian Corps.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

18. Canal du Nord.

The Canal du Nord, which connects the Sensée Canal with the Somme Canal, was at the outbreak of war in process of construction, and its state of completion varied considerably on the front of the First and Third Armies. In the southern portion a considerable length is carried through a tunnel, and so presented no obstacle to our advance, but the very deep rough cuttings on other portions made a formidable gap, and the steepness of the banks made approaches to low level bridges difficult. A very large number of temporary crossings were made, but the speed of our advance beyond the canal made it unnecessary to build many permanent bridges.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Owing to the length of the span it was thought necessary to provide extra horizontal bracing; for this purpose wire ropes were fixed 60 ft. from either end on both sides of the bridge, and tied back to anchorages on the bank 60 ft. from the centre line. This was all completed by 5.30 p.m. and the bridge was open to traffic at daybreak on the 6th October. *Photograph* XXVIII. shows the temporary diagonal wire rope bracing. *Photograph* XXIX. shows the total length of the bridge with tail. *Photograph* XXX. shows the bridge as it appeared from the bed of the canal. *Photograph* XXXI. shows the attachment of the tackle to the heads of derricks.

Measurement of the rollers used in launching showed that those supporting the heavier loads had been reduced in diameter from

$\frac{1}{4}$ in. to $\frac{1}{8}$ in. at the ends where the webs of the lower chord channels were supported.

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

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

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

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

Party in charge of Dump and directing Transport :—

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

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

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

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

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

In one case an effort was made to launch a 108-ft. Inglis span at night, but this was found impossible and had to be left till daybreak, when the work was completed in $4\frac{1}{2}$ hours. *Photographs* XXXII., XXXIII., XXXIV. and XXXV. show typical examples of work done.

19. The Haute-Deule Canal.

The heavy bridging of the Haute-Deule was carried out by the 560th A.T. Company, and the 250th, 257th and 3rd Australian Tunnelling Companies, all belonging to the Fifth Army.

Considerable difficulties were met with owing to the very complete destruction of the old bridges and abutments, which involved either an immense amount of clearing work, or very long new approach roads. The nature of the ground bordering the canal also made the work ot assembling long span bridges rather difficult.

Projects had been carefully worked out beforehand in anticipation of an advance, and all arrangements worked smoothly. No particular difficulties were found in the actual work of erection.

Two Hopkins bridges were put up, one of 105-ft. span, and the other 120-ft. span. In each case the actual work took about a week.

20. The Lys River and Canal.

The canalised Lys varies from 100 ft. to 150 ft. in width at normal water level.

When the Second Army began its advance at the end of September, 1918, every bridge was found to have been destroyed, and 17 main road bridges had to be erected or re-constructed.

Complete arrangements had been made early in September to form an Army bridging organisation. The *personnel* consisted of an Army Bridging Officer on the staff of the Chief Engineer, and the 554th (Dundee) A.T. Company, R.E. This company was specially selected as the *personnel* consisted chiefly of men who in civil life were engaged in the manufacture and assembling of heavy structural steel-work.

Two bridging depôts were formed, an Army Base Depôt at Les Attaques (Calais), and an Advance Depôt at Bailleul. Two sections of bridging stores were kept at Les Attaques, and one section at Bailleul, where in addition about 10 stock spans were kept ready for immediate use. These two depôts proved of great value, and the system of the army running its own depôt at the base was most satisfactory.

Owing to the rapid advance of the Army during October, the forward depôt was moved by train to Heule, north of Courtrai, on the 4th November.

The transport used for conveying bridging material and stores from the advance depôt to the sites of bridges consisted of two 5-ton Berna lorries, one 7-ton trailer, F.W.D. lorries with trailers from No. 9 Pontoon Park, and such 3-ton lorries as could be provided by Corps or Army.

The 554th Company was continuously employed throughout the months of September, October, and November on the following duties :—

Unloading, checking, sorting and stocking stores and bridge parts at the advance depôts.
Issuing spans and stores, and loading them in correct lorry loads.
Supervising the correct delivery of stores at bridge sites.
Repairing bridging stores and equipment, and making replacements of lost parts.
Making up complete bridges from R.S.J.'s and timber.
Dismantling bridges in back areas.
Salving bridging material in captured areas.
Assembling a power pile driver and training crew for same.

This unit also provided a little skilled *personnel* for bridge erection, and the *personnel* for the base depôt and the office of the Army Bridging Officer. An opportunity was also taken to train certain Field Companies and the 255th Tunnelling Company in the handling of steel girder bridges, and these units dismantled the Arques high level bridge which consisted of one 120-ft. Hopkins, and six short spans. *Photographs* XXXVI. and XXXVII. show the construction of a 150-ft. Hopkins bridge at Pont de Nieppe.

No features of interest occurred in the actual erection of road bridges except the building of two R.S.J. heavy pontoon bridges at Halluin and Harlebeke. These were quickly put together and proved of great value in getting heavy guns across the river before the completion of the steel bridges to take A. loads.

The traffic across the Halluin bridge between October 23rd and November 3rd was as follows :—

Lorries	4,813
Horse Transport	1,275
Tractors and Heavy Guns	97
Steam Wagons	20
Light Cars	1,690

Some difficulty was experienced in getting certain heavy tractors and caterpillars across these bridges owing to the great width over the wheels, which is 9 ft. 6 in. in one class of tractor.

The service chesses used for decking are only 10 ft. long, and when the ribbons are fixed it is not possible to obtain anything like this clear width.

21. St. Quentin Canal. The Escaut (Scheldt) River and Canal.

Four points were selected for bridging the St. Quentin canal, but when the Fourth Army crossed it early in October, only two bridges were found necessary, as the Germans had left the other two crossings intact.

At each of the two points bridged a rectangular Inglis bridge was first put up, and replaced as soon as possible by a 60-ft. Class A span with short R.S.J. extensions on standard piers. These two crossings were made by the 283rd and the 216th Army Troops Companies. *Photograph* XXXVIII. shows the bridges at Bellenglise. A Tank crossing was also made by the conversion of a German concrete dam into a causeway.

The Escaut (Scheldt) River and Canal, of which the St. Quentin Canal is a continuation, extended across the entire British front, and threatened to be a most serious obstacle.

On the front of the British Third Army the Escaut river flows independently of the canal, sometimes to the east and sometimes to the west of it.

The river was just passable by Infantry, but had to be bridged before guns or transport could get across.

The water in the canal was too deep for the passage of Infantry. Most of the approach roads are of necessity on a higher level than the canal itself, and the retaining banks of the canal are in many places themselves higher than the surrounding country. Under such conditions long approach ramps would generally be required, and the building of semi-permanent road bridges threatened to be a very slow process.

As the enemy was becoming more and more disorganised, the problem of enabling our advance to proceed unchecked was a highly important one. A solution was found by bridging the numerous locks with rolled steel joist spans capable of carrying the heaviest loads.

On the Third Army front alone there were 18 locks, and this method of bridging was carried out with the greatest success. The actual erection was only a matter of hours, and it was found possible to build such bridges during the night at a comparatively short distance from the enemy. Examples are shown in *Photographs* XXXIX. and XL.

Cambrai definitely fell into our hands on October 8th, and a large amount of bridging was done by both the First and Third Armies here. Traffic conditions through the town were very difficult owing to the wholesale destruction carried out by the enemy before he evacuated it, and bridges had to be built not only over the river and canal on the west side of the town, but also over the railway. *Photograph* XLI. gives an idea of this sort of work.

Very heavy work was also entailed in the removal of *débris* of destroyed overhead railway bridges.

On the Fifth Army front the most important bridge constructed was at Tournai, where an 85-ft. Class A span was erected by the 284th and 552nd A.T. Companies. A scheme was already complete, but work only actually commenced on the 11th November. A great deal of time was occupied in the removal of the steel-work of the destroyed bridge, much of which had to be effected by means of gun cotton charges. The river runs through the centre of the town, and this involved clearing the streets and houses in the neighbourhood, and also interrupted the work of assembling new girders. The new bridge was opened to traffic on the 21st November.

On the Second Army front the Escaut river varied from 100 ft. to 120 ft. in width at normal water level.

All existing bridges had been destroyed by the enemy, and in most cases the shore masonry abutments were also completely demolished.

The river was crossed on the 9th of November, and two R.S.J. heavy pontoon bridges were completed for all traffic before the Armistice was proclaimed on the 11th.

Six other semi-permanent bridges were constructed subsequently on the main routes. *Photograph* XLII. shows a typical series of R.S.J. span crossings; XLIII. and XLIV. are both 60-ft. Mark II. spans.

XLV. shows a bridge at Pecq consisting of two 30-ft. standard spans with three 10-ft. approach spans at each end. The two trestle piers in deep water are built on timber cribs, loaded and sunk.

22. The Selle River.

With the successful attacks by the First, Third and Fourth Armies in the second week of October, the enemy fell back behind the river Selle, where he took up a strong position on the eastern bank, having first destroyed all bridges and approaches.

This river was about 40 ft. wide and 5 ft. deep, running through open fields almost level with the banks, except in towns or villages. The western approaches generally sloped gently towards the river, and were almost everywhere overlooked by the enemy.

Under these conditions the work of divisional field companies was very arduous and dangerous, but the heavy bridging, which consisted almost entirely of short spans, was of no particular interest. *Photograph* XLVI. shows a bridge in Neuvilly, consisting of R.S.J. spans on a central pier of steel cubes.

During the period that elapsed between the crossing of the Escaut canal and the Selle river much work was done, especially by the Fourth Army, in the removal of bridges from back areas—work of considerable importance owing to the small reserve of stock spans that was left at the base. This army also had to establish a new advanced bridging depôt, and over 70 tons of bridging material was transported to an old German pioneer park at Bohain, where in addition large quantities of heavy timber were collected from the army forestry depôt.

Bohain remained the advanced army depôt up to Armistice day.

23. Canal de la Sambre.

This was crossed by the Fourth Army in the first days of November. The advance had proceeded so rapidly and distances became so great that Army control had become very difficult. Bridging material was therefore despatched direct to Corps and left to be used by them to the best advantage.

A number of stock R.S.J. bridges were erected, but owing to the existence of locks, and the comparatively small destruction of abutments, these were all of short span and presented no difficulties. Typical examples are shown in *Photographs* XLVII. and XLVIII.

The Third Army reached the Sambre river shortly before the Armistice, but up to the 11th November only pontoon and temporary crossings had been made.

24. Summary.

Numerous other small streams and tributaries had to be bridged, and involved much work on the part of Corps and Army R.E.

A complete summary of the semi-permanent bridges erected during the advance is given below.

These bridges were all made to carry heavy loads of 12-ton axle load and over, and the great majority would carry from 17 to 30-ton loads. *Photographs* XLIX. and L. show examples of road bridges across main lines of railway.

LI. is a road bridge 350 ft. long of R.S.J.'s on timber trestles at Valenciennes station.

LII. shows a bridge across the moat at Vieux Condé, and is a good example of the use of steel cube piers.

Map C, which is a portion of the $\frac{1}{100000}$ Valenciennes sheet, gives an idea of the amount of bridging that had to be done. The figures on this map are the numbers allotted to the various bridges in the Engineer-in-Chief's register.

It is not too much to say that the power of the British Army to advance depended upon the speed with which the Royal Engineers could construct bridge crossings. Railways were so completely destroyed that they were totally unable to keep within sight of the advance, whilst the steadily increasing depth of territory occupied made it equally impossible for the Roads Directorate to keep pace. Fortunately, main roads in the occupied territory were generally in good condition, and once bridge crossings were made good, lorry traffic was able to proceed unchecked.

The success of the Corps in meeting all demands that were made upon it in this respect was due not only to the devotion and energy of all engaged in the work of reconstruction, but also to the less obvious but at least equally important work of organisation and training that had been done during the preceding four years.

SUMMARY OF HEAVY BRIDGES ERECTED AUGUST—NOVEMBER, 1918.

WATERWAYS.	STANDARD STEEL BRIDGES.	HEAVY TIMBER OR SALVED MATERIAL.	TOTAL.
Ancre River	14	—	14
Somme River and Tributaries	44	16	60
Scarpe River and Tributaries	28	21	49
Haute Deule Canal	7	6	13
Lys Canal, Lawe Canal, Aire—La Bassée Canal	18	9	27
Lys River	16	7	23
Canal-du-Nord	10	10	20
St. Quentin Canal, Escaut Canal and River ...	60	32	92
Selle River and Tributaries	26	21	47
Ecaillon River, Harpies River and St. George's River	13	15	28
Rhonelle River, Annelle River, &c.... ...	30	17	47
Sambre River and Tributaries	21	16	37
Miscellaneous Canals and Streams	39	43	82
	326	213	539

Chapter IV.

TEMPORARY BRIDGES.

Introduction.—General types of Bridges.—Pontoon and Trestle Equipment.—Haute Deule Canal.—Canal du Nord—Hasty Bridges constructed by one Corps.—Work of the R.E. of another Division in crossing the Canal du Nord.—The Escaut Canal and River.—Tank Crossings.—River Selle.—Tank Bridge over the River Selle.

25. Introduction.

During the final advance from August to November 1918, an enormous amount of hasty bridge work was thrown upon the Divisional Royal Engineer units.

Every successive stage of the enemy's retreat finished by his taking up a position behind a water obstacle after destroying all existing crossings. The forcing of a passage of the waterway would therefore always become the first stage of the succeeding battle.

In the course of these three months many hundreds,—probably thousands,—of light bridges for Infantry and First Line Transport were made by Divisional Troops, in addition to many crossings for Tanks and Heavy Artillery.

A full account of this work is manifestly impossible ; all that will be attempted here is to give a description of some typical operations, and types of bridges constructed.

The names of units and formations concerned are purposely omitted.

26. General Types of Bridges.

Foot bridges of every variety were constructed, the type generally depending on material that happened to be most easily obtained at the moment.

Floating piers were made of cork, oil tins, captured German floats etc, in order to make hasty single file bridges for Infantry. *Plate* XX gives details of the usual type of cork pier, and *Plate* XXI a petrol tin pier. The standard pontoon equipment was extensively used for passing over field guns, and first line transport.

On one river there were actually 30 pontoon bridges in position simultaneously on the front of one single British Army.

The cork floats were probably the most satisfactory of all for Infantry troops, as they were found to be absolutely impervious to shrapnel or splinters.

The supply of cork was never equal to the demand, and is an interesting example of the difficulty in foreseeing requirements.

Cork floats had been experimented with before the advance and found sufficiently satisfactory to justify a considerable number being made up at the Base. Their use had been explained to all Armies, and Chief Engineers were asked in the early summer of 1918 to give an estimate of the amount they were likely to require during the rest of the year. The total estimate amounted to under 50 tons,—100 tons were actually ordered and made up into floats, and the whole of this was issued and used during the first few weeks of the advance. Further supplies had to come from overseas, and owing to shipping difficulties could not be obtained in time to be of much use.

So valuable were these floats considered by many units that, in spite of their weight after being any length of time in the water, they were frequently lifted and carried forward for re-use. Floats made of oil tins were lighter to carry, but were easily punctured and sunk. *Photograph* LIII. shows a bridge of petrol tins in actual use at Landrecies.

Pontoons are also liable to be damaged by shell fire, but on the whole they suffered remarkably little, and, provided that spare boats and equipment were at hand, damage could be very quickly made good.

Light pile foot bridges were used with good effect by some units, and were quickly and easily constructed when the river bottom was suitable.

A device for rendering pile bridges unserviceable in case of hostile attack is illustrated, and was employed by one Division. Though never actually tested in an attack, its efficiency was demonstrated by bathers catching hold inadvertently and drawing the pins, which were kept well greased. (*Plate* XXII.).

Pontoon and Trestle Equipment. During periods of trench warfare Field Company bridging equipment had been generally stacked under Divisional arrangements in order to avoid frequent moves of unnecessary loads, and also to set free the bridging wagons for carriage of other R. E. Stores.

By the beginning of 1918 nearly every Army had gone as far as to form central depots where the bridging equipment of all Divisions in the Army could be parked and looked after. These depots were generally at the headquarters of a Pontoon Park. When a Division left the Army, it would collect its equipment from the Pontoon Park, or in certain cases the Park actually delivered the equipment to the Division at its new location.

Difficulties arose during the operations when divisional reliefs were frequent and rapid, and Divisions would sometimes arrive with no bridging equipment in the area of an Army that was on the point of carrying out an attack.

In cases of emergency, divisional equipment could always be made good from an Army Pontoon Park, and the Pontoon Park would then demand an equivalent amount from the Base; but the drain on the Base reserves became so great that this system could not have continued indefinitely, and new equipment was not normally issuable from the Base except in replacement of an equal amount certified to be destroyed or beyond repair.

27. Haute Deule Canal.

The following is an account of work carried out by the Field Companies of one Division.

The preliminary scheme was to cross the canal on a 2-Brigade front, each Brigade to have 4 foot bridges ready prepared, as near as possible to the outpost line, which could be easily carried to the canal, and fixed in position.

In addition, under orders from the Corps, 2 pontoon bridges were to be thrown across the canal as soon as possible after the Infantry had crossed, and one of these bridges was to be of heavy type to carry motor lorries. Additional pontoons for these bridges were specially allotted to the Division.

Sites for the bridges were selected by means of air photographs supplemented by information from civilians.

Two Field Companies were employed in the work of getting the Infantry across the canal, and each company made four foot bridges, using petrol tin or wood floats. *Plate* XXIII. gives details of a wood float bridge.

The petrol tin floats took slightly longer to make, but were found much easier to carry to the canal.

Immediately the Infantry had made good the further bank, each company commenced a medium pontoon bridge. The previously selected sites were found entirely suitable, and very little work was needed on approaches. Both pontoon bridges were later converted to heavy type. This work was entirely done by night in bad weather. Each bridge took between 50 and 60 men, ten to eleven hours actual work.

On the same canal an interesting example of a heavy trestle bridge was made by a neighbouring Division to carry loaded lorries. This bridge did not form part of the original divisional scheme, and had to be designed and built at very short notice.

A dump of heavy bridging material consisting of rolled steel joists and timber of large section had been formed by the Division from locally salved material, and the bridge was designed to make use of this material.

The first reconnaisance was made at midday on the 16th. September. Work was commenced at 3 p.m. on the following day, and was completed and the bridge opened to traffic at 11 p.m. on the 18th. Two sections of a Field Company were employed with a company of

Pioneers to make up approach roads. Total span of the bridge was 112′, and was carried on 7 trestles. Road bearers consisted partly of R.S.J's, and partly of round timber.

Details of this bridge are given on *Plate* XXIV.

28. Canal-du-Nord.

Hasty Bridges Constructed by one Corps.—Preparations were difficult owing to the nature of the ground, and the fact that the approaches to the canal were subject to very heavy machine gun fire.

Information was obtained from maps, plans, aerial photographs, reconnaissance by R.E. officers on the ground, and also from the air. The canal averaged 100′ in width with banks varying up to 15′ in height, and depth of water in the wet portions of the canal over 8′.

On about half the front of attack the ground was marshy. The ground on both sides sloped towards the canal.

The scheme provided for seven Infantry foot bridges, and ten crossings for guns and first line transport, five of which were designed to be developed immediately for heavy traffic.

'A' Crossing, (Dry). At zero hour a party was sent out to keep touch with the Infantry, and as soon as the Infantry had cleared the canal, the company started their task, arriving on the work at zero plus 40 minutes. The approaches were only foot tracks, and these had to be first improved. Craters had been blown in the roadway in the centre of each embankment, and the banks were mined at the edge of each crater. One of these mines was exploded by a tank, which became disabled and blocked the passage. Another tank was called upon, and the obstruction quickly removed. The other mines were exploded by guncotton.

The crossing was ready for one-way horse traffic at zero plus 3 hours and 40 minutes.

'B' Crossing, (Dry). A good earth road led up to and from the crossing. A very large crater was blown in the roadway in the centre of the canal crossing, and a smaller one in the west embankment. The large crater was filled with boards, brick, etc., and earth and chalk from the embankment.

This crossing was ready for one-way traffic at zero plus 1 hour and 30 minutes, and two-way traffic at zero plus 2 hours, and for two-way lorry traffic at zero plus 3 hours.

'C' Crossing, (Dry). A party consisting of 2 Officers and 37 men R.E. arrived at site at zero plus 2 hours and 10 minutes, after being heavily shelled en route.

A very large mine had been blown by the enemy. The crater was filled in with timber and rock, and 2 tanks were put over the crossing to crush in the fill near the bottom.

By zero plus 2 hours and 40 minutes a crossing had been made good enough for the passage of Field Artillery.

Work was continued for the remainder of the day, and a 20′ roadway constructed with earth, steel rails, and timber cribbing.

A one-way lorry plank road was completed across the canal by zero plus 8 hours and 25 minutes.

On the second day the cribbing was completed, reinforced and braced. The planking was doubled to make it suitable for two-way traffic, and approaches strengthened.

'D' Crossing, (Dry). Work was started at zero plus 1 hour, and was ready for traffic by zero plus 3 hours and 30 minutes—this work consisted of filling in a road crater 30′ diameter and 10′ deep on the west bank of the canal.

A temporary diversion was made around the road to allow traffic to pass while the crater was being filled in. The first gun actually went over this crossing at zero plus 3 hours 20 minutes. The crossing was ready for two-way traffic at zero plus 12 hours.

'E' Crossing, (Wet).—Work on this crossing was held up by hostile machine gun fire and shrapnel, and the Officer in charge of the party was wounded.

This crossing consisted of a combined pontoon and trestle bridge of 90′ span. Ramps had to be cut through the bank on each side about 20′ long. Work was commenced at zero plus 13 hours.

'F' Crossing, (Wet). This crossing consisted of a 60′ span pontoon and trestle bridge over the canal, and two 30′ trestle bridges over a stream on the east side of the canal.

Work was commenced at zero plus 6 hours and 40 minutes, and completed at zero plus 8 hours and 10 minutes, in spite of enemy machine gun fire.

'G' Crossing. A bridge of 60′ span.—Great difficulty was experienced in launching the trestles in the muddy bottom of the canal, which was about 2′ to 3′ deep in water, but was not suitable for pontooning owing to the number of old piles sticking up in the water. Work could not be begun till zero plus 9 hours 40 minutes, on account of enemy machine gunners holding out in the swamp east of the canal at this point.

The bridge was finished at zero plus 10 hours 50 minutes.

Between 'E' and 'G' crossings half a company R.E., and half a company of Pioneers had advanced with the Infantry to make hasty foot bridges. The wagons carrying the cork floats came under heavy machine gun fire when within 200 yards of the canal bank. Several horses and drivers were wounded, and the teams were unhooked, and wagons pushed down by hand.

Six Infantry foot bridges were thrown across the canal. These were of two kinds—cork pier bridges, and a 16′ span light trestle bridge. The cork piers made a firmer bridge when erected, but took rather longer to make as the cork floats were heavy and difficult to carry. The trestle bridge was made of light 16′ span foot bridges resting on light trestles. This was very quickly erected and made a good bridge.

'H' Crossing, (Wet). Trestle and pontoon bridge consisting of 2 pontoons and 3 trestles, 90′ span.

'K' Crossing, (Wet). One Company R.E. constructed a Weldon trestle bridge alongside a demolished culvert, and replaced the culvert by an 18′ span rolled steel joist bridge. These were on the west side of the canal. Work was commenced within half an hour of the attacking Infantry passing this point.

The trestle bridge was completed in an hour and 10 minutes, and the steel bridge was ready for lorry traffic an hour and a quarter later. A second R. S. J. bridge was constructed the following morning to provide for two-way lorry traffic.

As soon as the Weldon trestle bridge had been completed, half the company went forward to the canal, and constructed a medium pontoon bridge 120′ long. This was open to traffic less than 3 hours after work on the trestle bridge had been completed.

A second Field Company constructed a D. type heavy pontoon bridge for lorry traffic on the other side of the demolished road bridge. This bridge was 120′ long, and considerable work was also required on the approach ramps. The whole job was completed in about 5½ hours' work.

Work of the R.E. of another Division in Crossing the Canal-du-Nord. The Infantry attack was made by one Brigade, and two Field Companies had been detailed to carry out bridging across the canal and a stream to the East of it.

The Infantry attack was held up by heavy machine gun fire from woods on the west of the canal. Both Field Companies, however, extended and worked their way round and through these woods, and succeeded in capturing the canal bank together with a number of prisoners.

One company reached the canal at 11.30 a.m. and the other at 12.45, both being well ahead of the leading Infantry.

The first company completed a cork raft and plank foot bridge across the canal and marsh by 12 midday, and an Infantry foot bridge across the river by 1.45.

The second company found the canal no obstacle to foot traffic, and completed an Infantry bridge across the river by 2.5 p.m.

The Infantry did not actually advance beyond these crossings until 5 p.m. and it was impossible to bring up pontoon wagons to the canal till after dark.

A medium pontoon bridge was commenced after midnight by the third Field Company, with an Infantry working party cutting through the banks to make approach ramps.

The work was all completed by 5 a.m.

On the front of another Army the Canal formed the dividing line between the British and German troops.

A particularly fine bit of work was done by a Field Company during the nights preceding the attack in the construction of a trestle bridge for Artillery and first line transport across the canal within a short distance of the enemy.

A section of the canal was taken at day-break, and gave the following measurements—width between towpaths 79′ 6″—width of bed of canal (dry bottom, brickwork) 40′ 6″—depth of Canal below towpath 15′ 6″.

The Field Company was organised in teams, each team being responsible for the construction of 1 trestle plus 1 bay.

As many fastenings as possible were designed to be by means of bolts, and great care was taken that these should fit easily, and only require to be pushed through.

Road bearers were notched to fit over transoms, and blocks were also nailed on transoms at the required distances, so as to avoid having to make any measurements on the night of operations. The material was carried to within 300 yards of the site on pontoon wagons, and then carried by hand along the canal, and distributed under cover.

Two nights before the advance sites were cleared out for the two shore trestles, and the trestles were placed in position and left leaning against the wall of the excavation. Shore transoms were also fixed into position, all being covered with scraps of canvas etc.

On the following night two of the larger trestles were assembled and left leaning against the brick walls of the canal.

On the night before the advance the company, organised in their trestle teams, started work about 8 15 p.m. and completed the bridge by 1.15 a.m., roughly four hours before zero. In the original scheme it was ordered to be completed within four hours after zero.

Although the enemy line was only 500 yards away, work went on without any interruption, owing to the very complete previous arrangements, and the complete silence that was maintained every night.

This fine piece of work enabled the Divisional Artillery to follow and come into action immediately behind the attacking Infantry, and had great influence on the success of the operations.

Photograph LIV. shows a crib and trestle bridge for lorries constructed by a Field Company, and *Photograph* LV. shows a trestle bridge alongside a typical ramp for tanks.

29. The Escaut Canal and River.

The following is an account of the work of one company in assisting an Infantry Brigade to force the passage of the canal.

The work consisted of :—

(1). Reconnaissances and preparations to throw floating bridges (cork) over the canal, and to furnish rafts and boats to enable the Infantry to cross when opportunity permitted.

(2). Actual putting over of 1 cork float bridge, and furnishing of rafts ; making passage over debris of old lock and bridge.

(3). Repairs of 2 destroyed foot bridges, and salvage of material.

Reconnaissances were made on the front of both attacking battalions, and the necessary material was brought up by lorry and carrying parties.

On the left battalion front the bridge was constructed in the courtyard of a mill with gates facing on the canal bank covered from view, some measure of protection being thus secured. Water in the canal was high, and the approaches ideal. On the right battalion front the approach and carrying were very difficult. A spot was selected, and preparations made to bridge if it should become possible.

The piers of the bridge (cork) were also fitted with an extra bale of cork to give sufficient buoyancy to allow their use as rafts if this should prove more feasible than the completion of the bridge. Paddles, etc., were held in readiness. Another alternative was the possibility of crossing on the debris of a destroyed bridge.

At zero on the day of attack the bridge on the left Battalion front was successfully put across.

The gates were flung open, and the bridge carried bodily to the water's edge and pushed over. The carrying party were actually the first Infantry to cross. During the operations the bridge broke, but was held together by hand until the first troops were over. No delay was caused, and it was afterwards repaired.

On this battalion front 6 cork rafts, each made from 3 bales of cork, were also used to ferry men across.

On the right battalion front the leading troops of Infantry and Sappers found the debris of the old bridge and lock passable—no new bridge was constructed, but the old crossing was improved.

Tank crossings.—Two tank crossings were constructed by one Field Company over the river and canal, each consisting of three 20′ spans, the standard 22′ rolled steel joist tank bridges being supplied direct from the Army Bridging Depot. In each case the canal crossing was effected by one span across the lock.

Bridges for the first crossing did not arrive until after dark, and were only brought up by lorry with the greatest difficulty and exertion. Work was commenced at 9.30 p.m. and went on continuously until 7 a.m. the following morning, when all three bridges were completed.

One section R.E. worked on each bridge, and the ramps were made by two platoons of Pioneers.

Considerable shelling went on all night, and the company had 12 casualties at the very beginning of the work, which made them shorthanded.

One bridge of the second series arrived at 10 o'clock the following night, and this was unloaded and erected by 1 a.m. in spite of continual shell fire. The other two bridges arrived the following afternoon, and were completed with ramps by midnight—in this case the lorries could not approach the site, and a long carry was required, which took much extra time.

The following extracts from the War Diary of a C.R.E. Division describe the bridging work done by the Field Companies for the crossing of the canal and river :—

September 28th.—Headquarters R.E. and Field Companies moved to ' F '.—All pontoon equipment was moved to ' F ', and during the night Officers went forward to reconnoitre forward area, and river and canal.

September 29th.—Early in the morning the advance section of ' A ' Field Company constructed a foot bridge over the canal from old German floats found lying about, and passed a battalion of Infantry over.

Officers of the three Field Companies made detailed reconnaissances of the canal and river.

Another foot bridge was put across the canal by ' A ' Field Company.

At 4 p.m. a pontoon bridge to take transport was put across the canal by the ' B ' Field Company.

The ' C ' Field Company repaired three existing bridges across the river and canal, and also put a medium pontoon bridge over the canal.

September 30th.—' A ' Field Company put across another foot bridge, and repairs to an old German bridge were carried out, and this bridge made passable for both transport and 4·5 howitzers.

' C ' Field Company reconstructed existing light bridge to take 60-pounders.

' B ' Field Company constructed a new trestle bridge over the canal, and a trestle bridge over the river was strengthened to take 60-pounders.

October 1st. and 2nd.—'A' Field Company commenced the construction of a trestle bridge to take lorries over the river—other companies were employed on the maintenance and strengthening of existing bridges, which was necessary owing to the heavy shelling. Approaches to bridges were improved.

October 3rd.—Trestle bridge was completed by 'A' Field Company. (*Photograph* LVI.).

'B' Field Company commenced two trestle bridges over the river, and a pontoon bridge over the canal.

All three bridges were completed by 9.30 a.m.

October 4th and 5th.—Maintenance of existing bridges, and of plank road leading to lorry bridge.

October 6th.—'B' Field Company commenced preparation for the construction of a 60′ steel girder portable road bridge over the river.

The other two companies continued maintenance work, and the 'C' Field Company put another pontoon bridge across the canal.

October 7th.—Owing to the advance being continued, work on the girder bridge had to be suspended. Companies concentrated on the work of strengthening existing bridges to take additional transport.

October 8th.—During the night 7th/8th it was reported that the water level in the canal was falling. Reconnaissances were made and this was found to be the case. Urgent messages were sent out to the companies instructing them immediately to replace all existing pontoon bridges by trestle bridges.

'C' Field Company replaced two pontoon bridges over the canal with trestles, and 'A' Field Company erected a new trestle bridge over the canal. These bridges were all completed by 5 p.m. and very little inconvenience was caused to traffic.

October 9th.—Canal bed repaired where culvert had been hit by shell, thus lowering water level.

'A' Field Company commenced the construction of a heavy trestle bridge to take lorries, and 'B' Field Company continued the construction of the steel girder bridge.

'C' Field Company concentrated on maintenance.

October 10th.—Work continued as on 9th.

October 11th.—Heavy trestle bridge and steel girder bridge both completed.

Practically all bridges were constructed and repaired under heavy enemy shell fire. Timber had in many cases to be salved from old bridges, and a great deal of work could only be done by night.

On the front of another Division, where the attack was made by one Brigade, arrangements were made for ferrying the Infantry across the river in 25 improvised canvas covered boats, simultaneously with the construction of 4 floating foot bridges.

The foot bridges were designed to carry Infantry in single file at 3 yards interval, and were composed of 10′ duck-boards on floating piers of German torpedo floats—the average width of the river was 100′.

Two Field Companies were told off for the work, two sections of each company being employed in ferrying, and the other sections each making a foot bridge. These latter sections each had a working party of one platoon of Pioneers attached to them.

The boats were most successful,and it was found possible by means of 12 boats to transport an entire battalion across the river before the foot bridges were ready.

Immediately the crossings had been made good, work was commenced on a timber trestle bridge with R.S.J's as road bearers to carry 17 ton axle load. Schemes for all this work had been very carefully prepared beforehand, and no hitch occurred in the actual execution.

Another Division ferried the leading Infantry across on four different types of raft, which are illustrated.

Type A. This was constructed of an ordinary bivouac sheet 13′ × 10′ wrapped round a wooden crate outside of which fascines made of reeds and straw were fixed to provide extra buoyancy. The chief points of this type were stability, and absence of noise when being propelled through the water.

The sheets are apt to become waterlogged, but are sufficiently waterproof to serve for a hurried crossing up to 8 or 10 hours immersion. This raft can be lifted and carried by 4 Sappers. (*Plate* XXV.).

Type B. This is an ordinary German pattern formed by 2 piers of 2 floats each, and is capable of carrying 3 fully armed men. It has the advantage of low freeboard and comparative absence of noise. (*Plate* XXVI.).

Type C. Explains itself. It is fairly rigid but is comparatively very heavy. (*Plate* XXVII.).

Type D. Is more unstable than Type C. and there was doubt as to its suitability—it was, however, used quite successfully on one sub-sector. The propulsion was by means of a tow-rope, and not by paddles. (*Plate* XXVIII.).

Plates XXIX. and XXX. give details of two bridges erected by Canadian Divisional Engineers, and *Photograph* LVII. shows a R.S.J. and trestle bridge to carry tanks built by a Field Company of another Division.

30. River Selle.

The crossing of this river involved probably more arduous work for the Divisional R.E. than that of any other.

The following extracts from the report of an Army Chief Engineer give a good idea of what was done :—

" During the period October 10th to 19th foot bridges of varied type, cork float, light trestles, duck-board and petrol tin bridges were erected at intervals along the whole Army front. All pontoon equipment was brought up, and numerous crossings for Infantry made.

These bridges were mostly protected from enemy fire by the height of the river banks, but the pontoons proved very vulnerable during the journey up to the line.

At one time over 30 pontoon bridges were in position on the Army front ; a wonderful total if it is considered that the river was practically the dividing line between the two Armies. Work was often done within 50 yards of the enemy, who kept up a constant machine gun and artillery fire on the river. Heavy casualties were often inflicted on Field Companies engaged, but the work was invaluable.

Preparations were now made to cross the Selle river on the 20th October.

It was essential for the success of the attack that the enemy should remain in ignorance of our intentions—it was decided therefore to postpone all work until the night of the 19th/20th October. During the preceding night bridges of all types were brought up and concealed near the sites, and the work of construction commenced immediately darkness fell on the night of 19th October.

On all Corps fronts the plans adopted were similar. It was decided to increase the number of foot bridges until a minimum of 1 per 100 yards of front was in position.

Light trestle bridges were to be erected in various places to allow the passage of field guns, and heavy bridges of the R. S. J. Type were to be placed in position as soon as the attack was seen to be successful.

On the " W " Corps front many foot bridges and pontoon bridges had been placed in position by the R.E. of two Divisions. On the night of the 19/20th October these bridges were increased in number until there were 20 on the Corps front.

During the night R.E. of one Division erected Weldon trestle bridges over the river at two points to take field guns.

These bridges were successfully used by the attacking forces, and the R.E. were able to commence the erection of heavy bridges on the morning of the 20th.

On the " X " Corps front the scheme for the attack of one Division necessitated the construction of foot bridges above and below the town of Solesmes. Surprise was essential—there was to be no preliminary bombardment, and the construction of bridges was to be put off until the last moment. Information was scanty owing to the fact that the enemy outposts were so near the chosen bridge sites.

It was decided to erect 8 foot bridges north of the town, and 4 to the south. Later 2 pontoon bridges were to be erected over the river to carry field guns. The material for these bridges was brought up and concealed near the sites.

The erection of the foot bridges commenced soon after midnight on the 19th. All bridges were completed before zero hour, and the operations were entirely successful. Slight floods were caused by debris damming the river, but the foot bridges were lengthened and the difficulty overcome.

To ensure that the position of the bridges was obvious to the Infantry, the bridges were marked with tapes and small red lights placed in position.

On the 21st October trestle bridges for horse transport were erected over the river at four points.

On the 23rd October R.S.J. spans were erected over the river at Solesmes.

On the front of another Division foot bridges were made of various types, and work began at 10 p.m. on the 19th. The heavy rains rendered work difficult, but all the bridges were thrown across successfully without alarming the enemy.

Great credit was due to the good discipline of the men, who preserved absolute silence, and to the avoidance of any splash in placing the piers. The organisation worked smoothly, and from midnight onwards one bridge was brought down to the river every 10 minutes on each brigade front.

Two Field Companies then undertook the construction of 2 pontoon and trestle bridges at zero minus 1 hour.

The construction of a heavy tank bridge was undertaken by the third Field Company—it was erected under considerable difficulties, but in spite of heavy gas shelling and rain, the work was completed on the same day.

On the "Y" Corps front the R.E. of one Division had during the week preceding the attack placed many foot bridges and pontoon bridges in position.

On the night before the attack 2 pontoon bridges and 4 light foot bridges were erected, in spite of considerable shelling and machine gun fire which caused many casualties, and a gas concentration, which necessitated the use of respirators for some hours.

On the day of attack bridging operations were divided between two fresh Divisions.

The approaches to the river are very difficult to traverse during the night on account of their openness. To obviate this tapes were laid down with notice boards to each bridge-head, and lamps lit which gave a red light to the rear.

On the day of attack the bridges were successfuly used by the Infantry, and R.E. of both Divisions were able to commence the erection of other types of bridges.

In addition to 16 foot bridges—2 Pontoon bridges, 2 trestle bridges for horse transport, and 1 R. S. J. tank bridge were erected.

On the "Z" Corps front the procedure was slightly different.

As with the other Corps, foot bridges and pontoon bridges had been erected along the whole front usually under very difficult circumstances, but assisted by the fact that the Infantry had established themselves slightly to the East of the river.

Bridging operations were shared by two Divisions.

On the night of 19th October a heavy tank bridge was completed across the river Selle north of Neuvilly in 1 hour, 45 minutes, the material having been previously brought to the site and concealed.

On the 17th and 18th October Field Companies of one Division erected 24 foot bridges, the work being of an extremely difficult nature owing to the proximity of the enemy, and the very light nights. Tank bridges were erected by Field Companies of the same Division.

One Field Company completed their bridging on the night 16th/17th, working breast deep in water for several hours under shell and machine gun fire, with the enemy's flares falling within 20 yards of the site.

Another Field Company erected a tank crossing consisting of sleepers threaded on iron rods, the work being completed on the night 19th/20th: being under the surface of the water it was not discovered by the enemy.

On the morning of the attack these bridges were successfully used by tanks, and close co-operation with the attacking Infantry greatly assisted the advance.

Two of these crossings were afterwards destroyed by enemy fire.

Half an hour after zero on the 20th, R.E. of the other Division erected trestle bridges for H.T. north and south of Neuvilly.

Later in the day heavy bridges were constructed in Neuvilly, one for Tanks and one for 12-ton axle load.

Both bridges were completed by the 22nd of October, in spite of direct hits while under construction.

One Field Company erected 2 trestle bridges for H.T. and one medium pontoon bridge, in the course of which 50 per cent of the company became casualties."

The following is an extract from the report by the C.R.E. of one of the Divisions engaged, which gives in greater detail an account of work carried out :—

* * * *

"Reconnaissances were carried out on the night of the 17th, and the width of the river at water level estimated to be about 25′, depth 3′ to 4′, banks very steep 6′ to 10′ high, and quite unclimbable by Infantry in fighting order.

The bed of the river had 1′ to 2′ of mud. It was decided that the northern set of bridges should consist of 6 light trestle bridges, and 2 cork bridges carrying Infantry in single file.

In addition, in case the bridges should fail, 4 wire netting mats were to be laid across the river to allow men to walk through the water over the mud.

Ropes were to be laid across the river at these crossing places from top to top of bank, to enable men to pull themselves up the steep banks.

Scaling ladders 10′ high were also given to the Infantry for the same purpose.

Owing to the necessity for absolute silence throughout the operations, and the steepness and height of the banks, petrol tin bridges, light pontoon bridges, and barrels were ruled out.

The night of the 18th/19th was used for carrying up material, and setting it out into bridges.

The carrying party of the Pioneer Battalion was organised in such a way that each party knew exactly what it had to do.

The party was attached to a Field Company for two days before the operation, and was given all possible instruction in handling the material, which had to be carried about 700 yards from the wagons.

On the night of the 19th/20th, zero hour having been fixed for 2 a.m. on the 20th, the erection of the bridges was started at 1.30, and completed at or before zero in every case.

A single cork float bridge was completed half an hour before zero to enable a company of Infantry to pass over as covering party—the company lay under the far bank of the river. The Infantry passed over the bridges without a check of any kind, and the operation was completely successful.

The limits for the southern set of bridges had been decided by reconnaissance on the night of the 17th ; a second reconnaissance on the night of the 18th showed that the river had risen several feet owing to the enemy having dammed it between the northern and southern bridging places, and the sites for the southern bridges had to be moved.

It was decided to make 2 petrol tin, and 2 cork float bridges on the night of the 19th, all the material having been carried up in the same way as for the northern bridges to the site of the work.

Bridging was started at 11 p.m. on the 19th. It was found that the river had risen still further, and the bridges were not long enough to span it—their number was accordingly reduced to 3, and an existing foot bridge patched up to serve as a fourth—the operation was quite successful, and the Infantry passed over without a check in due time.

The light trestles which were used were made out of hexagonal 16′ signal service telegraph poles.

They were 4 legged, with transoms 7′ 6″ above foot of leg ; the legs were splayed out 2′ 6″, each pair of legs 4′ 6″ apart.

Angle iron pickets were used as ledgers in order to sink the trestles —all lashings were of wire.

Trestles were stiffly cross braced and made up complete with the lashing fixed to the transoms before leaving camp.

The footways for the trestle bridges consisted of 2—15′ duck-boards 2′ wide, runners $3'' \times 3''$, slats $3'' \times 1''$ placed $1\frac{1}{2}''$ apart. The duckboards thus formed were stiffly trussed underneath with heavy telegraph wire windlassed tight. Each trestle was carried out into midstream by 2 men wading, and stuck into the mud without difficulty.

The cork bridges were formed of 3 piers of cork at 7′ centres, and the centre pier was anchored back to each bank.

The wire netting mats were made of German wire netting 1 metre wide with slats $1\frac{1}{2}'' \times 1''$ fastened on the top side of the wire 18″ apart. These were fixed down with screw pickets at the shore end, and rolled across the bed of the river by a man wading along and shoving the roll in front of him with his foot, and picketed down on the far bank. Slung ropes were placed alongside each mat to guide men over, and help them down and up the banks. These mats were not used owing to the success of the bridges.

Petrol tin floats in pairs were made with 2 frames each holding 24 tins spaced at 9″ centres, tins being encased in a crate of rabbit wire, and wedged tightly in a $3'' \times 3''$ timber framing.

At the southern site mauls muffled with sandbags could be used to drive pickets, but at the Northern site screw pickets had to be used.

Some specially strong kite balloon screw anchorage pickets were obtained, and found very successful on the northern site.

Absolute silence was necessary as the nearest enemy post was found to be only 50 yards off.

The approaches to the bridges were marked with tapes.

The river ends of the approaches were marked with number-boards painted white on black 1′ square, the other ends were marked with petrol tins punched with corresponding numbers with candles in them. These candles were quickly put out by shelling, but the moon gave sufficient light for the tapes to be found.

Organisation of the work was based on each party of R.E. having it's own working party of requisite strength, and having one job only to do; thus, each trestle bridge had 5 sappers and 10 carriers, each cork float bridge had 6 sappers and 12 carriers, each wire netting mat had 3 sappers, and so on."

A standard R.S.J lorry bridge built by a Field Company is shown on *Photograph* LVIII., and a lorry bridge of salved material on *Photograph* LIX.

Tank Bridge Over the River Selle. A crossing for tanks constructed entirely of old railway sleepers was made by one company—details are shown on *Plate* XXXI.

The most important feature of the design is the strutting of the cribs against the banks.

If the bottom of the stream had been soft mud, sills would undoubtedly have been necessary.

In this crib a total bearing of about 40 square feet was available, one-third to half of which would probably have to take the total weight at a time.

The actual settlement of the cribs after 4 tanks crossed was about 6″. The timbers of the crib were held in position by $1\frac{1}{2}''$ diameter rods which were driven into the bottom of the river.

The crib was built up to the surface of the water, the sleepers being bored and fitted over the rods until the required height was obtained—12″ being allowed for sinkage under the weight of the tank. The crib was weighted with pieces of iron rail, to keep it in position.

This work was all done by night in close proximity to the enemy.

Details of this work are given on *Plate* XXXI.

Chapter V.

MISCELLANEOUS.

31.—Dismantling Steel Bridges.

Soon after the Armistice instructions were issued from G.H.Q. for a number of steel bridges in the neighbourhood of Amiens and St. Omer to be dismantled, and returned to the base.

This work was organised by the Chief Engineer of the VII. Corps, and was carried out by the 227th Field Company in the Amiens area, and the 556th Army Troops Company in the St. Omer area.

Instructions were issued by the E. in C. as follows :—

" (*a*) Bridges taken down will have all parts clearly marked and packed in accordance with the Tables given in 'Portable Road Bridges' (I.I.S. War Office, March 1916, and additions issued from time to time).

(*b*) Bolts and nuts are short, and great care must be taken that they are undamaged, greased and packed in boxes, which will be carefully packed.

(*c*) Each Bridge will be packed complete with decking, etc., and a notification of any deficiencies will be sent to the Engineer in Chief's Office, in order that they may be replaced from the Base.

(*d*) *Disposal of Bridges.*—A notification will be sent to E. in C.'s office at least three days before the bridge is ready for despatch, when a destination for the bridge will be given, and truckage arranged for.

The bridge will be put on rail and will be conveyed to its destination by a suitable escort.

Duplicate way-bills will be made out and a copy signed by the officer in charge at the receiving dump or store will be forwarded to the E. in C.

(*e*) Slab approaches will be taken up and delivered at nearest railhead, and loaded on trucks.

Notification will be sent to E. in C's office of the number of trucks of slabs which will be delivered at each railhead, and the date when they will be ready for loading.

E. in C. will arrange truckage and give destination."

Nineteen bridges of various types were dismantled in the Amiens area, and eight in the St. Omer area. A large number of slabs and sleepers were also lifted and despatched from the approach roads. Labour was supplied by companies of prisoners of war, and was very satisfactory. No difficulties were found in the technical work of dismantling spans.

Generally speaking the lessons learnt were similar to those in the erection of steel bridges, that is to say that the most important work was that connected with the transport and packing of material.

The special plant and tools that were found necessary for the use of one Field Company employed on this work were as follows :—

Designation.	*Unit.*	*Quantity.*
Bag, Sand	No.	500
Bars, Pinching	No.	24
Brushes, Paint	No.	6
Cordage, 3 in. (130 fathoms per coil)	Coils.	2
Cranes, Loading, 1 ton	No.	2
Crow-bars 5ft. 6 in.	No.	24
Cutters, Wire	No.	6
Derricks, Lattice, (with 2 sets of blocks for each, 1 treble, 1 double, and 1 snatch)	No.	2
Grease (28 lb drums)	Drums.	2
Hammers, (5 lb.)	No.	24
,, ($2\frac{1}{2}$ lb.)	No.	48
,, Sledge (9 lb.)	No.	12
Handles, Hammer, assorted ...	No.	6
Heads, Pick	No.	12
Helves, Pick	No.	12
Jacks, Derrick (5 ton)	No.	4
Jacks, Derrick (6 ton)	No.	10
Oil, lubricating, Mineral	Drums.	2
Paint, Black	Drums.	1
,, White	Drums.	1
Rollers, launching, special ...	No.	8
Shovels, R.E.	No.	12
Spanners, $\frac{1}{2}$ in.	No.	24
,, $\frac{5}{8}$ in.	No.	24
,, $\frac{3}{4}$ in.	No.	24
,, Box	No.	2
Wire, plain, No. 14 gauge	Coils.	6
Wire Rope, 2 in.	Coils.	2
Winches, 2 ton	No.	4

The above stores were additional to the ordinary tools in possession of a Field Company, or obtainable from an Advanced R.E. Park.

Transport from bridge sites to rail in the Amiens district had to be chiefly done by 3-ton lorries, which caused a good deal of delay and difficulty in loading long girders and timbers.

In the St. Omer district, all material was loaded direct on to barge, and taken to the base by canal.

32.—Clearing and Regulating Operations on Canals.

During their retreat the Germans not only destroyed most of the road and railway bridges, but also succeeded in making considerable water obstacles by damming sections of the French and Belgian canals and cutting gaps through the banks up stream of the dams. They also carried out a large amount of wanton destruction of locks on the main canals.

The actual responsibility for clearing and repairing navigable canals lay with the Inland Water Transport, who were, however, quite unable to keep pace with the rate of advance, and the amount of destruction. The preliminary work of clearing waterways for flood water, and reduction of water level in the inundated areas, thus fell to the Chief Engineers of British Armies. The canal system of France and Belgium is a very complex one, and control of all water removal schemes had necessarily to be centralized. All possible information had been collected in the office of the E. in C., and instructions were issued to all the Armies concerned as to the best means, and channels through which to let out flood water.

The biggest inundations and most extensive damage were on the Scarpe and the Escaut, and the clearance of these waterways, and surrounding areas, was entrusted shortly after the Armistice to the Chief Engineer of the VII. Corps, and was by him divided into a Northern and Southern Sector, each under a Lieutenant-Colonel R.E.

Description of Locks.—The locks on these canals are from 38·50 metres to 38·70 metres in length, and from 5·10 metres to 5·20 metres in width, with 2 metres draught. In the masonry walls up stream, lock gates, slots or chases approximately 20 to 25 cm. square in cross section existed to take wooden stop-logs, or *poutrelles*, by which the waterway could be completely closed.

Similar arrangements are also provided on the bye-pass channels.

Description of Blocks or Dams made by the Germans.—The methods of blocking adopted by the Germans were :—

(*a*) Dams made of fascines and earth on the down stream side of a row of rough piling, and built up to the level of the canal banks.

(*b*) Block formed by filling in at a lock with bricks, fascines, mud and rubbish, between the *poutrelles* and the lock gates.

In some cases barges partially filled with bricks were also sunk in the locks.

The work of clearing some of these locks was made most unpleasant by the putrifying remains of dead horses which had apparently been

APPENDIX.

Formation of R.E. Bridging School.

1. The introduction into the British Army in 1915 of steel bridge spans, composed of sections of light weight for transport facilities, was an innovation which necessitated the training of Officers, N.C.O.'s and men of the Royal Engineers in their use and erection.

All bridge spans were originally landed at Havre, and it was decided to form classes of instruction in the erection of these bridges there, under the R.E. Stores Officer.

Eight courses were arranged at Havre and 86 officers and 281 N.C.O.'s and men were given practical instruction in the erection of steel spans, and timber piers and abutments.

It was found, however, that this arrangement was unsatisfactory since it entailed much extra work for the staff of the R.E. Base Park, and the classes could not be held as frequently as was necessary to train a sufficient *personnel* to deal with the large amount of bridging which obviously might at any time become an urgent service.

It was therefore decided in 1916 to establish a School of Instruction in bridging in an Army Area, and to hold classes regularly during the winter months.

Choice of Site.—Accommodation.

2. The considerations which governed the choice of a suitable site were :—

(i.) The school should be near a convenient rail centre, so as to facilitate transport of bridging material, and of the *personnel* of the classes.

(ii.) It should be near the canal system of the Armies.

(iii.) A suitable stretch of river, some 200 yards in length and about 60 feet wide, was required, with sufficient ground adjacent to it on which to build the spans and launch them.

(iv.) The river should be 6 to 8 feet deep, and have a fair current in order to give facilities for the erection of piers, etc., under the conditions usually met with in the field.

(v.) Sufficient accommodation should be available near the site for the staff of the school, and the *personnel* of the classes.

(vi.) There should be good facilities for entrance and exit of transport conveying bridging material.

In October, 1916, several sites were visited and reported upon by the newly appointed Commandant, and it was finally decided to establish the school at Aire on a by-pass of the River Lys.

The ground available was low-lying, but there existed a good stretch of water on which there was no canal traffic.

The site was excellent for the erection of bridges, though the transport facilities were not good, but the latter was not a matter of great importance at the time, since the quantity of material to be kept at the school was small.

Accommodation.—Accommodation for the staff was arranged in billets in the town, and the *personnel* of the classes was accommodated in barrack barges on the river.

Barge bridging depôts had been formed in 1915, and some of the barges so used were converted for use as barrack barges, the stores and bridge spans which they contained being unloaded and used at the school.

In October, 1917, a hutted camp was built at the site of the school for the accommodation of the staff. This was much more satisfactory than billets in the town.

Dining Hut.—In November, 1917, the efficiency of the school was greatly increased by the addition to the accommodation of a large hut 90 ft. by 30 ft. This was used as a lecture room for N.C.O.'s and men, and as a dining hut. It was erected near the existing cook houses so that meals were better served than in the barges.

This hut also enabled better instruction to be given to N.C.O.'s and men; diagrams of bridges were exhibited in it, and men could work there in their squads at schemes and exercises, and be visited by the assistant instructors.

Owing to the difficulty experienced in working on sodden ground during the winter of 1916–17 the bridging ground was, in October, 1917, covered with a layer of six inches of shingle. This greatly improved the site, and the men had always a dry ground to work upon even in bad weather.

Removal to new site.—The school was situated at Aire during the winters of 1916/17 and 1917/18.

Early in 1918, owing to the great increase in the amount of material which it became necessary to stock at the school in order to give instruction in all branches of the subject, it was found that the limited facilities for transport and handling of material at Aire were a serious disadvantage, and in April, 1918, the German advance made it imperative to evacuate all bridging stores from Aire. It was therefore, not considered advisable to re-establish the school there, and in August, 1918, a fresh site was selected.

Site at Monchy Cayeux.—The Communal ground at Monchy Cayeux on the River Ternoise was chosen. This site was eminently suitable for the work required. There was a large area of ground available with good soil for anchorages, etc., and plenty of room for the erection of large spans.

The river itself was only 22 ft. wide and 2 ft. 6 in. deep, but the width between banks, which were 5 ft. to 7 ft. high, varied between 70 and 100 feet.

In order, therefore, to provide a sufficiently large water gap, a timber dam was constructed below the bridging ground and the level of the water raised by 4 feet.

The design of the dam is shown in *Plate* XXXII. The construction of it provided useful experience for the first class at the school in October, 1918.

This gave a water gap of 60 feet with sufficient depth to float pontoons.

Camp.—A suitable field existed for a hutted camp.

The *personnel* of the staff and of the classes was therefore accommodated in huts, which were found much more satisfactory than the barges at Aire.

A plan of the R.E. Bridging School as it existed at Monchy Cayeux is given on *Plate* XXXIII.

Sports.—The surrounding country at Monchy Cayeux provided better facilities for games than existed at Aire, and a football ground, tennis courts, and a golf course were constructed.

DEVELOPMENT OF STAFF OF THE SCHOOL. WAR ESTABLISHMENT.

3. (*a*) *Original Staff.*—The Instructional Staff at the opening classes consisted of :—

Commandant and Chief Instructor	1
Instructors	2
Adjutant and Assistant Instructor	1
N.C.O. Assistant Instructors	3
Clerk	1
"B" *Personnel* for Camp Duties	12

(*b*) *First Increase.*—As the courses developed and the number and variety of steel spans increased, this staff was found insufficient to give all the instruction necessary to fully cover the ground, and an increase was made.

The establishment authorised under War Establishment No. 652 dated 15/8/17, was as under :—

Detail.	Personnel. Officers.	Warrant Officers.	Staff Sjts. and Sjts.	Rank and File.	Total.	Remarks.
Commandant and Chief Instructor. (*a*)	1	...	...	...	1	(*a*) Major R.E.
Instructors. (*b*)	2	...	...	...	2	(*b*) 1 Capt. R.E.
Adjutant	1	...	...	...	1	
Coy. Serjt. Major	...	1	...	...	1	
Coy. Qr.Mr. Serjt.... ...	...	...	1	...	1	
Assistant Instructors ...	...	...	3	...	3	(*c*) "B" *personnel.*
Storekeeper	...	...	...	1	1	
Clerk	...	...	...	1	1	
General Duties (*c*) ...	...	...	...	22	22	
Total ...	4	1	4	24	33	

(*c*) *Second and Final Increase.*—This Staff was sufficient to deal with the work done during the Winter of 1917–18, but in October, 1917, the number of different types of bridges had doubled, and there were no less than 24 different types in which detailed instruction had to be given, in addition to steel cube piers, piles, trestles and other bridging expedients.

In addition to the practical work, it was realised that very much more detailed instruction was required in Reconnaissance, Organisation, and Design.

Schemes (as set forth in another paragraph) had to be given to Officers and their solution fully discussed with them.

The necessity of ensuring a high standard of efficiency at the school was realised as a result of the bridging work carried out during the autumn of 1917.

Application was therefore made for an increase in the Establishment, which was authorised under War Office letter 121/France/1407 dated 16/12/17.

The War Establishment of the R.E. Bridging School, France, as authorised under War Establishments Part VII A. No. 990, is :—

Detail.	Personnel. Officers.	Warrant Officers.	Staff Sjts. & Sjts.	Rank & File.	Total.	Motor Cycles.	Bicycles.	Remarks.
Commandant and Chief Instructor (*a*).	1	...	...	...	1	...	...	(*a*) Major R.E. or Lt. Col.
Instructors. (*b*) ...	3	...	...	...	3	(*c*) 1	(*d*) 11	(*b*) Capts.R.E.
Adjutant	1	...	...	...	1	...	...	(*c*) with side car.
Senior Assistant Instructor. (*e*) ...	...	1	...	...	1	...	...	(*d*) for students
Coy. Serjt. Major ...	...	1	...	...	1	...	...	(*e*) W.O.Cl. 1.
Coy. Qr.Mr. Serjt. ...	...	...	1	...	1	...	...	(*f*) Includes 1 Cpl. and 2 Sappers
Assistant Instructors	...	...	6	...	6	...	...	
Corporal	...	...	...	1	1	...	...	
Storekeepers ...	...	...	...	(*f*) 3	3	...	...	(*g*) Sapper.
Clerks	...	...	...	(*f*) 3	3	...	...	(*h*) Includes Lce.Cpl.
Draughtsman (Mech.)	...	...	...	(*g*) 1	1	...	...	
Privates. (*j*) ...	...	...	...	(*h*) 33	33	...	...	(*j*) " B " *Personnel*
Batmen. (*j*) ...	...	...	...	5	5	...	...	
Total ...	5	2	7	46	60	1	11	

Supersedes W.E. No. 652.

War Office, (S.D.2.).
15th February, 1918.

The rank of Lieutenant Colonel was approved for the Commandant of the R.E. Bridging School under War Office letter 121/France/2578 (S.D.4) dated 13/8/18.

Composition and Duration of Classes.

5. When the school opened at Aire in December, 1916, each class consisted of 20 Officers and 100 N.C.O.'s and men. This figure was found the most suitable for working and was not altered subsequently.

Usually one-third of the *personnel* was drawn from Field Companies in the B.E.F., and the remainder from Army Troops and Tunnelling Companies R.E., Officer students included Field Engineers and representatives from the D.G.T.'s Branch. During 1916/17 the duration of each course was 10 working days.

As the work developed and increased it was found that in a course of 13 days the instruction had to be so concentrated, and there was so much to be got through, that it was thought advisable to further extend the course to 20 working days. This course was much more satisfactory, and was adopted in 1918. It gave the students more time to assimilate the lectures, and more time to devote to their schemes and exercises.

Special Course.—Early in 1917 after six ordinary courses had been completed, it was thought that a nucleus of specially trained Officers and N.C.O.'s should be available in each Army for bridging work.

It was therefore decided to hold, in March 1917, a special long course of one month, the class consisting of promising students of the previous courses, and officers who, in the appointments they held, would probably be called upon to do bridging work.

This course was composed of 12 Officers and 36 N.C.O.'s, and was held concurrently with Classes Nos. 7 and 8, which were of the usual size.

The special training included advanced instruction in design, erection and handling of the various types of spans.

ORGANISATION OF CLASSES.

6. For administrative purposes and for practical work the classes were divided into 10 squads of 10 men each. The ten squads were organised into five groups of 2 squads each.

A Serjeant Instructor was put in charge of each group, and was responsible under the Senior Assistant Instructor for the instruction of the group.

The Senior N.C.O. of each squad acted as squad leader during the course; his duties were to organise the work of his squad, especially the indoor work in the execution of schemes and exercises, and to arrange discussions of the various problems among the members of the squad.

The Assistant Instructors of each squad attended these discussions to answer questions and explain difficulties.

The N.C.O.'s of each squad were detailed as squad commanders in practical work in rotation, so that each N.C.O. would get practical experience in organising a small squad of men on bridging work.

An Officer Instructor was in charge of all practical work, and prepared the design of the bridges erected and programme of work, which was explained to all ranks before commencing.

The working hours were from 8 a.m. to 12 noon, and from 1 p.m. to 4 p.m. Lectures to N.C.O.'s and men were delivered during these hours; these lectures were generally of half an hour duration, and the remainder of the day was devoted to practical work on the ground.

For practical work officer students were put in charge of a group of two squads daily on the work, each officer being on group duty for three days consecutively, so that he could, as far as possible, carry out each scheme from the beginning till completion. These officers were required to take charge of the parties on the work, and to superintend N.C.O.'s and men of the class under the supervision of the officer in charge of practical work.

For indoor work on schemes and for reconnaissance work, the Officers' class was organised in syndicates of two officers; one solution being called for from each syndicate.

SYLLABUS OF COURSE OF INSTRUCTION.

7. As the number of steel bridges increased, so the syllabus of instruction at the school expanded.

New types of bridges were designed and ordered from England, and new methods of erection devised.

By February, 1918, however, samples of all the new types of bridges had been delivered at the school and erected, so that it was necessary subsequently to amend the syllabus.

The course was divided into :—

(i.) Practical Work.
(ii.) Lectures, indoor work, and Reconnaissance.

(i.) The practical work consisted of the erection of spans, construction of trestle and cube piers, pile-driving heavy and light, launching of heavy girders, use of derricks, tackles, pontoon rafts for pile-driving, etc., and in short, all operations likely to be required for bridging work in the field were practised.

(ii.) *Lectures, etc.*—There were 20 lectures delivered to officers of each class.

These included a complete course of 8 lectures embracing organisation of bridging work, description of type spans, supply of materials and transport, bridging dumps, etc. ; three lectures in reconnaissance including aerial reconnaissance, three lectures on piles and abutments, three lectures on tackles, anchorages and launching, one lecture on simple applied mechanics, and two lectures on special types of bridges.

In addition to these lectures officers were shown on the ground the details of the various spans, one type being taken at each lecture which lasted 20 minutes.

There were four exercises and two schemes issued to each class.

The exercises were simple applications of the principles taught in lectures and practical work, and included designs for a pile pier, a trestle pier, a short span bridge and tackles required for launching main girders of stock spans.

The first scheme embraced the reconnaissance of an existing bridge with a view to determining what loads the bridge would take.

There were 12 lectures delivered to N.C.O.'s and men of each class.

These were of a practical nature, and included the description of such practical details of the work as N.C.O.'s and men would require in the field.

There were three schemes issued to N.C.O.'s and men.

One solution was required from each squad, the members of which worked together and discussed the problem among themselves.

The scheme included taking sections of gaps, an easy reconnaissance scheme for the reconstruction of a short span bridge, and an exercise in the organisation of working parties on bridge erection.

A typical programme of a course at the school is attached. (Schedule A.)

LIBRARY.

8. In order to encourage study of the various branches of bridge engineering a library was formed at the school in October, 1917.

Standard books of reference on bridge engineering were obtained, and issued to officers of the classes.

On arrival all officers were issued with a copy of the " Memorandum on Road Bridges," pamphlets on the Inglis and Hopkins Bridges and "Portable Road Bridges."

The squad leader of each squad of N.C.O.'s and men was also issued with a copy of these publications.

MATERIAL.

9. In order to make practical work as complete as possible, it was necessary to have in stock at the school, at least one span of each type in use with the Army.

The following is a list of the stock spans normally held at the school during 1918, which were erected and launched during the courses.

120 ft. type Hopkins Bridge, 120 ft. Span.	1.
75 ft. Hopkins (type) 90 ft. Span.	1.
85 ft. Class A. Span.	1.
60 ft. Mark II. Span.	1.
60 ft. Class A. Span.	2.
30 ft. Class A. Span.	1.
30 ft. Reinforced Span.	1.
21 ft. 6 in. Portal Lifting Bridge.	1.
21 ft. 6 in. Davit Lifting Bridge.	1.
21 ft. 6 in. Pont Levis Lifting Bridge.	1.
21 ft. 6 in. Class A. Span.	1.
21 ft. 6 in. Mark II. Span.	3.
16 ft. Mark II. Span.	1.
16 ft. Class A. Span.	1.
Inglis Rectangular Bridge, 72 ft. Span.	1.
Inglis Medium type.	1.
Inglis Light type (Twin Bridge).	1.
Sankey Pontoon Bridge (84 ft. length).	1.
20 ft. R. S. J. Field Bridge for Tanks.	1.
18 ft. R.S.J. Field Bridge for Tanks.	1.
20 ft. R.S.J. Field Bridge for 12 T. axle	1.
60 ft. Class B. Bridge	1.
30 ft. Class B. Bridge.	4.
13 ft. Class B. Bridge.	1.

In addition to the above material, the stores for an Army Bridging Depôt were kept in stock; these stores provided sufficient launching gear for use of the classes, and a large stock of timber for piers, etc., was also held.

EXAMINATION AND REPORTS.

10. For the classes held during the winter of 1917/18 and in the autumn of 1918, a report on each officer, N.C.O. and man was made at the end of each course.

Officers were marked for their ability in practical work as group officers, and a verbal examination was carried out by the Commandant at the end of each course.

All exercises and schemes were marked and a percentage mark was arrived at for each officer in practical work, design, reconnaissance and organisation.

Officers were graded as to their capabilities for bridging work in accordance with the following standard :—

General qualifications for employment on Bridging Work.	Practical.	Design.	Reconnaissance.	Organisation.
	Per cent.	Per cent.	Per cent.	Per cent.
Specially Recommended ...	80	80	80	80
Recommended	70	70	70	70
Recommended for a Subordinate position, on Bridging work	60	50	60	60

Any officer not obtaining the qualifying minimum of marks in any subject as above was reported as "Not recommended for employment on Bridging Operations."

In the case of N.C.O.'s and men, marks for practical work were allotted by the Assistant Instructor in charge of practical work and the Commandant.

All N.C.O.'s when acting as squad commanders, were inspected and marked by the Commandant on their ability to command.

Marks for organisation and reconnaissances were given by the Commandant in a verbal examination held at the end of the class.

This verbal examination included questions on practical work given with a view to testing the man's powers of observation and the organising of parties, and, in general, on the students' knowledge of the work done during the course.

The following minimum marks were required for the qualifications stated :—

Qualifications for Bridging Work.	Practical. N.C.O's. and Sappers.	Organisation and Reconnaissance. N.C.O's.	Organisation and Reconnaissance. Sappers.
	Per cent.	Per cent.	Per cent.
Very superior	90	80	75
Superior	80	70	60
Skilled	50	50	40
Not Recommended	under 50	under 50	under 40

Competition Between Squads.

11. In each class a spirit of competition was engendered among all ranks.

Squads were marked collectively for the work done during the course.

The squad marks were calculated by averaging the marks obtained by N.C.O.'s and men of the squad in practical and oral work, and adding the marks obtained by the squad in the schemes carried out by them, as described above.

The marks of the best squad of the class were published in school orders on the last day of the class.

The names of the best serjeant, best corporal and the best sapper of the class, and marks obtained, were read out on the last parade of the course, and they were congratulated by the Commandant.

Their names were published in orders, and also the marks obtained by each N.C.O. and man of the class.

Records of *Personnel* Trained in Bridging.

12. A record was kept on a card index system of all officers passing through the school, giving the marks obtained in each subject and the Commandant's recommendation.

From the index to these cards it could be seen at a glance the number of officers trained in each Army and in each unit. A similar card was kept for each N.C.O. and man.

These cards were kept "by units," so that it could be seen how many men had been trained in each unit.

The index gave a cross reference for each N.C.O. and man by means of a serial number, so that any N.C.O. or man who had attended the school could be traced.

Numbers Trained.

13. 1916/17.—During the winter of 1916/17 the number of—

(*a*) officers, N.C.O.'s and men trained at the School were :—

Officers	150
N.C.O.'s and Men	806

The average number trained in each Army was 29 officers and 160 other ranks.

(*b*) 1917/18.—In 1917/18 the number trained were :—

Officers	166
N.C.O.'s and Men	861

The qualifications obtained by the officers were :—

Specially recommended for Bridging Work	20
Recommended	46
Recommended for a Subordinate Position	60
Not recommended	40
Total	166

The qualifications obtained by N.C.O.'s and men were :—

Very Superior for Bridging Work	48
Superior	169
Skilled	593
Not recommended	51
Total	861

The distribution of this *personnel* among Units was as follows :—

Field Companies	64 Officers and 269 Other Ranks.
Army Troops Companies ..	53 Officers and 407 Other Ranks.
Tunnelling Companies ..	28 Officers and 88 Other Ranks.
Other Units such as Cavalry Corps, H.Q.'s of Formation, D.G.T. etc. ..	21 Officers and 97 Other Ranks.

There were 156 Field Companies represented, 60 Army Troops Companies, and 28 Tunnelling Companies.

Taking the session 1917/18 as typical of the distribution of students between units, it will be seen that the average number of all ranks trained in each Field Company was two, in each Army Troops Company eight, and in each Tunnelling Company four.

The training of such a small number of other ranks in Field Companies would not have much effect, but for a Field Company commander to possess an officer trained in heavy bridging is valuable.

It is to be noted also that many Army Troops Companies sent a large proportion of their men to the school, especially those units which more or less became specialists in bridge erection.

(*c*) 1918.—During the autumn of 1918, before the cessation of hostilities the following numbers of officers and men were trained at the school :—

Officers	33
N.C.O.'s and Men	173

The qualifications obtained in the case of the officers were :—

Specially recommended	4
Recommended	15
Recommended for a subordinate position	12
Not recommended	2
Total	33

The qualifications obtained by N.C.O.'s and men were :—

Very Superior	17
Superior	42
Skilled	114
Total	173

(*d*) *Total Trained.*—Including the courses at Havre, it will be seen that the total number trained in heavy bridging from 1915 to 1918 was 435 officers and 2,121 other ranks.

In addition to these numbers, which were trained in the regular courses, there were held at the bridging school both during the summer of 1917 and the summer of 1918 short courses for officers and men in special bridging work in preparation for operations.

Approximately 20 officers and 250 other ranks received instruction of this nature.

Remarks on Standard of Work and Results Obtained.

14. (*a*) *Officers.*—Officers attending the courses were expected to have had some knowledge of the general principles of bridging as laid down in Military Engineering Part III., Sections III., IV. and V.

The general standard of engineering knowledge of officer students was, however, not as high as it might have been, but nevertheless they took a keen interest in the work, and learnt a good deal about bridging during the short course which they had.

It was invariably noticed that those who were backward at the beginning improved considerably towards the end of the course.

Design and organisation were the chief stumbling blocks, since the majority of students were young officers.

The percentage qualifications of the best Officers' Class was :—

Specially Recommended	16%
Recommended	48%
Recommended for a Subordinate position	32%
Not recommended	4%

The large number of students of the school who were employed on bridging work during the advance in the autumn of 1918, and the success of those bridging operations are sufficient justification for the existence of the school, and the results of the instruction thereat.

(*b*) *N.C.O.'s and Men.*—The standard of work shown by N.C.O.'s and men was excellent, and above the expectations of the instructional staff at the school.

The men were all very keen on the work, and greatly appreciated and benefited by the individual instruction which it was possible to give with the additional staff provided in November, 1917.

The answers given by N.C.O.'s and men in their verbal examination by the Commandant showed that they had worked hard during the courses, and had exercised their powers of observation to a remarkable degree.

The general inference to be drawn from this result is that the secret of training in bridge work is to provide a sufficient staff of capable instructors to give considerable individual attention to all students at the school.

Research and Experimental Work.

15. Careful records were kept at the school of the practical work done, and of the man-hours taken to erect the various types of spans.

These results were incorporated in the revised edition of "Memorandum of Road Bridges" written by the staff of the school, and published in 1918.

New methods of erection were devised and experimented with, and new appliances for use with the various spans and for pile-driving were tested, and improved upon until they were suitable for use in the field.

The results of these experiments were incorporated in the text book mentioned above.

Visits of Officers of Allied Armies.

16. In 1917/18 short visits of French and American officers were arranged at the school.

The work in progress was explained to them, and lectures were delivered in their own language.

Notes were also issued giving a description of the various bridges and the conditions governing their use in the field, and details of the practical work carried out each day.

Reconnaissance of Existing Bridges in Army Areas.

17. In the execution of the schemes set them officer students made a reconnaissance of many bridges in the neighbourhood of the school,

The results of these were tabulated, and further reconnaissance work was done by the staff at the close of the courses.

The loads which these bridges would take were then calculated and tabulated, and the results distributed to the formations in whose area the bridges were situated.

These notes were found to be of great value in subsequent operations, notably during the German advance on the Lys in April, 1918.

During the summer of 1918, some of the staff of the school were employed on a reconnaissance of all bridges in the area occupied by the British Army. The load for each bridge was calculated and the results published.

Erection of Bridges in the Army Area by the Classes.

18. In connection with the preparation of the defensive line in the Lys area in February and March, 1918, it was required to considerably improve the road communications in the Army area.

Some of the new bridges required were within reasonable distance of the school, and as the work of the erection of these spans was of a very suitable description for instructional purposes, it was decided to erect them with the classes at the school.

No. 8 Class erected two Lifting Bridges over the River Lys south of Armentières.

The general type was a Pont Levis bridge supported upon pile piers in the centre of the river, and short spans on pile abutments on either side.

It was arranged for the piles to be driven by the Inland Water Transport who had near the sites suitable plant for the purpose.

Another bridge of a similar type, but with only one pile bent at each abutment, was erected at Merville over the River Lys.

Time for Erection.—In the case of the two bridges south of Armentières the spans for each bridge were erected in three working days of 8 hours each by the N.C.O.'s and men of the classes, under the supervision of the staff of the school assisted by the group officers of the class.

The spans of the Merville bridge were erected in two working days.

These times were believed to constitute a record for bridges of this type, and demonstrate that with good organisation, steel bridges can be erected in a very short space of time.

Inglis Bridges.—A number of foot bridges were also required over the River Lawe in connection with the defence scheme.

The spans erected in each case were Inglis medium type bridges, of lengths varying from 48 feet to 72 feet.

No. 8 Class erected nine of these bridges in one working day of 10 hours, a notable achievement since the bridges were distributed over an eight miles length of the river.

Erection of Bridges in Army Areas by the Staff of the School.

19. After the German advance in the Lys sector in 1918, a large number of bridges were required in the First and Second Army areas near Aire.

A portion of the staff of the school was retained after the close of the ordinary courses at the school, to assist with these bridges. Forty-five bridges of various spans were erected under the supervision of the staff. Also a number of spans were prepared and stocked for use in the event of an advance.

The labour employed was usually supplied by formations in whose area the bridges were required.

ORGANISATION OF THE SCHOOL AFTER CESSATION OF HOSTILITIES.

20. The R.E. Bridging School was re-organised in December 1918, to take courses of 20 regular officers in bridge engineering and construction, in place of the ordinary classes of 20 officers and 100 other ranks.

The syllabus of these new courses included applied mechanics, masonry structures, timber design, design of steel bridges and roof trusses, reinforced concrete and reconnaissance.

SCHEDULE A.

PROGRAMME OF WORK.

NO. 1 CLASS—OCTOBER, 1918.

1. PRACTICAL WORK.

Bridges to be Erected :—

No. 1. 120-ft. Hopkins on ¾ T. bankseats.
2. 85-ft. Class "A" (on girder only).
3. 75-ft. Hopkins on ¾ T. bankseats.
4. 60-ft. Mark II. on ¾ T. bankseats.
5. 30 ft. Reinforced and 22 ft. R.S.J. Field Span for Tanks, with Cube Pier.
6. 60 ft. Mark II. and 20 ft. R.S.J. Field Span for Tanks with Cube Pier.
7. Pont Levis, 21 ft. 6 in. Class "A," and 16 ft. Mark II., with 2 pile piers.
8. 22 ft. R.S.J. Field Span for 12 T. Axle load on ¾ T. bankseats.
9. 20 ft. R.S.J. Field Span for Tanks on ¾ T. bankseats.
10. 25 ft. Bridge for First Line Transport.

Construction of Dam on R. Ternoise :—

SPECIAL WORK.

Date.	Group.	Squads.	Bridge No.	Work.
20th Oct. 1st day	1	A.B.	Dam.	Erecting 2 piledrivers and staging for same, transporting, preparing and driving piles.
	2, 3, 4	C. D. E. F. G. H.	No. 4	Preparing bankseats and launching tackle. Erecting Girders.
	5	J. K.	No. 7	Erecting piledriver and staging for same, transporting, preparing and driving piles.

Date.	Group.	Squads.	Bridge No.	Work.
21st Oct.	1	A. B.	Dam.	Driving 2 piles.
2nd day	2, 3, 4	C. D. E. F. G. H.	No. 4	Complete erection of steelwork and preparations for launching.
	5	J.	No. 7	Driving 1 pile.
		K.	No. 1	Excavation for bankseats and setting out.
22nd Oct.	1, 3, 5	A. B. E. F. G. J.	No. 4	Launching and decking.
3rd day.	2	C. D.	Dam.	Driving 2 piles.
	4	H.	No. 7	Driving 1 pile.
		K.	No. 1	Preparing bankseats and erection packings.
23rd Oct. 4th day.	1—5	A—K.	No. 1	Erecting steelwork.
24th Oct. 5th day.	1—5	A—K.	No. 1	Erecting steelwork.
25th Oct. 6th day.	1—5	A—K.	No. 1	Erecting steelwork
26th Oct.	1, 2	A. B. C. D. G. H.	No. 1	Completing bankseats and erecting launching gear.
7th day.		E. F.	Dam	Driving 2 piles.
	3	J.	No. 10	Erecting.
	5	K.	No. 7	Driving 1 pile.
27th Oct.	1, 2, 4	A. B. C. D. G. H.	No. 1	Completing launching arrangements.
8th day.		E. F.	Dam.	Driving piles.
	3	J.	No. 10	Completing.
	5	K.	No. 7	Driving pile.
28th Oct.	1—5	A—K.	No. 1	Launching.
9th day.	1	A. B.	No. 9	Transporting material and excavating bankseats.
	2	C.	No. 7	Driving pile.
		D.	No. 5	Erecting cube pier .
	3, 5	E. F. J. K.	No. 1	Fixing roadway and removing launching tackle.
	4	G.H.	Dam.	Driving piles.
29th Oct.	1	A.	No. 9	Completing.
10th day.		B.	No. 8	Erecting and Completing.
	2	C.	No. 7	Driving 1 pile.
		D.	No. 5	Erecting cube pier.
	3, 5	E. F. J. K.	No. 1	Fixing roadway and removing launching tackle.
	4	G. H.	Dam.	Driving 1 pile and fixing wales
30th Oct.	1	A.	No. 8	Removal and Re-erection.
11th day.		B.	No. 9	Removal and Re-erection.
	2, 4	C. D. G. H.	No. 1	Completing approaches.
	3	E.	No. 7	Driving 1 pile.
		F.	Dam.	Fixing wales.
	5	J. K.	No. 5	Assembling and launching 30-ft. Reinforced.
31st Oct. 12th day.	1—5	A—K.	Inglis Rectangular.	
1st Nov.	1, 5	A. B. J. K.	No. 4	Dismantling decking and withdrawing.
13th day.	2	C.	No. 9	Removal and re-erection.
		D.	No. 8	Removal and re-erection.
	3	E. F.	No. 5	Erection of 22 ft. R.S.J.Span.
	4	G. H.	No. 3	Excavating for bankseats and setting out.

Date.	Group.	Squads.	Bridge No.	Work.
2nd Nov. 14th day.	5	A. B. J. K.	No. 4	Dismantling complete.
	2	C.	No. 8	Removal and re-erection.
	2	D.	No. 9	Removal and re-erection.
	3	E. F.	No. 6	Erecting and placing cube pier.
	4	G. H.	No. 5	Withdrawing 30 ft. Reinforced.
3rd Nov. 15th day.	1	A. B.	No. 5	Erecting of 30 ft. Reinforced span.
	2, 4, 5	C. D. G. H. J. K.	No. 3	Erecting steelwork.
	3	E.	No. 9	Removal and re-erection.
	3	F.	No. 8	Removal and re-erection.
4th Nov. 16th day.	2, 4, 5	C. D. G. H. J. K.	No. 3	Erecting steelwork.
	1	A.B.	No. 5	Erecting of 30-ft. Reinforced span.
	3	E.	No. 8	Removal and re-erection.
	3	F.	No. 9	Removal and re-erection.
5th Nov 17th day.	1, 3, 5	A. B. E. F. J. K.	No. 3	Erecting, launching gear, launching and fixing roadway.
	2	C. D.	No. 5	Dismantling 30-ft Reinforced span.
	4	G. H.	No. 9	Removal and re-erection.
	4	H.	No. 8	Removal and re-erection.
6th Nov. 18th day.	1, 2, 5	A.	No. 7	Driving 1 pile.
	1, 2, 5	B. C. D. J. K.	No. 2	Erecting steelwork.
	3	E. F.	No. 3	Completing approaches.
	4	G.	No. 8	Removal and re-erection.
	4	H.	No. 9	Removal and re-erection.
7th Nov. 19th day.	1, 3, 4	A. E. F. G. H.	No. 2	Erecting steelwork.
	1, 3, 4	B.	No. 7	Driving 1 pile.
	2	C. D.	No. 2	Erecting launching gear.
	5	J	No. 9	Removal and re-erection.
	5	K.	No. 8	Removal and re-erection.
8th Nov.	1—5	A—K.		Dismantling tackle and returning to store.
20th day.	1—5			

2 (*a*). LECTURES—OFFICERS.

Date.	Day of Class.	Subject.
Oct. 20th.	1	Types of Stock Spans, Army Bridge Depôts and Base Park. Hopkins Bridges.
21st	2	Piles and piledriving. Bending Moments and Shear.
22nd	3	Preliminary Reconnaissance and Reconstruction Schemes. Short Span Bridges for Heavy Loads.
23rd	4	Piers and Abutments, Part I. Piers and Abutments, Part II.
24th	5	Supply of Materials and Transport. Launching Methods.
25th	6	Organisation of Bridging Work on the site. Tackles and Anchorages, Part I.
28th	9	Aerial Reconnaissance. Tackles and Anchorages, Part II.
29th	10	Description and details of canals and streams in enemy territory and preparation of forecasts of Bridging requirements. Examination of Bridge Spans.
Nov. 1st	13	Organisation of a R.E. Coy., for Bridge Work. Inglis Bridge.
2nd	14	Preservation of Timber, Metal Work and Stores. Army and Corps Bridging Dumps.
3rd	15	Organisation and Equipment of I.W.T., Salvage Units.

N.B.—The first lecture will be at 11.30 hours daily and the second lecture at 17.00 hours.

2 (*b*). Lectures—N.C.O.'s and Men.

Date.	Day of Class.	Subject.
Oct. 20th	1	Types of Stock Spans. Piers and Abutments, Part I.
21st	2	Hopkins Bridges. Tackles and Anchorages.
22nd	3	Organisation of Bridge Work, Part I. Piers and Abutments, Part II.
23rd	4	Organisation of Bridge Work, Part II. Manipulation of Heavy Loads.
24th	5	Transport. Bridging Stores and Tools.
25th	6	Inglis Bridges.
26th	7	Sections of gaps.
28th	9	Reconnaissance and simple reconstruction.

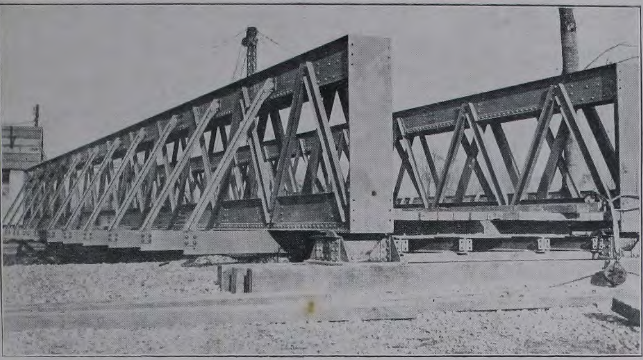
3 (*a*). Schemes or Exercises—Officers.

	Issue.				Handing in.	
Date.	Day of Class.	Hour.	Exercise or Scheme.	Date.	Day of Class.	Hour
Oct. 21st	2	12.30	Design of Pile Pier.	22	3	20.00
22nd	3	18.00	Design of Short Span Bridge for Tanks.	23	4	20.00
23rd	4	18.00	Design of Trestle Pier.	24	5	20.00
26th	7	08.00	Preliminary Reconnaissance Scheme for half Class.	28	9	20.00
27th	8	08.00	Preliminary Reconnaissance scheme for half Class.	29	10	20.00
28th	9	18.00	Design of Launching Tackle.	½ Class on 29th, ½ Class on 30th.	10 11	20.00
30th	11	08.00	Bridge Inspection Scheme for half Class.	Nov. 1st	13	20.00
31st	12	08.00	Bridge Inspection Scheme for half Class.	2nd	14	20.00

3 (*b*). Schemes or Exercises—N.C.O.'s and Men.

	Issue.				Handing in.	
Date.	Day of Class.	Hour.	Exercise or Scheme.	Date.	Day of Class.	Hour.
Oct. 23rd	4	08.30	Organisation Scheme.	25	6	18.00
26th	7	08.30	Sections of Gaps.	27	8	12.00
28th	9	08.30	Reconnaissance and Reconstruction Scheme No. 1.	30	11	18.00
29th	10	08.30	Reconnaissance and Reconstruction Scheme No. 1.	31	12	18.00

INDEX.



Photograph I.—85-Ft. Class "A" Span.

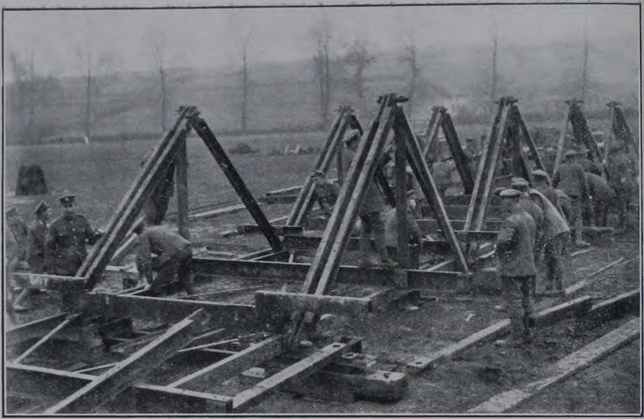
Photograph II.—Launching Hopkins 120-Ft. Type Span.
View from near bank, showing temporary wire rope cross bracing.

Photograph III.—Launching Hopkins 120-Ft. Type Span.
Span launched 45 ft. Fixing slings for main launching tackle.

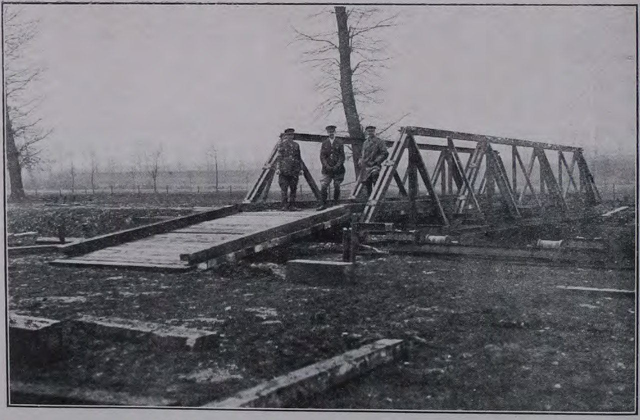
Photograph IV.—Launching Hopkins 120-Ft. Type Span.
Span launched 100 ft.

Photograph V.—Hopkins 75-Ft. Type.

Photograph VI.—Hopkins 75-Ft. Type.



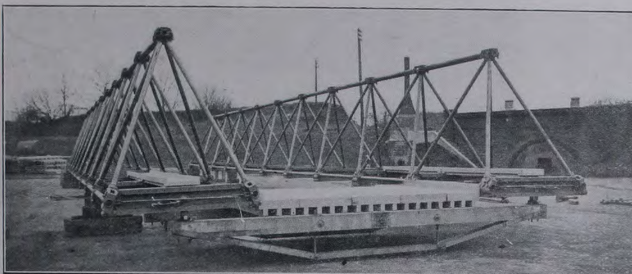
Photograph VII.—Hopkins Lorry Bridge.



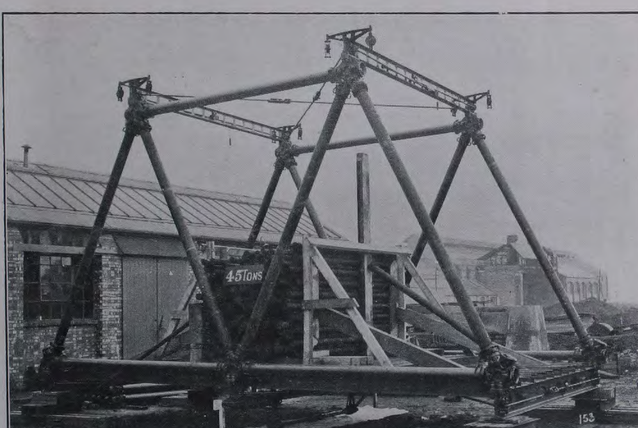
Photograph VIII.—Hopkins Lorry Bridge.

Photograph IX.—Pont Levis.
Showing derrick used in erection.

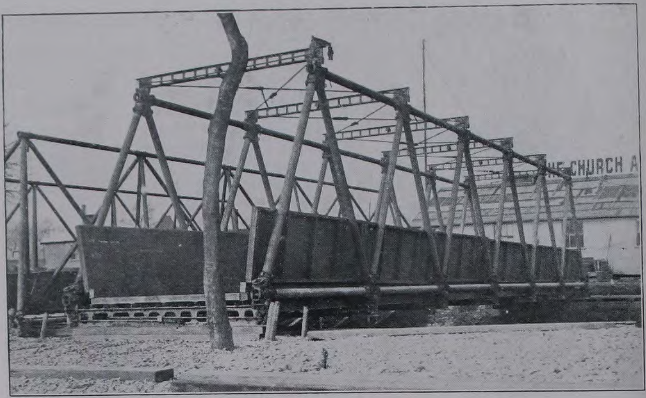
Photograph X.—Inglis Bridge: Second Pattern.



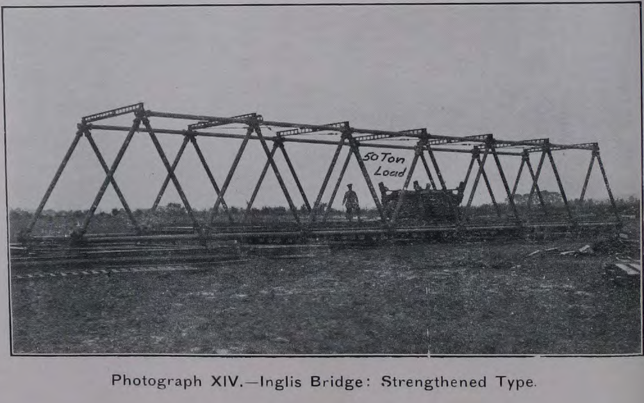
Photograph XI.—Inglis Bridge.



Photograph XII.—Inglis Bridge : Rectangular Pattern.

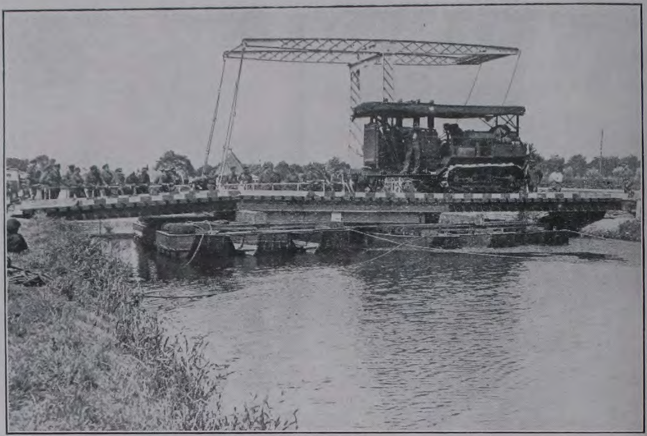


Photograph XIII.—Inglis Bridge: Rectangular Type.
Inglis Bridge, Heavy Type, in background.

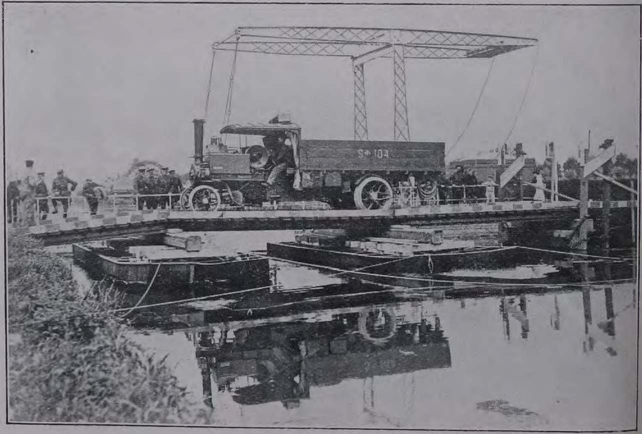


Photograph XIV.—Inglis Bridge: Strengthened Type.

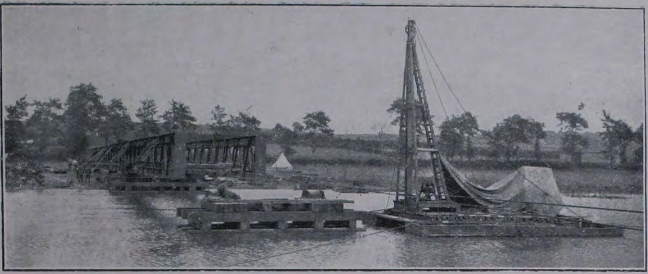
Photograph XV.—Inglis Bridge: Strengthened Type.



Photograph XVI.—Bridge "B."
Showing Caterpillar—Weight 14 Tons.



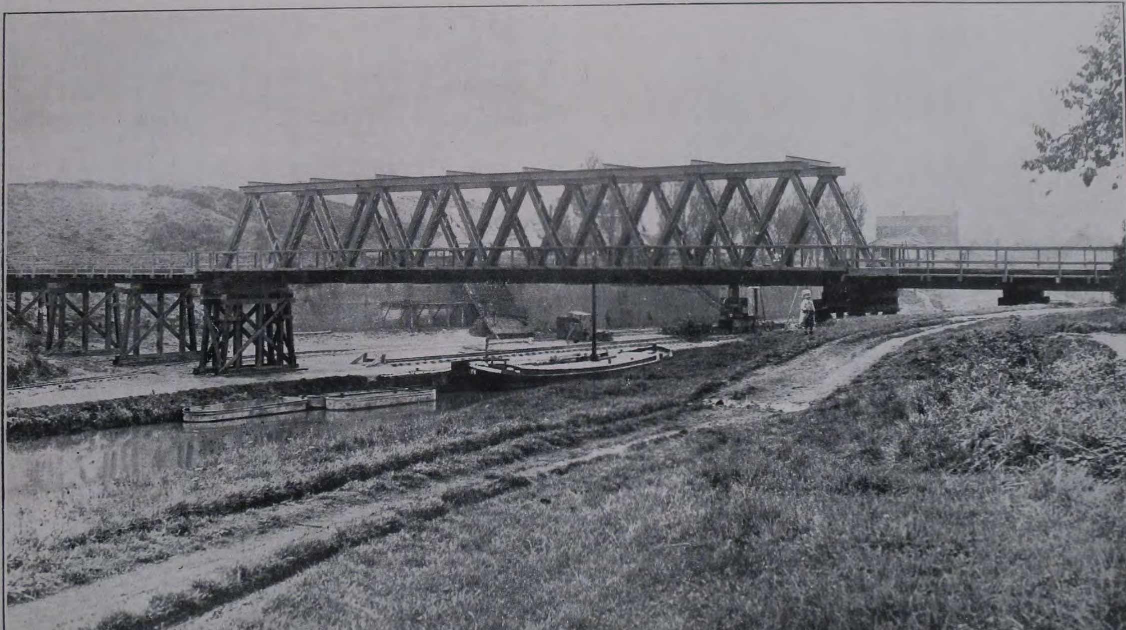
Photograph XVII.—Bridge "C."
Showing Loaded Foden Lorry—Total Weight 11 Tons.



Photograph XVIII.

Photograph XIX.

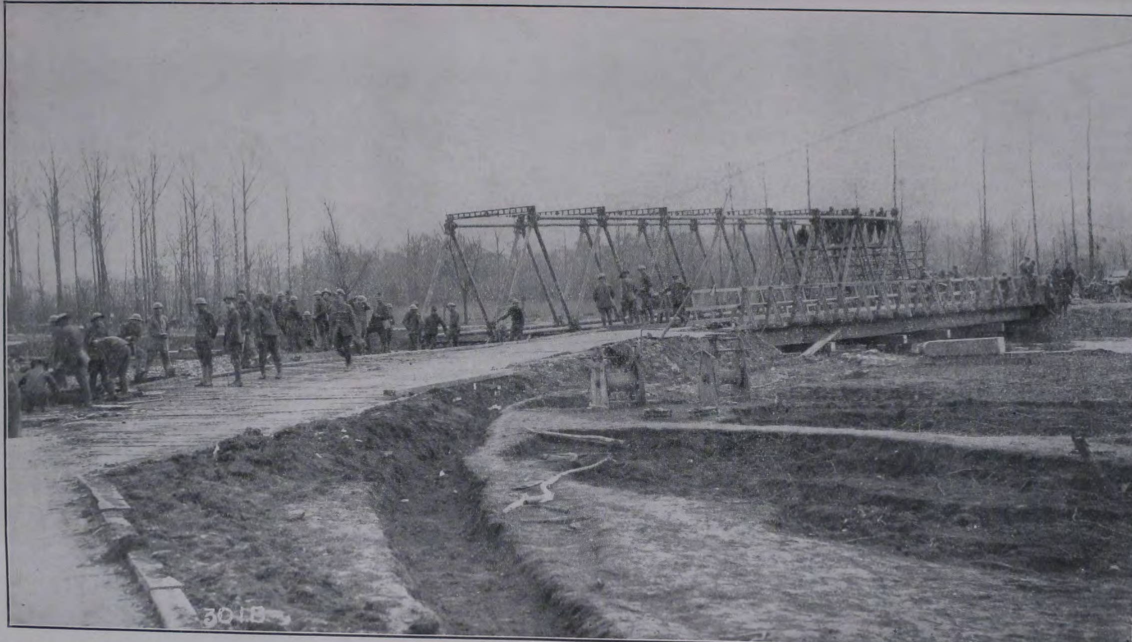
Photograph XX.—Erection of a Two-Span 85ft. Bridge at Beutin.



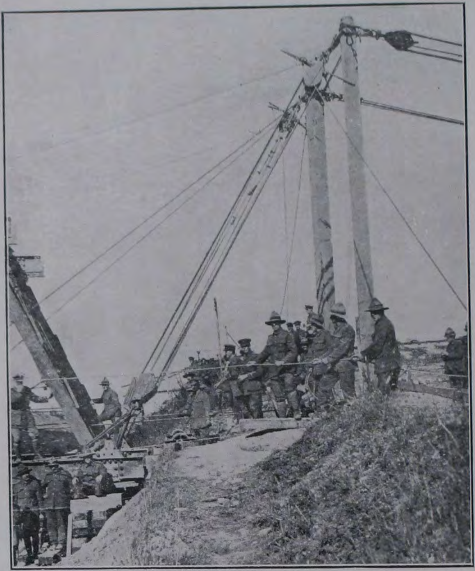
Photograph XXI.—120ft. Hopkins Bridge at Arques.

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.

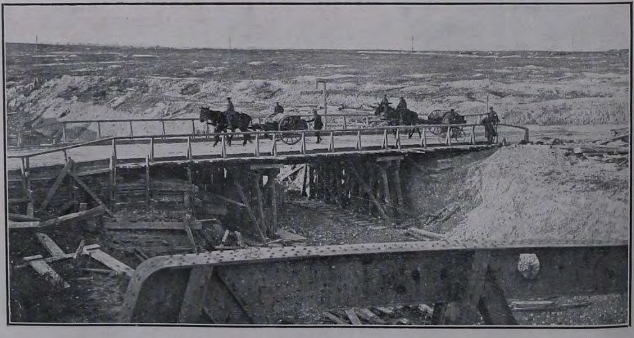


Photograph XXIV.—K. 84-ft. 0-in. length of Inglis Rectangular Type at La Motte, April, 1918; also to the right is shown K1. Replacement Bridge, consisting of 2 21-ft. 6-in. and 2 16-ft. 0-in. Spans, Mark II. N.14.d.1.3. View shows Inglis Bridge being dismantled. 4th Army.

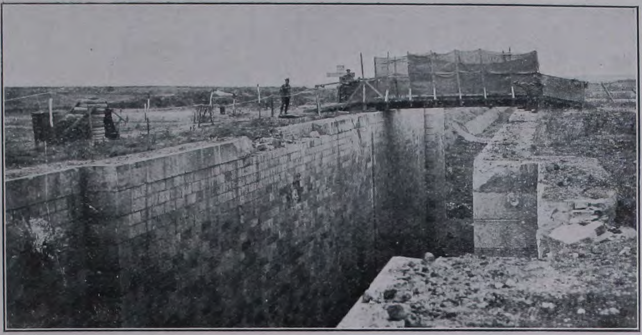


Photograph XXXI.—Havrincourt, Canal du Nord: Attachment of the tackle to the heads of derricks.

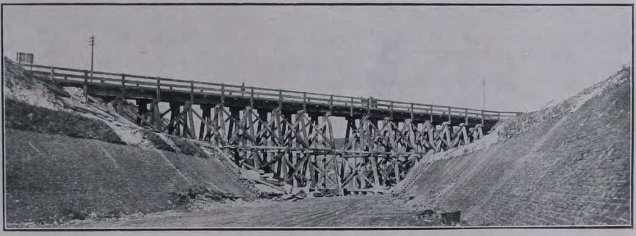
Hopkins 120-ft, Type Bridge, Clear Span 180 ft.
Work started 28th September, 1918.
Photo taken 3rd October, 1918.
Bridge opened for Traffic 6th October, 1918.



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

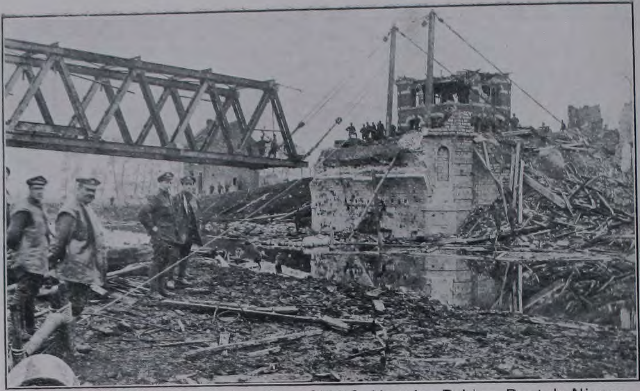


Photograph XXXIII.—Canal du Nord : Typical R.S.J. Span across Lock.

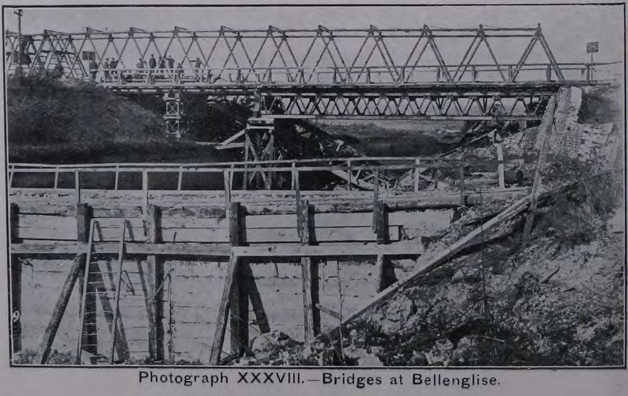


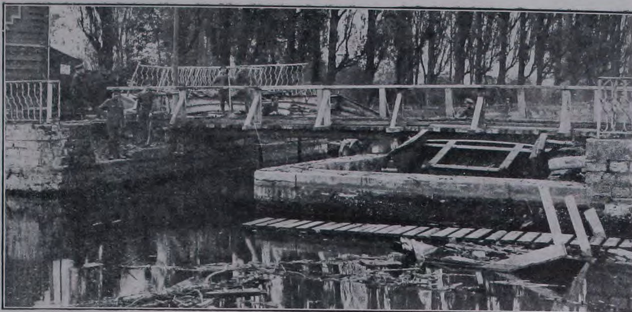
Photograph XXXIV.—Canal du Nord ; Timber Railway Bridge.

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


Photograph XXXVI.—Construction of 150-ft. Hopkins Bridge, Pont de Nieppe.


Photograph XXXVII.—Construction of 150-ft. Hopkins Bridge, Pont de Nieppe.

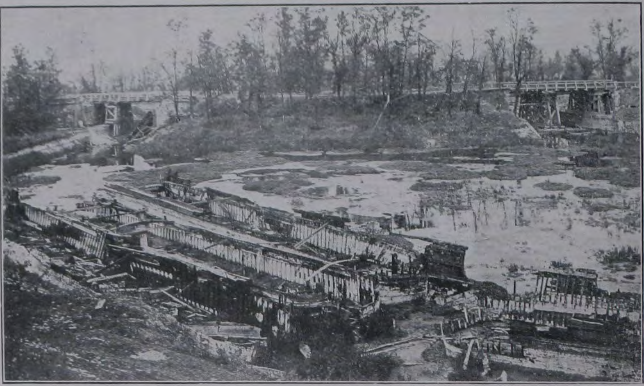

Photograph XXXVIII.—Bridges at Bellenglise.



Photograph XXXIX.—Bridging Locks.

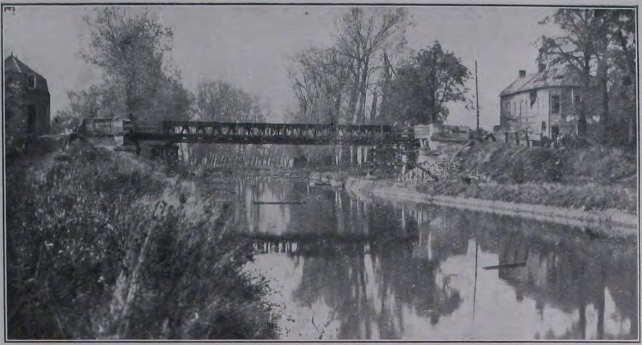
Photograph XL.—Bridging Locks.

Photograph XLI.—Cambrai.

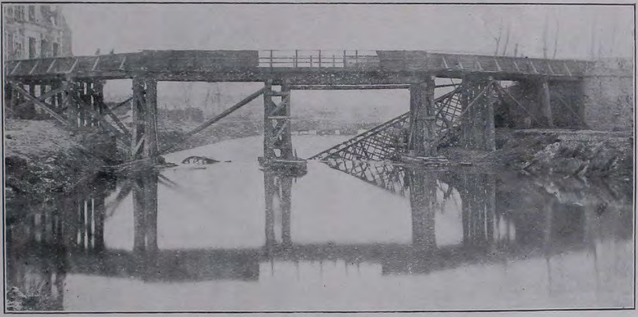


Photograph XLII.—Typical R.S.J. Span Crossings.

Photograph XLIII.—60-ft. Mark II. Spans



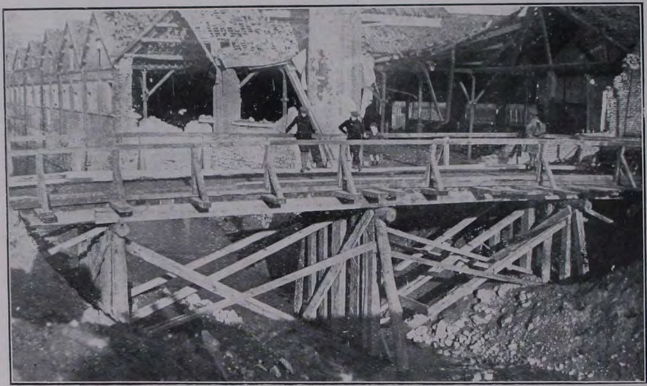
Photograph XLIV.—60-ft. Mark II. Spans.



Photograph XLV.—Pecq Bridge.

Photograph XLVI.—Bridge at Neuvilly.

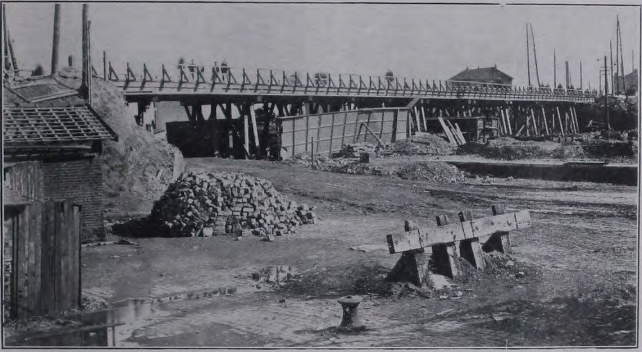
Photograph XLVII.—R.S.J. Bridges at the Canal de la Sambre.



Photograph XLVIII.—R.S.J. Bridges at the Canal de la Sambre.

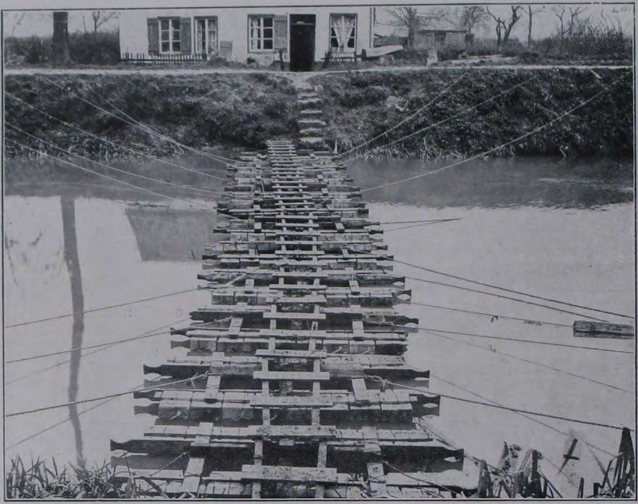
Photograph XLIX.—Road Bridge across Main Lines of Railway.

Photograph L.—Road Bridge across Main Line of Railway.



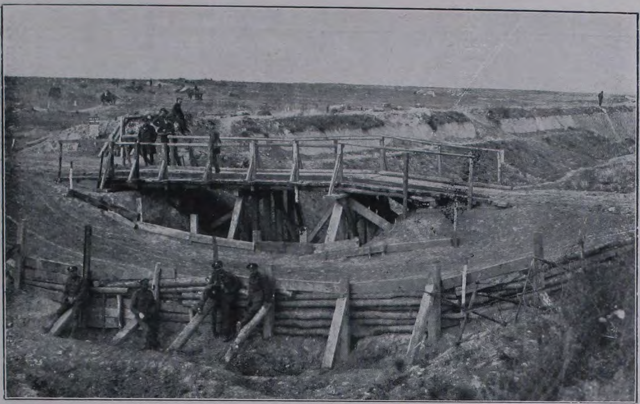
Photograph LI.—R.S.J. Bridge on Timber Trestles at Valenciennes, 350 ft. long.

Photograph LII.—Bridge, Vieux Conde, with Steel Cube Piers.



Photograph LIII.

Photograph LIV.

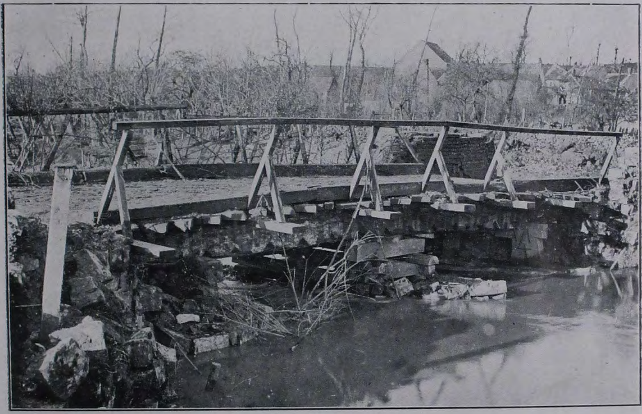


Photograph LV.

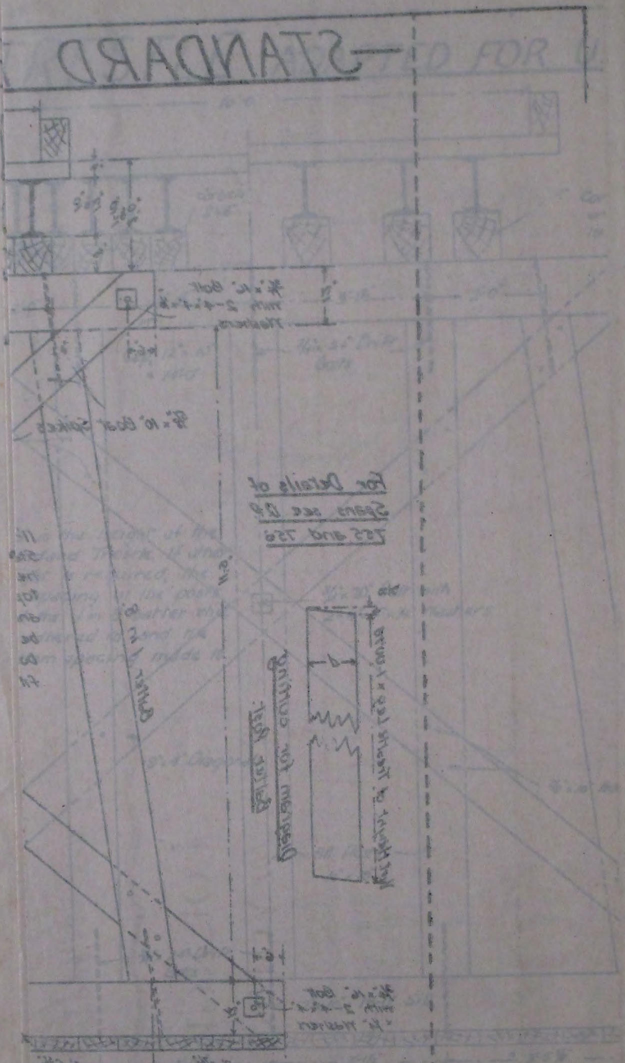
Photograph LVI.

Photograph LVII.

Photograph LVIII.

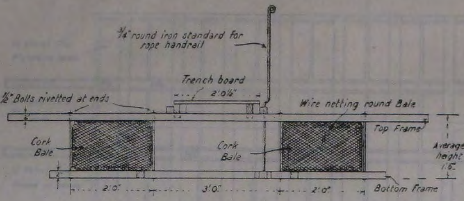


Photograph LIX.

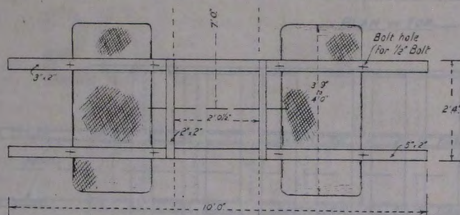

STANDARD
For Details of Spans see pp 755 and 756
Diagram for cutting Batter Post
Batter
HALF ELEVATION

CORK BRIDGE PIERS.

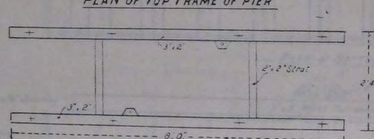
PLATE XX.



SECTION OF PIER



PLAN OF TOP FRAME OF PIER



PLAN OF BOTTOM FRAME OF PIER

Piers at 7 feet centres will carry Fully equipped infantry in single file
The Cork Bales are squared up and tightly bound in wire netting, 1½" to 2" mesh, before being compressed between the frames.

NOTES:-

(1) Average Weights:

Cork	2 x 75 lbs.	150 lbs
Top Frame		39 "
Bottom Frame		24 "
Bolts		3 "
Grating		47 "

(2) Buoyancy of Pier. 430 lbs.

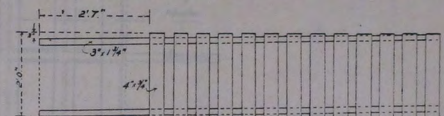
(3) Four Bays with superstructure, pack on a pontoon wagon.

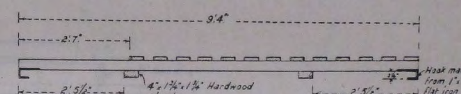
(4) The ½" Bolts require to be made specially.

(5) Wooden crates have been used to contain the Cork, but are of course, much heavier than the wire netting.

(6) Cork Slabs are superior to Cork Chippings.

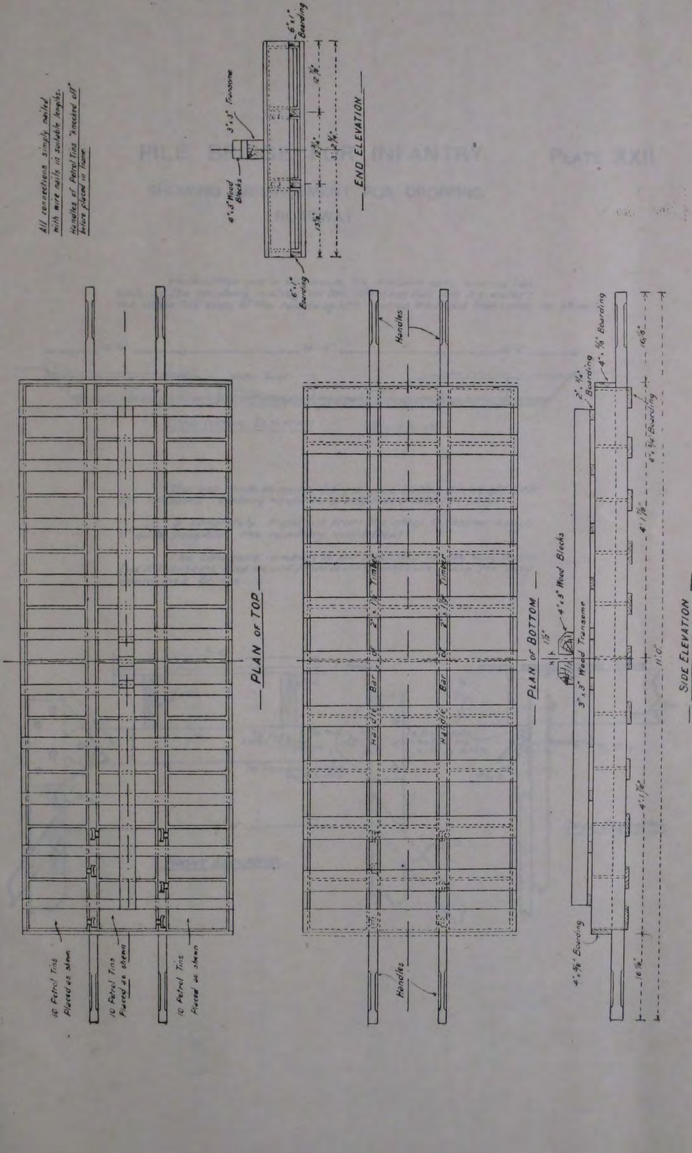
(7) ¾" to 1" Steel cables are preferable to hemp cables as anchorages, as the latter are easily damaged by shell fire.





TRENCH BOARD

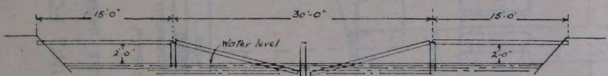
PONTOON (PETROL TIN FLOATS). PLATE XXI.



PILE BRIDGE FOR INFANTRY. PLATE XXII.

SHOWING ARRANGEMENT FOR DROPPING ROADWAY

When either pin is withdrawn, the transom falls, and the two ends of the roadway resting on this transom fall into the water; the other two ends of the roadway still rest on the fixed transoms as shown.

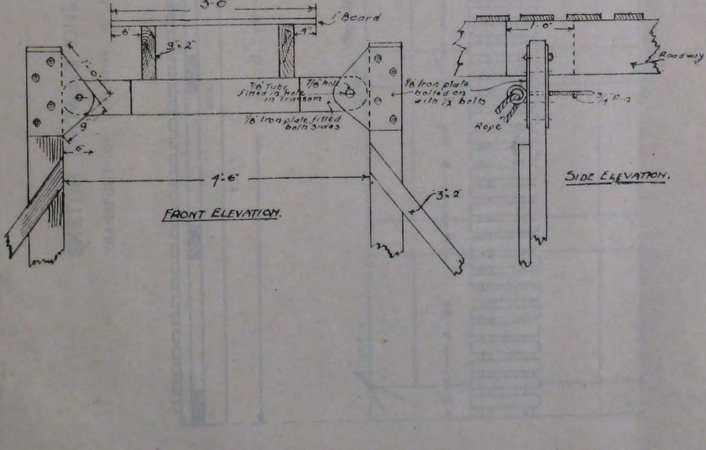


LONGITUDINAL ELEVATION — 1/8 inch Scale.

The gap made measures 30'; anyone putting his weight onto the collapsed roadway would be precipitated into the water.

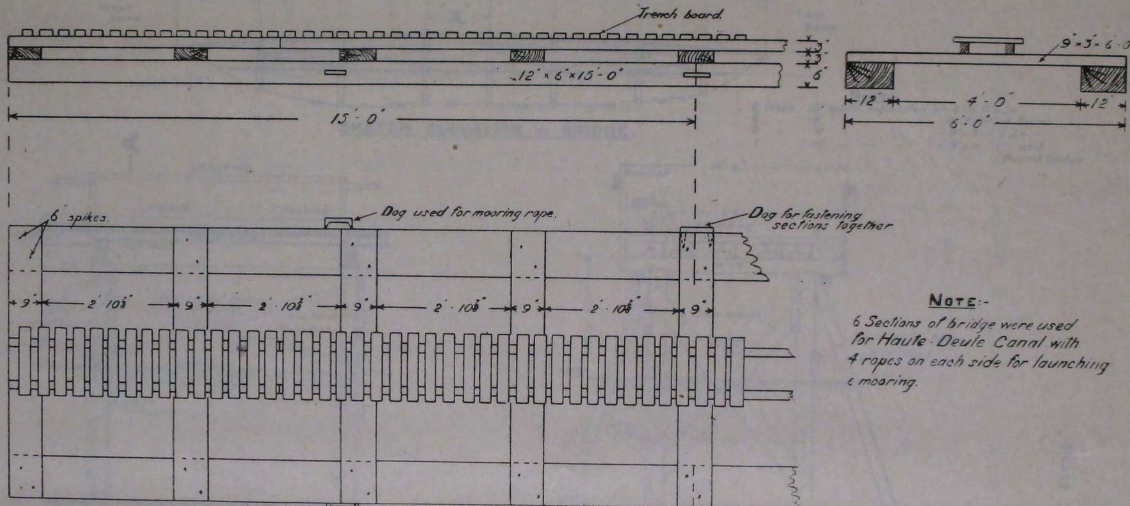
If completely displaced from the other transoms which is quite possible, the roadway would float.

The collapsed roadway is not fastened in any way to the fixed transoms, and would form a most insecure basis for any improvised bridge.



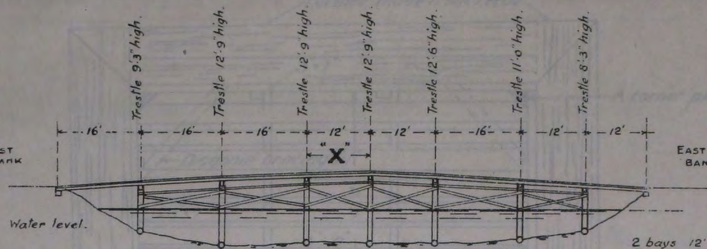
SKETCH SHOWING ONE SECTION OF FLOATING FOOT-BRIDGE. PLATE XXIII.

TRANSPORT OF INFANTRY IN SINGLE FILE OVER HAUTE-DEULE CANAL. OCT., 1918.



NOTE:-

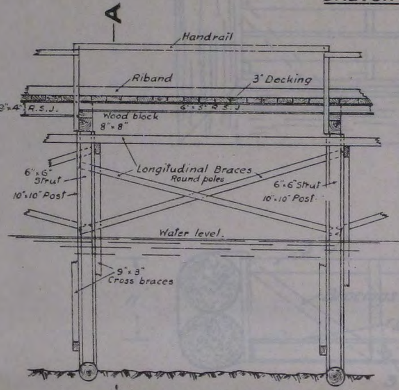
6 Sections of bridge were used for Haute-Deule Canal with 4 ropes on each side for launching & mooring.



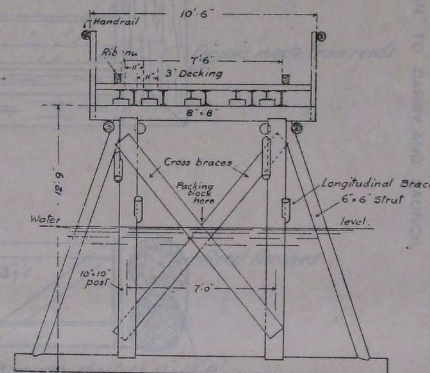
SKETCH ELEVATION OF BRIDGE.

NOTE:-

2 bays 12' span supported on 6" x 5" R.S.J.s.
2 " 12' " " " 8" x 8" Timber Beams.
3 " 16' " " " 9" x 4" R.S.J.s.
1 " 16' " " " 9" x 4" " and Round Timber



ELEVATION OF BAY "X".

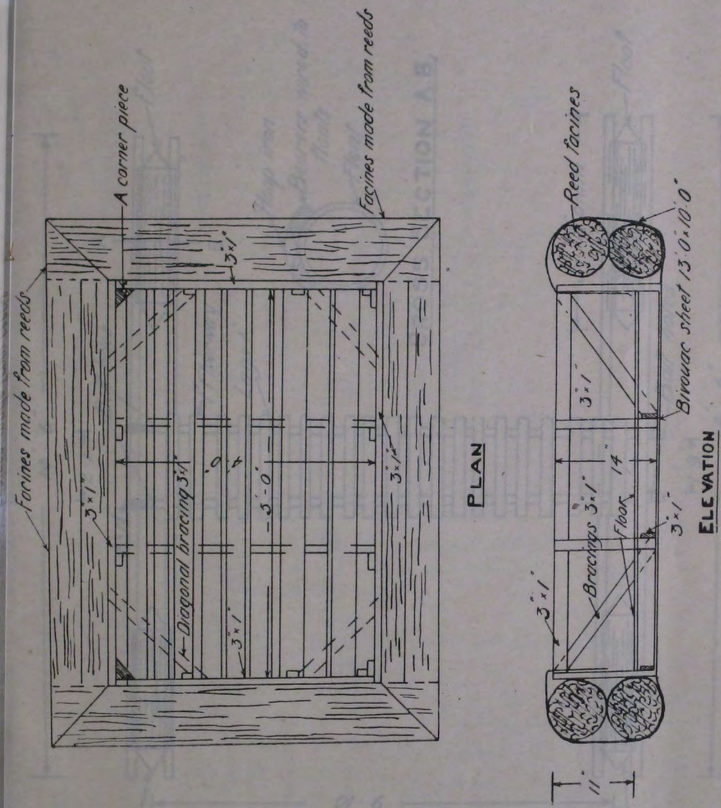


TRANSVERSE SECTION 'A-A'.

PLATE XXIV.

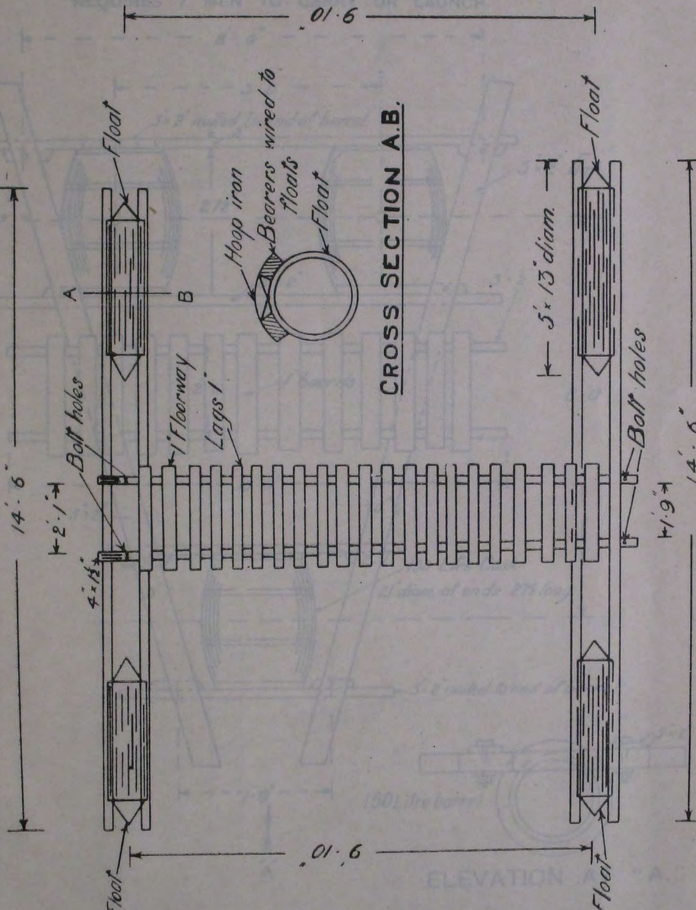
RAFT TO CARRY 4 MEN. PLATE XXV.

REQUIRES 4 MEN TO CARRY AND LAUNCH.



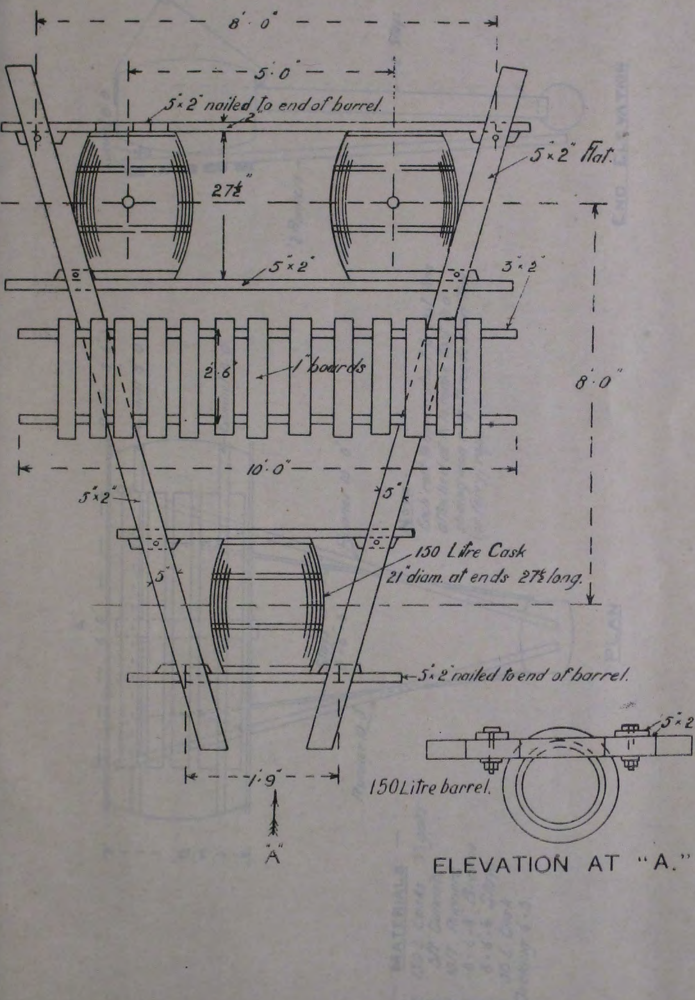
RAFT TO CARRY 3 MEN. PLATE XXVI.

REQUIRES 5 MEN TO CARRY OR LAUNCH.



RAFT TO CARRY 3 MEN. PLATE XXVII.

REQUIRES 7 MEN TO CARRY OR LAUNCH.



ELEVATION AT "A."

Plate XXVIII.

CATAMARAN FOR RIVER CROSSING AT ESPAIN.

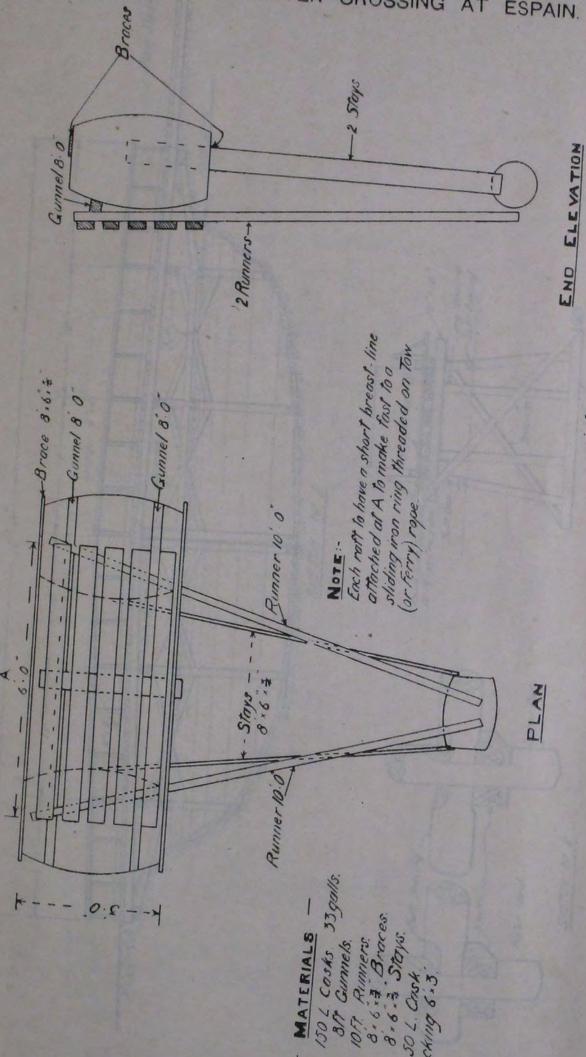


PLATE XXIX.

PLAN OF TIMBER TRESTLE BRIDGE AT PROUVY.

OCT. 28, 1918.

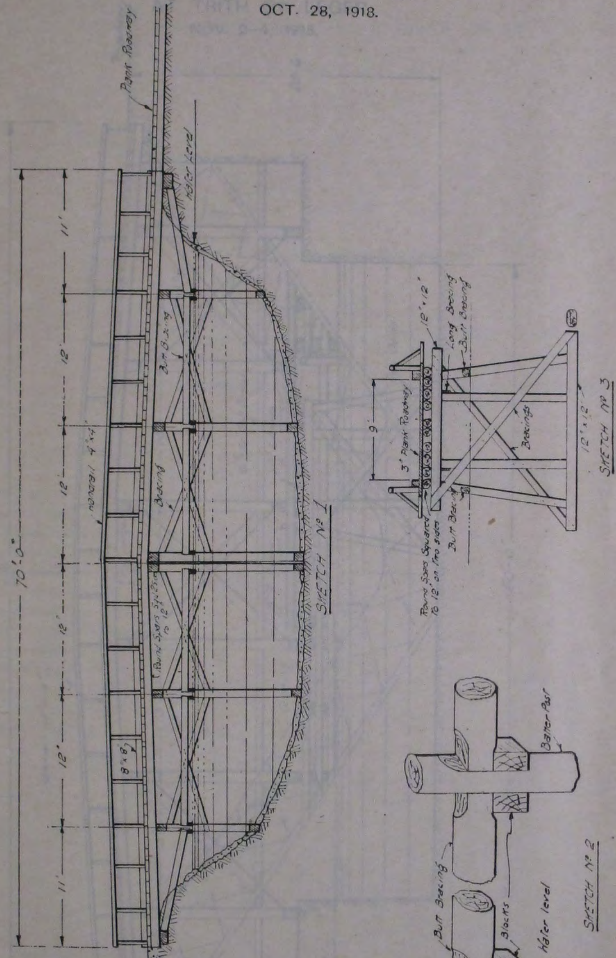
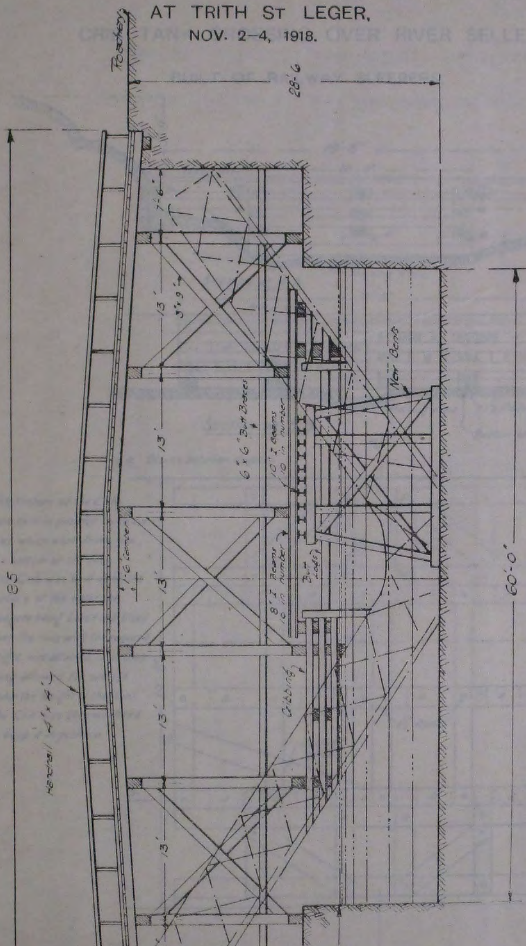


PLATE XXX.

PLAN OF TIMBER TRESTLE BRIDGE AT TRITH ST LEGER, NOV. 2–4, 1918.



CRIB TANK CROSSING OVER RIVER SELLE.

BUILT OF RAILWAY SLEEPERS.

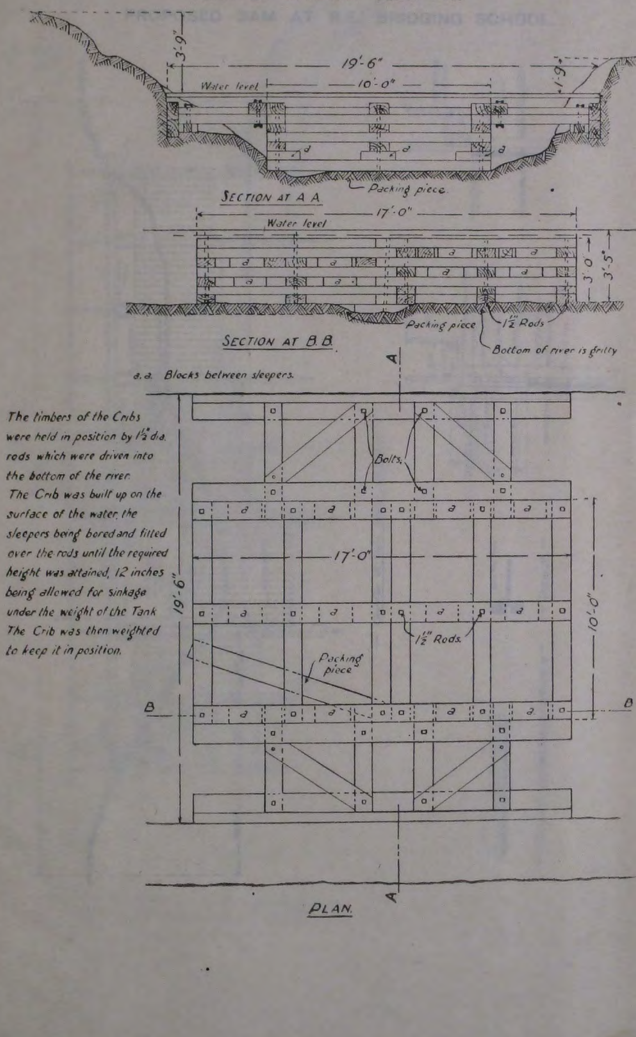


PLATE XXXII.

REPORT ON R.E. BRIDGING SCHOOL.

PROPOSED DAM AT R.E. BRIDGING SCHOOL.