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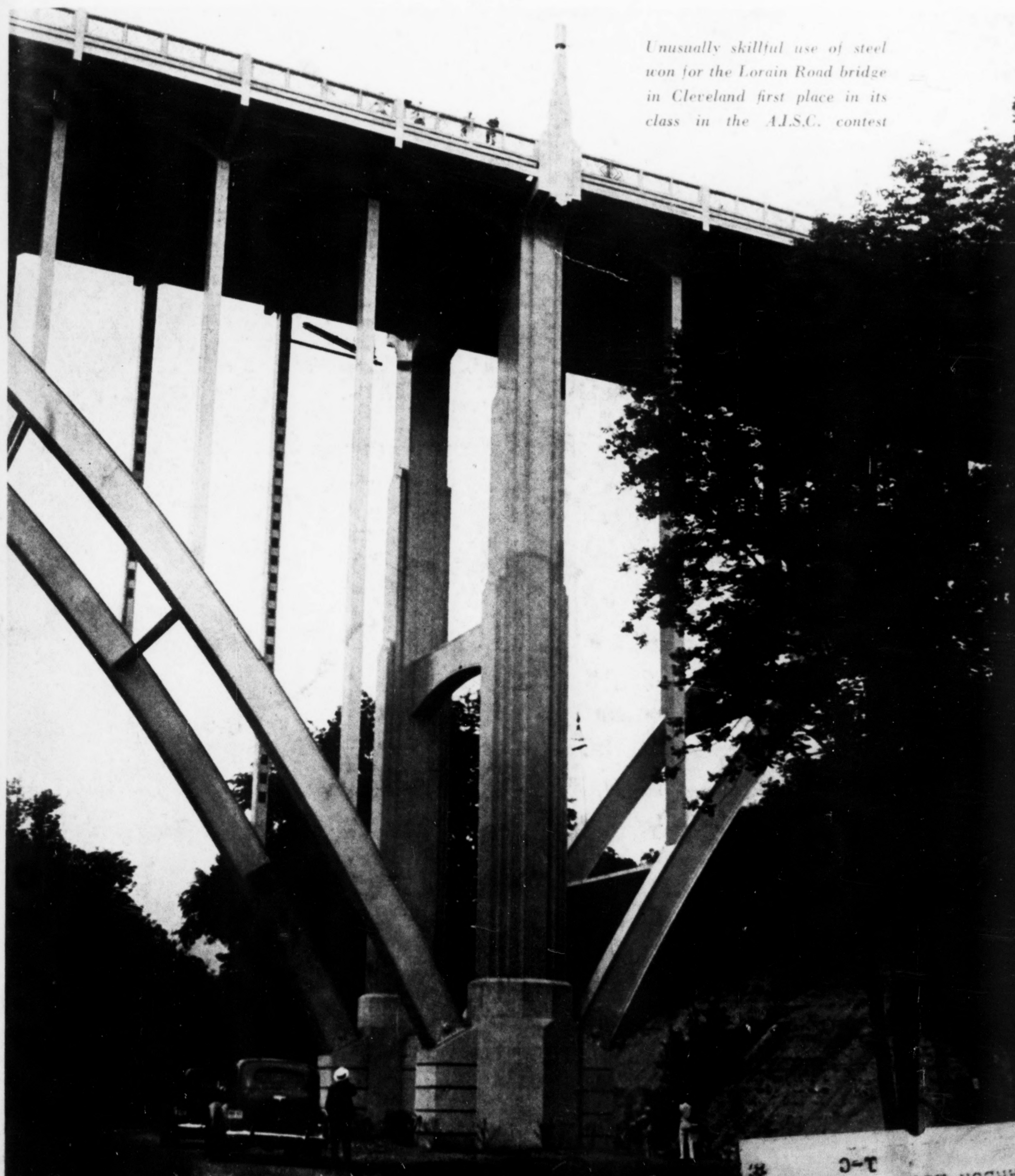

Unusually skillful use of steel won for the Lorain Road bridge in Cleveland first place in its class in the A.I.S.C. contest

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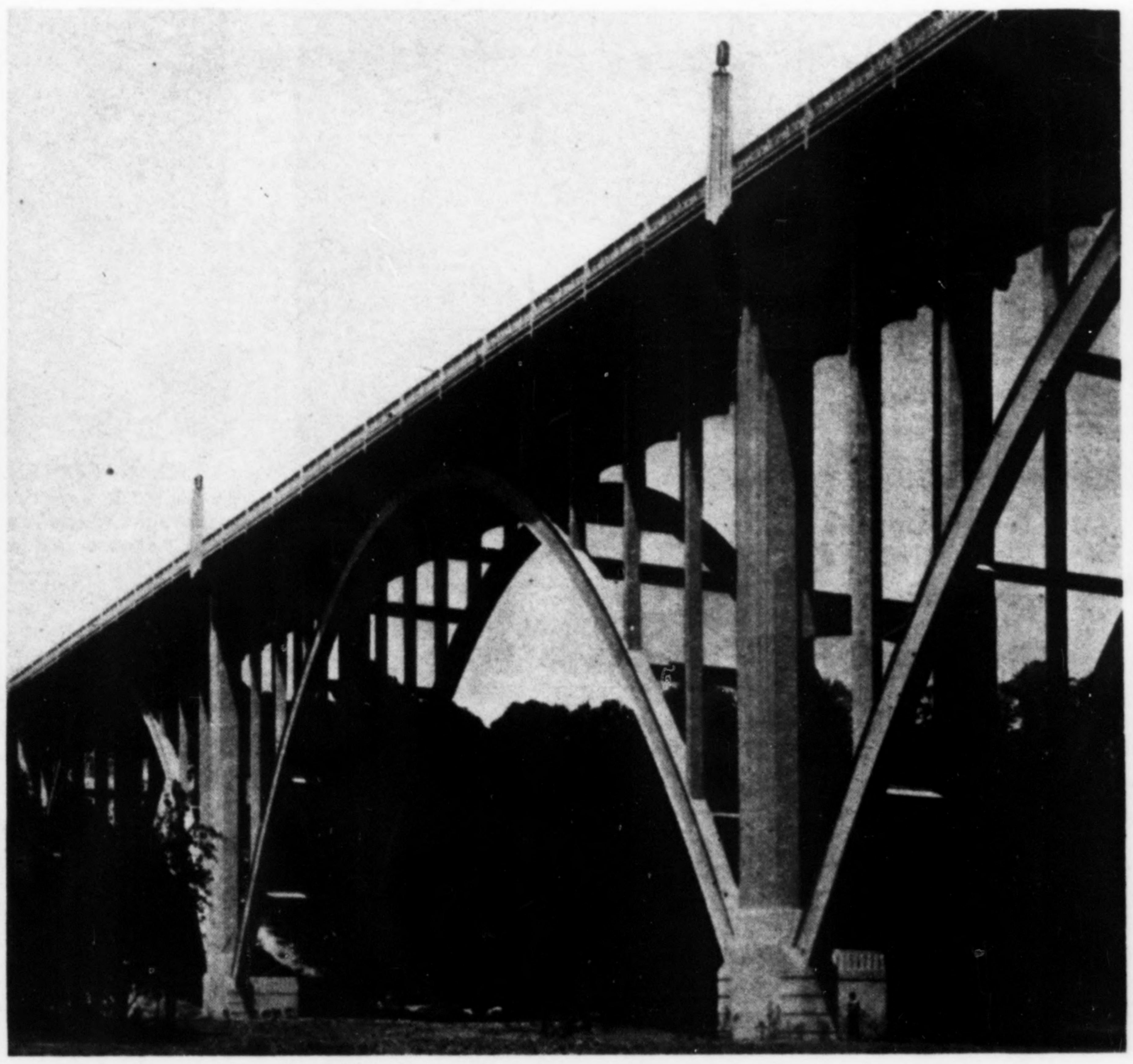

SIMPLICITY, smooth surfaces and dominating pier towers characterize the Lorain Road arch viaduct at Cleveland, a significant example of an attempt to design beauty into steel bridges.

Steel Arch Viaduct Design Governed by Architectural Objectives

Ohio state highway department's Lorain Road bridge at Cleveland introduces a new note in steel viaduct design.

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A STEEL VIADUCT of unusual design was recently completed at Cleveland by the Ohio department of highways. Located on Lorain Ave., state route 10, about 8 miles west of the center of the city, it crosses Rocky River and a portion of the Cleveland metropolitan park in a series of four arch spans whose design was largely predicated upon achieving a pleasing appearance. As a result, all cross bracing has been eliminated or concealed and only such rivet heads are permitted to show as are believed to aid the architecture and to be necessary to give honest expression to the riveted nature of the construction. At the same time a considerable amount of welding is used where it is logical and advantageous. The bridge was adjudged the most beautiful, in its price class, of any steel bridge constructed during 1935 in the competition announced by the American Institute of Steel Construction two weeks ago.

A steel bridge was chosen for the location since the state highway department had built three large concrete viaducts in the Cleveland metropolitan park area in recent years (*ENR*, Oct. 11, 1934), and felt that, if a design could be developed that would do justice to the natural beauty of the valley and its recreational use, steel should be considered from the standpoint of variety if nothing else. Preliminary estimates indicated that the cost of such a bridge would be comparable with that of any other suitable structure, especially when one took into account the length of the construction period during which all traffic would be interrupted on a busy thoroughfare. An arch type structure was chosen because of its adaptability to the topography and the site.

The new bridge consists of four two-hinged arches flanked by deck girder approach spans (Fig. 5). The two central arches are symmetrical and measure 256 ft. center to center of piers. The end arches were made unsymmetrical, to fit the natural topography, and have a span of 236.7 ft. There is a single girder span of 57.8 ft. on the east end and four 38.6-ft. continuous spans on the west end. The bridge is 1,260.9 ft. long overall and has

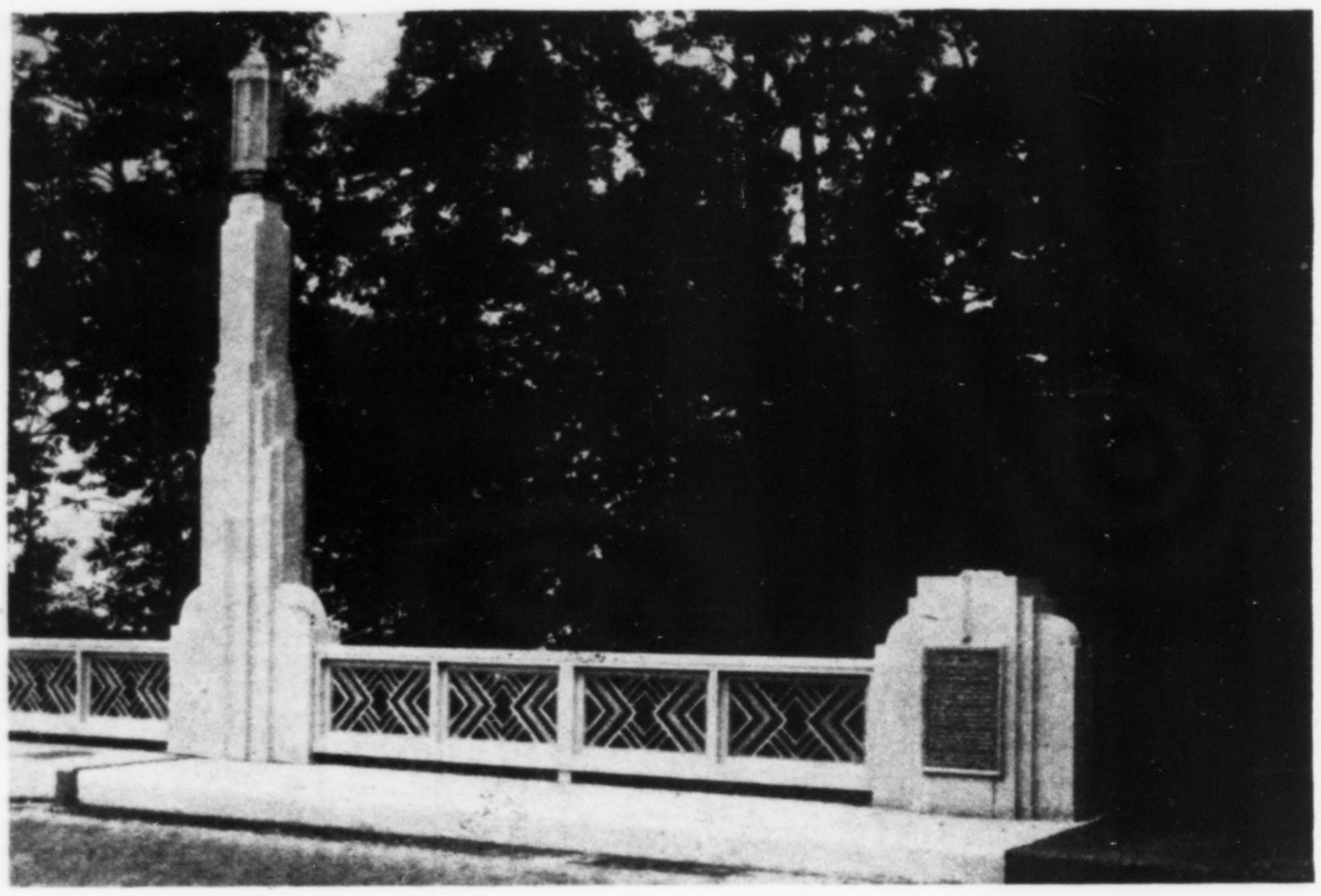


FIG. 2—MODERNISM in steel construction as expressed in the pylons and railings of the Lorain Road Bridge.

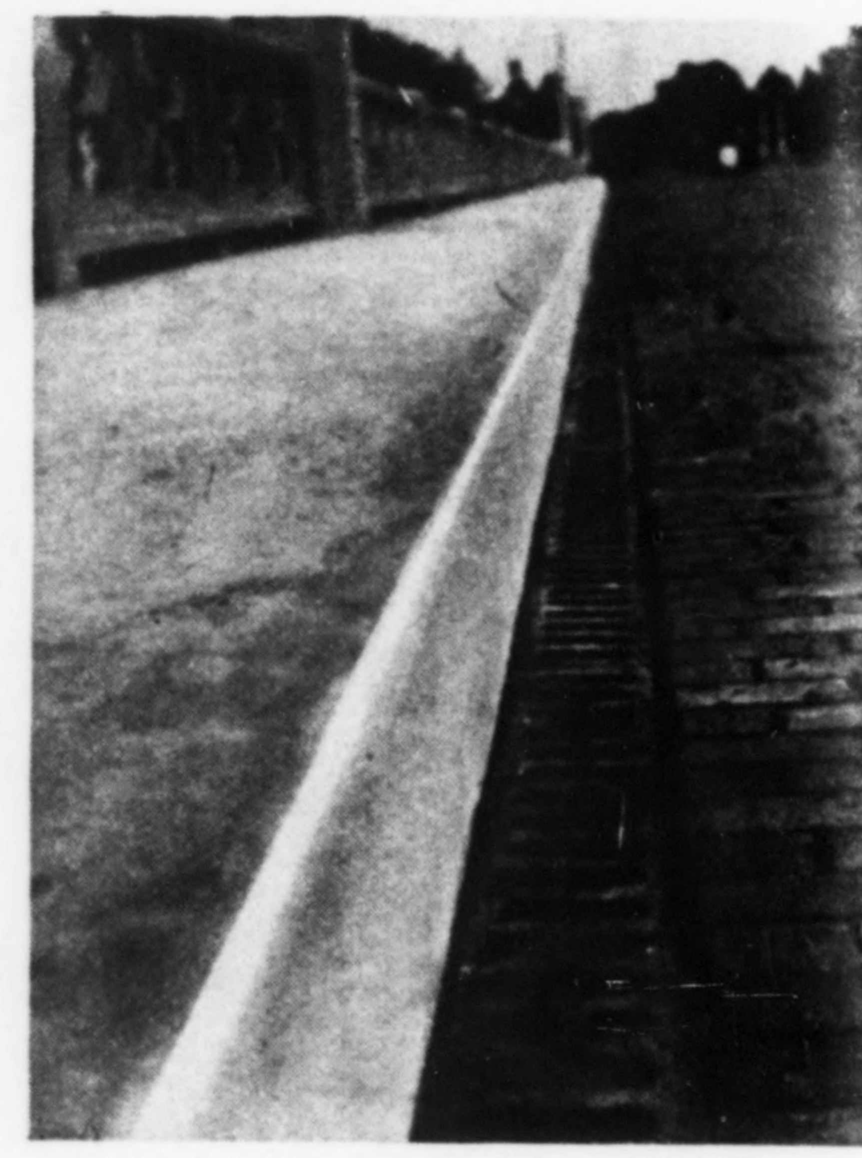


FIG. 3—CONTINUOUS GRATING along the curb line drains the deck into copper troughs that slope toward 8-in. pipe downspouts inside the pier tower legs.

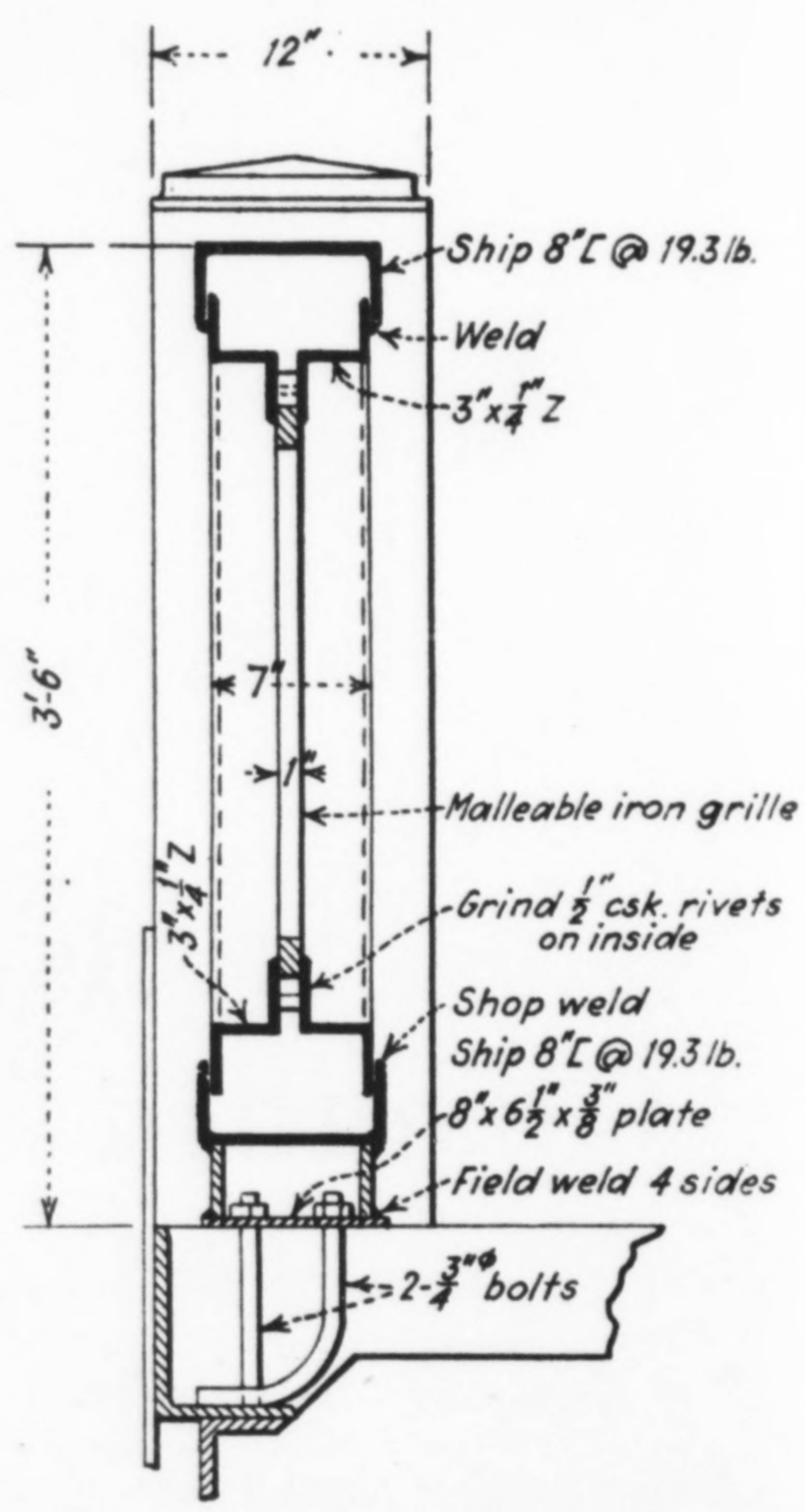


FIG. 4—RAILING of welded shapes with malleable iron grilles. A 5-ft. sidewalk and a 12-in. curb supplement the rail in its function of keeping cars on the bridge deck.

a roadway width of 40 ft. between 5 ft. sidewalks. The height is 131 ft. from the bottom of the river under the east arch span to the surface of the pavement. The arch rise is 97 ft. The pier pedestals, and abutments, roadway slab and sidewalk slab are of reinforced concrete, and the roadway is paved with 3-in. brick on a granulated slag cushion. The footings extend an average of about 20 ft. below the surface of the ground and rest on shale.

Smooth surface arch ribs

The arch ribs, of box type, have a constant depth and section. The arch spans are identical except that the two unsymmetrical end spans are one panel shorter than the intermediate ones. All stiffeners and splice plates are concealed on the inside of the ribs and all joints in the cover plates and webs are butt-welded and ground smooth. All rivets, except in the flange angles, were countersunk, chipped and ground. Holes were placed on the inside vertical face of each rib, one in each panel, to permit access for construction, inspection and maintenance, and are equipped with flush cover plates secured with cap screws. The arch ribs are spaced 34.5 ft. center to center and are braced at each panel point with 36-in. rolled I-sections, the webs being placed normal to the rib axis.

Columns without lacing

The spandrel columns are closed on three sides and batten plates, 15 in. wide and spaced 15 in. apart, are used on the inner side. At the top and bottom of the columns, full plates instead of battens, are provided, to develop the stresses induced in the columns by the cross floorbeams, since the columns and floorbeams are designed to act together as rigid frames. The closed portion at the top of each column is filled with concrete to assist in resisting the compression induced by the action of the floorbeams, brackets and jack arches, which are framed into the four sides of the column. No bracing is provided for the spandrel columns, the longest of which is about 82 ft.

The floorbeams are spaced 19.3 ft. apart and the stringers 6 ft. The latter are designed for full continuity (Fig. 5), the connections between stringers being made by splice plates welded to the stringer flanges; the upper splice plate passes over the top of the floorbeam and the lower splice plate through a slotted hole in the floorbeam web. These connections were not completed until after the arch ribs were swung free of the centering.

Pier towers made prominent

The steel towers, which are placed over all arch pier pedestals, play an important part both structurally and architecturally. Each tower consists of two shafts connected at the top by crossgirders and also at mid-height except on the end towers. From the low concrete pedestals the shafts rise to the deck where they blend into the light standards, finally terminating with the ornamental luminaires about 20 ft. above the sidewalks. The vertical lines of the shafts are accentuated by avoiding any visible diagonal bracing and by concealing all horizontal joints and splices, as well as all rivets except the vertical lines of rivet heads at the corners. It is thought that the presence of the park, with its boulevard, drives and bridle paths, justified these refinements which affect appearance at close range.

The piers, consisting of the towers and the concrete pedestals, are designed as rigid bents to carry the full wind force from the arch deck to the ground, as no diagonal bracing other than within each shaft is provided. The transverse reaction of the deck is transmitted to the towers through flanged expansion plates. Two such plates are used at the ends of each span and are placed near the center of the roadway in order not to interfere with lateral expansion and contraction of the deck. The shafts are built of $\frac{1}{2}$-in. plates and standard channels and angles. Each shaft is trussed on the inside and is rigidly anchored to a steel grillage extending

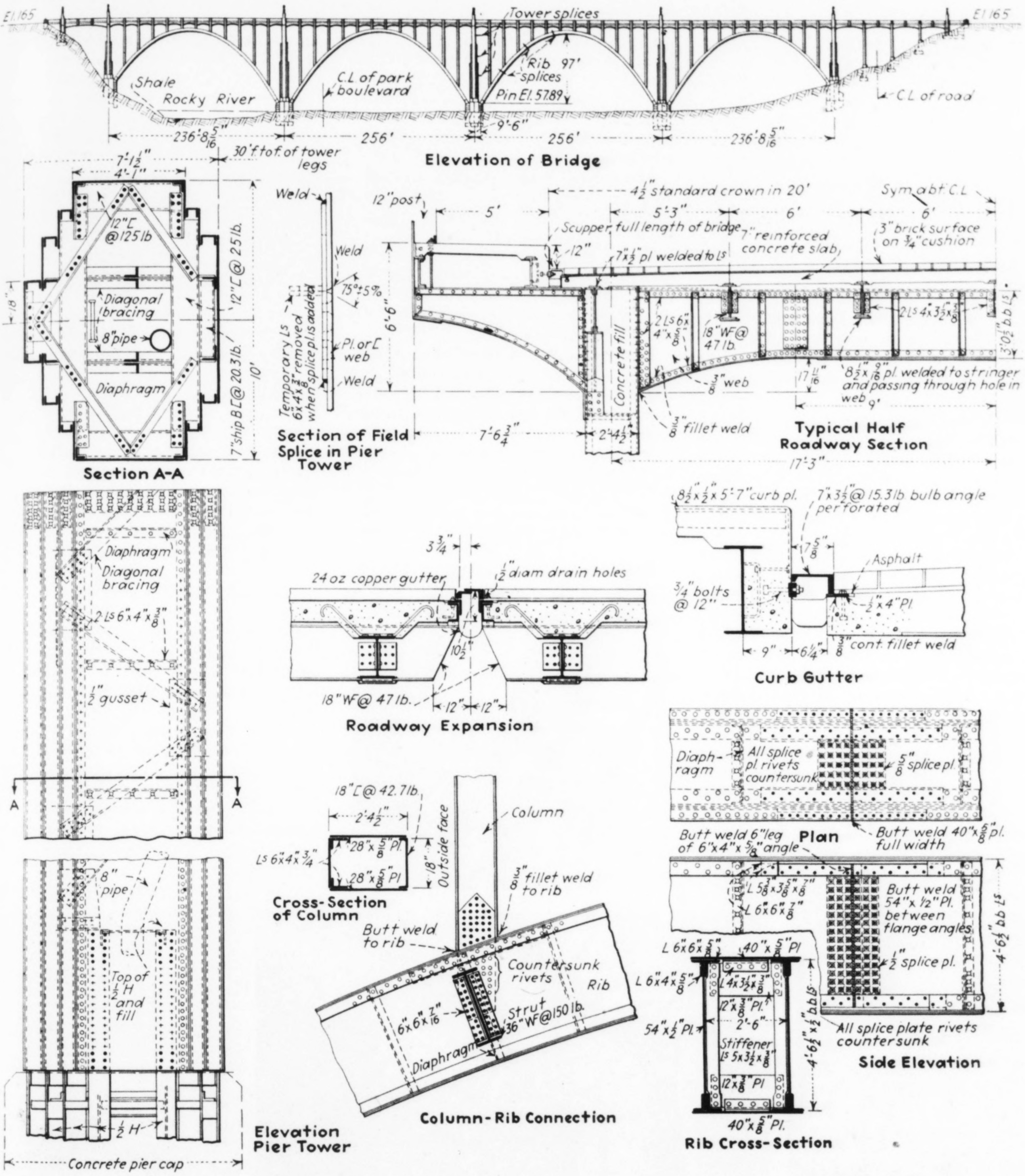


FIG. 5—STRUCTURAL DETAILS include countersunk rivets, welded joints, continuous stringers, rigid frame bents and novel gutters.

20 ft. into the concrete pedestal (Fig. 5).

Erecting the pier shafts

This grillage consists of half I-beam sections or tees braced and shop fabricated into pier units. The shaft was designed to permit it to be slipped over the grillage, which projects 5 ft. above the finished pedestals. The upper 5 ft. portion of the concrete pedestals was omitted until after the shafts were placed, to provide space for temporary steel supports for the shafts during erection. Steel shims of variable thickness were placed between the grillage and the shell of the shaft for the necessary field adjustments. Rivet holes in the shaft shells were shop punched but in the grillages and shims the corresponding holes were field drilled.

Access to the inside of the shafts is gained through manholes in the sidewalks and through steel doors near the base. Openings at the top and louvres on the door near the bottom permit circulation of air through the shafts, thus reducing condensation to a minimum. The shafts house the transformers and other electrical equipment as well as the conductor heads and downspouts for the drainage system. Steel ladders extend from top to bottom of all shafts, to facilitate inspection and maintenance.

The standards, which support the aluminum lighting fixtures (Fig. 2), were fabricated from $\frac{1}{8}$-in. plates and all joints are welded and ground smooth. Each lighting fixture is equipped with two 4,000-lumen lamps arranged one above the other on separate circuits. An automatic time switch is also used so that the lower lights may be turned off at any desired time during the night.

Malleable iron rail grilles

The metal railing was designed to give a sturdy appearance and to harmonize with the modern motif used on other portions of the structure. Each panel consists of four malleable iron grilles, 1 in. thick, set in and riveted to a welded steel frame built up of 3-in. zee sections and 8-in. ship channels (Fig. 4). All of the welded joints were chipped and ground. All rivets on the roadway side of the railing were countersunk. The finished railing weighs about 100 lb. per lineal foot.

The bridge is on a level gradient, to fit the approach elevations, which necessitated the development of a special drainage system since open scuppers would have been considered objectionable over the park. The solution is depressed copper gutters (Fig. 5) installed in continuous longitudinal openings left between the roadway slab and each sidewalk, to form closed scuppers. Sufficient gradient was provided in these gutters, by using a trough section of variable depth, to conduct the water to the piers where it is dropped into an 8-in. steel pipe down the inside of the pier shaft to a sewer laid under the centerline of the bridge. The copper gutters are protected by steel gratings (Fig. 3) built of bulb angles, punched with slotted holes and made in lengths of from 6 to 8 ft. The gutter is also designed to permit drainage of any water which seeps into the cushion under the bridge surface course. A transverse copper trough is also installed under each expansion joint between spans.

Many splices and connections in the structure were both riveted and welded, such as those in the arch ribs and pier shafts. The welding in such cases was always done first so that initial stresses would not be developed in the rivets due to the shrinkage of the weld metal. All welding was done by the electric arc process, using coated electrodes.

In the erection of the viaduct, a stiff-legged derrick operating from deck level was used to place all structural steel in the end approach spans and the end arch towers including as much of the end arch spans as could be reached from the end tower position. Two other stiff-leg derricks operating on runways at ground level, one on either side of the structure, were used to erect all intermediate steel in the four arch spans that could not be reached from the tops of the two end towers.

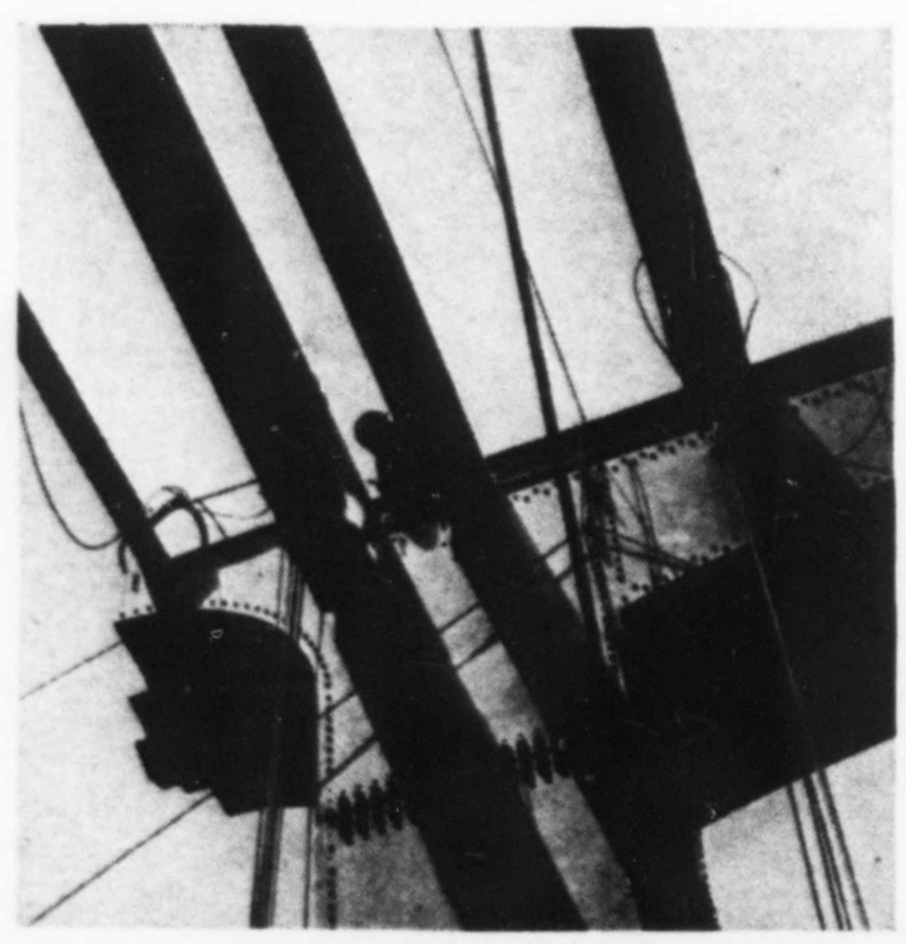
Steel centering was used in the erection of three arch spans and timber centering for the other, the latter being added to hasten completion. Each rib was erected in seven sections, the longest being 50 ft. and weighing 17 tons. Wood blocks and wedges were used to support the ribs on the centering, the individual sections being raised or lowered to their proper elevations by means of jacks.

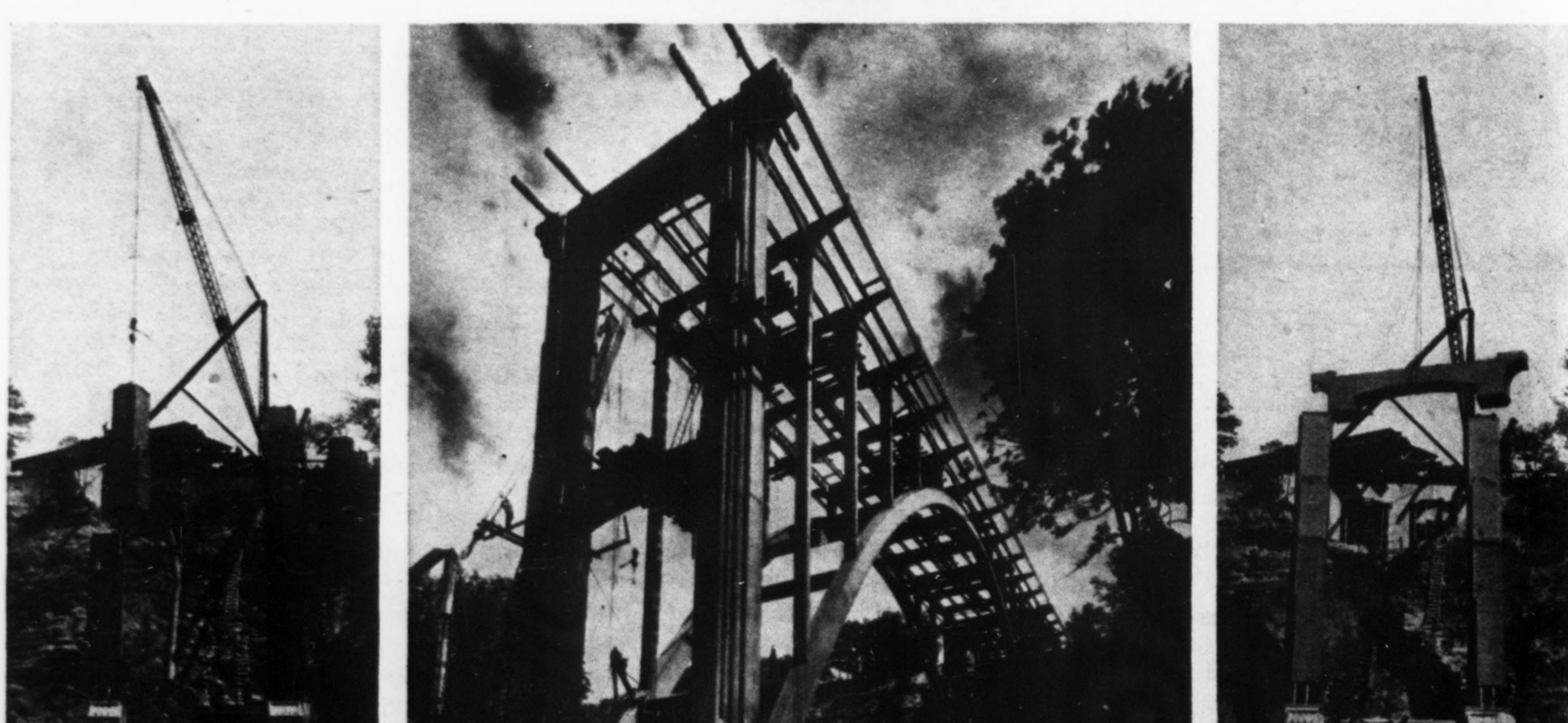
The end tower shafts were each erected in two vertical lifts, the longer intermediate shafts in three. The cross-girder sections joining twin shafts were erected in one piece. The largest tower sections were 54 ft. long and weighed 26 tons. Each spandrel column was fabricated and erected in one piece.

Temporary bracing

As the finished structure depends on the concrete slab for the transfer of the lateral forces to the towers, it was necessary during construction to install temporary diagonal bracing between floorbeams, which was left in place until the deck concrete had attained its required strength. Temporary diagonal bracing was also used between arch ribs and between spandrel columns, to hold the bridge in line during construction and to avoid excessive construction stresses.

FIG. 6—ERECTION SCENES on a unique steel arch viaduct. Because of the absence of diagonal bracing on the Lorain Road Bridge a considerable number of temporary guy cables were necessary prior to the erection of the floorbeams and the placing of the concrete deck slab.





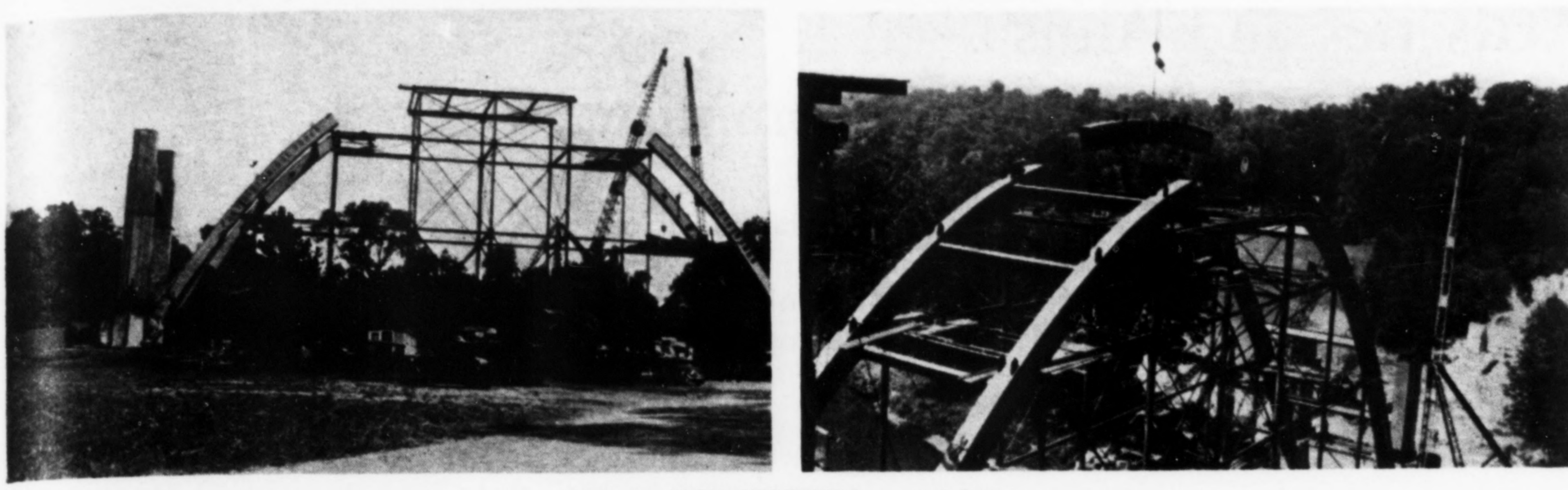


FIG. 7—ARCH ERECTION on steel falsework using steel stiffleg derricks.

The absence of permanent diagonal bracing between ribs, the small dimensions of the rib section in relation to fabricated lengths, and the omission of milled joints, which would have been unsuitable for the butt-weld used to join sections, made the erection of the ribs a delicate problem. Alignment was carefully controlled by transit while elevations were established by vertical measurements from ground points to a bolt in the top hole of spandrel column gussets.

In order to prevent excessive footing pressures from eccentric loading during construction, the specifications required that no concrete be placed on any arch deck until all structural steel in the adjoining spans was in place and free from the falsework. To prevent undue distortion of the arch ribs, the roadway slab for each span was placed in five sections in the following order: two and one-half panels at each end, four panels at the middle, and finally, the remainder near the quarter points. The concrete sidewalks were placed after the roadway slab had been completed and thoroughly set. This procedure, it is believed, minimized stresses in this thin section due to composite action with the remainder of the structure and facilitated refinement of construction in this conspicuous part of the deck.

Asphalt emulsion waterproofing was applied over the roadway slab. This also served for curing and was applied with spray guns. The first application was made as soon as the concrete had hardened sufficiently to bear the weight of workmen, followed by two other applications at 24-hr. intervals, using a total of about 0.5 gal. per square yard.

As the color of a structure has such a decided influence on its appearance, considerable study was given to the final coat of paint. For the shop coat sublimed blue lead was used. Two such shop coats and one field coat of white lead were applied to the interior of the arch ribs. All other surfaces were painted one shop coat and two field coats except the railing and light standards which received an additional color coat. The first field coat for the interior of the towers was blue lead and for all exterior surfaces tinted white lead. The second field coat for all exterior parts, except cross struts between arch ribs and certain portions of the railing grilles, consists of white lead tinted to make a light greenish gray, with sufficient yellow added to produce a warm neutral tint. The horizontal cross struts have a darker and more subdued shade of the same color, to accentuate the vertical lines of the bridge. This darker shade as well as an intermediate shade are used on certain portions of the railing grilles to produce a three-tone repeating pattern.

Administration and personnel

The contract for the bridge and approaches was awarded to the Lowensohn Construction Co., Cleveland, in November, 1934, for its low bid of $535,472 by O. W. Merrell, who was then state highway director. The bid for the bridge was $496,341 and for the brick-paved approaches and landscaping $39,131. The structural steel was fabricated by the Fort Pitt Bridge Works, at Canonsburg, Pa., and was erected by the Peoples Steel Co., Cleveland, both acting as sub-contractors.

Active construction did not start until March, 1935, and the bridge was opened to traffic in December of the same year, although some of the field painting and landscaping were delayed until the following spring.

The work has been carried on under the supervision of John Jaster, Jr., director of highways; G. M. Anderson, assistant director; J. R. Burkey, chief engineer of bridges; Elmer Hilty, chief engineer of construction; L. L. Drasler, division engineer; and J. O. McWilliams, resident engineer. The design was prepared in the bureau of bridges of the Ohio department of highways; W. H. Rabe is chief designing engineer and D. H. Overman was the principal designing engineer in charge of this project. Those engineers who had a principal part in the construction of the bridge are R. R. Heckman and R. L. Keller. The right-of-way was provided by Cuyahoga County.

Road and Street Program Largest WPA Activity

WITH THE ARRIVAL of warmer weather the WPA has continued its road and street program as its largest relief employment activity. During February there were 1,163,927 persons employed at an average of about 37c. an hour on some 26,400 road and street projects.

On the basis of February statistics, the latest month for which figures are available workers on road and street programs represented 38.3 per cent of the 3,038,973 persons then working on WPA projects. Of the $1,367,839,799 worth of projects selected for operation through March 16, the sum of $503,363,376, or 36.8 per cent of the total, went for this type of project. Of this sum, $160,221,587 represented farm-to-market and other secondard roads, and $343,141,789 represented other highways, roads and streets. There were 422,417 persons or 13.9 per cent of the total WPA employment engaged in the farm-to-market road program and 741,510 on the other types of roads in February.

There are 11,556 farm-to-market road projects as compared with 14,928 other road and street projects in cities and small towns. The total amount of money to be contributed by local sponsors reached $111,000,000, or 22 per cent of the total cost of the road and street program, as compared with a 16.5 per cent average for all other WPA projects. Sponsors of farm road projects contributed 27 per cent, or $43,321,890 of the total cost, compared with 20 per cent or $68,446,057 contributed by sponsors of other road and street projects.