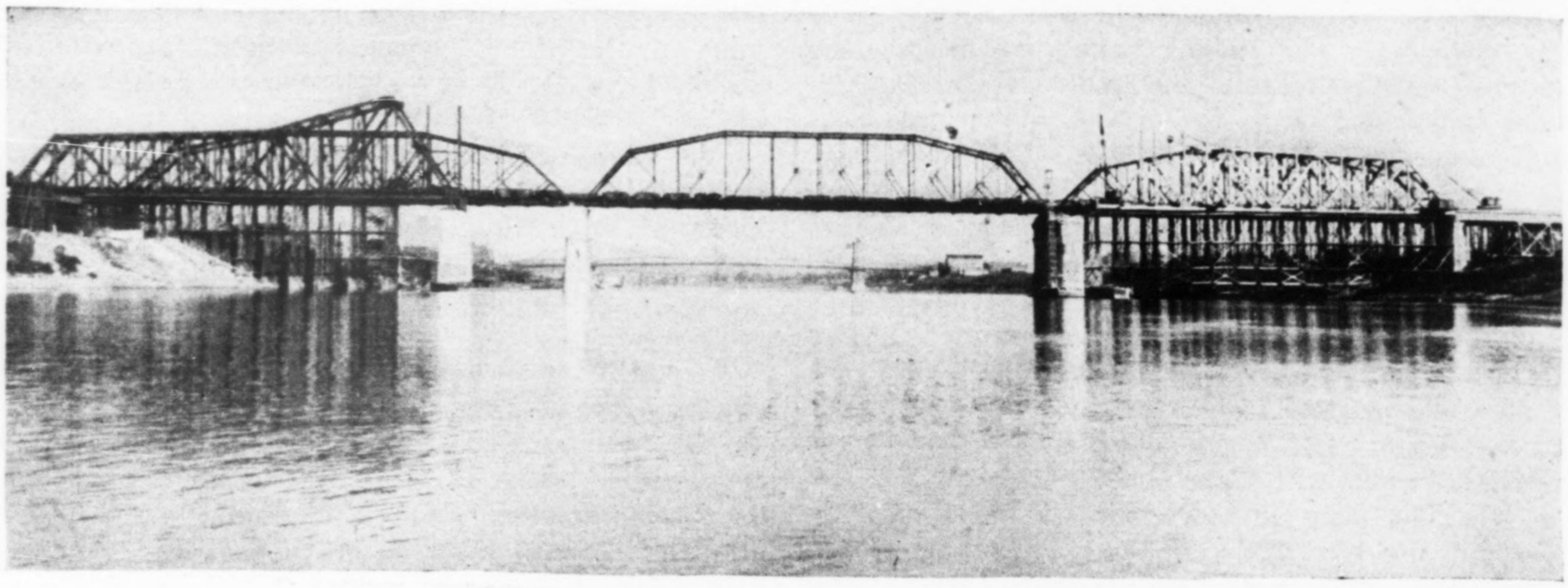


FIG. 1—ERECTING A 1,575-FT. CONTINUOUS TRUSS RAILROAD CROSSING OVER THE OHIO RIVER AT CINCINNATI
Sidespans erected on falsework. Old railroad bridge upstream to be converted to a highway toll structure upon completion of new crossing. Note widened channel (675 ft. c. to c. to piers) provided by new bridge.

Continuous Truss Bridge 1,575 Ft. Long at Cincinnati

Ohio River Structure Part of $12,000,000 Improvement Program of C. & O. Railway—Replaces Old Structure, Which Will Be a Toll Highway Crossing—Erection by Locomotive Cranes

ONE of the heaviest and longest continuous truss bridges in existence has recently been completed by the Chesapeake & Ohio Railway in connection with its improvement program in Covington, Ky., and Cincinnati, Ohio. The structure, a double-track E-70 silicon steel continuous truss bridge 1,575 ft. long center to center of end bearings with a center span of 675 ft. and two side spans of 450 ft. each, is to replace an old two-track E-40 bridge of three simple spans directly upstream. In fact, the river pier of the old bridge on the Kentucky side, has been extended to carry the south end of the new 675-ft. center span. The north end of the new center span could not be carried in a similar manner, because the War Department demanded a minimum span center to center of piers of 675 ft., whereas the distance between the channel piers on the old bridge is only 550 ft. The old bridge, in addition to carrying two railroad tracks, carried a highway deck cantilevered out on each side. The downstream cantilever deck interfered with the erection of the new bridge, so it was removed and all highway traffic was handled on the upstream roadway with the aid of block signals. With the completion of the new railway bridge, the tracks on the old bridge will be removed and replaced with a floor, thus revamping the structure for use as a highway toll bridge.

The old bridge was built in 1886-88 by the Covington & Cincinnati Elevated Railroad & Transfer & Bridge Company, a subsidiary of the Chesapeake & Ohio Railway. Entirely adequate for all expected traffic at that time, the bridge proved to be a bottleneck for the heavy traffic passing between Cincinnati and Covington in recent years. It was used daily by 34 passenger trains of the Chesapeake & Ohio and the Louisville & Nashville, all of which moved across the bridge twice, because both roads maintain engine terminals and coach yards on the Kentucky side. It was also used by other passenger trains and by many transfer trains handling freight.

Four elevated lines of railway track connect to the new bridge at either end. On the Kentucky side of the river, 1,600 ft. of old viaduct approach has been replaced by a new double-track plate-girder viaduct. This work is part of a grade-separation plan in Covington. The separation through the business part of the city has been accomplished by placing the railway approach to the bridge on a 0.3 per cent grade extending from the river to replace the 1 per cent grade of the old approach, thus permitting a majority of the streets to underpass the railway. Two streets have been closed to traffic and three of the streets farthest from the river are carried over the tracks. The Ohio approach has three arms embracing a total of about 6,200 ft. of steel viaduct and a considerable length of wood trestle. One of these branches goes to the Fourth St. station of the C. & O., another extends westward to a connection with the tracks of the Big Four and affords a means of access to the Central Union station, and the third connects with the Chesapeake & Ohio of Indiana.

This article will consider briefly the somewhat difficult foundation work, the design methods used on the statically indeterminate trusses and the methods of erection used, which were interesting and unusual largely because of the simplicity with which the entire work was handled by locomotive cranes without any interruption to traffic on the old bridge.

Foundation Work—The foundation work involved the construction of piers on both the Ohio and the Kentucky shores, the construction of a new pier 125 ft. shoreward of the old bridge pier on the Ohio side of the main channel and the extension of the old bridge pier on the Kentucky side of the channel a distance sufficient to carry the shoes of the new bridge. The latter work was rendered more difficult because the track level on the new bridge is approximately 3 ft. higher than on the old structure, a requirement made necessary to avoid a reduction in the established waterway headroom as a consequence of the use of a deeper floor system on the new structure.

For the river piers the caissons were sunk by open dredging and were covered over and subjected to air pressure only in order to clean out the working chambers and permit inspection of the foundation beds. Foundations were on shale and limestone overlain with 40 to 50 ft. of silt sand and gravel. The shore piers are monoliths of concrete, the north pier being of unusual design and size. It consists of a transverse wall about 60 ft. high and 12 ft. wide, braced by two counterforts under the truss bearings, having a length parallel to the bridge center line of 45 ft. 4 in. and a width of 15 ft. It is supported on 400 concrete piles in a footing 61 ft. square designed to resist the longitudinal wind and tractive forces on the 1,575-ft. span whose shoes are fixed at this end. Reinforced-concrete sheetpiles 8 in. thick and 25 ft. long placed on the north and south faces of the footing of this pier provide additional resistance.

The task involved in widening the south pier of the old bridge to carry the new bridge seat was the most interesting and difficult foundation work. The old pier was 79 ft. wide at the base, supporting on a shallow concrete block a rock-filled timber crib 35 ft. high, from the top of which the stone masonry pier rose some 100 ft. to the old bridge seat. The extension of the pier was accomplished by sinking a caisson 40 ft. wide and 50 ft. deep beside the old pier considering it as a separate foundation clearing the rough face of the old pier by about 10 ft. Above the top of the caisson the extension is joined to the old pier. The width of the extension is such that it lines up with a reinforced-concrete jacket 2 ft. thick placed around the old pier. In addition to dowels, this jacket includes steel channels set vertically above the belt course and held in place by tie-bolts passing through the old pier. The pier as completed is 121 ft. wide at its base and carries the old bridge with trusses 30 ft. center to center and the new bridge with trusses 34 ft. center to center, providing a clearance between the center trusses of 10 ft. 4 in. The weight of the upstream side of the new bridge is divided between the old pier and the extension.

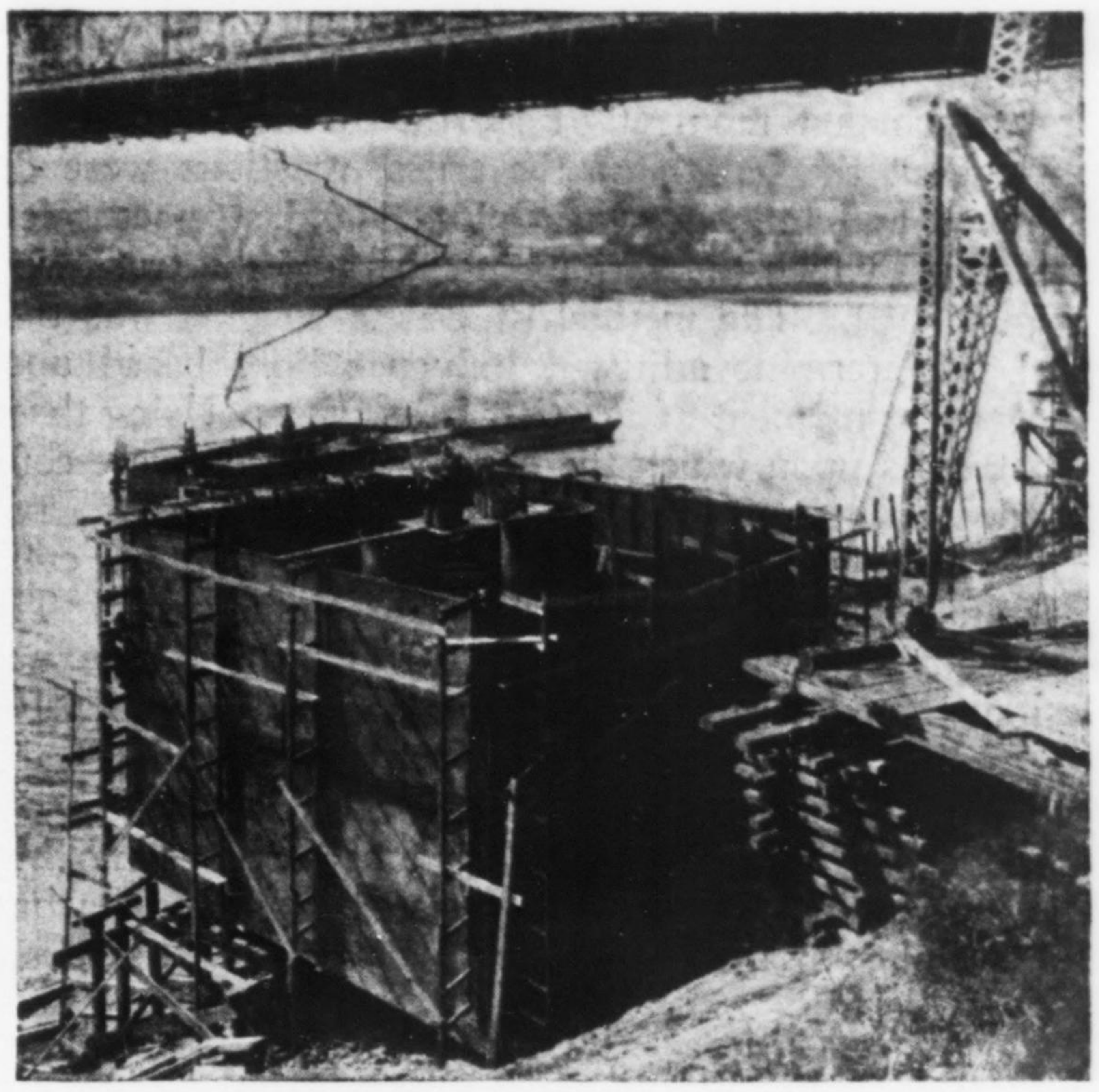


FIG. 3—CAISSON FOR SOUTH RIVER PIER BEFORE LAUNCHING

Note concreting work for north river pier in background; concrete brought out on track on old bridge in cars and spouted to place.

The concreting plant was placed on shore and was provided with an elevating tower of sufficient height to deliver the concrete to narrow-gage cars operating on a track carried on the roadway, which was bracketed to the west side of the old bridge. A gasoline locomotive hauled these cars across the bridge to the particular pier under construction, where the concrete was dumped into spouts as shown by Fig. 3.

Design—The bridge is one of the longest and heaviest continuous trusses in existence. Resting on four supports, it is fixed at the north or Ohio end and fitted with expansion shoes at both the river piers and at the Kentucky end. The continuous design permitted a saving in steel over a series of simple trusses, according to the designers. The use of silicon steel afforded a further decrease in weight with attendant economy which was advantageous particularly from an erection standpoint.

In the preliminary plan the chords were made closely parallel, the top chords sloping slightly. However, consideration of economy and appearance led to the adoption of a truss of considerably greater depth over the channel piers than in the outer ends of the side spans and the middle portion of the center span. This resulted in a truss with top chords not parallel to the bottom chord except in the middle part of the center span. The analysis of stresses in such a truss is considerably

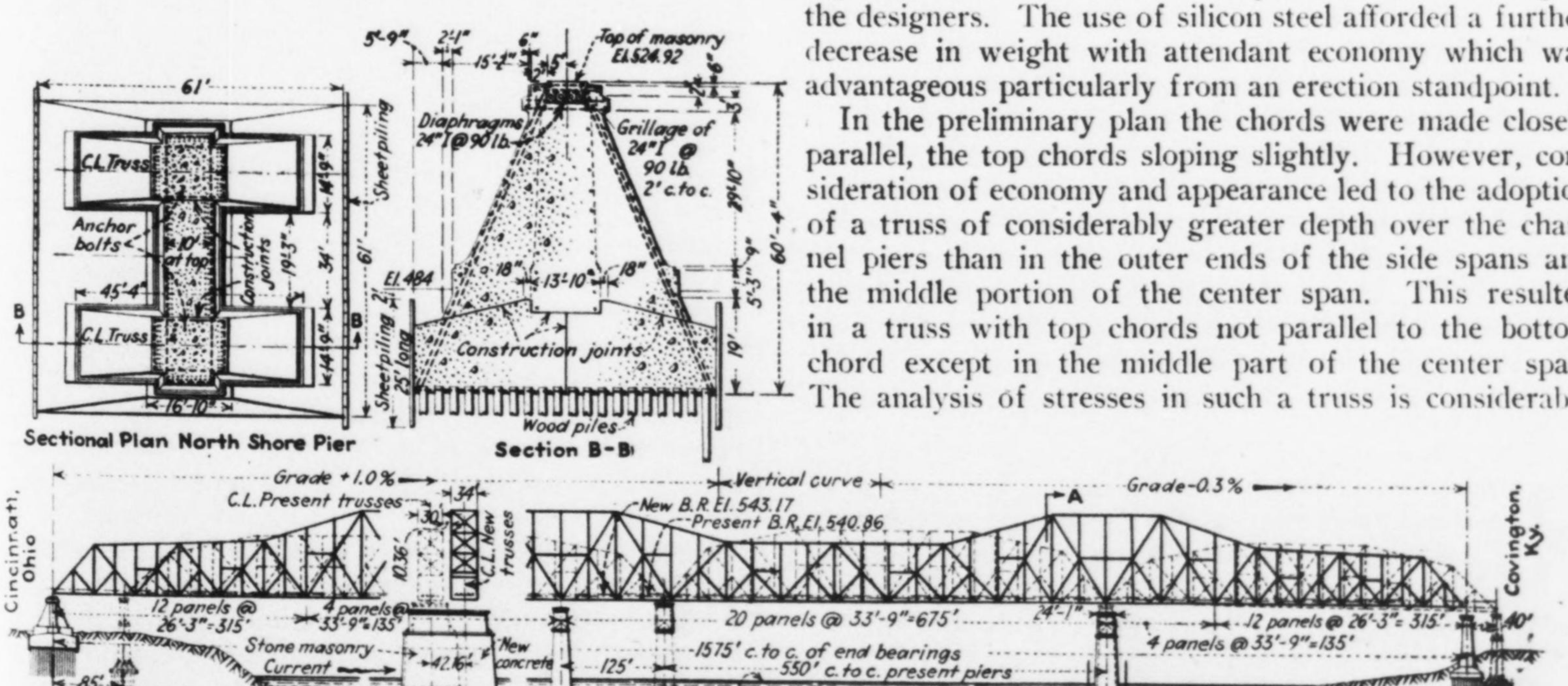
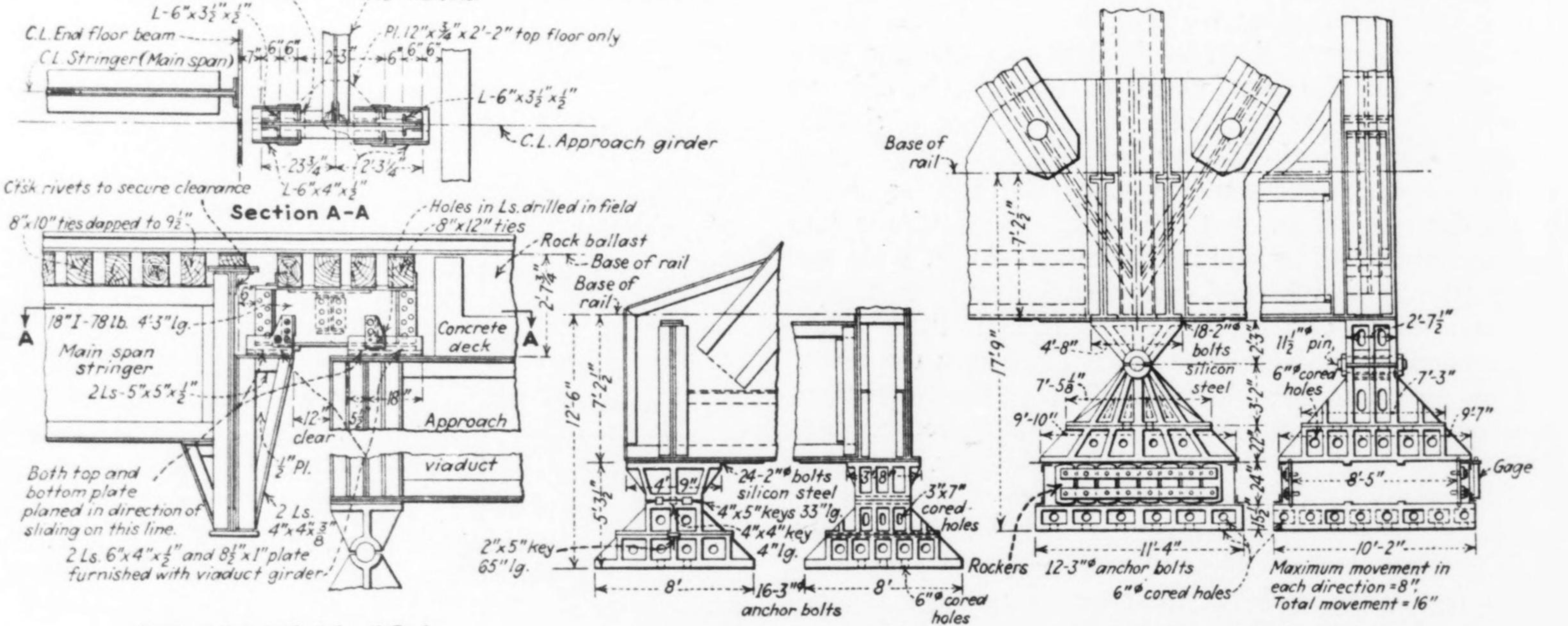


FIG. 2—ELEVATION OF 1,575-FT. CONTINUOUS TRUSS AND FOUNDATION DETAILS

more complex than in one with parallel chords. After assuming a weight of the finished structure and assuming first a constant moment of inertia of the truss section throughout the length of the truss, reactions were determined and influence lines plotted and stresses calculated from which the various members of the truss were proportioned. The method of elastic weights was then used to determine adjusted influence lines based upon the varying moment of inertia of the truss. Using these, the stresses upon which the design was based were computed.

The dead load was figured for steel at 490 lb. per cubic foot and track at 700 lb. per foot of single track. The live load used was Cooper's E-70 and the bridge was designed for lateral forces on the loaded chord of 1,100 lb. per linear foot plus 10 per cent of the specified train-load on one track and 400 lb. per linear foot on the unloaded chord, these forces being considered as moving. The longitudinal forces to be resisted from the starting and stopping of trains were calculated with a coefficient of friction on the engine drivers of 20 per cent and on the remainder of the train of 10 per cent.



Expansion Detail at South End

Fixed Shoe Ohio Shore Pier

Expansion Shoe Intermediate Piers

FIG. 4—SHOES AND EXPANSION DETAILS

Provision was made in the design for the erection of the two side spans on falsework supported on piles driven in the river bottom, with the halves of the center span erected as cantilevers. Large secondary stresses over the piers were relieved by giving extra section to the lower chord and the adjacent end posts. Also, the first hanger on either side of the pier was made $\frac{3}{8}$ in. short, and the lower chord jacked to a connection therewith so as to introduce a temporary secondary stress of opposite sign to that expected in the completed bridge, which was therefore relieved when the trusses were fully loaded.

An interesting feature of the fabrication was that the fabricator, because of crowded shop conditions, did not lay out the trusses in the yard, as is customary, but figured the length of the steel to produce the desired camber. With the lengths figured, the holes were reamed out with the aid of a steel templet.

The bridge is anchored to the north pier and an expansion joint of unusual design is provided at the south end of the structure, this joint permitting a longitudinal movement of 24 in. in the structure without disturbing the track. The detail of this expansion joint is shown in Fig. 4. In this same illustration are shown details of the fixed shoe of the north abutment and of the rocker shoe on one of the center piers. The other rockers used are similar, except that the one at the south end allows for a maximum movement in either direction of 11 in., or a total movement of 22 in.

Erection—In many respects the erection work on this important structure was its most interesting feature. It is believed to be the heaviest bridge yet erected by locomotive cranes. The elimination of the special traveler, which in addition to being expensive is unusually heavy and cumbersome, is said to have effected considerable saving in the erection cost.

As previously stated, the 450-ft. side spans were erected on an elaborate system of wooden falsework resting on wood piles in the river, while the center span was cantilevered from both ends to the center. The falsework is shown in place in Fig. 1. It was approximately 100 ft. high above pool elevation of the river. Its supporting piles were driven with a hammer and leads hung from a crane boom on the falsework deck. Piledriving was assisted by a barge in the river anchored so that one of its sides lined up with the falsework bent to be driven. The leads were lowered by the crane and clamped to this side of the barge. A double-acting steam hammer was used.

The approach viaducts were completed before erection of the main span was begun and thus gave access to both ends of the bridge for the 60-ton standard-gage locomotive cranes which erected the falsework and the steel superstructure. The Kentucky shore span was set longitudinally $6\frac{7}{8}$ in. north of its final position—that is, toward the river—to facilitate joining at the center of the bridge later.

The floor system of these side spans was erected on the falsework, steel being brought out from shore. With the floor system in place, the cranes picked the truss steel directly from barges in the river and set it in the bridge. At the completion of the side spans they were swung off the falsework and it was removed.

In erecting the center span by the cantilever method, working from both ends toward the middle, the heaviest and longest pieces occurred over the piers. Here the trusses were 105 ft. deep and the locomotive cranes were rigged with 145 ft. booms (Fig. 5). Where the trusses became shallower, the length of the boom was reduced, first to 120 ft. and later to 95 ft. Some time was lost in changing the booms, but it was necessary and not considered a material disadvantage. The greatest difficulty with the locomotive cranes was caused by troublesome high winds. However, special precautions were taken to anchor the cranes to their tracks and no accidents occurred.

In its final position the bridge is fixed on the Ohio shore pier and is free to move on the rockers at the three other piers. During erection, however, it was fixed by temporary lock bars at piers 2 and 3 (the river piers) and free to move at both land piers.

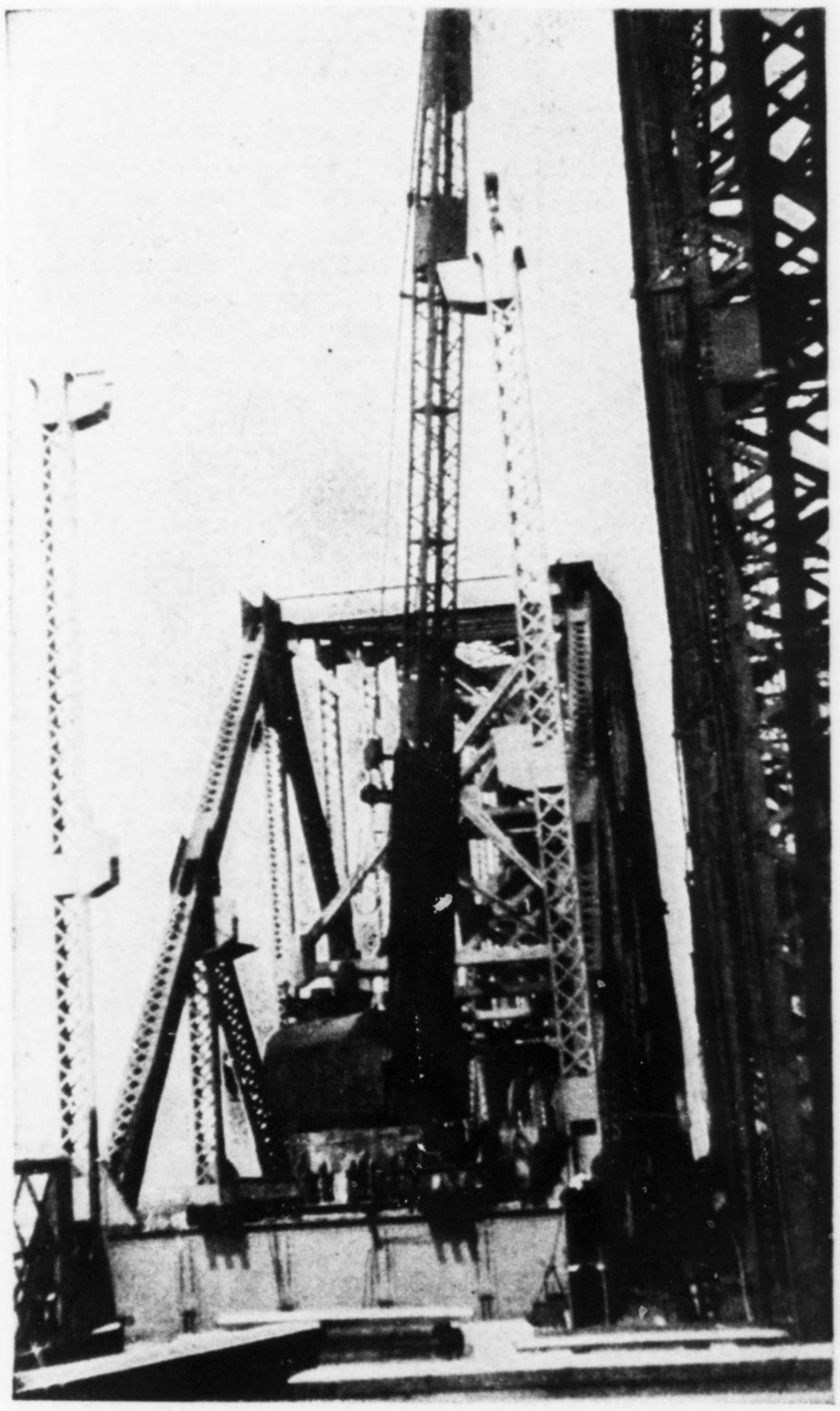


FIG. 5—LOCOMOTIVE CRANE SETTING HEAVY STEEL ON C.&O. RAILWAY BRIDGE AT CINCINNATI

At the middle of the center span the bottom chord members were first joined by a 9-in. pin in a slotted hole 15 in. long in the direction of the axis of the bridge. The ends of the shore spans at piers 1 and 4 were supported on jacks. As these were lowered, the effect was to raise the cantilever arms at the center of the 675-ft. span, thus providing end clearance for the closing top chord members. With these closing members in place, the ends of the shore span were raised until the top chords came to a bearing. The top chord splices were then bolted and the temporary lock bars removed from the expansion rockers on pier 3. This permitted the south half of the bridge to be moved longitudinally on piers 3 and 4. Jacking at the ends of the shore span was then resumed, and the raising of these ends resulted in pushing the south half of the bridge toward the shore until the 9-in. pins in the bottom chords reached the ends of the slotted holes. In this position the bottom chords began to take tension while the top chords began to take compression. The bottom chord splices were then bolted and jacking was continued until the shore ends were approximately at their final elevation. Then the shoes at pier 1 were fixed and the rockers at pier 2 were unlocked.

After the tracks were laid on the bridge in permanent form and the dead load was all in place, the bearings at the center piers were adjusted to proper elevation by jacking to bring the reaction at each of the shoes to the desired amount; shims were inserted at the shoes to hold the ends of the bridge at this correct elevation.

The Cincinnati-Covington bridge and the grade-separation work was handled under the direction of C. W. Johns, chief engineer of the Chesapeake & Ohio Railway, Richmond, Va., with G. G. Lancaster, assistant engineer at Covington, Ky., in charge. The erection of the superstructure was under the general direction of Richard Khuen, Jr., general manager of erection, and in direct charge of James L. deVou, central district erecting manager of the American Bridge Company. The J. E. Greiner Company, consulting engineers, Baltimore, Md., designed the bridge.

Letters to the Editor

A Forum for Discussion of Views of Engineers and Contractors

Traffic Accidents—Correction

Sir—Permit me to call your attention to an error in your Oct. 10, 1929, issue, in which you quote from my paper on traffic accidents, stating that "traffic-light intersections are 50 per cent more hazardous after signalization," whereas the paper stated that "light traffic" intersections were more hazardous following signalization, meaning by the words "light traffic," intersections having traffic below an average of 800 vehicles per hour.

As it is set up in *Engineering News-Record*, the statement is a direct contradiction of the statement just preceding it.

HAWLEY S. SIMPSON,
Traffic Engineer,
County of Essex, New Jersey.

Newark, N. J.,
Oct. 15, 1929.

Meetings and Papers of the American Society of Civil Engineers

Sir—There are two items referring to the American Society of Civil Engineers in your issue of Oct. 17 which will bear considerable emphasis. The first is your editorial about "Specialization" and, by the by, there's a booklet by Chic Sale about that. Really, however, I feel that for myself I have received incalculable benefit from the papers read in the old days at the meetings of the society in New York about those branches of the profession about which I knew very little. Items of information garnered at these meetings have been extremely valuable to me in connection with my own specialty, and I believe that the conventions would be more valuable if all those attending were brought together at one meeting place to hear the papers to be presented. That paper at Boston on the Lake Champlain bridge should have been interesting to every engineer, and