Grand Trunk Relocates Its Line Through South Bend, Ind.

New Elevated Line Eliminates Street and Track Crossings—Six-Span River Bridge—Erection Methods

BY A combination of relocation and track elevation through the city of South Bend, Ind., the Grand Trunk Western Railway has eliminated all its fifteen street crossings at grade as well as a grade crossing of the tracks of the New York Central Lines, and has obtained access to a new union station. A somewhat spectacular feature in the construction of the new line was the erection of a six-span plate-girder bridge across the St. Joseph River, shown in Figs. 1 and 2.

South Bend's rapid development as an industrial center made the many existing grade crossings dangerous and inconvenient. The double-track main line of the New York Central traverses the city diagonally from northwest to southeast. The old single track of the Grand Trunk Western Railway, entering from the east, ran due west along Division St. and then turned southwest, crossing the New York Central Lines at grade. After extended negotiations, both railroads entered into separate contracts with the city in 1924, agreeing to elevate their tracks, to build about 25 street subways and to maintain separate stations. In 1928, however, an agreement was consummated between the city and the two railroad companies whereby the route of the Grand Trunk Western was to be altered so as to enable it to join the New York Central and use jointly with the latter company $1\frac{1}{2}$ miles of its elevated line, as well as a new station to be constructed for the use of both railroads as a union station.

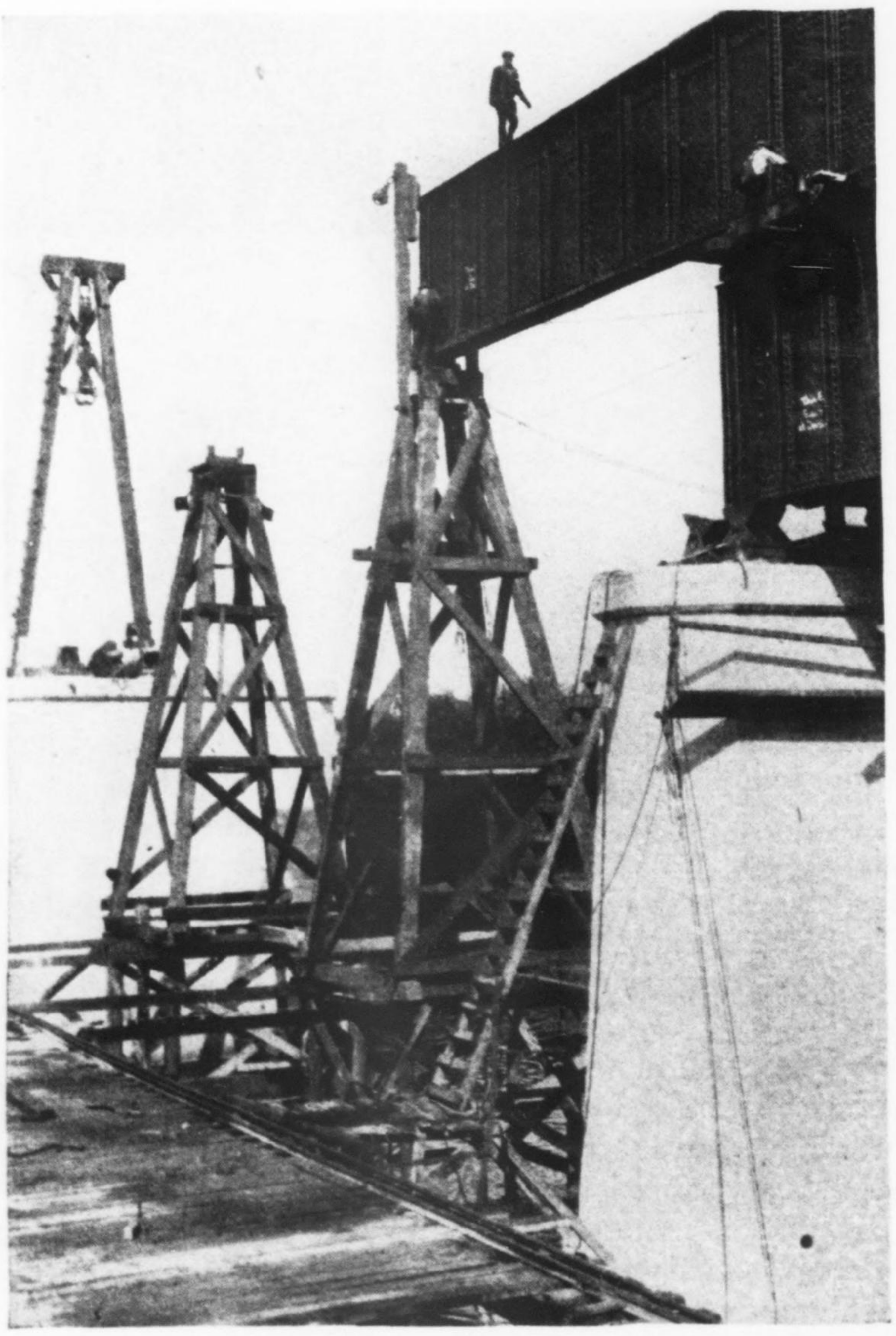

FIG. 1—LAUNCHING GIRDER FOR RIVER SPAN

Rear end held and pushed by locomotive crane, as forward end is outhauled by gallows frame. Temporary towers form intermediate supports.

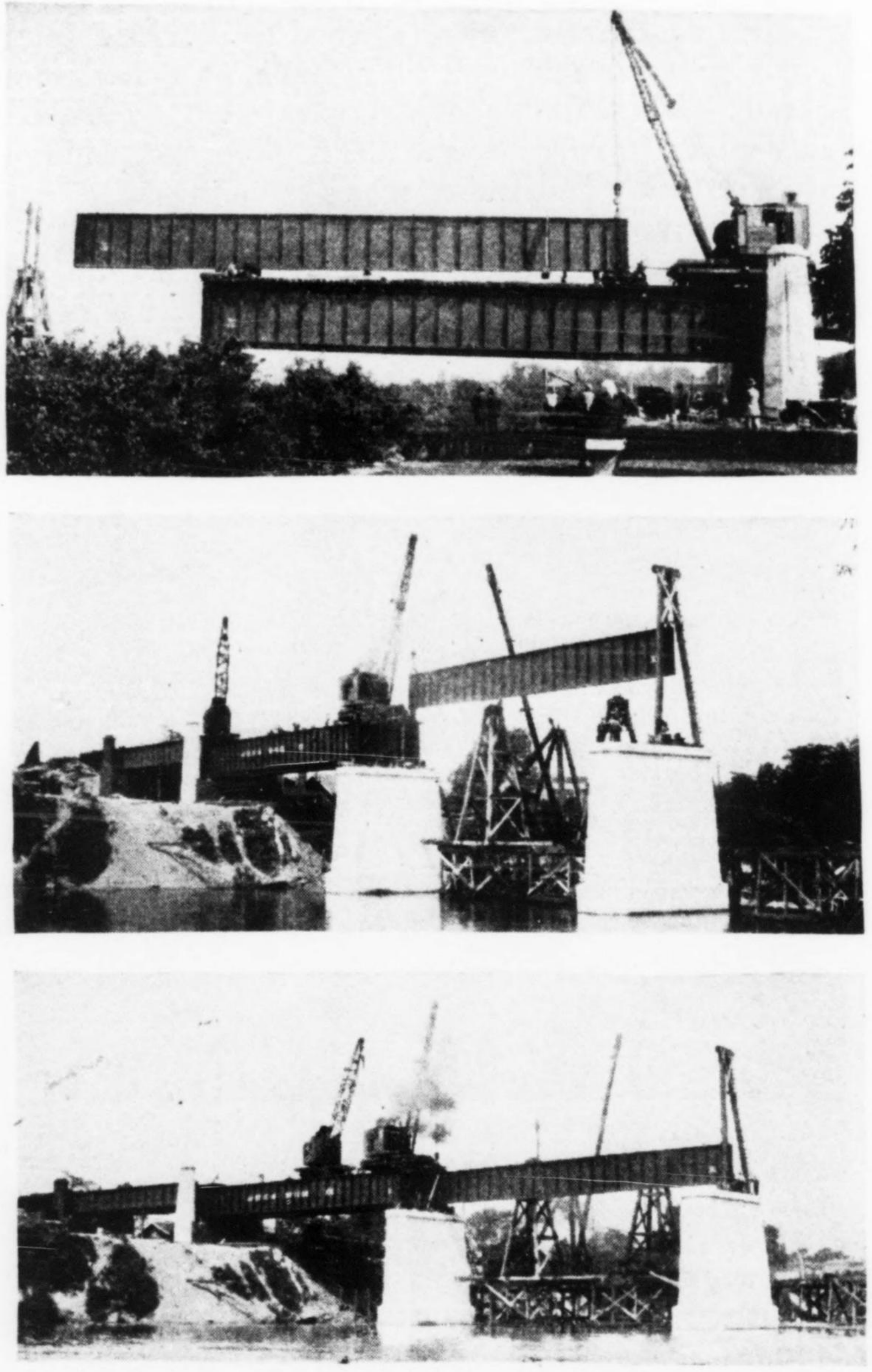

FIG. 2—ERECTING A GIRDER, ST. JOSEPH RIVER BRIDGE

Top—June 5, 4:20 p.m.; girder being pushed out on car trucks to first temporary tower. Middle—June 6, 10:40 a.m.; girder swung clear by crane and gallows frame and ready to be lowered when temporary tower is removed. Bottom—June 6, 10:50 a.m.; girder landed on its bearings.

Under this agreement the Grand Trunk Western has constructed 1.3 miles of double-track railroad, with all grade crossings eliminated, to connect with the New York Central and will divert its traffic to the new line and station early in October. On the Central, the track elevation has a length of about $2\frac{1}{2}$ miles and consists mainly of an earthfill between concrete retaining walls, with steel bridges over the streets. The new union station occupies the site of the old New York Central station.

From the map (Fig. 3) it will be seen that on the east

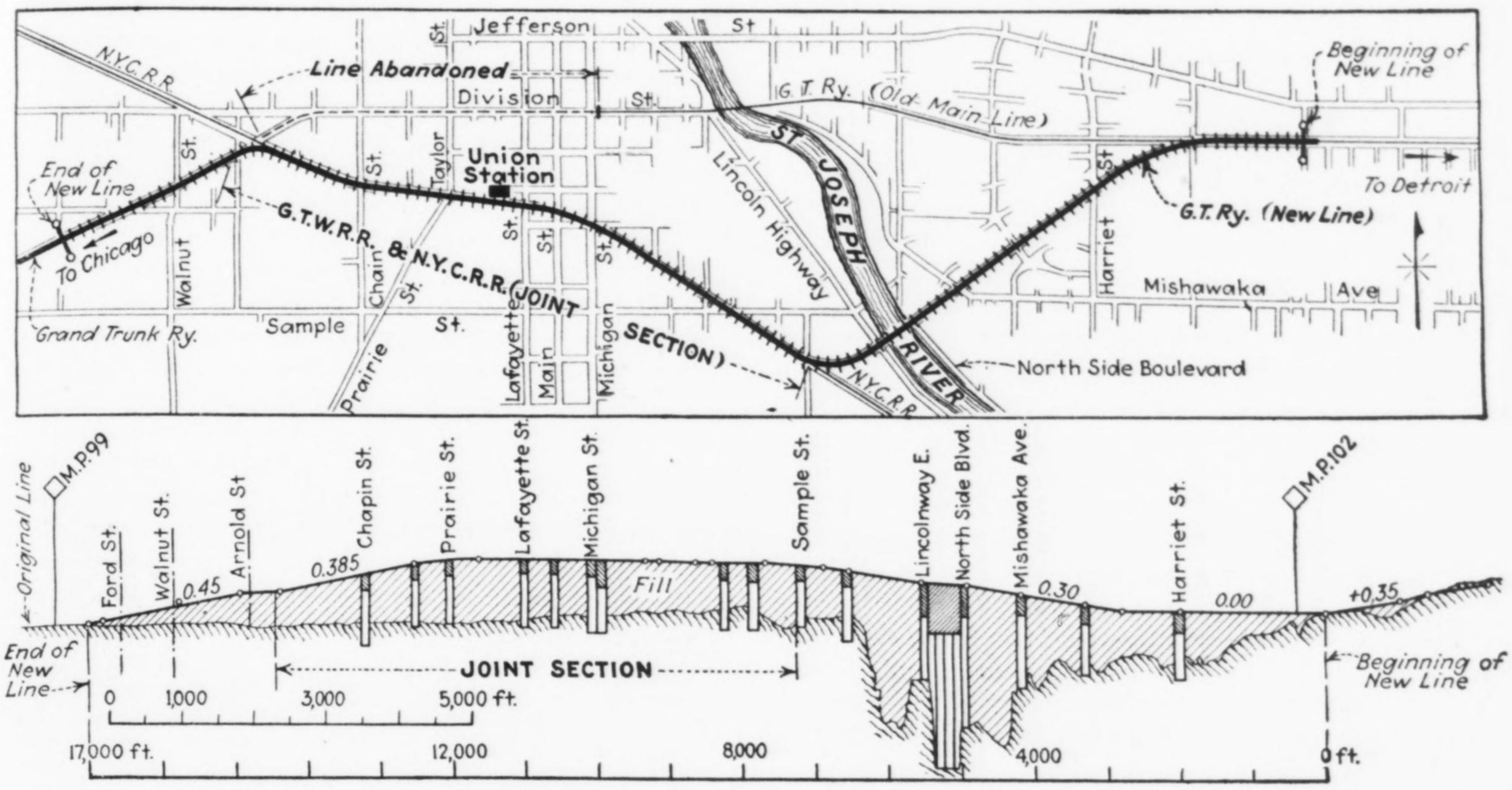

FIG. 3—RELOCATION OF GRAND TRUNK WESTERN RAILWAY AT SOUTH BEND, IND.

side of the St. Joseph River the Grand Trunk Western Railway had its own right-of-way, but that on crossing this river it entered Division St. and followed this thoroughfare to the western part of the city. As it had been proposed to extend the double-track through the city, the river bridge was completely rebuilt in 1910 as a double-track structure, but the second track was never laid across the river or through the city. Instead of this and in accordance with the agreement noted above, the railroad has built a new double-track line 1.3 miles in length, crossing the river farther south by a six-span bridge and connecting with the elevated tracks of the New York Central. It has joint use of this line for about 1½ miles, including the union station, and then diverges to its original right-of-way, descending to ground level by a fill with a grade of 0.45 per cent. The east end of the old line will be retained as far as Michigan St. in order to serve the freight house, team tracks and a group of industries, but beyond that point the tracks will be removed, in order that Division St. may be fully developed as a main thoroughfare.

Two principal structures on the new line are the St. Joseph River bridge and a concrete arch spanning Mishawaka Ave. On the eastern end of the line are two subway bridges having spans of I-beams (parallel with the tracks) incased in concrete and supported on concrete abutments and intermediate reinforced-concrete bents. All bridges have concrete decks and ballasted tracks. As this end of the new line is in a residential and park district, the slopes of embankments are dressed and covered with turf, thus giving a good appearance and preventing wash or erosion.

St. Joseph River Bridge—The new river crossing (Figs. 1, 2 and 4) consists of four 107-ft. plate-girder spans crossing the river channel and at each end a 90-ft. span, over the Lincoln Highway along the west bank and the North Side Boulevard along the east bank. These two shorter spans have the outer girders masked by a concrete fascia with decorative treatment and their piers are carried up as pylons to add to the architectural effect. In order to keep the grade line as low as practicable and still give the required headroom over the boulevards as well as to avoid girders of great depth, each span consists of four girders forming two single-track spans.

Substructure—The east bank was originally a swamp, covered gradually by 12 to 15 ft. of rubbish. Wooden piles were driven for the end pier and 50- and 60-ft. precast concrete piles for a cellular concrete approach behind it (see Figs. 4 and 5). All other piers and the west approach have footings direct upon gravel, but permanent steel sheetpiling 20 ft. long surrounds and is anchored to the footings of the river piers, so that there can be no movement or scour of the material beneath them.

The west abutment or approach, where there is a high approach fill, is a rectangular cellular structure buried in the earthfill. To tie the walls together and also to reduce the weight of inclosed fill, a deck is provided at mid-height. A top slab forming the sub-grade is cantilevered out on either side to form a walk and is curved on the

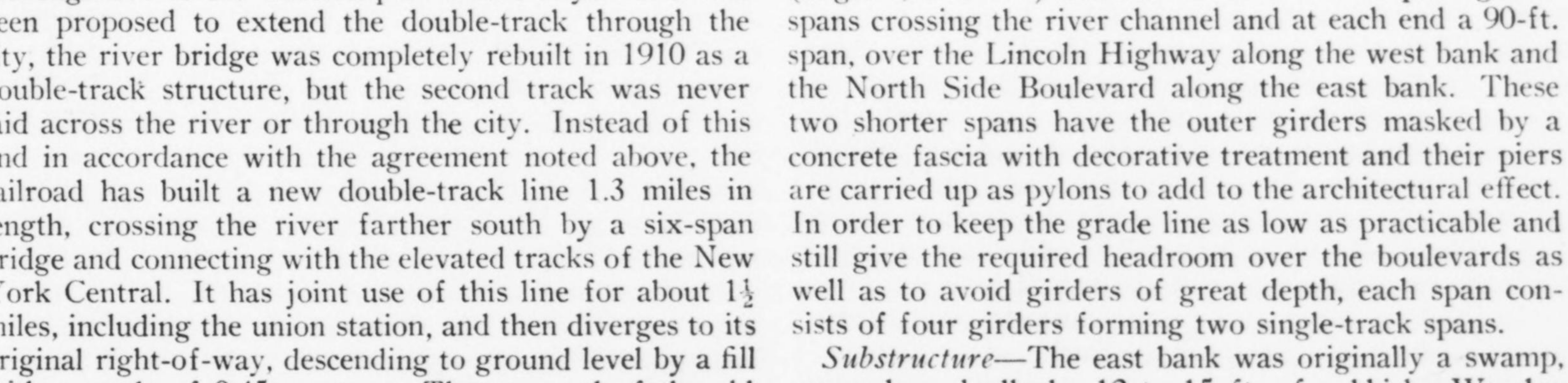

FIG. 4—ST. JOSEPH RIVER BRIDGE, GRAND TRUNK WESTERN RAILWAY

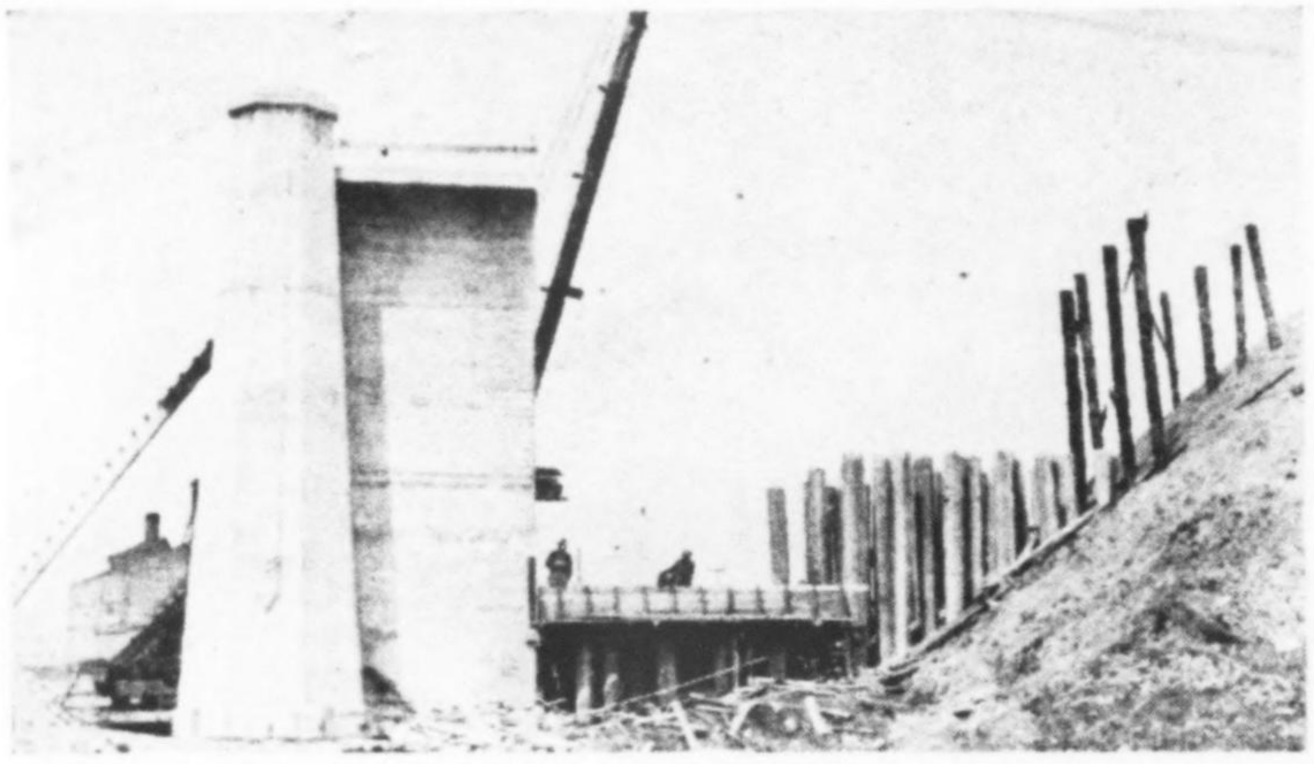

FIG. 5—EAST PIER, WITH CONCRETE PILES TO CARRY APPROACH

face to give a good appearance, conforming to the fascia treatment of the girders in the boulevard span. Solid parapet walls are built along the walks.

All piers are of mass concrete, reinforced on each face with scrap rail and having a double layer of rails in the base of footings. There is also a network of vertical and horizontal bars in the upper portion of each face to prevent temperature cracks. No ice-breaker nose is provided, as there is little heavy ice and the river current is swift. Concrete was made with washed gravel or crushed stone as coarse aggregate. After removal of the forms, the surface of all exposed concrete was finished with a grinding wheel and afterward received a coat of waterproofing followed by a cement application which leaves a white and dense surface.

Solid Floor on Steel Spans—In the 107-ft. river spans (Fig. 7), the girders are 10 ft. deep and 8 ft. center to center connected by the usual type of laterals and cross-bracing. The deck consists of a 17-in. slab of reinforced concrete, which rests directly on the top chords of the girders and extends slightly below their surface so as to form a lateral tie. But where it would come in contact with the connection plates of the lateral bracing, a ½-in. pad of felt is placed between the concrete and the steel. This slab forms a trough for the track and ballast and is cantilevered out 4 ft. 9 in. on the outer sides to form walks for the trackmen. Below the walk, the face of the slab is curved for the sake of appearance, to harmonize with the end spans and concrete approaches. Concrete posts along the edges of the walks carry a double railing of pipe with butt-welded joints.

On the track slab is a layer of waterproofing consisting of a two-ply fabric membrane with asphalt mopping. This is protected with a pavement of asphalt blocks 1¼ in. thick, upon which is placed the stone ballast, with a minimum depth of 12 in. under the ties. The surface of the slab is crowned and graded in drainage planes, leading water to a collector head with a 4-in. iron pipe or downspout placed between the inner girders and of such length as to discharge water clear of the steelwork. A slotted cap or inlet prevents ballast from entering the drainpipe. In the end spans, over the boulevards, the drainpipes are carried to the rear sides of the piers and are not exposed to view.

For the two 90-ft. boulevard spans, a half-through construction was adopted, in order to give the required headroom under the girders. Here the girders of each track are 8 ft. deep and 10 ft. 6 in. apart. For each track there is a floor of 21-in. transverse I-beams spaced 3 ft. and supported by standard beam connections to the girder webs. These beams are incased in concrete, forming a ribbed deck with top slab having a minimum thickness of 7½ in. at the center. The concrete is carried up

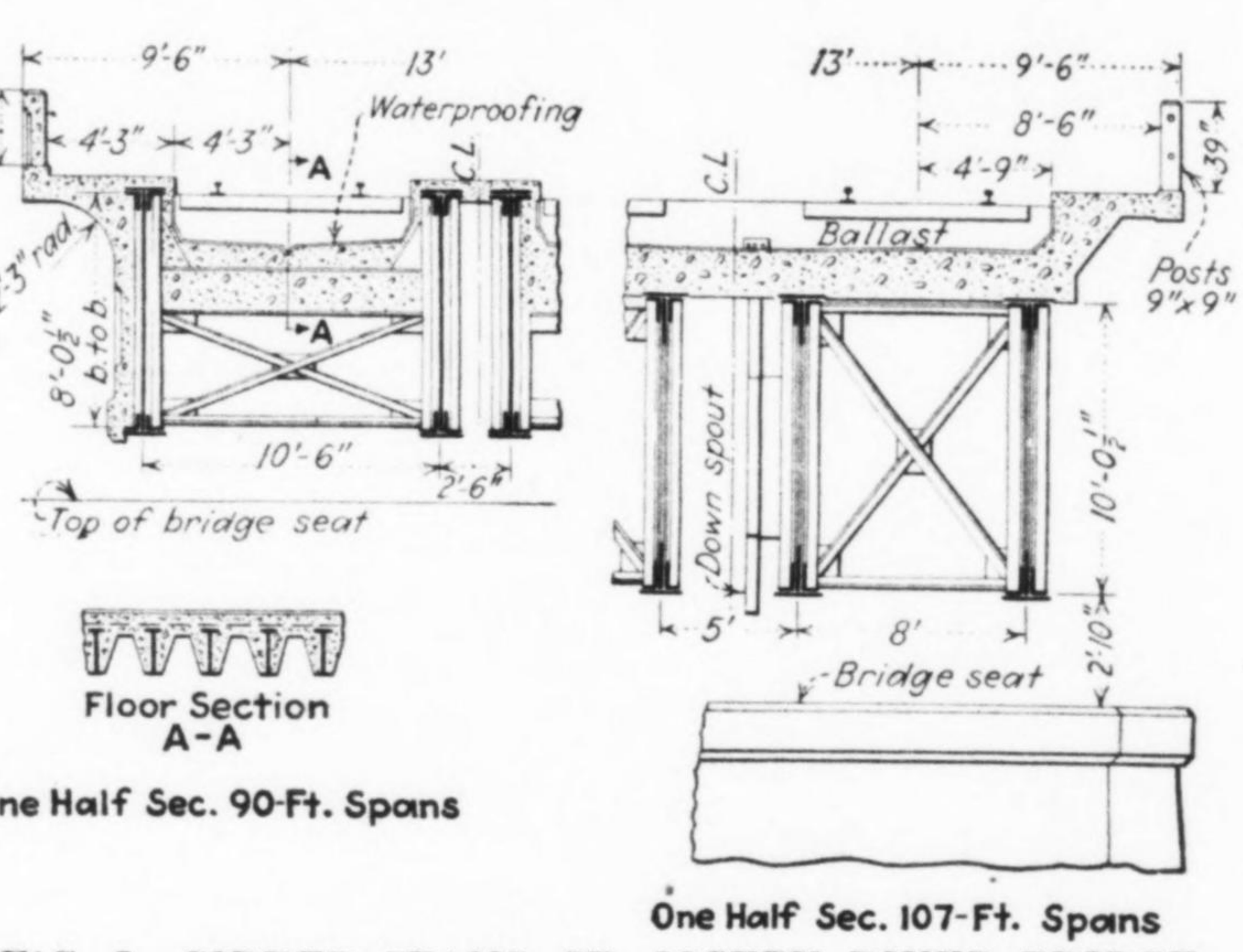

FIG. 7—GIRDER SPANS, ST. JOSEPH RIVER BRIDGE

over the tops of the girders and cantilevered out on each side, as in the river spans. But in order to give a satisfactory appearance from the street, the concrete is also extended down on the outside of each outer girder to form a paneled fascia. This concrete is reinforced by wire mesh attached to longitudinal rods carried through holes in the stiffener angles.

Erection of Girders—In building the bridge, the spans for one track were erected first, working from the west end, the girders being delivered on cars through the joint section of line at this end. For the first or 90-ft. span, each of the two 53-ton girders was placed by a powerful derrick car with 60-ft. boom, which picked up the girder from its car and carried it out far enough to lower it upon its bearings. As this first span crossed the Lincoln Highway, which has a car line in addition to its other heavy traffic, no falsework or obstruction was placed in the street. Traffic was halted temporarily, however, during the placing of each girder, as a measure of safety.

For the 107-ft., 74-ton girders of the river spans, a launching arrangement was devised. At the first river span, each girder on its cars was run out on the 90-ft. span, the derrick car above mentioned then raising each end in turn so that blocking could be placed under it and the flat cars then withdrawn. Two car trucks were run into position and the girder landed upon them. A 50-ton locomotive crane, holding the girder by the boom, then pushed the girder out slowly, until its end rested on a timber tower at about one-third of the span. The forward truck was then removed. For the first 107-ft. span, a locomotive crane on the ground, with crawler traction, took hold of the forward end of the girder as it was pushed out to a second tower. A line from a gallows

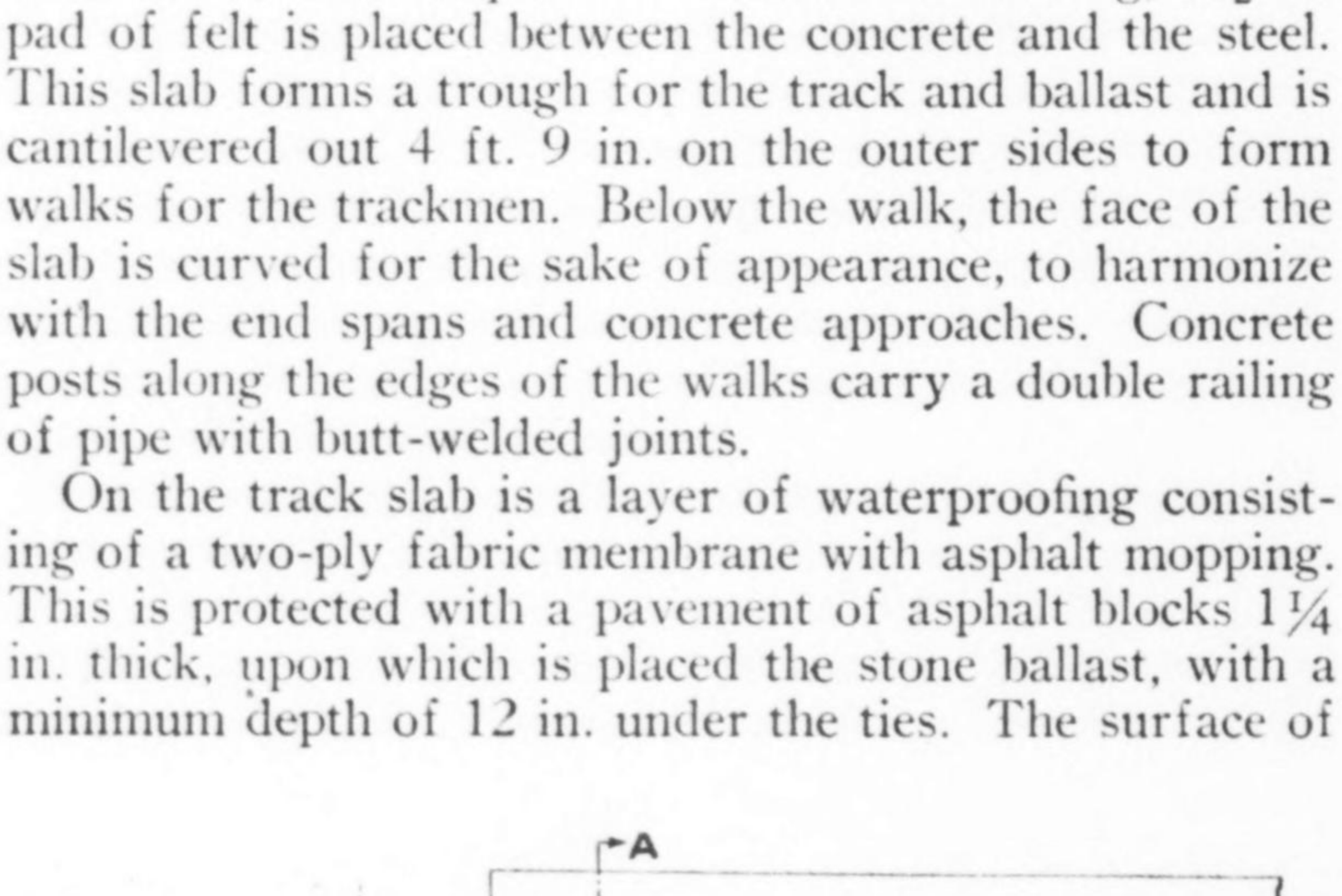

FIG. 6—CONCRETE APPROACH FOR EAST PIER

frame on the pier then held the end of the girder for its third movement to the pier. Each tower had on its top a pair of well-greased horizontal iron rollers to support the girder and vertical guide rollers to hold it in line and prevent any lateral movement. To provide for this method of handling, the bottom chord of the girder was fitted with oak planking, notched for the cover plates and recessed for the rivet heads. This plank, having a minimum thickness of 2 in. and protected on the face by a steel plate, was bolted to the bottom flange.

For the next three spans, over the channel, the forward end of each girder was outhauled and supported by tackle from a gallows frame on the farther pier. The rear end was held by the boom of a locomotive crane on the track, as the crane pushed the girder out on its trucks, until it was supported by the two timber towers. When the girder reached the farther pier, it was held suspended from the crane and gallows frame and lowered into position on its bearing. Piles were driven to support the temporary timber towers in the river spans. These towers were not dismantled, but were picked up and carried from one span to the next by a derrick traveling on a low construction trestle on the downstream side of the bridge. When one span for the westbound track had been erected and field riveting completed, the girders for the eastbound track were brought ahead and placed in position by the same methods.

These erection methods are explained by the illustrations Fig. 1 and 2, which show the work on span No. 3, or the second river span. In Fig. 1 (June 5, 1929, 4:30 p.m.), the first girder has been run out as far as the first tower. At the left is the gallows frame on the farther pier, the tackle of which is operated from a hoisting engine on the farther or eastern bank. In the top view of Fig. 2 (June 5, 4:20 p.m.), this first girder is being pushed out by the locomotive crane, the girder riding on the car trucks. In the middle view (June 6, 10:40 a.m.), the girder has been swung clear, being held by the locomotive crane and the gallows frame, while a derrick traveling on the construction trestle is removing one of the temporary intermediate towers. In the bottom view (June 6, 10:50 a.m.), the girder has been landed on its bearings.

Concrete Arch Span—For the crossing of Mishawaka Ave., which has a double-track electric car line, a barrel arch bridge was adopted, having a clear span of 70 ft., with a headroom of 20 ft. at the center and 13½ ft. at the gutters of the 54-ft. roadway. The springing line is about 6 ft. above the sidewalk. As the crossing is at an angle of 71 deg., the actual span parallel with the railroad is 74 ft. At the site 10 to 15 ft. of gravel is underlain by 15 to 18 ft. of stiff clay. The abutments are of cellular construction, with creosoted wood pile foundations and sand filling to subgrade. A double layer of scrap rail is placed over the piles and similar rail is used also in the abutments, as shown in Fig. 8. Views of the construction of the bridge are given in Fig. 9.

The arch barrel has a radial thickness of 4 ft. 6 in. at the haunches and 2 ft. 6 in. at the crown. Grooves at each side form mortise joints for the spandrel walls, the tops of which have similar joints for the parapet. Gussets or counterforts extend from these walls to the surface of the arch. The barrel of the arch is waterproofed with a membrane of fabric with asphalt mopping, and upon this is a protective coat of asphalt block covered with a 6-in. bed of broken stone for drainage of the slag fill. Iron drainpipes are also laid in this stone layer. The spandrel walls and parapets are relieved by recessed and bush-hammered panels. For concrete finish, the exposed surfaces received the same treatment as the river substructure. To retain the slopes of the approach fills and prevent material from sliding over onto the sidewalks, there are circular curb or toe walls, 8 in. thick. These are 5½ ft. deep and project 2 ft. above the ground line, similar to those at the fills of the river bridge, shown in Fig. 7.

In the construction of this bridge, the concrete of the abutments was placed by spouting from a bucket in a hoisting tower. For the arch itself and the spandrel walls, a narrow-gage track was laid along the falsework,

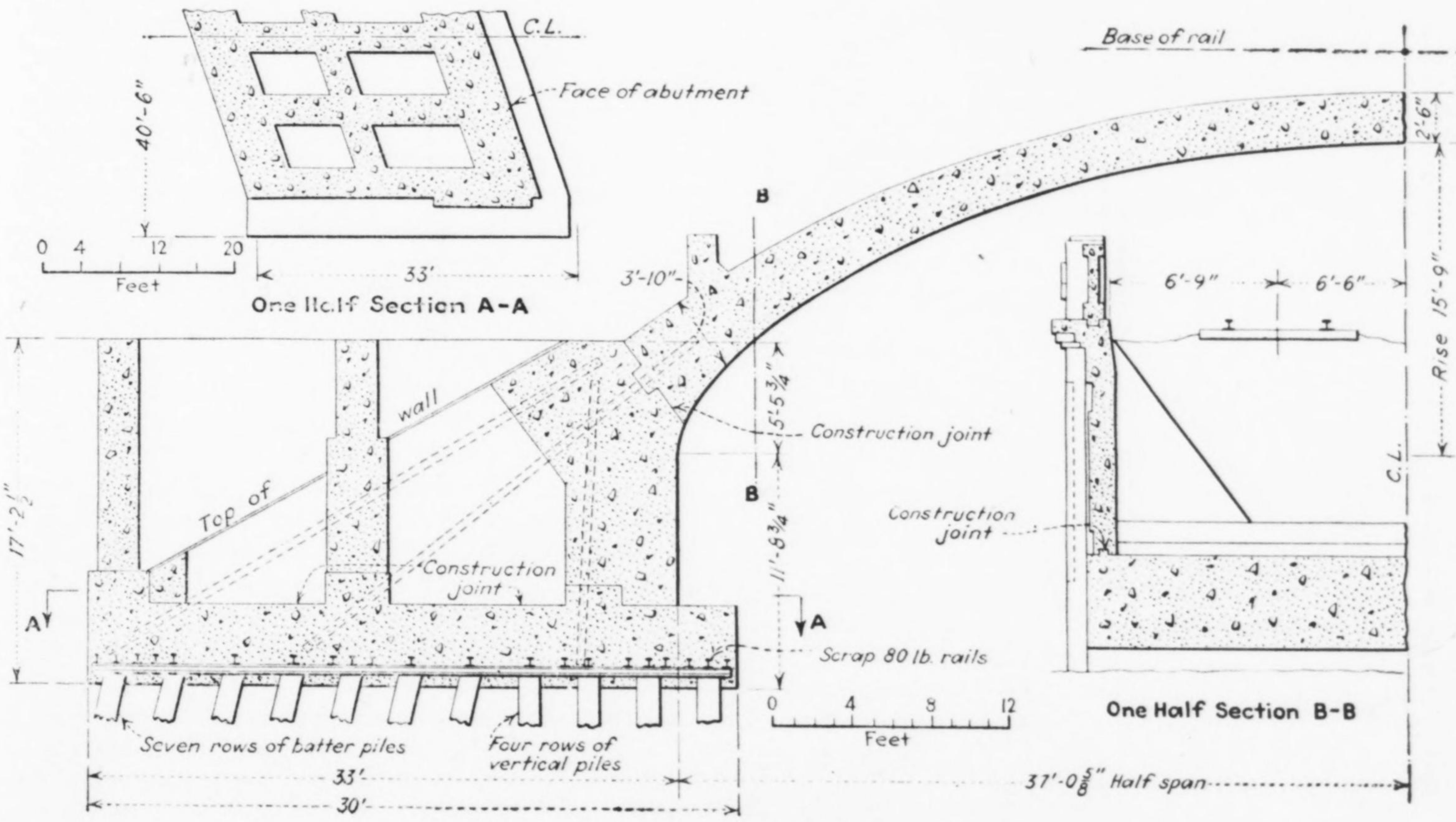

FIG. 8—ARCH SPAN OVER MISHAWAKA AVE.

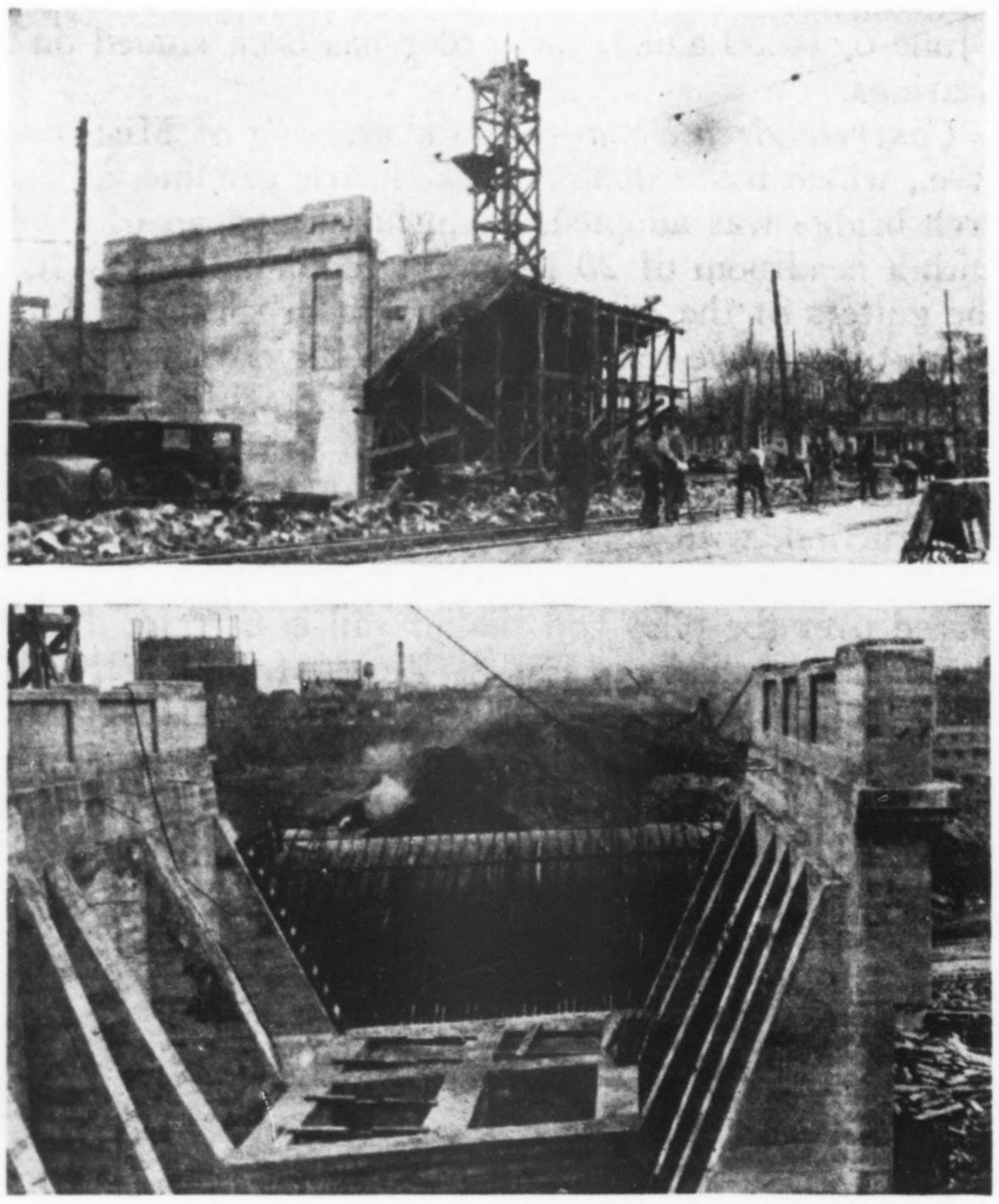

FIG. 9—CONSTRUCTION OF ARCH BRIDGE
Above—East abutment and first section of arch. Below—cellular abutment, with reinforcing steel placed for 70-ft. arch.

on the side adjacent to the tower, and on this ran two steel bottom-discharge hopper cars, pushed by hand. They were loaded from the hoisting bucket and dumped the concrete into portable chutes leading to different parts of the form, as required. The street-car tracks were gantleted by means of temporary portable turnouts, the permanent tracks and street paving being laid after the bridge was completed.

Engineers and Contractors—Both design and construction of the new line and its structures were under the direction of J. A. Heaman, chief engineer; F. P. Sisson, principal assistant engineer, and A. N. Laird, bridge engineer, of the Grand Trunk Western Railway, with W. G. Heggie in charge of the field organization. The grading was handled by Whitman & Keller, South Bend, Ind., and the Walsh Construction Company, Davenport, Iowa; the concreting and steel erection for the river bridge and the Mishawaka Ave. arch was done by Foley Bros. and Fulton & Peppard, St. Paul, Minn. Concrete finishing and surface waterproofing was done by the Wertz Company, Cleveland, Ohio. Two subways were built complete by the Mead-Balch Construction Company, Indianapolis, Ind. All superstructure steel was fabricated and furnished by the American Bridge Company. The total cost of this Grand Trunk Western Railway project was about $1,800,000. Of this cost, the city paid $671,000, a portion of this sum being contributed by the city in consideration of the Grand Trunk Western relinquishing its rights in Division St. and joining with the New York Central for its line through the city, thus eliminating the situation of two railroads traversing the city with a multiplicity of grade separation structures, while also providing the additional advantage of a union station. In addition to the above, the city paid 25 per cent of the cost of work at street crossings where grades were separated, in accordance with the requirements of the Indiana law.

Chemical Treatment of Hydraulic Dam Cores

Physical Chemist and Engineer Develop an Application of a Colloidal Phenomenon of Clays

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RESEARCHES in Honolulu on soil materials available for dam construction have brought out an important practical possibility of utilizing colloid phenomena known to the physical chemist. Some specific results shown by these studies are:

1. Surface deposits of many mountain soils are highly acid in reaction, and when classified according to the scheme of Dr. Charles Terzaghi they fall within the limits of sandy loams or silts.

2. When agitated with water many of these soils fail to impart their acidity to the water, and a condition of semi-permanent dispersion of soil in water is frequently obtained.

3. An acid soil which will produce a dispersed semi-permanent cloudy mixture with water will, upon neutralization with alkali, immediately flocculate and settle out, forming a well-defined and granular deposit under the clear water remaining above it. Under the Terzaghi tests the precipitated and neutralized soils resulting from this treatment are classified now as sandy silts and are much more permeable, more granular and also carry a greater percentage of voids than the same material in its natural acid condition as first described.

4. When treated with enough alkali to produce a soil reaction of about 10 on the pH scale (15 to 35 lb. Na_2O per ton of soil), the precipitated neutral soil described in the preceding paragraph is altered by the treatment so that it falls within the classification of the fat clays. In addition this alkaline-treated soil has become from 200 to 1,000 per cent more impermeable than the same material when neutral. The voids have been reduced to a remarkable extent, and the physical appearance is suggestive of a very sticky and heavy clay.

The relatively small amount of alkali (soda ash) required to produce this effect on the colloidal structure of the soil, affecting to such a marked extent its permeability and reduction in voids, has led the writer to propose:

(*a*) That further research be encouraged with systematic studies on the physical and chemical properties of soils in relation to its usefulness to the engineer in foundation problems and in special problems of core trenches in dams.

(*b*) That a field of usefulness to the engineer may be developed from other physical chemical tests and consequent predictions as to consolidation, stability, etc., now in vogue in this laboratory.

(*c*) That the free-flowing and highly impermeable yet readily consolidated alkali-treated soil be employed as a fill in a wedge-shaped trench immediately surrounding a concrete cutoff wall, the latter carried down to bedrock through a stratum of gravel beneath the foundation of a dam.

Practical application of the alkali treatment is now being made in actual construction of the dam in question. Fuller details will not be available until later.

The object of this memorandum is to state a premise