Mid-Hudson Bridge to Be 1500-Ft. Suspension Span

General Features Outlined by Modjeski & Moran—Unusual Tower Design—Piers to Go 125 Ft. to Rock

REPORTING on the Hudson River highway bridge authorized by the legislature of New York State last year, Modjeski & Moran, engineers for the bridge, recommend a crossing at the foot of Church St., Poughkeepsie, with eastern approach diverging slightly northward to reach Union Square in that city. Their borings on the line of this crossing indicate that the maximum depth of rock in the middle portion of the river is about 180 ft., but that near the shore rock can be reached at depths of 120 to 130 ft. For this reason and with a view to avoiding navigation interference by river piers, their choice of bridge type is in favor of a suspension bridge of 1,500-ft. main span and 750-ft. side spans, reaching direct rock anchorages on either bank. The main span is to be flanked by a concrete approach viaduct at the east end, while the west end connects directly with the West Shore highway.

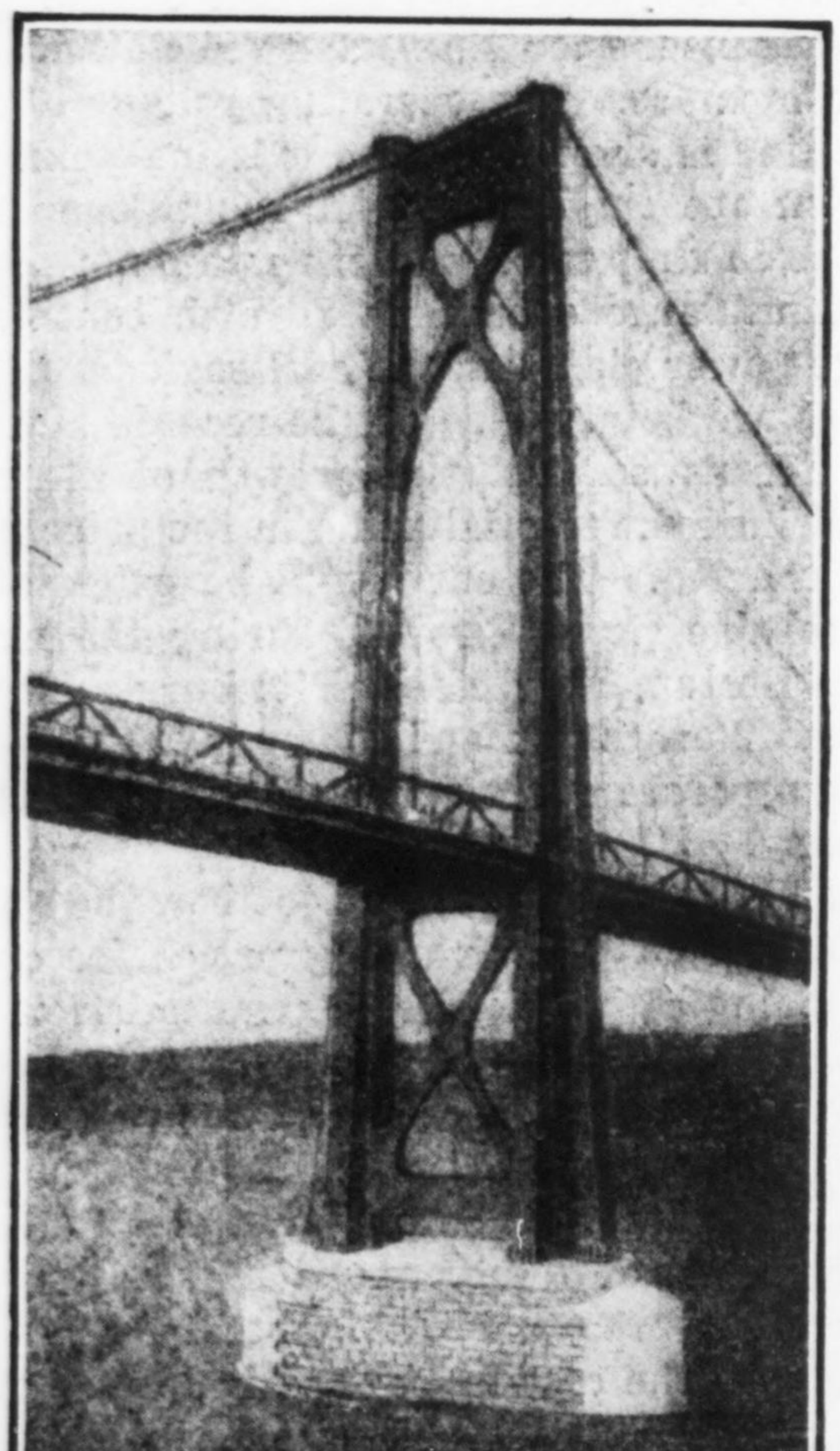


FIG. 1—UNUSUAL TOWER OUTLINE

According to the plans, the supporting members of the structure will be two main cables spaced 42 ft., each about 17½ in. in diameter, laid up of parallel wires of 0.192-in. diameter, and carried on steel towers 280 ft. high above the piers or 315 ft. above low water. The cables will be fixed to the towers and the towers fixed on their bases, and bending of the towers is relied upon to accommodate temperature and load variations. A batter leg on the outer side of each main tower post will increase the lateral stability (Fig. 3). The roadway is to be 30 ft. wide.

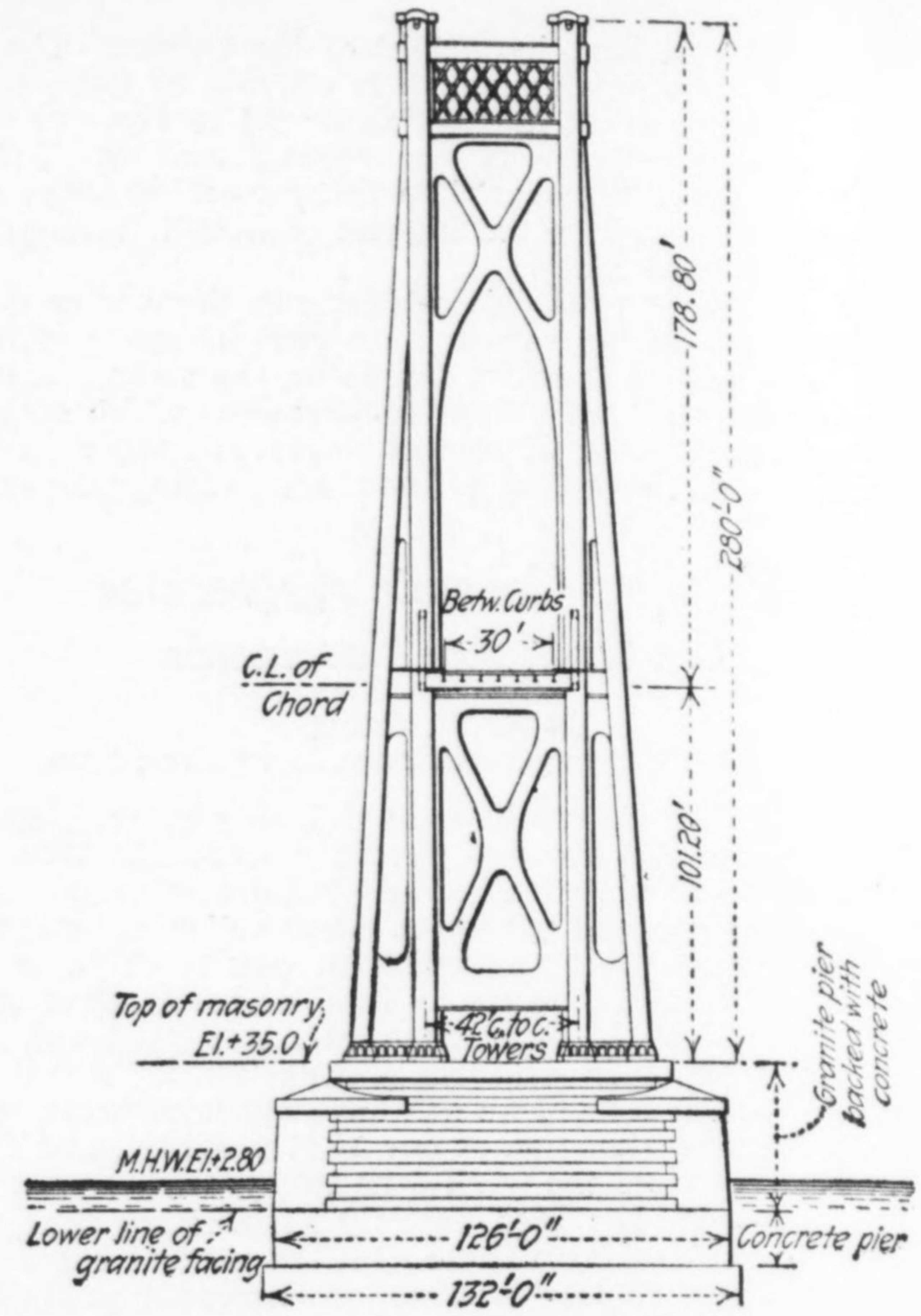


FIG. 3—ELEVATION OF TOWER

Open dredging is to be used for sinking the piers, which are to be concrete cylinders 54 x 132 ft. at the base and 35 x 126 ft. at the top.

The cost estimate for the bridge is:

Substructure	$1,800,000
Superstructure	2,867,000
East approach and anchorage	413,000
West approach and anchorage	234,000
Engineering and contingencies, 10 per cent	531,000
Total	$5,845,000

The engineers believe that the bridge can be completed within three years from the time the substructure contract is let. The enterprise is in charge of the State Department of Public Works, under Col. Frederick Stuart Greene.

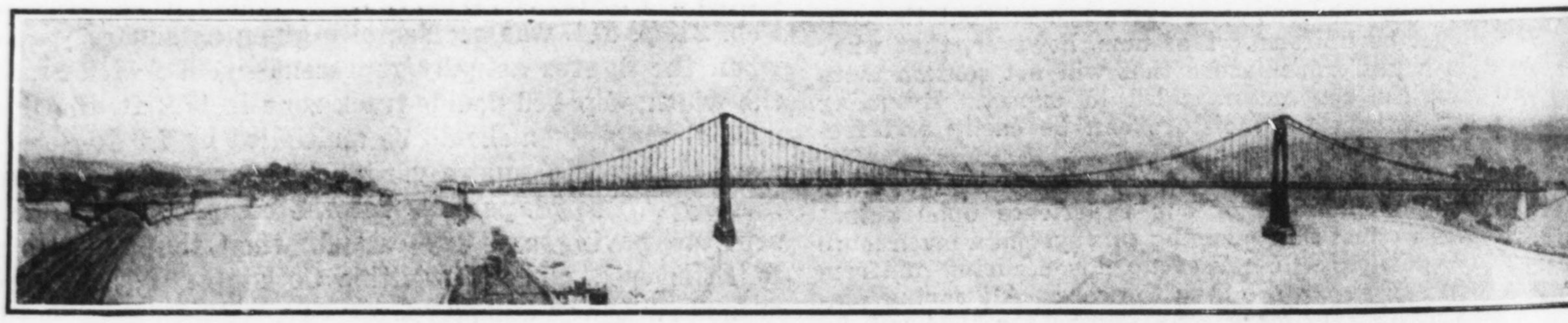


FIG. 2—SINGLE SPAN FOR MID-HUDSON BRIDGE, CHOSEN WITH REGARD TO NAVIGATION AND FOUNDATION CONDITIONS

other municipal improvements. Akron, Ohio, will spend $12,530,000 for street improvements, grade-crossing eliminations, schools and water-works. Baltimore, Md., voted $10,000,000 for port improvements and $6,000,000 for the extension of Howard St. to relieve traffic congestion.

Pennsylvania Adds Forester to Highway Department

Reduced maintenance cost and not beautification of the highways is the primary reason for the transfer of John W. Keller, formerly nursery chief in the Pennsylvania Department of Forests and Waters, to the Department of Highways as a special engineer in charge of highway forestry, according to a statement issued by the highway department. It is expected that the proper use of evergreen trees as windbreaks will eliminate many miles of costly snow fences and that proper planting along the roadway will reduce damage by wind and flood.

Large Highway Contract Awarded by Costa Rica

An American firm will build a total of 135 miles of highway in the vicinity of San Jose, Costa Rica, at a total price of approximately $3,000,000, according to the terms of a contract recently awarded the Simmons Construction Corporation, Charlotte, N. C. Work is to start immediately and is to be completed in 30 months.

Arthur S. Tuttle to Be Consulting Engineer to City of New York

Arthur S. Tuttle, for the past eight years chief engineer of the Board of Estimate and Apportionment of the city of New York, has been appointed consulting engineer to the board, a newly created position. The change has been made to relieve Mr. Tuttle of administrative duty in order that he may devote his entire time to the broader aspects of the work which the city has in hand or in prospect. H. H. Smith, the present deputy chief engineer, has been appointed acting chief engineer.

Mr. Tuttle has been in the service of the city of New York since 1902, when he was appointed principal assistant engineer and subsequently deputy chief engineer of the Board of Estimate. Previous to that time, except for two years spent in Honolulu, he was in water-supply work in Brooklyn, first as a rodman upon graduation from New York University, and then as an assistant engineer.

Mr. Tuttle at numerous times has acted in a consulting capacity on water-supply work outside of the city of New York and has been active in engineering society affairs, having served as a director and as treasurer of the American Society of Civil Engineers and as president of the Municipal Engineers of the City of New York.

Two Rail Connections Authorized in West Virginia

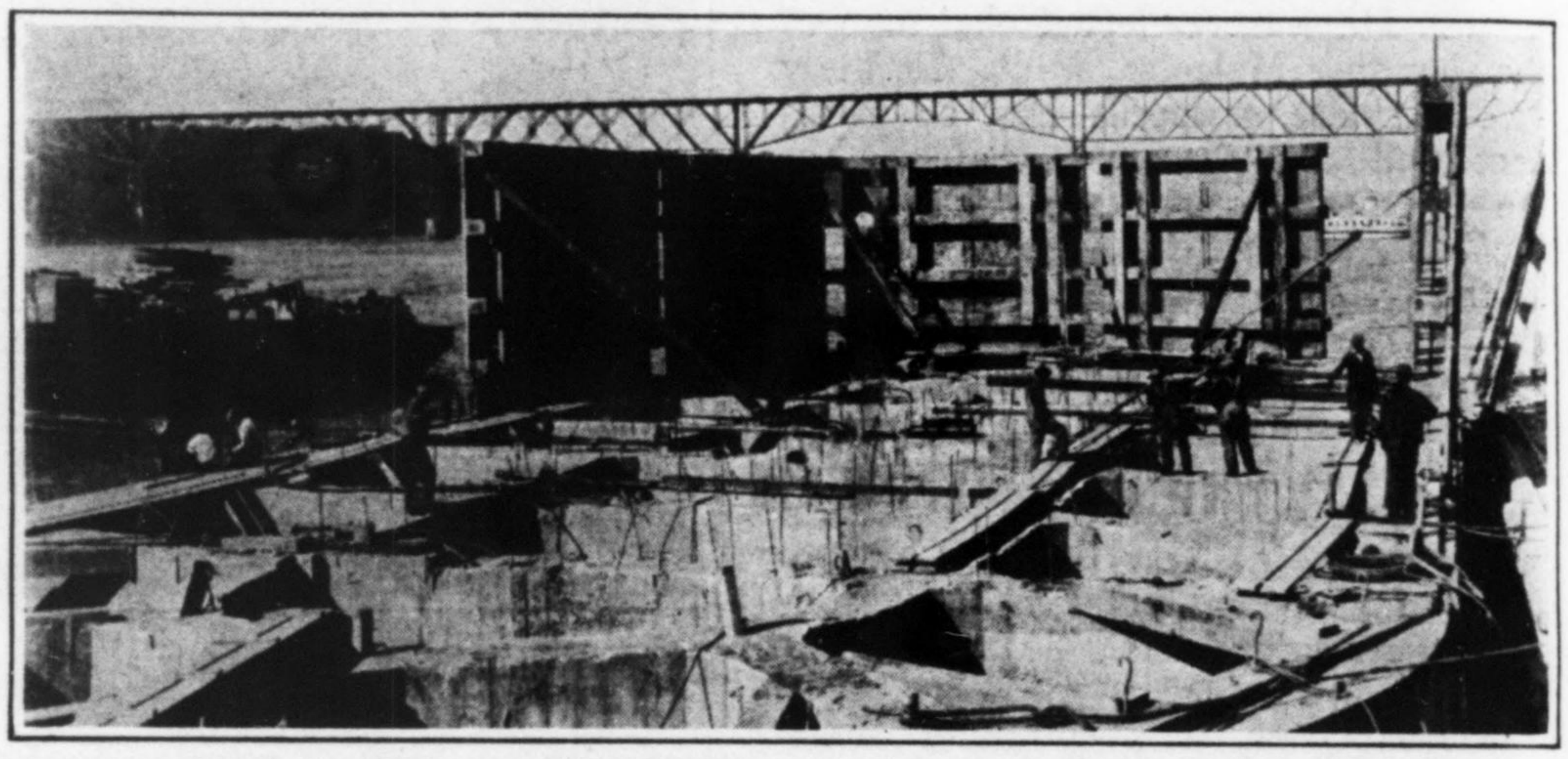
Construction of two new connecting lines in West Virginia has recently been authorized by the Interstate Commerce Commission. One of these will be built by the Nicholas, Fayette & Greenbrier Railroad from Swiss, Nicholas County, W. Va., a point on the New York Central, to a connection with the Loop & Lookout Railroad in Fayette County, a distance of 29 miles. The second road authorized will be built from Bryce to Beech Glenn, W. Va., by the Chesapeake & Ohio Railway, which is also granted trackage rights over the Kanawha & West Virginia Railroad from Beech Glenn to Swiss.

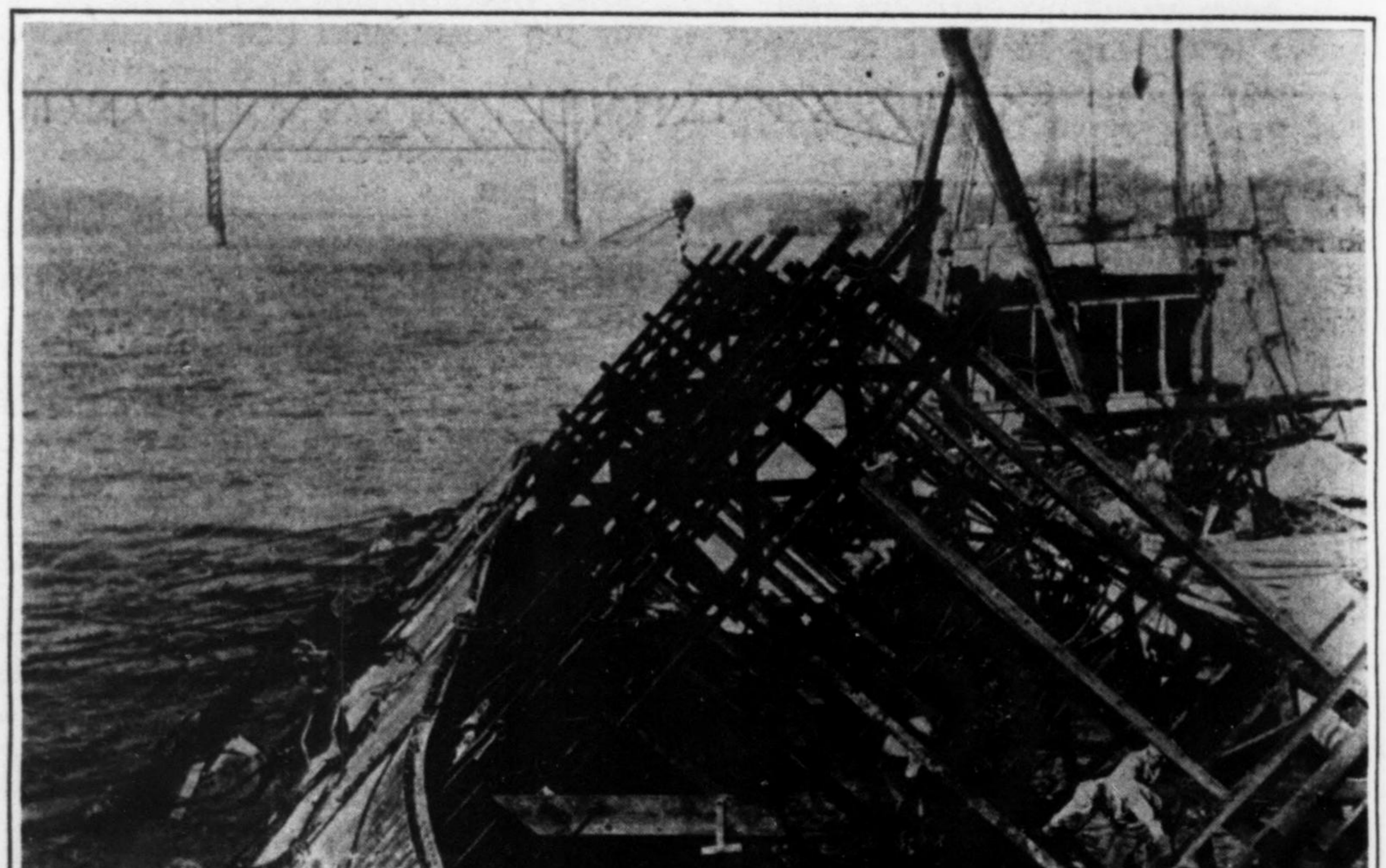
The new lines will open up a territory of approximately 230 square miles which is at present without railroad service. It is stated that this section contains many large tracts of merchantable timber and that it is underlain almost entirely by deposits of high-grade bituminous coal.

Rock Island Applies for New Extension for Subsidiary

Application has been filed with the Interstate Commerce Commission by the Chicago, Rock Island & Pacific Railway and its subsidiary, the St. Paul & Kansas City Short Line Railroad, for permission to construct a new extension from Coburn to Birmingham, Mo., a distance of 84 miles. The new line will be built to avoid congestion between Trenton and Cameron Junction, and will connect at Birmingham with the Chicago, Burlington & Quincy Railroad, affording access to the railroad of the Kansas City Terminal Company.

SUCCESSFUL RIGHTING OF MID-HUDSON BRIDGE CAISSON





Two views taken before and after the righting of the east caisson of the Mid-Hudson bridge at Poughkeepsie, N. Y., which suddenly listed a year ago when sinking had just been started. It is an open dredging caisson 60x136 ft., built to a height of about 84 ft. at the time it listed. Since then the Blakeslee-Rollins Corporation, contractor for the piers, has been working energetically to right it. As the upper picture shows, this difficult task has been successfully accomplished, and the caisson is now being built up preparatory to sinking to final depth. The cutting edge is to go to 135 ft. below water; it is now down about 110 ft.

Erection of 276-Ft. Towers for Mid-Hudson Suspension Bridge at Poughkeepsie

Lower Steel Placed and Traveler Assembled by Derrick Boat—Creeper Traveler Handles 45-Ton Column Sections—Steel Fabricated for Minimum of Field Riveting

By John T. Martin
Field Engineer, American Bridge Co.

NOTABLE FEATURES in the erection of the two towers of the Mid-Hudson suspension bridge recently opened between Poughkeepsie and Highland, N. Y., were: the rearrangement of shop riveting and the fabrication of large column sections to minimize the amount of field riveting; the design of a traveler with sufficient capacity to handle 45-ton sections, yet light enough to be easily moved; and the use of the traveler for work subsequent to the tower erection. The suspension bridge is a highway structure with a 1,495-ft. center span and suspended side spans of 750 and 755 ft. respectively. Each of the two cables, 16¾ in. in diameter, is made up of nineteen strands of 320 wires—a total of 6,080 wires per cable.

The stiffening structure is of the through-truss type, carrying a 30-ft. roadway and two 4½-ft. sidewalks. The towers are 276.45 ft. high, measured from top of pier, (El. 35) to bottom of saddle casting (El. 311.45) For lateral stability the two legs of each tower, which are composed of plates and angles riveted together to form a closed cross-section, are crossbraced above and below the roadway level.

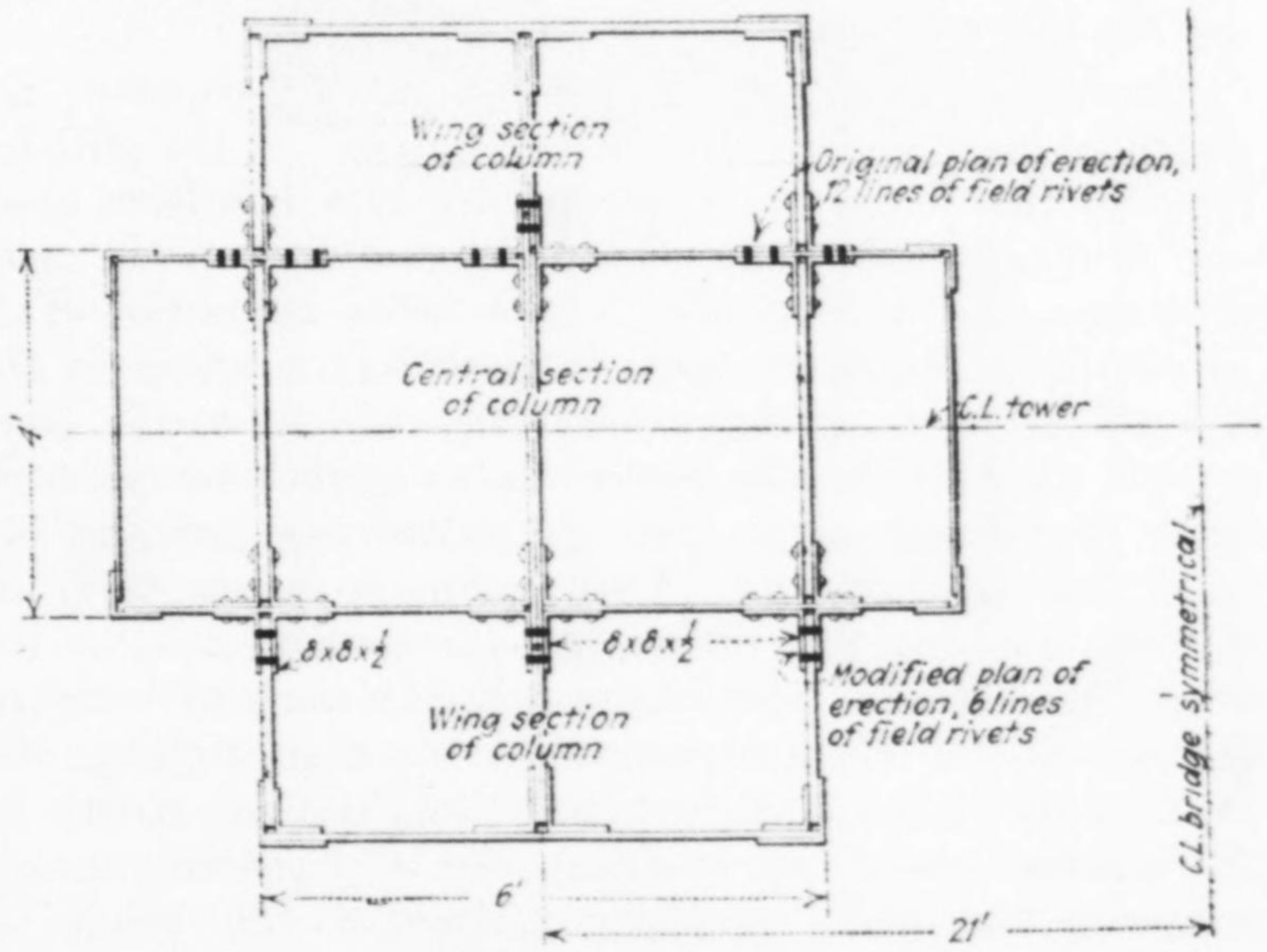


FIG. 2—CROSS-SECTION OF TOWER LEG
Showing how original plan of twelve lines of field rivets in each wing section was modified to six lines of field rivets.

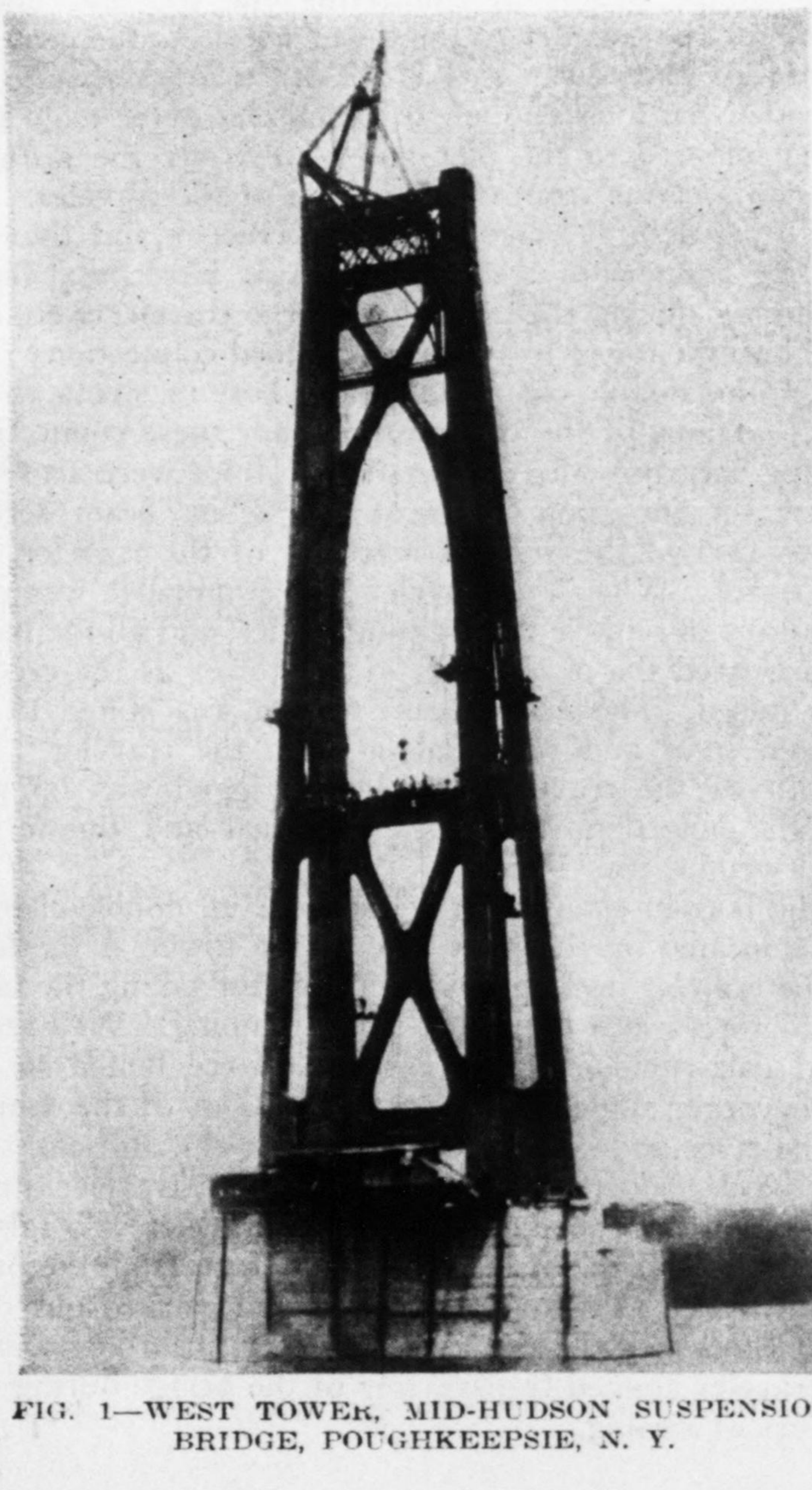


FIG. 1—WEST TOWER, MID-HUDSON SUSPENSION BRIDGE, POUGHKEEPSIE, N. Y.

The erection equipment for each tower consisted of an A-frame derrick supported on a steel framework which was bolted to the towers at different heights as the erection proceeded. The traveler was located on the shore side of the tower in each case, in order to help, in a measure, the temporary deflection of the towers toward the shore—required in order that they would assume proper relation to the vertical when the full dead-load was on the bridge.

The largest sections of column erected by the travelers were 32 ft. long and weighed 45 tons. These formed the sixth section of main column above the pier level. This feature and a change in the original detail, by which the three pairs of angles forming the vertical splice between the central and wing sections of column were shop-riveted to the central section with ⅛-in. clearance for entering the three webs of the wing sections, resulted in a saving in the number of field rivets as can be seen in Fig. 2. There were only 25 field rivets per ton of steel.

Both towers are located several hundred feet from the respective shores, which suggested derrick-boat erection of the base sections, the lower sections of column and the creeper travelers. The fact that the heaviest sections of base weighed 50 tons and that a column section with upper splice at 96 ft. above mean low water had to be erected before the creeper underframe could be bolted to the tower in its first position necessitated the use of a heavy derrick boat. The "Colossus" of the Merritt-Chapman & Scott Corp., having a boom 120 ft. long and a lifting capacity of 90 tons, was used for this portion of the work. The derrick boat erected approximately 600 tons of steel in each tower, in addition to the creeper traveler and an engine platform. It also placed the hoisting engines on the platform. The traveler and its supporting framework were assembled in sections on the deck of the lighter so that the number of lifts required to place it on the tower in its first position was reduced to a minimum.

All steel was transported by barge from Greenville Piers, N. J., 5 miles from the bridge site, where it had been in storage since the summer of 1927. The tipping of the caisson of the east tower foundation in July of that year delayed the start of erection of the towers about a year and a half (see *Engineering News-Record,* August 4, 1927, p. 194), so that work was not actually begun until April 22, 1929.

Traveler Design—In the design of the traveler, the A-frame type of derrick was used instead of the stiff-leg type for two reasons: If the stiff-leg type had been used, one stiff-leg would have been in tension and one in compression while setting most of the tower members. This would have produced opposite bending stresses in the two tower legs at the same time, which would have caused warping in the tower and would have possibly made it difficult to connect the transverse bracing between the tower legs. Using the A-frame type of traveler avoided this difficulty. The second reason for using the A-frame type of derrick was that, with minor alterations, the A-frame assembly, the rear stiff-leg, the front cross-girder and the center longitudinal girder of the traveler used in erecting the Carquinez Straits bridge in California could be adapted to the design of the traveler for the Mid-Hudson bridge. Practically the only new material required was the supporting underframe.

The foot of boom was placed 15 ft. $4\frac{1}{2}$ in. from the transverse center line of the tower. This provided clearance between the A-frame legs and the boom when the wing sections of the column nearest the A-frame were set. The spread of the A-frame legs was 31 ft. 9 in., permit-

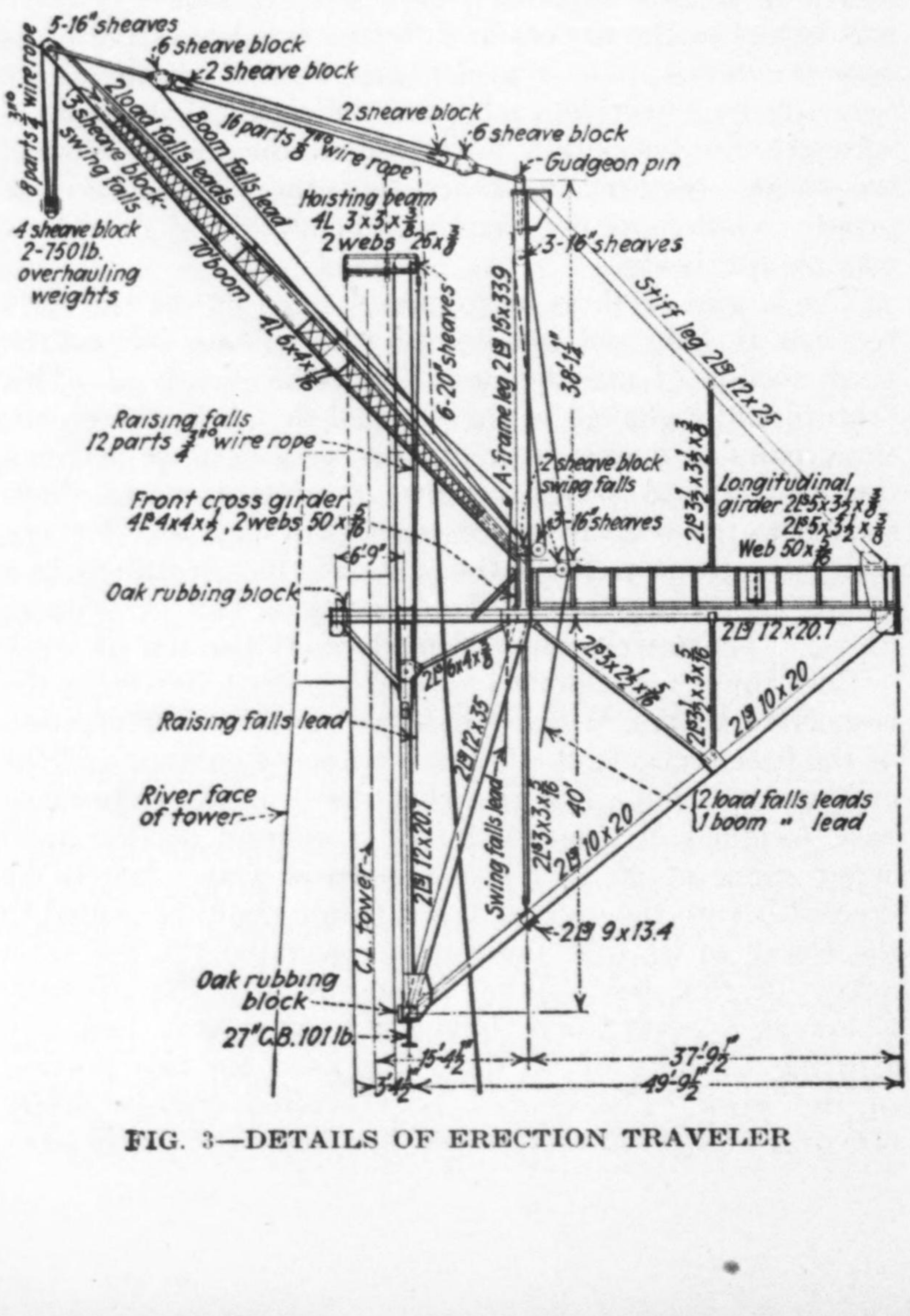


FIG. 3—DETAILS OF ERECTION TRAVELER

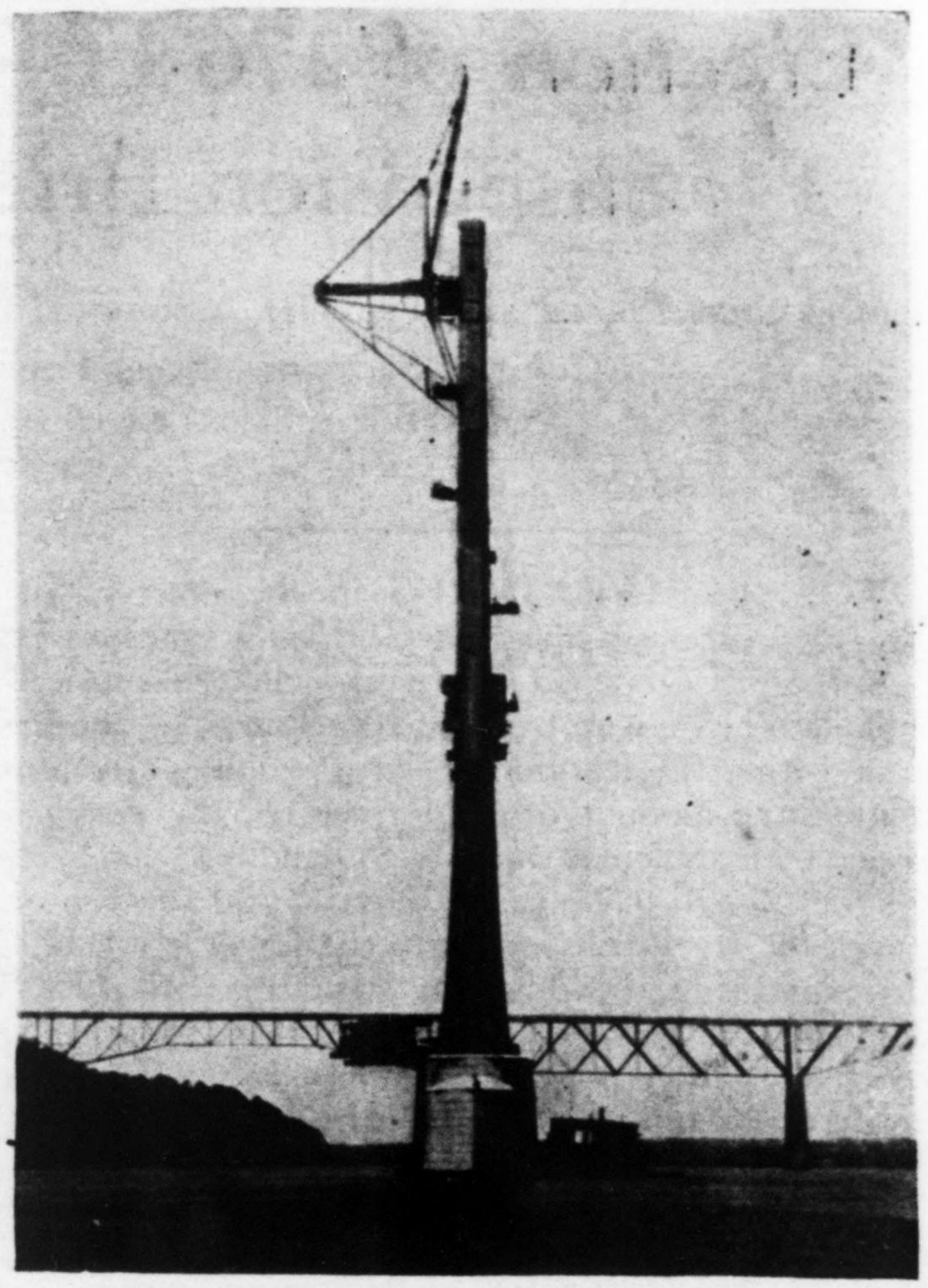


FIG. 4—SIDE VIEW OF WEST TOWER, ERECTION COMPLETE

ting simple details in connecting the top and bottom struts of the traveler to the tower legs. As the center to center of the tower legs is 42 ft., a 70-ft. boom was found to be long enough to reach the outer edge of a barge moored to the pier and also to set the different column sections from each position of the traveler.

The structural make-up of the creeper and the supporting framework is shown in Fig. 3. Horizontal forces occurring during the operation of the traveler were carried into the tower by means of framed connections from the 15-in. double-channel top and bottom struts to the wing sections of the column, holes for these connections having been provided in the shop. Holes were also provided for the connections of the 27-in. beam section which carried the vertical reactions of the traveler into the tower. When the traveler was jumped it was only necessary to remove the framing angles, and all the members cleared the rivet heads of the tower as the creeper was raised. The 27-in. beam section was bolted to the bottom strut and raised along with the traveler. The weight of the traveler completely rigged was 63 tons and the deflection of the towers toward land, due to this dead weight, was $1\frac{1}{2}$ in.

The bottom channel strut and a 12-in. double-channel strut, located on the river side of the tower at the level of the traveler deck, provided means for taking the horizontal forces into the tower when jumping. Well-lubricated oak rubbing strips, $2\frac{1}{2}$x6 in., were bolted to the inside corner angles of the central sections of the column on the river and shore faces of the towers, and oak rubbing blocks bolted to the top and bottom traveler struts tracked on the rubbing strips as the traveler was raised. The use of the oak strips was a departure from the ordinary practice of using steel rollers and worked out very well. Steel rollers were used, however, in order to keep the traveler aligned transversely of the bridge during the process of raising.

Two sets of falls, each composed of twelve parts of $\frac{3}{4}$-in. wire rope, were used in raising the traveler. The top blocks were built into two hoisting beams bolted to the top splice of the last central section of column erected previous to the jumping. The lower blocks were built into the two vertical posts of the supporting underframe. It required only six hours to disconnect the traveler from one position, raise it, and complete bolting it to the tower in its next position ready to set steel. The traveler was raised seven times.

A two-drum, 80-hp. electric hoist was used in operating the two sets of raising falls, and a three-drum, 175-hp. electric hoist was used in operating the lead line and the becket end of the load falls and the lead line of the boom falls. These hoists were located on an engine platform, supported by four 30-in. beam sections 50 ft. long, cantilevered over the edge of the pier. The upward reaction at the pier end of the beams was resisted by two 24-in. I-beams framed between the bases of the tower columns. The electric motors on the hoists were of the alternating current type, 60-cycle, 3-phase current being supplied by means of submarine cables from the east and west shores to the respective piers.

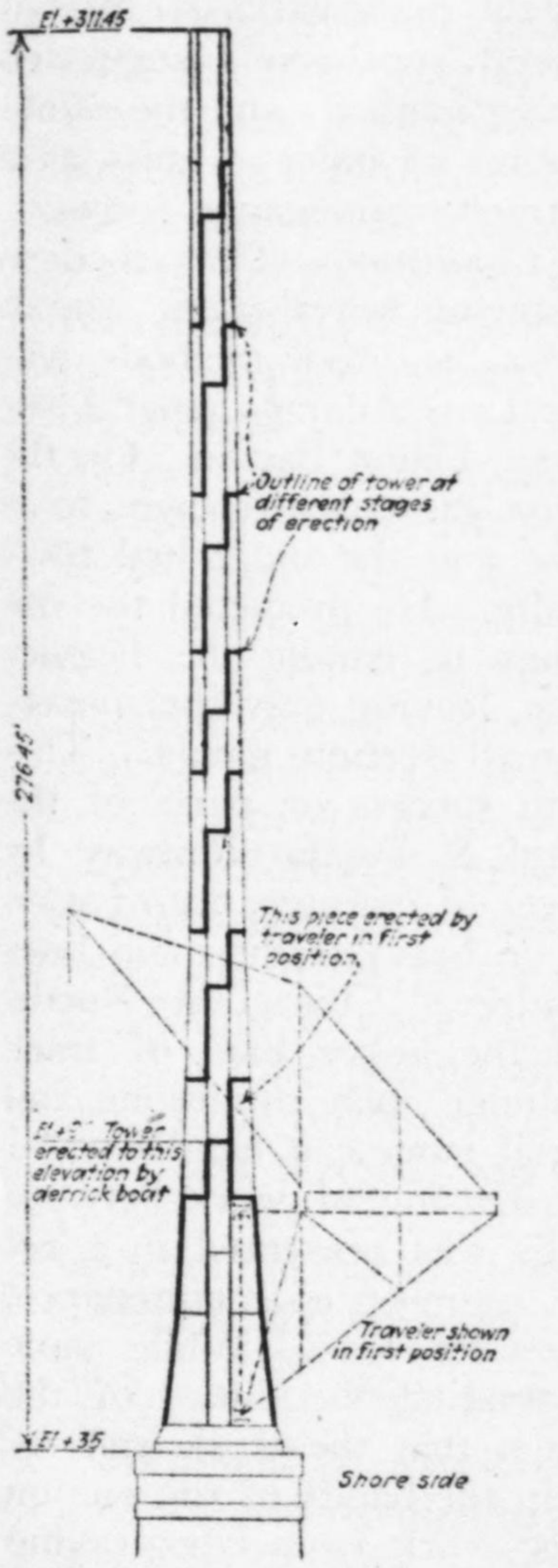


FIG. 5 — ELEVATION OF TOWER, SHOWING OUTLINE AT DIFFERENT ERECTION STAGES

Erection Procedure—The heavy lines in Fig. 5 show the outline of the towers at the completion of different stages of erection. The traveler is shown in its first erected position as placed by the derrick boat. From this position only one section of column was erected in each tower leg. From the other positions the traveler erected three sections in each tower leg, in addition to pieces of batter column and bracing as the work proceeded. The bracing had to be set after the traveler deck got above the space to be occupied by that particular bracing, on account of the sway rods of the traveler lying between the tower legs at the level of the traveler deck. When the traveler reached its last position, the 12-in. double-channel strut on the river face of the tower was removed in order to provide space for the erection of the tower bracing at the top.

The travelers were left in their last position where they played an important part in erecting the footwalk ropes, the footwalk panels, and the steel gallows frames for the cable spinning. They were also used to take down this temporary equipment, to erect the first three panels of stiffening truss on the river side of the towers, to assemble both the middle and side-span deck travelers, and to aid in erecting the suspender ropes. After the shore-span travelers reached the land and could no longer pick the stiffening truss steel from barges, the tower travelers hoisted this steel to the roadway level at the towers, and truss members were run out to the deck

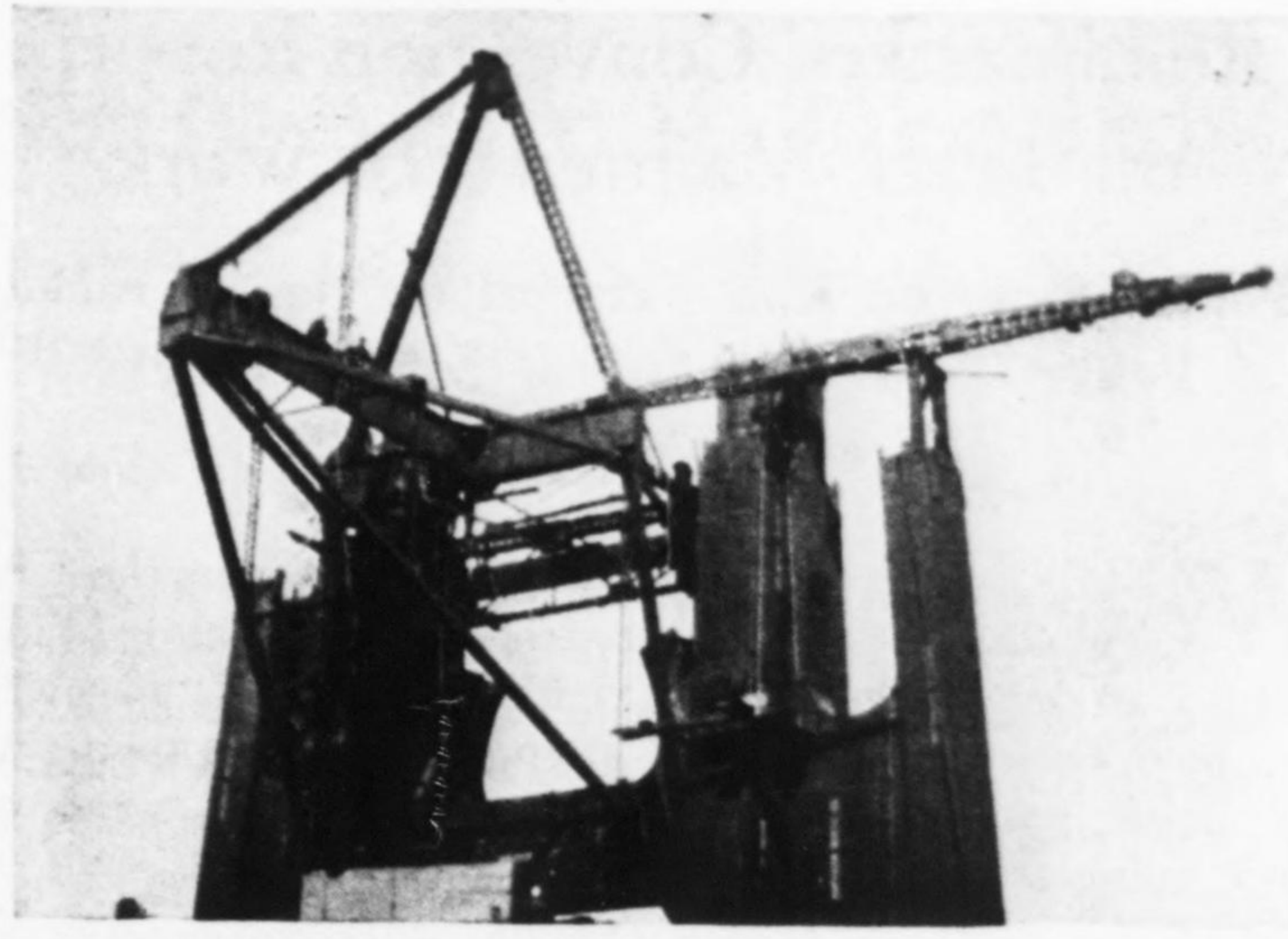


FIG. 6—TRAVELER ERECTED COMPLETE EXCEPT FOR REEVING UP

traveler on push cars. As a last operation, the deck travelers were dismantled by the tower travelers.

Riveting—The rivets were 1 in. in the main column sections and $\frac{7}{8}$ in. in the batter sections and bracing. Riveting and fitting up were done from steel scaffolds. The heaters were located on the scaffolds, except at the first few splices above the piers and at points where there were communicating manholes between the different compartments of the tower. These manholes were located at the bottom of the tower, at the roadway level, at the lower end of the upper crossbracing and at the top. At these points rivets were dropped from one level to another through 3-in. flexible metal tubing. The scaffolds were moved from point to point by the tower traveler. Two scaffolds on the east tower were suspended from the tower top by means of wire hoisting rope leading to the two-drum electric hoist after the traveler had been raised to its last position. Two other scaffolds were hung from the stiffening truss tower brackets by means of $1\frac{1}{2}$-in. manila lines leading to spools on the hoisting engine. This increased the mobility of the scaffolds and effected a saving of time in moving from one point to another. Riveting was not begun until practically all the tower steel was in place. This was done in order to eliminate the hazard of working the riveting gangs beneath the raising gangs.

The total number of field rivets in one tower was 52,000. Of these 48,000 were 1-in. and 4,000 were $\frac{7}{8}$-in. The average number of rivets driven per gang per day was 200.

Time of Erection—The erection of the west tower was begun April 22 and was completed July 3, 1929. The east pier was completed June 8. Erection of steel on the east tower was begun June 13 and was completed Aug. 19. Of the 2,000 tons of steel in each tower, approximately 600 tons were erected by derrick boat and 1,400 tons by traveler.

Organization—The bridge was built as a toll structure by the state of New York under the direction of Col. Frederick Stuart Greene, superintendent of the department of public works. Modjeski and Moran were the consulting engineers for the state with C. W. Hanson as resident engineer. The American Bridge Co. was the general contractor for the superstructure and the completion of the anchorages. The towers were fabricated at the Ambridge plant of the company and were erected by the Eastern division erecting department; J. B. Gemberling, manager; H. H. Starr, assistant engineer, in charge; W. James Ward, superintendent; and the writer as field engineer.