Bascule Bridge with All Mechanism Below the Deck

Six-Track Plate-Girder Bridge in Four Parallel Units—Trunnions Mounted on Tall Steel Bents—Construction Kept Clear of Main Tracks—Cars Haul Concrete from Mixer Plant

A SIX-TRACK bascule bridge having an 85-ft. plate-girder deck span, with all operating machinery and the counterweights housed below rail level, was built in 1925 by the Illinois Central R.R. for its crossing of the Little Calumet River at Riverdale, just south of Chicago. In connection with track elevation at this point it was necessary to build a new bridge, and as this river is classed as a navigable stream (though not now navigated) the War Department required that a drawspan should be provided to permit future navigation.

To meet this requirement, a special design was made for a bascule bridge of the trunnion type, to be built as a fixed span, resting on its end seat and trunnion bearings. The operating machinery, counterweights and end-lock apparatus will be installed at some later time when the opening of the bridge becomes necessary. Two flanking spans of 60 and 65 ft. complete the new structure, which is shown in Figs. 1 and 2. The old structure, prior to 1919, consisted of one 171-ft. double track through plate-girder draw span, with one single-track 40 ft. deck plate-girder span for each track at the south end, all resting on dressed stone masonry. In 1919, two additional tracks were provided. For these, two 90-ft. single-track plate-girder through spans on pile piers were set to the west of and opposite the south arm of the draw, flanked with an open deck pile trestle approach at either end.

Bascule Span—In the present arrangement, there are six tracks, spaced 13 ft. c. to c., except that the last two tracks on the west side are spaced 26 ft., leaving room for a future seventh track, so that the total width over the girders is about 87 ft. From the cross-section, Fig. 3, it will be seen that across the river channel each track is carried by a pair of girders, spaced 8 ft. 10 in. c. to c. In addition to the cross frames and lateral bracing for the girders of each track, it will be noted that the adjacent girders of tracks 2 and 3 and tracks 4 and 5 are also connected by bracing so as to form two double-track structures. Ordinarily the entire bridge, thus consisting of two single-track and two double-track units, will be operated simultaneously by six motors on the trunnion pier, geared to line shafting having an operating pinion for each girder. In case of needed repairs, the double-track spans can be separated from the other units, so that the span needing attention can be left in the open position while repair work is done, leaving the remainder of the bridge in operation. When fully open, the bascule span will stand at an angle of 77 deg. from the horizontal.

Each of the bascule girders, Fig. 4, is 10 ft. deep and has a ½-in. web-plate reinforced by additional plates at the hole for the trunnion, which is a pin 16½ in. in diameter and 3 ft. 8½ in. long. The top chord is of double channel section, formed by four angles, with reinforcing plates riveted against the vertical legs of the angles. This chord has no cover plates. The bottom chord has two flange angles and three cover plates. Below the trunnion and under the bottom chord are two segmental rack plates, 6 in. apart, between which the cast steel rack is fitted and secured by turned bolts. In the tail end of the girder is a hole for a 6½-in. pin, 15½ in. long, from which the counterweight is suspended.

These girders are 105 ft. long, including the 17-ft. tail ends. As their tail ends extend beyond the pier and into the adjacent 60-ft. fixed span, the girders for each track of the latter span are spaced only 6 ft. c. to c., so as to fit inside the 8 ft. 10 in. spacing of the bascule girders, as shown by Fig. 3. To provide for the electrification, which will soon be extended across the bridge, the girders have structural steel brackets to carry posts with overhead transverse and longitudinal ribs and bracing for the support of the overhead trolley-wire system.

For the tracks, 90-lb. rails are laid on tie-plates on long-leaf yellow-pine ties 10x10 in. and 12 ft. long, spaced 14 in. c. to c., each tie being bolted to the flange angles of the bascule girders to prevent creeping. Inside 75-lb. guard rails, without tie-plates, are spaced 8 in. clear from the track rails; outside guard timbers 6x8 in., dapped 2 in. and laid flat, are bolted to the ties.

Trunnion Tower—In view of the approaching electrification of this part of the line, it was necessary to avoid any overhead construction that would interfere with the trolley line. But with the counterweights hung below the tail ends of the bascule it was necessary to provide room for them to swing under the trunnion bearings as the bridge opens. This condition made it impracticable to carry up a masonry pier to support the trunnions. The plan adopted was to build this pier a little above high water level and on it to erect steel bents 31 ft. high, capped by the trunnion bearings, as shown in Fig. 3. Then the counterweights were designed to swing between these bents. With this arrangement there can be no continuous bracing to form a tower, but the bents are partially connected transversely and the end bents have brace bents seated on the pier, as shown.

These steel bents are shown in Fig. 5. In the ordinary construction, the trunnion post is composed of four angles and two 17-in. web plates with tie-plates on the open sides, while the bracing post has four angles laced on two sides. A transverse 12-in. I-beam carries an oak bumper to engage the tail ends of the bascule girders when the span is in full open position. Bracket plates on the brace posts of all bents form supports for the line shafting, while bracket plates on the trunnion posts of the intermediate bents carry pin bearings for the counterweight links.

Certain of the tower bents, however, have to carry the girders of the adjacent 60-ft. fixed span. Here the trunnion post has web plates 34 in. wide and is reinforced by a transverse 10½-in. web plate or vertical diaphragm riveted to a pair of interior angles. The brace post is composed of four angles and two web plates. At the top of the bent, the land side of the trunnion post is cut away and carries a 4½-in. pin form-

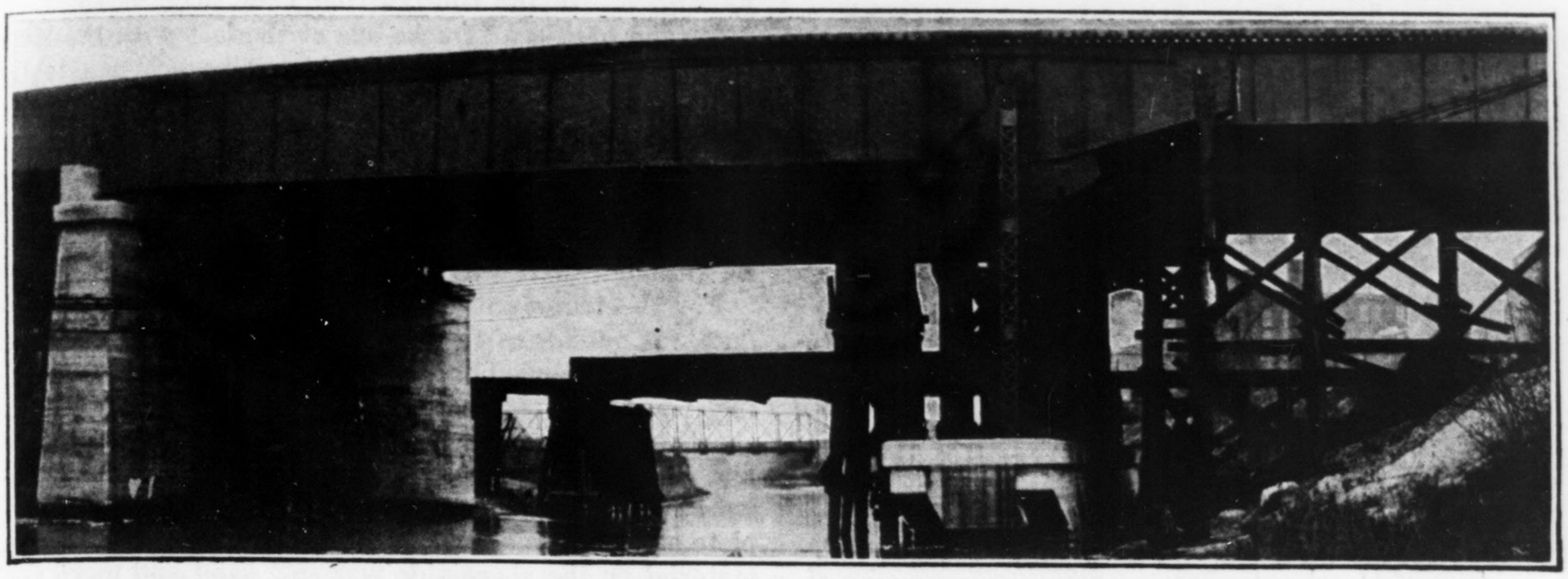

FIG. 1—DECK-GIRDER SIX-TRACK BASCULE BRIDGE
Note segmental rack girder under trunnion, and hanger for counterweight at tail of bascule girder. Plate-girder bridge beyond carries low-level side track.

ing the shoe bearing of the fixed girder. A vertical member seated on the brace post supports a 15-in. I-beam which carries the bridge deck from the end of the fixed span to the break in floor of the bascule span.

Concrete cantilever brackets on the west end of the trunnion pier will carry a tower for the operating house. Platforms on the bents will support the operating machinery, which is of simple design, as already noted. No end locks will be fitted until this machinery is installed, and for the present, while the structure constitutes a fixed bridge, no end rail connections are placed, the track rails being laid continuously across the bridge.

Underhung Machinery—In view of the number of tracks, the great width of the structure, and the installation of overhead trolley wires in the near future, it was not desirable or economical to provide a tower over the tracks to carry the machinery and counterweights, and a special feature of the design is that all this equipment is arranged beneath the tracks. The operating racks are attached to the bottom chords of the girders, as noted above, and the counterweights will be suspended from the tail ends of these girders. These counterweights will swing through between the steel bents carrying the trunnion bearings and machinery, and in order to provide sufficient weight to balance the span, there will be but little clearance from the columns. With the bridge closed, the counterweights will be housed between and below the tail ends of the bascule girders. For each counterweight, there are two triangular steel trusses suspended from pins in the girders and embedded in a concrete block of the form shown. In swinging, the block is guided by a pair of bars or links pivoted to pins in the block and on the steel bents. These counterweights weigh from 101 to 132 tons each, with a total of 688 tons.

Steel Erection—Four tracks were kept open to traffic during construction and erection work. Starting from the east side, the steel for new track 6 was erected first, track 5 having been put out of service. Steel for track 6, with the exception of the bascule spans, was placed from track 6 by derrick cars. Girders for the bascule span were set from track 5. Steel for track 5 was then set from track 6 with derrick cars, tracks 1, 2, 3 and 4 being open to traffic. Steel for track 4 was in turn set from track 5, tracks 1, 2, 3 and 6 being open to traffic. This method was continued across to track 1, which was set from track 2. All erection was handled from above with derrick cars, the track under construction and the one next east of it being put out of service.

Substructure—A trunnion pier, a rest pier and two

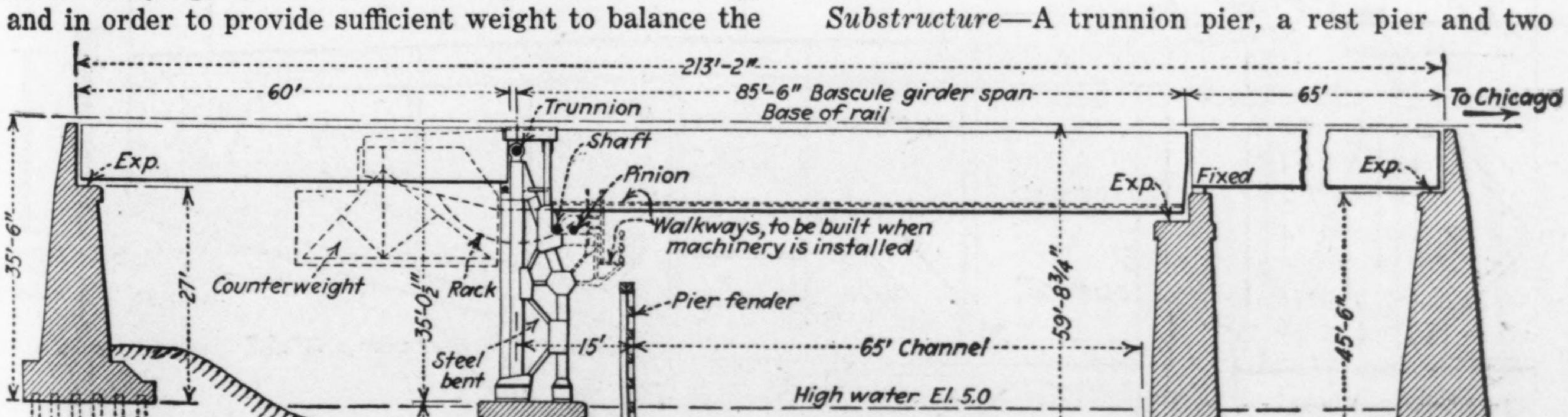

FIG. 2—LITTLE CALUMET RIVER BRIDGE; ILLINOIS CENTRAL R.R.

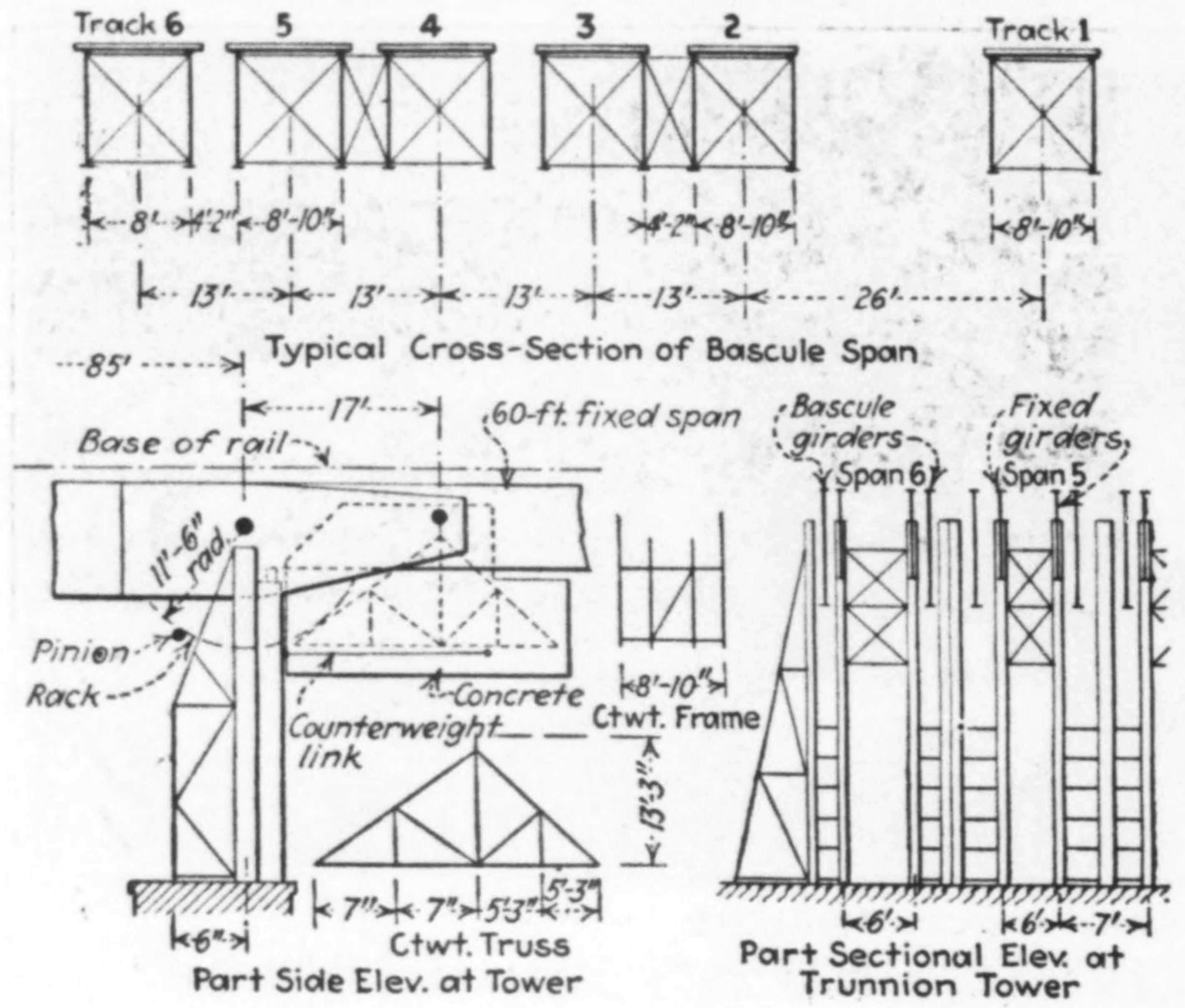

FIG. 3—TRUNNION TOWER AND SECTION OF BASCULE

abutments constitute the substructure. The piers are of monolithic concrete without reinforcement, but the abutments are of a semi-reinforced type, made considerably thinner than the standard gravity design and having bars in the back to take the tension. All these are founded on wood piles in a gravel formation. At the south abutment, creosoted piles are used, as it is on relatively high ground, with its footing above high-water level. This substructure involved the placing of 7,400 cu.yd. of concrete, 1,529 piles and 58 tons of reinforcing steel. It was commenced in October, 1924, and completed on April 1, 1925, one month ahead of the contract time. The working force averaged 100 to 150 men.

Substructure Work—Construction of the foundations and substructure was attended with difficulties due to the lack of room, the necessity of keeping clear of traffic over the old four-track high-level main tracks and the single low-level transfer track. This work was complicated also by the presence of falsework which had been built to carry the high-level tracks during the reconstruction work, to permit the removal of the two old masonry piers. This temporary structure is shown by Fig. 6. In the construction view, Fig. 7, the new piers and high-level tracks are at the left with the low-level transfer track at the right. All work had to be done without occupying or interfering with the railroad tracks. Cofferdams of 26-ft. steel sheetpiling were built, the piles being driven with a portable steam pile-hammer. Only one row of sheeting was necessary, as the blue clay was so dense that very little water came in, although there was a head of about 20 ft.

For the trunnion pier, the river front of the cofferdam was outside of the falsework, while the wings were inside and extended back into the bank. No steel sheeting was used on the land side, where 3-in. timber sheeting was placed. For the rest pier the river side and east wing of the cofferdam were outside the falsework, while the back was inside the falsework. A complete steel cofferdam was required for this pier, as the material on the shore side was soft sand and muck for about half way down, where the clay was reached.

Excavation was done with compressed-air spades, the material being handled by buckets and derricks and dumped into 1-yd. narrow-gage cars which were run about 100 to 300 ft. to a dump. The depth from base of rail to bottom of concrete was about 60 ft.

Timber foundation piles were driven by steam hammers and a drop hammer, giving an average penetration of 18 ft. below cutoff. At two of the foundations an overhead traveling crane was rigged beneath the temporary bridge to carry the steam hammer, as there was no room for a derrick from which to sling the hammer. The crane bridge, 25 ft. long, was mounted on grooved wheels on rails laid upon timber wales bolted to the falsework at about 6 ft. below base of track rails. On the crane bridge was a traversing trolley from which the steam pile hammer was suspended, so that with the movements of the crane and trolley the hammer could be spotted over any desired location.

For handling excavation, piling and cofferdams there were three stiffleg derricks with 50-ft. booms and a self-propelling locomotive crane. On one side of the main-line fill, the railroad has a transfer track on the ground level; the crane track was laid between this transfer track and the fill so that the boom could reach under the bridge. On the other side of the fill, at ground

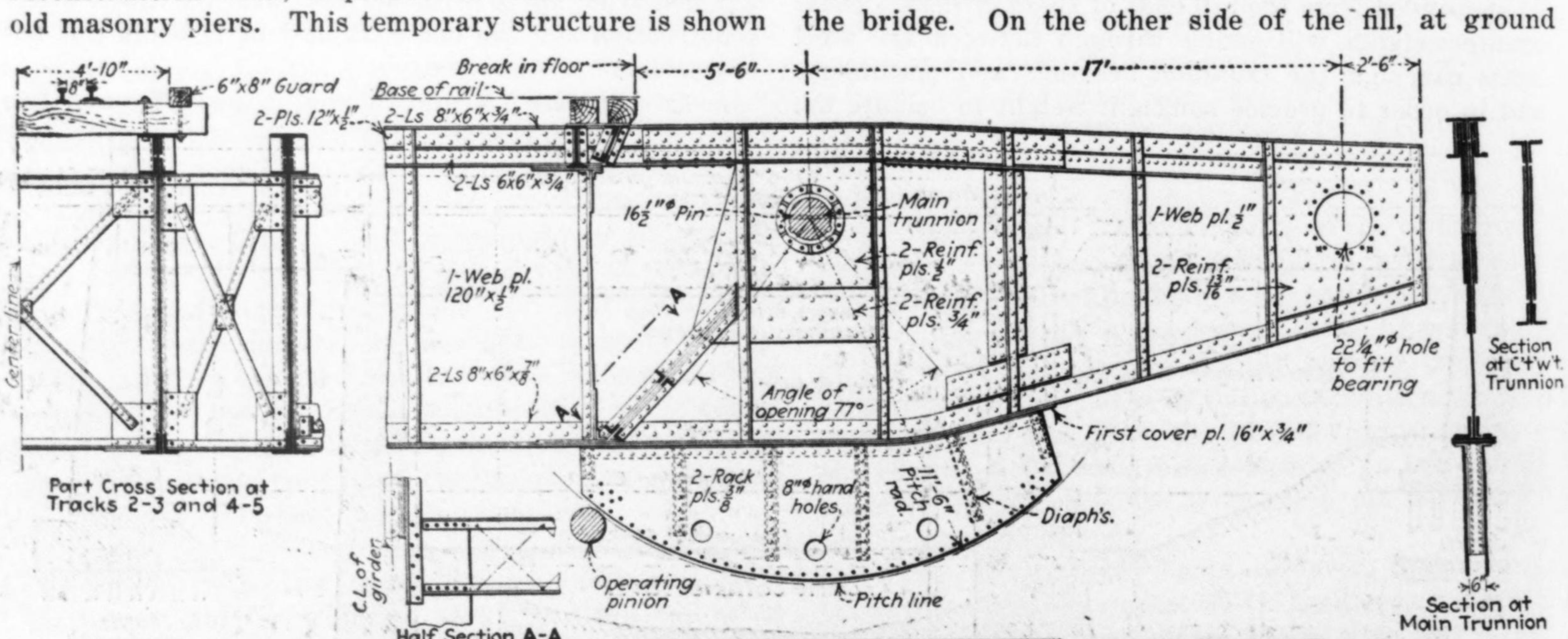

FIG. 4—TRUNNION END OF BASCULE GIRDER

level, were the derricks, so placed that the booms would clear the steel spans and reach under them. The headroom above water level was about 35 ft.

Handling Concrete—Haulage of concrete from a mixer plant about ¼ mile north of the bridge was made necessary by the fact that at no nearer point was it practicable to locate this plant. It was placed on low

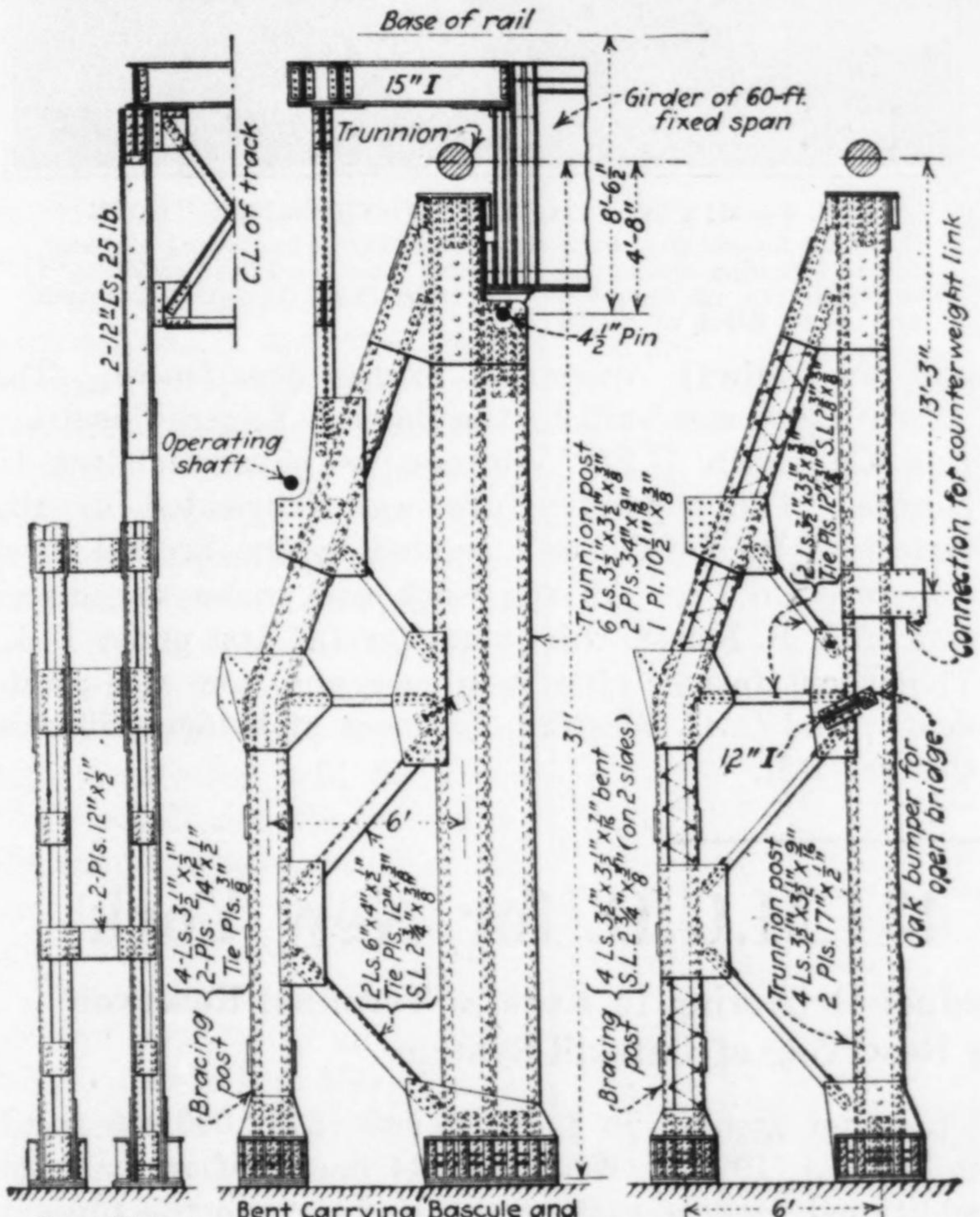

FIG. 5—STEEL BENTS CARRY TRUNNION BEARINGS

ground on the east side of the railroad fill. All material was brought in on railroad cars, the gravel and sand being unloaded by derricks into a stockpile sufficient for about 3,000 cu.yd. of concrete, as shown by Fig. 8. Cement was stored in a shed.

Derricks delivered the gravel and sand to bins of 30-yd. capacity over a 1-yd. mixer, which discharged the concrete into an elevator bucket in a wooden tower.

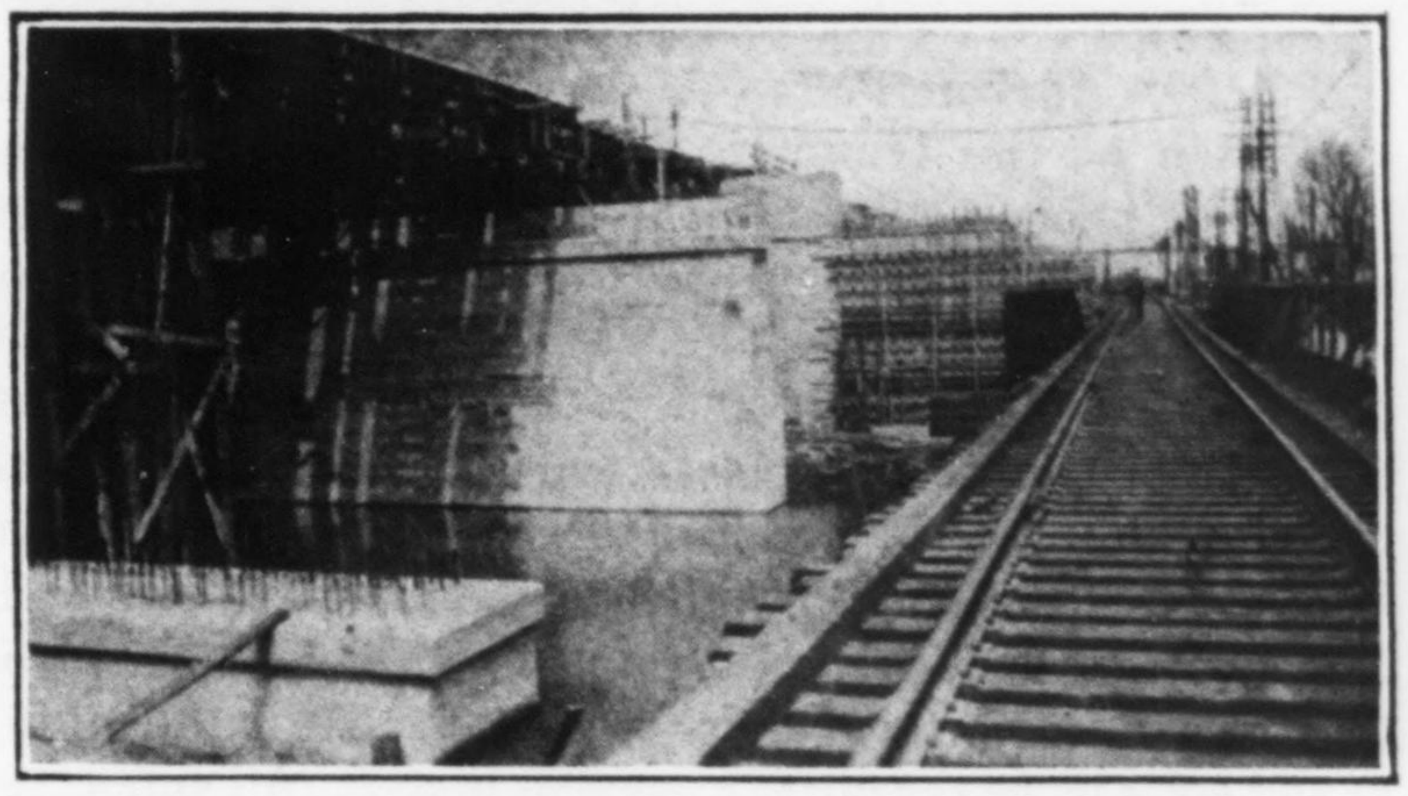

FIG. 7—SUBSTRUCTURE FOR NEW BRIDGE
Trunnion pier at left, with rest pier and abutment beyond. High-level main tracks on temporary structure at left. Low-level side track at right. In distance, note bridge for concrete trains spanning this track.

A bridge at main-track level, spanning the low-level transfer track, was run from the railroad fill to the tower, passing on one side of it, so that concrete could be spouted from the elevator bucket to the 1-yd. bottom-dump steel cars. These cars, with a gasoline locomotive, operated on a track of 24-in. gage laid along the shoulder of the fill. Trains of two or three cars were handled. Fig. 8 shows a locomotive with three cars standing at the tower ready to take a load of concrete.

For delivery to the forms of the trunnion pier and south abutment, the construction track was carried on a bridge cantilevered out from the falsework and from the outside of the 60-ft. temporary girder span over the main channel. The cars dumped the concrete into steel chutes which discharged at the required position. Reinforcing steel was secured by tie-wires so that it would not be displaced by the concrete. All form work was of wood.

As this was winter work, provision had to be made for heating the materials and protecting the concrete. Sand and gravel were heated by steam from a boiler, led to perforated pipes and well-points laid under the stockpiles and through jets into the hopper. This heating was continuous, whether or not concreting was in progress. During concreting, the water also was heated. At the end of each day, the concrete in the forms was protected by a complete canvas covering, under which coke-salamanders were kept burning.

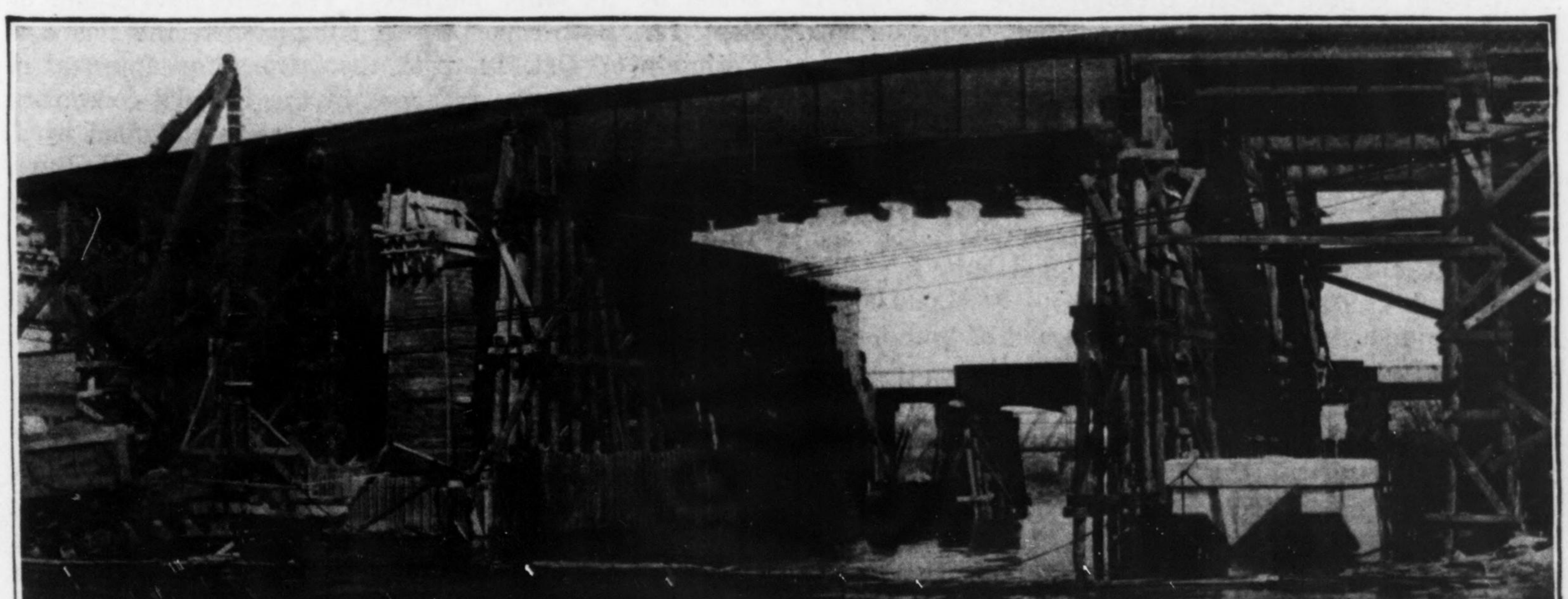

FIG. 6—TEMPORARY BRIDGE DURING SUBSTRUCTURE WORK
Girders of channel span on timber towers. Steel cofferdam of rest pier in place at left. Completed trunnion pier at right, with trestle approach beyond.

Placing Anchor Bolts—A peculiar and troublesome condition at the trunnion pier was the placing of a forest of anchor bolts for the steel bents of the seven parallel track spans. There were 219 bolts, 3 in. in diameter and 4 to 12 ft. long. It was necessary to place these in exact position and to hold them in position while the concrete was placed around them. One main templet and several supplementary templets above it held the bolts in position. Below the main templet and 2 ft. above their lower ends, the bolts were held between two 2x8-in. sticks wired to the form. At mid-length of the bolts were temporary wooden braces. All supports were so closely spaced that it was not an easy matter to find places through which to pour the concrete. Careful instrument work was done by the railway engineers to insure exact location of the bolts to fit the future steelwork and maintain them in position.

Engineers and Contractors—The Calumet River bridge is designed for Cooper's E-60 loading, with an impact allowance of live-load squared and divided by live-load plus dead-load, according to the railway company's specifications. Its bascule span was designed under the patents of the Strauss Bascule Bridge Co., the details being worked out jointly by this company

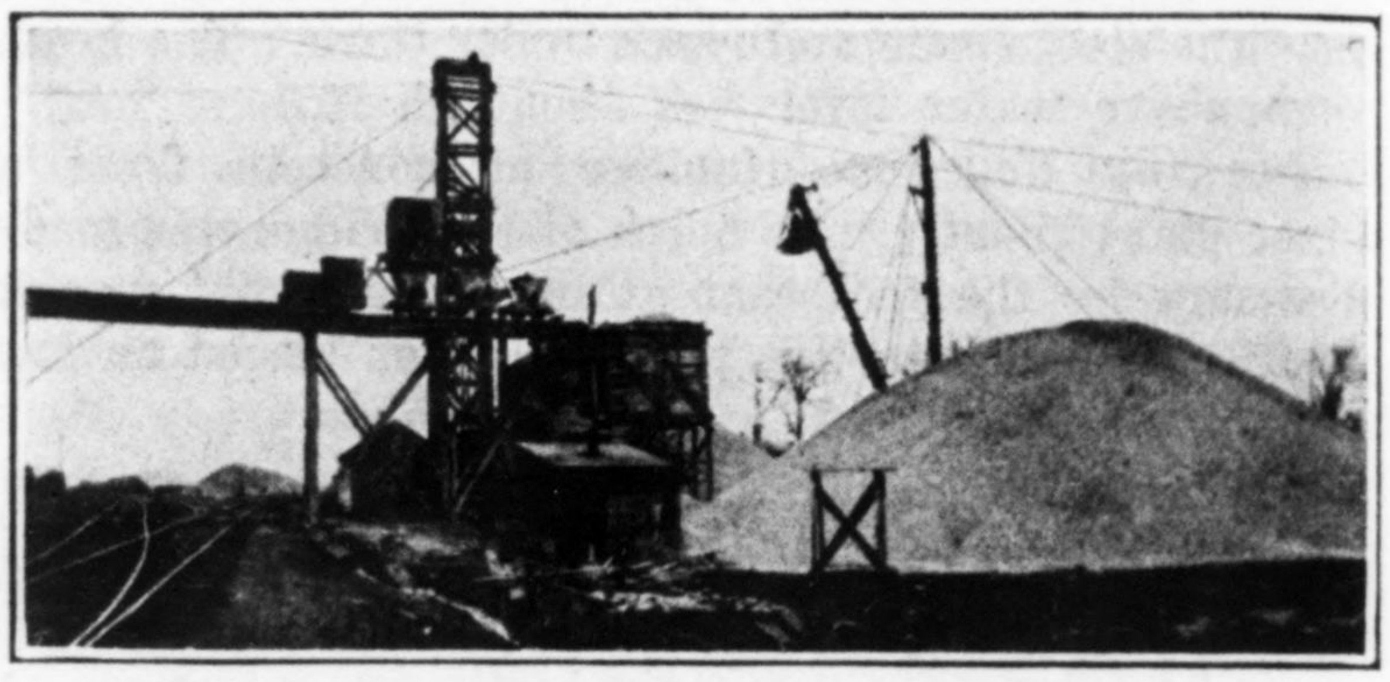

FIG. 8—MIXER PLANT AND CONCRETE TRAIN
Gasoline locomotive with three cars being loaded at elevator tower. Bridge spans the low level side track and extends to embankment of high-level main tracks. Material hoppers and stock piles at right.

and the railway company's bridge department. The substructure was built by the Bates & Rogers Construction Co., with E. S. Whitney as superintendent in charge. The superstructure was fabricated by the American Bridge Co. and erected by the Strobel Steel Construction Co. All the work was under the direction of A. F. Blaess, chief engineer (at first under F. L. Thompson, former chief engineer and now vice-president); and C. C. Westfall, engineer of bridges, Illinois Central R.R.

Additional Water Supply of 434 M.G.D. for New York

Gravity Sources East of Hudson River with Aqueduct Delivering to Kensico Terminal Reservoir and Thence to Hill View Equaling Reservoir of Catskill System

A PLAN for an additional water supply of 434 m.g.d. for New York City, to be drawn from streams east of the Hudson River, has been submitted to the Board of Estimate and Apportionment by the Board of Water Supply. Except for 12 m.g.d. to be obtained from an undeveloped portion of the Croton drainage area, all of this additional supply would be impounded in a string of reservoirs extending northward from the present Croton drainage area nearly to Troy. All the water would be delivered into the present Kensico storage reservoir at the southerly end of the existing Catskill aqueduct. In addition to the 434 m.g.d. of new supply so delivered, 121 m.g.d. would be diverted from the present Croton system through three reservoirs in the Croton drainage area, one of which would be new, although two are from a portion of the Croton drainage area already drawn upon. By means of the diversion from these three Croton reservoirs over a third of the water from the Croton system, the safe yield of which is 336 m.g.d., may be delivered by gravity at a considerably higher elevation than is now possible.

The estimated cost of the additional supply of 434 m.g.d. is $347,934,000, of which about $183,000,000 is for new aqueducts, not including the cost of gate houses and control works, the balance being for dam and reservoir construction. The total sum named, however, does not include $67,249,000 for a new delivery tunnel from the Kensico reservoir through New York City, recommended by the Board of Water Supply, Dec. 30, 1924, but not yet acted upon by the Board of Estimate. This delivery tunnel, which is deemed highly necessary regardless of the proposed additional supply, would bring the total cost of needed water-supply construction up to $415,183,000. This does not include a final total investment in the new Catskill system which will altogether amount to $188,000,000 [$182,000,000 spent to Dec. 31, 1925]. With the 434 m.g.d. of water from additional sources east of the Hudson and the present sources of supply, there would be available 1,534 m.g.d. of safe yield against an estimated consumption in 1947 of 1,529 m.g.d., leaving a margin of only 5 m.g.d. The estimated time for completing the works recommended is 15 years, so assuming a beginning in 1927 the works on completion would, with the earlier works, give a safe yield already nearly exhausted by the prospective consumption.

The recommendations of the Board of Water Supply, summarized above, are based on a report made to the board by its chief engineer, Thaddeus Merriman, on Sept. 12. Both reports were submitted to the Board of Estimate on Oct. 14, with resolutions for approval of the plan, and were referred to the board's committee as a whole. Mr. Merriman's report is endorsed by J. Waldo Smith, John R. Freeman, and William H. Burr, consulting engineers to the Board of Water Supply. The members of the board are George J. Gillespie, president, James P. Sinnott and Philip F. Donohue.

In the introduction to his report, Mr. Merriman states that during the past nine years the water consumption in New York City has increased at the average rate of over 31 m.g.d. per annum, the averages for 1916 and 1925 being 566 and 847 m.g.d. The total safe yield of all the sources of water supply of New York City is now 1,100 m.g.d., distributed thus: Catskill system, including the Bronx and Byram Rivers, 600 m.g.d.; Croton, 336; Ridgewood (old Brooklyn supply on Long Island), 90; various borough sources, 30; private water companies, 44 m.g.d. Of these sources only the Ridgewood could be developed to produce more, but that would yield only 30 m.g.d. additional; while among the