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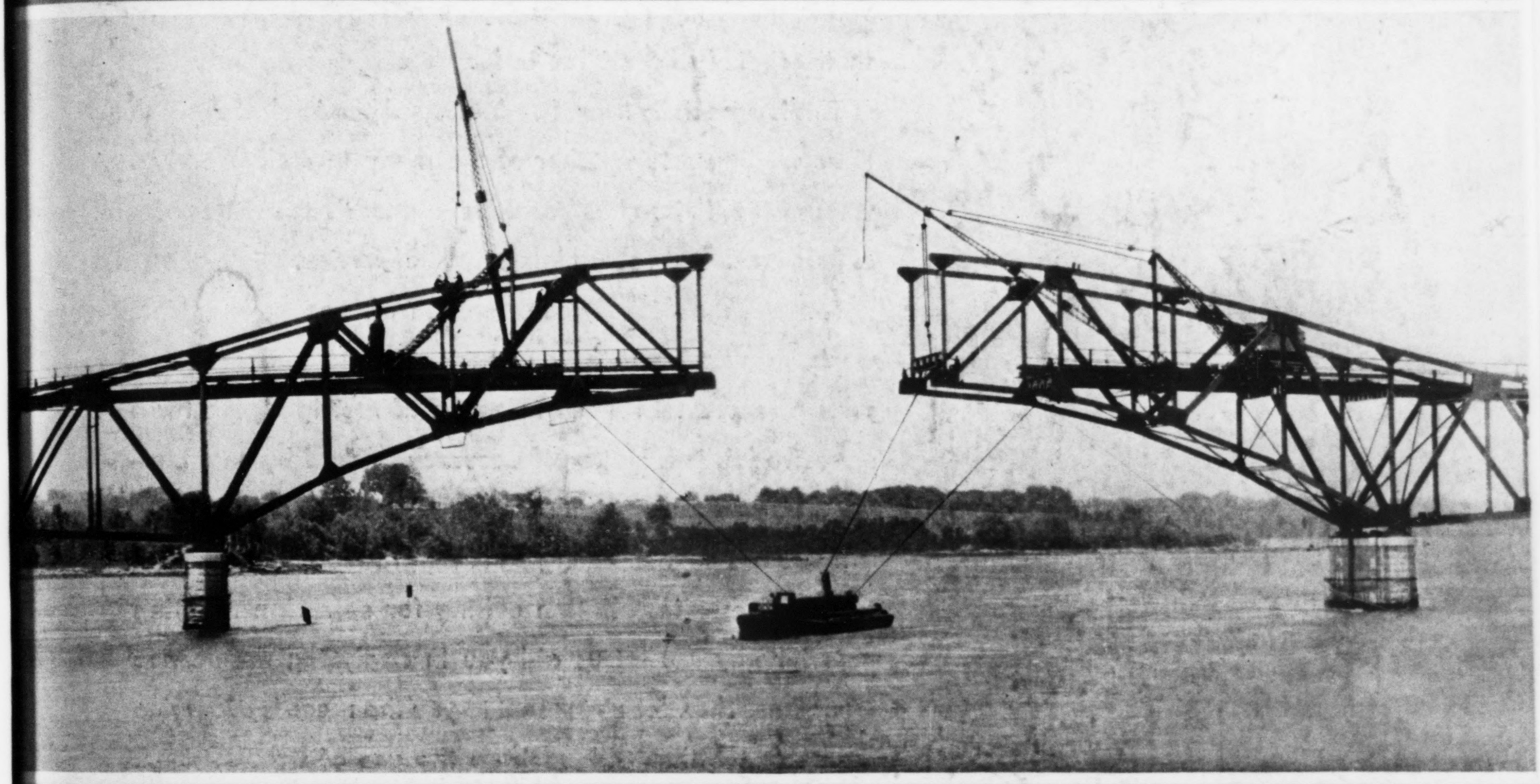

Erecting the channel span of the new Little Bay crossing north of Portsmouth, N. H., a 1,500 ft. structure featured by three groups of continuous spans

High-Level Bridge Link in Dover-Portsmouth Road

Large Centrifugal Pumps on English Drainage Works

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Enlarging Conneaut Harbor on Lake Erie

The Mettur Dam—Largest in the British Empire

Three Long-Span Steel Bridges for Washington Highways

A National Water Policy In the Making

By Carey H. Brown

Formerly Secretary

Mississippi Valley Committee, PWA.

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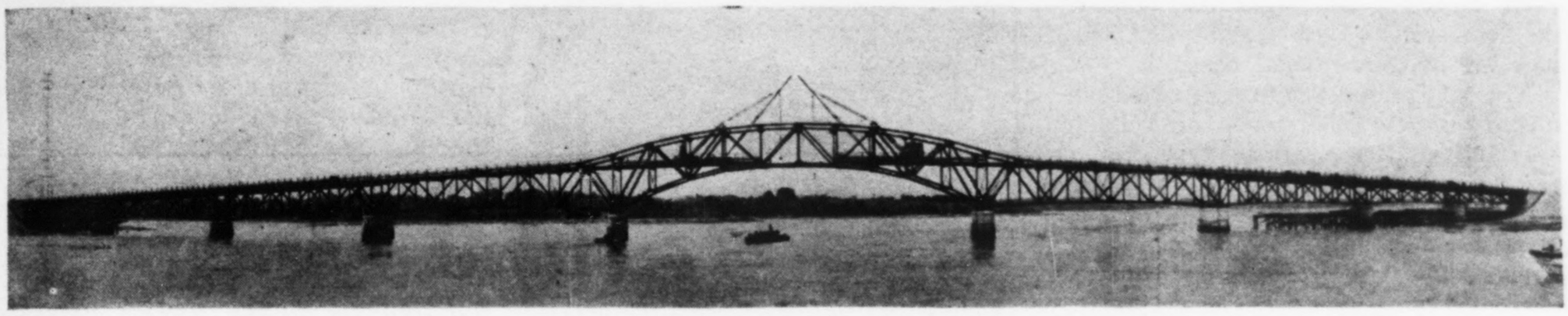
High-Level Bridge Link in the Dover-Portsmouth Road



Trunk-highway development in southeastern New Hampshire is focused in a high-level steel bridge over the tidal estuaries that bar Portsmouth and the ocean beaches from northern New England

NEW highway connections now under construction between Portsmouth, the principal ocean port of New Hampshire, and the cities of Dover and Durham rank high among current road-engineering operations in the New England states. The principal structures of the improvement are: (1) a 20-ft. concrete road from Dover to Little Bay at Dover Point; (2) a high-level steel bridge 1,528 ft. long across Little Bay from Dover Point to the Portsmouth side; (3) a concrete trestle of unique pile construction 660 ft. long across Bellamy River on the road from Durham and the west; and (4) various short stretches of new road linking up the bridges with existing routes. The locations of the several elements of the improvement are shown by Fig. 2.

Portsmouth, as shown by the map, is rather remarkably shut off by waters from the state to the north and west. It is also on the natural travel route from these parts of the state to the beach resorts at Hampton and south to Boston, Providence and the resorts of Cape Cod and Narragansett Bay. At present the only access from north and west to Portsmouth is the old and inadequate toll bridge of the Boston & Maine Railroad. The new project provides a modern main road and bridge entrance from Dover and the north into which travel from the west through Concord and Durham has access by means of the Bellamy River bridge and its connecting roads. With a high-level bridge over Little Bay travel has also no interruption from navigation. The project is therefore a major traffic improvement and an expensive one costing about $1,675,000.

In general, the roadwork classifies as modern high-class paved main road without markedly unusual features. The main stretch is from Dover to Dover Point, about 5½ miles, mostly over old grade; connections to the bridges aggregate about 2½ miles and are over new grade. The prevailing pavement is two-lane reinforced concrete, but there are shorter stretches of bituminous macadam over new grade. Typical sections of both types are shown by Fig. 3; they show all the normal conditions of cut and fill and the corresponding sub-base construction; at special locations changes are made to curb-and-sidewalk sections as the location requires. The general roadway design and pavement structure are, however, sufficiently well indicated by Fig. 3.

The exceptional structures are the bridges, which are notable in design and particularly for the construction methods employed. The larger of these is the steel bridge over Little Bay, which is described in this article. A following article will describe the pile trestle over the Bellamy River.

Little Bay bridge

The design and structure of the high-level steel bridge over Little Bay are shown by Figs. 4 to 6. Both are closely similar to the design and structure of the road bridge across Lake Champlain designed by the same engineers and described in *Engineering News-Record*, Nov. 21, 1929, p. 796. The general elevation (Fig. 4) shows the span grouping and dimensions. The bridge spans are end-supported structures, and the

seven spans are divided into three units of continuous structure, one of which includes the center three spans. All spans are riveted trusses set on 18-ft. centers, except the middle three spans in which the spacing is 32 ft. The floor system is floor beams and stringers with a deck of reinforced concrete, giving a 24-ft. roadway and sidewalks as shown by Fig. 5. All steelwork was designed for the loadings and to the requirements of the bridge specifications of the American Association of State Highway Officials.

Concrete deck details call for notice, particularly in respect to the two-course concrete construction and the method of reinforcement both as shown by Fig. 5, and in respect to the deflection joint (Fig. 5) and expansion joints (Fig. 6). For piers 1, 6 and 7 the expansion-joint steel is anchored to and supported by the concrete slab. At pier 3, where especially large movements will occur, the joint parts are attached to the steel of the floor system. Rocker and roller bearings are of conventional types.

The bridge substructure is two reinforced-concrete abutments of cellular type and eight conventional-type granite piers (backed with concrete) to about 2 ft. below water (El. 100) and of concrete down to rock, which runs down from about El. 100 at the abutments to about El. 60 at pier 5. The design involved only usual features, but the construction presented problems.

Substructure construction

As shown by Fig. 2, the bridge is across a tidewater channel that connects Great Bay, Little Bay and their arms with the Piscataqua River, which connects with Portsmouth at the ocean. The waters of the bays form a large reservoir that is filled and emptied by every tide cycle. As all inflow and outflow of the bay waters are through the channel, fast currents up to 7 to 8 miles an hour are created. The construction problem was to build the piers in these currents, which of course were alternately in opposite directions.

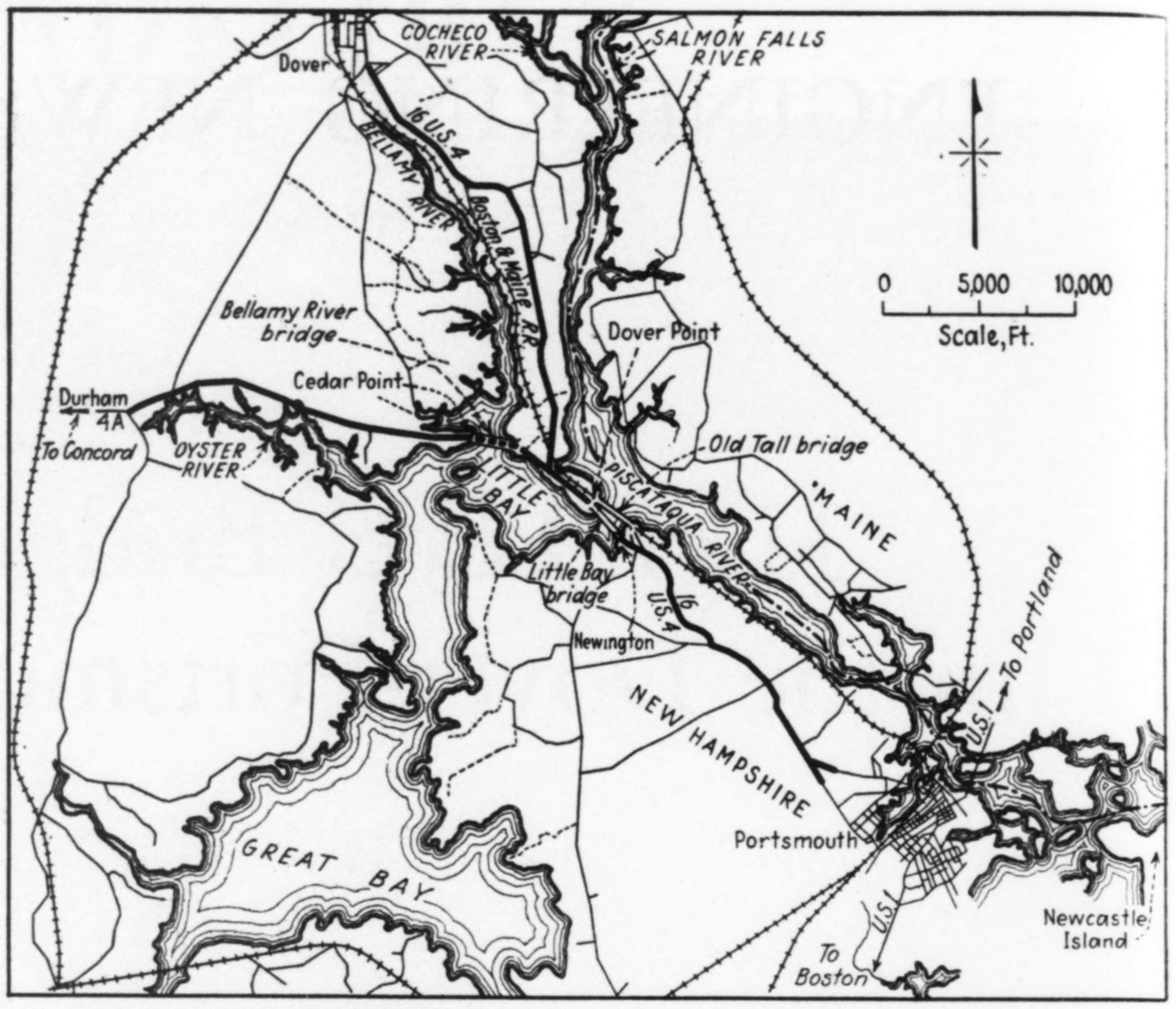


FIG. 2—LOCATION MAP of bridges and roads for improving traffic facilities out of Portsmouth to western and northern New Hampshire.

The rock bottom of the channel, which, as stated, was from a few feet to about 40 ft. below mean sea level, was covered with 4 to 10 ft. of clay, sand and gravel varying from a fairly compact mixture at the top to hardpan near the ledge surface. The specifications required the construction of the pier masonry in the dry in cofferdams, but later a change was made in the specifications, which permitted the placing of a part of the base concrete under water. The four deepest piers (Nos. 3 to 6) had bases 55x14 ft., and the others had bases 38x12 ft., which set the minimum sizes of cofferdams.

Construction was begun by building out from the shores trestles to reach piers 1, 2 and 3 from the north and piers 8 and 7 from the south end. Working from these trestles with traveling cranes, the construction of five of the cofferdams was fairly simple. The three deep-water coffers in the main thread of the tidal current were more difficult to construct.

The first step in building a deep-water coffer was to anchor a derrick boat (Fig. 7) adjacent to the pier site by means of cables running to heavy concrete blocks sunk at outlying points in all directions. Sheetpiles were then spotted around the perimeter of the cofferdam to hold guide wales; wales and piles were then tied to the boat by block and tackle, and the sheetpile wall

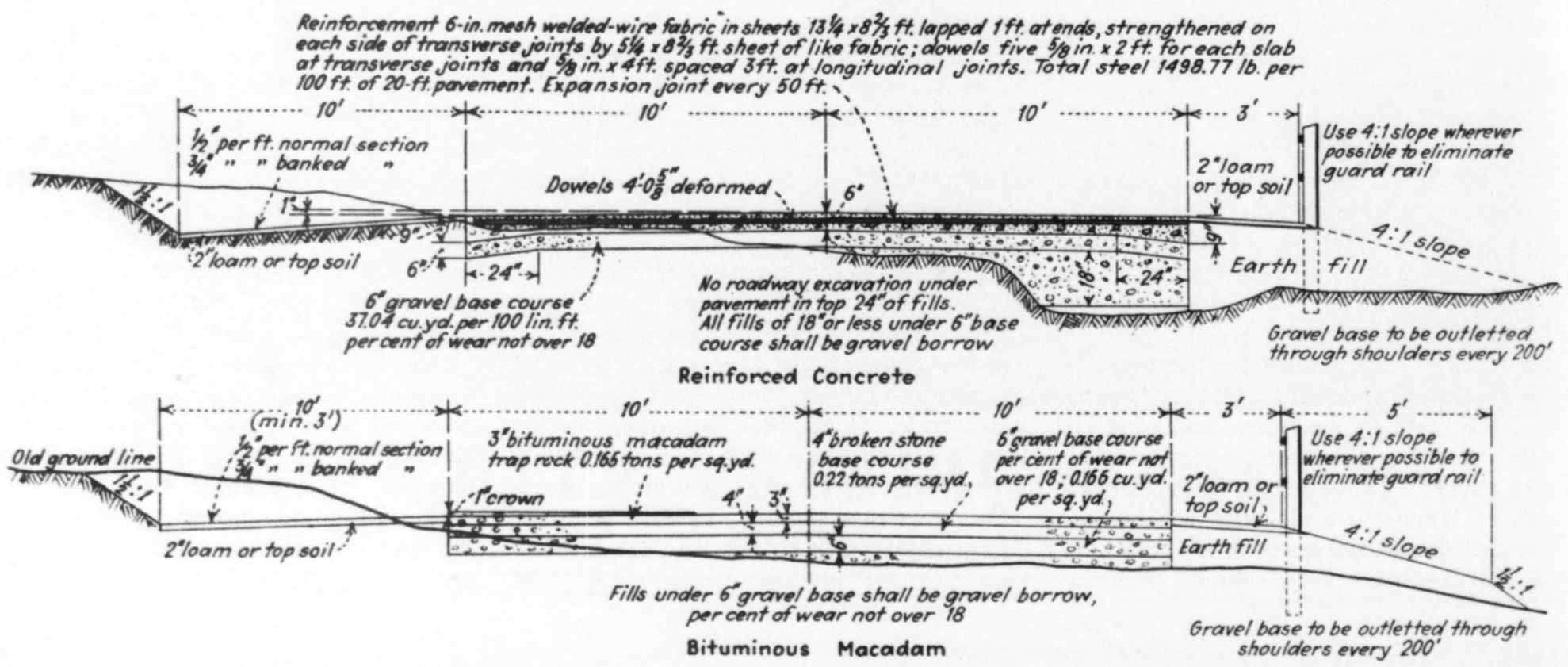


FIG. 3—PAVEMENT SECTIONS, showing base and subgrade construction on Dover-Portsmouth road.

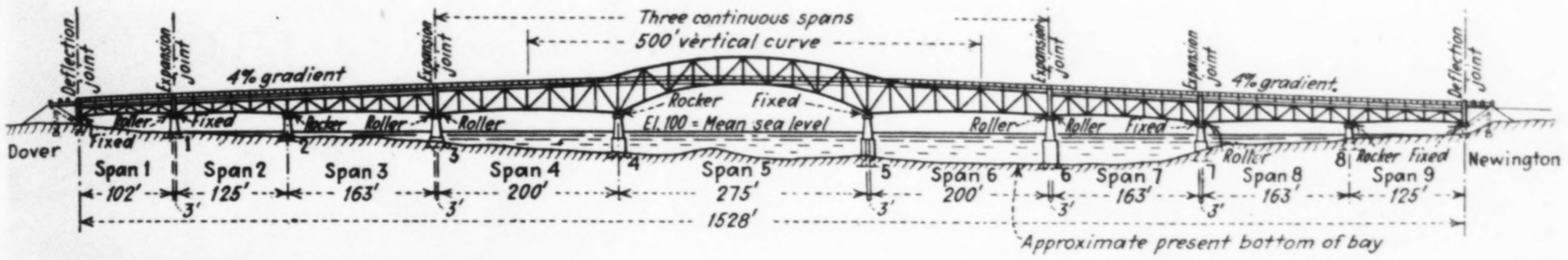


FIG. 4—DIAGRAM ELEVATION of Little Bay Bridge, showing span grouping and principal profile features.

was closed. Inside this wall a second wall of arch-web sheetpiles was driven and stiffened by waling. With this construction the cofferdams proved remarkably tight and were pumped out and excavated by ordinary processes. The pier base was concreted against the inside sheeting as a form; the outside sheeting was pulled.

Piledriving for the cofferdams was practicable only during an interval at the turn of the tide. During the full flow of flood and ebb the current swept away anything that was not fast and strong. An indication of the rip and turbulence of the current is given by Fig. 8, which shows a part of a guide frame for sheeting in process of erection.

A 1:2:3½ gravel concrete was used for the base and core of the pier. A barge was rigged up with bins and a portable mixer, which discharged into buckets handled by derrick boat to the pier. As stated, the cofferdam sheeting was the form for the base; the granite masonry built up ahead provided the form for the core concrete. The barge received its materials from cars on the railway trestle of the old toll bridge (Fig. 2). The substructure was completed and turned over to the steel contractor on Jan. 23, 1934.

Erection of superstructure

The contractor for the substructure had constructed pile and timber ramps on the center line of the new bridge extending from the Dover abutment to pier 3 and from the Newington abutment to pier 7. An arrangement was made for the superstructure contractor to take over these ramps for use as falsework for the erection of spans 1, 2, 3, 8 and 9. Blocking and timber bents set on the ramps were used to bring the falsework up to the proper elevation to support the steel for these spans.

Steel shipments from the contractor's shops arrived in Dover beginning early in January and were so arranged as to insure a continuous erection operation. Two 10-ton steel derricks were set up, one at each abutment, and all preparations were made to start the erection of the steel as soon as the substructure was completed. Steel erection was started on the Dover side Jan. 23, and on the Newington side three weeks later. The steel was hauled by truck from the storage yard for spans 1, 2, 3, 7, 8 and 9, transferred to pushcars on rails at the abutments and hauled out to derricks traveling out on the steel structure as it was erected.

Span 1 (a simple span) and spans 2 and 3 (continuous spans) were erected without any unusual difficulty, although the extremely cold weather made it impossible to maintain the erection schedule. Spans 8 and 9 were continuous spans and duplicates of spans 2 and 3. Span 9 and one-half of span 8 were erected when a sudden warm spell and heavy rains, with the high tide, broke up the ice for a short distance above the bridge. On March 7 the ice carried away the ramp for span 8, and it floated downstream about 600 ft. close to the old Boston & Maine Bridge, when the tide reversed and carried it back upstream past the new bridge and washed it ashore about a mile up the bay. The engineers and contractor then concluded that it was unsafe to proceed with the erection until the ice had gone out and the job was shut down.

Erection operations were resumed on April 9, 1934. A tower of steel piles and bracing was erected at the center of span 8, and the rest of this span was erected by the cantilever method. Span 7, a simple plan, was erected by the cantilever method by providing necessary connections at the top and bottom chords to span 8 over pier 7 to make the structure continuous over this pier. After erecting one-half of span 7 by the cantilever method the tower used for span 8 was used at the center of span 7. The erection then proceeded by the cantilever method to pier 6.

Spans 4, 5 and 6 were a continuous structure. The high tide and swift current and also the bare-rock streambed made the use of falsework for spans 4 and 6 impracticable. Spans 4 and 6 were placed by the floating method. Two deck scows 30x110 ft. (Fig. 9) were moored alongside span 3, and steel falsework was placed on them so that span 6 could be completely erected and riveted, except for a portion of the deck steel. Tugs were used in placing the completed span on the piers, as, due to the unusual stream conditions, it was not considered safe to handle the barges with runner lines. Span 4 was erected

FIG. 6—EXPANSION-JOINT design for reinforced-concrete deck structure of the Little Bay Bridge.

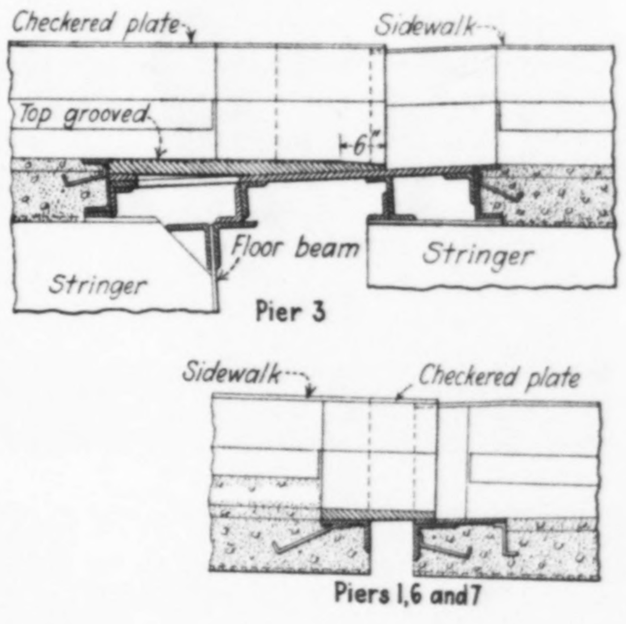
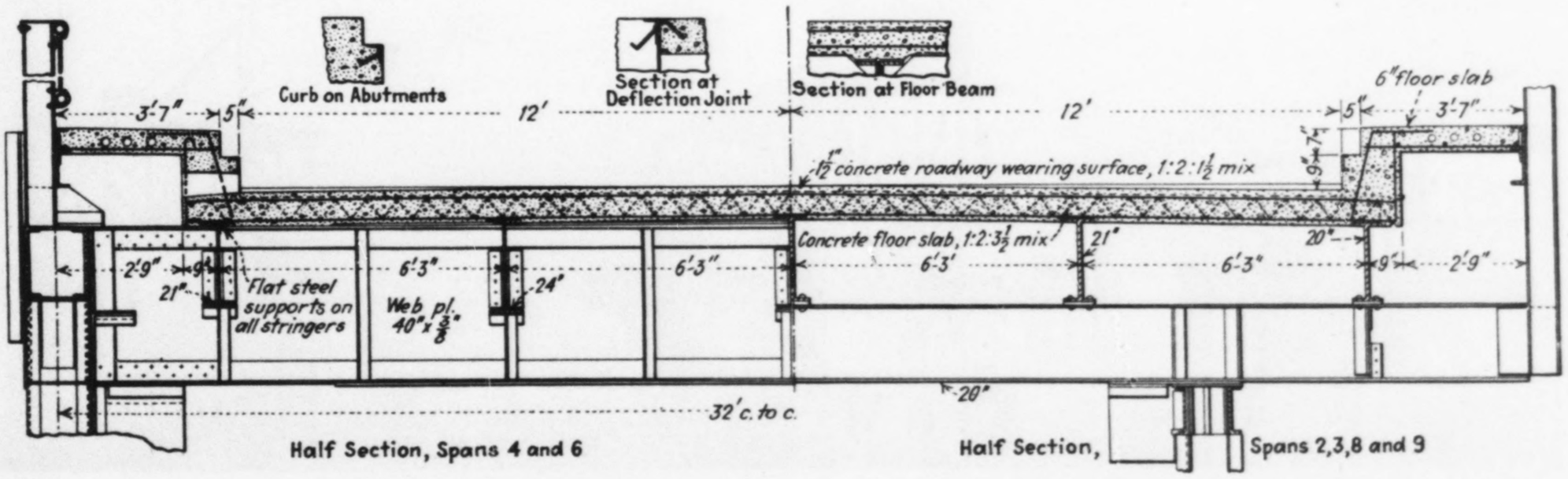


FIG. 5—BRIDGE ROADWAY sections, showing heavily reinforced-concrete deck with integral concrete wearing surface.



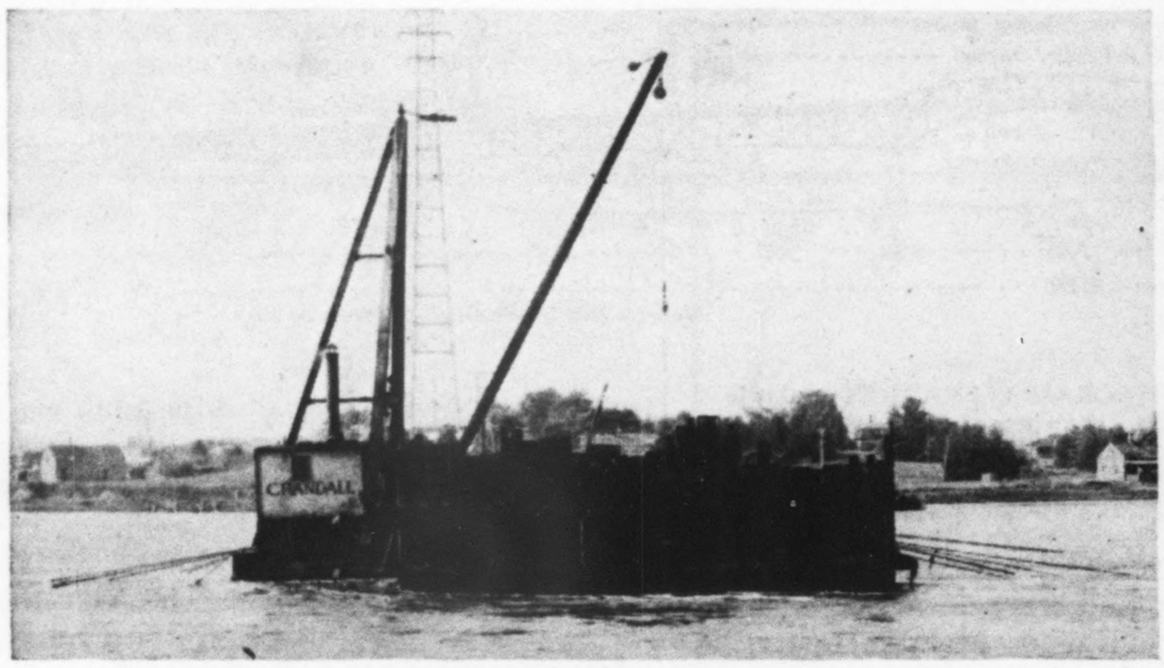


FIG. 7—BARGE PLANT constructing steel sheetpile cofferdam for deep-water pier. An inner wall of arch-web sheetpiles provided the form for the concrete pier and was left in place.

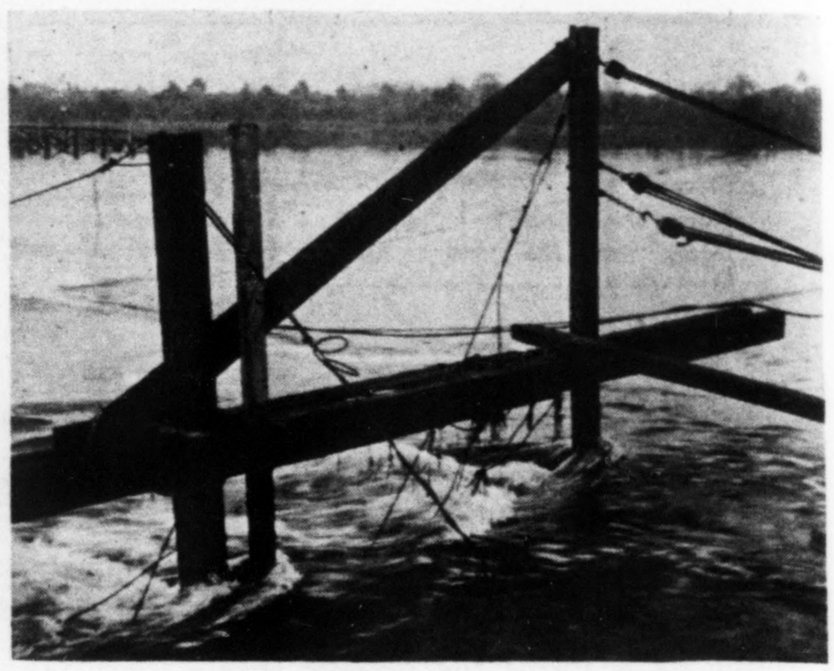


FIG. 8—SWIFT TIDAL current is indicated by the turbulance around the pilot piles for a cofferdam. Pile driving was practicable only during intervals at the turn of the tides.

and placed in the same manner as span 6. After spans 4 and 6 were placed on piers, the derricks on spans 3 and 7 moved out over spans 4 and 6, filling in the portion of that steel not erected with the spans on the barges.

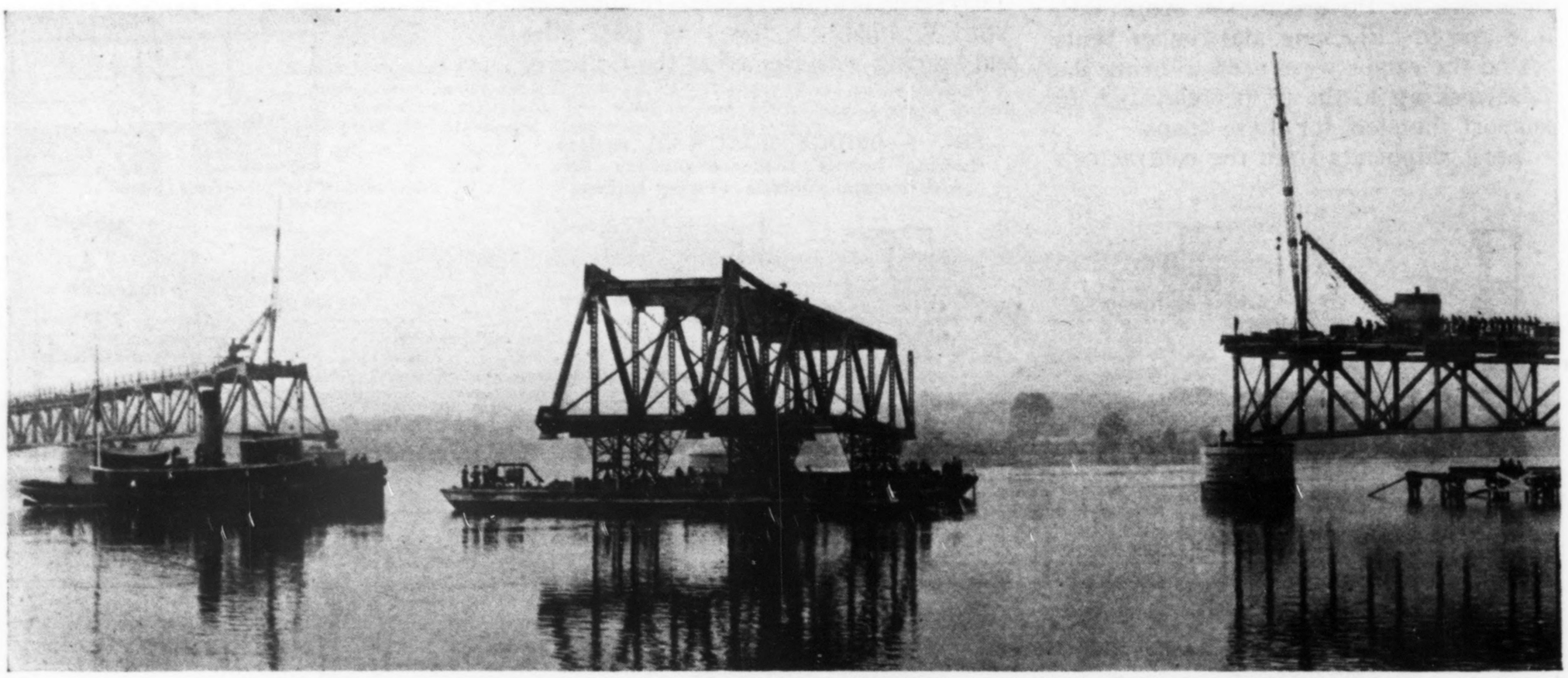
Cantilever center span

Span 5 was erected by the cantilever method by both derricks moving out on the floor system as steel was raised. In order to provide clearance for erecting the closing pieces at the center of span 5, the shoes for spans 4 and 6 at piers 3 and 6 were provided with shims so that these points were sufficiently lower than their permanent location to raise the center of span 5 enough to enter closing pieces. Riveting in span 5 was carried on as erection proceeded, following up the erection very closely. Before riveting span 5 at the center, the ends of spans 4 and 6 at piers 3 and 6 were jacked up to proper elevation, and the necessary shims were placed under the shoes. Jacking girders were provided by the design for this purpose. In order to insure reactions for spans 4, 5 and 6 being as calculated in the design of the structure, proving rings were used to weigh the reactions for spans 4 and 6 at piers 3 and 6, and the shims under the shoes at these points were adjusted to suit.

The steel for spans 4, 5 and 6 was handled from the storage yard on cars out on the old B.&M. Railroad bridge to the point where it could be loaded on a barge with the locomotive crane and then transported to the new bridge and handled by the derrick into position direct from the barge.

For placing the concrete deck, a mixing plant was set up at each abutment. Forms and reinforcing steel, shop-welded into mats the full width of the roadway and about 7 ft. wide, were placed for the three spans at each end, and the concrete was hauled out in trucks over planked runways laid on the welded mats. This operation was carried on during the erection of the steel for spans 4, 5 and 6. The concrete deck for spans 4, 5 and 6 was placed in a similar manner, working both ways from the center of span 5. The roadway curbs and sidewalks were placed after the roadway deck as a separate operation.

FIG. 9—FLOATING a 200-ft. side span of Little Bay Bridge into position to seat on piers as the tide ebbed; the span was erected on barges moored near the piers.

Direction

The bridge was constructed for the New Hampshire Toll Bridge Commission as a PWA project with Fay, Spofford & Thorndike, Boston, Mass., as engineers. The contractor for the substructure was the Crandrall Engineering Co., Cambridge, Mass., and the contractor for the superstructure was the Lackawanna Steel Construction Corp., Buffalo, N. Y. The roadwork was carried out under the direction of the New Hampshire highway department, of which F. E. Everett is commissioner and D. H. Dickinson chief engineer.