Reinforcing Railroad Bridge Piers Under Heavy Traffic

Work on Lower Maumee River Structure at Toledo Involves Difficult Underpinning Work Using Open Cofferdams in Water 15 to 30 Ft. Deep

TWO abutments and eight piers, including a swing span pier of the lower Maumee River bridge of the Toledo Terminal Railway Co., have been strengthened and widened to carry heavy double-track traffic by methods involving interesting procedure in open cofferdam work. The job was rendered more difficult because it had to be carried on without interrupting railway traffic and because unforeseen conditions, requiring extensive repairs, were encountered on the old piers.

The Toledo Terminal Railway Co. operates a belt line railroad around Toledo, Ohio, affording transfer facilities for the ten major railroads that serve the city. This belt line consists of double trackage, with the exception of two single-track bridges across the Maumee River, one at the lower end of the river and the other some 10 miles upstream. Traffic at the latter is not unduly heavy, but at the lower bridge, a through-truss structure of five fixed spans and one swing span, an average of 80 trains per day has to be accommodated. Inasmuch as these trains are all long and slow freights, the old single-track bridge was greatly overtaxed.

Although the old bridge was a single-track E-40 structure, its piers from the bottom to the water line had been designed and built to accommodate a double-track bridge. However, the required E-70 loading had not been anticipated, and it was quite evident from the beginning that the piers would have to be reinforced. Before letting the contract, however, the railroad company made a careful examination of the old piers. The conditions disclosed were so unusual and gave promise of being so variable that a cost-plus-fixed-sum contract was decided upon.

The old foundations consisted of sandstone piers on timber grillages 4 ft. thick, located from 8 to 23 ft. below river level and resting on wood piles driven to firm bearing. The piles had been cut off at the river bottom and the timber grillages set directly on them, but considerable scour had removed material from beneath the grillages to depths of 5 to 10 ft., leaving the top portions of the piles without lateral support. Also, one of the piers (No. 6, Fig. 1), which carried one end of the swing span, had been shoved upstream by a steamer so that its timber grillage overhung the last pile by about 10 ft. In addition all of the piles in this pier were found to be inclined approximately 10 deg. to the vertical, as shown in Fig. 3.

Construction—Test piles driven nearby were found to support a maximum load of 40 tons. Assuming a design load of 20 tons, all the old piers were found to have insufficient piles to support the new structure. It was therefore necessary to drive extra piles, and since it was advisable not to increase the base area more than absolutely necessary, the piles were confined to a narrow belt around the piers.

FIG. 2—DEWATERED COFFERDAM INCLOSING OLD PIER
Piling being driven to enlarge base of pier.

The open cofferdam method was adopted. The abutments presented no particular problem, a pier type being used, resting on creosoted piles. For the river piers the work involved the construction of six steel arch-web sheet-piling cofferdams varying in depth from 15 ft. to 35 ft. and having outside dimensions of approximately 76x33 ft. The cofferdam bracing, in the form of cribs, was towed into position and blocked against the old piers before the sheet piling was driven. Two 14-in. steam centrifugal pumps, operated by compressed air, were used to dewater the cofferdams. Later the cofferdams were maintained dry by means of small plunger pumps and small electric centrifugals.

An interesting method of utilizing ordinary cinders for calking the cofferdams was developed and involved

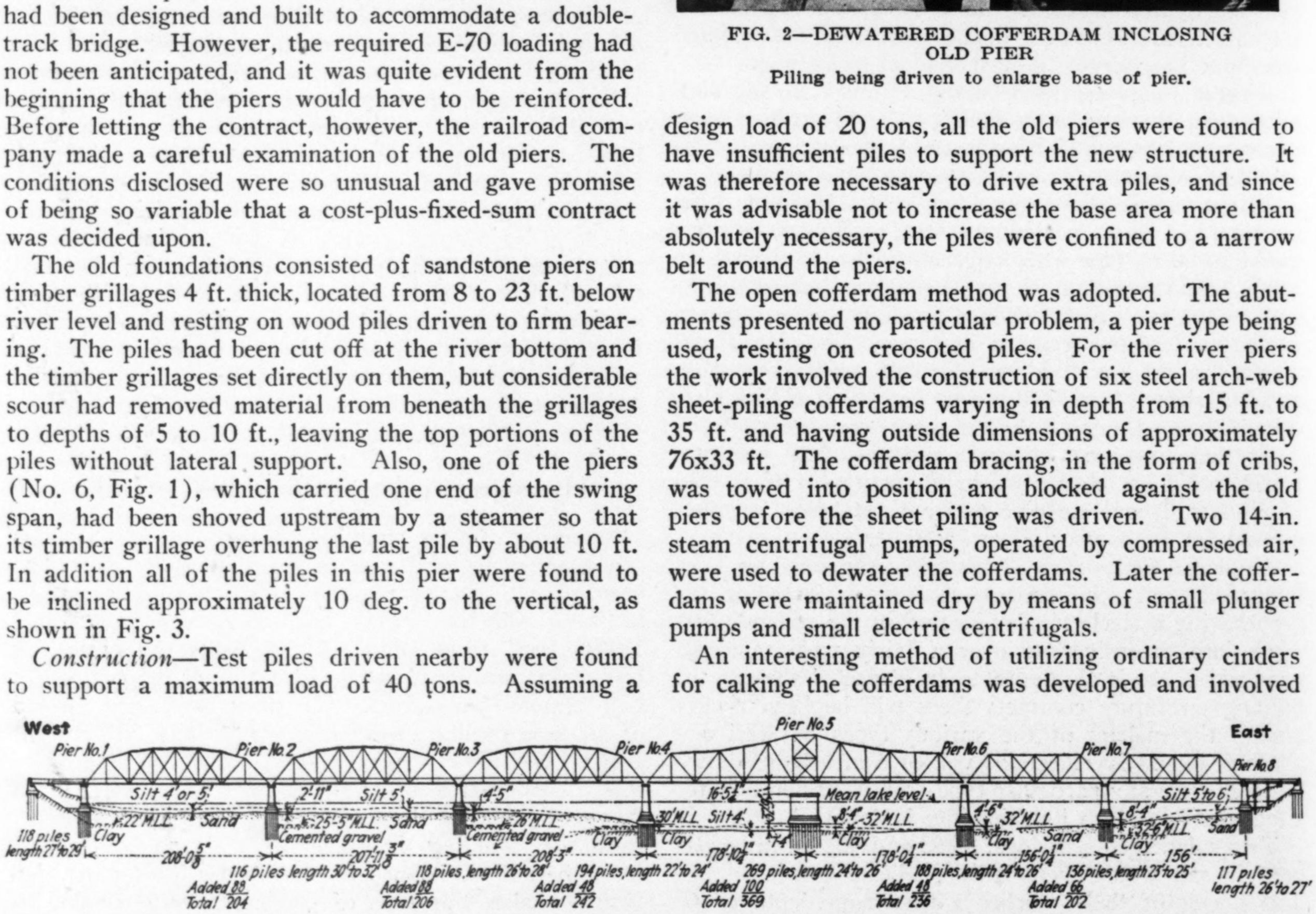


FIG. 1—LOWER MAUMEE RIVER RAILWAY BRIDGE, TOLEDO, OHIO, SHOWING PILES ADDED FOR NEW DOUBLE-TRACK STRUCTURE

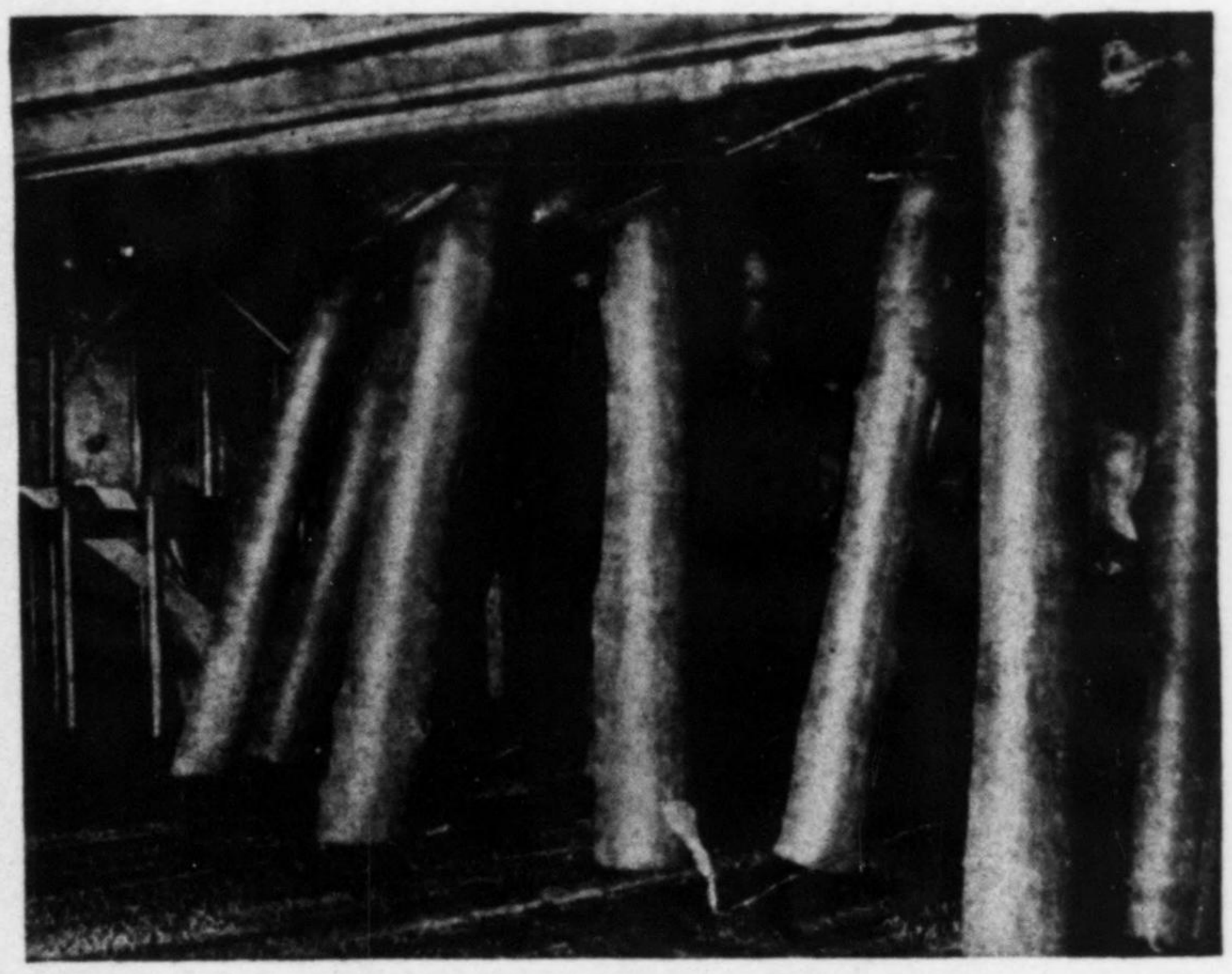


FIG. 3—RESULT OF STEAMER COLLISION WITH BRIDGE PIER

View taken beneath pier No. 6, showing how supporting piles were pushed from vertical. Note rail reinforcing placed for concrete mat; also permanent steel sheet piling cutoff wall in background.

merely depositing the cinders on top of the water outside the cofferdams. Then as the cofferdams were unwatered the cinders were drawn down and sucked into the loose openings. Later as leaks developed more cinders were applied to those cracks which were visible.

The silt between the piles under the old piers was excavated by hand, after which permanent steel sheet piling was driven around the edges of the area outlining the enlarged piers. Inside of this inclosure the new wooden piles were driven. The clay bottom was very stiff and it was found necessary to drive a few piles at one end and then a few at the other end in order to keep the old piers approximately level. All piling was driven from floating equipment.

With the new piles driven, reinforcing steel consisting of railroad rails as well as bars was placed, and a new concrete mat poured in the dry. This mat filled the spaces between the river bottom and the old wood grillages and in addition incased the grillages on all sides. In order to be sure that the new concrete was tight against the bottom of the grillages, grout pipes were attached on the sides and ends of the piers and allowed to project about 4 ft. above the top of the grillages. After all concrete was poured grout was forced through these pipes at 90-lb. pressure. All concrete was mixed at

FIG. 4—WIDENING PIERS OF MAUMEE RIVER BRIDGE

View shows work incident to adding new copings. Note industrial railway track outside of bridge trusses on which concrete was transported from land mixing plants.

central mixing plants on either end of the bridge and transported to the piers over a narrow-gage track suspended on the outside of the bridge trusses.

The repair of the piers also required cutting off about 4 ft. from the tops and replacing this with reinforced-concrete copings, the tops of which were 2 ft. below the original pier coping in order to accommodate deeper trusses on the new superstructure. The new copings were built by cutting away all of the old coping except a small pedestal for the present bridge bearing and constructing a new coping over the removed portion. After this concrete had set sufficiently the load of the bridge was carried to it by shoring beams, permitting the pedestals to be removed and the new coping completed.

Pier No. 5, supporting the swing span, presented a more difficult problem, since river traffic could not be interfered with. However, work on this pier was not undertaken until river traffic was closed down for the winter, and then the method used was in general a repetition of that used on the other piers.

In the six piers and two abutments 5,000 cu.yd. of

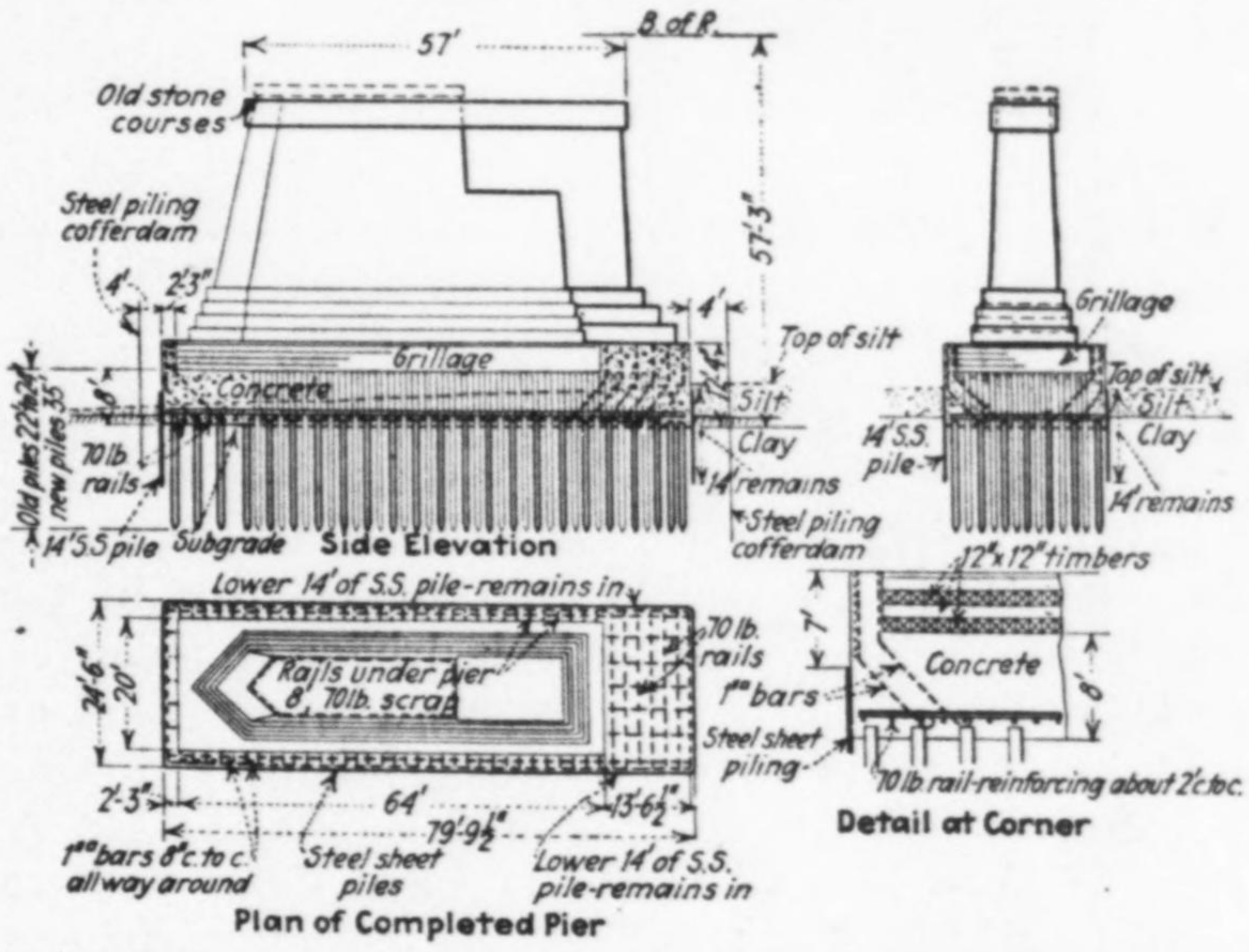


FIG. 5—PIER NO. 6, TYPICAL OF OTHER PIERS

concrete was placed. The concrete was designed utilizing the water-cement ratio theory. The proportions were 1 : 2.7 : 3.6, and cylinders tested after six months had a strength of 5,100 lb. per square inch. It was claimed by the engineer in charge that 1,000 bbl. of cement was saved by taking advantage of the water-cement ratio method of mix design and that this was accomplished in spite of the fact that one-half to one bag of extra cement was used when water was encountered.

Special care was taken in ordering the steel sheet piling so that a minimum amount of it would need to be purchased. Thus enough piling was ordered for pier No. 7, for one of the short piers and for the center pier. The 50-ft. piling ordered for pier No. 7 was used on piers Nos. 6 and 7, and then cut in two and used as cutoff walls on the swing pier. Also most of the cofferdam sheeting on other piers could be used for cutoff sheeting, so that at the end of the job the only secondhand sheeting to be sold was that in the cofferdam of the last pier completed.

F. J. Bishop, bridge engineer of the Toledo Terminal Railroad Co., was in charge of the design and supervised the construction for the railroad company, with H. Ibsen, consulting engineer, Michigan Central Railroad Co., as consulting engineer. The Foundation Company was the general contractor and the work was handled by its Pittsburgh office.

Swing Draw Span During Erection

By F. J. Bishop

Engineer of Bridges, Buildings and Signals, Toledo Terminal

Unusual methods were employed in renewing the superstructure of the Lower Maumee River bridge at Toledo, Ohio

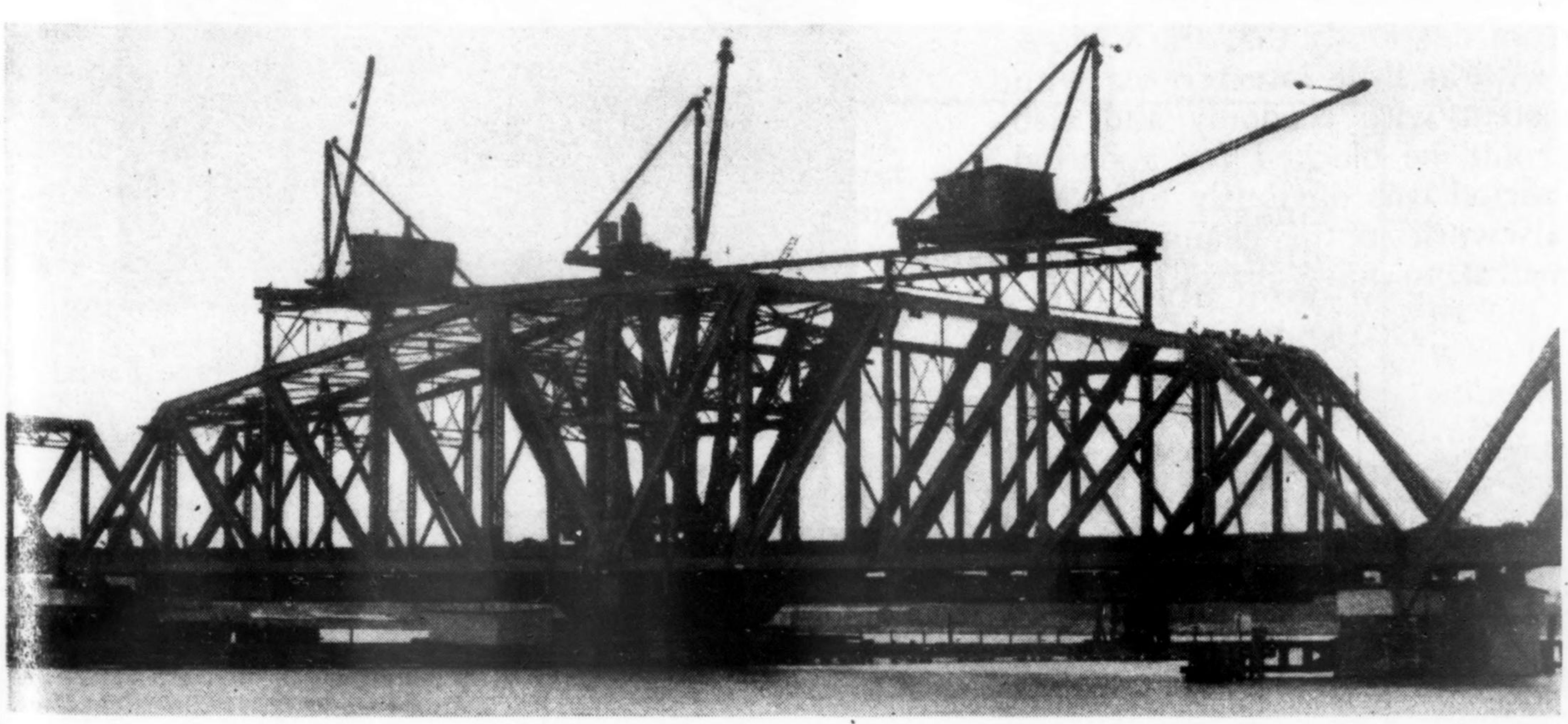
TWO expedients not ordinarily attending the erection of a bridge were adopted in the renewal of a single-track bridge at Toledo with a double-track structure on the same site. One of these embodied the erection of a new through-truss swing span around the old span in such manner that the two spans could be swung as a unit to accommodate navigation as the erection proceeded, the channel being closed only for one month while the new center and machinery were placed under the old span. The other innovation was the supporting of the old fixed spans from the new ones, which were erected alongside, thus precluding the need for falsework to support the old spans during the lateral shift and subsequent dismantling.

After the New Spans Had Been Erected to the Right of the Old Spans, Cantilever Beams Hung Under the New Spans Were Used to Support the Old Spans During the Lateral Shift and While the Old Spans Were Being Dismantled

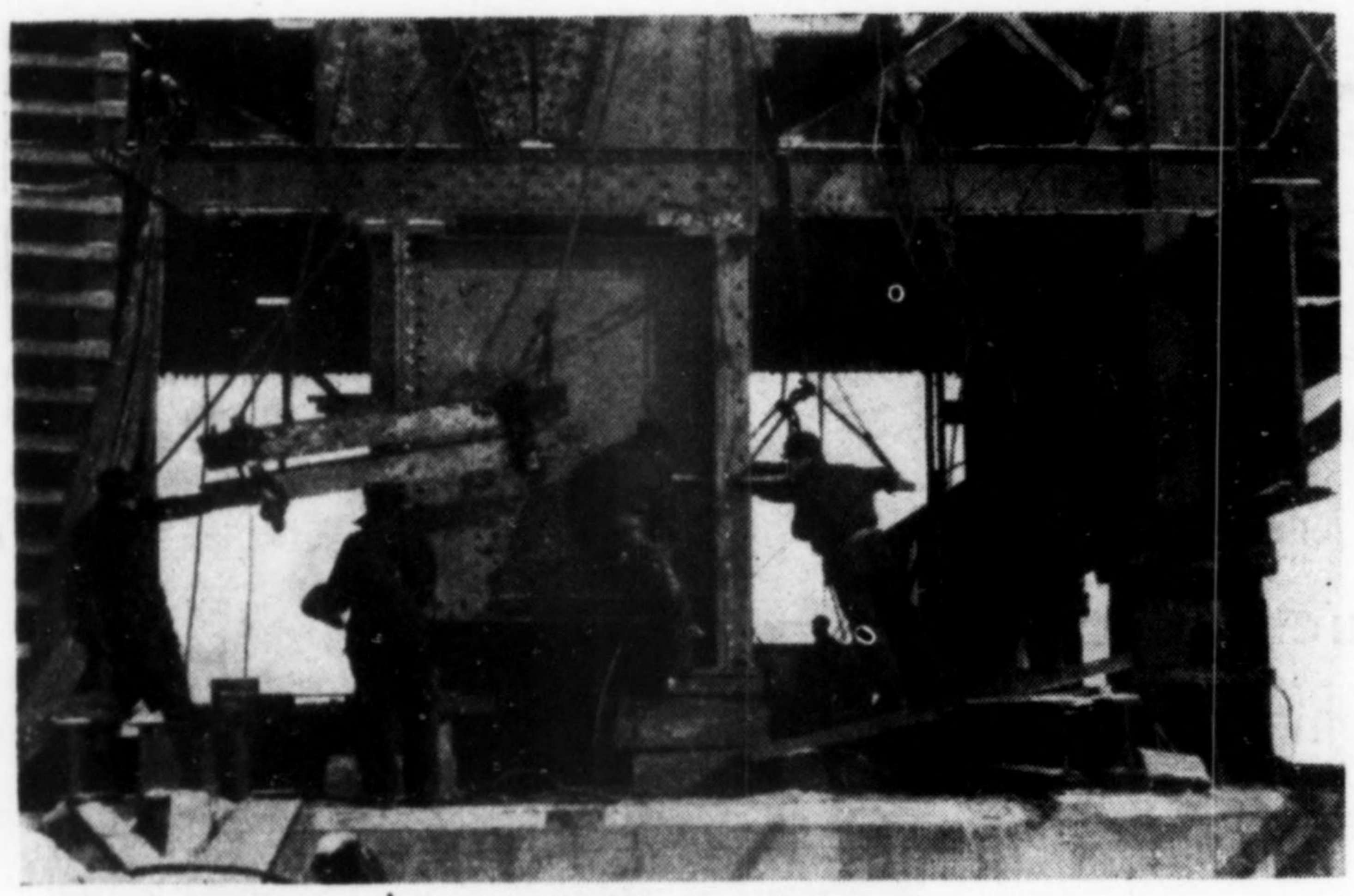
The bridge in question, known as the Lower Maumee River bridge of the Toledo Terminal, carries the tracks of the Toledo Terminal across the mouth of the Maumee river. All lake shipping entering and leaving Toledo passes through the bridge. The rail traffic consists of about 80 freight trains in 24 hours, no passenger trains using the structure.

The original single-track bridge built for Cooper's E40 loading, consisted of pin-connected, through-truss spans as follows:—Three 204-ft. spans of eight panels; two 152-ft. spans of six panels and one 353-ft. 4-in. swing draw span of the rim-bearing type. These spans rest on a stone and concrete substructure that was recently reconstructed as described in the *Railway Age* of February 22, 1930.

The new superstructure consists of double-track, through-truss spans of the same length as the spans they replaced, with the addition of a 60-ft. deck girder approach span at each end. The new swing span is of the center-bearing type. The new structure was designed for E70 loading and has a total length of 1,415 ft. from backwall to backwall of abutments. The tracks on the structure are level and tangent and approach from both ends on earth fills about 700 ft. long. The draw span is electrically operated, the main source of power being supplied through submarine cable. A gasoline-driven generator was provided to furnish power in case of failure of the main supply. Separate 50-hp. motors were installed at each end of the swing span to handle the lifting type rail locks and drive the end wedges. These motors are equipped with solenoid brakes and limit switches so that when wedges are



Placing of New Center and Turning Machinery and Symmetrical Erection of New Trusses Around Old Ones, Made It Possible to Turn the Draw Span at All Times During Erection of the New Structure and Dismantling of the Old Steel



Placing the New Center Loading Girders Under the Old Span

fully driven the power is cut off and the motors stopped in the correct position, regardless of the position of the operator's control lever. The position of the wedges and rail locks is also assured by mechanical and electrical interlocking with the signals controlling train movements over the bridge. The turning and center-wedge motors and gear trains are located under the deck in the center of the draw span. The turning machinery is designed virtually as two duplicate units, each driven by a 50-hp. motor, these motors being further interchangeable with the end-wedge motors. The turning motors are equipped with special electrically-operated brakes, a compressed-air release being provided to guard against a power failure and a sudden stopping of the draw while being opened or closed.

The machinery is designed to swing the draw through a 90-deg. arc in 90 sec. While every operation of the draw is interlocked to provide for the correct sequence of the various functions, the draw can be swung through a full circle in either direction. This provision materially reduces train delays resulting from the opening of the bridge as it enables the operator to swing the span ahead of a boat in opening and follow it with the draw in closing. It is often possible to keep the span in continuous motion during the passage of a boat, thus reducing materially the elapsed time required to open and close the draw.

Erection

After a careful study of both the rail and water traffic it was determined that the rail traffic demanded that the bridge be in practically continuous service except for an occasional period of two to three hours. River traffic operates through the draw during the full year except for a period of about 30 days beginning January 1. It was evident from this study that the various spans had to be erected with as little interference with rail traffic as was consistent with economy and also that the river channels could be blocked for a period of only 30 days. This period was obviously too short to permit the use of falsework in the channels as it would have been impractical to have placed and removed such falsework in winter weather in so short a time.

The fixed spans were, therefore, erected on timber falsework on the downstream side of the old bridge, access to the new structure being obtained by the construction of tracks independent of the main track. As each span was erected, the falsework between piers was taken down and moved ahead to the next span. Heavy beams hung below the new spans at each intermediate panel point and cantilevered laterally under the adjacent old spans furnished the support for the old spans during the shifting of the spans and until the old spans were dismantled. Each new fixed truss span was erected on rollers, and when ready for the lateral shift, was raised enough to lift the old spans clear of the bridge seats. The new spans were then rolled into final position, carrying the old spans with them. The old spans were dismantled with the aid of a derrick on the top of the new spans and the use of a temporary track in the position of the new or second main track. The dismantling operations were thus carried on without traffic interference. The average time that traffic was suspended during the rolling operations of the five truss spans was 3 hr. 59 min.

Swing New and Old Spans Together

The erection of the draw span was considerably more difficult because, in addition to maintaining rail traffic, it was necessary to make provision for the passage of boats at any time except during the month that navigation was suspended. To meet the difficult erection

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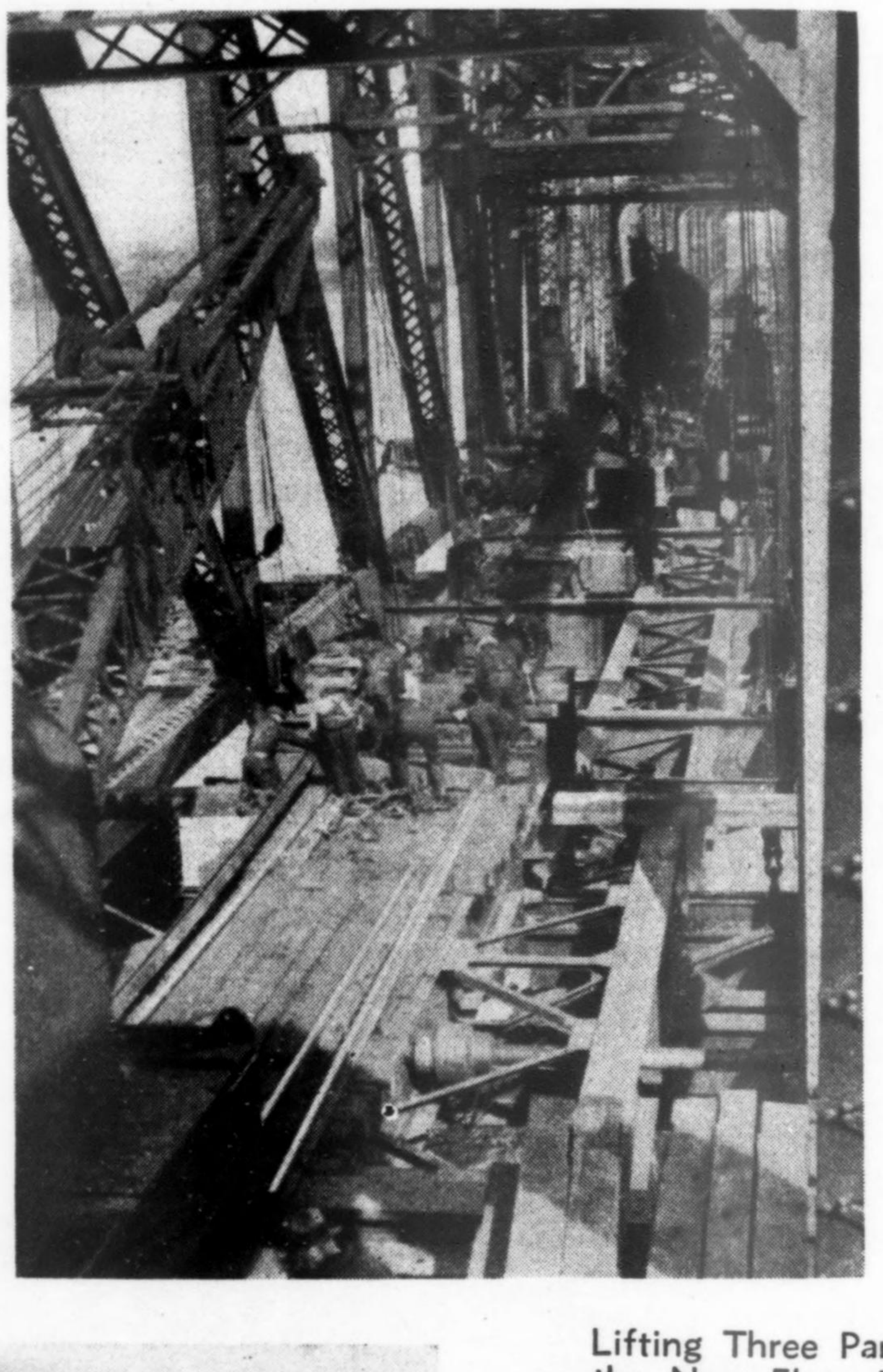

Lifting Three Panels of the New Floor in One Operation

The New Double Track Bridge

them for that length of time. I have simply come to the conclusion that we are not satisfied if some of us cannot twist the meaning into something else. The first thing we do, and apparently it is an inherent weakness and human nature, when some fellow tells us we have to do a certain thing we try to find ways to beat it. That's just what happens with interchange rules.

You have a lot of questions and answers in the rule book. How do you suppose they got there? When the Arbitration Committee is considering a rule, the first thing they begin to ask themselves is: "What is some fellow going to try to do with it?" Therefore, to avoid having to answer the question to one at one time and to another at some other time, we try to view what the average human thinks about and put down the question and answer. Don't blame the rules for being technical, don't blame the rules for what they are. You and I have made them.

Lack of Compliance Rather Than Lack of Rules

While there are rules there I don't like, I don't see how to get them out of the book under the present conditions. And don't forget another thing. If there are interruptions in interchange, if somebody says the joint interchange rules deter free interchange, the question of interference doesn't result from not having rules to cover, but because of lack of compliance. Get that straight.

If we play the game, we ought to play it fair and then there will not be any difficulty in interchange and in car movement. And again, as a proof of that statement, I want you to think again of the little statement I read to you covering the shopping out of perishable loads. If we want to make a success out of anything there is only one way to do it and that is play the game. Let's look at the rules as they come to us and endeavor to figure out the spirit of the rule.

Notable Reduction in the Proportion of Perishable Loads Delivered Which Were Delayed in Interchange in the Chicago District

Month	Record of delayed perishable loads in proportion to perishable loads interchanged	The same ratio expressed in percentage
December, 1930	1 in 111	.90
March, 1931	1 in 178	.56
April, 1931	1 in 194	.51
May, 1931	1 in 259	.39
June, 1931	1 in 311	.32
July, 1931	1 in 329	.30
August. 1931	1 in 453	.22

I read a book years ago which impressed me very strongly. The book, which is out of print now, was called "Strange Case of Randolph Mason." Randolph Mason was a very bright attorney who specialized in taking cases where some fellow had infringed either the state or federal act and wanted to know how he could evade his responsibility under the act. Randolph Mason could show a solution every time. Too many of us are playing that game with the joint interchange rules. Instead of trying to evade our responsibilities under the rules, let's try to ascertain the spirit of the rules and live up to them.

"We are never going to have a successful mechanical car maintenance with free interchange movement without interference until (1) full interchange authority is placed in the hands of a central bureau not subservient to local officers or rules; (2) inspection is based on car condition and lading set to go to destination, with the delivering line compelled to assume its full obligation in this respect; (3) all roads unite in an honest effort to abide by the spirit of the rules."

Swing Draw Span During Erection

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condition on the draw span it was determined to erect the new draw around the old single-track span in such a manner that both spans could be swung together whenever necessary. To do this it was necessary to convert the old draw span from a rim-bearing span to a center-bearing span, for the reason that the new turning machinery had to be put in place in the 30 days that the river channels were closed. The required additional members and reinforcing were all added and the new turning machinery assembled before the old turning machinery was dismantled. On January 1, or the beginning of the thirty-day period during which the river channels were blocked, all of the old machinery was dismantled, together with all the structural parts of the old span below the bottom chords, this center portion of the old span being supported on hydraulic jacks and special fabricated pedestals. The new center bearing and main loading girder were then placed in final position, after which the old draw span was shifted laterally to correspond with the center line of the new double-track draw. The complete new machinery units were assembled on skidways and rolled into final position. The old draw was then swung on the new center with the new machinery.

Had to Keep New Steel Balanced

The trusses and top lateral bracing of the new span were erected around the old span starting at the center and progressing toward each end. This was done by means of traveler derricks mounted on top of the span. In order to swing the draw for river traffic during the course of erection, the span had to be kept balanced about the center, the work progressing on both arms of the draw simultaneously. The new floor system, with the exception of the end and center panels, was suspended under the floor of the old span by providing extensions of the intermediate posts below the bottom chord into which the intermediate floor beams could be framed in a position below their final elevation. The end panels of the floor system, which carry the wedge machinery were pre-assembled and placed in final position as units, rail traffic being interrupted during this operation.

The new trusses having been completed, the new end wedges were placed and the old span was blocked up on the floor of the new span, thus relieving the old span of all load. The overhead derricks used for erecting the new trusses then worked back toward the center, dismantling the old draw except the floor. Rail traffic was then interrupted, the old floor was removed and the three panels of the new floor in each half of the span, that had been erected below final position, were raised into place. This section of the floor in each half of the span was raised as a unit.

Trains were handled successfully over the structure during the progress of the work by means of block offices at the ends of the double track on each bank of the river. These offices were connected by telephone with the dispatcher and with a phone house maintained at the center of the draw.

The structure was fabricated and erected by the American Bridge Company, under the direction of A. B. Newell, president, Toledo Terminal; J. C. Weber, resident engineer; and the writer. H. Ibsen, consulting engineer, Michigan Central, Detroit, served as consulting engineer.