Erecting Long Bridge Spans Over Niagara River

Superstructure Work of Buffalo-Fort Erie Bridge Handled With Help of Ingenious System of Removable Steel Spud Cribs as Falsework Supports—Entire Erection Carried Out in One Season

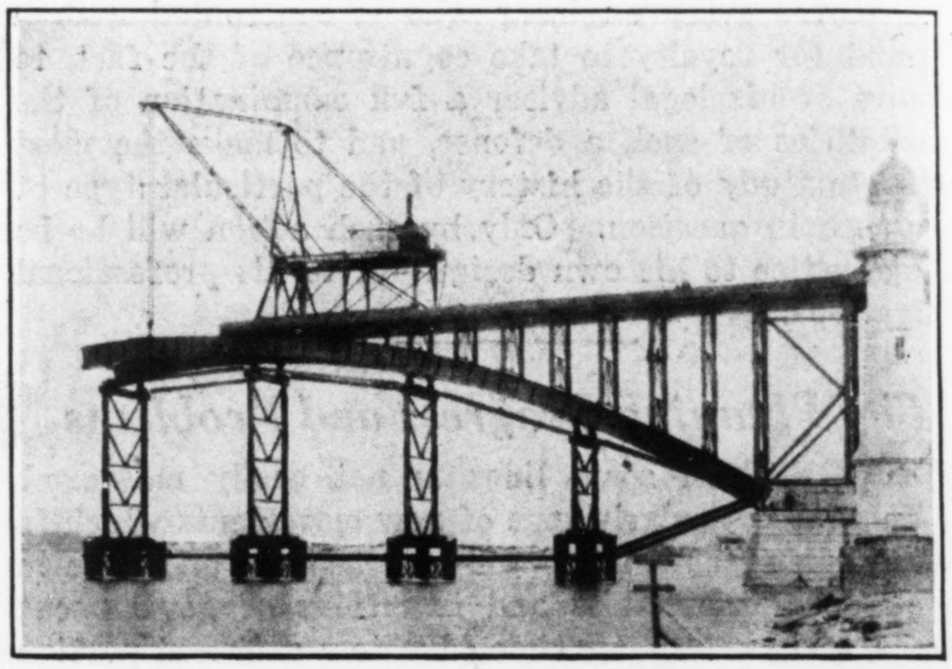
ERECTION of the international bridge between Buffalo, N. Y., and Fort Erie, Ont., now nearing completion, presented a number of quite unusual difficulties. On the one hand, rock bottom and a rapid swirling current made the question of supporting the falsework for superstructure erection quite formidable. On the other hand, the contract for the superstructure set a working schedule which in view of the river conditions could be met only by the most energetic and systematically planned work. It was specified that liquidated damages should be deducted from the contract price for failure to complete on time, while a bonus would be paid for completion before contract date, so that it was of great importance to the contractor to complete the erection as rapidly as possible. These and several related difficulties led to the development of a new and very successful type of falsework support—a steel skeleton crib carried by pointed steel spuds resting on the bottom—and resulted in a remarkably rapid piece of steel erection. A brief account of the work is given in the present article.

This bridge, to be named the Peace bridge in commemoration of the more than 100 years of continuous peace between the two countries which the bridge will join, will be the first highway crossing of the Niagara River south of Niagara Falls. Ferry service between Buffalo and Fort Erie has existed for many years, but it has been inadequate and slow, and subject to interruption in very stormy weather. In 1912 a bridge across the Niagara River at Buffalo was planned, as a memorial peace bridge, to be one of a series of monuments along the frontier, but the federal governments of the two countries did not act on the plan, and later the World War compelled the project to be postponed. It was taken up in 1919 by citizens of Buffalo, who, with the support of individuals and communities on the Ontario side, organized a company which is building the bridge as a private undertaking for public use. The corporate obligations are to be paid off by toll revenue, and thereafter the bridge is to become the property of the State of New York and the Dominion of Canada, or agencies designated by them. Under these circumstances, there was no difficulty in financing the enterprise and the required bond issue was oversubscribed three times.

Conditions of the Work—For better understanding of the conditions controlling the erection an outline drawing of the structure is given in Fig. 3. The main part of the bridge consists of a 360-ft. through riveted span over the Black Rock ship canal and five plate-girder arch spans ranging in length from 423½ ft. to 346½ ft. center to center of end pins. The rather unusual profile is dictated by the topography of the shores and the War Department's requirement of 100-ft. clearance height over the full width of the canal. The structure carries a single deck with 36-ft. roadway and two 6-ft. sidewalks, the roadway having a 7-in. reinforced-concrete floor slab crowned 2½ in. and paved with 4 in. of granite block. The slab is supported by 21-in. 60.4-lb. I-beam stringers spaced 4 ft. 9 in. to 5 ft. 8 in. apart, except that under the (future) street-car rails the stringers are doubled 15-in. I-beams. For the present the rail spaces will be floored with a continuation of the regular pavement, but bent plate clips are provided on top of the stringers to permit ready attachment of rails at a later date, after removing the pavement.

The water at the site of the bridge is 16 to 20 ft. deep, with bare rock bottom and very swift current. Except for a few sand barges and small tugs, all water traffic goes through the canal.

About 9,000 tons of steel are contained in the superstructure. Contract for its fabrication and erection was let on Nov. 6, 1925, and it was stipulated that the steel-



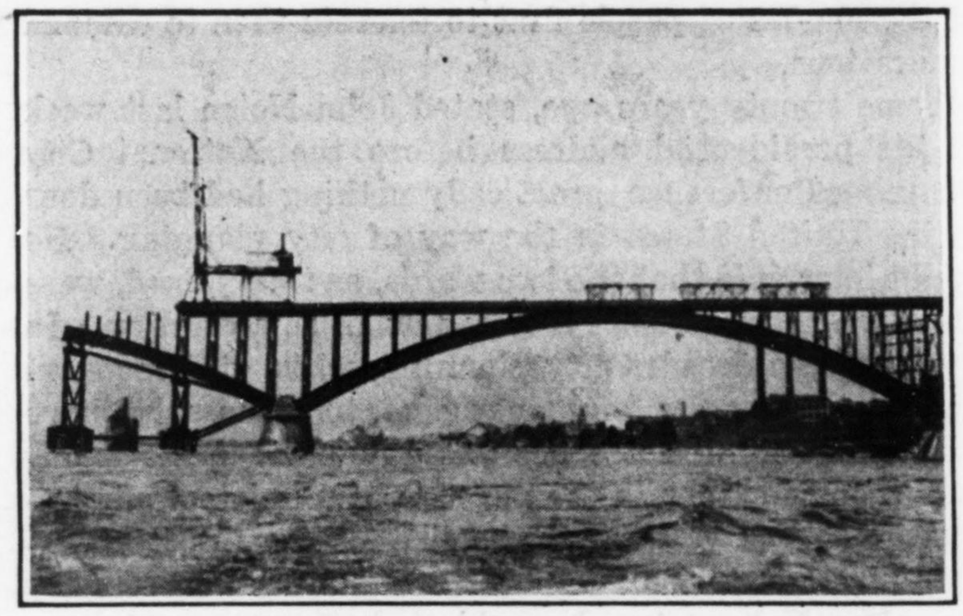


FIG. 1—ARCH ERECTION, FIRST AND SECOND ARCH SPAN

work should be completely erected by March 1, 1927, subject to liquidated damages or bonus ranging from $100 to $250 per calendar day for various parts of the work. A further condition was imposed by the War Department, which in view of navigation through the canal, usually extending over the season April 1 to Dec. 15, required that falsework must be removed from the canal before opening of traffic or else tug service would have to be provided to take all boats through, and further required a minimum opening in the falsework 94 ft. 4 in. wide by 89 ft. 3 in. high. This condition was particularly difficult to meet as high winds, snow and cold weather prevailing between December and

March limited the effective working season practically to the time from March 15 to Dec. 20, leaving only about nine months in which to erect, rivet and paint nearly 9,000 tons of steel.

Accordingly, the major conditions which the contractor faced were: (1) Erection over the canal must be started in March; (2) falsework must be removed from the canal before navigation opened; (3) falsework had to be devised that would withstand the unusual current and be suitable for the rock bottom, and at the same time could be erected and removed expeditiously; (4) the various parts of the work must be completed at a record pace to avoid damages and if possible earn a bonus. It was also necessary to plan for some flexibility, so that if the work was delayed at one point, even

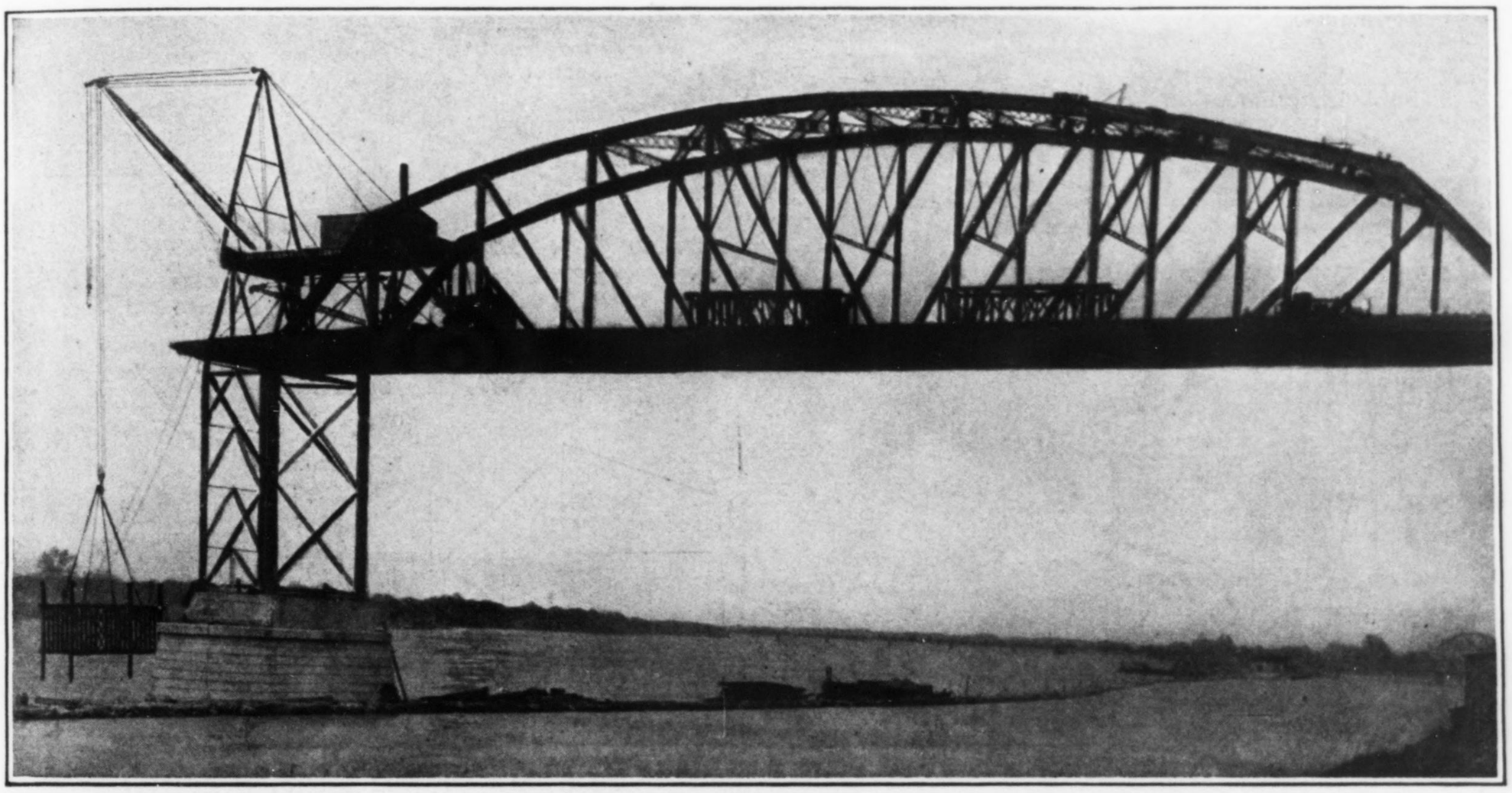


FIG. 2—SETTING FIRST CRIB IN RIVER FROM WEST END OF CANAL SPAN

though the contractor was not responsible for this delay, it could be carried on at another point and the lost time be kept to a minimum. Extension of time due to delays caused by others was of comparatively little value, because if erection was not completed by the winter of 1926, the contractor would either have to work through the winter or carry the job over and reorganize the next spring at considerable expense.

General Erection Plan—The following plan of procedure was adopted: Erection was started at the plate girder span east of the canal, whose foundations were among the first to be completed. Material could be delivered to this point by rail. Equipment could be placed on this span and erection of the canal span could immediately be started, following then with the arch spans over the river, from east to west. At the same time a second gang and equipment would erect span 6-7 on the other side of the river, this second gang either continuing erection eastward over the river or transferring with equipment to the Buffalo side to erect the Buffalo approach, or do both, as conditions permitted. A third gang and equipment would erect the plate girder work on the Canadian approach.

As material shipped into Canada for use west of pier 7 would be subject to duty and to a sales tax, this part of the work was sublet to the Hamilton Bridge Works Co. of Canada.

Making the detail drawings, particularly for the structure just east of the canal, which is on horizontal and vertical curves, was carried out as a rush job by draftsmen sent to the office of the consulting engineer so that material could be ordered and fabrication begun at the earliest possible moment. Meanwhile the erection plan, equipment and other features of the field work were being developed.

Special Falsework—Special studies were made of the falsework to be used, as it was evident that ordinary wooden falsework would not hold on the smooth rocky bottom against the swift current. While cribs loaded with stone could be used, they would be expensive and difficult to set, and would form a serious obstruction in the river. A large force would have to be used to place and remove them if work was not to be delayed.

An unusual type was developed, which was planned to offer little resistance to the current and to hold fast on the rock bottom. It is shown by drawings in Fig. 3 and by views in several stages of erection and use in Figs. 2 and 4. These illustrations represent the typical falsework used for the canal span and for all the spans over the river; under spans 5-6 and 6-7 it was slightly modified, as the water was shallower and the current not so strong.

The steel crib is 12 ft. by 47 ft. 8 in. in horizontal dimensions and is made up of two vertical trusses forming the long sides, each 14 ft deep, held 12 ft. apart by cross-frames at 10 to 12-ft. intervals and by a lateral system. Fastened to the trusses are vertical I-beam guides, between which steel piles or spuds made of 14x10-in. H-sections pointed at the lower end and reinforced at the point could be driven down. There were 20 such piles per crib. The crib itself was attached

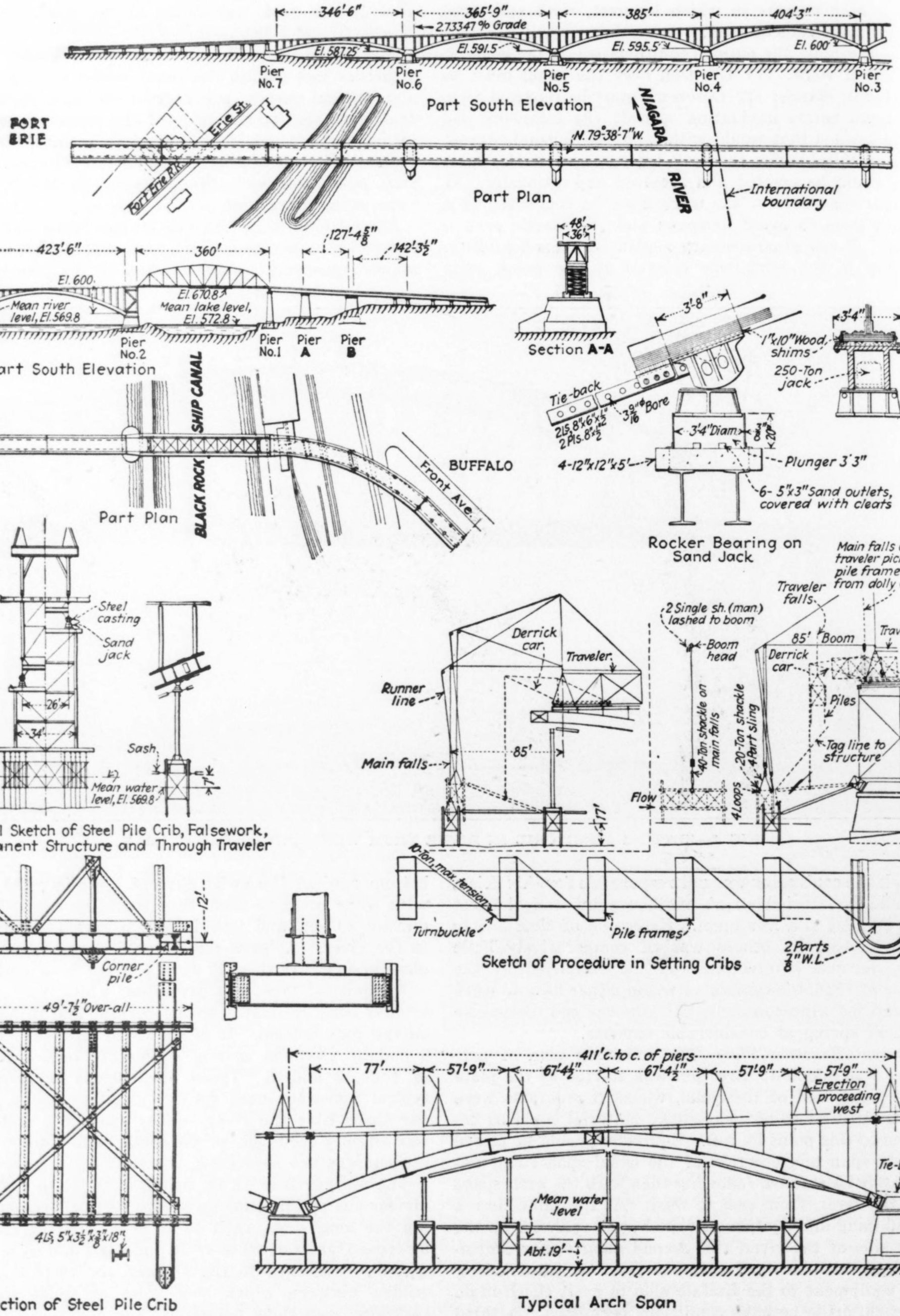


FIG. 3—THE PEACE BRIDGE AND SOME FEATURES OF ITS ERECTION EQUIPMENT

to the four outside corner piles by a bolted connection which by the provision of a series of holes over a vertical range of 7 ft. permitted raising or lowering the crib and fixing it at the required elevation. The crib was placed in the river just high enough for high water to pass under the struts connecting adjoining cribs, while the lower part of the crib was several feet under water.

Above the crib the tops of each pair of piles were connected by transverse I-beams by adjustable connections, permitting placing the beams level and at the proper elevation. Blocking on top of these beams carried the sill of the steel falsework bent which supported the bridge superstructure during erection. On the downstream side the sill was also clamped to the crib.

the remaining falsework bents and superstructure steel, completing its work by June 1.

On the American side field work started on Feb. 8. A 60-ton locomotive crane erected span A-1 and also placed a 50-ton material derrick on the east end of the span. With this derrick a traveler was erected on the west end of the span, and a derrick car was lifted up to feed the traveler and erect cross frames, top laterals and the like for the canal span. The traveler itself erected all the main material for the 360-ft. through span over the canal.

In the construction of the canal span, the steel crib falsework as described had its first use, three cribs being used. Experience soon showed that it could be set quickly and held well on the rock bottom. The last

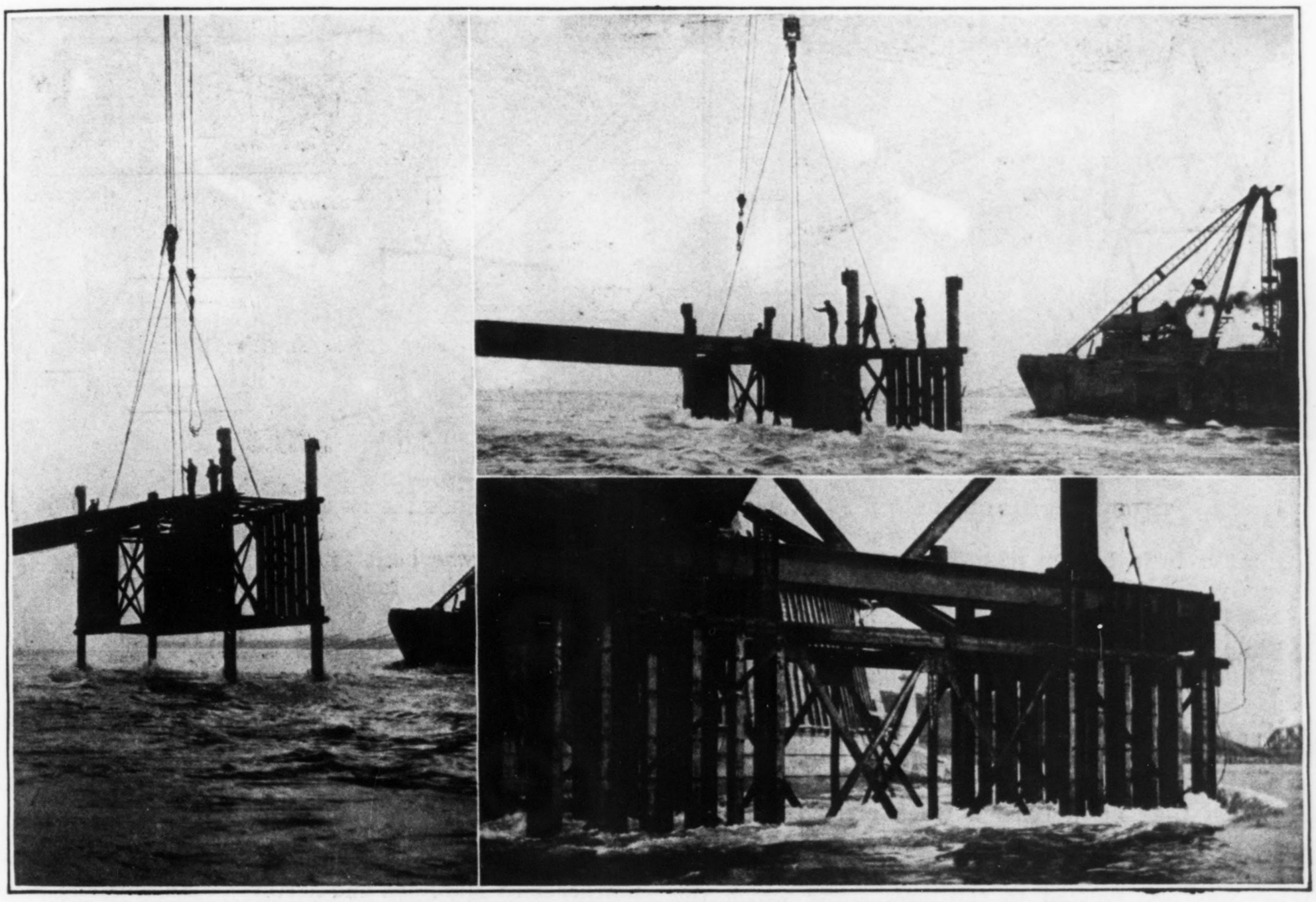


FIG. 4—A FALSEWORK CRIB IN THREE STAGES
Lowering crib into water—Landing the crib—Crib in service carrying steel falsework bent.

The falsework bent had splices in its legs to permit building up to various heights to suit the different elevations of the arches. The connection of the top struts of the bent was also made adjustable for the purpose of leveling up. On this top strut were carried two sand-jacks on which rested castings whose lower face was cylindrical so that they could take proper bearing notwithstanding the different slopes of the arch sections.

Patent on this crib construction has been applied for.

Erection Procedure—Work on the Canadian side started on March 23, 1926. The first falsework bent and the first section of steel for arch 6-7 were erected by a 30-ton locomotive crane, which then placed a traveler on top of this steel. This deck traveler placed

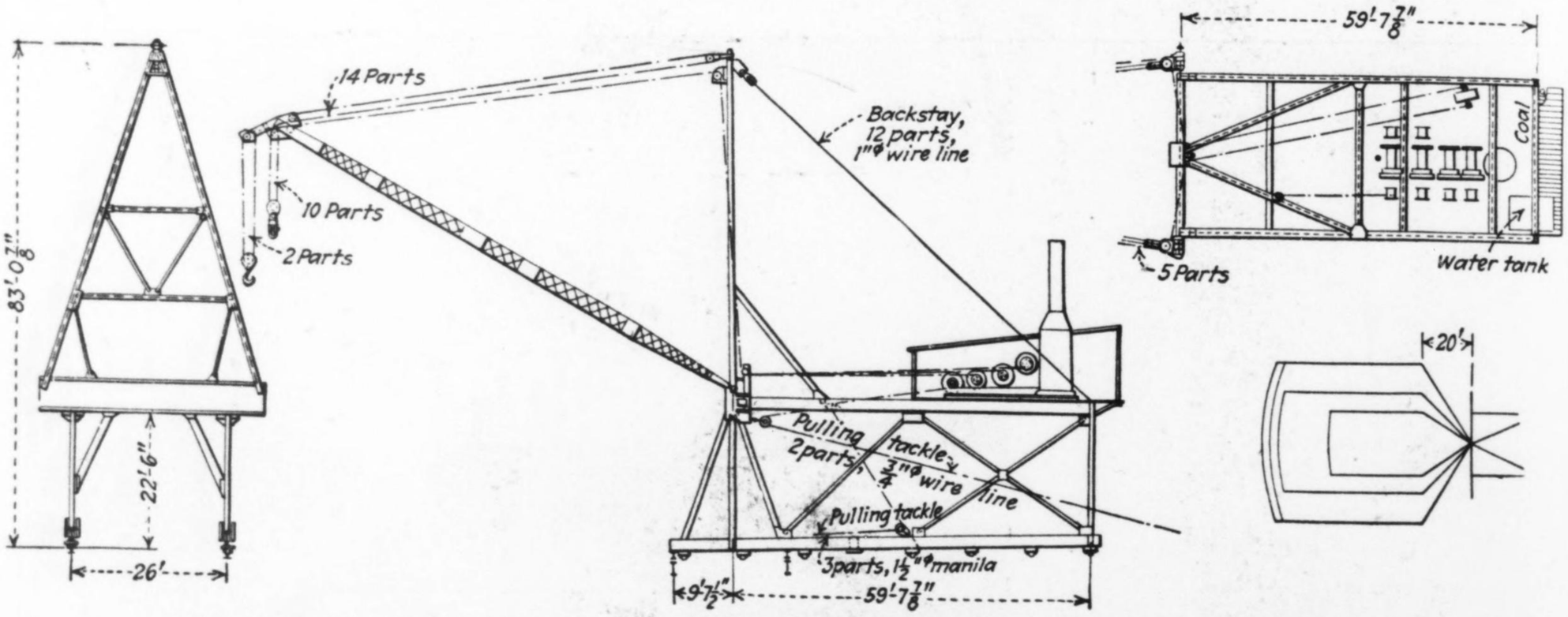
of the falsework was removed from the canal by June 2, about a month after navigation opened.

When the canal span and the tower at its outer end had been erected, the traveler began the erection of the first arch span in the river, span 2-3. It first set the upper and lower shoes of the arch on pier 2, and then set the first falsework crib in the river. This crib was connected to the permanent arch shoes by an upstream and a downstream strut, turning on a horizontal pin at each end, which located the crib at the right distance from the masonry and in the line of the bridge. It was also held by a horizontal guy from its lower corner to the upper edge of the pier, to take the pressure of the current. After the crib was in position the other sixteen piles were dropped into place and tapped with

a hammer to see that they took proper bearing; then the cross beams were connected to the tops of the piles, the sills placed on them and the falsework bent erected. The position of the top of this bent was fixed by two pin-connec ed struts from the permanent arch shoe.

This operation completed, the first section of the arch rib and floor was set in place. The traveler then moved forward and placed another falsework crib, bent, etc., and so in sequence to the end of the span. Each crib was connected to the one previously in place by an upstream and a downstream strut pin-connected at each end, and its downstream end was guyed to the upstream end of the previous bent.

Each section of the arch as it was placed was lined



THROUGH TRAVELER USED FOR ERECTING ARCH SPANS OF BUFFALO-FORT ERIE BRIDGE

up, set a little higher than final elevation, and then securely pinned and bolted to the preceding section. When the shoes at the far end of the span had been placed on the forward pier and bolted to the masonry, and the sixth and closing section of the arch set, the sand-jacks were lowered, after which the joints of the arch ribs were made good and the bolts re-tightened. The ribs had been drilled in the shop and assembled in lengths of not less than three sections, as a result of which they fitted so well when erected that they caused no delay and required no reaming of the joints.

With the span completely swung the falsework was taken out and hoisted to the deck, after which the traveler placed the shoes for the next arch and proceeded with the erection of falsework and arch material.

The falsework was found to be excellently adapted to the physical conditions of the site. It could be handled quickly and cheaply, was firm, did not slip or settle, and offered little resistance to the current.

Riveting of the floor system of the arch spans was begun before the falsework was taken out. Riveting the joints of the arch rib and the laterals was begun as soon as the arch was swung.

The ice in Lake Erie did not break up until unusually late in the spring of 1926, and it was not possible to start work on the substructure of piers 4 and 5 until after the ice had gone down the river. Due to the late start on these piers, the west or Canadian traveler erected not only span 6-7 but also the larger part of span 5-6. Thereafter it was taken down and shipped to the Buffalo side, where it erected the approach steel from pier B to the east abutment.

The span over the New York Central tracks (span A-B) was erected by a special gin pole. The girders of this span, weighing about 70 tons apiece, were each shipped in one piece and hoisted to place as units.

Rapid Completion—Erection of the various parts of the work was completed as follows: Spans A-1, 1-2 and 6-7, completed by July 1, 1926; superstructure west of span 6-7 and span A-B, completed by August 16, superstructure east of span A-B, completed by October 31; arch spans in river completed by November 15. The contractor's own men thus erected 7,800 tons of steel between April 15 and November 1.

The bridge was built for the Buffalo and Fort Erie Public Bridge Co., in general charge of Edward P. Lupfer, chief engineer, and William Russell Davis, consulting engineer. R. W. Cady was their resident engineer. The Bethlehem Steel Co. was the contractor for the fabrication and erection of the superstructure, and its engineers supplied the information on which this article is based.

Canada Plans Extensive Air-Mapping Program

The Canadian government has approved plans for extensive aerial mapping for development purposes in northeastern Manitoba and northern Manitoba and Saskatchewan. The plans involve the mapping, with the aid of aerial photography, 24,700 square miles of territory. The program includes an area of 12,000 square miles centering on the prospective water-power site where development is contemplated by the Flin Flon mine interests. One advantage of the survey will be to enable the finding of the best route for a power transmission line to the mine site, 60 miles to the southeast. An area of 6,000 square miles is to be mapped in northeastern Manitoba, north of Berens River, which will complete the mapping of the territory east of Lake Winnipeg to the Ontario boundary and facilitate the selection of pulpwood for the Manitoba Paper Co. The remaining territory will include 700 square miles proposed as a national park in northern Saskatchewan, and another area of 6,000 square miles northeast of Prince Albert.