Replaces Bridge Across Sandusky Bay

New York Central substitutes permanent construction for timber trestles that have been maintained with difficulty for almost a century, doing the work under heavy traffic

THE maintenance and operation of a sea-going railway has never been an easy task, even under the most favorable conditions. When the operation of such a line is menaced repeatedly by heavy ice gorges piled up by strong and long-continued winds during the winter or by high waves raised during storms at all seasons, both operation and maintenance may be come extremely difficult. This is the situation with which the New York Central, along with its predecessor companies, has been contending for almost a century on that part of its line which crosses Sandusky bay.

As early as 1850, a line of road, chartered in 1846 as the Junction Railroad, had surveyed a route between Sandusky, Ohio, and Toledo, the construction of which included a mile-long trestle across Sandusky bay, an extensive body of water that indents the south shore of Lake Erie between Sandusky and Port Clinton. The principal reason for making this crossing was that the line across the bay shortens the distance between Cleveland and Toledo by six miles, compared with the next shortest route.

Trestle Was White Elephant

Train operation across Sandusky bay was started in 1853. However, from the beginning, the maintenance of the trestle proved to be a continuous struggle, since ice gorges during the winter and wave action at all seasons caused frequent temporary interruption to traffic and extremely high costs for maintenance. In effect, the project developed into something of a white elephant that consumed an excessive portion of the earnings of the none-too-opulent road. The Toledo, Norwalk & Cleveland was chartered in 1850 to build an independent line between Toledo and Cleveland. In 1853, the year that rail traffic was opened across Sandusky bay, this line and the Junction were consolidated as the Cleveland & Toledo. Traffic was maintained over the trestle until 1858, when it sustained extensive and severe damage during a series of violent storms, and rail service over it was abandoned in the belief that sufficient traffic could never be developed to warrant the expense of maintaining the structure. As a result, all traffic that had formerly used the trestle was diverted to the longer route through Norwalk.

In 1869 the various local lines between Buffalo, N. Y., and Chicago were merged to form the Lake Shore & Michigan Southern. The management of the consolidated line realized immediately the advantage of shortening its route between Buffalo and Chicago and, in 1872, rebuilt the bay crossing as a single track. Most of the original trestle was replaced with a rock fill, leaving five well-separated openings which were spanned by pile trestles, one of which included a swing-draw span. These openings were considered necessary to care for the strong tide-like currents that sweep in and out of Sandusky bay, depending on the direction and velocity of the wind.

Bird's-eye view of crossing looking east from Port Clinton

Additional Line an Aid

Within 15 years after this restoration, traffic had increased to the point where a second track was considered necessary, and this was completed with the construction of a double-track swing-draw span in 1892. No serious interruptions to traffic have occurred since that time, although high maintenance costs have been incurred almost every winter, in addition to which the trestles have had to be renewed about every 12 years. Incidentally, in 1915, the Lake Shore & Michigan Southern became an integral part of the New York Central system.

As constructed originally, the trestle and the short fills at its ends aggregated 1¼ miles, and this remains the length of the bay crossing today. The top of rail ranged from 10 to 12 ft. above mean low water, and both the trestle and the rock fill that succeeded it in part were maintained at this elevation until 1944, when the replacement of the easterly three trestles with permanent structures was undertaken, including a new and heavier draw span of the rolling-lift type.

Water Not Deep

Along the line of the crossing the depth of the water ranges from 6 to 15 ft., averaging about 8 ft. The rock overburden is composed of silt and marl ranging in depth from 4 ft. at the easterly shore to 25 ft. at the westerly shore. Below this overburden is a stratum of broken and fissured limestone which increases in depth from east to west, while underneath this is a solid bed of unbroken limestone of unknown depth, but well below all exploratory drilling. The five bridges, which are numbered 64 to 68, inclusive, from west to east, were 290, 165, 442, 824 and 534 ft. long, respectively. The center bridge, No. 66, included a double-track, pin-connected swing span, 179 ft. long, center to center of pins, on stone masonry, with open-deck pile-trestle approaches at each end.

The trestles were of standard construction with treated pile bents, containing 12 piles each, driven to rock or hard-pan, the treated piles having been installed the last time these bridges were renewed. The bents, which had 14-in. by 14-in. caps, were spaced 12 ft. center to center, and supported three 9-in. by 18-in. untreated Douglas-fir stringers under each rail. At the last previous renewal, the old untreated pile bents had been left in place, although they carried no appreciable load. These old bents had to be removed where they interfered with the installation of the piers of the new permanent structures.

At the time of the 1942 inspection of the crossing, it was considered that, while all of the trestles were again in need of renewal, only the easterly three should be undertaken immediately. Meanwhile, clearance and speed restrictions imposed on rail traffic by the old swing span were hampering the movement of vitally-important war materials. Together with the increased traffic brought about by the war, this made removal of the restriction imperative, so priority assistance was obtained for the reconstruction of the easterly three trestles, including the steel swing span, with substructures of reinforced concrete cylinders and steel I-beam, ballasted-deck spans.

Work on these structures was started early in 1944, and the replacement of the three trestles was completed in that year. The new bridges were built across the existing openings and on the existing alinement, without detours for the rail traffic. However, crossovers were installed at each end of the project and the track was signaled so that trains could be operated in either direction on each track. During the period of construction an average of four trains an hour passed over the work. To avert accidents, a slow order of 10 miles an hour was maintained over the project, and this caused delays ranging from 5 to 10 min. for each train.

The construction methods followed were the same for all three bridges and were unusual in that floating equipment was employed for all operations, except those of handling track materials and the deck materials for the bridges. This floating equipment was utilized for all drilling operations, for driving the cylinder shells, for welding the shells, for grouting and for placing concrete. In other words, this section of track was too busy to make it profitable to employ on-track machines and work trains for any operation where it was possible to avoid using them.

Necessitated Careful Planning

Because uninterrupted operation of trains over the project was a primary requirement, all of the work had to be planned and executed to insure minimum interference with traffic. Single-track operation was permitted during daylight hours where necessary, but double-track operation was always restored between 6 p.m. and 7 a.m.

To facilitate the work, two docks were built at the east end of the project for the contractor's marine equipment, which consisted of two large steam-derrick boats a large steel scow carrying a crawler-mounted crane, two smaller scows carrying two rubber-tired Loraine truck cranes, several smaller scows for transporting materials and a scow having a concrete mixing plant. In addition, three shallow-draft motor boats were used for towing and a smaller motor boat was assigned to general utility work.

The floating concrete plant included three hoppers—one for sand and two for coarse aggregates—at one end of the scow over batching scales. The aggregates were discharged in batches from the hoppers to the scales, from which they were sent on a belt conveyor to a mixer at the opposite end of the scow. When mixed, the concrete was discharged into the hopper of a concrete pump. A cement platform was placed adjacent to and at the same elevation as the mixer to facilitate the addition of the cement.

A crawler-mounted crane was used on shore for unloading material from cars and for charging the hoppers on the scow or storing the aggregates in stock piles. After the scow was loaded with concrete materials, it was towed to the site of the bridge and the concrete was placed without interfering with rail traffic. This plant was used for all of the concrete placed in the easterly three bridges, including that in the counterweight of the bascule bridge, the top of which was 60 ft. above the water. Another method was employed for placing the concrete in Bridge 64, which will be described later.

Since bridges 67 and 68 did not have sufficient clearance above the normal water level, it became necessary to raise the track approximately 42 in. to keep the concrete work above lake level and provide working space under the existing bridges. This was done in two lifts, making one lift per bridge per track per day—approximately eight hours.

In making this lift, the track was taken out of service, the spikes were removed from every third tie across the structure, and the rails, with the remaining two ties, were jacked high enough to slip a 9-in. by 18-in. longitudinal timber flatwise under the rail between the up and down ties. This gave the track a raise of 16 in. Other ties were then fitted in to replace those that had been left down.

This operation was repeated later for the second lift, making a total raise of 32 in. The remainder of the lift, 10 in., was made on ballast after the new spans and the new deck had been installed. At Bridge 66 in which the draw span is located, the raise was only 18 in., and this was made in a single lift. All of this work was done by company forces.

The piers for bridges 67 and 68 are carried on three 5-ft. reinforced concrete columns anchored into the rock and topped with reinforced concrete caps, the whole designed as a rigid frame, while the abutments for these bridges are made up of two outside columns 8 ft. in diameter, and one 5-ft. center column, with a reinforced concrete backwall to retain the fill. The spans of these bridges were made 36 and 48 ft., multiples of 12 ft., to permit the location of the new concrete piers between the 12-ft. bent spacing of the old timber trestles. The superstructures, consisting of five 36-in. wide-flange I-bears to each track, is supported on the new pier caps.

A solid deck, made up of 6-in. timbers with 12-in. by 12-in. ballast guards, rests directly on the carrying beams and is fastened to them by means of hook bolts. All timbers were preframed and creosoted before they were applied.

Lift Bridge Installed

As mentioned previously, Bridge 66 had timber-trestle approaches at the ends of the draw span, the easterly approach being of sufficient length to accommodate a new Scherzer rolling-lift type of bascule bridge with a clear channel span of 65 ft. This double-track span is supported by four reinforced concrete columns, 8 ft. in diameter, anchored into the solid rock. The rest pier is made up of two outside 6-ft. columns and a 5-ft. center column, all of which are anchored into the rock.

To provide for the small amount of water traffic, it was the intention originally to keep the old draw span in service until the new lift bridge had been completed. Because of delay in securing the necessary materials, however, it was not possible to erect the new span in time to take the old bridge out of service and replace it with fixed approach spans before severe winter weather set in. In view of this situation, permission was obtained to restrict the channel temporarily and make the swing bridge a fixed span. The construction of the piers for the new approaches through the area of the old draw span was then carried on simultaneously with the erection of the rolling lift span and the installation of the operating machinery.

In general, the piers for the westerly approach to Bridge 66 consist of concrete columns 5 ft. in diameter, which are surmounted by reinforced concrete caps 6 ft. wide and 3 ft. 6 in. deep. The spans on this approach vary in length from 32 ft. 6 in. to 55 ft. 6 in. All of the steel spans consist of five 36-in. wide-flange I-beams under each track, except the 55-ft. 6-in. spans, which required six beams for each track.

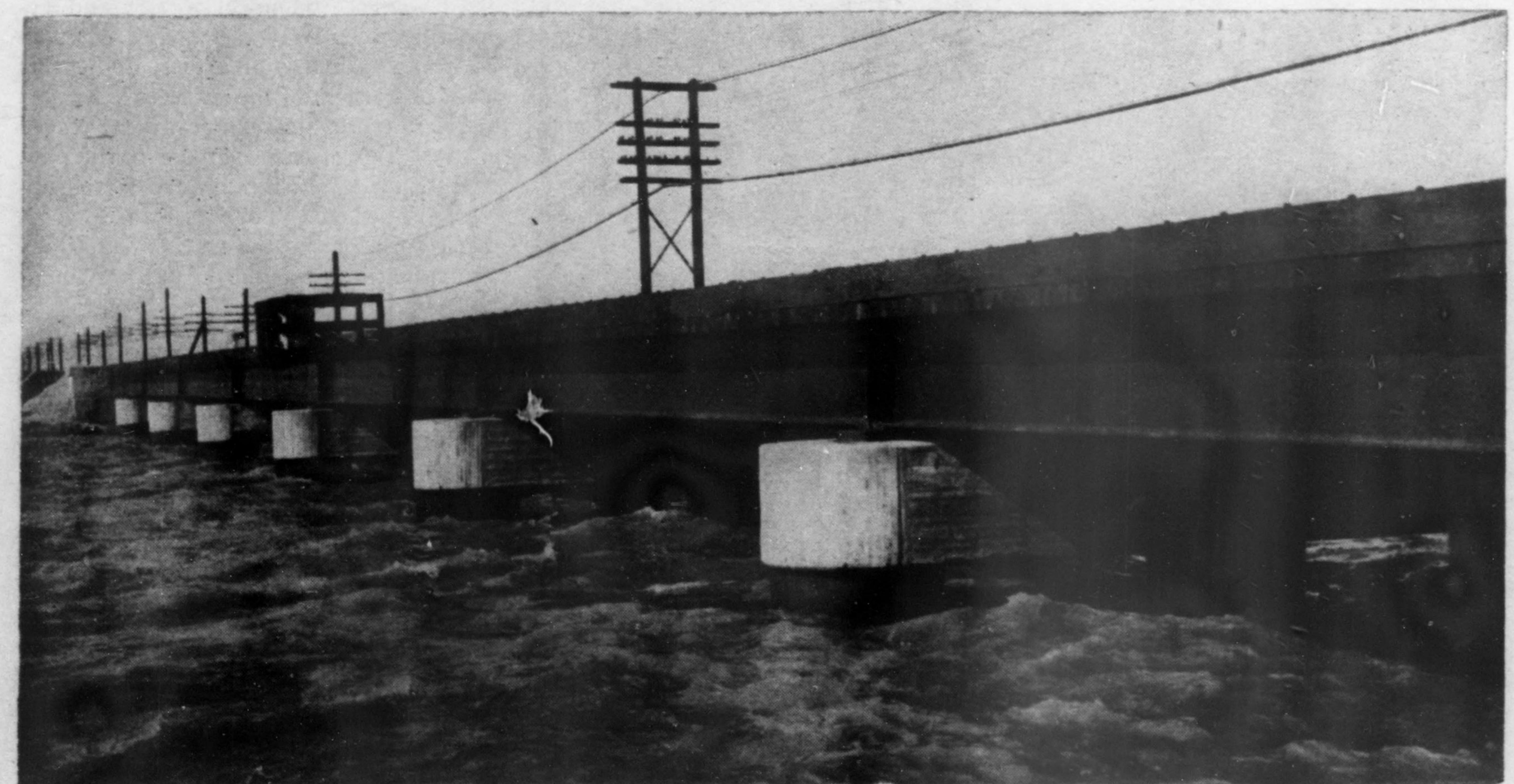
All of the reinforced concrete columns in both piers and abutments were constructed inside welded cylindrical shells made of 5/16-in. and 3/8-in. steel plates. These cylinders served the dual purpose of acting as cofferdams for excavating the overburden and the fissured rock, and then as forms for placing the concrete.

Bridge 68 before work was started in 1944, looking west

Making the Cylinder Fit

When a cylinder was to be sunk, it was set in place carefully in a timber guide, with the open bottom resting on the mud. Each cylinder was of such length that, when set in position for sinking, the top was below the top of rail, and trains could pass without fouling it. To sink the cylinder, a heavy steel plate and driving head were fitted over the top and a McKiernan-Terry 9B-3 steam hammer was employed to drive it to rock or to refusal. If the cylinder continued to sink when the top reached one foot above the surface of the water, driving was stopped and additional length was added by welding, and driving was continued to refusal.

After driving, the cylinder was pumped out and the overburden was ex-



Bridge 68 after completion, looking west, showing features of new pier and superstructure construction cavated. In some cases the cylinders landed on rock that was suitable as a foundation. In other instances, however, the lower portion was damaged by obstructions embedded in the mud. When this occurred, the damaged parts were cut out and new plates were welded in. The surface of the rock was also quite uneven at places, and at a number of piers the lower edge of the cylinder bore on the highest point. If this high point was not easily removable, exact measurements were made and the cylinder was extended downward to fit the contour of the rock by welding on additional steel plates.

In a large number of instances, however, the cylinders did not land on rock that was suitable for foundation purposes. Where they landed on material that could not be cut out with a calyx drill, the excavation was continued by hand and the bottoms of the cylinders were carried down as the excavation continued, by welding steel plates to the lower ends.

On the other hand, in some cases excessive leakage through the fractured rock made it impossible to carry on the excavation unless the water was sealed off. This sealing was done in some instances by straight grouting over the area both inside and outside each cylinder; in others it became necessary to place a concrete seal in the bottoms of the cylinders before the grouting could be done. The excavation was then continued by hand and the calyx cut was made through either the solid rock or the grouted rock.

All piers and abutments were anchored to resist the pressure of ice floes and of ice gorges, as well as that of wave action. This was done by extending the reinforced-concrete columns forming the substructures well into solid rock. To expedite the rock excavation required to obtain this anchorage, a calyx drill was designed to bore a core 54 in. in diameter out of the solid rock.

To fit the limited vertical clearance under the old trestles, a special model of this drill was designed, designated Type TU-48, with a barrel 60 in. long. This was equipped with a cutting edge, and a 4½-in. hollow drill shaft was attached to the barrel. Drill rods came in sections 1, 2, 3, 4, 5, and 10 ft. long, and were connected with bolted, quick-breaking couplings. The action of the 54-in. bit, in conjunction with steel shot in the slot in the rock, cut out a chase or runway in the rock.

The core barrel was equipped with a shot-distributing frame to distribute the shot evenly around the cutting edge. Water and shot were pumped into the top of the rotating shaft through a swivel connection. Chilled-steel shot furnished by the drill manufacturer were used for cutting out the core.

Starting the Calyx Drill

When the excavation had been completed and a cylinder was ready to receive the calyx drill, it became necessary to cut a chase into the rock so that an even bearing would be obtained all around the cutting edge of the drill. Steel shot were then placed in this chase and the drill was lowered to begin cutting.

A core 50 in. deep could be drilled out in about three hours, provided the rock contained no seams. Where seams occurred, shot were lost into the seams and the rate of cutting was slowed down. If the seams were discovered before the drilling was started, they were grouted to prevent loss of the shot. Broken, soft and seamy rock was the most difficult to drill, since pieces broke off and jammed the barrel. In a few such cases whole sections of the core broke off and became wedged inside the barrel.

When the drilling was completed and the drill and core barrel had been removed a 2-in. hole was drilled through the center of the core, into which a quarter stick of dynamite was introduced and packed level with the bottom of the core cutting. This was set off with a battery and almost invariably broke the core loose at the level of the bottom of the cutting. The whole core was then lifted out easily by means of a sling that had been applied around the outside of the core before the explosive was set off. Solid cores were lifted intact from many of the holes.

To handle this drilling with greater facility, a steel scow 100 ft. by 26 ft. was equipped for the work. A crawler-mounted crane was placed on the deck to handle the heavy parts of the drill and the rock cores. The drilling machine was equipped with six flanged wheels which could be moved along a track laid beneath and at right angles to the railway track, and was thus moved from one cylinder to another, it having been found economical to cut and remove consecutively the anchor cores in all three cylinders at a pier, doing this with one set-up of the drill. To support the drill track, steel hangers were placed on each side of each cylinder of the pier, and 12-in. by 12-in. timbers were supported by them. Timbers 8 in. by 8 in. in section formed the track upon which the calyx drill was moved from cylinder to cylinder.

Floating concrete plant placing concrete for easterly pier supporting Scherzer rolling-lift span, Bridge 66

Replacing the Westerly Bridges

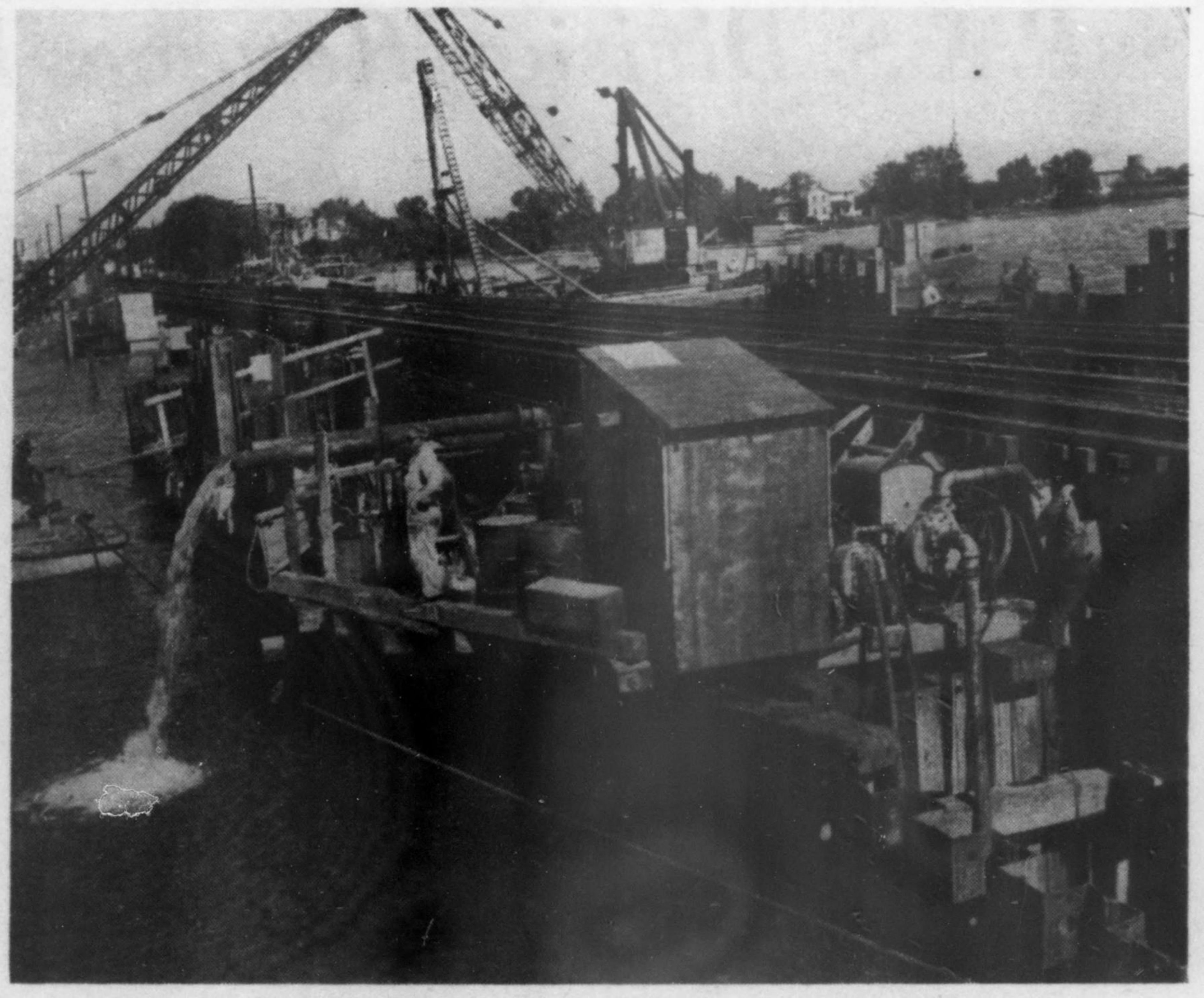
Reconstruction of the westerly two bridges was not undertaken until 1945, owing partly to delays in the receipt of material, partly to the desire not to have too much track open at one time, with consequent interference with traffic, and partly to the need for additional marine equipment if so many jobs were to be carried simultaneously.

The opening at Bridge 65 was filled with crushed stone and the old structure was abandoned. This stone filling was held in place under water by a 2-ft. blanket of one-man stone, and the whole fill was then protected further by a 5-ft. blanket of derrick stone reaching from 5 ft. below to 5 ft. above normal lake level. In addition, similar derrick-sized riprap was placed in front of and alongside all abutments. The filling material behind all the abutments of the four bridges also consisted of crushed-stone ballast, making fills at these points in which little settlement has occurred.

Owing to the depth of the overburden and the character of the material at Bridge 64, it was necessary to employ construction methods that differed in important particulars from those that were followed in replacing Bridges 66, 67 and 68 in 1944. At Bridge 64 the west abutment and the five piers were founded on rock, but the east abutment was supported on concrete piles driven to rock. All units of the substructure of this bridge were of the gravity type.

However, to facilitate the construction of the substructure, an outside cofferdam was driven in two stages around the entire bridge, two-thirds in the first stage and one-third in the second stage. The cofferdam measured 60 ft. laterally and was of sufficient length to enclose each of the stages successively. As soon as completed, the cofferdam was pumped out and the overburden was excavated to the elevation required by the new channel, by means of clam-shell buckets operated from floating equipment. Further excavation to an additional depth of 10 ft. was then carried out for the piers and west abutment. Following this, short sheet piles were driven to rock around each pier and abutment to form inside cofferdams that afforded protection to the timber trestle, which was continued in service during the period of construction.

These inner cofferdams were then excavated individually to solid rock and the concrete placed for the finished pier. The sheeting for the inner cofferdams was left in place, but that in the outer cofferdam was pulled and redriven for the second stage of the work, which progressed in the manner already described, except that after the inner cofferdam was constructed for the easterly abutment, excavation was omitted and piles were driven instead.



Cofferdam and marine equipment at Bridge 64, summer of 1945

Used Transit-Mixed Concrete

Because of the gravity sections, the concrete for the substructure of Bridge 64 was placed in larger batches than for the substructures built in 1944. The batching plant was moved to Danbury yard near the west end of the bay crossing, about a half mile from the bridge. A road was constructed adjacent to the fill and the concrete was transported to the site of the work in transit-mixing trucks. The concrete was delivered to a concrete pump set up about 100 ft. west of the new bridge, and approximately 350 ft. from the easterly abutment.

Steel for the superstructure of Bridge 64 was of the same design as that for the easterly three bridges. For all four of these bridges, the fixed spans were assembled adjacent to yard tracks east of the project. Owing to the width of the superstructure, these spans could not be shipped assembled, so they were riveted together at the assembly point. The timber floor, in the form of 8-ft.-wide pads, was then placed on the steel. Individual spans were unloaded at one end of the bridge, adjacent to the track into which it was placed later by means of 50-ton stiff-leg derrick cars.

One derrick car lifted out the old timber deck for a single span, and the second one picked up the new span and set it in position on the new concrete piers.

Track was then built over the span by railway forces, and this operation was repeated for succeeding spans until one track was completed. For this work 7 a. m. to 6 p. m. constituted a working day, as many as 12 spans having been set during this interval, and at 6 p. m. the track was connected and turned over to the operating department for double-track operation. While the work was in progress, heavy-duty fire pumps gave fire protection at each bridge.

While this job was well organized and generally progressed according to schedule, it should not be assumed that all of the operations that have been described went along as smoothly as this description may have implied. It should be remembered, however, that the work was done under the pressure of war conditions, and there were many times when it seemed that vital materials could not be obtained and that badly needed labor was completely unavailable.

In addition, while 1944 was not particularly stormy, there were times when it became necessary to suspend work temporarily because of rough water. All in all, both the railway and the contractor's forces that were engaged on the work completed it with a higher degree of appreciation of the men of a century ago who maintained the mile-long trestle by manual methods and hand tools, without the advantages of modern power machines and power tools.

These bridges were designed by J. B. Hunley and George E. Robinson, engineers of structures, New York Central, Lines West of Buffalo, under the general direction of F. J. Jerome, chief engineer of the Lines West of Buffalo. The construction work was carried out under the supervision of George T. Donahue, district engineer, and A. M. Westenhoff, assistant engineer of structures. All field work was in direct charge of W. A. Bogart, resident engineer.

The Walsh Construction Company was the general contractor, of which J. H. Gill was resident vice-president and Frank Mosher, superintendent. Subcontractors were the Bethlehem Steel Company for the fabrication and erection of the bascule span; and the Ferro Construction Company, which placed the fixed spans.