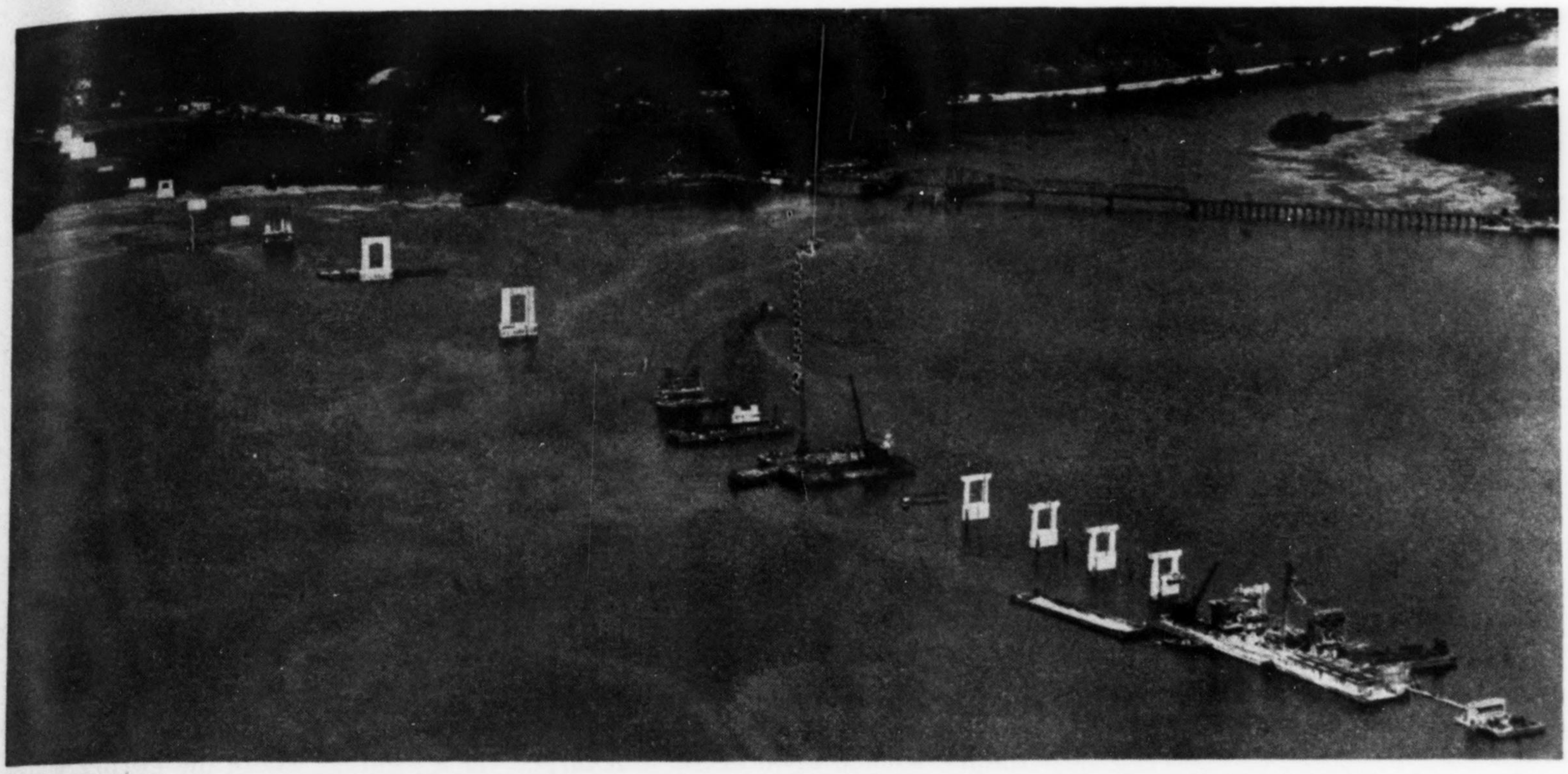

Fig. 1. For the 4,745-ft. bridge over the Illinois River at Peoria, 28 piers are required, all but five being in the river.

Underground Water Supply Complicates Bridge Pier Construction

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***Contents in Brief**—Foundation piles for the highway bridge now being built to span the Illinois River at Peoria penetrate the water-bearing stratum from which water for Peoria is obtained. Described are the special precautions taken during pier construction to prevent pollution of this supply, and the procedure followed when an unstable gravel complicated the foundation work at the west abutment and three piers. Also outlined is the precise triangulation work required for the location of the 23 river piers.*

IN CONSTRUCTING THE PIERS for a new 4,745-ft. long highway bridge to provide a 26-ft. wide roadway and two 2½-ft. wide safety walks over the Illinois River at Peoria, Ill., unusual conditions were encountered, presenting problems of considerable magnitude, both in design and construction. The Peoria Water Works Co., a private utility supplying water for Peoria, obtains its supply from wells extending into a sand and gravel stratum carrying an underground flow. This stratum is separated from the river flow and groundwater by layers of clay and shale of varying thickness, tests indicating that a 20-ft. head of water was required to penetrate this seal. However, some of the steel H-section bearing piles, planned as foundation support for the bridge, which calls for a 3-span, continuous, through, truss unit over the main channel, were expected to extend into the water-bearing gravel (Fig. 3). Thus, pollution of the company's supply would result unless special precautions were taken. This fact was established, during design of the substructure, by test holes at the approximate locations of the 23 river piers.

As expected, water company officials objected strenuously to river work in any way contaminating the supply, and representatives of the state geologist's office, the Illinois department of public health, the highway department, and the water company held several conferences to discuss the many phases of the problem. The first step, it was generally agreed, was to define the area drained by one of the company's wells.

To do this, a number of test wells were extended into the water-bearing gravel and observations were made hourly for seven days, then daily for two months, and then less often for several more months. By means of floats in these wells the water level could be noted at a glance while pumping was in progress at a company well. These studies indicated that the piling for four piers would extend into the stratum drained by the company's wells.

Protection of the supply during construction was next considered.

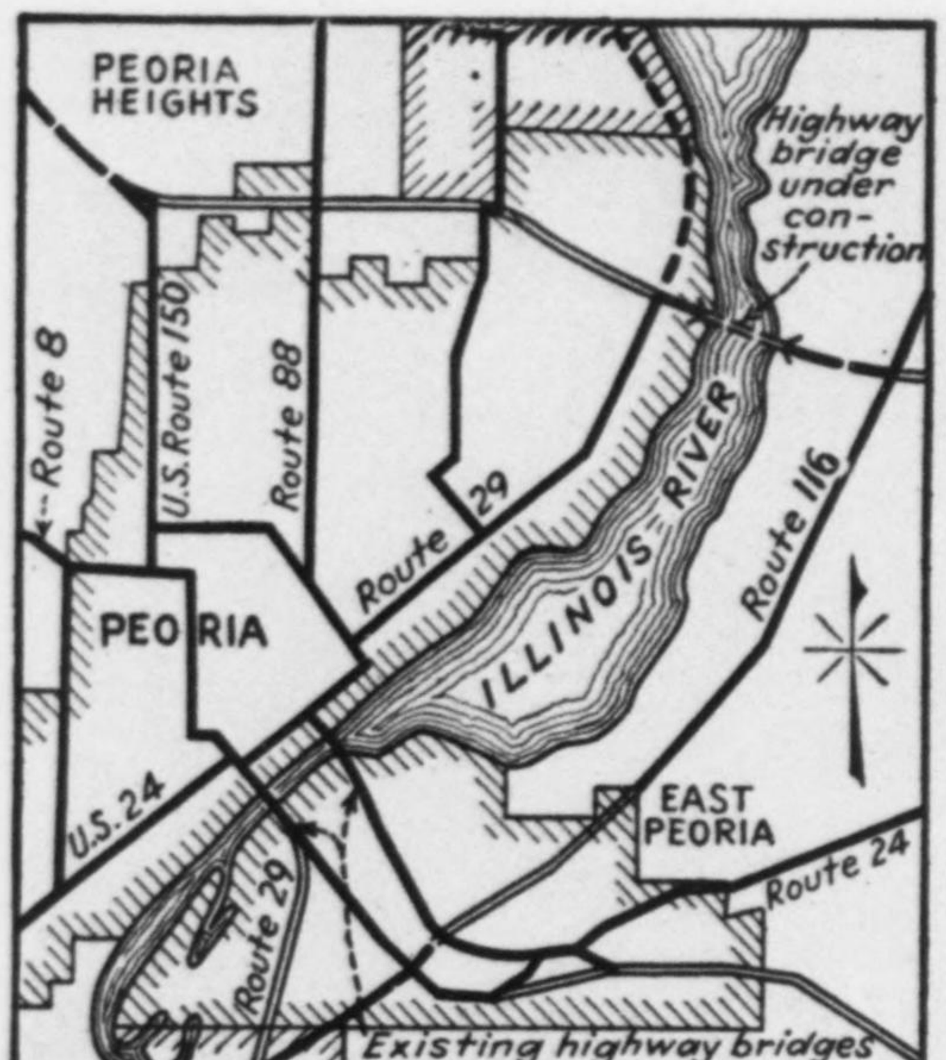

Fig. 2. Located at Harvard St. in northern Peoria, the crossing will disperse traffic over main arteries to the business district, as well as residential areas.

That the method should prevent leakage into the supply was apparent. As a first step, test wells were drilled outside the locations for the four piers involved. These were to determine the groundwater elevation and observe its action as construction progressed.

After the deep-web cofferdam sheet piling, which weighed 42.7 lb. per sq. ft. had been driven the contractor installed pumping equipment to keep water in the inclosed areas at river-bed elevation. Some leakage through the cofferdams occurred, but dumping cinders outside the cofferdams at the points where leakage was taking place greatly reduced the inflow. The pumping, which was to relieve the water head and prevent infiltration into the underground stream before the concrete seals could be constructed, was maintained throughout the excavation and pile-driving operations. This period was from two to three weeks at each pier. Three centrifugal pumps—a 4-in., a 6-in. and an 8-in.—were used to unwater each cofferdam, but after the water was down a 6-in. pump kept each cofferdam dry. With the foundation piles in place and the thick concrete seals poured and cured, the cofferdams were allowed to fill, as the seals removed the pollution danger.

The first cofferdams were designed to extend a minimum of 10 ft. below the seals but, from the test borings, it was impossible to determine with any degree of accuracy the stability of the river-bed material overlying the clay. This necessitated new cofferdam calculations with no resistance allowed for friction between this unstable material and the cofferdam sheeting. To overcome cofferdam buoyancy the thickness of the seal slabs was increased as much as 4 ft. for some piers. A maximum seal thickness of 14 ft. for the tallest piers resulted, which in turn required the contractor to change the cofferdam bracing. The bracing finally decided upon at the four large piers was small steel trusses at the upper levels and heavy steel I-beams lower down. Once the seal slab was in place the trusses could be removed and reused, as could all the I-beam struts above stream-bed level. With the piers in place, the steel sheet piling could also be removed without danger of pollution, since the sheet piling did not penetrate into the water-bearing strata.

The design contemplated construction of the west abutment and nearby Piers 3, 4 and 5 without bearing piles on dry foundations where borings had indicated a thick gravel stratum near the surface. Furthermore, when excavation for these piers was completed, clean coarse gravel was present and although apparently short in fines, appeared to be entirely satisfactory as a foundation material. Construction of the footings was undertaken according to plan, but after the concrete for the second footing had been in place about six hours, there appeared a 20-ft. long crack extending from the footing's edge to almost the center. In addition a segment of the footing settled almost 2 in.

After careful examinations, it was apparent that the crack had formed at a location where the curing water, as it drained off the concrete surface, had concentrated under the footing. Experiments and loading tests definitely indicated that the gravel was not stable when flooded and that shrinkage had apparently occurred, leaving a portion of the footing partly unsupported. The supposition is that the rise and fall of the underground water over many years removed the fines and greatly reduced the gravel's bonding qualities.

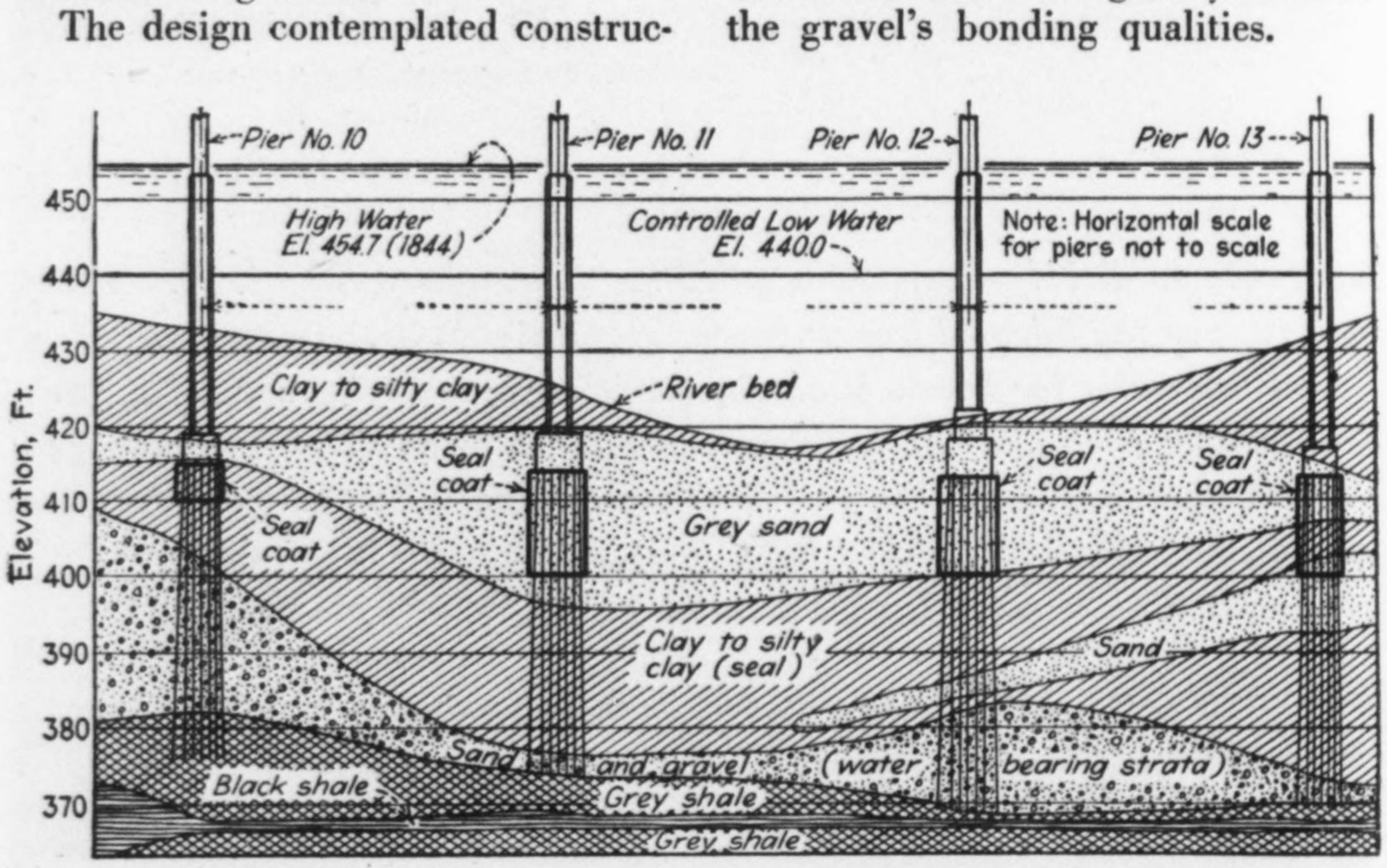

Fig. 3. Foundation piles for Piers 10, 11, 12 and 13 penetrate the stratum from which water is obtained for Peoria and neighboring communities. The vertical scale is ten times the horizontal.

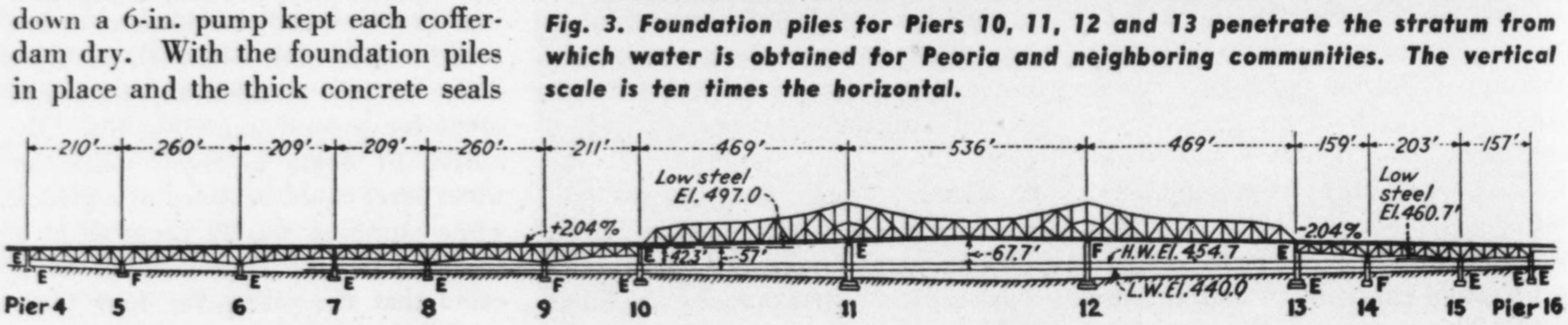

Fig. 4. Central portion of the bridge is of truss construction and includes a 3-span continuous unit providing a 66-ft. clearance over the main channel. In addition to work shown at the left end, two 3-span continuous steel girder units will be required, while at the right end three 3-span continuous girder units, and two 2-span continuous girder units are called for.

Since construction on such foundation material was definitely not advisable, a change in design was made using steel H-section bearing piles for the abutment and all piers originally designed without such support. The two footings already in place were removed and rebuilt with foundation piling used. Although to obtain a maximum pile penetration of 90 ft. was possible, it was necessary to depend, to a great extent, on skin friction on the piling for pier support. The gravel at the west abutment and at Piers 3, 4 and 5 proved to be over 90 ft. deep, since the points of the longest piles were still in that material.

Locating the piers

Because 23 of the 28 piers required were located in the river, which is about 4,000 ft. wide at controlled pool stage, locating and staking out those structures created no small problem. This was solved by an elaborate triangulation system involving six triangles with their legs to the piers, varying from 1,000 to 3,000 ft. Three of these triangles, with their bases along the center line of the bridge and their apexes at three main control points, were generally used. Permanent concrete monuments were erected at several control points and, to protect the precise transit used, houses were erected over the points employed most often.

This entire triangulation system was set up prior to any construction and considerable time was required in checking the many angles involved. To eliminate poor visibility due to light refraction, haze and smoke, a great deal of the instrument work was done at night. An illuminated telescopic transit graduated to ten seconds was used, and the angles were turned to read in series of 10 to 20 times with independent checks of the results in the same manner.

When this system was satisfactorily completed, the actual location of a pier could be quickly given when requested by the contractor. For this work two instruments were used, one at the control point from which the angle to the pier was measured and the other at a shore control point on the bridge's center line. Intersection of the lines of sight located the pier.

At the point thus established the contractor drove a cluster of temporary wood piling on which a platform was constructed. From this the contractor was supplied measurements for locating the cofferdam. With the cofferdams in place, accurate points were established for the footings and then the operations repeated for the pier stems. These several operations proved excellent for the location work.

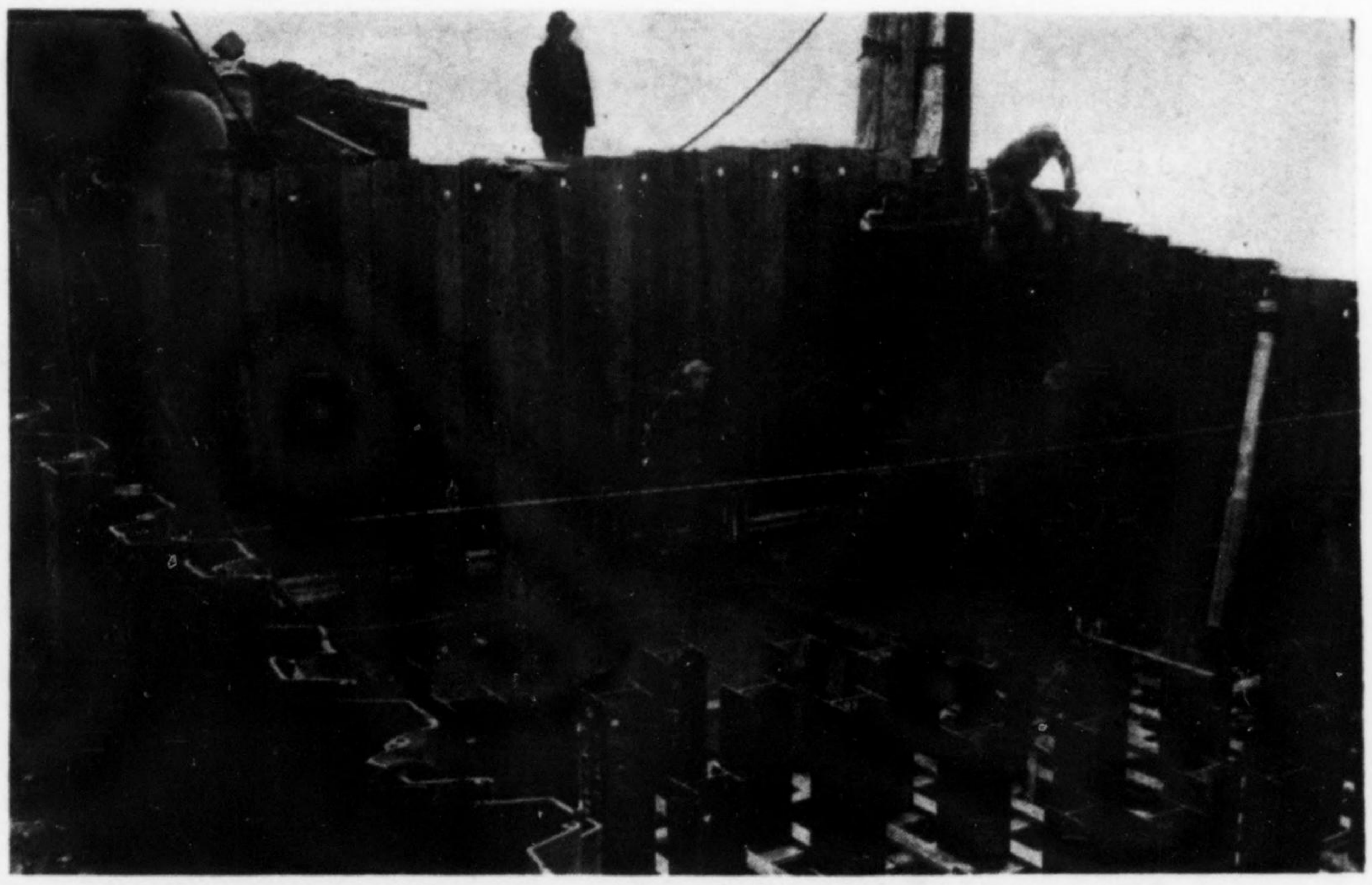

Fig. 5. Pile driving operations, underway for Pier 12, which will have a spread footing. Piles at left have been driven to bearing.

Tall river piers

The two piers to support the main cantilever span are practically identical and the height from the bottom of the seal to the bridge seat is 101 ft., which makes the seat 61 ft. above pool stage. Materials required for a single pier include: 148 12-in., 53-lb. H-section piles, totaling 7,400 lin.ft. in all; 2,600 cu.yd. of concrete; 63,000 lb. of reinforcing bars; 65 carloads of gravel; and 35 carloads of sand. To provide ice protection the two piers are encased with $\frac{3}{8}$-in. thick steel plates, 12 ft. high, as are the two neighboring piers. The bottoms of these plates, are 2 ft. below pool stage.

Equipment and materials for the river piers were delivered by barge. Sand and gravel arrived in separate barges and the bag cement in inclosed scows. Two cranes unloaded the materials and charged the material hoppers on the mixer barge. For the work below water the six-bag mixer charged a bucket elevated by a tower and the concrete was delivered to its final location through chutes and tremies. For the pier work above water the concrete was deposited directly into the forms by buckets handled by a crane on the falsework.

Two pourings of about fifteen hours each were required for the thicker seal slabs. Once the seals were cured, one pouring was required for the footing, two operations to finish the pier's solid part, one pouring for the pilaster portions, and then one pouring for the beam or top portion. Thus, for the larger piers seven separate operations were required, forms being erected for each unit after the preceding pour. About eight to twelve hours of continuous work was required for each of the five last-mentioned operations. Work was carried on 24 hours per day, and concreting was started at any hour during the night and extended continuously until the required placement was finished.

The $2,000,000 project, financed by Illinois and federal funds, is under the jurisdiction of the Division of Highways, Illinois Department of Public Works and Buildings. Designs were executed by George F. Burch, bridge engineer, and construction is supervised by C. M. Hathaway, engineer of construction in the highways division; Theodore Plack, district engineer; the writer, district construction engineer; and V. O. Hart, resident engineer. Great Lakes Dredge & Dock Co., Chicago, L. Filitan, superintendent, and R. N. Trotter, civil engineer, is the substructure contractor. American Bridge Co., Chicago, is fabricating the superstructure steel, and Strobel Construction Co., Chicago, holds the contract for the superstructure erection.