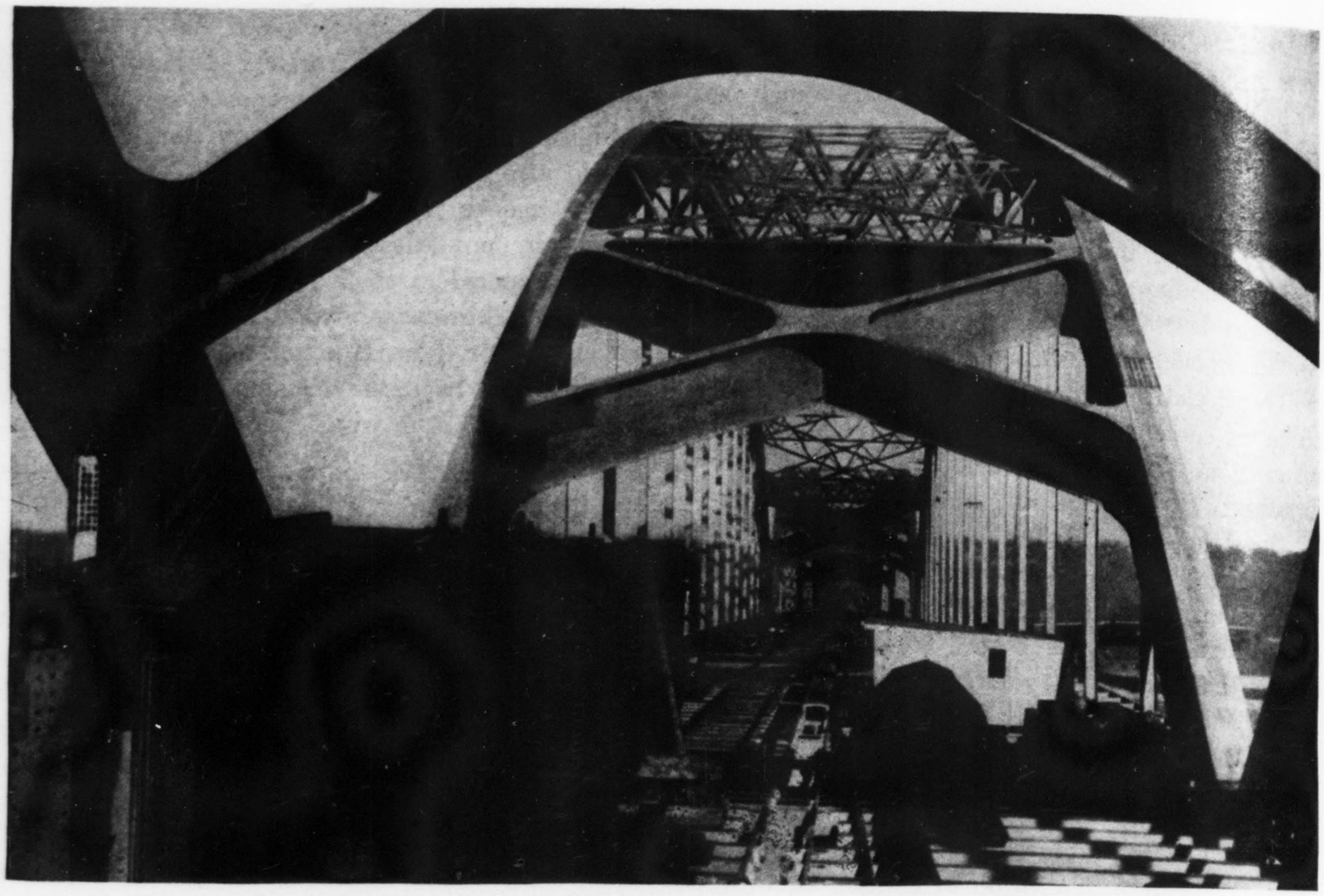

FIG. I. PLATE GIRDER PORTALS ARE DISTINCTIVE CHARACTERISTIC OF ROCK ISLAND ARCHES.

Tied Arches to Span the Mississippi

Contents in Brief—Rock Island, Ill., is building a five-span steel arch bridge, first of its type across the Mississippi River. Financed entirely by private capital, its revenue bonds will be retired by a 10c. toll on vehicles using its 22-ft. roadways. Span lengths are 395 and 540 ft. Ribs are box girders, hangers H-sections, ties are special rolled H-sections weighing 398 lb. per ft., and the shoes are of rocker bar instead of pin type. Erected on steel falsework, the spans were swung with the aid of jacking posts temporarily substituted for the hangers.

CUTTING THE NATION IN HALF as it does from Canada to the Gulf, the Mississippi River is crossed by many bridges. And the engineers responsible for these numerous crossings have over a long period of years met the varying requirements imposed by foundation, topography and traffic in such a variety of ways that one can travel from St. Paul to New Orleans and see nearly every type of long span bridge that the art has developed. Yet, despite simple trusses, cantilevers, suspension spans and steel and concrete arches, a new type of bridge will soon be added to the list, for on June 11, Rock Island, Ill. will open to traffic its steel tied arch crossing to Davenport, Iowa.

The steel tied arch is not a common type anywhere, let alone across the Mississippi where its relatively short span would normally be ruled out because of the large number of deep piers required for a long crossing. At the Rock Island site, however, a firm foundation of hard clay or shale occurs at a relatively shallow depth (50 ft. or less) into which it seemed possible to drive steel H-piles economically. As finally built, the bridge proved even more economical than contemplated since piledriving for the first pier indicated that the clay was so hard as to permit founding the remaining piers directly on it and dispensing with the piles. These good foundation conditions also satisfied another essential of tied arch construction—ability to use falsework with reasonable ease and economy. The net result is that Rock Island will have a new bridge of simple, pleasing lines which has been economical to build and is distinctive for a Mississippi River crossing.

Heavy traffic will be served

Rock Island is part of the prosperous industrial Tri-City area, which also includes Moline, Ill., and Davenport, Iowa, in a metropolitan unit that is virtually one big city. For many years the federal government bridge to Arsenal Island was the only Mississippi River crossing in the locality; its earliest predecessor,

incidentally, is claimed to have been the first bridge that was ever built across the river. Traffic on the Arsenal Island bridge, a two-lane structure that also carries two street car tracks, reaches rush hour volume per lane as great as any bridge in the country. Several years ago the Bettendorf suspension bridge was built several miles upstream, and it is now a successful toll structure without having greatly relieved Arsenal Island bridge traffic, which still approximates 9 million vehicles annually. Traffic studies, therefore, established that another bridge, connecting directly the business sections of Rock Island and Davenport, could get enough business to support it at a 10 cent toll. Despite the favorable prospects of such a bridge, however, PWA turned down a loan-and-grant request after which the city sold all of the revenue bonds to a private banking syndicate. The financing of the Rock Island bridge, therefore, is as unique as its structural design.

Known as the Galbraith Bridge (the name of the town's mayor) the Rock Island bridge project is 4,447 ft. long between Second Ave. in Rock Island and Second St. in Davenport. Continuous plate girders spans on concrete piers resting on steel H-piles constitute the Davenport approach of 1,075 ft., which is on a 2½-deg. curve and has a maximum grade of 6 per cent. Similar construction, 511 ft. long on tangent, is used on the Rock Island and except that for a long span over the railroad tracks, a cantilever with a suspended section is introduced. The main river crossing consists of 5 tied arch spans of the following lengths from the Rock Island end—395, 540, 540, 395, 395 ft. The bridge deck accommodates two 22-ft. roadways, separated by a 2½-ft. steel center island, while a 5-ft. sidewalk is bracketed out at either side.

From a technical standpoint the bridge contains both design and erection characteristics of interest. Designers would note first the use of a steel H-section for the vital tie member. They would also be impressed by the solid box section rib, the detail of joining the tie to the rib at the pier support and the H-section hangers.

Steel erection men would be interested in the use of adjustable falsework, the handling of 45-ton erection pieces by the deck traveler, the utilization of temporary jacking posts in place of every second or third hanger to adjust the arch rib for closure, and the method of swinging the arch spans free of the falsework. Paving contractors would be interested in the curb and center island detail, which is ideal for the direct support of the finishing machine.

Foundations

Few sites on the Lower or Middle Mississippi have as good foundation conditions as are present at Rock Island. Absent is the deep and

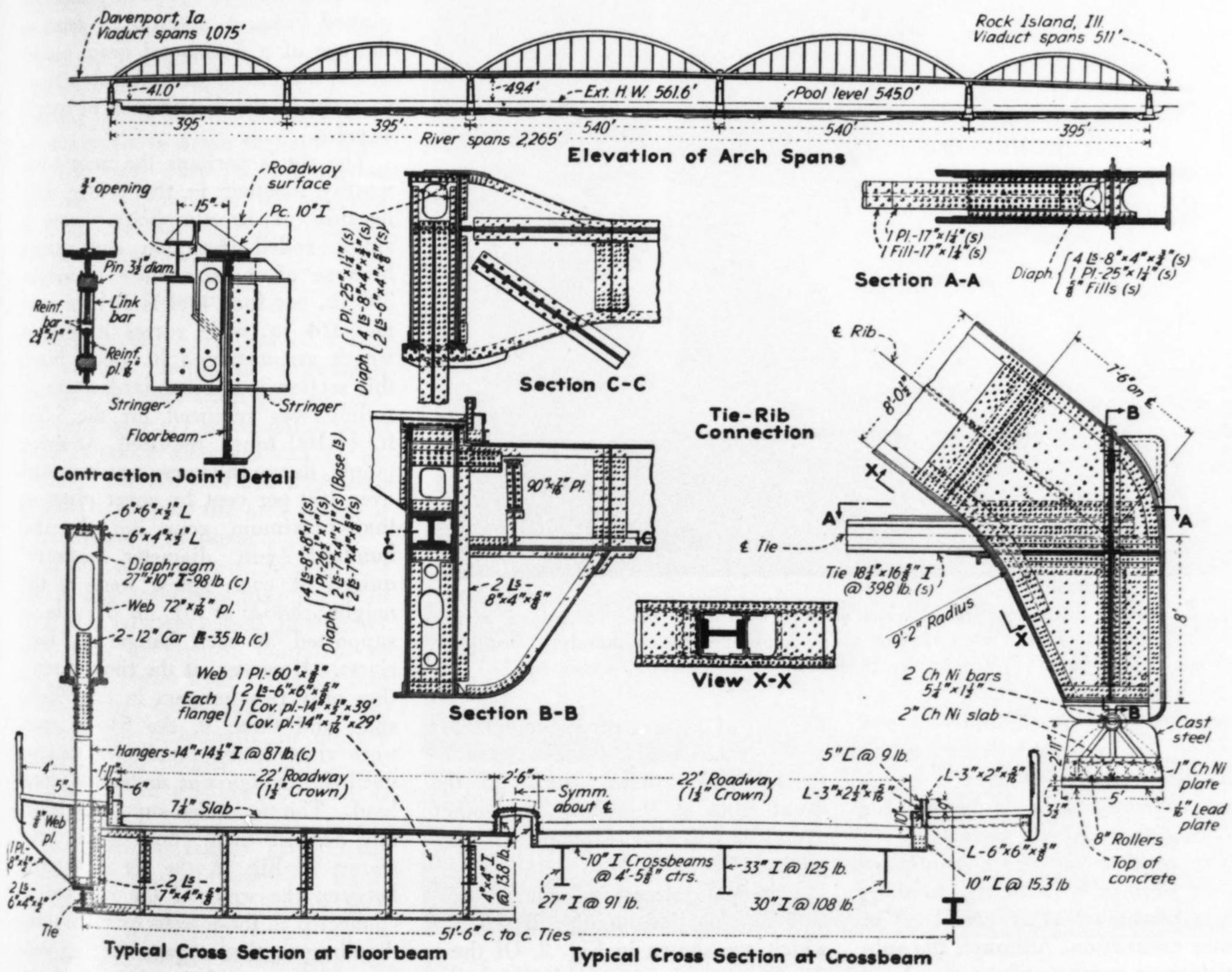

Fig. 2. Structural details of tied arches of Mississippi River bridge at Rock Island. Particularly notable are the box girder rib, the H-section tie and the connection of the two at the piers.

characteristic mud overburden; instead sand and gravel at a depth of 15 or 20 ft. overlies a hard clay shale seldom over 40 ft. below pool level. The two easterly piers for the main spans are founded on rock, a limestone, and as previously stated steel H-piles are used for only one of the four other main piers, the remainder resting directly on the shale. Single-wall sheetpile cofferdams were put down (after the use of a double-wall design on the first pier showed the single wall to be adequate). Excavated to about 20 ft. below river bottom, the cofferdams were sealed by tremie concrete and pumped out, permitting the piers to be built in the dry, using a barge plant equipped with a derrick for handling the concrete buckets.

The concrete approach bents are all on steel piles, with the footings only slightly below ground level to reduce excavation. Although the substructure is comparatively simple, a great deal of study was given the form of the piers and concrete bents to make them pleasing in appearance without any applied ornament.

Superstructure design

In utilizing the 9,000 tons of steel required for the bridge, a guiding objective was to use as many large members as possible and to eliminate small members. The choice of plate girders for the approaches and of the tied arches for the main spans was in keeping with this objective. The use of box girder ribs without lacing bars, the selection of an H-section tie instead of bars or multiple plates, the use of plate girder members for arch portals and the substitution of special rocker bars instead of the usual pins at the shoes are other examples of this attempt at simplicity.

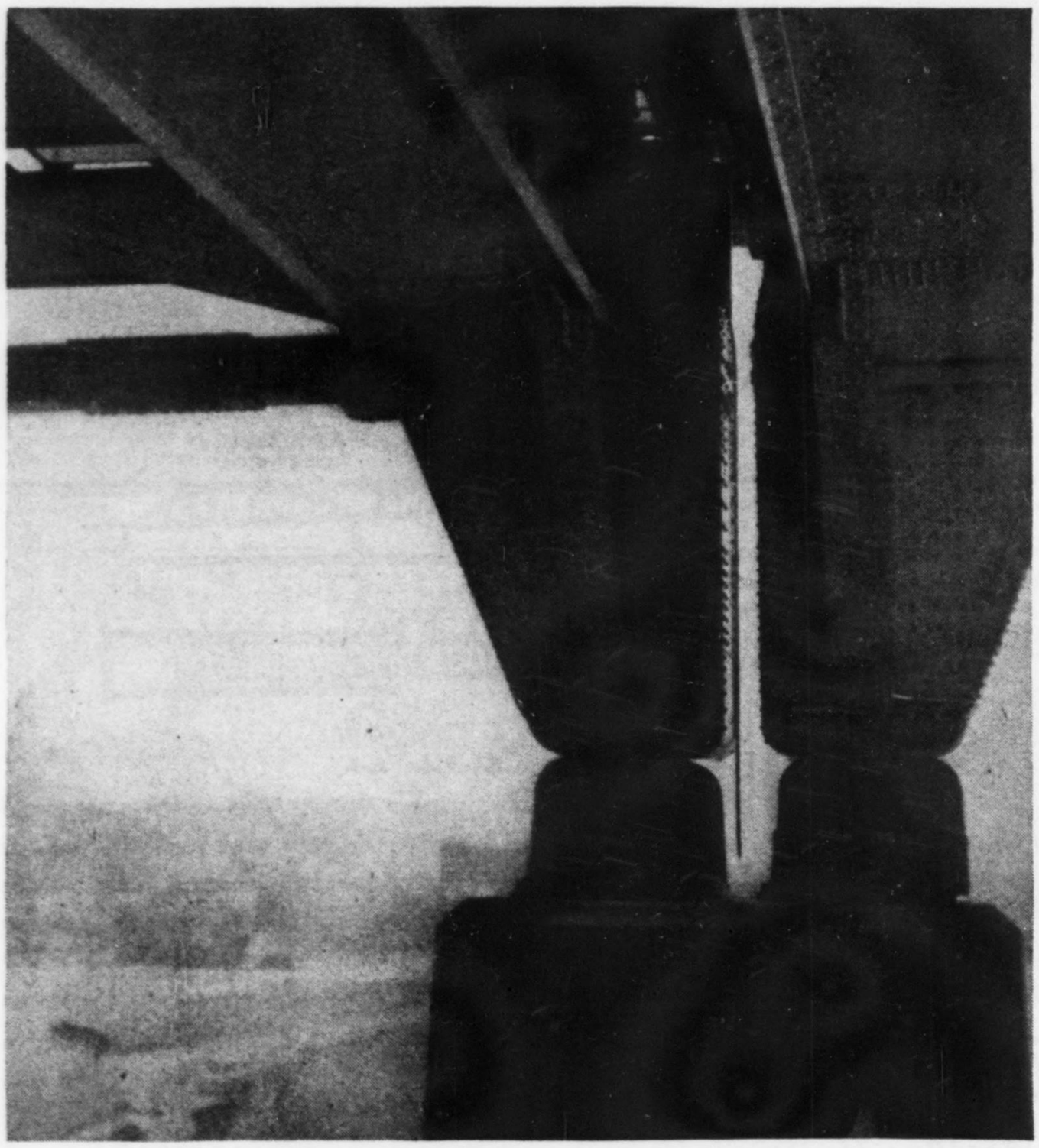

Fig. 3. Rocker bar shoes of adjacent arches; expansion shoe on rollers at left and fixed shoe at right. What appears to be a pin bearing is merely a dust plate over the rocker bars. Splice in the H-section tie is shown at upper left.

Principal interest, of course, centers in the tied arches, details of which are shown in Fig. 2. Of these details several are worth comment.

The rib is of constant section between tie connections, 27 in. wide and 8 ft. deep. In reducing the section below the tie connections to bring the ribs to bear on the shoes much study was given to its proportions so that it would blend gracefully into the lines of the piers. Diaphragms in the rib, spaced about 5 ft. apart, consist of rectangular frames made up of 6x3½x⅜-in. angles, except at hanger connection points where a 27-in. I-section is used. The H-section hangers (maximum length 94 ft.) are joined to these diaphragms by 12-in. car channels; at the bottom the hangers are connected to the floorbeams by 7x4⅝-in. angles.

Floorbeams consist of 60-in. plate girders and stringers (35.5 ft. long) of I-sections from 27 to 30 in. deep. The 7½-in. bar-truss-reinforced concrete slab is supported on 10-in. I crossbeams at 4-ft. 5⅜-in. centers. Expansion joints at the end of each arch span are of cast steel finger type, and in each span there are four contraction joints detailed as in Fig. 2. Stringers at the contraction joints are attached to the floorbeams by pinned links. A noteworthy detail is the use of a horizontal beam placed at the bottom of each end floorbeam to assist in the distribution of lateral stresses.

The tie is perhaps the most noteworthy member in the bridge, first because of its simplicity, being a single rolled H-section and second because of its size since it weighs 398 lb. per foot, and is 18¼ in. deep and 16⅝ in. wide across its flanges which are nearly 3 in. thick. Since this section is not standard, a special rolling was required for the 5,500 ft. (1,100 tons) required. At splice points, flange thickness was increased over 100 per cent by cover plates so that maximum grips for the two hundred 1¼-in. diameter rivets required at each splice were in the neighborhood of 6¼ in. The tie is supported at each hanger by four rivets. However, at the time of erection only two hangers in the 395-ft. span and three in the 540-ft. span were riveted, the remainder waiting until the bridge was under full dead load. The tie is also supported laterally against each floor beam. As shown in Fig. 2, the tie is entered between the webs of the rib and is connected to these webs by horizontal diaphragms that engage the top and bottom flanges of the tie, which are reinforced and widened at the con-

nection by means of cover plates.

Another detail of interest is the cast steel shoe, in which rocker bars are used instead of pins. These bars, of chrome nickel steel, are 5 x 1¾ in. in section and 3 ft. 4½ in. long. The contact surface of the bar in the upper half of the shoe is plane while that of the bar in the lower half is rounded to a radius of 5 ft. 2½ in. Shoes at one end of each arch are fixed while those at the opposite end are on six 8-in.-diameter rollers moving between chrome nickel steel plates, the lower plate resting on a 3½-in. cast steel bed plate separated from the concrete of the pier by a 1/16-in. lead plate.

A final detail, also shown in Fig. 2, is the steel stepped curb. Supporting members, consisting of short channel posts, extending 10 in. above the pavement are riveted to each cross-beam and thus occur at about 4½-ft. intervals. A longitudinal angle carried on the top inside corner of this channel serves as the lower curb rail, while a vertical angle riveted to the channel post and extending 9 in. above it carries the upper rail consisting of a channel and an angle. This curb design being open at the roadway except for the channel posts permits water to drain through readily. The lower curb rail has proved ideal as a support for the concrete finishing machine during construction of the roadway slab.

Erection

Fundamentally, erection of a tied arch consists simply of building a falsework support from pier to pier, with bents at every panel point, upon which the floor members can be assembled. The hangers are then used as posts to support the arch rib as it is erected piece by piece.

All tied arch erection follows this pattern but variations may occur in the type of falsework used, in whether each panel is erected complete at once or the entire floor system is laid down before rib erection is commenced, and principally in closure procedure the details of which depend largely on whether tie or rib is closed last.

On the Rock Island bridge, the spans were erected panel by panel and closure was made in the arch rib, tie splices being riveted up as erection progressed. Work began at the Davenport (west) end of the bridge, where the material yard was located, and proceeded eastward.

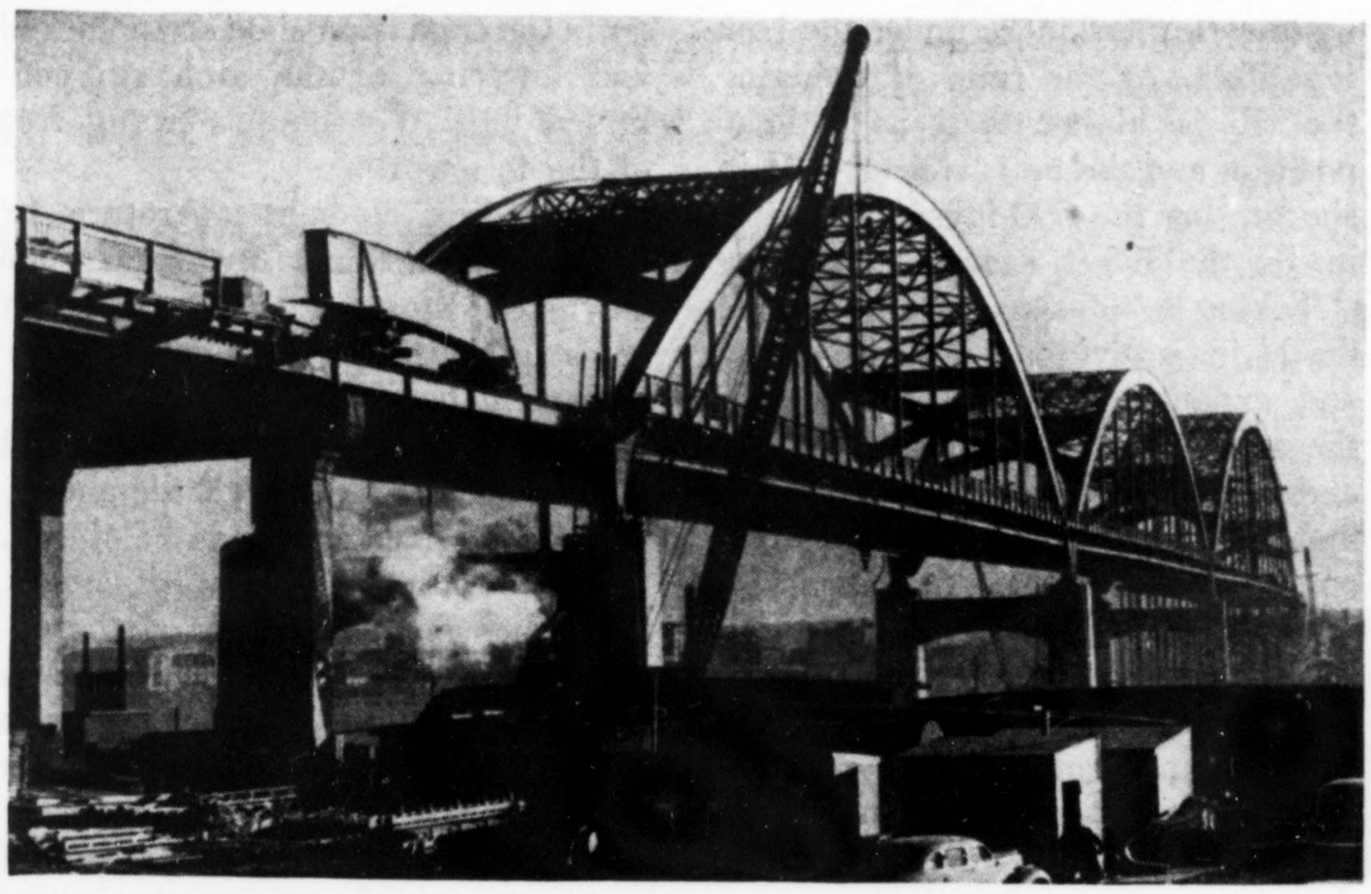

Fig. 4. With three arches complete, first section of rib for fourth arch has just been raised from material yard to a push car on the deck. A gas locomotive will move it out to the erection traveler.

First operation was erection with crawler crane of the first approach girder span next to the river. On this a 65-ton deck traveler with 105-ft. boom was assembled in position to start work on the first arch. Falsework of steel H-piles, with adjustable top sections, was placed by a derrick boat which also erected all floor steel and the arch tie. The traveler then moved out on this completed platform and, always backing away, erected the hangers and the arch ribs in two-panel lengths which were brought out to it on push cars on the deck. Heaviest pieces lifted were the crown sections of the ribs, weighing 47 tons in the long arches and 43 tons in the shorter ones.

The key to the erection procedure was the use of special temporary jacking posts in place of some of the hangers. For the 395-ft. spans of 11 panels, jacking posts were used at points 3 and 5 in each half span; for the 540-ft. spans of 15 panels, they were used at points 3 and 6 in each half span. By means of these posts the arch rib could be raised or lowered to effect connections between the various erection pieces and in the end to adjust the rib for closure and swing the arches free of the falsework. The jacks were also utilized to close the clearance at the last joint in the tie; on one or two spans some horizontal jacking at the end shoe was also required before the last tie splice could be made.

Swinging the spans

As each span is completed it is swung free of its falsework supports

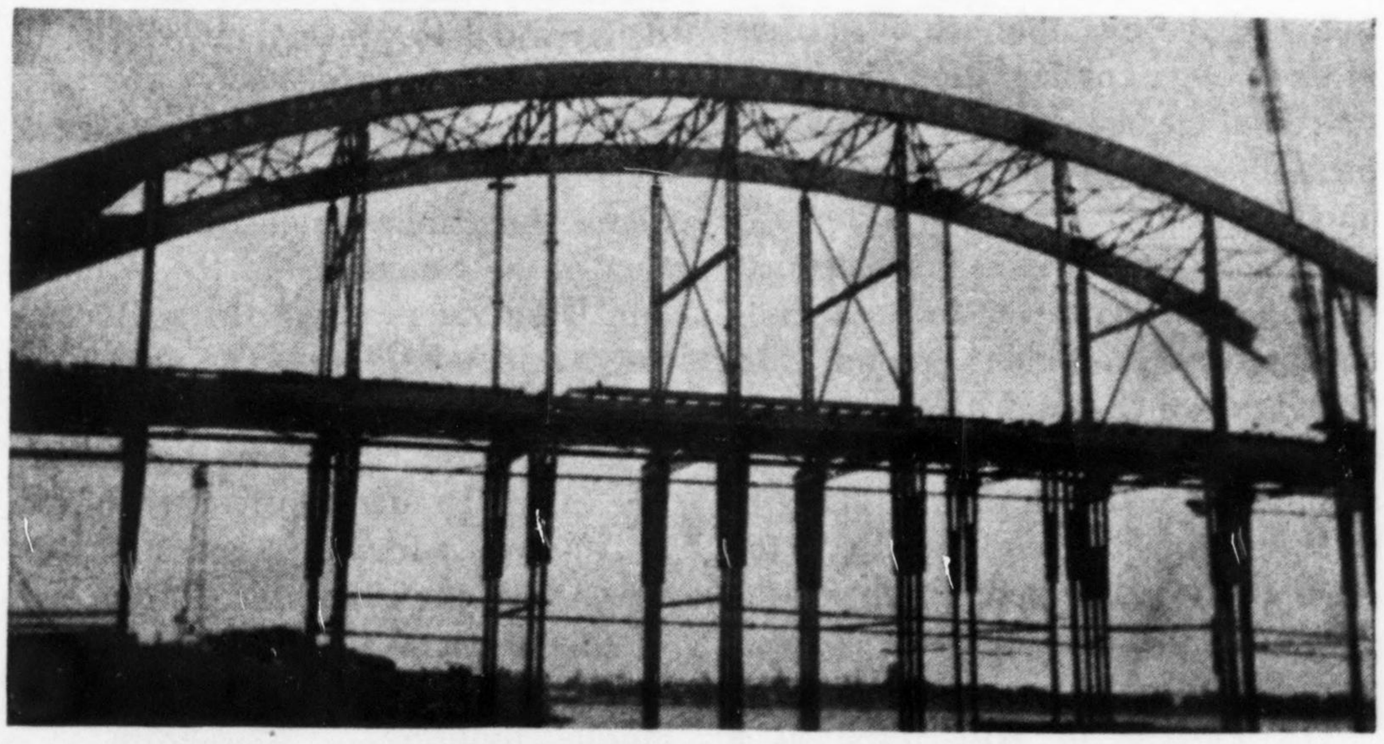

Fig. 5. One of spans approaching completion. Note the jacking posts (with sway bracing between) used temporarily in place of some of the hangers to permit adjustment and closure of the arches. Adjustable steel falsework is also shown.

by lowering the jacks under the jacking posts. At the time of swinging, the rib is higher than its ultimate position and the tie is shorter—2½ in. shorter for the 590-ft. spans and 1½ in. for the 395-ft. spans.

Taking a 395-span as an example, the 1½ in. is divided between the fixed and expansion ends of the arch in the theoretical amounts of 1 11/32 in. and 15/32 in. The anchor bolt holes having been drilled on both piers previous to steel erection, the expansion shoe is bolted down and the rollers locked; the fixed shoe is left free and set 15/32 in. inside (toward the center of the span) from its final position. As the two 100-ton jacks under each jacking post are lowered, the fixed shoe moves outward until the anchor bolts can be dropped in. During this operation the fixed shoe is raised a fraction of an inch on jacks so that it clears the concrete as it moves. With the fixed shoe in place the rollers in the expansion shoe are unlocked and lowering of the arch rib continued until the span is swung free of the falsework.

Depending upon temperature or erection conditions, the fixed shoe may stop short of the anchor bolt holes after all of the allowed-for movement has taken place. This requires that the whole span be shifted toward the fixed end until the anchor bolts of the fixed shoes can be placed. Such a situation is present, of course, only when erection begins at the expansion end of a span, which was necessary with one of the long spans on this bridge since the fixed shoes of the adjacent long spans were placed on one pier for convenience in locating the toll house.

After the closure the jacking posts were taken out one at a time and replaced by the permanent hangers, jacks on the falsework being used to make the hanger connections when necessary. As a final operation the hangers were connected to the tie at those points not previously riveted up and the tie was connected to plates extending out from the bottom of the floorbeams to give lateral support.

Personnel

The Rock Island bridge was designed and its construction is being supervised by Ash-Howard-Needles & Tammen, consulting engineers, Kansas City, Mo., under the direction of R. N. Bergendoff of that firm. Foundation contractor was the McCarthy Improvement Co., Davenport, Ia., and superstructure contractor is the American Bridge Co. Crouse & Saunders, Detroit, have the contract for the concrete deck. William Schmidt is resident engineer for the consultants, with Stephen Collins as assistant. Ned L. Ashton as chief designer and Carl S. Harper as chief draftsman were in charge of design.

Cities Move To Escape Floods

Contents in Brief—Floods and a flood control dam are the reasons why four communities in different parts of the country are moving to new sites.

When the citizens of Hill, N. H.—a town of 400 population—voted recently to move their community to a new location, they followed the example set by citizens of three other communities who, within recent years, decided to relocate their towns to escape floods or aid in flood control.

Two of the towns—Shawneetown, Ill., and Leavenworth, Ind.—already have moved to higher ground from the sites which, in 1937, were covered by Ohio River floodwaters that almost completely destroyed many of their buildings. Greenville, Mo., is the other town; its present site has been designated as part of a St. Francis river flood-control reservoir system.

The citizens of Hill voted at a town meeting to relocate, and to establish a model village, after the federal government made known its plans for building a flood-control and water conservation dam which will flood the present site.

With the assistance of the New Hampshire state planning and development commission, plans for a model town were drawn up and submitted to Hill's citizens. The plans were studied during several town meetings, and accepted when the residents voted to move their village to the new site.

State and federal agencies assisted in planning the new Shawneetown, about three miles from the old location at the confluence of the Wabash and Ohio rivers along the southeastern border of Illinois. The new town is oval in design, and no part is more than three blocks from the center. The main street is 100 feet wide, and a 30-foot parkway separates the street from the sidewalks. At one end of this street is the Gallatin County courthouse; at the other end, a community building.

Parking areas for the town are behind, instead of in front of, the stores. Houses that were not destroyed by the flood were moved to the new site, and the rest salvaged. Public buildings, for the most part, were built anew. Landowners received deeds to plots at the new town site, which was purchased by the state with $150,000 supplied by the state legislature. The old site will become a state park.

Leavenworth's 450 residents moved to a bluff high above the old site, which had been flooded eleven times since the town was founded. State and federal agencies cooperated in drawing up the town plan and relocating state highways. Work projects Administration officials estimated the cost of streets, sidewalks, water and sewer systems, a town hall, and other construction at a total of $125,000.

Many agencies are cooperating in moving Greenville from its present site to a new one about a mile up the highway. The Missouri state planning board is drawing up the new town plan, with technical assistance provided by consultants supplied by the National Resources Planning Board. Topographic maps of the new site were made by the United States army engineers. The town must be moved by 1941, when the new dam, to hold back waters of the St. Francis River from the Missouri River, is scheduled for completion.