Renewing Heavy Swing Span by Floating Into Place

Old North Western Bridge in Milwaukee Removed and New Span Weighing 800 Tons Placed in One Day

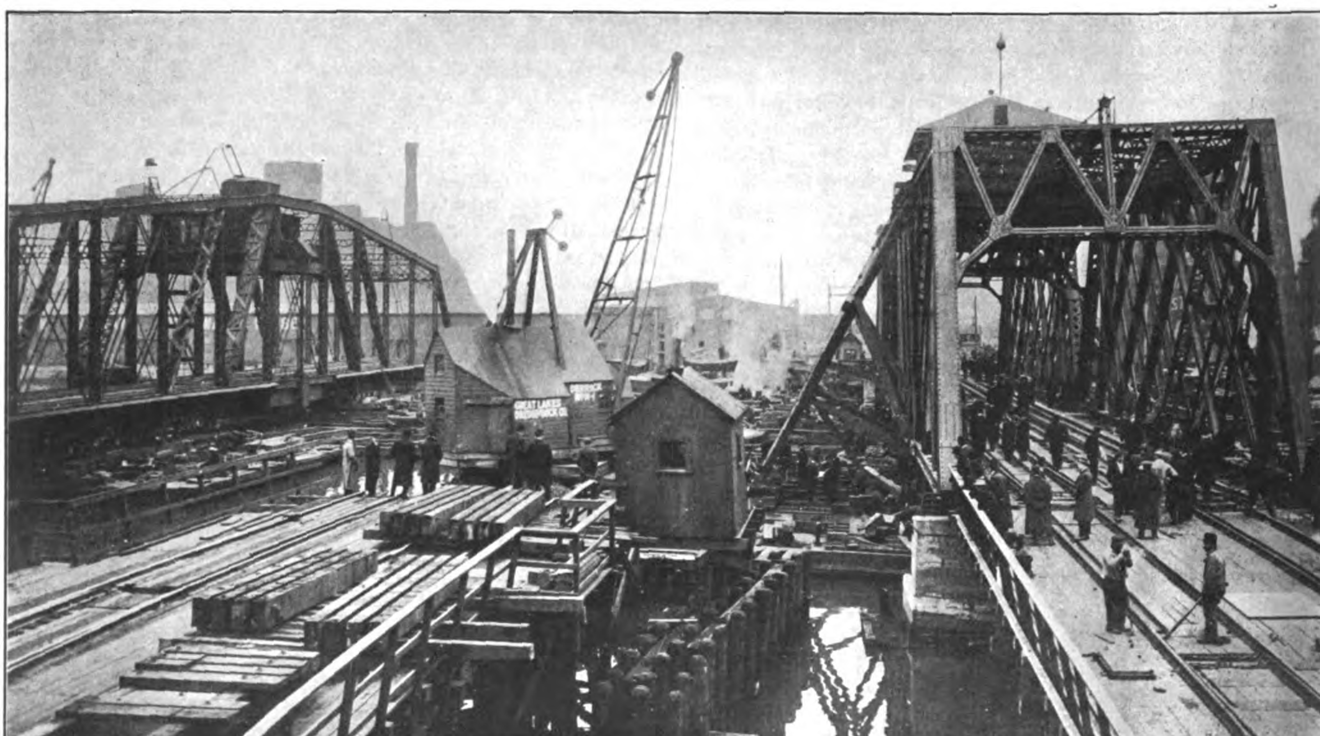
The placing in service of the new Chicago & North Western swing bridge over the Milwaukee river, in Milwaukee, Wis., on March 14, involved the simultaneous handling of two heavy spans on scows. The large amount of floating equipment necessary for such an undertaking and the care with which all details had to be worked out to safeguard the structures during the movement are noteworthy features.

This bridge is located about ¾ mile south of the Milwaukee passenger station on the main line to Chicago and about ¼ mile from the mouth of the river. It is a double-track structure, carrying all main line passenger trains and numerous freight and switching movements to and from the Milwaukee freight houses, the engine terminal just north of the river and the adjacent industries. Through freight trains use the belt line around the city.

The old bridge built in 1890 and operated by a gasolene engine was too light to carry the increasing wheel loads of modern equipment and the substructure also was in need of repair. Since another swing bridge could be built without the necessity for securing a new permit from the government, and the city and government officials were inclined to favor that type, it was decided to replace the old span by a new one of the same length, 240 ft., providing two clear channels of 90 ft. each.

It was essential on account of yard connections and the proximity of structures on the water front that the old alinement be retained on the new bridge, but in order to rebuild the center pier and the abutment it was necessary to remove the old bridge. It was, therefore, floated downstream about 60 ft. to a temporary location and traffic carried over it during the repair of the permanent substructure and the erection of the new bridge. The narrow right of way and the presence of elevators and docks close to the line limited the amount of this move so closely that the new bridge could not be erected in the open position on its permanent center pier. Falsework was therefore driven in line with the center protection pier upstream from the site to support the new bridge during erection.

The operation of placing this structure in position on the new substructure, without undue delay to traffic, required the movement of both bridges in one day. First the new span was blocked up on scows and floated out into the north channel, taken upstream to clear the falsework, then turned and brought down over the falsework to the permanent location. This movement could not be completed with the old span still in its temporary location on account of the difficulty that would then have been connected with the removal of the old bridge. So the new span was anchored about 100 ft. from the permanent location, while the old span was blocked up on scows and moved downstream a sufficient distance to clear the operations at the permanent location, after which the new bridge was brought down and centered on the permanent pier.



New Bridge in Final Location Before Scows Were Removed; Old Bridge Shown at Left Has Been Moved Downstream from Its Temporary Location

The moving of the old bridge to its temporary location on October 25, 1914, and of the new bridge to its permanent position, as mentioned above, were both carried out on Sunday, when river traffic could be stopped and the tracks cut between 10:15 a. m. and 4:00 p. m., during which time passenger trains were detoured around the belt line. In connection with the new work, a 56-lever General Railway Signal Company's all-electric interlocking plant was installed in a new tower, just north of the bridge, to govern movements across the river.

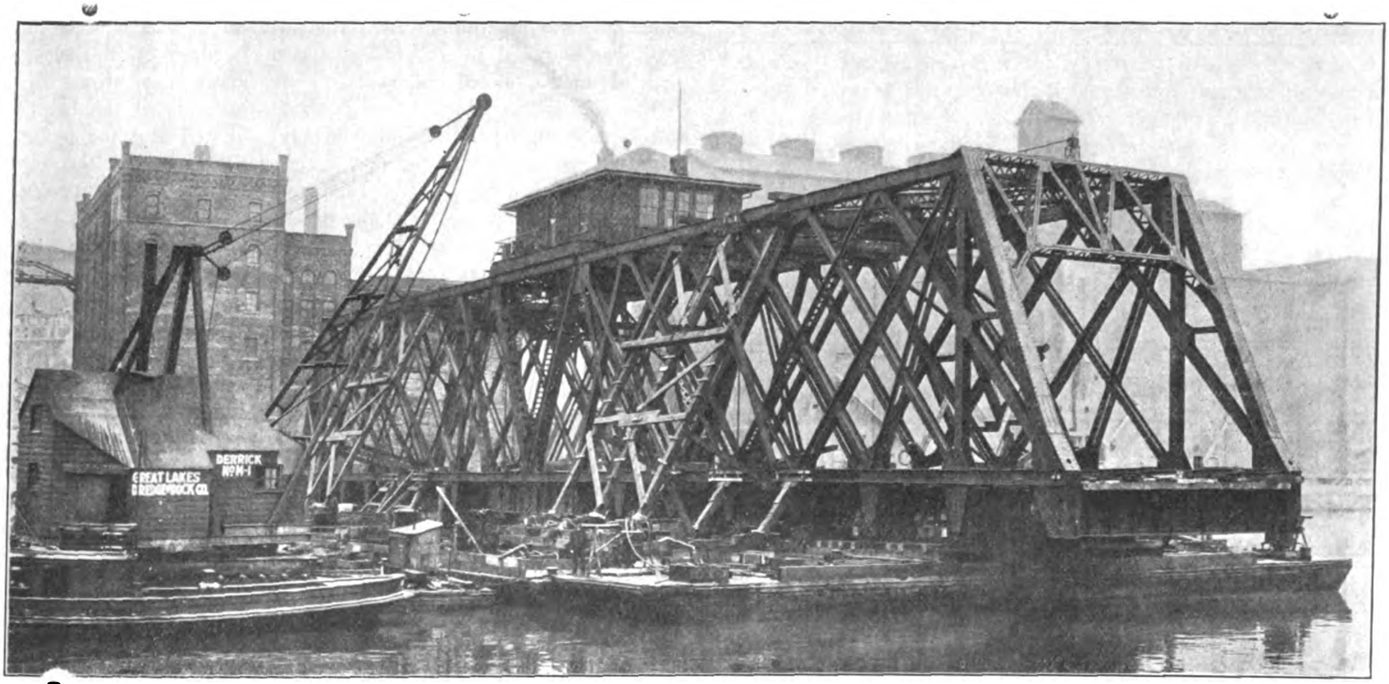
The first step in the renewal of the old bridge was the driving of piles for the temporary center piers, abutments and approaches on the downstream side of the bridge in its original location. At the same time, timber wedging and bracing was provided along the I-bar diagonal members in the two spans each side of the center in each truss, to allow them to take the compressive stresses, which would result in carrying the bridge on scows located in the two channels. The movement of this bridge was successfully made on a steel scow 100 ft. by 35 ft. by 8 ft., and a wooden scow 112 ft. by 33 ft. by 9 ft. The bridge weighed about 500 tons, making it necessary to place the blocking against the stringers in order to secure the 2 ft. greater height for distribution of the load on the scows and to reinforce the bottom chords of the trusses in the wooden scow.

The old substructure consisted of stone masonry on timber piles. In the reconstruction, new concrete bridge seats and backwalls were placed on the abutments and a new octagonal concrete top on the center pier, after removing the old masonry down to a level as near the water as possible. The new pier top has a diameter of 34 ft. and is reinforced by ¾-in. radial bars 6 ft. long and five ¾-in. bars 14 ft. long, placed parallel to four of the faces.

The new bridge is 237 ft. 6 in. long, center to center of bearings, 31 ft. wide between centers of trusses, and 32 ft. high between centers of chords. The trusses are of the quadruple intersection type, with a panel length of 14 ft. 9 in. The structure was designed for a live loading of Cooper's E-55, with the following impact allowances: With the bridge closed, $I = \frac{3}{4} L + \frac{L}{L + D}$ for the trusses and floor beams, and $I = L + \frac{L}{L + D}$ for the stringers; for the bridge swinging I = 0.25 D. The bridge is of the combination center and rim bearing type, the load being equally divided between the 2 ft. 6 in. phosphor bronze and steel center castings and the 64 rim bearing wheels. The estimated weight of the bridge, with the operating machinery, was about 800 tons.

The bridge will be operated normally by electricity. Two independent sets of machinery for turning have been installed, each driven by a 75-hp. motor, which can operate the bridge in the necessary time. In addition to this, an emergency plant is provided at the operating house, consisting of a 32-hp. Fairbanks-Morse gasolene engine, operating at 200 r. p. m., which can be connected to the operating shaft in case of failure of the electric power. This power is purchased from the local public service company and is brought to the operating house through a submarine cable and a drag cable on the center pier. A 15-hp. motor at each end of the bridge operates the end latch, end lift and rail lift at that end, both of these motors being operated through one controller in the machinery house on top of the bridge. Three sets of lights above the controllers indicate to the operator when the movements of the rail lift, the end latch and the end lift, respectively, have been completed. The machinery is interlocked from the signal tower and the separate circuits in the operating house are also interlocked.

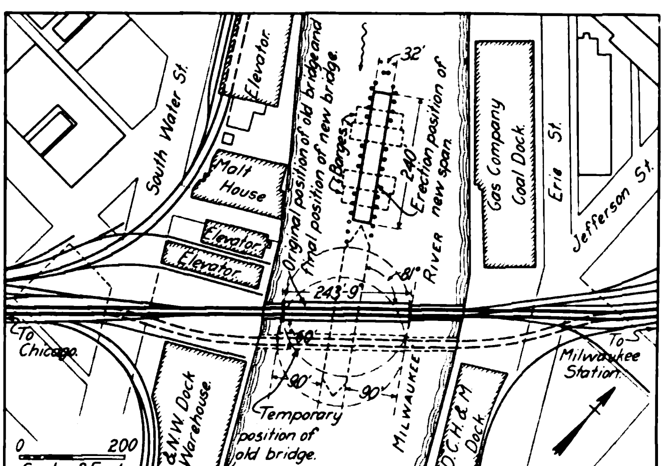
The erection car was placed on the new falsework from the end of the old span in the open position by blocking up that span and extending the rails on blocking, and all steel was delivered to the site on scows without interruption to river traffic. Two girder spans were provided in the falsework to allow the placing of the barges on which the bridge was to be moved into position. The operating rack, tread rim bearing wheels and spider and the lower two center bearing castings were located on the new pier. To assist in centering the bridge on the bearings a 10-in. steel band made in three pieces bolted together was placed around the center on the pier. Two short sections of the operating rack at diametrically opposed points on the circle were omitted before the new bridge was put in place in order to allow the pinions on the bridge to be lowered into position without damage to either the rack or the pinion. The bridge was later turned by tugs to mesh the rack and pinion, after which the short sections were put in place to complete the circle. In order to provide for any difference in the deflection at the ends of the bridge from that computed in advance, the end bearings were set one inch below the calculated elevation and two ½-in. and several thinner shims were provided to adjust this height properly.



Floating the Milwaukee River Bridge on Four Scows Showing Diagonal Bracing for Distributing Loads on Two Main Scows

All preparations for the placing of the new bridge had been completed before February 21, and an unsuccessful attempt was made to carry out the work that day. The weather conditions and the surge in the river caused by winds from the lake prevented the movement of the span on the two succeeding Sundays, but on the next Sunday, March 14, the conditions were favorable and the movements were made with complete success. To make sure that enough time would be available on Sunday for the movements of both bridges, the water-filled scows were placed under the new bridge and the blocking wedged up by the Saturday night preceding the day of the movement. These scows were watched during the night by crews and tugs to protect the outfit from damage by passing boats and also to be ready to remove the wedges immediately if any considerable change of river level occurred due to a shifting of the wind.

Four scows were used under this span instead of two, as originally planned, enough of the falsework being removed to provide clearance for the additional scows outside of the other two. The new bridge with all of the blocking on the scows made a total load of nearly 1,000 tons. The plan provided for carrying this load on a steel scow 35 ft. by 100 ft. by 8 ft., and a wooden scow 33 ft. by 110 ft. by 9 ft. These two scows had ample capacity to support this load but in order to distribute it more evenly over their length, and also to support the bridge more rigidly against tipping, diagonal bracing from the top and bottom chords to the scow decks was placed as shown in one of the illustrations. This bracing was designed to carry 60 per cent of the load of the bridge, the remaining 40 per cent being transmitted to the blocking from the floor beams directly over the scows. Two feet of combing was provided on the steel scow and one foot on the wooden scow as a precaution against filling with water on account of listing or washing. The two additional scows were used to give greater stability to the span during the movement and also to assist in supporting the load during the lowering of the bridge on its new center pier. When nearly submerged a steel scow



Location Plan of Milwaukee River Swing Bridge on the Chicago & North Western Showing Permanent and Temporary Locations and the Erection Position of the New Span

is not thoroughly reliable and for this reason it was considered advisable to have the additional scows in position to help support the load at this critical point. These two scows were 90 ft. by 24 ft. and 98 ft. by 24 ft., respectively. They were blocked up under the floor beams but carried no diagonal bracing.

As Saturday night passed without a change in weather conditions the pumping out of the scows to raise the bridge was started by 6:30 a. m., river traffic having been stopped at 6 a. m. Eight pumps were used in unwatering the scows, with leads of steam hose from tugs, etc. The new bridge had been erected 1.5 ft. above its permanent elevation and was lifted about 17 in. off the falsework by the scows. This lift was completed by 7:30, and during the following hour the bridge was shifted sideways into the north channel, taken upstream far enough to turn it across the channel and brought down over the falsework, the caps and blocking of which had been removed in the meantime to allow ample clearance for the operating pinions. These movements of the structure on the scows were accomplished by hand operated lines, the tugs and other floating equipment standing by in case of need. On the downstream movement the current was more than sufficient to move the scows, making it necessary to hold back continually on the lines. The floating outfit was tied up within 100 ft. of the permanent location of the bridge and men left to watch the scows while the movement of the old bridge was effected.

By 10:00 a. m. the old bridge had been wedged against the blocking on four water-filled scows, two in each draw. These scows were from 75 to 80 ft. long and 24 to 28 ft. wide, lashed together in pairs with continuous blocking over the two. The last train passed over the old bridge at 10:15, and immediately afterward the eight pumps were started pumping out the water. By 11:15 the old bridge, with the rack, tread, etc., had been lifted about 16 in. off its pier and removed downstream out of the way, where it was tied up during the remaining operations on the new span.

The final movement of the new span was begun about 11:25, the scows being kept parallel to the protection pier until the northeast corner of the span was about one foot from the west end of the north pier. It was then held stationary while the south end was swung downstream to bring the bridge parallel to its final position. Keeping this relative position, it was then floated over the center pier and held as nearly as possible in the true alinement. The centering ring on the center casting was adjusted so that its diameter was about 3 in. greater than the diameter of the casting on the bridge, and as soon as this casting had entered the ring three men were stationed at the joints to tighten up the bolts, thus accurately centering the bridge. This adjustment was made with the span about 6 in. above its final position. When the adjustment was correct the span was lowered to a bearing and the wedges on the scows were at once knocked out, releasing the scows soon after. Before 4 o'clock the track connections at the ends of the bridge had been completed, the end bearings adjusted and the power cable connected so that the first train was passed over the new bridge without delay. After this train had passed the bridge, the span was swung to mesh the pinions and the operating rack, the power was tested and the bridge operated at 5:20, allowing river traffic to be resumed according to schedule at 6:00 p. m.

During the centering of the new span the old bridge was floated downstream and was held on the scows for several days until a favorable opportunity offered for landing it endwise onto a dock. This landing was accomplished by sliding it on the floor beams on lines of rails placed on blocking at the proper height. The scows were removed one at a time and additional supports provided as necessary to carry the proportion of the weight of the bridge still over the water.

The design of the new bridge and the method of renewal were worked out under the direction of W. H. Finley, chief engineer, and W. C. Armstrong, formerly bridge engineer. H. M. Spahr was the resident engineer in charge of railway company's work in field. The substructure was built under contract by the Cleary-White Construction Company, Chicago, the superstructure was fabricated by the American Bridge Company and erected by the Bernhisel Construction Company, Chicago. The power equipment was installed by George P. Nichols & Brother, Chicago, and the Great Lakes Dredge & Dock Company handled the movements of the spans.

WAR TRAFFIC ON THE METROPOLITAN RAILWAY OF ENGLAND.—Since August the Metropolitan Railway, which connects with the Midland and Great Northern systems in the north of London and with the South-Eastern & Chatham, and London, Brighton & South Coast systems in the south, has been the means by reason of its lines under the "Circle," near Farringdon street, of conveying over these lines no fewer than 2,738 troop trains. During the despatch of the expeditionary force as many as 58 troop trains a day passed over the Metropolitan lines without any sensible interference with the ordinary passenger traffic. In addition to this burden during the first fortnight of February, 2,935 freight trains, equal to 210 a day, have passed over the Metropolitan lines, in addition to special trains with troops and government stores and the ordinary local passenger service throughout the day. This has been carried out without interference with normal traffic, except on one or two days of exceptional pressure, and without mishap of any kind.

BRIDGES

Design and Construction Work Preliminary to the Actual Shifting of a Double-Track Swing Bridge on the Chicago & Northwestern Ry., at Milwaukee, Wis.

(Staff Article.)

The shifting of a new swing span at Milwaukee, Wis., from the temporary falsework on which it was erected to a bearing on its substructure involved some interesting preliminary work and some difficult shifting operations. The bridge, which is on the line of the Chicago & Northwestern Ry., and spans a part of the channel of the Milwaukee River, is a double-track structure, with a length between end bearings of 237 ft. 6 ins. The new span was placed on the reconstructed pivot pier of an old draw bridge. To permit this reconstruction work, and to interfere as little as possible with traffic, the old span had previously been moved a short distance downstream and placed on a temporary substructure. In this position it formed part of a temporary double-track line which was continued in use until the new span was practically completed. The old span was moved on scows to its temporary location Oct. 25, 1914, and remained in this position until March 14, 1915, when it was moved to afford sufficient space for the shifting to place of the new span. The width of the river at the bridge site is about 350 ft., which required the construction of pile trestle approaches at each end of both the new and temporary structures. The old pin-connected bridge had a length of 237 ft. 6 ins. between end bearings, and weighed about 500 tons, while the new span, which is a riveted latticed structure, has the same length, but weighs about 740 tons. This article will deal mainly with the preliminary work done in connection with the erection of the new span on falsework, the reconstruction of the old substructure, and other work preliminary to the actual shifting operations, the latter being performed on March 14, 1915.

As will be noted by referring to Fig. 1, the new bridge was erected on falsework a short distance upstream from the position it was finally to occupy. Its longitudinal axis was in line with the protection work of the permanent and temporary pivot piers, while its distance from the new location of the old span was such that material entering into its construction could be unloaded from the old span directly onto the falsework of the new span. The new bridge, as erected on its falsework, was about 6 ins. higher than the temporary span.

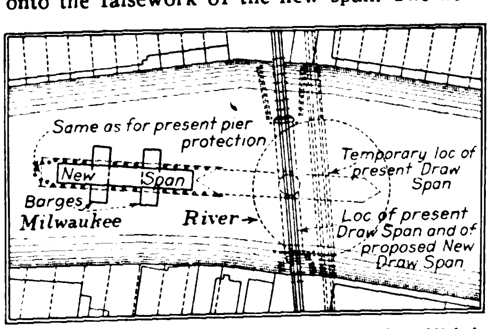


Fig. 1. Layout Showing Position in Which New Span Was Erected, Its Final Location, and Temporary Position of Old Span in Diversion Line—C. & N. W. Ry. Bridge, Milwaukee, Wis.

NEW SPAN AND REPAIR WORK REQUIRED.

The trusses of the new span are spaced 31 ft. on centers, and are 32 ft. high between centers of top and bottom chords. The distance from top of masonry to base of rail is 8 ft. 1 in. The bridge has a clear width of 29 ft. and a clear height of 22 ft. 6 ins.

During the time that the new span was being erected on its falsework, repairs were made on the old pivot pier and on the end supports for the span. The repairs for the pivot pier consisted of a reinforced concrete cap placed on the old masonry. This cap is octagonal in plan, with a short diameter of 34 ft. Figures 2 (a) and (b) show a plan and cross section of the top portion of the pivot pier. These drawings show clearly the details of the new concrete cap. The quantity of concrete (1:2:4 mix) required for the repair of the pivot pier was 88 cu. yds.

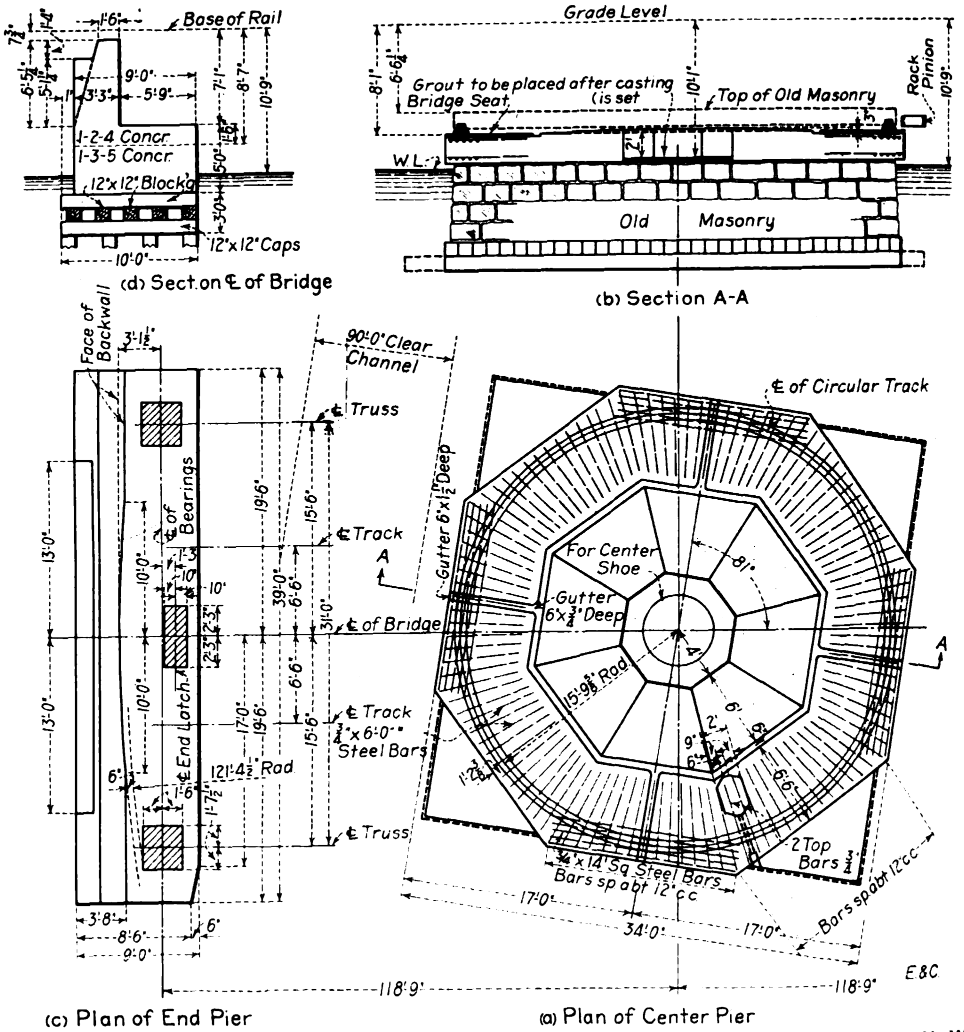


Fig. 2. Plans and Elevations of End Piers and Top Portion of Pivot Pier of C. & N. W. Ry. Bridge, Milwaukee, Wis.

Figures 2 (c) and (d) show a plan and a cross section of the new end piers of the swing span. The distance from the end bearings of these piers to the center of the pivot pier is 118 ft. 9 ins. To construct these two piers required 100 cu. yds. of 1:2:4 concrete and 91 cu. yds. of 1:3:5 concrete.

Figure 3 (a) shows a cross section of the center bearing for the new span. In this drawing the top portion is shown raised above the phosphor bronze disk, to indicate the division line between the portion which was erected with the draw span and the portion erected on the substructure. It will be noted that the top concave bearing was erected with the superstructure. This procedure made it necessary to drill holes through this concave bearing and bolt it to the top portion, the heads of the bolts (not shown in the drawing) being countersunk at the lower plane of the concave bearing. It will be noted that the top concave bearing was beveled, at "B" around the circumference, to make it enter its socket more easily.

The centering band shown in Fig. 3 (a) and (b) was used as a guide during the placing of the superstructure on its bearing. This band was built in three sections. When the bolts connecting these sections were loosened, the inside radius of the band was about 1 ft. 10 ins. The band was placed on the center bearing, as shown in Fig. 3 (a), with the bolts loosened. After the superstructure was floated approximately to its final position, and the top bearing was made to enter this band, it was accurately centered by tightening the three bolts of the band, the radius thus being reduced to 1 ft. 7 13/16 ins.

Fig. 3 (c) is a cross section of the rack circle and bearing at the turntable circumference. The portion above the line B-B was erected with the superstructure. The rack circle was made in section, and during the shifting operations two sections were removed opposite the rack pinions, to avoid interference between pinions and rack while lowering the bridge.

The new span is electrically operated, the operating mechanism being furnished in duplicate, to provide against accidents. A 32-hp. gasoline engine is also installed for emergency use. As a further precaution hand-power machinery is also installed. The specifications for the machinery require that the bridge be turned through an angle of 90° in 50 seconds, against an unbalance wind pressure of 1 lb. per square foot, this movement to consist of: acceleration through 22.5°, 17.25 seconds; constant velocity through 49.5°, 19 seconds; and retardation through 18°, 13.75 seconds. Against the same unbalanced wind pressure it was required that the hand-power equipment be capable of turning the bridge through an angle of 90° in 11 minutes by 8 men (4 at each capstan) walking at the rate of 3 ft. per second and exerting a force of 50 lbs. each.

WEIGHT OF STRUCTURE MOVED.

The following are the itemized weights of the structure moved, the weights of machinery and structural steel being taken from the shipping statement:

	Lbs.
Gasoline engine and 4 motors and machinery	18,000
Trusses, laterals and portals	634,000
Floor system except center panels	296,000
Loading girder system	168,000
End lifting and turning machinery and machinery supports	136,000
Stairs, etc., and floor system for engine house	73,000
Engine house, wooden framework	26,000
Ties and rails in place	130,000
Total	1,481,000
Approximate weight of blocking	210,000
Total weight on scows	1,691,000

ERECTION FALSEWORK.

As has been noted the new span was erected on falsework a short distance upstream (see Fig. 1). On account of the size and weight of this double-track swing bridge, an extensive system of falsework was required, special construction being necessary to permit the placing of the scows used in shifting the span. This falsework was designed to give support to the trusses at each panel point, which necessitated the use of 18 timber bents, in addition to the special construction over the scows. To span the scows the following old girders were used, these girders being material from old bridges taken from various points along the line of the C. & N. W. Ry.: One 54-ft. girder; one 53-ft. girder; two 51-ft. 10-in. girders, and four 39-ft. 1¾-in. girders. The weight of these girders was about 183,700 lbs.

Figures 4 (a) and (b) show a general plan of the falsework and a section of it along the center line. Figures 4 (c) and (d) are half elevation of bents Nos. 4, 5, 6 and 7 and bents Nos. 13 and 14, respectively. Figures 4 (e) and (f), are half elevations of bents Nos. 1, 2 and 3, and bents Nos. 8 to 12 and 15 to 18, respectively. These drawings give the essential details of the system of falsework used. To afford protection to the falsework, pile clusters were placed around it, as shown in Fig. 4 (a), these clusters being extended to the protection work of the pivot pier. With the exception of two clusters, near the upstream end of the bridge, these clusters contained seven piles each, wrapped with chains; the two end clusters contained 19 piles each.

To provide for the camber of the lower chord it was necessary to use great care in bringing each panel point to its relative position; this was done by means of oak wedges placed near the ends of the floorbeams, as shown in Fig. 4.

BLOCKING AND BRACING USED TO SUPPORT SPAN ON SCOWS.

It was originally planned to use only two scows in floating and shifting the spans (see Fig. 4, b). To give greater stability, and to provide against unforeseen conditions, two small auxiliary scows were used, these scows being placed near the ends of the span. They did not enter into any of the calculations, however, as the two large scows, a 35x100x8-ft. steel scow and a 33x110x8-ft. wooden scow, were of sufficient capacity to float the span and raise it to the required height.

After the span was erected and the substructure made ready to receive it, the scows

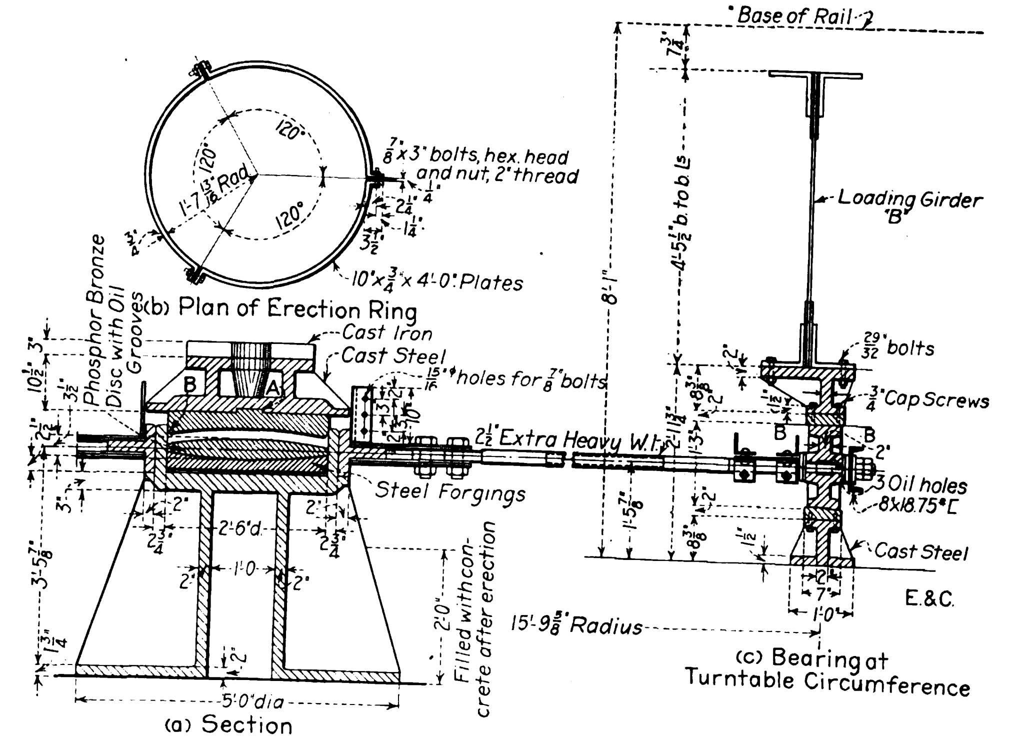


Fig. 3. Cross Sections of Center Bearing and Turntable Circle and Bearing of C. & N. W. Ry. Bridge—Note Erection Ring Used in Setting Span on Center Bearing.

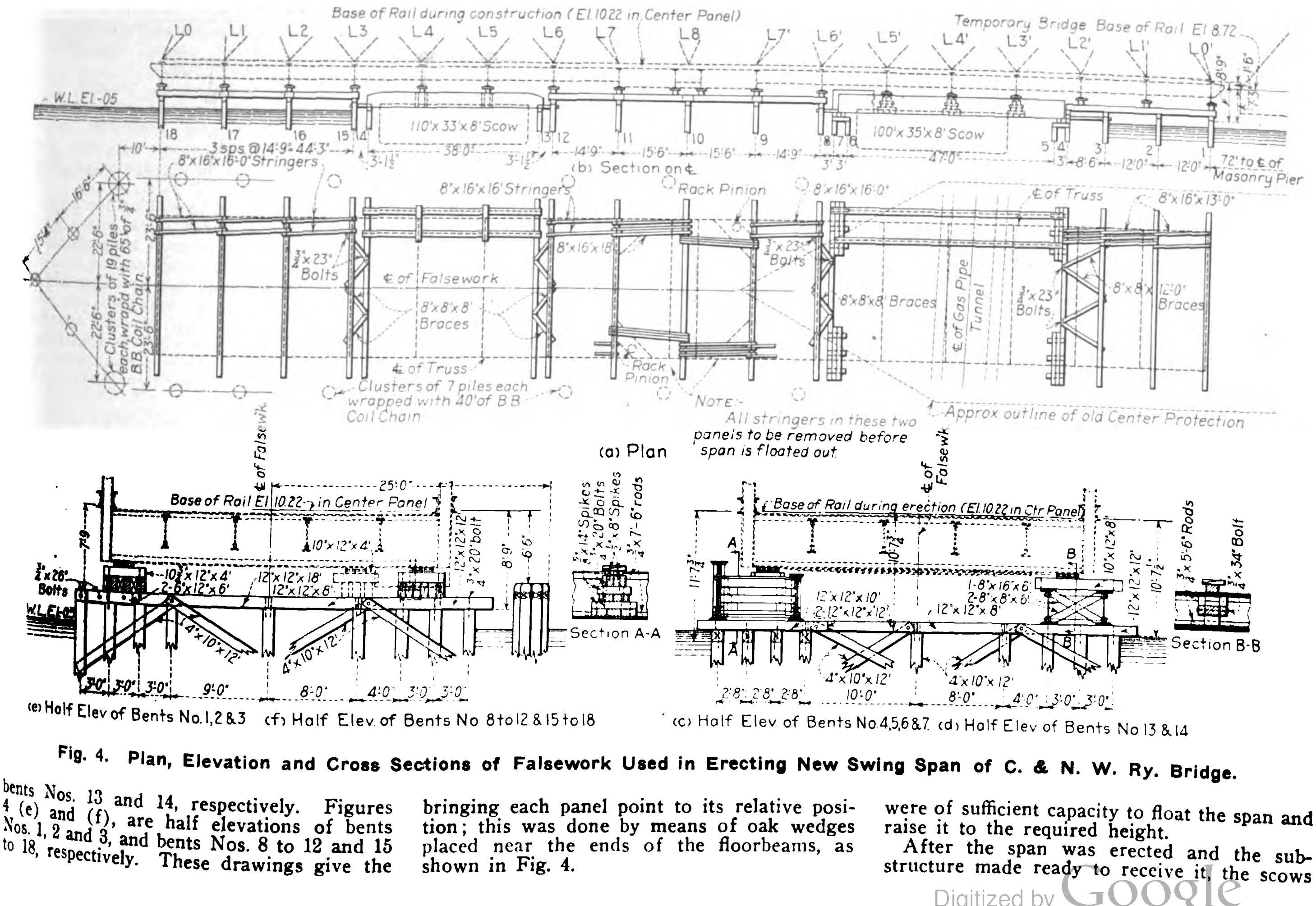


Fig. 4. Plan, Elevation and Cross Sections of Falsework Used in Erecting New Swing Span of C. & N. W. Ry. Bridge.

were placed in position, and the span was blocked up on the scows and braced as shown in Fig. 5. The span was brought to a bearing by means of the oak wedges shown in the drawings. The struts shown in Fig. 5 were so placed as to distribute a part of the weight of the swing span to the ends of the scows, and thus give a more even distribution of the loading.

Figure 6 gives computed data in connection with the floating in of the scows, the loading of them, and the landing of the span on its substructure. Figure 6 (a), (b) and (c) apply to the 35x100x8-ft. steel scow, and Figs. (d), (e) and (f) to the 33x110x8-ft. wooden scow. It was specified that, if the elevation

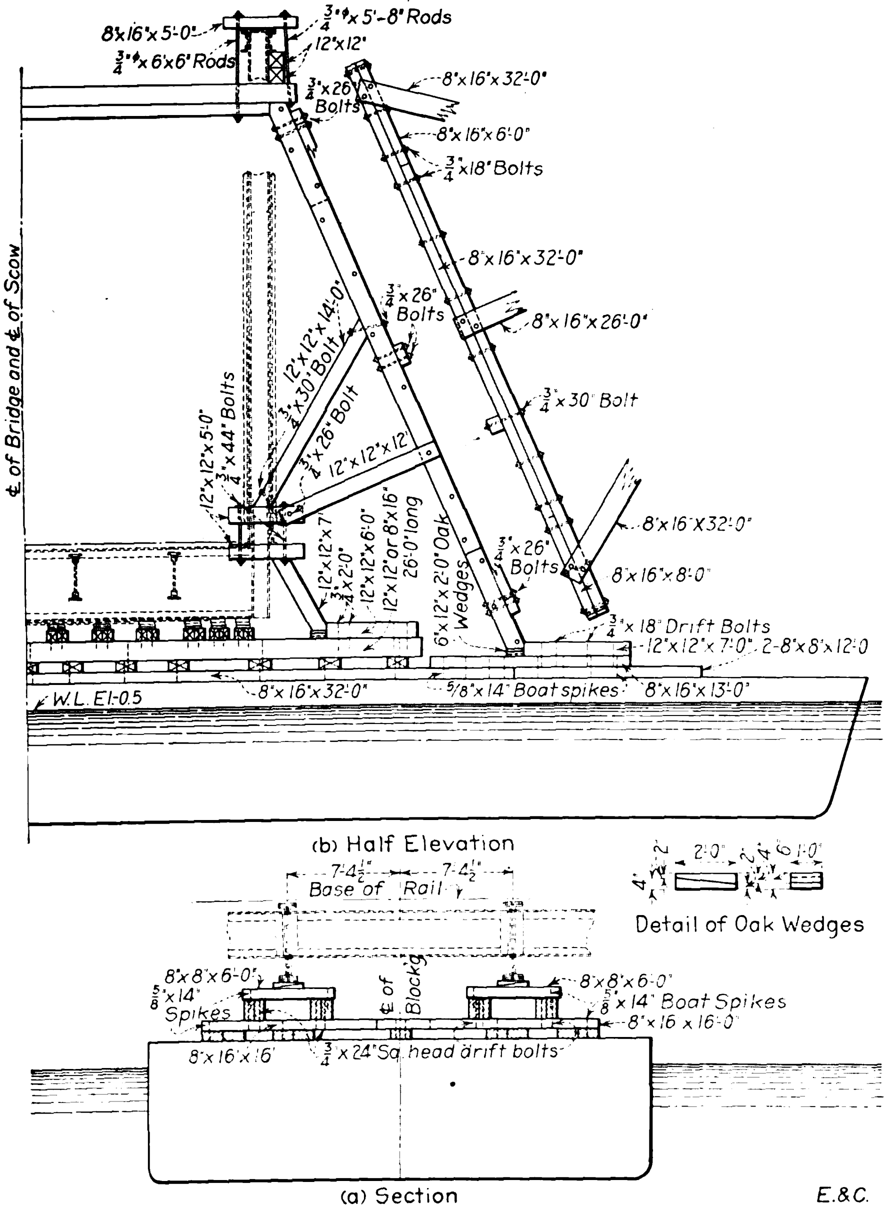


Fig. 5. Elevation and Cross Section, Showing Blocking Used to Support New Swing Span on Scows, and Struts Used to Distribute Loading Over Scows—C. & N. W. Ry. Bridge.

of the water was greater or less than that shown on the drawings, the difference was to be subtracted from or added to the height of the blocking. It was further specified that the draft of the scows should be measured after the blocking, pumps, etc., were placed; and that, if this draft plus the calculated draft from the bridge plus 6 ins. of water in the scows exceeded 6 ft. (see Figs. 6, b and c), the height of the blocking should be increased by this excess and the freeboard correspondingly reduced.

SHIFTING PROCEDURE AS OUTLINED BY C. & N. W. RY.

The following data give each step of the work, connected with the shifting of the swing span, as outlined by the Engineering Department of the Chicago & Northwestern Ry.:

First Period—7:00 *to* 10:15 *a. m., Mch.* 14. 1915.—River traffic will be closed at 7:00 a. m.

Work of the Great Lakes Dredge & Dock Co.:

(a) On new span:

(1) Drive the wedges under the new span, bringing it to bearing on the scows. The scows will have been previously floated into position with all the blocking adjusted to give a free board, when wedges are driven of 10 ins. on the steel scow, and 1 ft. 10 ins. on the wood scow. (Note.—This free board is to top of deck, and does not include the combing.)

(2) Pump out the scows, raising the span 1 ft. (not less) above the elevation at which it was erected.

(3) Remove all the stringers in the falsework span under the west half of the loading girders, to make the way clear for the west pinion in floating out the bridge.

(4) Float the span into the channel north of the falsework, and upstream far enough to turn the span square across the channel beyond the end of the falsework. Make the turn in such a way that the stairway on the span will be on the downstream side when the span is turned.

(5) Remove all the timber in the falsework down to the level of the tops of the caps.

(6) Float the span toward the piers, straddling the falsework piling. Stop about 100 ft. from the new pier, and hold stationary until the old span has been floated out of the way.

(b) On old span:

(1) Float the four scows into position under the old span. (The blocking on these four scows will have been previously adjusted to give the free board indicated on the blocking plans, when scows are in position under the bridge.) Hold the scows in true position with lines and timbers, so that they will be ready for driving the wedges under the span when signal is given.

Work of the Railway Company:

On old span:

Connect up all the parts used in carrying the center castings, wheels, rack and treads. (Span must not be swung after these parts are connected up.)

Second Period—10:15 *a. m. to* 4:00 *p. m.*—Traffic over bridge will be closed at 10:15 a. m. after train No. 119, north bound, has passed:

Work of Great Lakes Dredge & Dock Co.:

(a) On old span:

(1) Drive the wedges under the old span, bringing it to bearing on the scows.

(2) Pump out the scows until the span is raised not less than 1 ft. 0 in. above the present elevation. (The two scows nearest the center of span should be pumped as nearly dry as practicable. The other two scows should be pumped out until the bridge is raised the required amount.)

(3) Float the old span down stream to the place designated by the Railway Company for landing the span, and anchor the scows securely.

(b) On new span:

(1) Float the new span toward the piers, keeping the scows parallel to the protection pier, until the northeast corner of the span is about 1 ft. from the west end of the north pier. Then hold the north end stationary and swing the south end down stream until the bridge is parallel to its final position.

(2) Float the span to position over the piers, keeping it always parallel to its final position, guiding it by the ends, and controlling the scows by ropes running to the drums of hoisting engines on scows or floating pile drivers anchored above and below the bridge, in each channel.

(3) When span has been brought to true alignment, and centered over the center pier, hold it against horizontal displacement by stop timbers at both ends, and by ropes holding it firmly against wedges at the south pier.

(4) Lower the span by sinking the scows until the span is about 6 ins. above its final position. The span must be perfectly level when the lowering is stopped at this stage.

With the span at this elevation, the Railway Company's crew will place the centering ring on the center casting and center the span accurately over the turntable.

(5) Lower the span to permanent position on the turntable, keeping it perfectly level at all stages.

Work of the Railway Company:

(a) On new span:

(1) After the span is lowered to its bearings, and before any more water is pumped into the scows, fit the end rails into place and make all the necessary adjustments at end bearings, so that bridge will be ready for trains.

(After all the necessary adjustments have been made, and before any train is allowed to pass, the Great Lakes Dredge & Dock Co. will lower the scows until the wedges can be released and the scows swung free below the bridge.)

(2) Release the bridge for turning, and turn it (moving north and toward the west) with ropes at each end, until the rack pinions have cleared the open spaces in the rack circle where rack sections have been omitted. (During this movement one man must be stationed at each pinion to give the pinion the proper angular position for meshing with the rack, and prevent it from

locking against the first rack tooth encountered.)

Replace the two sections of the rack, and the two sections of the spacing ring. Use bolts for splices in the spacing ring.

Close the bridge and make it ready for trains. (Note: The above operation will require about one-half hour. It may be deferred to the third period if there is not sufficient time for it in the second period.)

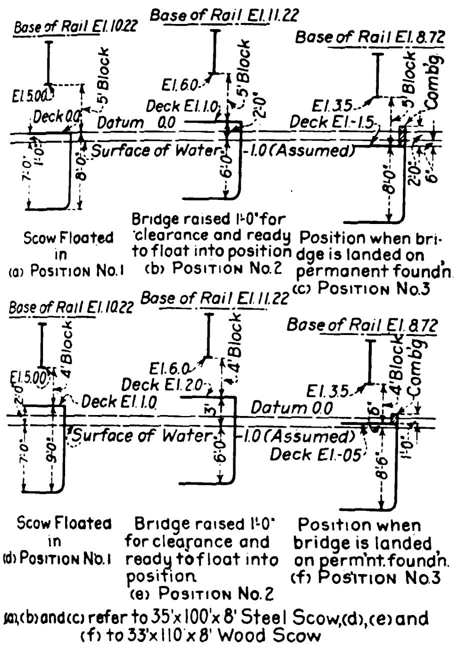


Fig. 6. Computed Elevations of Base of Rail of New Swing Span and Draft of Scows During Various Floating, Shifting and Setting Operations—C. & N. W. Ry. Bridge, Milwaukee, Wis.

(3) Make all the connections in the power-transmission system, completing the circuit up to the switchboard in the operator's house.

(4) Remove the top course of timber on the temporary center pier, and all drift bolts or other obstructions above the level of the second course of timbers. Also remove all the timbers of the old center pier protection that project above this level, over all that portion within 120 ft. of the center of the new bridge.

(5) Remove from the north temporary pier the end bearings of the old span, the pony bent, and the first course of timbers forming the bridge seat. Also remove the west railing, the deck, and the stringers under the west track on the first span back of the north temporary pier.

Third Period—4:00 p. m. to 6:00 p. m.:

Work of the Great Lakes Dredge & Dock Co.:

(1) Remove the scows from across the channel, out of the way of the river traffic.

Work of the Railway Company:

(1) Make all connections of the power-transmission system and other parts of the electrical installation that may not have been completed in "Second Period."

. Test the operation of the bridge with electric power by turning 90° in each direction from closed position.

Have bridge ready for operation so that traffic on river can be resumed at 6:00 P. M.

General:

In order that there may be no misconception of authority and responsibility, and no conflict of orders, it must be understood that all work of lifting and moving the bridges on the scows, and of lowering the new span into place, will be done under the direction of the Great Lakes Dredge & Dock Co., whose superintendent and foremen will give all orders and signals for the movements of the spans while on the scows.

(The actual shifting operations are covered in the following article.)

PERSONNEL.

The work described in this article was in charge of the Engineering Department of the Chicago & Northwestern Ry.: W. H. Finley, chief engineer; W. C. Armstrong, engineer of bridges, and H. M. Spahr, resident engineer, in charge of field work. The Cleary-White Construction Co. built the new end piers and reconstructed the pivot pier; the American Bridge Co. fabricated the steelwork; the Bernhisel Construction Co. erected it; and Geo. P. Nichols & Brother installed the power equipment. The actual shifting operations were in charge of the Great Lakes Dredge & Dock Co.

Actual Operations in Connection With the Shifting of Double-Track Swing Spans on the Chicago & Northwestern Ry. at Milwaukee, Wis.

(Staff Article.)

In the preceding article data are given on the design of the substructure, falsework and bracing for the new swing span of the Chicago & Northwestern Ry., at Milwaukee, Wis., together with a description of the construction features preliminary to the actual shifting of the new span and the removal of the old one from its temporary position, the article being based on data furnished by the engineers of the railway company. This article treats mainly of the work done in connection with the actual loading, shifting and setting of the new span, the data being furnished by the Great Lakes Dredge & Dock Co. The work here described was done on Sunday, March 14, 1915. A study of the drawings and data given in the preceding article will make clear the following operations.

FLOATING, SHIFTING AND SETTING OPERATIONS.

As Saturday preceding the shifting of the span was a day of favorable weather, with little surge in the river at the bridge site, the new bridge was wedged up against the blocking on the water-filled scows. It remained in this position until Sunday morning, being watched all night by crews and warning tugs to protect it from damage from passing boats, and to enable the wedges to be knocked out should any considerable change in the river level occur, due to shifting winds. As conditions were favorable during the night, and as the fair weather prevailing early Sunday morning gave promise of continuing throughout the day, the pumping out of the scows with

Fig. 1. View Showing New Double-Track Swing Span on Scows—Note Struts Used to Distribute Loading—C. & N. W. Ry. Bridge, Milwaukee, Wis.

eight pumps, using leads of steam hose from tugs, was started at daybreak; and at 7:30 a. m. the bridge had been lifted about 17 ins. off of its falsework. At 8:30 it had been shifted sideways out of the falsework, towed upstream far enough to turn around in the river, and brought down across the falsework, the upper timbers of which had been removed in the meantime to give clearance to the large operating pinions projecting below the bridge. The floating span was tied up within 100 ft. of its permanent location, with men on it to give attention to the scows, and work was then directed toward floating the old span from its temporary location, by placing under it four water-filled scows, two on each side of its transverse axis. Figure 1 is a view of the new span, the view being taken at 9:00 a. m. This view shows the type of superstructure used, and gives the position of the struts used to assist in distributing the weight of the span more evenly over the scows. It will be noted that no struts are provided for the end scows (one of which is shown), as the two center scows are intended to carry the greater part of the load.

At 10:00 a. m. the old bridge was wedged against the blocking on the scows, and at 10:15, after the last train had passed over this structure, the eight pumps on this set of scows were started. At 11:15 a. m. the old bridge had been lifted about 16 ins. off of its pier. It was then moved downstream a sufficient distance to permit the new span to be set over the permanent pier.

The new span was then moved toward its final location. At 11:40 it had reached the upstream ends of the end piers, and was being shifted to place over the pivot pier. At 12:00 noon the span was in line with its approaches, and the work of lowering it was started, by pumping water into the supporting scows. At 12:45 the adjustment of the center bearing was pronounced correct; the wedges were at once knocked out, and the scows released soon afterward. This placed the new bridge in position for railroad traffic by about 2 p. m. Further work was required, however, to complete the adjustments necessary to permit the bridge to be swung for navigation purposes, as a section of the turntable rack had been taken from each side of the bridge, to give clearance to the two large rack pinions. These pinions were quickly meshed by partially swinging the span by tugs, after which the missing sections were placed and the operating machinery tested for both kinds of power. The first train to pass over the new bridge was the regular 4:00 train.

Figure 2 is a view of the bridge in its final location, the view being taken at 1:30 p. m. The view also shows the old span and a part of the temporary diversion track.

The old bridge was towed to a slip, about a mile from the bridge site, where it was landed and dismantled.

COMMENTS ON PROCEDURE AND EQUIPMENT USED.

The work was complicated, and the equipment required was extensive, as it was necessary to float both the new and old spans at the same time. This was due to the fact that the new span could not be swung for navigation until the old span was removed from its position in the temporary line. Considering the weight of the structures moved, and the difficulties encountered, the time required to complete this double operation is noteworthy. The last train passed over the old bridge on the temporary line at 10:15 a. m., and the first one over the new span passed at 4:00, an interval of 5¾ hours.

Although it was planned to float the new span on two scows, and the falsework was designed to provide for only two scows, four were actually used, which made it necessary to tear out some of the falsework before the auxiliary scows could be floated into position. Four scows were also used under the old span. Each scow for both spans was fitted with two comparatively large wrecking pumps, making sixteen such pumps in use, in addition to twelve large syphons, which were used to blow out the water near the bottom of the scows where the pumps could no longer operate efficiently. Four steam tugs were used to furnish steam with which to operate the pumps and to assist in moving the spans. Two pile drivers, two floating derricks, and an air compressor plant were also employed, to furnish power and steam at various stages of the operations and to stand by, to provide against emergencies.

The use of the auxiliary scows, which actually carried only about 100 tons of load each, was due mainly to the fact that the range in the elevation of the bridge during the various operations was about 18 ins. greater than that originally considered. The critical feature therefore was, not the lifting capacity of the scows, but their ability, when at the permanent center pier, to be sunk this additional 18 ins. and still possess sufficient buoyancy to maintain the entire bridge load absolutely level while the structure was being accurately located upon, and lowered to, its center bearing. Moreover, one of the two large scows, which were originally intended to carry the entire load of the new span, was of steel construction, and as it is very difficult to control such a craft when well filled with water there would be danger of serious accident should this scow list quickly or sink entirely. This danger was augmented by the fact that the bridge site is near the mouth of the river, where storms on the lake create a heavy surge in the river. Even though wooden combings were constructed above the decks of the scows it was thought expedient to use the auxiliary scows, mainly to give stability to the bridge, which projected about 45 ft. above the water surface.

The system of struts used to distribute the load over the two main scows is worthy of comment. The use of these struts was considered advisable as the lengths of these scows (100 and 110 ft.), and the relative narrow width of the bridge (which was placed crosswise at the center of them), would cause large stresses for which the scows were not designed. As the usual loadings of such scows —sand, gravel or stone—give a fairly uniform loading the struts were intended to approximate such a loading. By means of the long struts from the top chords, and the inclined posts and A-frames from the bottom chords, it was estimated that about 60 per cent of the total load would be carried away from the center of the scows and counter-moments would be avoided near the ends. The use of steel girders and I-beams to distribute the loading was considered, but their use was thought to be impracticable, due mainly to excessive deflections.

The use of the long struts necessitated a very careful adjustment of the wedges at their lower ends, in order to distribute a proper proportion of the loading to the ends of the scows as the pumping operations progressed. In the case of the wooden scow, the deflection of the scow trusses was compensated by the compression of the 40-ft. struts. There was little deflection in the steel scow, however, due to its stiffness, and the proper proportion of the loading could be brought to the ends of the struts only by wedging the struts tightly before the pumping was started and by "slacking off" the jacks under the bridge at the center of the scows as the load came on.

The care with which the preliminary work and calculations were conducted is evidenced by the fact that all conditions of buoyancy, displacement, deflection, etc., as computed, were very closely approximated during actual operations.

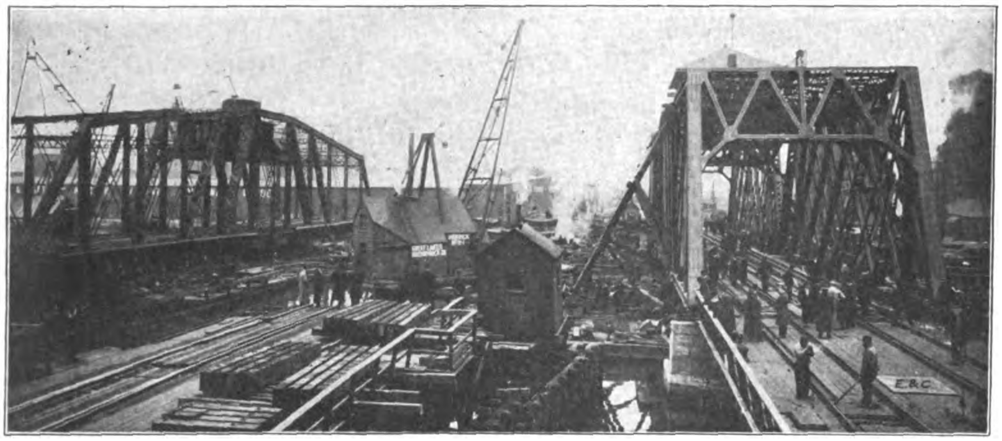


Fig. 2. View Showing New Swing Span in Final Position on Reconstructed Piers—View Also Shows Old Span and Part of Temporary Diversion Track—C. & N. W. Bridge, Milwaukee, Wis.

PERSONNEL.

All work in connection with the shifting of the spans for the bridge was in charge of the Great Lakes Dredge & Dock Co., of Chicago.

Novel Method Used in Supporting a Pratt-Truss Span During the Reconstruction of Its Abutments.

(Staff Article.)

To insure maintenance of traffic during the reconstruction of the abutments of a bridge on the Rochester & Eastern R. R.. an interesting and unusual construction procedure was adopted. The bridge, which carries the traffic of this interurban freight and trolley line, spans the State barge canal at Bushnells Basin, near Rochester, N. Y. It is a through pin-connected Pratt-truss bridge of 150 ft. span, the original foundations of which were very shallow, being only about 3 ft. below the surface of the ground.

As the contemplated barge canal improvements involved the widening and deepening of the canal prism, it was decided that new abutments would be required by such improvements. The subsoil at the site is a very light sandy material, which, coupled with the fact that the foundations of an old highway bridge located about 200 ft. west of this structure had washed out during a break in the canal embarkment, emphasized the need of new abutments. As the contractor for this section of the canal desired to carry on work adjacent to the bridge site, it was impracticable to erect and maintain a temporary wooden trestle; hence it was necessary to maintain traffic over the bridge itself. The plans for reconstruction involved the replacement of the old abuments with two new abutments and one pier, the north end of the bridge resting on a pier. The use of an auxiliary abutment at the north end was due to the requirement that a driveway be maintained at this end. It was specified that the footings of the new abutments and piers be lowered to the bottom of the new canal prism and founded on piles.

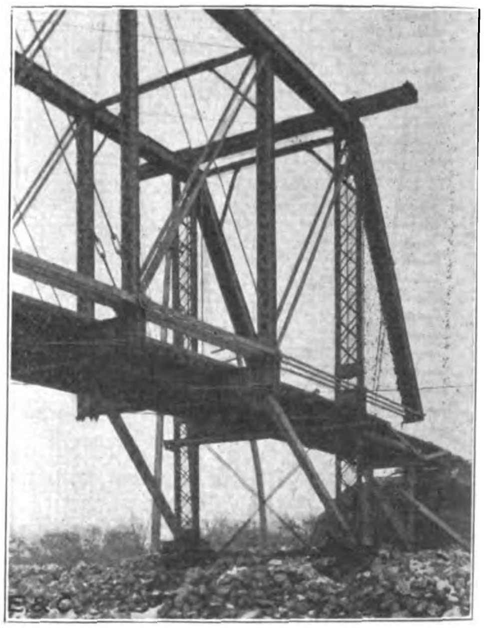


Fig. 2. View of End of Span, Showing Details of Construction Used to Support Span During Reconstruction of Abutments.

CONSTRUCTION METHOD USED.

The construction method adopted by the engineers of the Rochester and Eastern R. R. was to support the bridge by placing steel columns at the hips, or ends of the top chords, thus taking the load off the abutments and transferring it to blocking inside of the lines of the new and old substructure.

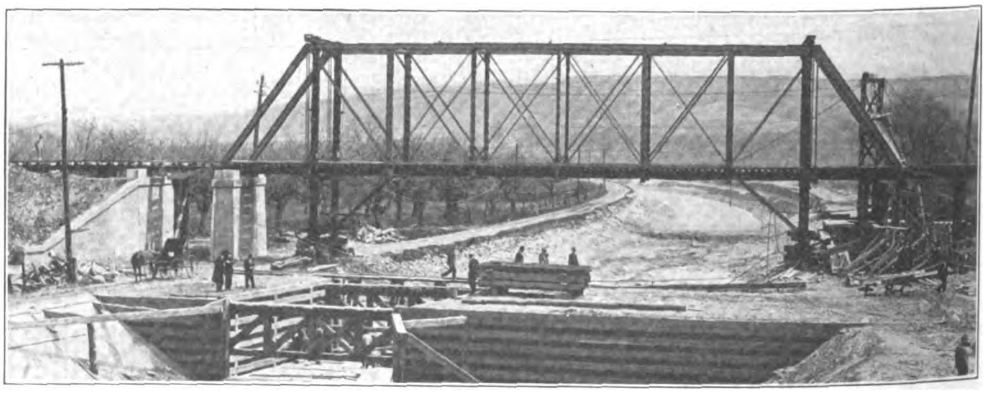


Fig. 1. View of Pratt-Truss Span During Reconstruction of Abutments—Note Manner of Supporting Span.

Figure 1 shows the manner of supporting the bridge on the temporary blocking during the construction of the foundations. It will be noted by referring to this view that the