Three Major Bridges Completed This Month

St. Lawrence River at the Thousand Islands in New York, St. Clair River at Port Huron, Mich., and the Connecticut River at Middletown, Conn., are scenes of construction achievements

By coincidence, three of the major bridges that have been under construction in the northeastern part of the country during the past two years were brought to completion this month. All three are described in the articles that follow, each article emphasizing that phase of the work on a particular bridge that is of most interest and significance.

Two of the bridges are international structures, the Bluewater Bridge connecting Michigan with Ontario and the Thousand Islands Bridge joining New York with the same Canadian province. The former bridge will replace a ferry across the St. Clair River, the latter provides a wholly new crossing of the St. Lawrence River. Both are toll structures, financed in large part by revenue bonds.

The third bridge, over the Connecticut River at Middletown, Conn., is a free, state highway bridge which owes its existence to the fact that the great flood of March, 1936 flowed over the floor of the adjacent old bridge, dramatically emphasizing its inadequacy. The new bridge floor is 50 ft. above this record highwater mark.

Five Bridges in One

Thousand Islands Bridge involves two suspension bridges, a steel arch, a continuous truss and a rigid frame concrete span

Rising high on graceful suspension spans over the Canadian and American channels of the St. Lawrence River, winding across wooded islands on new connecting roads, and spanning placid waters by short structures between adjacent islands, the Thousand Islands Bridge project breaks a main traffic barrier between the United States and Canada. Located in the heart of the historic and scenic Thousand Islands region, the new crossing extends for 7 miles—7,920 ft. of it on structures —from Collins Landing, near Alexandria Bay, New York, to Ivy Lea, below Gananoque, Ontario. The series of bridges is the only physical connection between the two countries along 325 miles of water-bound international boundary, extending from Lewiston, N. Y., on the Niagara River, through Lake Ontario and down the St. Lawrence to Cornwall, Ontario, near the New York-Quebec border. At Cornwall, highway traffic uses a plank-decked railroad bridge when the trains aren't using it; otherwise, up to now, there has not been a highway crossing of the river between Montreal and Lake Ontario.

Not only will the new crossing provide a direct route between northern New York and eastern Ontario, but it also gives access by car to two of the larger islands. One of the objectives of the project will be to develop this scenic region as a recreational and tourist area. In a 55-mile stretch of the river, from Lake Ontario to Brockville, Ont., there are 1,692 islands ranging in area from rocky points to 20,000 acres. Distance between river banks varies from 1 to 10 miles. Many of the islands and parts of the mainland are already designated as state and provincial parks, and local interests on both sides of the river are working to have the public domain enlarged.

History

Bridging the St. Lawrence River at the Thousand Islands has been considered for more than 50 years. One of the original proposals was that of Capt. Alexander Farlinger, who secured a charter about 1882 under the name of the Ottawa, Waddington and New York Railway & Bridge Co. This charter lapsed when the railroads changed their plans and finally built the bridge at Cornwall.

In 1888, plans were proposed for a railway bridge at Ogdensburg. This never materialized, but in 1895 a bridge was actually started between Brockville, Ont., and Morristown, N. Y. One pier completed at that time is still standing. In 1915, a crossing was proposed for the narrows above Brockville, and in 1929 a company obtained a charter in both Ottawa and Washington for a revival of this project.

In 1926 and again in 1927, private interests were blocked by New York State to obtain rights to build a toll bridge near the site of the present one. The state set up a commission in 1930 to investigate the various possible bridge locations, and reports covering six sites were filed with the legislature that year.

Actual promotion of the present project started in 1932 when citizens of Watertown, N. Y., succeeded in

Photo by A. W. Santway, Watertown, N. Y.

Fig. 1. Three of the five bridges that make up the Thousand Islands Bridge. These are over the Canadian half of the St. Lawrence River.

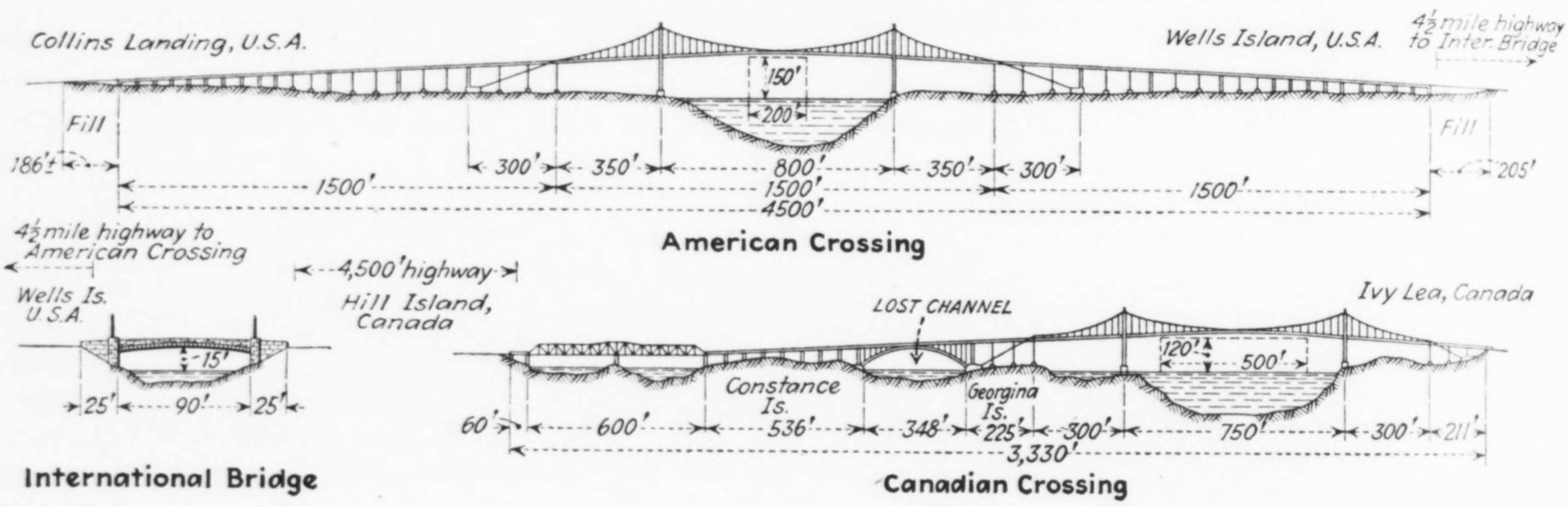

Fig. 2. A mile and a half of structures stretching from island to island and connected by new roads make up the Thousand Islands bridge project over the St. Lawrence River.

having Jefferson County create a Thousand Islands Bridge Committee which applied to the R.F.C. for funds. A Canadian committee attempted to arrange financing for its part of the project at the same time.

The Thousand Islands Bridge Authority was created by the New York state legislature in 1933, and at the same time a private company in Ontario was authorized to build the Canadian structure. Subsequent state, provincial and federal legislation in both countries enabled transfer of the Canadian rights to the American authority. Unsuccessful attempts were made to secure PWA funds, and finally revenue bonds, aggregating $3,050,000, were sold by the Authority.

Ground was broken on April 30, 1937, the last day permitted under the federal franchise. Tolls will be charged until the bonds are paid, then the project becomes a free crossing.

Series of structures

About midway between Clayton and Alexandria Bay, a short stretch of new highway leads off from New York Route 12 to the approach of the American channel span. This approach is a 1,500-ft. deck girder viaduct rising on a 5½-per cent grade to meet the suspended span.

The American suspension bridge has a center span of 800 ft. and side spans of 350 ft. each. Another 1,500 ft. of steel viaduct carries the roadway down to Wells Island, whose 10,000-acre area makes it the largest in the American group. From the end of this bridge a 4½-mile highway, built by the state, winds across the island, skirting the rocky shores of Lake of the Isles for most of the way and ends at the International Rift, a narrow waterway marking the boundary between the two countries. Here has been built one of the smallest international bridges in the world, a rigid-frame concrete structure of 90-ft. span, faced with pink granite blasted from the site. Two bronze plaques on the inside face of the stone railings and a bronze strip extending diagonally across the floor slab indicate the exact location of the boundary.

From the Canadian end of the International Bridge a new road, built by the Province of Ontario, extends for 4,500 ft. across rocky Hill Island to meet the Canadian series of bridges. The first or southerly structure is a two-span continuous through truss, 600 ft. long, supported

on a center pier resting on a tiny island. The north end of this bridge touches Constance Island, which is crossed by a deck girder viaduct, 516 ft. long, tying in with a 348-ft. steel deck arch spanning Lost Channel.

The north abutment of the arch, on Georgina Island, is a three-service structure (Fig. 4), taking the thrust of the arch, supporting a high concrete pier for the viaduct approach to the Canadian suspension bridge, and serving as the south anchorage for this bridge. The main Canadian bridge is similar to the American span except for length, having a center span of 750 ft. and side spans of 300 ft. A curving steel viaduct, 211 ft. long, lands the roadway on the Canadian mainland.

To provide direct access to the bridge, the provincial government is relocating King's highway No. 2,

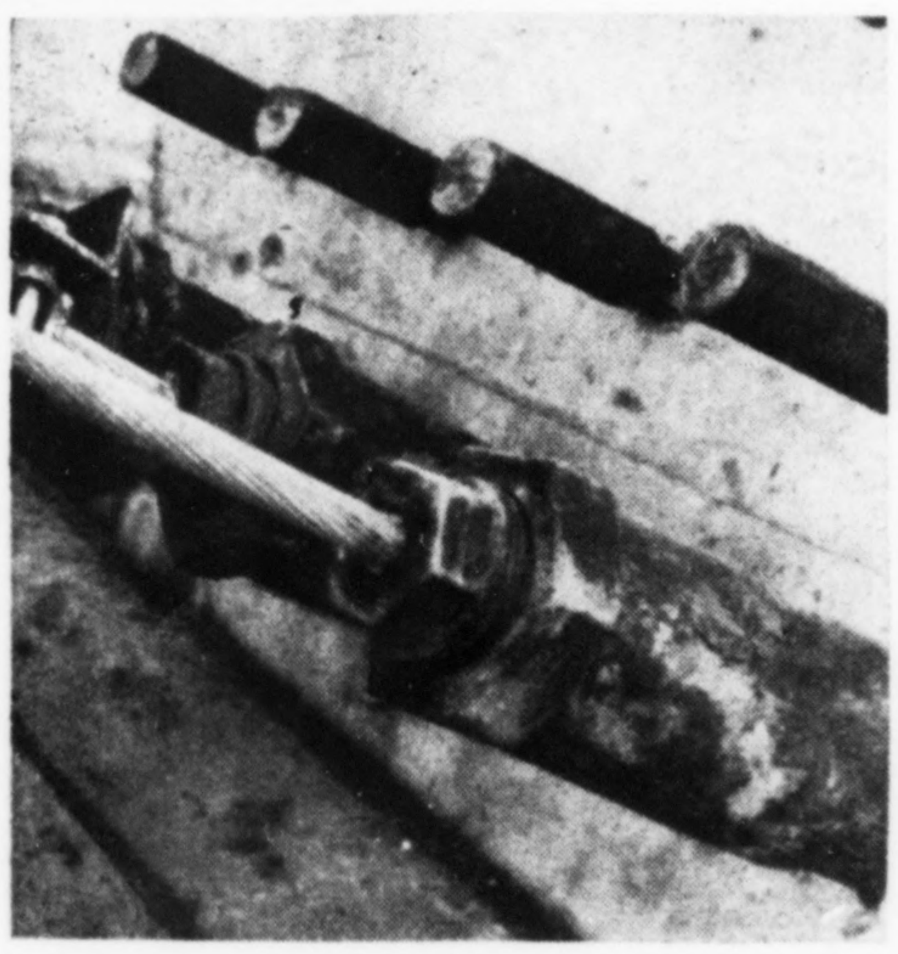

Fig. 3. Threaded sockets connected to threaded anchor bars by adjustable sleeves form a new type of cable anchorage.

the main transcontinental route, for 28 miles. In keeping with the scenic beauty of the north shore, the new route is a four-lane parkway, with numerous turnouts and parking spaces.

Details of design

The designers of the project were faced with several basic problems. First was the economics of the scheme, for not only were available funds limited, but as the project was to be self-liquidating, costs had to be kept down to permit reasonable tolls. Next was the question of design that would harmonize with the scenic surroundings. Another problem was that of navigation clearance—150 ft. for a 200-ft. width over the American channel; 120 ft. for 500 ft. over the Canadian waterway.

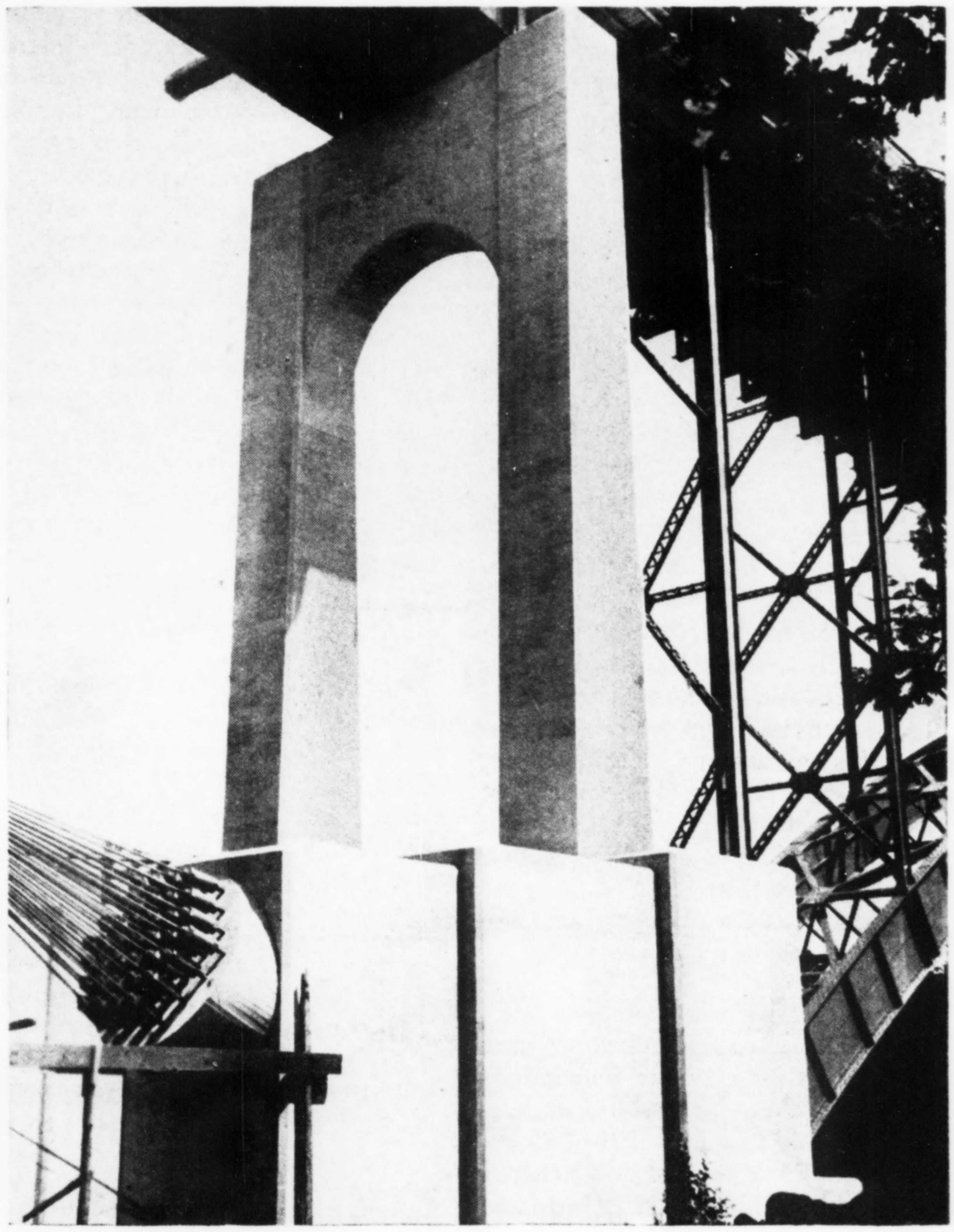

Fig. 4. Combination cable anchorage, arch abutment and viaduct pier base in the Canadian group of structures.

Studies showed suspension bridges were most economical for the main channel spans, and they not only easily provided the required navigation clearances, but their design blended best with the natural surroundings. Cantilever, arch and simple truss designs were also considered. The two main bridges are similar in design except for length and tower height. The cables, $30\frac{1}{2}$ ft. apart, are $7\frac{1}{2}$ in. diameter, each composed of 37 prestressed strands of $1\frac{1}{4}$-in. wire rope, arranged in hexagonal pattern. Final treatment of the cables includes painting, then wrapping with wire around wooden fillers to form a circular finished section, 9 in. in diameter.

The anchorages consist of $2\frac{3}{8}$-in. steel bars at each end of each strand, deeply embedded in concrete. The bars, in hexagonal arrangement, converge as they leave the anchorage to meet the diverging strands of the cable. The strands terminate in cast-steel sockets, externally threaded. These are fastened to the upset and threaded ends of the anchor bars by an internally threaded sleeve which permits adjustment of the strand length by turning with a wrench (Fig. 3). After the strands were adjusted to length, the sleeves were spot welded to keep them from turning.

The main towers are two-post bents, with x-bracing below the roadway and lattice girders at the portal and at the top. On the American span the towers rise 251 ft. above water; on the Canadian span 220 ft. The long approaches on both sides of the American channel bridge are three-

span continuous deck girders. Every third pier is a concrete bent to allow for expansion of the approach structure; intermediate piers are flexible steel bents. The shorter approaches to the Canadian bridge are simple-span deck girders on concrete piers.

On both suspension bridges the roadway is 22 ft. wide between curbs, flanked by 3-ft. sidewalks. To allow for a full view from the roadway, the stiffening plate girders were held to 6-ft. depth, and the cross beams are set high to place the roadway slab near the top of girders. An open pipe railing guards the sidewalks without obstructing the view. On the suspended spans the roadway is a 4-in. armored concrete slab; on the approaches and the other steel structures it is 8-in. reinforced concrete.

The 600-ft. continuous Warren truss span was kept as low as possible for the sake of appearance. First designs for the structure over Lost Channel called for a through truss, but later studies showed this location ideal for a steel arch.

Foundations

Substructures were relatively simple, for rock was found at or near the surface for all main foundations except the New York shore anchorage which is founded on steel H-section piles, both vertical and battered to take the cable thrust. A fortunate discovery of an uncharted shoal offshore from the south side of the main Canadian channel simplified the design of the structure at this point, for by founding the south pier on the shoal and the cable bent on the shore, the south anchorage could be located far enough away to permit a satisfactory slope of the cables. The pier on the shoals required a cofferdam only 14 ft. deep.

Construction

There were no outstanding construction problems involved in the project. The American suspension bridge was built by contractors from the United States; the Canadian structures and the International Bridge by firms from Ontario. American labor was used exclusively on the American span, Canadian labor on the Canadian bridges, and workmen from both countries on the International Bridge.

Construction features of the American bridge included pumping of all the concrete for the main foundations and the high approach piers. Because the channel on this side is the main navigation lane, it was impossible to anchor the steel supply barges in midstream, so steelwork for the stiffening girders and floor had to be run out from shore on lines from the cables. No such restriction prevailed on the Canadian spans, so the steel was hoisted from barges. Electric power was available from the New York side, but all construction equipment on the Canadian bridges was powered by steam or gasoline. The arch was erected by the tie-back method; falsework was used for the truss span erection.

Direction

The Thousand Islands Bridge Authority, set up by an act of the New York state legislature, includes E. H. Miller, F. J. Martin, Leon Schwerzmann, E. C. Sawyer, and Ross Parker. W. G. Mitchell is executive secretary. Design of the entire project and supervision of construction were by Robinson & Steinman, consulting engineers of New York City. Monsarrat & Pratley, Montreal, were associate engineers. William T. Field, of Watertown, N. Y., who was one of the leaders in promotion of the project, was retained as advisory engineer by the Authority. R. Boblow represented the consulting engineers as resident engineer directly in charge of the job and J. London was in charge of the office force on design.

The contractors on the structures were: American span substructure, Dominion Construction Co., Niles, Mich.; American span superstructure, American Bridge Co., and Street Bros. Construction Co., Syracuse, N. Y., subcontractor on the roadway; foundations for Canadian bridges, Cameron & Phin, Welland, Ont.; Canadian superstructures, Canadian Bridge Co., Walkerville, Ont., and Cameron & Phin, subcontractor on the roadway. The International Rift bridge was built by R. A. Blythe, of Toronto.

Economy and Good Appearance Rule Cantilever Design

Bluewater Bridge between Michigan and Ontario sets a new style in line and proportion

In designing the new international bridge over the St. Clair River between Port Huron, Mich., and Sarnia, Ontario, finished this month, the engineers and architects exerted every effort to produce a cantilever design that would dispute the reputation for ugliness that is usually attached to this type. That their efforts met with considerable success is evident from the accompanying photograph of the finished structure. It is also worthy of note that the attempt to provide the bridge with a good appearance did not increase its cost but rather resulted in a more economical and efficient structure.

Named the Bluewater Bridge because of the clear blue character of the stream which it crosses, the bridge has an 871-ft. main span, extending from shore to shore, and 326-ft. anchor arms. A deck girder approach, including two deck truss spans adjacent to the main bridge, totals 2,657 ft. on the Canadian side, and a similar layout is 2,283 ft. long on the American side, bringing the total length of the bridge to about 1¼ miles. The main span clears the river by 150 ft. to accommodate the heavy shipping that plies beneath it between Lake Huron and Lake Erie. The roadway (of concrete-filled steel-grid type on the main span), is 32 ft. wide, and there are two sidewalks—4 ft. 2½ in. and 1 ft. 8½ in. in width.

Before choosing a cantilever design, other types of bridges were studied. Foundations were found to be unsuitable for an arch. The relatively short span in combination with the high shipping clearance defied the use of a suspension bridge that

Fig. 1. Providing 150-ft. clearance over the St. Clair River, the Bluewater Bridge presents an interesting outline featured by a flat-arch cantilever central span and steel framed anchor towers.

would not look freakish; and moreover, the high cost of anchorages made the suspension design uneconomical. A cantilever design proved to be best suited to conditions, was least costly and could meet the requirement of construction without falsework in the river. The principal problem was to work out such outline and proportions that the bridge would have esthetic appeal.

Detailed study of the cantilever type brought out the possibility of developing an outline which, in combination with the anchor arms, would suggest a three-span continuous truss with an arched center span. Whereas in most such cantilever designs, the bottom chord of the main span trusses is carried above the roadway to suggest an arch, the bottom chord of the Bluewater Bridge was kept slightly below the level of the roadway, curved at the ends but practically horizontal over the center half of the span for a width sufficient to provide navigation clearance. By this expedient, the material that would have been required in the conventional arch cantilever for hangers and for wind chords in a bottom lateral system was saved. In addition, the height of the structure could be made a minimum consistent with the vertical clearance required, thus keeping wind stresses throughout the main span low in comparison with the other types of structures studied. Finally, an agreeable simplicity of appearance was created.

Another feature of the design that enhanced the appearance of the bridge is evident at the anchor arm piers, which mark the transition between the main bridge and the approaches. The difficulty of making a suitable transition at this point was increased by the fact that the trusses of the main bridge are 40 ft. 7 in. apart and outside the roadway and sidewalks, while the approach trusses and girders are only 29 ft. apart and support an overhanging deck. An original design placed a high masonry pier at this point but the final studies substituted a structural steel tower on a short pier. Such a steel tower, with short architectural posts projecting above the roadway, furnishes the necessary defining feature at the end of each anchor arm and at the same time fits in naturally between the anchor arm truss and the approach truss. The transition is aided by continuing the chords of the approach trusses on the same lines as those of the anchor arm chords.

In its structural details the bridge is not particularly unusual. There is a liberal use of silicon steel. The main bridge truss members are built-up sections and most of the Canadian approach work is of the same design since rolled beams in the larger sizes are not available in Canada. In the American approach, however, rolled sections predominate.

One interesting detail in the approach girder spans permits the saving of a floorbeam at each girder end where expansion does not occur. In general, the approaches consist of groups of three simple girder spans, from 61 to 78 ft. long, supported on bents, with braced towers of 44 ft. span placed between the groups. The girders are fixed at each tower bent and expand toward that bent which

Fig. 2. Location map of Bluewater Bridge joining Port Huron, Mich., and Sarnia, Ont.

is one span removed from the tower on its high side. Whereas each point of fixed support would normally have a double floorbeam and a fixed bearing under each girder span, a strap is used to tie the top flanges of the girders together at these points, permitting a continuous floor system with a single floorbeam over the support, but requiring a bronze sliding bearing under one of the girder ends to allow for girder deflections. Two floorbeams are, of course, used at the expansion bents.

Other facts about the bridge

The two main bridge piers, each consisting of two 26-ft. dia. caissons with 8 ft. dredging wells, were sunk to rock at a depth of 95 ft. below low water level. Above the ground the caissons are surmounted by two shafts about 50 ft. high tied together at the top with a cross strut. The Michigan approach piers are on

spread footings and, except for a few pile-supported piers, the Canadian approach foundations are of the same type.

Toll collection, customs, immigration and administration facilities are provided at both ends of the bridge. The Michigan plaza is an elevated area of flat slab design, 120 ft. wide at the toll booths, and connected by ramps to the Port Huron streets.

The bridge will be lighted with sodium vapor lamps on two circuits, one from each side of the river.

Engineers and Contractors

Engineers for the design of the entire structure and for the supervision of the construction of the main bridge were Modjeski & Masters, formerly Modjeski, Masters & Case, who had as their Canadian associates the firm of Monsarrat & Pratley. Paul P. Cret served as consulting architect on the main bridge. The main bridge superstructure was fabricated and erected by the American Bridge Co., the Ontario approach superstructure by the Sarnia Bridge Co., and the American approach superstructure by the Wisconsin Bridge & Iron Co. The Missouri Valley Bridge & Iron Co. and the Kansas City Bridge Co. were joint contractors on the main bridge substructure.

General direction of the work was under V. B. Steinbaugh, deputy commissioner and chief engineer of the Michigan highway department, and chairman of the Michigan State Bridge Commission; Murray D. Van Wagoner, Michigan state highway commissioner; T. B. McQuestion, minister of highways in Ontario and R. M. Smith, deputy minister of highways in Ontario.

The main bridge was financed through the sale of revenue bonds by the Michigan State Bridge Commission, a public body. The Canadian approach was constructed and paid for by the Ontario highway department assisted by the Dominion government, and the American approach by the Michigan state highway department with assistance of the U. S. Bureau of Public Roads.

Balanced Cantilver Erection Of Twin Tied Arches

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Middletown Bridge in Connecticut built with minimum of falsework by resort to cable tiebacks.

WITH the opening, Aug. 6, of the bridge over the Connecticut River between Middletown and Portland, Conn., an old dream of the residents of the two towns was brought to realization. Consisting of two 600-ft. three-hinged tied arches and plate girder approaches, the bridge has a total length of 3420 ft. Under construction since May 1, 1936, it is the largest bridge in the state and the only highway crossing of the river between Hartford, 15 miles upstream, and East Haddem, 13 miles below. In its construction, the erection of the two arch spans that cross the river was the most difficult part of the job and of main interest because of the method used, which involved building two half-spans as cantilever arms balanced by temporary cable tiebacks between the top chords of the trusses over the pier in the center of the river. This method was adopted because it required a minimum of falsework and eliminated it entirely in the west three-quarters of span B into which the swing span of the adjacent old bridge (Fig. 3) had to move when opened to pass boats. Also this method proved to be more economical than others considered, since the required amount of cable was available at a reasonable rental price. The five falsework bents required (three made and two re-used) could be built-up of floor beam material from the Portland approach and therefore did not present a material expense.

The principal dimensions of the arch spans are given in Fig. 2. Between the two main trusses, 50 ft. apart, is a 45-ft. roadway consisting of a 3½-in. steel grid floor filled with fine-aggregate concrete. Two 6-ft. sidewalks are cantilevered outside the trusses. An underclearance of 93 ft. above mean low water is provided, compared to 23 ft. on the adjacent old bridge, which will be removed. Silicon steel is used in all truss members, and carbon steel for the floor system, the sway frames and the lateral system, which occurs only in the plane of the top chord of the trusses.

The Middletown approach, 990 ft. long, on a 4.45 per cent maximum grade, is composed of seven simple girder spans varying from 87 to 110 ft. and two 175-ft. spans in a continuous girder layout that was adopted because of economy; also simple spans of 175 ft. would have required deep girders that would have interrupted the uniformity of girder depth (8 ft. 4½ in.) that was desired throughout the approach. The Portland approach, 1220 ft. long, is of typical viaduct design using 35-ft. braced tower spans alternating with single span girders from 70 to 110 ft. long. There are 8 tower spans and 11 girder spans. The maximum grade is 2 per cent. The girders on both approaches, which are mainly of silicon steel, 45 ft. c. to c., support a four-lane 45-ft. concrete slab roadway 8 in. thick. A 6-ft. sidewalk is cantilevered on the outside of each girder. Both approaches were erected by a deck traveler which, upon reaching the main arch piers, set the first false-work bent, erected the first two panels of arch steel and then assembled a traveler on the top chord, thus setting the stage for arch erection.

The erection plan

Erection procedure on the twin tied arches is diagrammed in Fig. 2. The half of arch A from pier 9 eastward and the half of arch B from pier 11 west were erected by ordinary cantilever methods over two falsework bents. Procedure on the two halves was identical. Erection of the west half of span A was completed first. Then the two inner halves, balanced about pier 10, were erected.

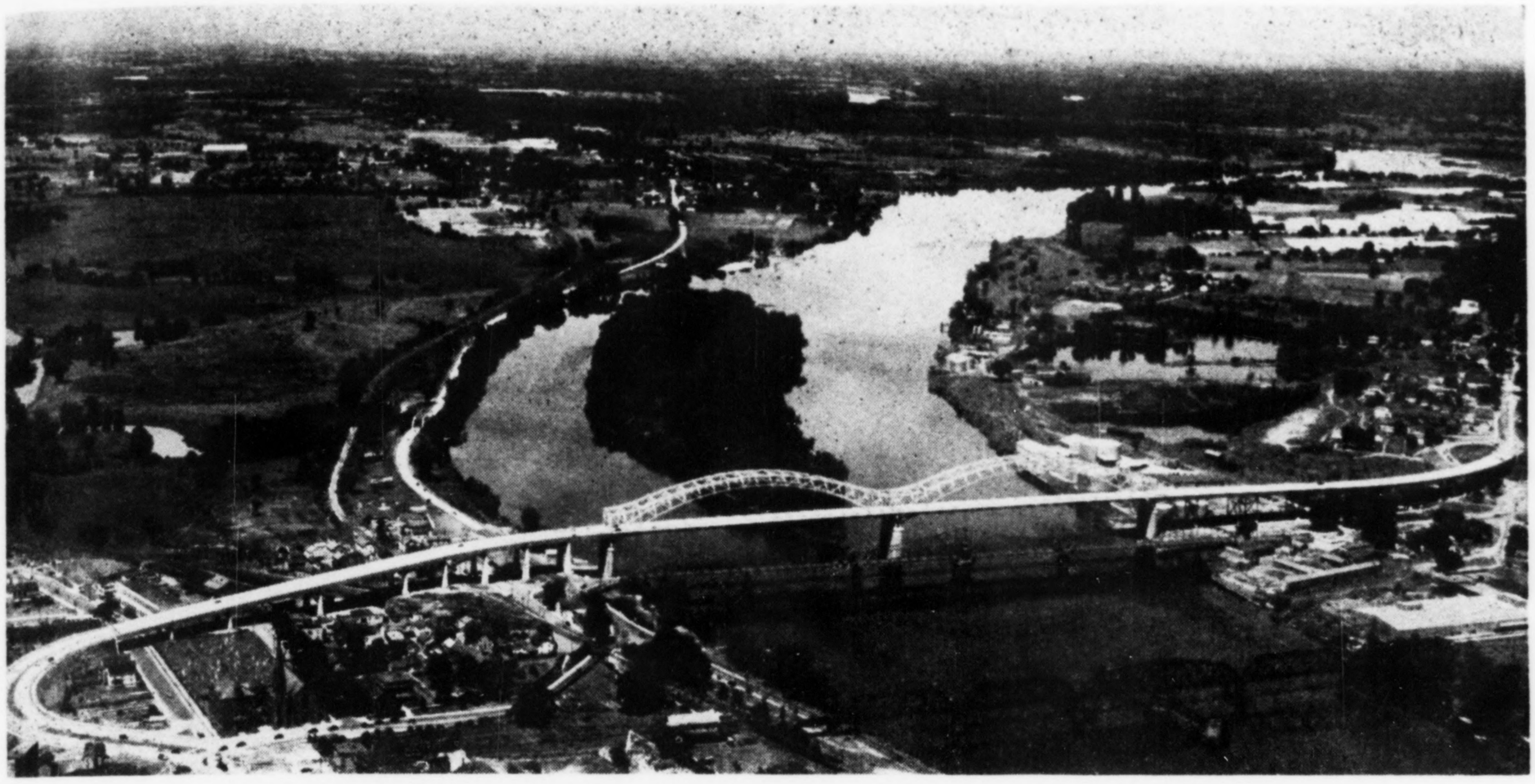

Fig. 1. High above the adjacent old bridge, the twin arches of the new Middletown Bridge are out of reach of Connecticut River floods. The curved approach at the left comes to a grade on high ground on the main street of Middletown. Largest bridge in Connecticut, the cost was about $3,500,000.

and span A closed and the floor system hung. The east half of span B was the last completed. The tie eyebars and the floor hanger cables in each span were erected with the arch steel, but no floor system steel was suspended until the eyebars were joined at the center of each span, and the arches swung free of temporary supports. Only two arch travelers were used at one time.

While the first half arch was progressing out from pier 9, a guy derrick with 90-ft. mast and 80-ft. boom, set up on pier 10, erected falsework bent III, two panels west of the pier, and then by a series of steps erected the first two panels of each arch. No falsework bent comparable to bent III could be used in span B, since it would foul the opening of the old

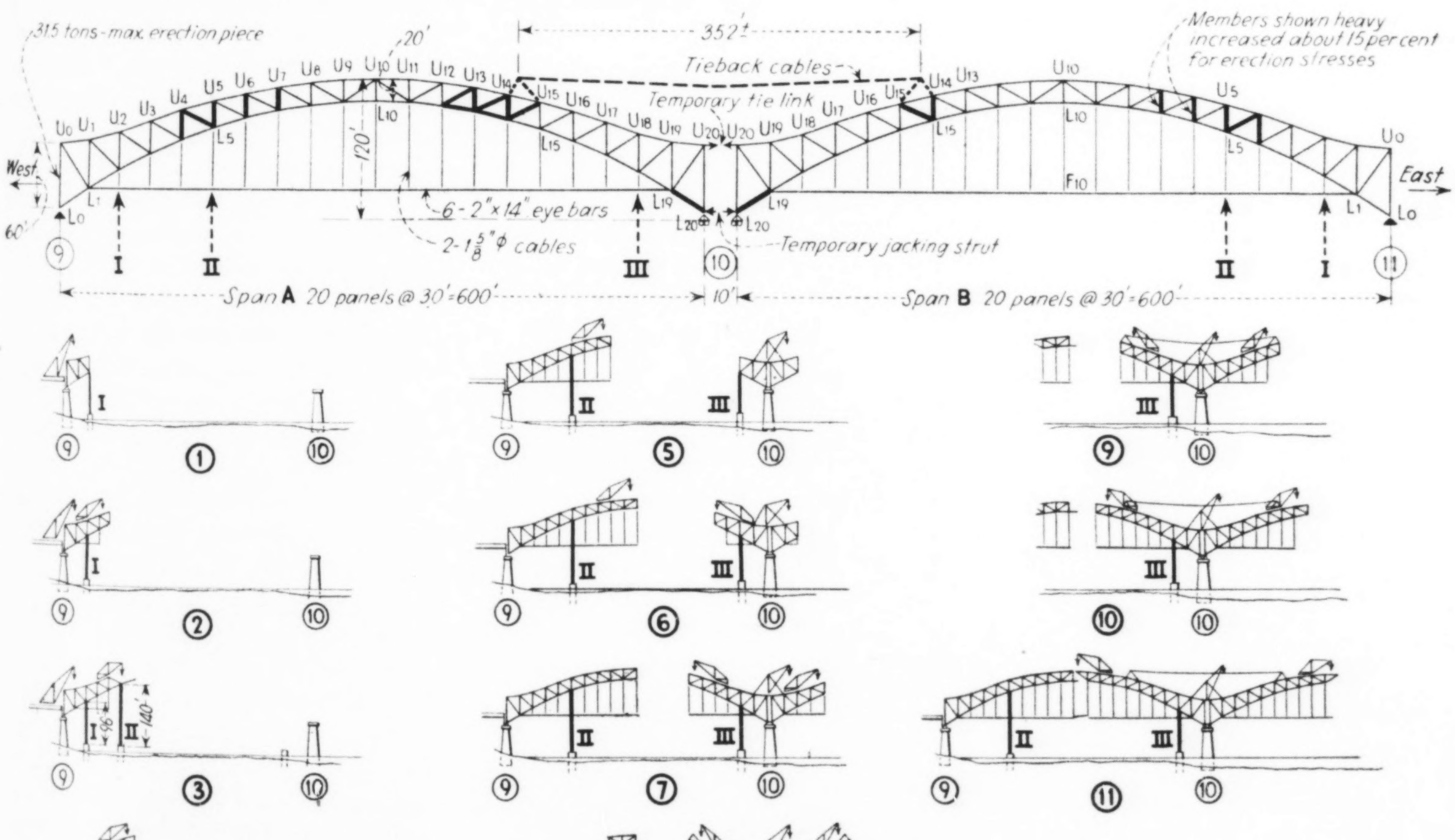

Fig. 2. Steps in the erection procedure used on the new Connecticut River crossing between Middletown and Portland, Conn.

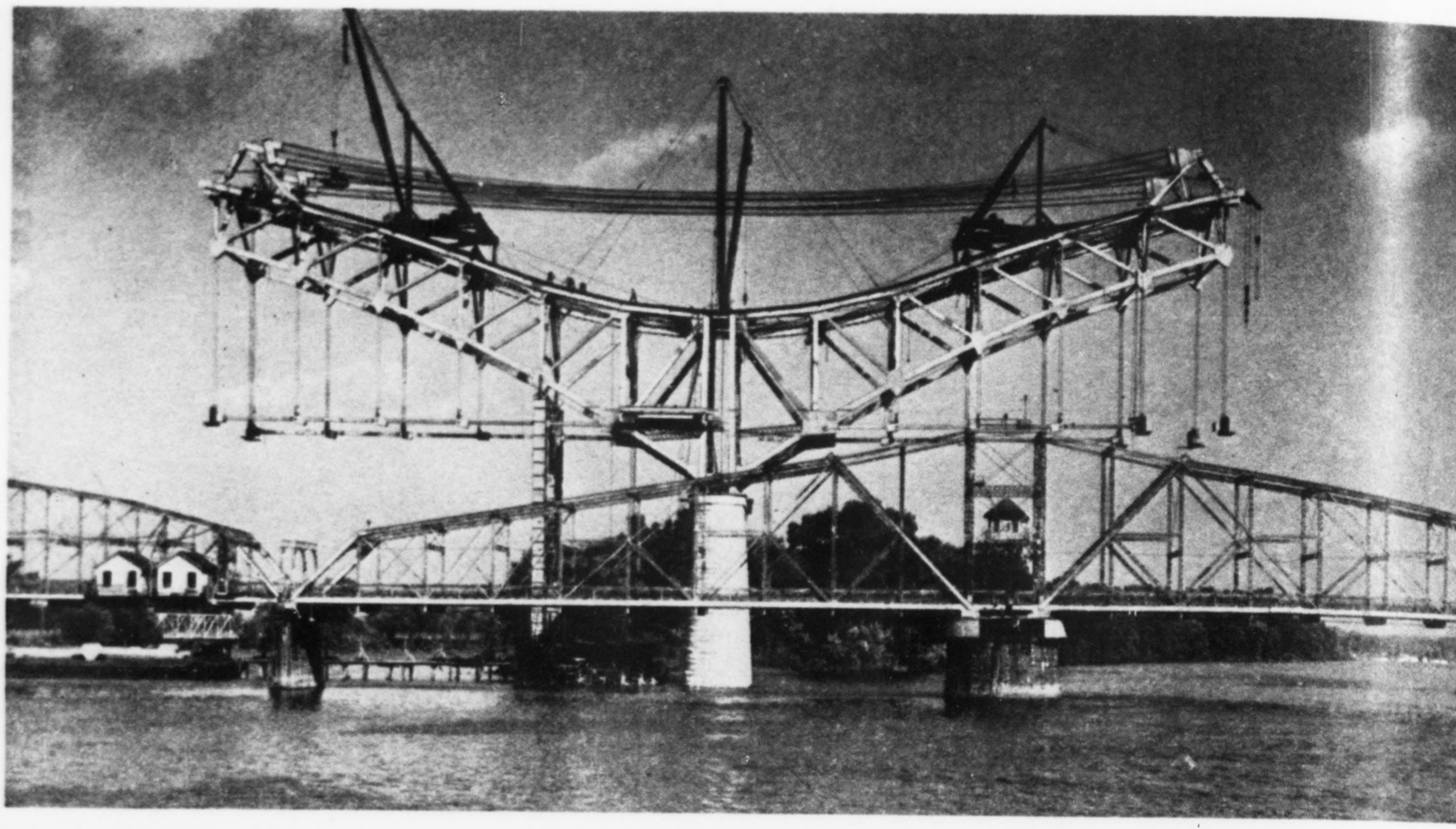

Fig. 3. Balanced cantilever erection of twin 600-ft. tied arches about a center pier with the aid of a cable tieback system. The old bridge that is to be removed is in the foreground.

swing span, and therefore the west half of span B had to be supported at all times from the east half of span A. Accordingly, two temporary silicon steel links of fixed length, each 26x2 in. in gross section, were pin connected between the U_{20} points of both trusses, and adjustable jacking struts, with two 350-ton hydraulic jacks each, were placed between the L_{20} points. These details not only supported span B from span A but also provided means for raising or lowering the arch halves by jacking; with one roller shoe "killed" and the other free, horizontal movement in the jacking strut was translated into vertical movement of the trusses by virtue of the fixed length ties at the U_{20} points.

After the guy derrick completed erection of the first two panels of each arch, it was jumped to the top chord level and assembled the two arch travelers which were to proceed simultaneously in opposite directions from the pier. With the traveler on span A at all times slightly ahead of the other traveler in number of pieces in place, in order to maintain a downward load on falsework bent III, the two travelers erected trusses, hangers and eyebars by cantilevering ahead until panel point 14 was reached. At this stage of the work, the special tieback system between the two arches was assembled to take the cantilevered weight of span B and allow erection to proceed to the center of each span without excessive erection stresses in the truss members; only a few members adjacent to the tieback supports were required to be reinforced.

The cable tieback system

The design and erection of the cable tieback system presented a number of problems. Although span A could be closed by lowering falsework bents II and III, the closure of span B depended upon the length of the tiebacks, the deflection of the two half arches from the tieback support and over bent II at the east end and also the upward deflection of the trusses in span A due to the cable tieback pull. The stresses, truss deflections and panel point positions, therefore, had to be predetermined with great accuracy in order that the adjustments available by jacks in the cable supports and in the struts over the center pier would be sufficient. It was particularly important that the actual length of the tieback cables should agree with the calculated length.

In general, the tieback equipment consisted of four A-frames in the plane of the trusses, pin connected to the top chords at U_{14} and U_{15} of each truss on each span and laterally supported on the outside of the trusses. To the apex of each frame were attached members containing 2 sets of 30-in. diameter cast steel sheaves on 9-in. diameter pins. Over these sheaves were reeved four sets (two per truss) of 12 part 1½-in. diameter wire rope falls. The tension leg of each frame (the side away from the cables) was made adjustable with a 500-ton hydraulic jack for tightening and releasing the cable ties. The sheave supports over span B were made stationary (triangular in shape) while those over span A were of a toggle type (Fig. 5) for equalizing stress in the two sets of cables during adjustment.

Reeving and adjusting the cables

Instead of handling and reeving the 1½-in. diameter tieback cables directly over the sheaves, a ⅝-in. diameter wire rope guide cable was first reeved. One end of this cable was attached to the 1½-in. cable by a special Kellum's grip and the other end to a hoisting engine below the bridge, and the 1½-in. cable pulled over the two sets of sheaves as the guide cable was pulled out. After the twelve parts of each set of cable were reeved, the two ends of the cable were entered through the tieback support on span A and temporarily clamped with an 18-ft. tail overhanging. This gave the cables

about an 18-ft. sag at the center.

To bring each cable set from the initial 18-ft. sag to the $6\frac{1}{2}$-ft. sag indicated by the calculations, it was found necessary to pull in the two ends of each cable about 12 ft. By taking up the slack on each end, overhauling of cables over the 30-in. sheaves was minimized. The guy derrick at pier 10 was used to "shake up" the strands of each set that were seriously out of line. This was accomplished either by raising up or pulling down on the strands to cause them to overhaul slightly on the sheaves in the supports.

After this rough adjustment of strands was performed, a pre-measured music guide wire, 0.045 in. in diameter, was stretched between the sheave pins, and the sag of the cable sets compared to that of the guide wire. Small adjustments of a few inches to a foot were made in the cable by taking in or letting out on one or both ends if and as required. An average of two adjustments per cable was required.

Jacking

After the cables were adjusted to the $6\frac{1}{2}$-ft. sag, the next step was to jack at both tieback supports and at the center pier jacking struts to release the tie links at U_{20}. First the jacks in the supports on span B were run up 7 in., which removed an appreciable amount of the cable sag. Then the jacks in the supports on span A were run up $2\frac{1}{2}$ in. Next the jacking struts at L_{20} were released about 7 in. at which time one pin in the U_{20} tie link on each truss began to be free. It was decided, however, to use the full amount of jacking available in the supports on span A, so the jacks were expanded 3 in. more, after which the link pins at U_{20} were easily removed.

The time required to erect the tiebacks, adjust them and swing the two half arches onto the cable system was $14\frac{1}{2}$ working days. The total weight of steel in tieback supports, pins, sheaves, etc., and including 16,320 ft. of $1\frac{1}{2}$-in. cable, was about 150 tons.

Closing the arch spans

After the cable tiebacks were made effective, the two halves of the arches were erected to their respective span centers by ordinary cantilever procedure. Arch A was the first to be

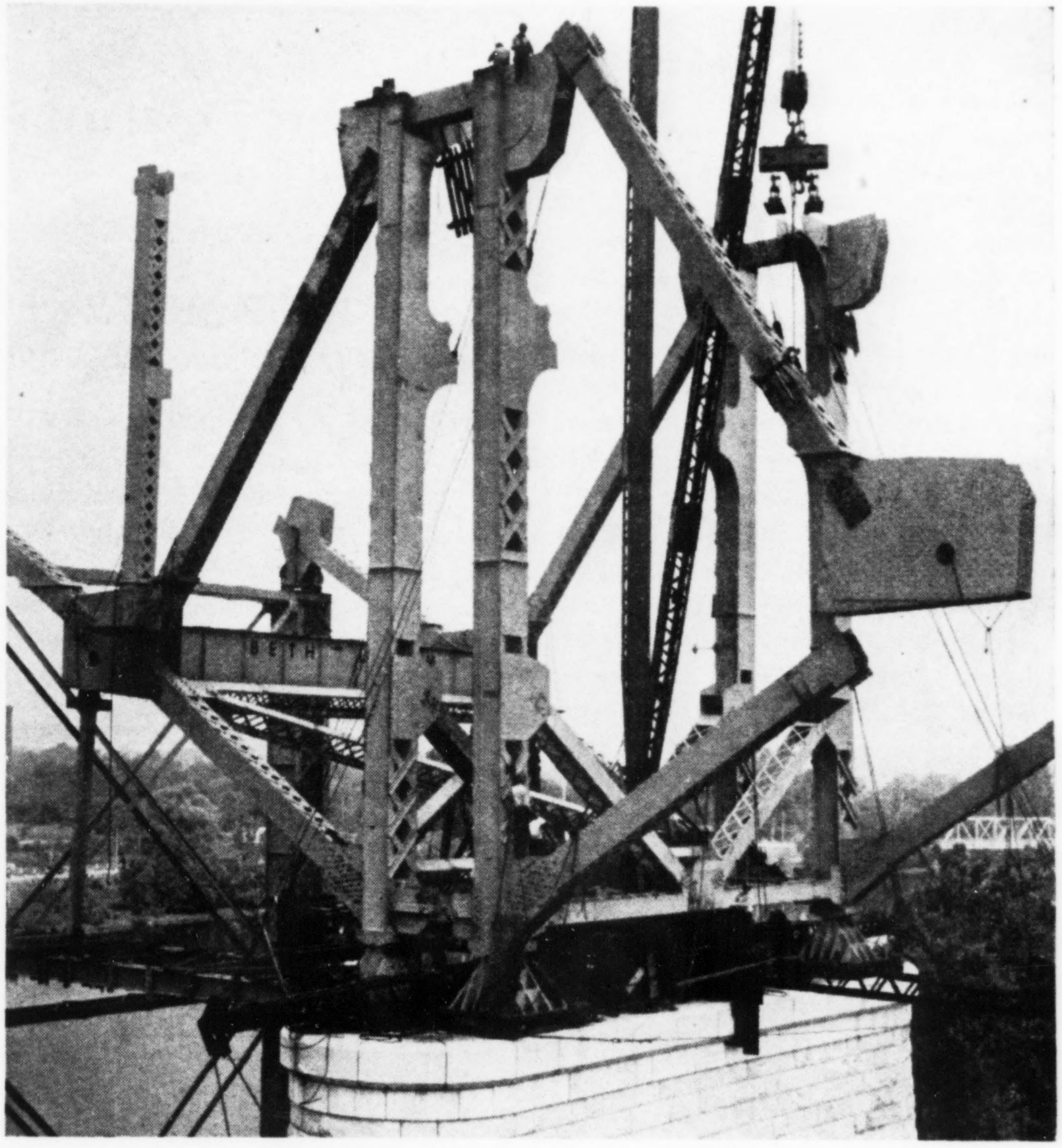

Fig. 4. Start of erection operations on the center pier, using a guy derrick to set up the first two panels of each span. Note the tie bars between the end posts at the top and the jacking struts between them at the bottom.

Fig. 5. Erecting an A-frame of the cable tieback system. The member being placed will incorporate a 500-ton hydraulic jack for adjusting the cables.

closed. During the entire period the arch sections were being erected, falsework bents II and III were kept several inches high so that there would be an opening of about 8½ in. at U_{10} when the closing top chord section was erected. To compensate for this raised position of the two halves, tending to separate the closing ends of the bottom chord eyebars, the L_{20} expansion shoes of this span were jacked 10 in. west by means of the jacking struts over pier 10, permitting the pin at F_{10} to be driven. During this operation the expansion shoes of span B on this center pier were held fixed.

After the eyebars were joined, falsework bents II and III were lowered simultaneously until the eyebars became effective and the arch was self-supporting. The jacking strut over pier 10 was also decreased in length as the slack was taken up and the slight elongation developed in the eyebars.

Span B was closed in a similar manner, the eyebar chord being first connected at the center. Then falsework bent II was lowered and the cable tieback lengthened simultaneously until the eyebars became effective, after which the arch was self-supporting.

Finally the two arch travelers on span B backed down the top chords, filling in the floor system of the span from the center toward the piers. The floor system in span A, from which the arch travelers had been removed, was erected by a small deck traveler working eastward from pier 9 toward pier 10.

Contractors and engineers

The Middletown-Portland bridge was built by the Connecticut state highway commission under the direction of E. C. Welden, deputy highway commissioner, L. G. Sumner, engineer of bridges and structures, and W. G. Grove. The substructure contract for all approach piers and the three main river piers was completed by Merritt, Chapman & Scott Corp. at a cost of about $1,000,000. The superstructure, including roadway slab and painting, was built by the fabricated steel construction division of Bethlehem Steel Co., at a contract price of about $1,100,000. The entire bridge project, including property damages and connecting approaches, cost about $3,500,000.

Highway Officials Meet at Reno

Exchange of ideas and adoption of specifications for truck sizes and loads feature gathering of representatives of eleven western states and Texas

THE seventeenth annual meeting of the Western Association of State Highway Officials at Reno, Nevada, August 10 to 13, was attended by about 400 delegates and guests representing eleven western states and Texas. Papers on a highly diversified program ranged from relations with union labor to roadside improvement. A national flavor was given to the program by participation of officers of the American Roadbuilders Association, Associated General Contractors, American Automobile Association and American Association of State Highway Officials. Effective cooperation resulted from the presence of officials of the U. S. Bureau of Public Roads, U. S. Forest Service, and the National Park Service.

L. V. Murrow, director of highways, state highway department, Washington, presided over the sessions in a way to encourage discussion, and very general participation resulted. Topics of special interest were made the subjects of general discussions by calling for expression from each of the member states. The two and a half days of general sessions were supplemented by a 50-mi. motor trip to Cal-Neva Lodge on Lake Tahoe where 425 gathered for the annual banquet.

Union labor diffifficulties

E. P. Palmer, president, Associated General Contractors, outlined problems resulting from the infiltration of union labor organization into highway and public works construction fields. Notable are the craft- and territorial jurisdictional disputes now appearing in the highway field just as they have heretofore in the building trades. An injustice in this is that it operates to prevent the contractor from taking his trained organization from one job to another. Unions are open to criticism, he said, in claiming all the work possible for their craft in the highway field, disregarding present practices in the industry. The lines of demarcation between the various crafts are not clearly established in road construction, and the possibility of jurisdictional disputes are multiplied many times over as compared to some other fields. Contractors want to pay fair wages but there is a limit to unreasonableness of union officials, and labor must learn to take its share of responsibility.

The AGC does not arbitrate such disputes but some of the chapters have successfully negotiated agreements covering entire cities or even on a statewide basis. One conclusion that is sure, he said, is that highway officials, contractors and labor must meet on the common ground of furnishing the taxpayers with the maximum in highway construction for each dollar expended. To that end, at least, there should be a willingness for each to try to see the other's side of the question and to sit down together to work out an acceptable solution of common problems.

The round-table discussion on future roadside improvement brought contributions from nearly every state. The general opinion was that care must be taken to plan roadside improvements that will not involve high maintenance expense.

Some states feature facilities for picnicking, drinking fountains and roadside camps. Texas reported 400 roadside parks, 150 lunch places and 264 historical markers. Texas acquires a 300-ft. right-of-way for important routes.

Emphasis was placed on the greatly improved appearance of roads resulting from rounding off the edges of slopes in cuts. T. C. Carpenter, National Park Service, pointed out that the use of flatter slopes, which greatly improve the appearance of cuts, does not unduly add to the cost; part of the expense is justified by the stabiliza-