Railway Age

SEVENTY-SECOND QUARTO VOLUME

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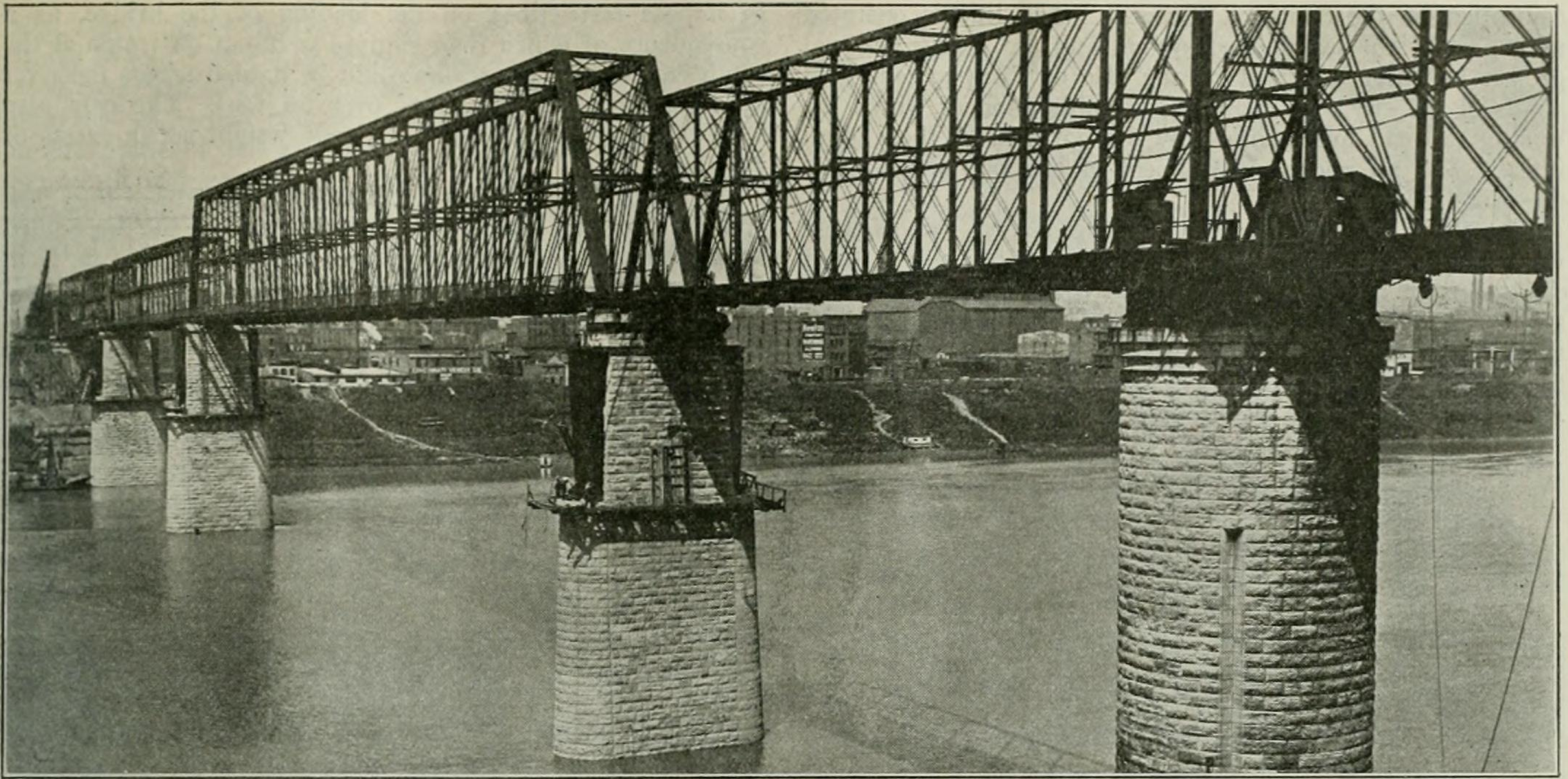
(Established in April, 1856)

SIXTY-SEVENTH YEAR

1922
FIRST HALF



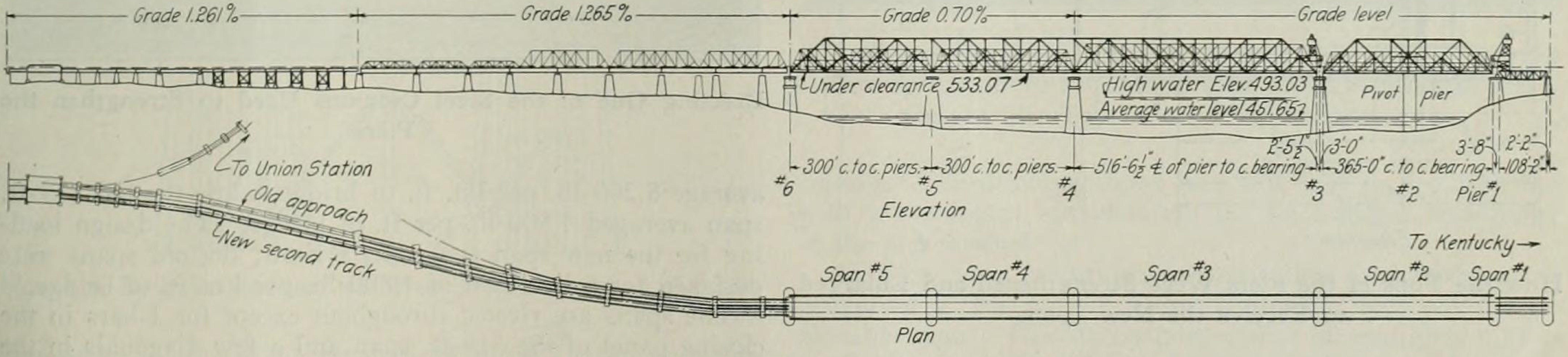
After Supporting These Single Track Spans for 45 Years, the Piers Now Carry a Heavy New Double-Track Superstructure

Double-Track Spans Placed on Single-Track Piers

Utilize Forty-Five Year Old Substructure in Renewal of the Cincinnati Southern Bridge Over the Ohio

The renewal of the Cincinnati Southern bridge over the Ohio, now nearing completion, is noteworthy as the only large railway bridge project in progress for some time. Aside from this it merits the attention of engineers because of the many original and ingenious methods employed in meeting the problems imposed in this important reconstruction project. Chief among these is the utilization of the original piers, built in 1876 for single-track spans, to carry a new superstructure several times as heavy and designed for double-track. This, of course, reflects well earned credit on J. H. Linville, the designer of the original bridge. However, it was only through the exercise of a high degree of engineering skill on the part of those responsible for the reconstruction work that these old piers could be adapted to their present use.

The new superstructure represents the fourth instance of trusses continuous over three or more supports to be built in America during the last five years, a further evidence of the advantages of this form of construction for conditions favorable to cantilever erection. The erection followed the rather common procedure of building the new spans around the old trusses, but according to methods that are essentially original. Provision for a high water channel opening for river transportation requiring a vertical headroom of only 13 ft. more than that afforded by the fixed spans was fulfilled by a 365-ft. vertical lift span, and this short lifting distance afforded opportunity for the development of elevating equipment essentially different from that normally employed in bridges of the vertical lift type.



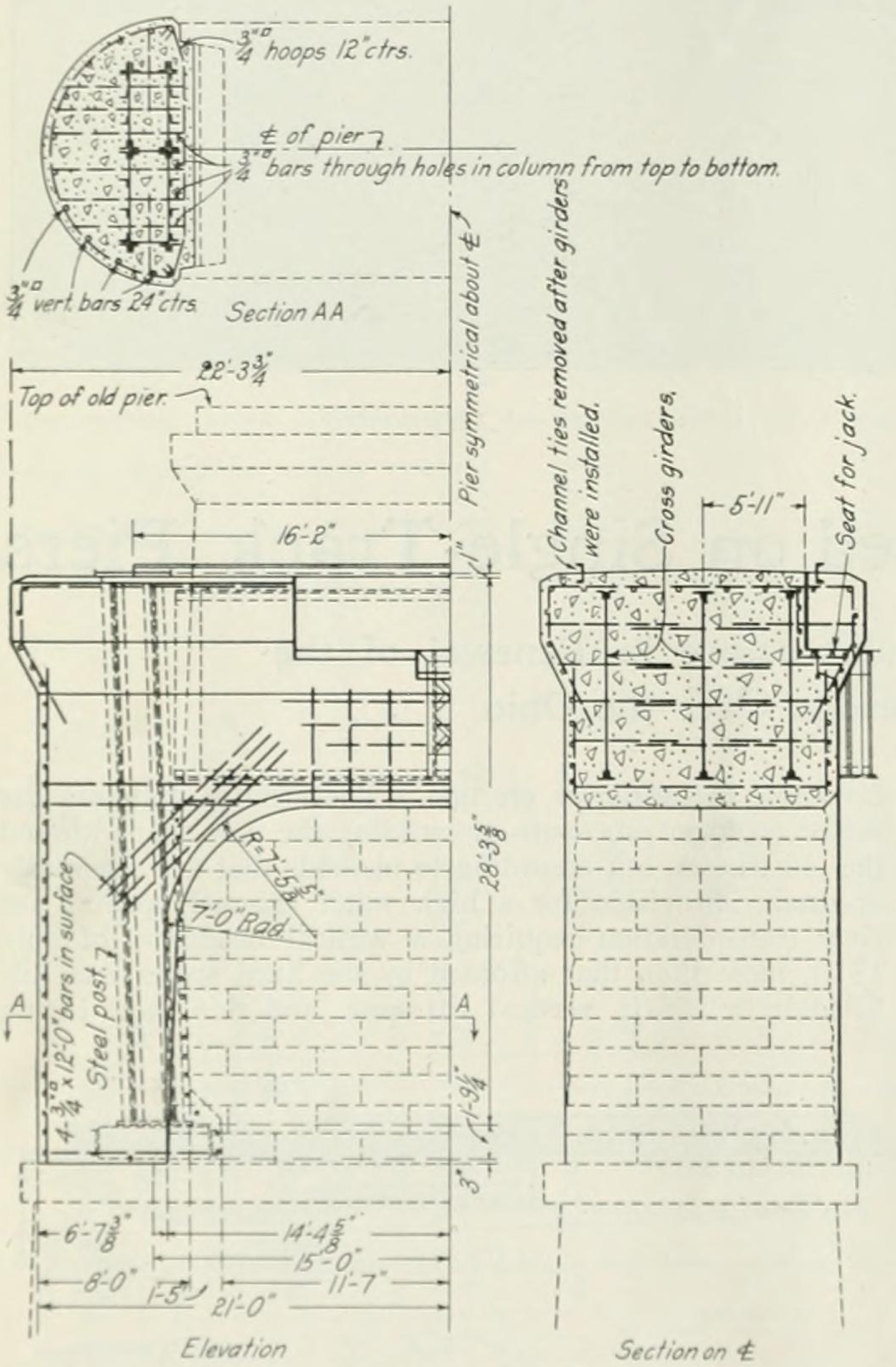
General Plan and Elevation of the New and Old Structures

Bridge Owned by City of Cincinnati

Aside from the structural considerations considerable interest is attached to the Cincinnati Southern bridge because of its ownership by the city of Cincinnati as a part of the Cincinnati Southern, one of the few municipally owned steam railroads in the United States. The property is under lease to the Cincinnati, New Orleans & Texas Pacific, a line controlled by the Alabama Great Southern, which in turn is

controlled by the Southern Railway. The line is operated as a part of the last named system and the bridge renewal project has been financed by the sale of five-per cent gold bonds of the city of Cincinnati, the obligation of which the leasing railroad has assumed by the payment of the annual interest and an annual installment of one per cent against the principal.

The old bridge consisted of four river spans. Two of these were simple fixed spans of 300 ft., the third was a fixed channel span of 519 ft. and the fourth was a symmetrical swing span of 370 ft. center to center of rest piers, this swing span being intended for use at times of high water when there would be insufficient clearance under the 519 ft. span. All of the spans were of wrought-iron, Whipple trusses on



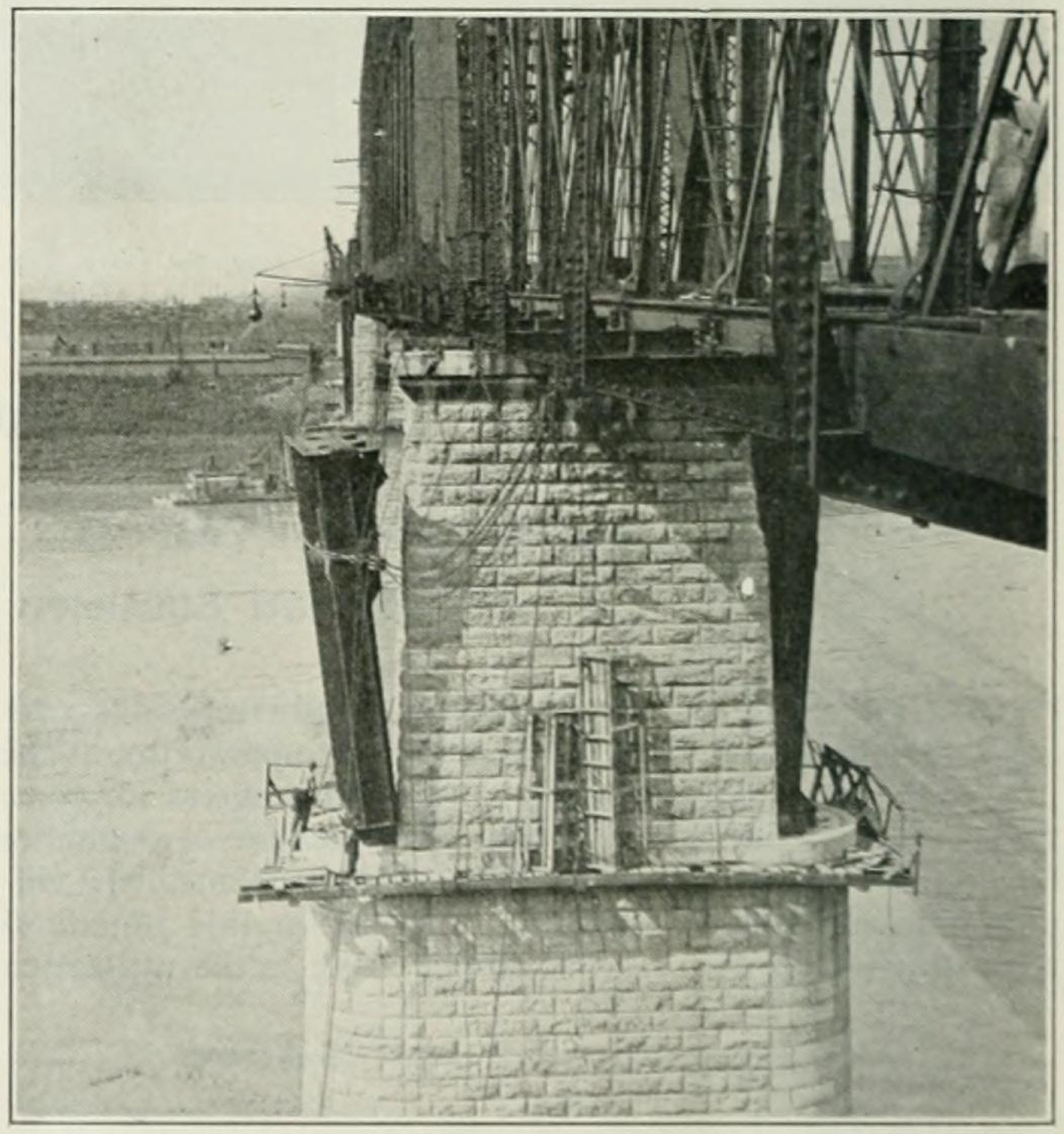
How the Tops of the Piers Were Strengthened and Enlarged to Receive the New Spans

limestone piers carried to rock (blue limestone) foundation by the open coffer dam process. The design and details were of a character such that the construction of this bridge marked an important milestone in the progress of bridge engineering in America, particularly as the 519-ft. span was at one time the longest simple truss span in this country. The south approach comprised one 112-ft. truss span, while the north approach embodied 1,660-ft. of viaduct, partly on masonry piers and partly on viaduct towers.

Use of Old Bridge Restricted

Obviously, a structure designed 45 years ago developed limitations on its loading capacity with increases in the weight of railway equipment. This had made it necessary to impose restrictions on the loading of the bridge, as a consequence of which road engines were cut off trains at the south end so that the trains could be hauled across the river by locomotives weighing not over 65 tons. The cars also were restricted to such as had a gross weight not in excess of 115,000 lbs.

As stated above, the bridge has been renewed with a new superstructure on the old piers. In the case of the three fixed spans, continuous trusses have been provided, extending from Pier 3 to Pier 6. In the place of the swing span a vertical lift span has been provided spanning from Pier 1 to Pier 3, thus eliminating the pivot pier. All the spans have been made the same depth, this being determined primarily by the requirements of the long span. The depth was kept the same primarily for convenience of erection equipment operated on the top chords of the trusses. An idea of the difference between the new and the old superstructure is to be had from the cross section showing the plan of erection. The new trusses are nearly twice as deep and are spaced more than twice as far apart as the old trusses. The new spans



Erecting One of the Steel Columns Used to Strengthen the Piers

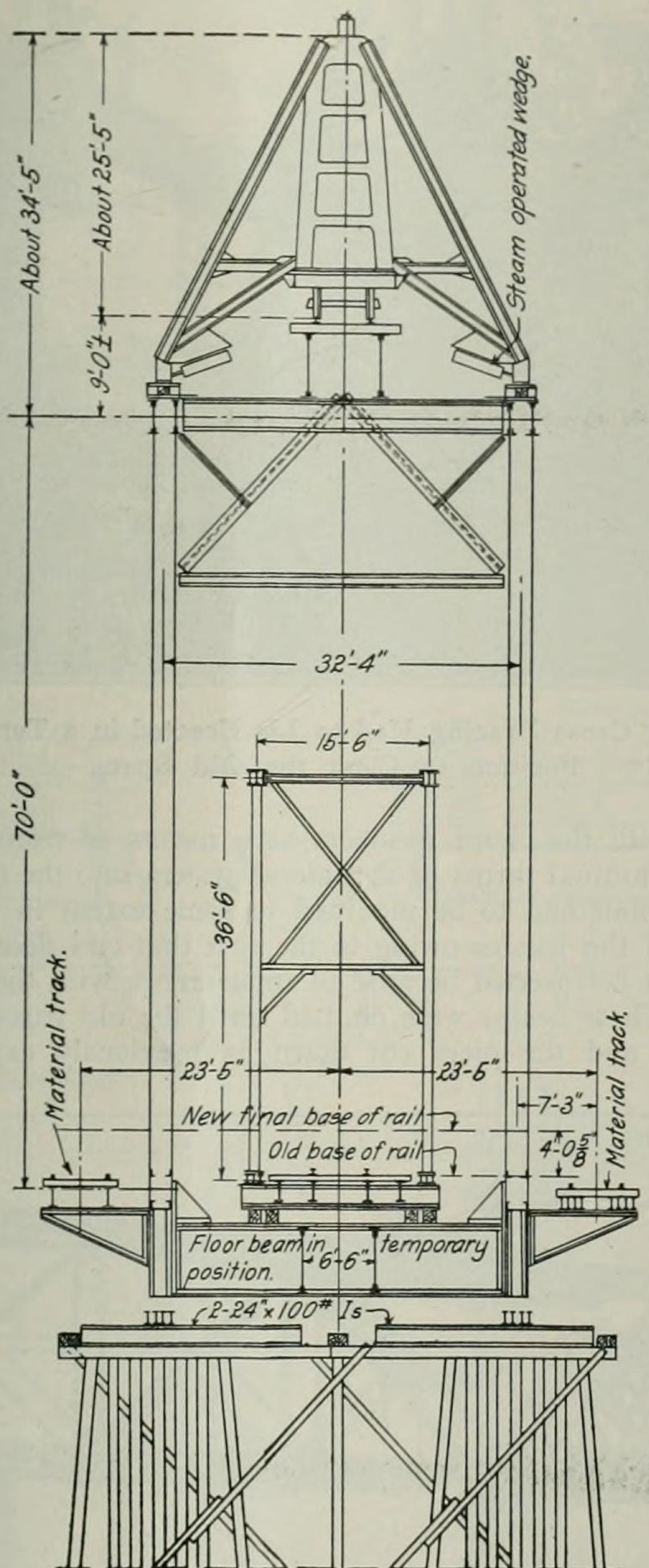
average 8,200 lb. per lin. ft. of bridge, while the old 519-ft. span averaged 4,500 lb. per ft. of bridge. The design loading for the new span is Cooper's E-60; the old spans were designed for a live load of 1,800 lb. per lin. ft. of bridge.

The spans are riveted throughout except for I-bars in the closing panel of the 519-ft. span and a few diagonals in the web system. The main panel lengths are about 74 ft., so that with subdivided panels the stringer span is 37 ft. All riveted members except the bracing are of silicon steel. The I-bars are heat-treated, high-carbon steel.

In the north approach, the old through truss spans have been replaced by deck plate girders on masonry piers for double track, covering a total length of 921 ft. Of these the longest span is 120 ft. For a length of 658 ft. the existing single track viaduct is supplemented by a new single track viaduct alongside.

Spans 1, 2 and 3 of the bridge are level; the other two spans are on a grade of 0.7 per cent rising to the south. Owing to the fact that the floor of the new bridge is four feet deeper than the old floor and it was necessary to maintain the

established under-clearance, the track grade on the new bridge is four feet higher than on the old one. This necessitated considerable change in the viaduct structure which was subjected to further change because of a raise of seven feet in the grade of the approach at Gest street, where a new reinforced concrete viaduct has been provided. The entire project required the fabrication and erection of 8,200 tons of structural steel, of which 3,914 tons are in the three con-



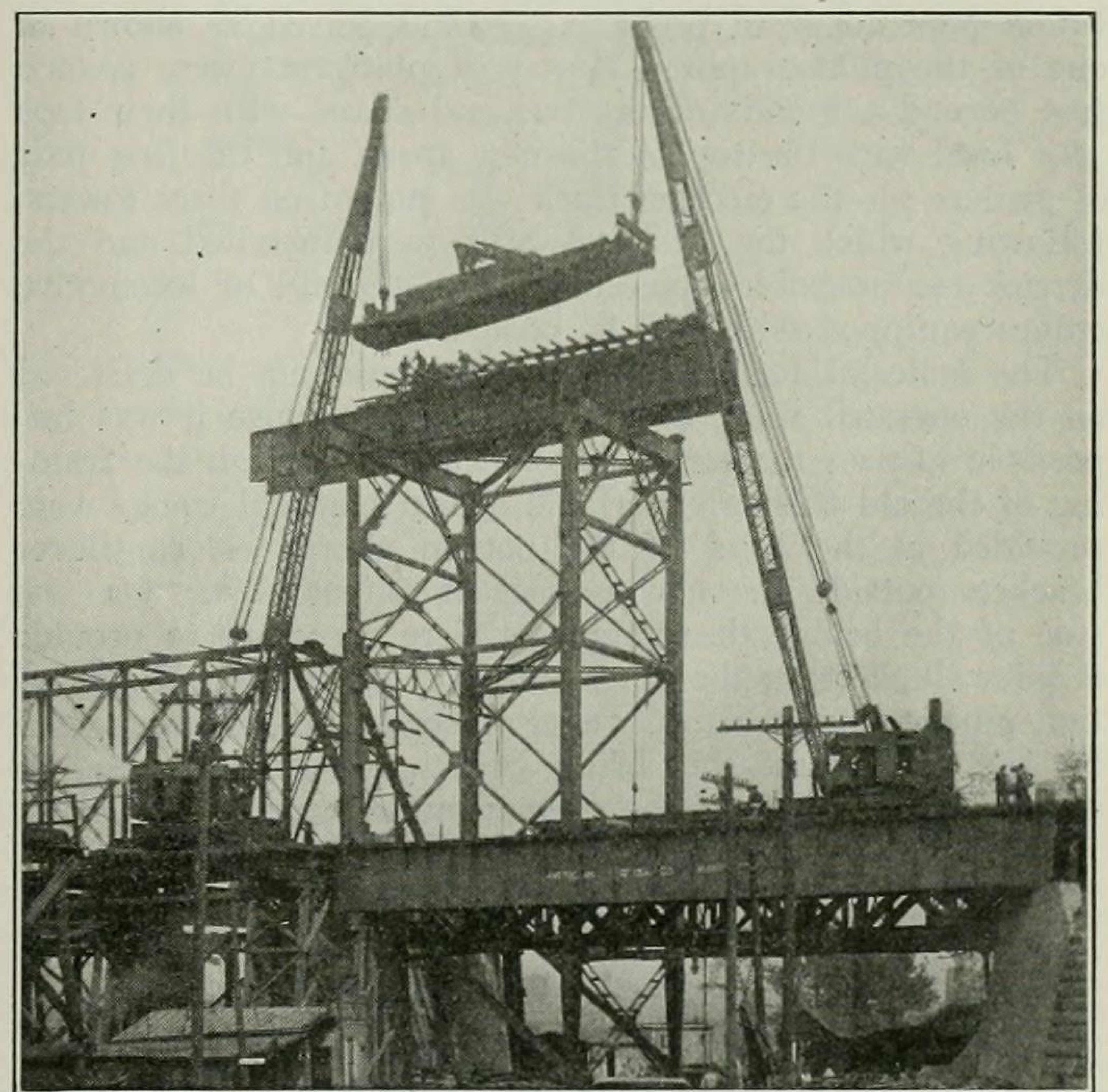
How the New Superstructure Was Erected Around the Old

tinuous spans and 1,251 tons are in the lift span, exclusive of the towers and machinery.

Work on the Piers

To support trusses spaced 32 ft. 4 in. center to center on piers having a top length of only about 28 ft. over the coping was by no means the least of the problems imposed in the renewal of the bridge. Fortunately, the over-all length of the piers at the top of the starling, 30 ft. below the coping, was about 42 ft., thereby offering a solution in the reconstruction of the pier above that point. The great concentrations to be imposed by the new span, together with the need of supporting the existing span during erection of the new work, called for the use of structural steel bents as a means of applying the new load to the piers. The starling coping was removed and enough of the pier ends cut away to make room for heavy steel columns and grillage footings to take the end bearings of the new trusses. To apply the load as far from the end of the pier as possible, these columns were inclined inward so that the bases are 14 in. closer to the center line of the bridge than the tops of the columns, the resultant outward thrust at the top being resisted by tie members extending across the faces of the piers and connecting the tops of each pair of columns. However, application of the superstructure load is to be further distributed (following the removal of the old spans) by taking down enough of the pier top between the columns to permit the introduction of three cross girders. These will serve as diaphragms connecting the two columns of each pair and will be wedged up on the masonry so that a considerable portion of the column load will be distributed to the center portion of the pier.

The top of the piers will be jacketed with concrete to enclose the structural steel and provide a bridge seat and



A Delicate Piece of Erection—Setting One of the Derrick Cars on a Scaffold So That It Will Lie in Position to Run Out on the Top of the New Superstructure

coping. The drawing shows how this will be accomplished with a maximum consideration of the finished appearance of the pier.

At Pier 3 an additional complication is introduced in providing a seat for the lifting equipment required for the movable span. This necessitated a pair of cantilever girders projecting from the side of the pier as shown in the drawing. Pier 1 at the south end of the lift span is on pile foundation and has been completely encased in a heavy concrete jacket, also on pile foundation.

Erection Methods Original

Spans 2 and 5 were erected on falsework while Spans 3 and 4 were erected by the cantilever method with the closure in the center of Span 3. The use of continuous trusses for Spans 3, 4 and 5, provided the necessary continuity over Piers 4 and 5 for erection purposes. This was provided over Pier 3 by temporary connections between the top chords of Spans 2 and 3. As shown in one of the photographs, this consists of girders provided for use in the north approach viaduct equipped with temporary end details as re-

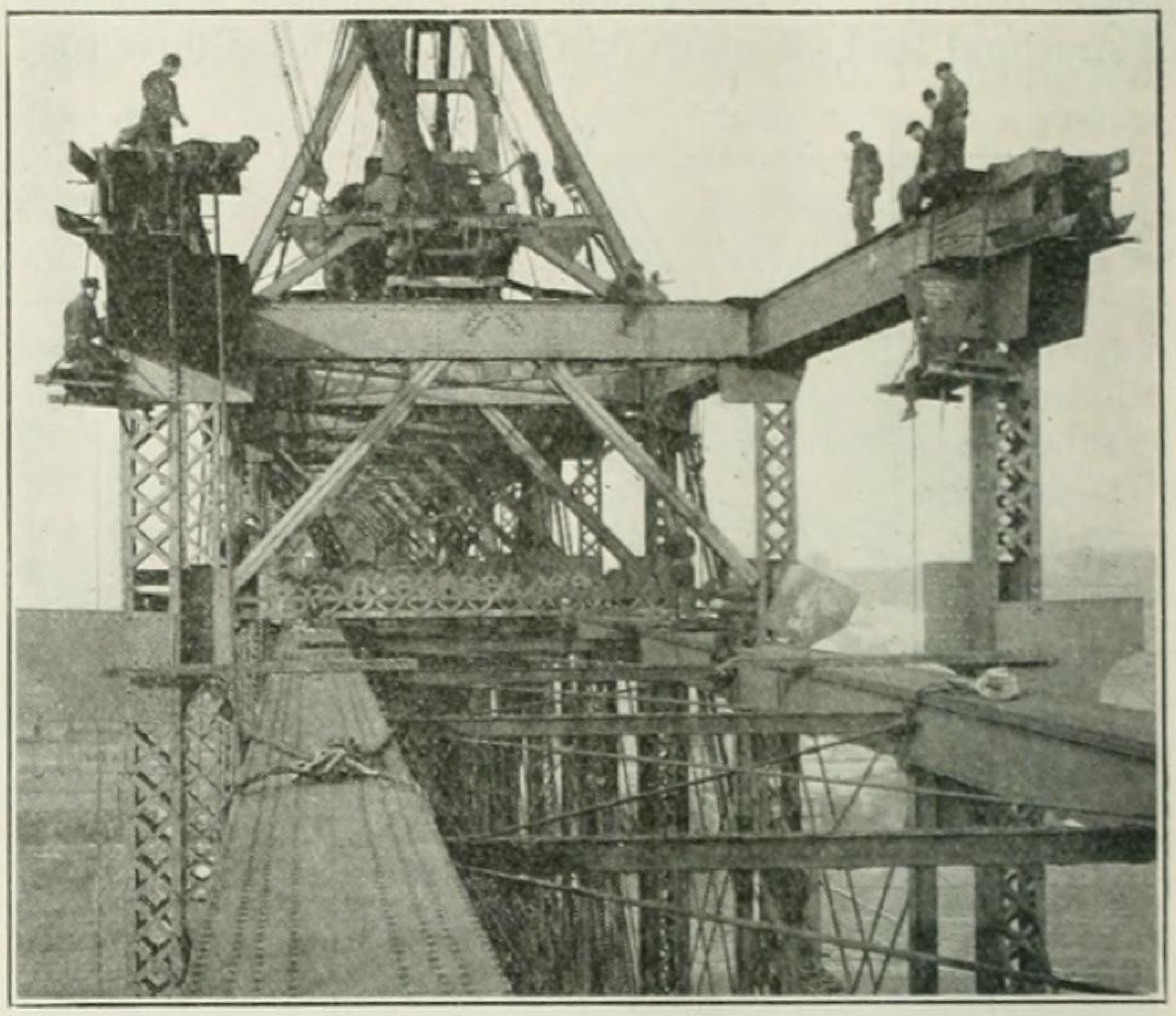
quired for pin connection to the hip-joints of the two adjacent spans.

Obviously, the cantilever method of erection imposed conditions requiring the erection equipment to travel on the top of the structure, but instead of using a creeper traveler running on the top chords, two standard-gage, 60-ton bridge derrick cars with 70-ft. booms were used for this purpose, traveling on a track supported by a floor system composed of bridge stringers spanning between the cross struts of the top lateral bracing. These were the stringers provided for the two outside lines of the stringers in the floor system, as only the two inside stringers were erected at once in final position. The only special equipment provided for the derrick cars was an A-frame designed to provide side bearings and tie downs on the top chords when loads were being lifted. The application and release of the side bearing was accomplished by hydraulic-operated wedge blocks as shown in the drawing and photograph.

The placing of these two derrick cars in position to start work at an elevation 74 ft. above the track level on the old bridge was no mean problem. It was solved as shown in one of the photographs. Four-post platforms were erected just beyond the ends of the two end spans with their tops at a level with the top of the new spans and the first pair of girders for the erection track was placed on these towers, following which the ties and rails were installed and the derrick car assembled piecemeal with the aid of locomotive cranes equipped with 110-ft. booms.

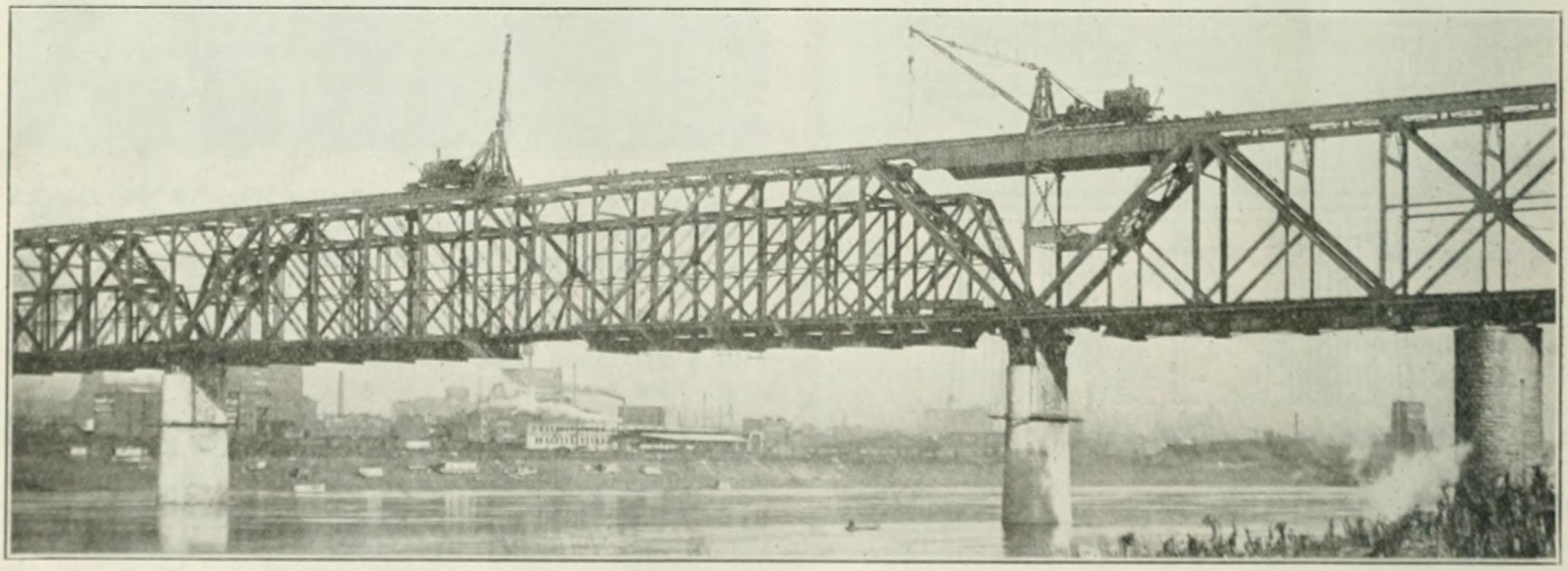
The material for the new trusses could not be delivered on the operated track of the old bridge because it was impossible to pass the large chord members through the framing of the old trusses. For this reason material tracks were provided at the level of the bottom chords on cantilever brackets outside the new trusses on either side. On one side of the bridge these brackets were necessary to provide a sidewalk, but on the other side they served only for erection purposes. In all 801 tons of structural steel was used for the erection of this bridge which was not required in some way as a part of the permanent structure. The material was delivered on these material tracks on standard-gage cars, but to avoid undue loading a light narrow gage locomotive was used to handle the cars. This necessitated the use of a third rail in the material tracks and an offset coupling for connecting the locomotive with the cars.

The erection of the new span around the old one introduced certain complications to avoid interference of the new members with portions of the old structure. The floor beams had to be erected so as to hang below the old floor and thereby provide a means of supporting the old spans when the time came for wrecking them. These beams and two lines of stringers were assembled complete in the temporary position with the bottom lateral system and the beams were equipped with special brackets to receive the lateral plates in the absence of the bottom chords, while short diagonal struts were introduced to connect the bottoms of the floor beams with the chord members as a means of transmitting the longitudinal thrust of the lateral system into the chords.



The New Cross Bracing Had to Lie Erected in a Temporary Position to Clear the Old Spans

This plan had to be modified to some extent in the end panels of the trusses owing to the fact that end floor beams could not be inserted because of interference with the bridge piers. These beams were omitted until the old trusses were removed and the piers cut down as previously explained. The portals and cross-frames also interfered with the old trusses, as a consequence of which the upper portions of the cross-frames were omitted temporarily and the lower portions erected in a raised position. This is clearly shown in some of the photographs which show only the lower part of the X-bracing in position.

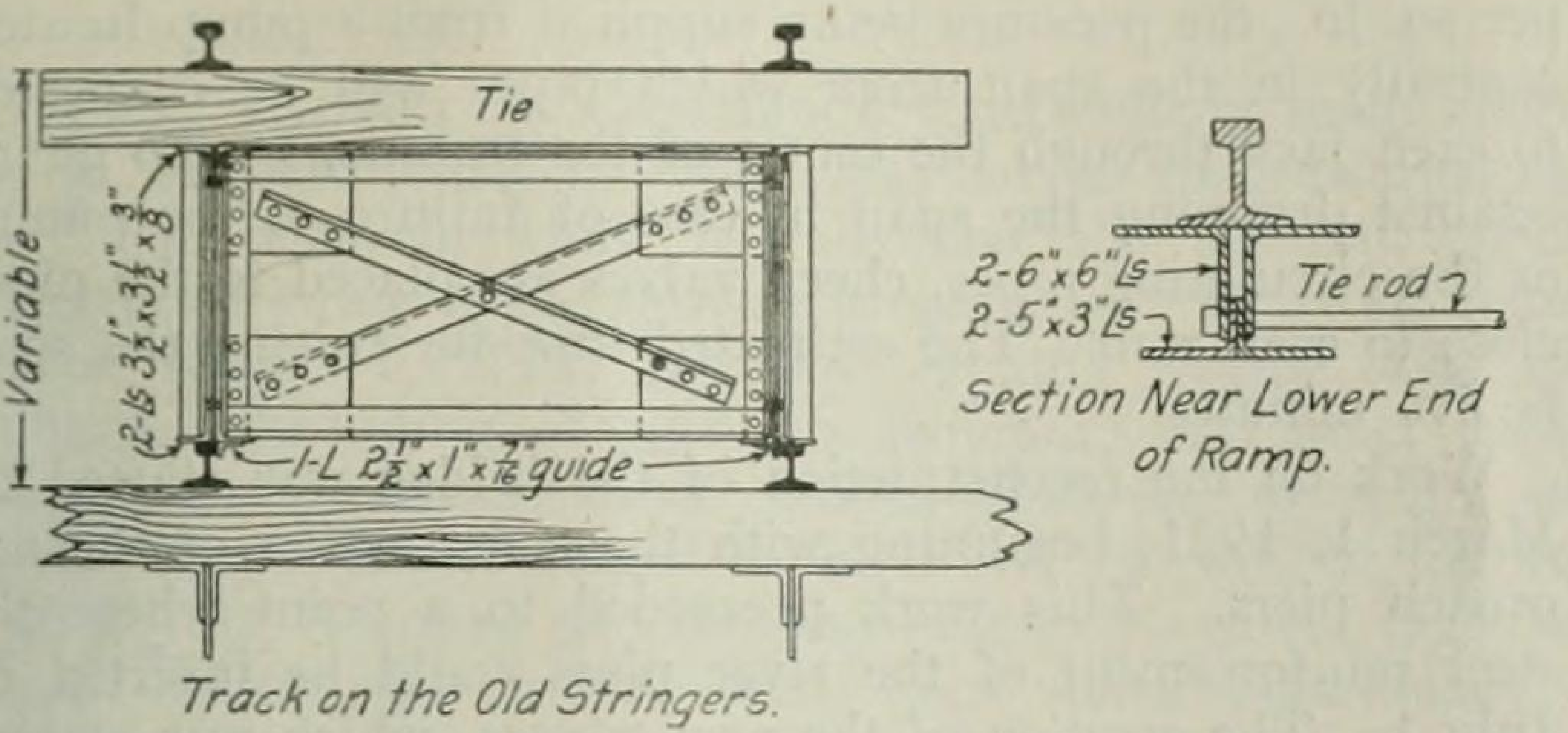


Closing the Gap in Span 3—Note the Kinks in the Bottom and Top Chords at the Ends of the Closing Panel

How Span 3 Was Closed

Extensometer measurements were made in the top chords of the trusses over Piers 4 and 5 during the course of erec-

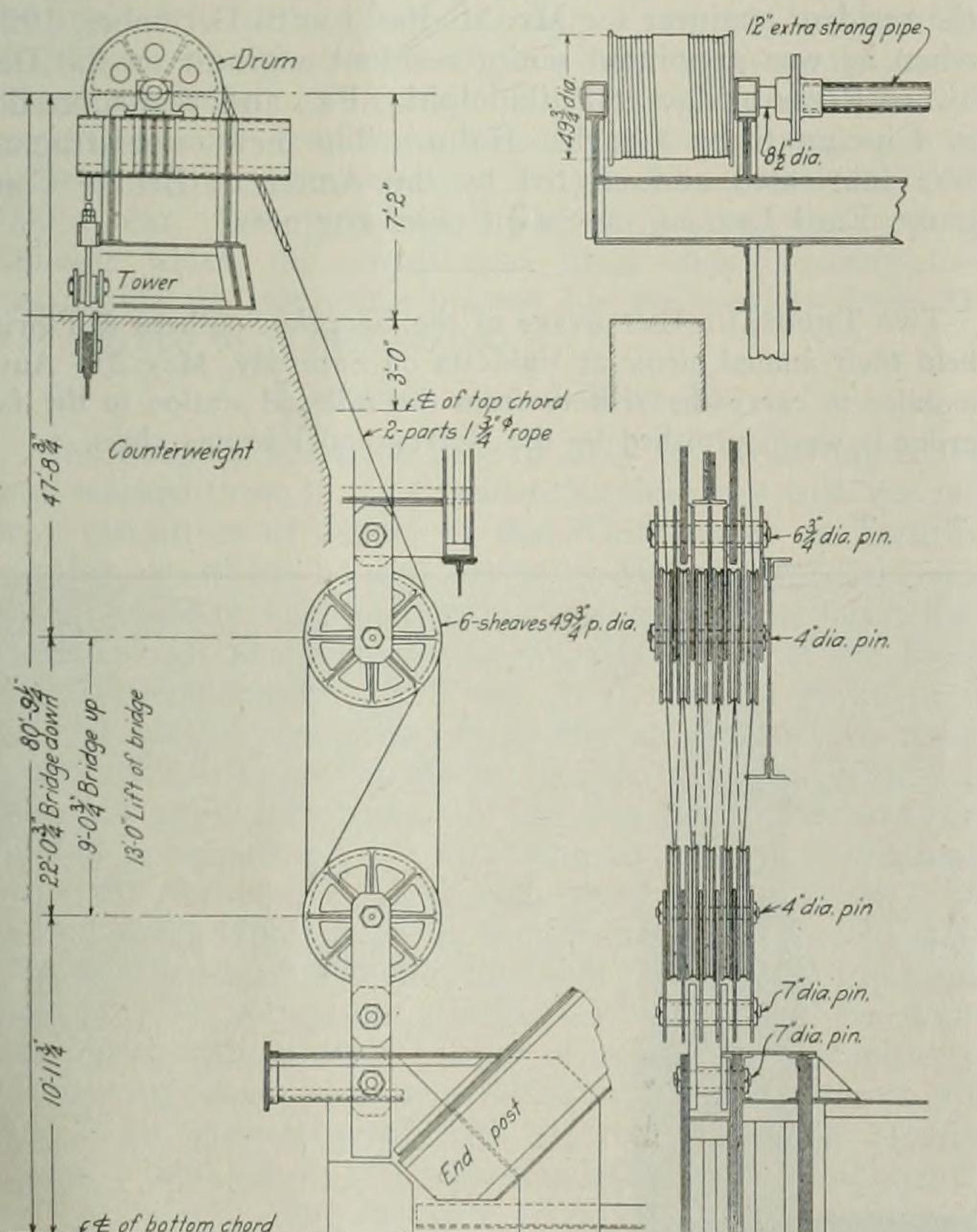
tion and the results checked very closely with the calculated stresses for various stages of the work. Thus, readings of 26,000 lb. per sq. in. were obtained for conditions under which the calculated stress was 25,000 lb. per sq. in. The adjustment of bearings on Span 4 after the erection had reached Pier 4 was accomplished by the use of jacks at that



Two Sections Through the Ramp Used While the Old Floor System Was Being Removed

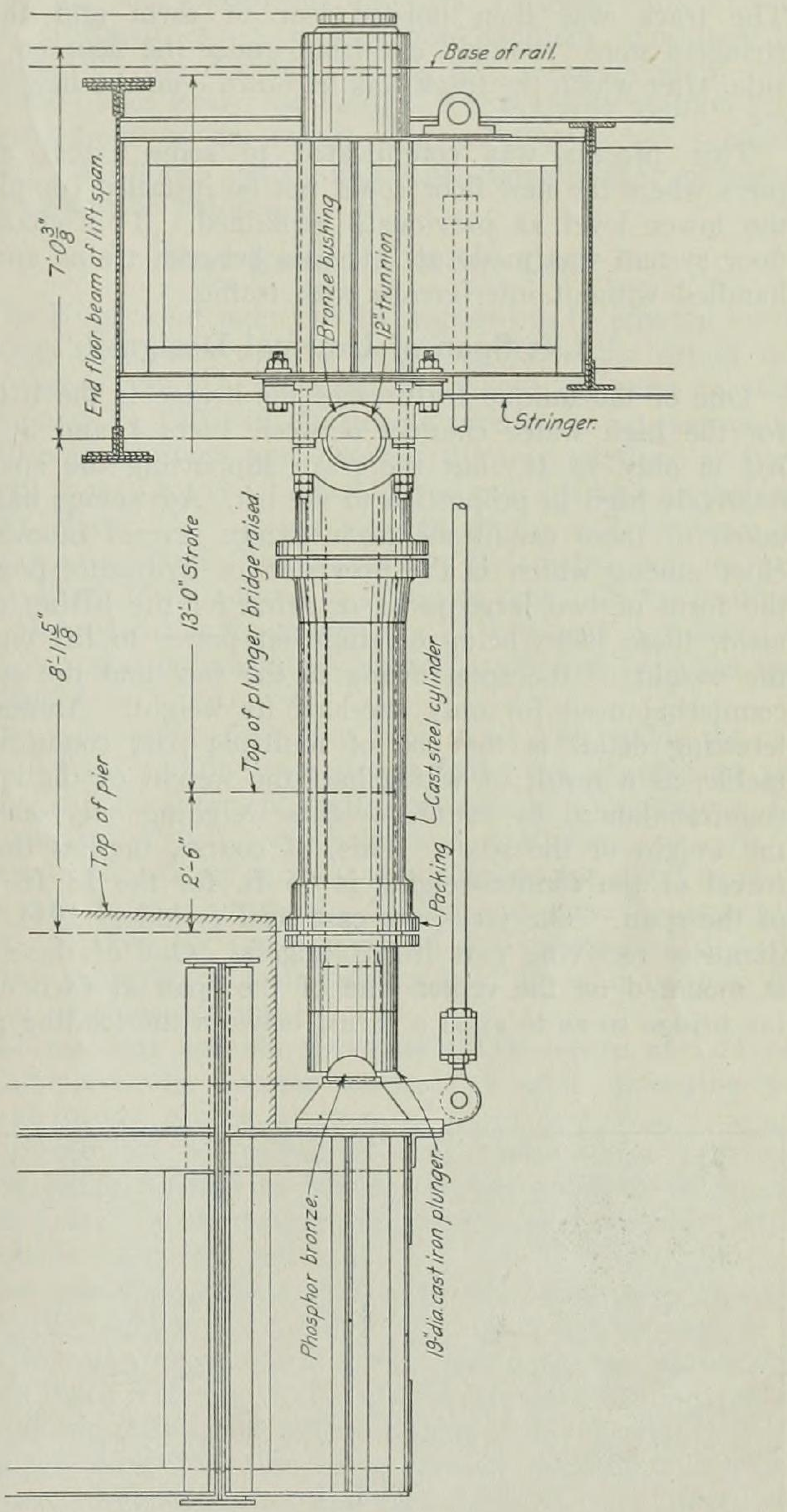
pier, after which no changes were made in the levels at Piers 4, 5 or 6 in connection with the closing of Span 3. This was accomplished entirely by adjustment in elevation at Pier 1 in connection with a unique method of inserting the members in the closing panel.

The closure was made in the central panel on this span



The Counterweight Rig for the Lift Span Is Arranged to Give a Five-Time Multiplication (Copyright American Bridge Company)

as shown in the photograph, the closing members comprising bottom chord eyebars and diagonals with slotted pin holes and a top chord member having butting ends planed on a slight chamfer so that only about the middle third of the member was in bearing. As erected the outer end of the north cantilever was below final position, while the outer end of the south cantilever was above final position through the adjustment of jacks at the south end of Span 2 on Pier 1. This arrangement allowed a sufficient clearance for the entrance of the closing members in the gap between the ends of the two cantilevers. With the members in position the south end of Span 2 was slowly raised, thus lowering the end of the south cantilever. This action served to shorten the top chord length and gradually introduced compression in the closing member of the top chord. This in turn served to raise the outer end of the north cantilever until Span 3



Details of the Jack Provided to Operate the Lift Span (Copyright American Bridge Company)

gradually assumed the elastic curve for the condition of continuity over Pier 4 and simple support at Pier 3.

Following the erection of the new trusses complete the old spans were blocked up on the new floor and the old trusses cut apart and removed. The members were lowered and loaded by the derrick cars from the erecting track on top of the new spans, the material being loaded on to cars standing on the operated track within the bridge. After this work was completed there remained the removal of the old floor and the raising of the new floor to the final level. This work was carried on simultaneously for about four stringer panel lengths at a time, making two or three changes per week. This was complicated by the fact that there was