Roller-Gate Dam Erection at Rock Island, Ill.

World's largest installation of roller gates signalizes first navigation dam completed for 9-ft. canalization of upper Mississippi River

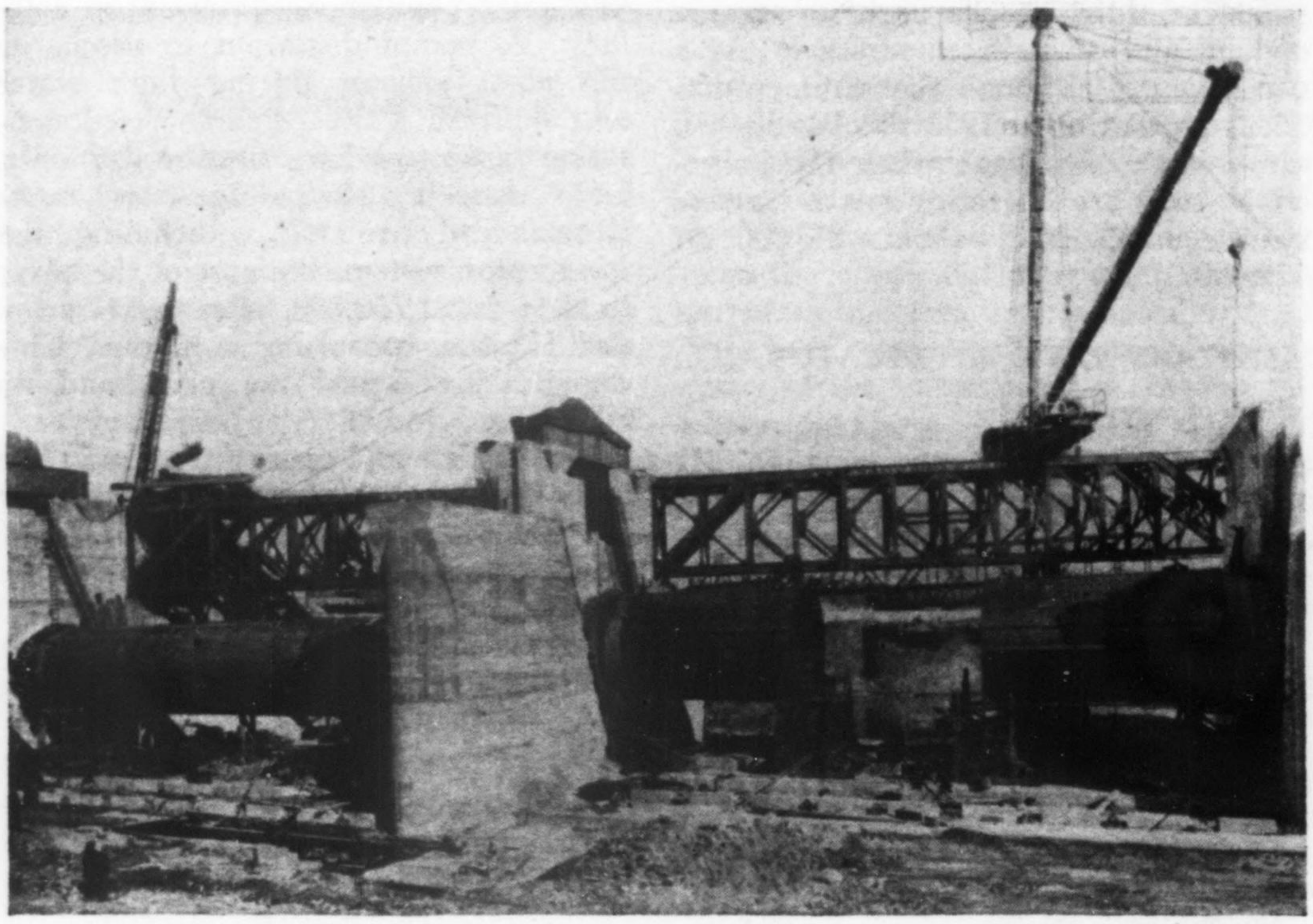


FIG. 1—ROLLER GATES for Rock Island navigation dam being erected from service bridge by 60-ton derrick. Roller ends travel on racks in pier niches.

A ROLLER-GATE DAM extending 1,200 ft. diagonally across the Mississippi is an outstanding part of the canalization works at Rock Island, Ill., the dual ship locks of which were described in *Engineering News-Record,* March 15, 1934, p. 342. This dam, with the inclosing locks, seawall and levees, creates a 6,000-acre pool over what was formerly the Rock Island Rapids. The installation, officially opened on March 2, is the first to be completed of the two-dozen new navigation dams built to provide a 9-ft. channel on the Mississippi River from St. Louis, Mo., to St. Paul, Minn. In length and number of gates it is the largest roller-gate installation ever made, although individual gates both longer and larger have been constructed in America and more particularly in Europe, where this type originated.

In an article to be published soon the design of the roller-gate movable dam will be reviewed. The present article deals solely with the structure and construction of the Rock Island dam, officially designated as Dam 15 in the Mississippi series (*ENR,* March 8, 1934, p. 322). Like others of the series its structural elements are: a concrete sill or fixed crest carrying the gate piers and appurtenant stoplog and poiree-needle bulkheads, the movable gates and a service bridge. These parts will be considered in order.

Dam structure

Unlike most of the dams of the Mississippi series, the Rock Island dam has a full roller-gate spillway; generally a combination of roller gates and tainter gates has been adopted. Another feature is the installation of two gates with a crest elevation $4\frac{1}{4}$ ft. lower than that of the other gates to provide a continuous overflow for sluicing out ice or drift from the upper pool when the gates are necessarily closed or but slightly open. All gates are $109\frac{1}{4}$ ft. long over all and have a 100-ft. clear opening; the two end gates forming the sluiceway have a damming height of $21\frac{3}{4}$ ft., and the nine intermediate gates a damming height of 26 ft.

The unusual arrangement of the gates in steps (Fig. 2) was adopted to insure the greatest effective spillway length. By this plan of dam it was possible to reduce the pier width to 11 ft., and for every 111 ft. of distance between pier centers to obtain 100 ft. of clear spillway. Thus 90 per cent of the dam length can be removed from the water if the need arises. The fixed crest of the dam is the top of the sill against which the apron of the roller-gate seats, as shown by Figs. 4 and 6.

Piers and Sills—Each pier, as shown by Fig. 3, is recessed on both sides for the trackways of the roller gates. These trackways are more clearly indicated by Fig. 6. To take the stresses developed by gate operation and the head of water, unusual reinforcement of the thin concrete pier shafts was necessary. Similarly the sill slab between piers was closely laced with steel; the crest sill is to take the pressure of the roller gates, and the bulkhead and poiree dam sills will withstand the pool heads when the crest sill is cofferdammed off for repairs. A general indication of the extent and arrangement of the pier and the sill-slab reinforcing is given by Fig. 3. In round figures, 32 tons of reinforcing steel was required for each pier.

In addition to the roller gates, the piers had to take the load of the service bridge and the pressure of the upstream emergency bulkheads when the gates were out of service for repairs. These are steel stoplogs with roller ends (Fig. 4), which slide down between piers in vertical slots and seat on a sill; when in place, they cofferdam the roller-gate sills for the upper pool. Each stoplog is a steel truss 106 ft. long, 3 ft. 7 in. high and $11\frac{1}{2}$ ft. deep with wood seals to prevent leakage. Eight of these trusses laid flat form a bulkhead. To provide the downstream wall of the cofferdam, a poiree needle dam is carried on downstream sills, which are indicated in Fig. 4 and more clearly in Fig. 8; with the frames raised and the needles placed, the lower pool is shut off from the roller-gate sill. These unwatering facilities are developments of very recent American practice.

Roller Gates—The general arrangement of a roller gate and its operating appurtenances at Rock Island is illustrated by Fig. 6, and by the several views, Figs. 6 to 9. Design elements of roller gates will be discussed in a future article, and at the moment only structure and mode of operation will be outlined.

As shown by the illustrations, the roller gate is a riveted steel cylinder with a permanently attached lip or apron. The apron extends the full spillway distance (100 ft.) between piers, but the ends of the drum extend beyond the ends of the apron into niches in the piers and so transmit the water load to the piers. The niches are inclined, and by rolling the drum up or down in them the gate is open to discharge water or closed to dam the pool. At Rock Island the over-all gate length is $109\frac{1}{4}$ ft.; the two end-gate drums are 16 ft. 2 in. in inside diameter, and the nine intermediate-gate drums are $19\frac{1}{3}$ ft. in inside diameter; the damming heights are $21\frac{3}{4}$ ft. for the end gates and 26 ft. for the intermediate gates; all drums have a clearance of $6\frac{1}{2}$ ft. when rolled up above high water.

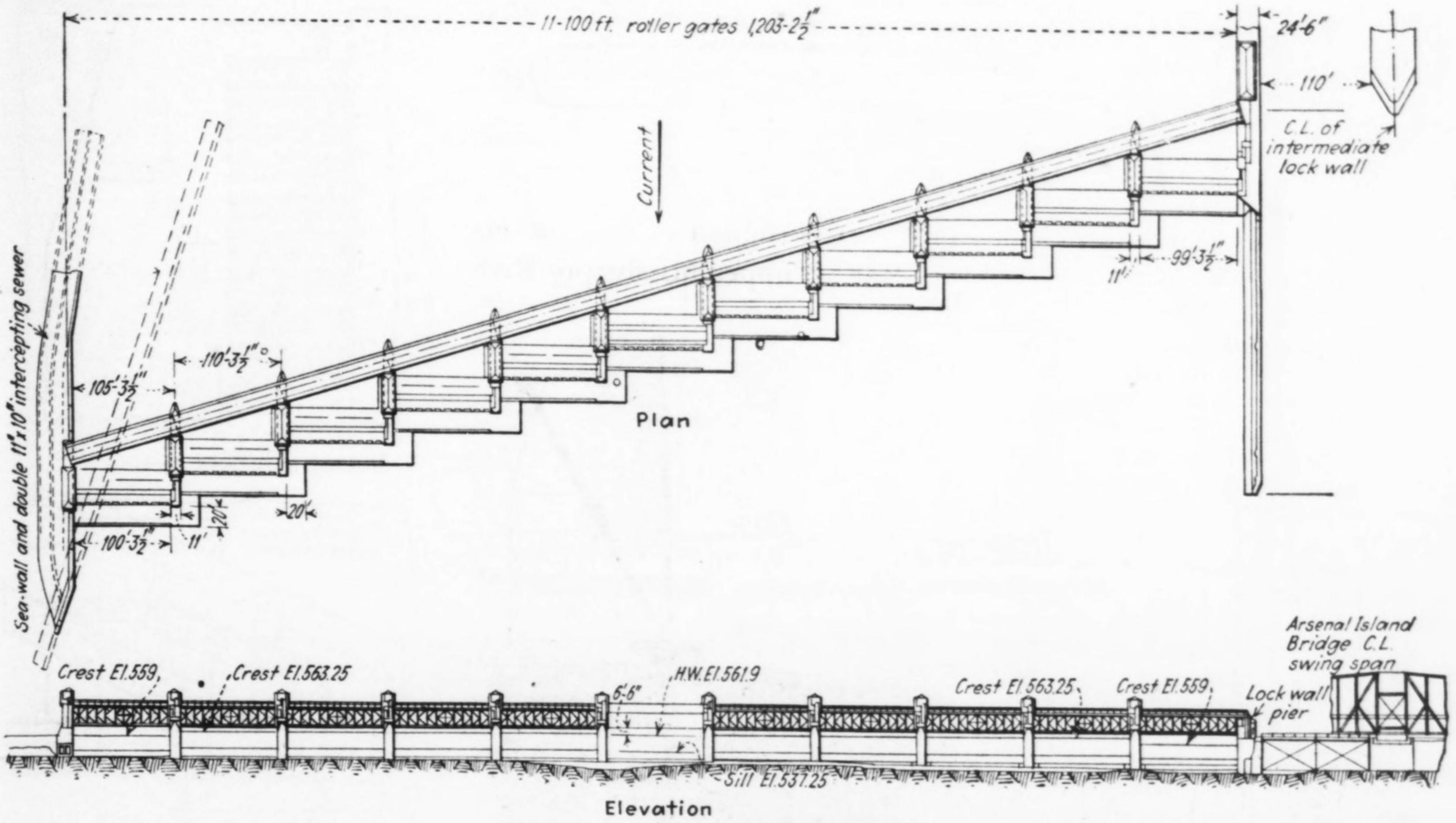


FIG. 2—ELEVEN roller gates arranged in steps enable 90 per cent of channel width to be opened at Rock Island navigation dam.

The gate is raised and lowered by rolling, exactly as any cylinder is rolled freely on an inclined plane. The rolling contact is made in the pier niches by drum racks meshing with track racks on the downstream ledges of the niches. A hoist and chain pulling on the gate at one end operates the gates. When closed, the apron of the gate bears against the crest sill. To seal the ends, a steel-plate shield is attached to each end of the drum. To the side of each shield next to the pier is bolted a timber that bears against a metal plate on the pier.

An interesting feature of the gates is the heating arrangement to keep the ends clear of ice. Each side seal is equipped with three 3-kw. heating units, and each end of the drum has three 4-kw. units.

Each gate is raised and lowered through a travel of 27 ft. 4¼ in. for the large gates and 30 ft. 10 in. for the small gates by a triple-reduction, herringbone-gear hoist having a working load of 426,000 lb. It is designed to raise the gate at a speed of 6 in. per minute; the time required to open a gate fully is 55 min.

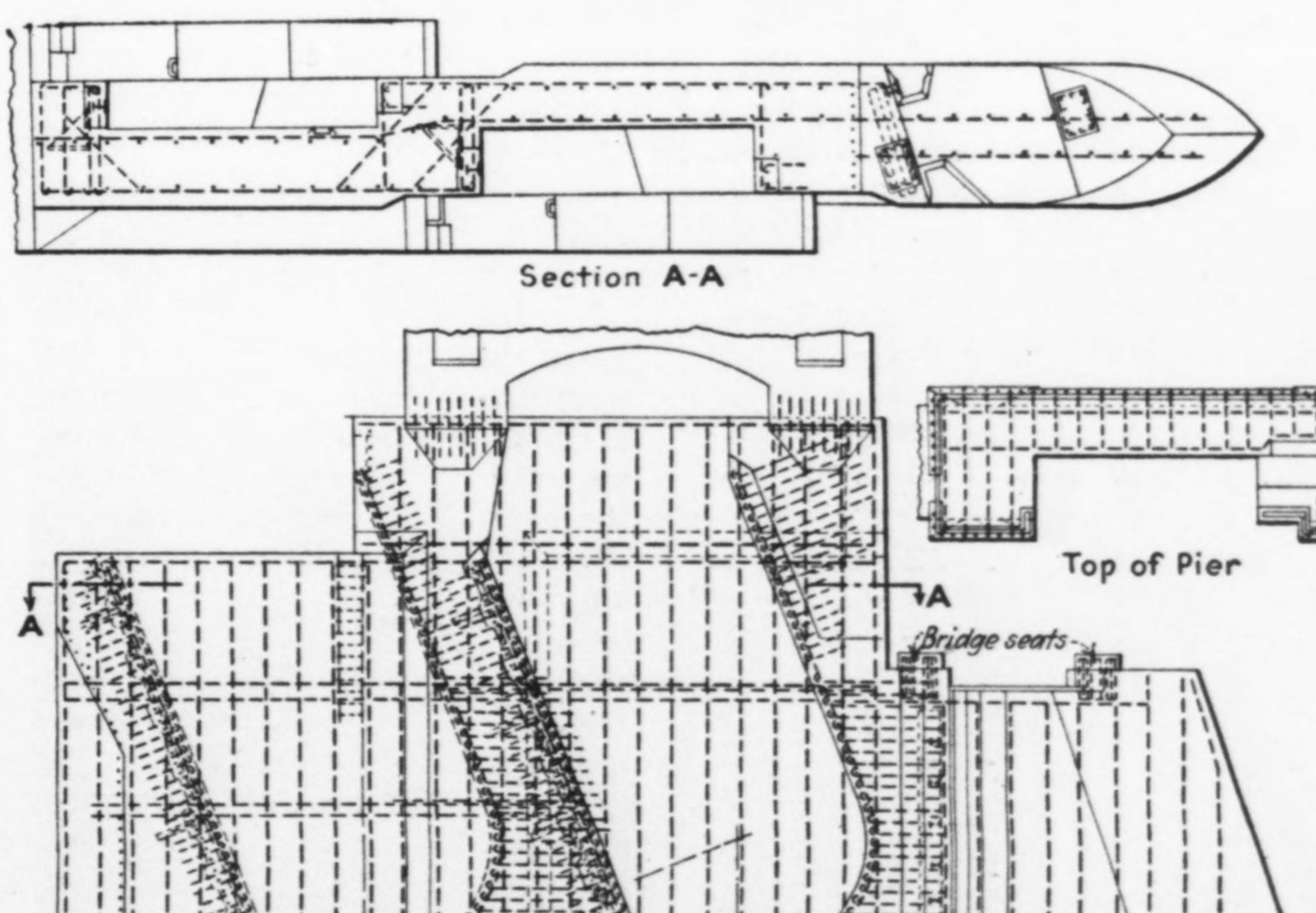
Service Bridge—The service bridge, as shown by Fig. 2, is an access way to the roller-gate hoists and a working platform for a locomotive crane on the top-chord deck and a bridge crane on the bottom-chord deck. The bridge crane handles the stoplogs for the upstream bulkhead, and the locomotive crane handles the poiree dam units and is used for general service.

Dam construction

Interest in the construction operations centers principally in the erection of the roller gates. For clear description this operation is best considered in respect to: (1) shop assembly of the gate parts into units convenient for shipment and field erection; and (2) field-erection procedure and plant. The construction of the masonry parts departed little from conventional river practices.

Pier Construction—All masonry and gate work was done in cofferdam. Starting at the Davenport side, the coffer was carried across the river in installments or sections about 500 ft. long, 200 ft. wide and 20 ft. high. The structure of the coffer was cellular, of steel

FIG. 3—HEAVY REINFORCEMENT required in piers and sills of Rock Island dam to resist gate, bridge and bulkhead loads.



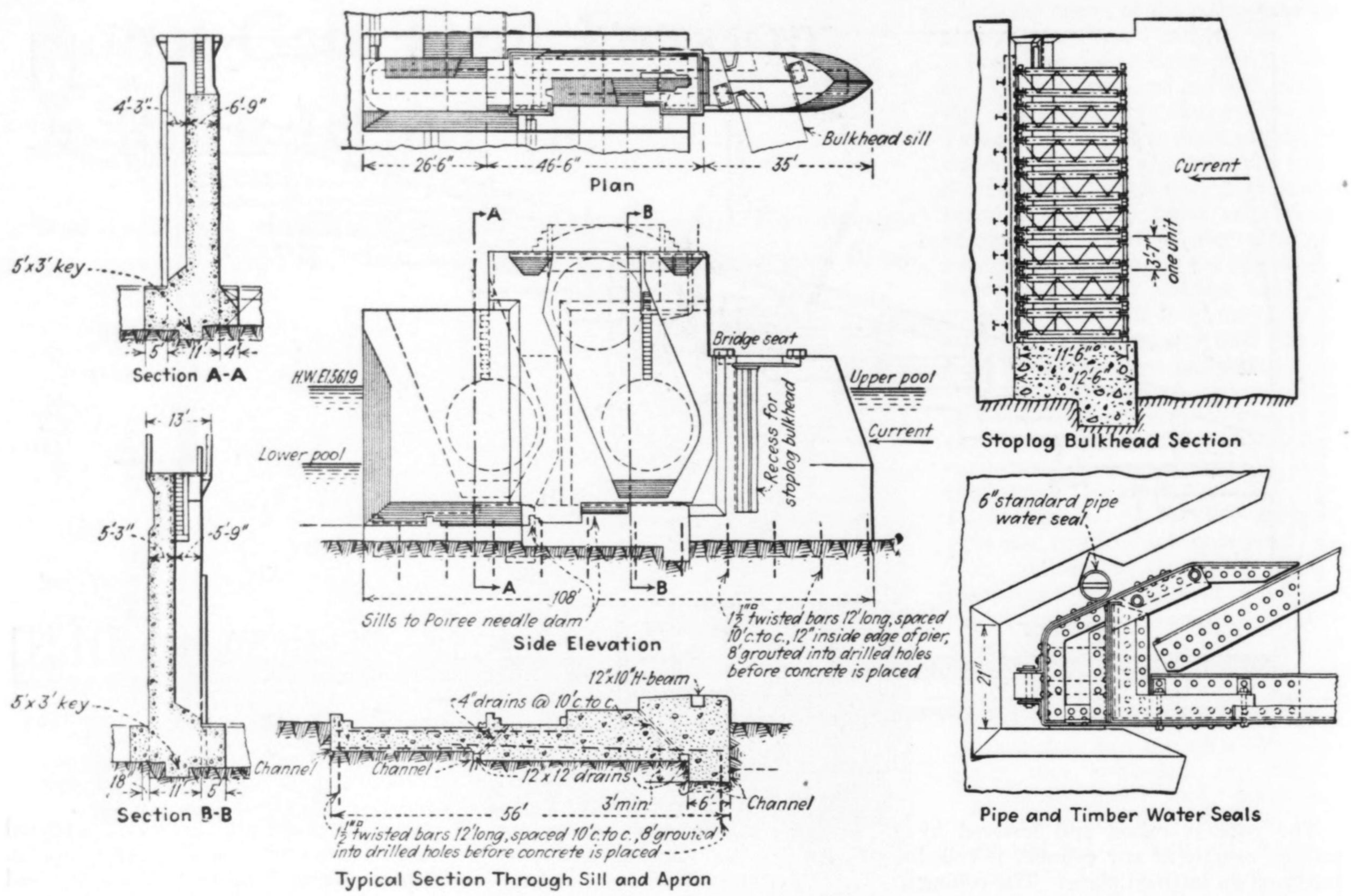


FIG. 4—PIER AND SILL details for roller-gate dam at Rock Island, Ill.

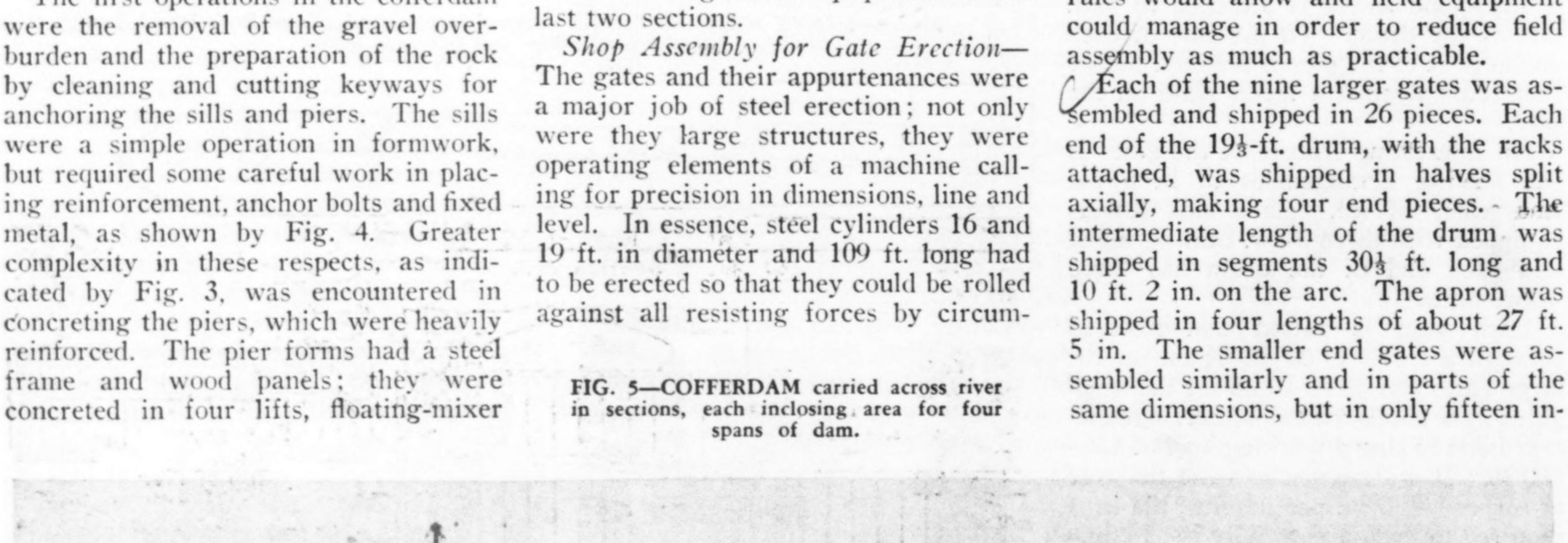
sheetpiles, as shown by Fig. 5, the cells being filled with sand. A section of coffer embraced four gates, and these were completed in full before the inclosing structure was removed.

The first operations in the cofferdam were the removal of the gravel overburden and the preparation of the rock by cleaning and cutting keyways for anchoring the sills and piers. The sills were a simple operation in formwork, but required some careful work in placing reinforcement, anchor bolts and fixed metal, as shown by Fig. 4. Greater complexity in these respects, as indicated by Fig. 3, was encountered in concreting the piers, which were heavily reinforced. The pier forms had a steel frame and wood panels; they were concreted in four lifts, floating-mixer equipment being used for the concreting operations in the first sections and track-traveling-mixer equipment in the last two sections.

Shop Assembly for Gate Erection—The gates and their appurtenances were a major job of steel erection; not only were they large structures, they were operating elements of a machine calling for precision in dimensions, line and level. In essence, steel cylinders 16 and 19 ft. in diameter and 109 ft. long had to be erected so that they could be rolled against all resisting forces by circumferential torsion applied at one end and not distort or lose expected sealing contacts or demand excessive operating power. This obligation indicated as complete a shop assembly as shipping rules would allow and field equipment could manage in order to reduce field assembly as much as practicable.

Each of the nine larger gates was assembled and shipped in 26 pieces. Each end of the 19⅓-ft. drum, with the racks attached, was shipped in halves split axially, making four end pieces. The intermediate length of the drum was shipped in segments 30⅓ ft. long and 10 ft. 2 in. on the arc. The apron was shipped in four lengths of about 27 ft. 5 in. The smaller end gates were assembled similarly and in parts of the same dimensions, but in only fifteen in-

FIG. 5—COFFERDAM carried across river in sections, each inclosing area for four spans of dam.



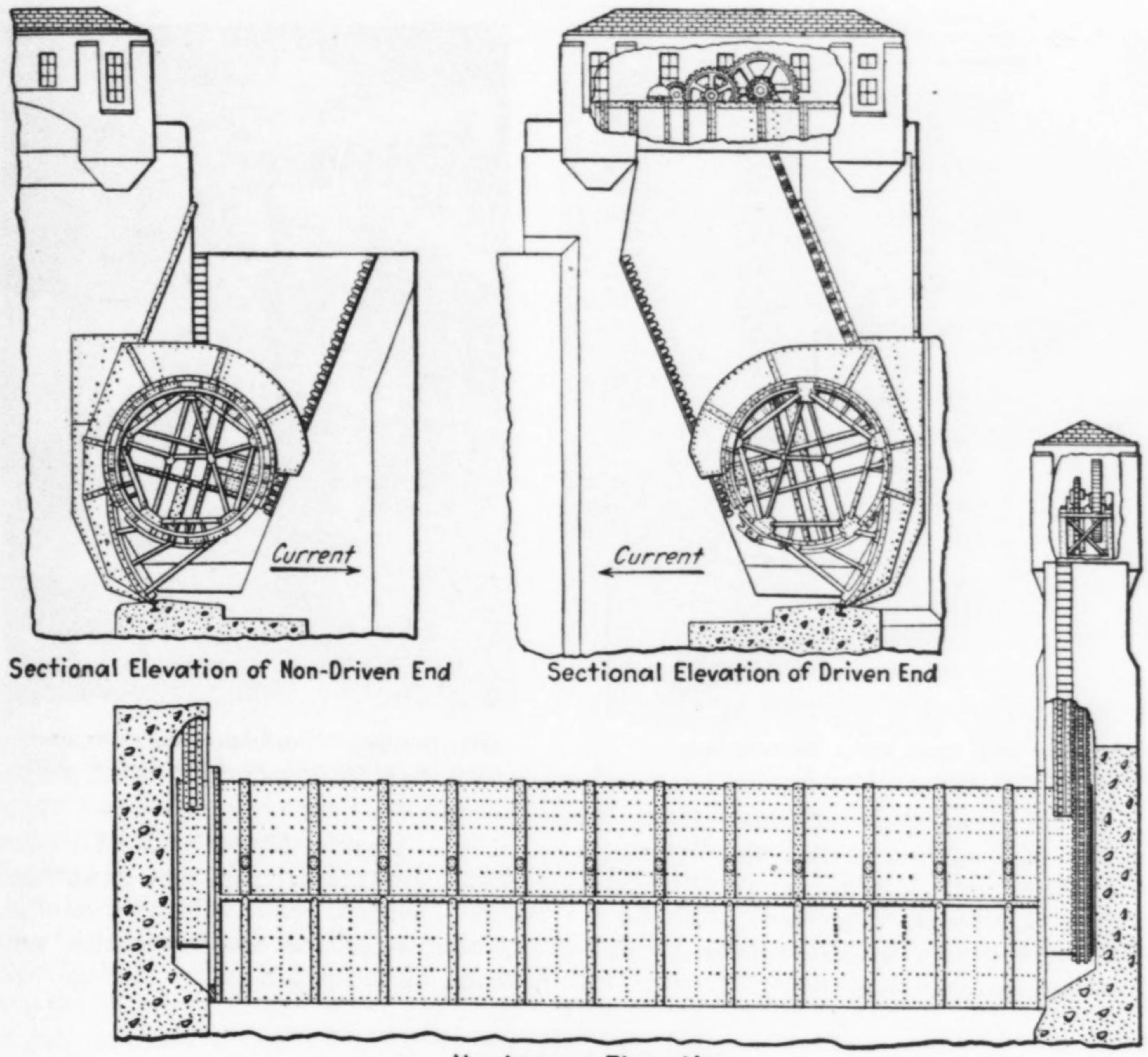


FIG 6—ROLLER-GATE ASSEMBLY, indicating gate structure and operating machinery

stead of eighteen parts for the intermediate length of drum. The hoist for each gate was shipped completely assembled. The chains 79 ft. long for the longer gates and 85 ft. long for the smaller gates were shipped in three pieces. Other minor parts were shipped in such sections as were convenient.

Field Erection—Gate erection began at the Davenport end of the dam in the cofferdam shown by Fig. 5, building out the service bridge, span following span and assembling the gates one after another. Side tracks and a yard crane on shore handled the gate and bridge parts. The method of erecting any gate was the same, and only the erection of the first gate on the Davenport side is described.

The first operation was to place 50 ft. of the service bridge on falsework. A 60-ton derrick (Fig. 1) was set up on the bridge to handle the gate parts into the hole for erection; the yard derrick placed the parts on a small car on the bridge. The falsework for the driven end of the gate was then erected and accurately lined.

The drum was erected in five rings, two end rings, two intermediate rings and a middle ring. First the intermediate ring next to the driven end was erected, beginning with the bottom segment and working up both sides to the top segment, bolting all connections. The two parts of the driven-end ring were then erected and bolted, and this ring was bolted to the intermediate ring. Next the driven-end rack and guide-rail was set in the pier niche, and the gate hoist and chain were then set on top of the pier.

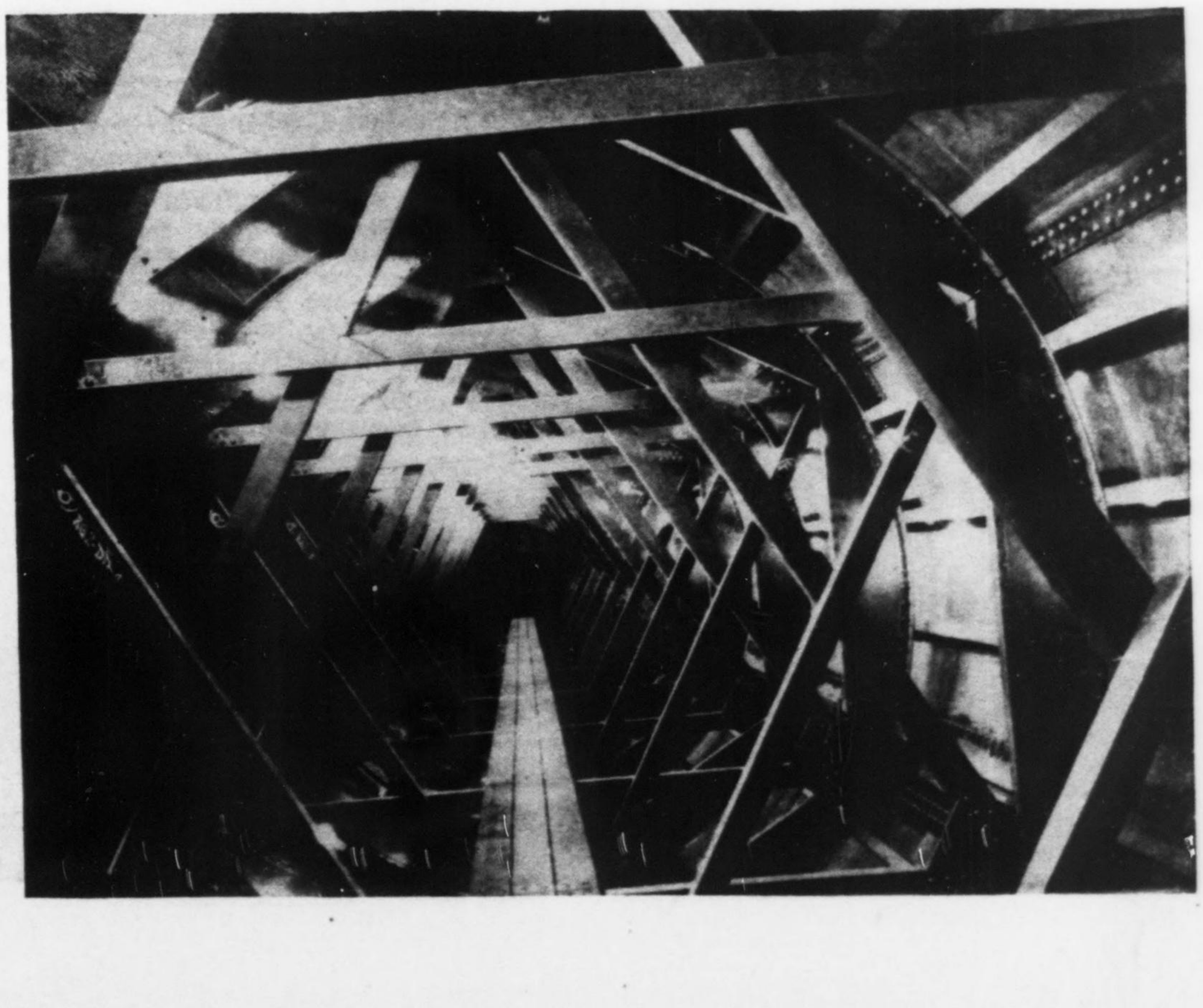
A 60-ft. extension of the service bridge was made, and from it the crane erected the falsework for the non-driven end of the gate. On this, as described for the driven end, the intermediate ring and then the non-driven end ring were bolted up and then together. The end-ring seams were then riveted, and the niche racks and guide-rail at the non-driven end were set.

With the two end sections (two rings each) of the gate erected as described, they were rolled longitudinally back into the pier niches into exact operating position. The middle ring of the drum was then erected and bolted to the intermediate rings. Next the full drum was lined up, and seams where the apron was to seat on the drum were riveted. The apron was then placed and bolted, and the whole gate was again lined up. All seams and connections inside and outside, except for the apron braces, were then riveted.

After the gate was riveted and both drum and apron were lined up accurately, the niche racks and guide-rail and the gate hoist were lined and leveled and grouted in place. The grout was allowed to set about ten days, when the hoist chain was connected and adjusted. The gate was then rolled up and the falsework dismantled, after which the gate was lowered to the closed position and checked for the line of the seal timber. The seal timber was then bolted in place, the end shields straightened and lined, the end-seal timbers placed and planed to a close fit, the heaters installed and the interior walkway built. To test the gate, it was opened and closed fourteen times. In all there were 250 carloads of steel in the gates, bridge and bulkheads.

The dam was built under the immediate direction of the Rock Island District, Upper Mississippi Valley Division, U. S. Army. George R. Spalding, colonel, Corps of Engineers, was divi-

FIG. 7—INTERIOR BRACING of roller-gate drum made heavy to resist pressure head and torsion caused by applying rolling force to one end only.



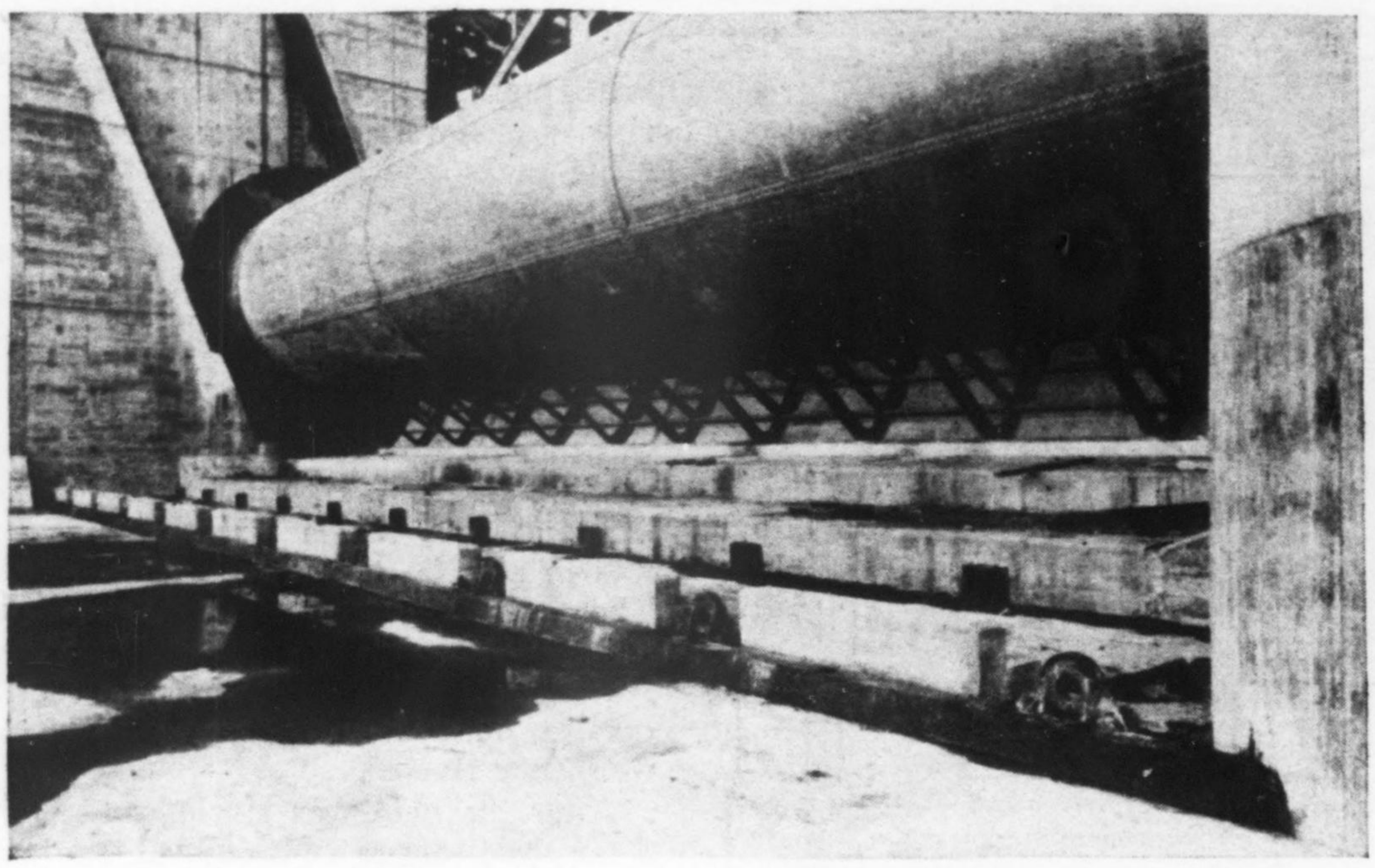


FIG. 8—ROLLER GATE closed with apron in contact with fixed sills. Downstream sills show hinges in place for poiree dam.

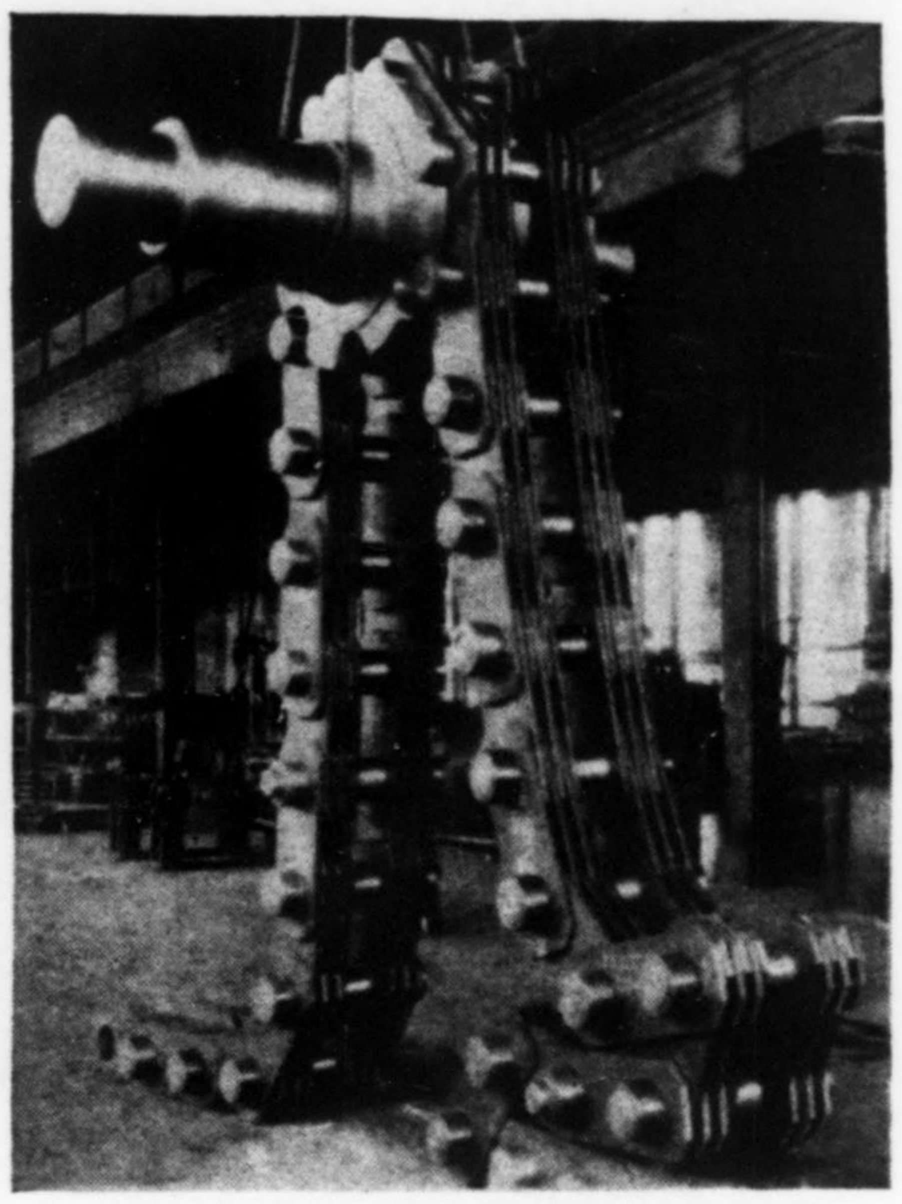


FIG. 9—CHAIN and hoist shaft for operating a roller gate at Rock Island dam.

sion engineer until Oct. 31, 1933. E. L. Daley, lieutenant-colonel, Corps of Engineers, has been division engineer since that date.

Glen E. Edgerton, lieutenant-colonel, Corps of Engineers, was district engineer until Sept. 4, 1933; R. A. Wheeler, major, Corps of Engineers, has been district engineer at Rock Island since that date.

S. A. Healy, Detroit, Mich., was general contractor for the dam, and the S. Morgan Smith Co., York, Pa., was contractor for the fabrication and erection of the roller gates.

Notes From the Road:

I—Winter Work in Wisconsin

Milwaukee,
March 2, 1934.

HIGHWAY WORK makes up the bulk of Wisconsin's winter construction program, with a few scattered bridges and grade-crossing eliminations in evidence as one travels through the state. Road contracts have been let at a fast rate, but continued cold weather seriously hampered progress in the field. When frost gets 36 in. deep in Wisconsin clay, excavation or grading work becomes difficult. To the credit of officials and contractors alike, strenuous efforts have been made to keep road jobs under way. Projects were shut down reluctantly, and only after weather conditions made work impossible. Some jobs were discontinued only for a few days during the coldest weather.

Contractors on bridges and grade-elimination structures have solved the cold-weather problem with steam boilers and paper or canvas protection, and have succeeded in making mid-summer progress. Although the weather has been extremely cold, little snow has fallen, which is of some slight advantage to the shivering superintendents who dread the mess and hazards snow brings to every construction job. Perhaps it is because the finishers like to linger within warm inclosures, but at any rate the appearance of finished structures built in cold weather is remarkable.

CWA work disorganized

Orders to curtail Civil Works projects caught officials unprepared. Hundreds of projects are being abandoned in critical stages. If the counties and townships can't finish up some of the road jobs started by CWA, traveling is going to be rough in spots this summer. School projects are reported to be in particularly serious condition, with repairs started, heating plants, walls and floors ripped out and no provision made for completion. Milwaukee got in some good work on its extensive park system with CWA labor. Throughout the state, wailing is loud and long on the part of merchants who claim CWA material and supply bills have never been paid. Government auditors are said to be going over all bills.

Baby bonds in Milwaukee

Two years ago Mayor Hoan was extolling Milwaukee's financial condition. Today the city is operating on baby bonds—IOU's of $10 face value—that

TWO WISCONSIN BRIDGES built in winter. Left: rigid-frame grade-separation structure in Washington County. Steam heat kept this job going to scheduled completion, while the accompanying grading work has fallen far behind because of 3 ft. of frost in the ground. Right: three-span arch over Brown Deer River widened from 24 to 40 ft. The canvas and paper housing incloses freshly placed sidewalk and rail posts.