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1914

SECOND HALF

the canting of rail has little to recommend it in practice on any individual road, since fully 90 per cent of the wheels are worn by service on rails laid vertically.

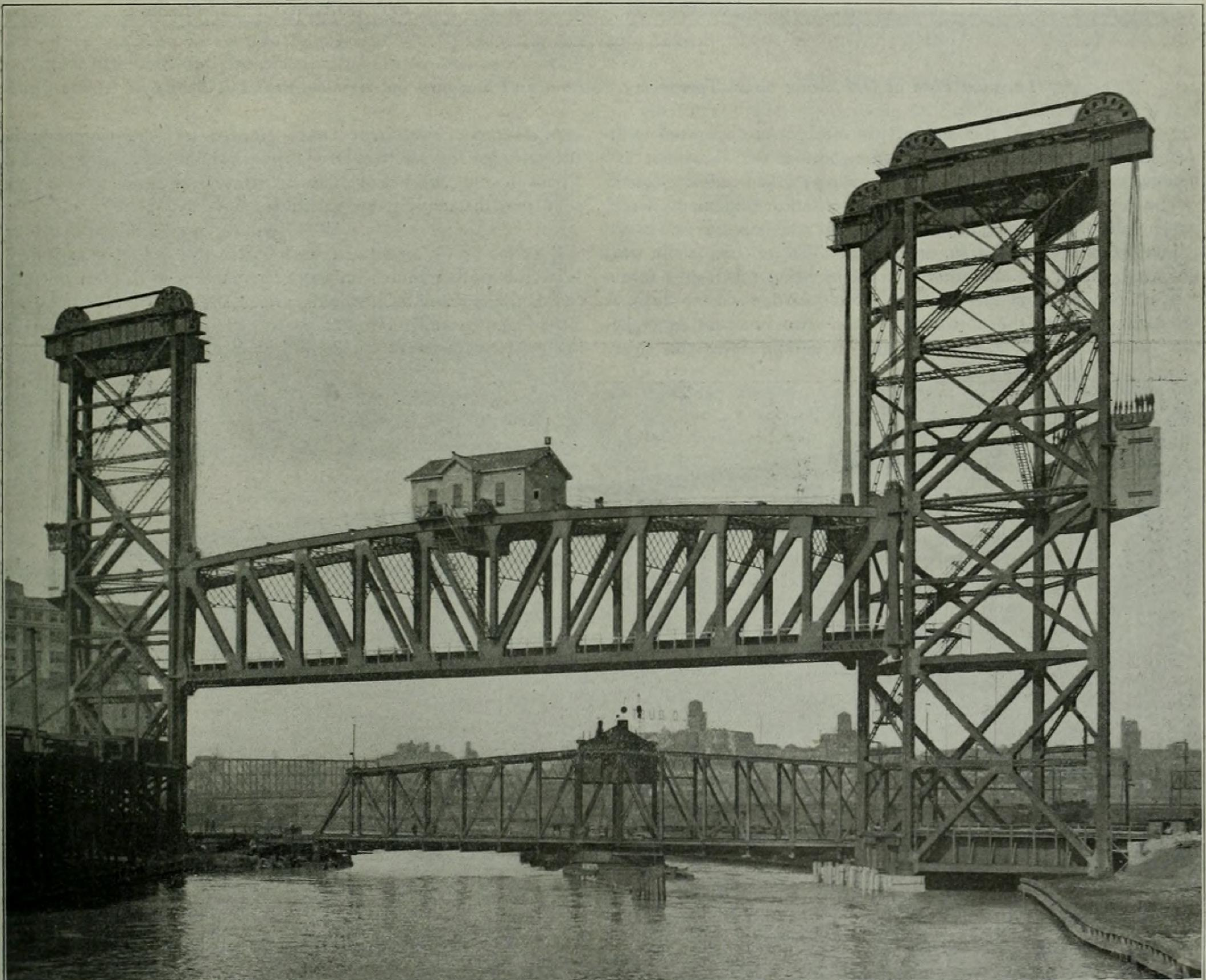
Among other roads which do not cant rail when laying are the Chicago, Rock Island & Pacific, the Seaboard Air Line, the Grand Trunk Pacific, the Southern Railway, the Pennsylvania Railroad, and the Louisville & Nashville.

REPLACING A SWING BRIDGE WITH A VERTICAL LIFT STRUCTURE

The new double track vertical lift bridge of the Pittsburgh, Ft. Wayne & Chicago and the Chicago & Alton over the south branch of the Chicago river a little less than two miles south of the Chicago union station was placed in service on July 29. As the old swing bridge, which was formerly in use at this point, extended under the new structure, one-half of the old bridge had to be removed before the new bridge could be lowered into position.

The old structure was a double track through pin connected revolving draw span on a stone center pier and wooden abutments. Its length out to out was 223 ft. 6 in. This bridge was put in service in 1883 and was reinforced in 1893. It was obsolete and did not accord with the latest government requirements as to channel width, making it essential to replace it.

The new bridge is of the vertical lift type, designed by Waddell & Harrington, Kansas City, Mo., with a movable span 272 ft. 10 in. center to center of end pins, which is the second longest span of this kind ever built. The ends of the span are skewed about 45 deg. The supporting towers at each end are 53 ft. 6 in. long, 29 ft. 6 in. wide and 195 ft. high from top of masonry to center of sheave wheels. The bridge has a clearance of 9 ft. above the water when closed and a maximum clearance when raised of 120 ft., requiring a lift of 111 ft. The clear river channel is 200 ft. The weight of the moving span, including tracks, machinery and machinery house, is about 1,600 tons. This weight is counterbalanced by blocks of reinforced concrete suspended from sheaves at the rear of the end towers. The moving span is carried by 64 2¼-in. steel cables, 16 at each corner, passing over the 15-ft. sheaves at the top of the towers.



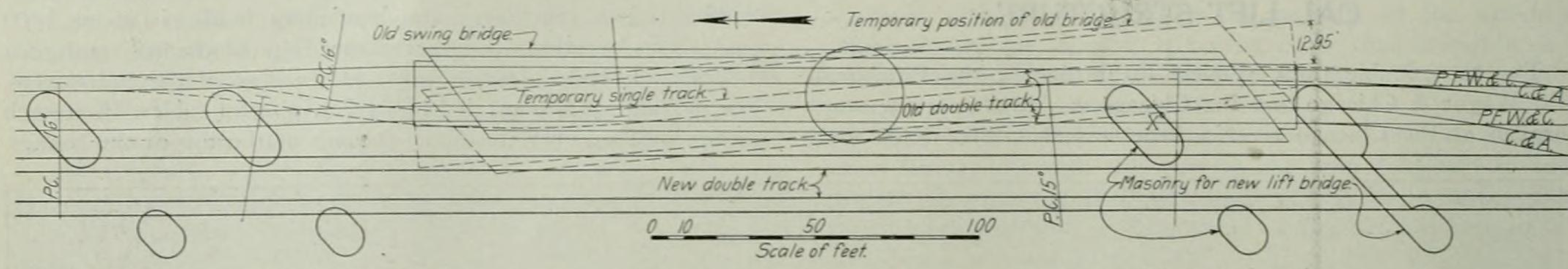
New Vertical Lift Bridge Over Chicago River Replacing Old Swing Span Shown Below

In erecting the bridge, the towers were built first and the movable span was erected by the cantilever method in the open position. Fan falsework was used to support the end panels of the lift span from the towers until the lower chord had been closed. The overturning tendency in the towers due to this method of erection was balanced by the counterweights. On account of the position of the old span it was impossible to lower the new lift span to the closed position until everything was in readiness for the operation of the new bridge and traffic could be diverted long enough to remove one-half of the old span and adjust the new bridge for operation. When the bridge was finally lowered in position after cutting out the old span the error in grade and line was very small.

The accompanying sketch shows the original location of the swing span, the temporary position that was made necessary in order to clear the post of the new end tower at the point marked "X," and the location of the new bridge. The north end of the swing span in the temporary position extended too far west to allow the two tracks to be carried around the masonry for the new bridge and to clear the fan falsework supported from

The end of the remaining portion of the old draw span was jacked over about four ft. on the center pier in order to clear the new bridge. This allowed the new lift span to be lowered into position, adjusted, and traffic put back on the new structure. The south half of the old bridge was dismantled in place, being supported on falsework.

The design and the erection of the new bridge were handled under the supervision of R. Trimble, chief engineer maintenance of way, and J. C. Bland, engineer of bridges, of the Pennsyl-



Location Plan of Old Swing Span, Temporary Position and Masonry for New Vertical Lift Bridge

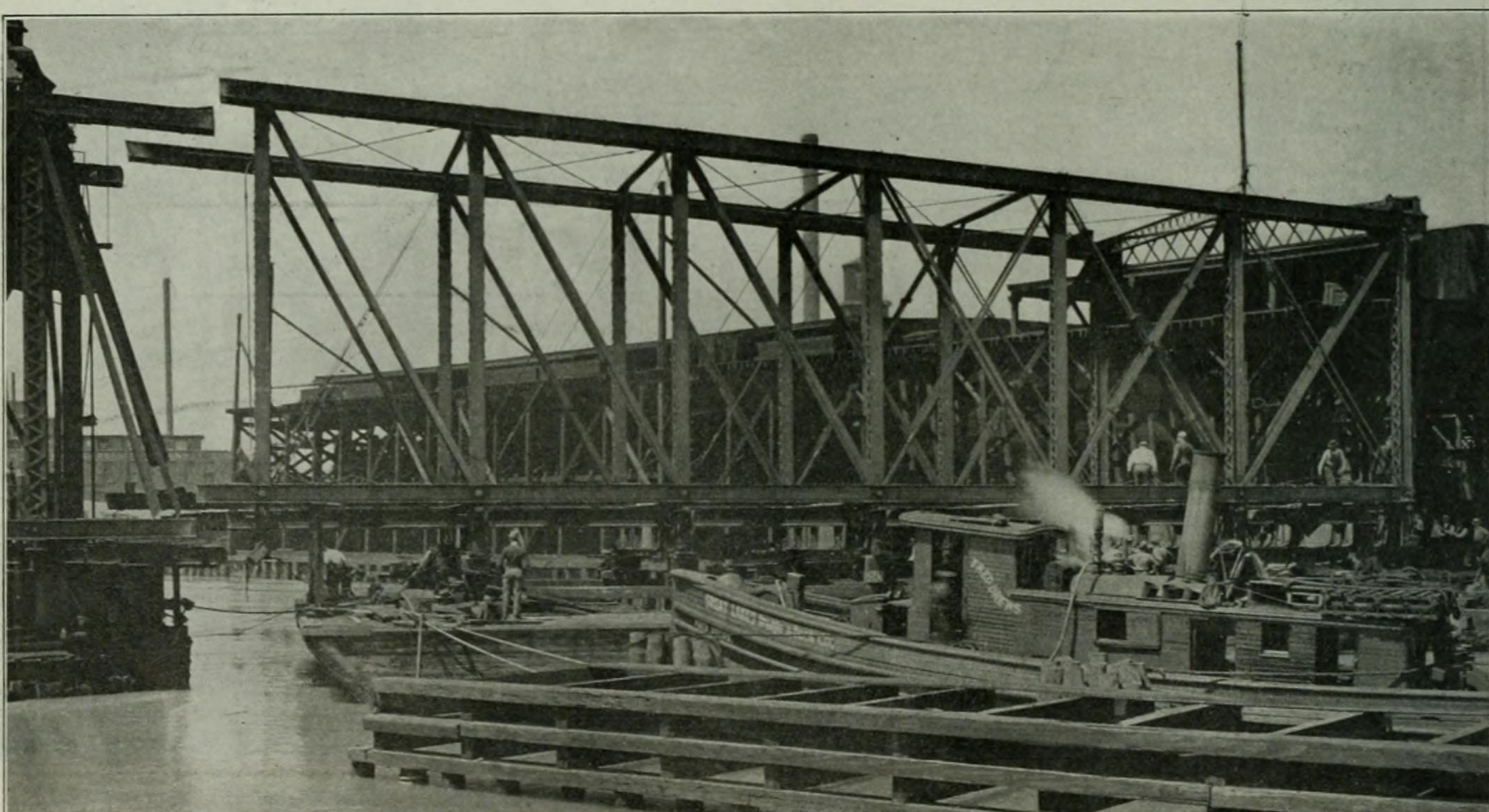
the north tower. On this account the bridge was operated with a single track during the construction period, the alinement including a 16 deg. curve, a part of which was on the swing span.

The new bridge being ready for service, all arrangements were made with the shipping interests to close the stream for navigation between 5 and 9 a. m. on July 29. The railroad traffic was detoured during the operation, the tracks being taken at 4 a. m.

The first operation in removing the old bridge was to cut off the skew panel at the north end of the span in order to make this arm of the bridge short enough to handle down the river

vania Lines. The Great Lakes Dredge & Dock Company had the contract for placing the masonry for the new bridge and the Pennsylvania Steel Company fabricated and erected the new span and dismantled the old draw.

Rolling Stock on the Italian State Railways.—On June 30, 1913, the Italian State Railways had in service a total of 10,261 passenger cars, 98,095 freight cars, 2,312 work and repair cars, 3,408 baggage and mail cars, 5,102 steam locomotives, 56 electric locomotives, 95 steam trucks and 51 electric trucks. There were



North Half of Old Span Supported on Scows and Completely Severed from the Rest of the Bridge

on scows. Two steel scows lashed together were placed under the north arm and blocking was placed under the floor beams. The water ballast in the scows was then pumped out by tugs and steam siphons until the weight of that end of the bridge was transmitted to the scows. Oxy-acetylene torches were used to burn off the truss members adjacent to the panel over the center pier and the north half of the bridge was then floated away. This portion of the old span was landed some distance down the river where it could be dismantled at leisure.

also 383 narrow gage cars, of which 224 were in Sicily and the remainder in Tripoli. During the fiscal year 1912-1913 there were constructed for the Italian State Railway 4,750 freight cars, 500 baggage and mail cars, 327 passenger cars, 160 steam locomotives, 51 electric locomotives, 17 narrow gage locomotives, of which 12 were for Sicily and five for Tripoli, and 197 narrow gage cars, of which 59 were for Sicily and 128 for Tripoli. All the new rolling stock was built in Italy, preference being given to Italian firms as an aid to national industry.

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and equal side slopes of 1:1, we have by substituting values in equation A,

$$C = \frac{(H + 3.14)^2}{z^2 - 1}$$

For any section having equal side slopes, s, as usually found in railroad sections, equation A reduces to a simple form similar to the above equation. Thus, from equation A,

$$C = \frac{1}{2}\left[\frac{(M + Hs)^2}{z - s} - \frac{(M + Hs)^2}{z + s}\right]$$
$$= \frac{1}{2}\left[\frac{(M + Hs)^2(z + s) - (M + Hs)^2(z - s)}{z^2 - s^2}\right]$$
$$= \frac{(M + Hs)^2 s}{z^2 - s^2} \qquad \text{(C)}$$

COMMENTS

Equation C may be worked very rapidly on a slide rule for all points shown on the topography to have a steep side slope, it not being absolutely necessary to have prepared tables or curves. The writer prefers to use a level cutting table, to which is added the correction found above, rather than prepare extensive tables for the areas and quantities of the several slope sections. Areas can easily be reduced to cubic yards per station by multiplying the result found from the above equations for corrections by 3.7. After a few sections have been corrected in this way, one can tell at a glance whether the side slope is sufficient to warrant any correction at all.

In case tables or curves are desired, they can be computed for the correction C according to the above forms. In the case of curves, sufficiently accurate results can be taken off very rapidly for the majority of sections likely to occur.

There is considerable time and labor involved in preparing tables such as Mr. Hammond's, and the average job will hardly warrant more than the plotting of a few curves showing the correction to be applied on steep slopes. If more accurate results are desired, very often it would be better to go out and rapidly and roughly cross-section by means of a hand level, after the location has been run in.

Electric Drag-Lines on Little River Drainage Project

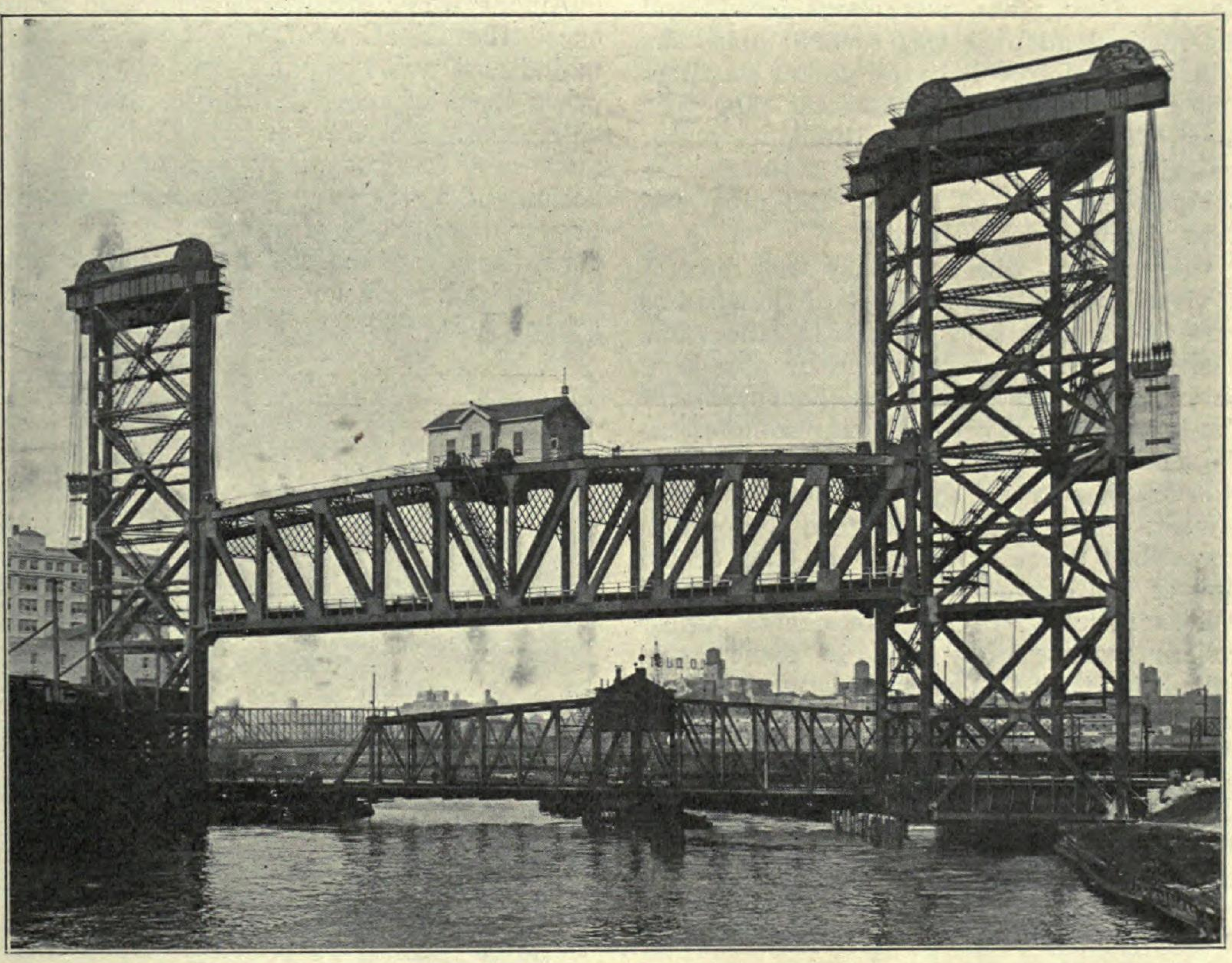
THE use of drag-line excavators on the diversion channel of the Little River Drainage District, in Missouri, was described in the Engineering Record of April 3, 1915, page 429. Since that article was prepared new machines have been ordered and the work is now being done by two electrically-driven drag-line excavators built by the Bucyrus Company, of South Milwaukee, Wis., while two other machines of the same general type are now under order with the same company. One of the machines now in service has a 4½-yd. dipper and a 100-ft. boom, while the other has a 3½-yd. dipper and a 125-ft. boom.

A VAST AMOUNT OF UNDEVELOPED WATER POWER that can be developed without interfering with the use of water for irrigation is to be found in Wyoming, according to J. B. True, State engineer. As a matter of fact, it would eventually aid materially in the reclamation of lands by lifting water to those lands that are too high to be reached by gravity.

Special Conditions Govern Selection of Lift Bridge and Method of Erection

Structure of Pennsylvania Lines Over South Branch of Chicago River Designed for Future Elevation of Tracks and Possible Duplication

THE REPLACEMENT of the old double track swing bridge of the Pennsylvania lines over the south branch of the Chicago River by a structure which would not only permit a future 25-ft. elevation of track but also allow erection of the new bridge to proceed without in any manner restricting either railroad or river traffic has recently been accomplished. The new structure also had to be selected to permit future duplication if necessary to meet increasing traffic requirements. These conditions were met by the selection of a double-track lift bridge, raised by cables running over high towers at each end, and erected by means of a fan-like arrangement of falsework built out from the main towers.



NEW SPAN AFTER ITS COMPLETION AND THE REMOVAL OF FALSEWORK

The falsework was unusually heavy. The outer leg was nearly 147 ft. long and required a cross-section of 1344 sq. in., which was obtained by the use of ten large timbers bolted together. The following details of the design, the difficulties encountered and the methods of erection have been abstracted from papers prepared under the direction of J. C. Bland and presented before the Western Society of Engineers by W. L. Smith and W. W. Triest.

GENERAL DESCRIPTION AND OPERATION

The new bridge consists of a double-track riveted-truss lift span, 272 ft. 10 in. center to center of end posts, with two Pratt trusses with inclined top chords, and a tower at each end. The towers are from 30 ft. 2 in. to 30 ft. 8 in. wide, 53 ft. 6 in. long and about 185 ft. high. The structure is skewed at an angle of 47 1/3 deg. At each end of the bridge is a sectional counterweight consisting of two structural steel frames covered with about 315 cu. yd. of 1:2:4 slag concrete, the approximate weight of each counterweight being 1,582,000 lb. Careful estimate showed that the cost of the counterweight would be substantially the same whether slag or broken stone were used, with possibly a slight difference in favor of broken stone. Rivet plugs were also considered, but were not used because they were difficult to obtain in sufficient quantities, and were quite expensive.

To permit the passage of vessels, the truss span can be raised in 45 sec. from the normal position to the maximum height of 111 ft. The span and its counterweights are suspended by sixty-four 2¼-in. plow-steel ropes over eight 15-ft. sheaves of structural and cast steel. Sixteen 2¼-in. ropes connected to the top chord at each end of each truss pass over a pair of sheaves and are attached, by means of equalizing devices to the counterweights.

The span is operated by two 300-hp motors, geared to four cast-steel operating drums, each of which carries four 1⅛-in plow-steel operating ropes. These ropes pass over deflection sheaves at the ends of the span—two going up and two going down at each corner—and are fastened to the top and bottom, respectively, of the towers. Either motor alone can operate the driving mechanism. A 50-hp gasoline engine will be installed for emergency service. This engine will lift the span to its maximum height in about 10 min. Limit switches cut off the current when the span has reached its limiting position, and solenoid brakes are applied automatically. Hand brakes are provided as an additional safeguard.

By far the most serious trouble, and the most expensive as well, has developed in connection with the sheaves. Owing to their size—15-ft. pitch diameter—they are of built-up construction, i.e., each sheave consists of a center steel casting or sleeve and seven sections of cast-steel rim segments, the rim and sleeve castings being connected with a web of built-up riveted-steel construction. The detailed drawing for the sheaves called for "all contact surfaces between rim segments, between web plates and rim, and between web plates and sleeves to be finished to accurate bearing over entire area." The sheaves as manufactured, however, did not meet this requirement. To insure proper action between the rims and webs, four splice plates were added to each connection between the web diaphragms and rims, this affording eight additional turned bolts in double shear at each of these points. To prevent creeping of the built-up portions of the sleeves, four plans were considered, and the method adopted was to drill holes for 1-in. pins on line between center castings and hub and drive tight-fitting pins into them. The cost of adding the splice plates was about $390 per sheave or $3100 for the bridge; the cost of adding the pins was about $3500 for the bridge.

Operation of the rail locks was difficult at times owing to the failure of the span to seat itself each time in exactly the same position. This was remedied by attaching entering tongues to the end floorbeams of the truss span. These entering tongues engage centering guides which are carried by the floorbeams at the span ends of the towers. As originally designed the operating cables were supported on the center line of the curved top chord by gumwood rollers mounted in steel brackets. These rollers wore rapidly and in some cases failed to turn. The ropes, when slack, abraded each other and the top chords of the trusses. To overcome this excessive wear on the rollers and to remedy the other conditions above described, deflection sheaves were mounted on the upper chords at each end of each truss.

Deficiencies in the Design

In constructing another bridge of this type there would also be provided a device whereby there would be no unbalanced load from the counterweight ropes. The lift span as designed is supposed to be perfectly balanced when at midheight only. At all other points of its travel there is an unbalanced effect from these ropes. This unbalanced condition is plainly a maximum amount when the lift span is at the extreme limit of its travel. When beginning to lift the span from its normal position, therefore, besides overcoming frictional resistances from the weight of the moving span, counterweights, etc., there must also be overcome this maximum unbalanced condition.

Provision should be made for cutting off the power when the operating cables break at either end of the span. As designed, there is nothing to prevent the operator from continuing to hoist the span after the operating ropes break at either end. If the span is not properly counterbalanced, it can be seen that the end of the span where the breakage occurred might, under certain conditions, be pulled down.

Governing Conditions

It is expected that the tracks will be raised from 20 to 25 ft. at this point in the future. This type of bridge is particularly well adapted to making such a change. The tower bracing has been so arranged that when this track elevation is attained the present lower transverse struts can be replaced with the present tower floorbeams. All that then remains to be done to the superstructure before putting it in service is to place the supporting columns under the corners of the lift span and raise the tower floor system and the approach girder spans to their new positions and rivet them up. It will be noted that the entire truss span is raised to bring the track to the new grade—not the floor system alone. This means that not only is the expense and delay incidental to disconnecting the floor system and riveting it up again in its new position avoided, but the underclearance is increased so as to permit the passage of many small boats which would otherwise require operation of the bridge.

Among other considerations which influenced the selection of this type, its estimated cost was less than that of the three other types of movable bridges under consideration. Furthermore, as the operating machinery is very simple and direct in its action and as the wire rope should not, with proper care, require renewal for a long time, the cost of maintenance would be very low, indeed much lower than that of many other types. Sufficient clearance was provided throughout for the construction of a second bridge of this type at a minimum distance from the present bridge of 35 ft. 6 in. center to center.

Details and Sections

At both ends of the lift span centering castings on the trusses engage corresponding centering castings on the tower columns. At the fixed end a small clearance is provided; at the other (expansion) end ample clearance is provided for the longitudinal expansion and contraction of the span. The shoes consist of massive cellular cast-steel blocks with vertical lips (two each) which project above their top surfaces and engage the vertical sides of the truss pedestals, which are pin-connected to the trusses. At the expansion end their bearing surfaces are curved, affording ordinary rocker action for the truss span under expansion and contraction.

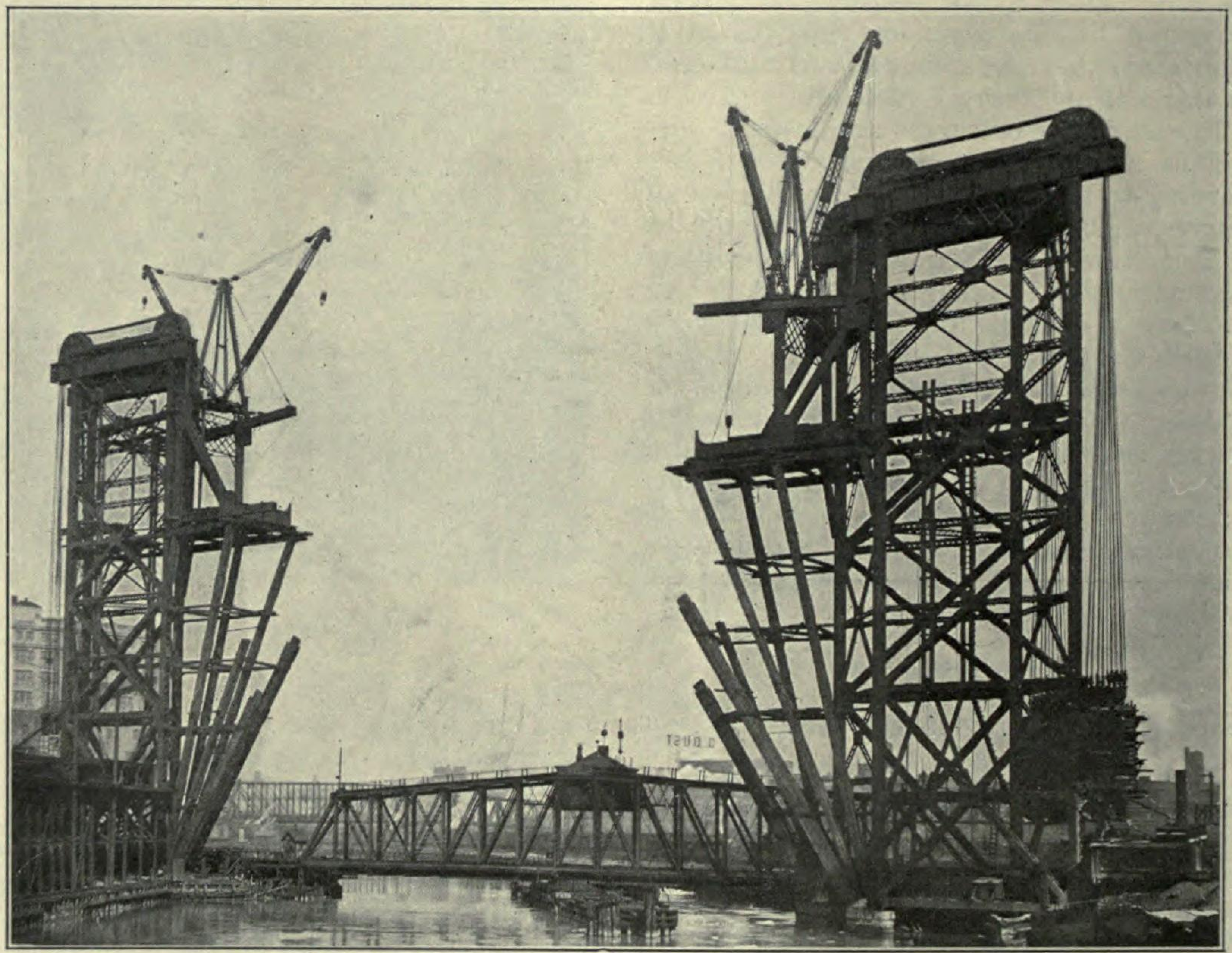
An expansion joint is provided in the floor system at the connection of the stringers to the floorbeam near the center of the span. Train-thrust frames, to prevent lateral bending in the floorbeams, are provided at about one-quarter span length from each end of the truss span to carry the horizontal loads (from braking trains, etc.) directly into the trusses.

The top chord members of the lift bridge are of the usual type of construction, consisting of two built-up channels connected with a cover plate. All web and bottom-chord members consist of two built-up channels with flanges turned inside, connected with lacing. The largest top chord has a section of about 240 sq. in., the largest bottom chord a section of 226 sq. in. The tower columns are composed of built-up H-sections consisting of eight angles and three web plates. The lower portions have a cross-section of about 216 sq. in., are 80 ft. long and weigh about 40 tons each.

Loading and Specifications

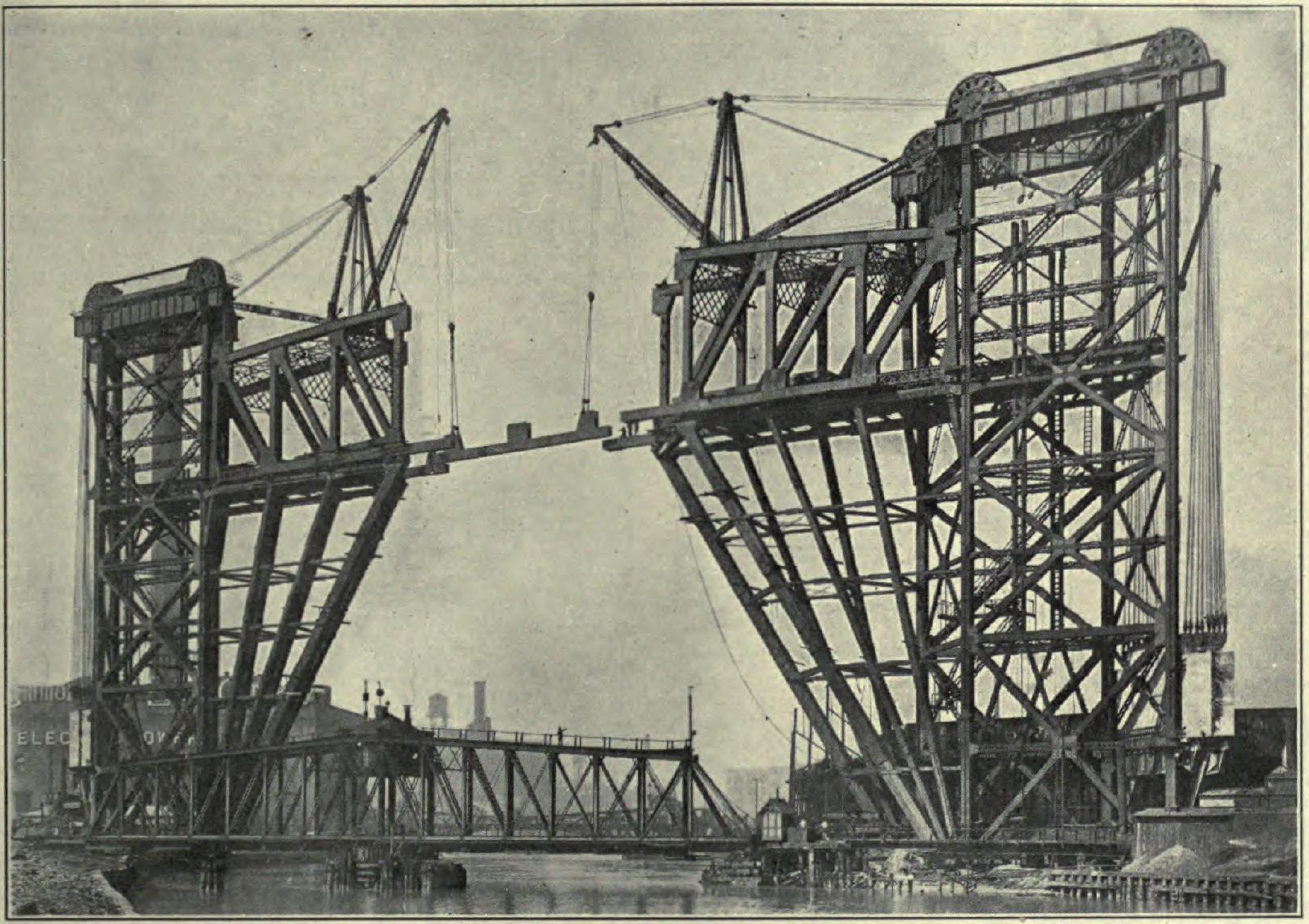
For the trusses, in addition to the dead load of 9740 lb. per linear foot for the double-track truss span, a uniform live load of 5500 lb. per foot plus a concentration of 66,000 lb. per track is assumed. The floor-system connections are designed for a concentrated live load of 99,000 lb. per track. The wind loads are 150 lb. per foot of span for upper laterals and 500 lb. for lower laterals. Of the latter 300 lb. is considered as moving load. For the towers, the wind load is assumed as 30 lb. per square foot with span down, and 15 lb. with span up, in each case reduced by Duchemin's formula. The tower columns were designed for both present and future loading according to certain specified combinations.

The specifications for railway bridges, Pennsylvania Lines West of Pittsburgh, dated April, 1906, were used for the design and manufacture of the structural steelwork except that (1) the allowable unit



FRAMES IN END POSITIONS ON LIFT SPAN, ERECTING SPAN AND FALSEWORK stresses were increased 15 per cent for all members carrying loads from two tracks at the same time; (2) those in the tower columns were increased one-third when wind loads were included, and (3) those in the tower and traction bracing were 12,000 lb. per square inch for tension, 12,000 — 44l/r lb. per square inch for compression, and 9000 lb. per square inch in the truss laterals.

The operating ropes were designed in accordance with the following clause: "The ratio of the total stress (including bending) to the elastic limit shall not exceed 75 per cent; the ratio of ultimate to direct stress shall not be less than 4½." In explanation of what may seem an excessively high ratio of total stress to elastic limit, it may be added that the consulting engineers considered this ratio a proper one because while bridge steel is ordinarily stretched to about one-half its elastic limit, impact included, it is less thoroughly worked in its manufacture and is less uniformly reliable than the material entering into the construction of wire rope.



A-FRAMES IN FINAL POSITION—TOWER CHORD BEING SWUNG INTO PLACE

CONDITIONS GOVERNING ERECTION

In deciding on the method for erecting the new bridge, two important points had to be kept in mind: (a) That no interference with navigation would be permitted, and (b) that it was necessary to maintain the railroad traffic on the old swing span up to the time it was transferred to the new bridge. Therefore the latter would have to be erected so as to permit the operation of the old span, and also so the transfer of the railroad traffic to the new bridge could be made in the shortest possible time, bearing in mind that the old span would have to be removed before the new span could be put in position for traffic.

Two methods to take care of these conditions were considered, one of which entailed the erection of the lift span on falsework parallel with and close to the dock line at some point on the river, and afterward floating it into its permanent position on barges. The other method contemplated erecting the span in its permanent position on falsework high enough to clear river navigation. The latter was adopted because it seemed to offer less chance of delay to navigation and a better opportunity to transfer the railroad traffic quickly from the old to the new bridge.

The tower columns were erected in three sections, the bottom section being about 81 ft., the middle 47 ft., and the top 57¼ ft. long. After setting the bottom sections of the columns by a derrick car, the bracing for these sections was bolted in place and a derrick specially designed for completing the erection of the tower was set up on the part of the tower erected. In order to erect these towers within a reasonable time it was necessary to provide a derrick that would handle a load of about 30 tons at a 44-ft. radius, and could be shifted from point to point easily and quickly. The design adopted called for a derrick with a timber A-frame and two booms set up on a combination wood and steel beam which was secured to vertical timbers bolted to two sides of the tower, these timbers being extended as the erection of the tower progressed.

FALSEWORK FOR TRUSS SPAN BUILT IN A FAN SHAPE

In order to clear the river navigation, the falsework for the lift span was built in a fan shape and could only extend from the towers to the third panel point from each end of the span, leaving a gap of 108 ft. under which no falsework could be placed. This falsework consisted of three main legs under each end of each truss, arranged as are the sticks in a fan, the lower ends of all legs being set close together on the concrete foundation built on the masonry at the foot of the inner columns in the towers. Their upper ends were secured to the towers by means of eyebars and plates, and were all thoroughly braced at properly spaced intermediate points.

The inner and center legs of the span consisted of four 10 x 12-in. timbers bolted together, and the outer leg of four 10 x 12-in. and six 12 x 12-in. timbers bolted together, making a sectional area of 1344 sq. in. This outer leg was nearly 147 ft. long on its center line and was built to sustain a load of 360 tons applied at its upper end.

ERECTION BY A-FRAME DERRICK

The method of erecting the lift span by the use of the A-frame derrick is indicated in the accompanying progress photographs. The gap of 108 ft. between the ends of the falsework supports was cut down to 73½ ft. by the projecting ends of the bottom-chord sections already in place, and was closed by connecting the bottom chord with a center section 73½ ft. long, which was swung into position by the two A-derricks as shown. This center section weighs about 36 tons. The erection of the trusses was then completed and the remaining four panels of floor system, lateral and sway systems put in place. The span was erected at a clear height of 130 ft. above low water.

During the erection of the span the counterweight frames were erected and the concrete forming the counterweights poured. They were supported by steel brackets attached to the foot of the columns until the lift span was ready for trial operation. As soon as the erection of the lift span was completed, the machinery house was erected, the machinery was installed, and the floor deck and tracks were put in place. The falsework under the lift span was not removed until the span was loaded with practically all the weight it would carry when completed ready for traffic.

Three schemes were considered for removing the old swing span. The method finally adopted consisted in floating two scows partly loaded with water under the north end of the span, blocking up on the scows under each panel point of this end of the span, cutting the span in two at a point near the north side of the pivot pier with an acetylene flame, and floating the north end out of the way. When this was done the end of the span resting on the pivot pier was jacked east about 4 ft. so as to clear the new span, and left in this position until dismantled.

When the new span was finally lowered into position on the bridge seat it was found that the line and surface of the tracks on the span required some adjustment, and also that the operating ropes required adjustment properly to land the span. It was 21 hours 10 min. from the abandonment of traffic on the old swing span to its restoration on the new lift span. From the time of beginning the erection of the towers to the time the structures were put in service ten months and twenty-six days elapsed.

Waddell & Harrington, of Kansas City, Mo., were the consulting engineers for this work. They prepared the stress sheets, general detailed drawings and special specifications for the mechanical and electrical equipment under the general direction of J. C. Bland, engineer of bridges, Pennsylvania Lines West of Pittsburgh. The bridge was fabricated and erected by the Pennsylvania Steel Company, Steelton, Pa. It was completed and put in service last year at an approximate cost of $750,000.

HYDROELECTRIC PLANTS IN NEW ENGLAND are producing more than 2,000,000,000 kw-hr. of energy, which, if produced by coal, would mean the annual consumption of 3,000,000 tons of that fuel, according to figures given by Henry I. Harriman, president of the Connecticut River Power Company, in an article in the General Electric Review.