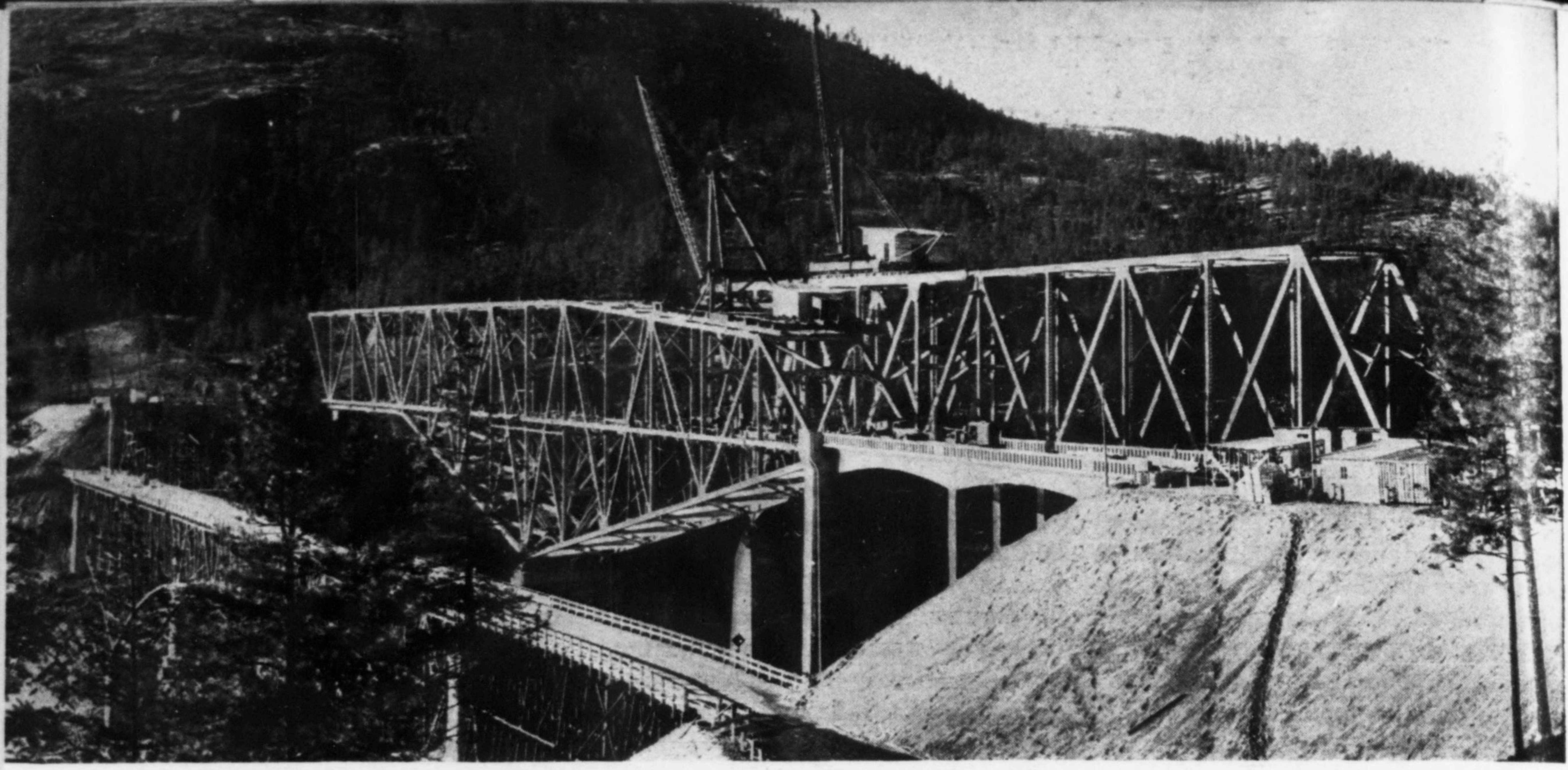

Fig. 1. New railroad bridge at right and new highway crossing in center with old highway span at lower level.

An Unusual Railway Cantilever Bridge

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Contents in Brief—*First described are the various studies carried out by the Bureau of Reclamation to determine the best type of bridge to carry the Great Northern Ry. across the Columbia River in Washington. This is followed by design and construction details for the cantilever bridge decided upon, which is unusual in that the center span is fixed while each end span is made up of a cantilever arm and a suspended span.*

Construction of Grand Coulee Dam in Washington, with its resulting reservoir, made necessary the relocation of State Highway No. 3 and the Republic branch line of the Great Northern Ry. where they cross the Columbia River. The existing crossings, the railway bridge at the town of Marcus and a few miles downstream, the highway bridge at the rapids known as Kettle Falls, were made unsuitable for use with the higher water elevations of the Grand Coulee reservoir. Investigations for new crossings at higher elevations showed the most suitable site to be at the existing Kettle Falls Bridge.

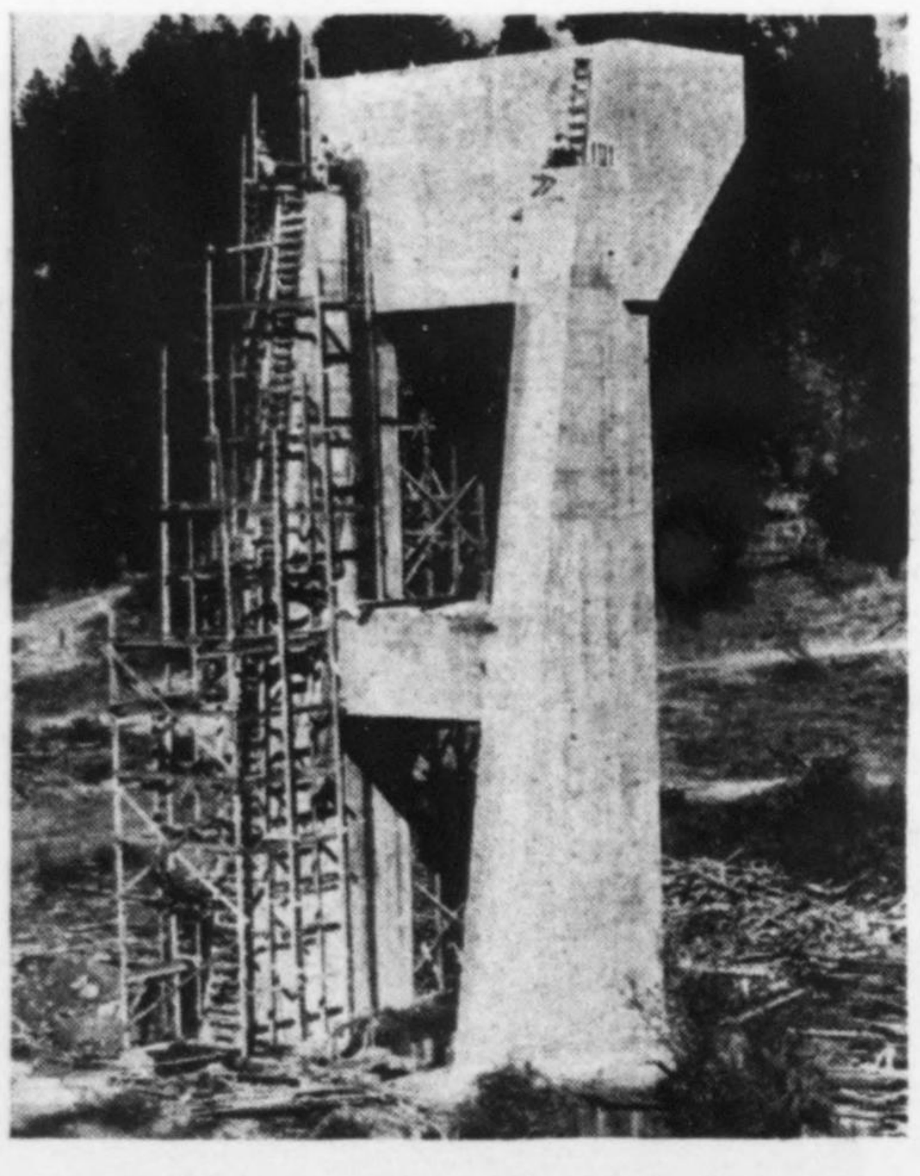


Fig. 2. Abutment 1 complete except for concrete surface finishing, which is in progress. The greater part of the abutment will be embedded in an earth-fill.

To raise the existing highway bridge, which was a deck structure with the truss depth at the piers 90 ft., sufficiently to clear the reservoir water surface would have placed the roadway 40 ft. higher than a new crossing. The longer and higher approach spans and embankments thus required, as well as facilities for maintaining traffic during construction, made uneconomical the raising of the old highway bridge. Therefore, the problem resolved itself into providing a new crossing for both highway and railway traffic.

Problems of joint ownership

When studies were made by the Bureau of Reclamation to determine whether a combined structure or separate crossings would be best, factors considered were: (1) economy; (2) completion of the work within a relatively short time, so as to avoid delays in construction of Grand Coulee Dam; (3) possible negotiation of a contract between the State of Washington and the Great Northern covering future ownership and maintenance for a combined bridge; and (4) objections of the Washington State Highway Department to a combined highway and railroad bridge.

Although the studies showed a combined crossing to be more economical than two separate structures, it was decided that a railroad bridge should be built by the Bureau of Reclamation and a separate highway span by the state highway department. In this way the difficulty of negotiating a joint contract of ownership was avoided, and the construction program was greatly expedited. The new railway cantilever bridge is unusual and its design and construction will be described in detail in the following paragraphs.

During the spring flood stage the river at Kettle Falls is a fast-flowing stream approximately 425 ft. wide and 100 ft. deep. Granite banks rise steeply to about 40 ft. above the water surface and provide an excellent pier foundation. It is anticipated that future navigation will require a vertical clearance of 45.5 ft. between the reservoir water surface and the lowest steel of the central span. Likewise an allowance of 8 ft. for the railroad floor system was made in determining the lowest possible elevation of the track.

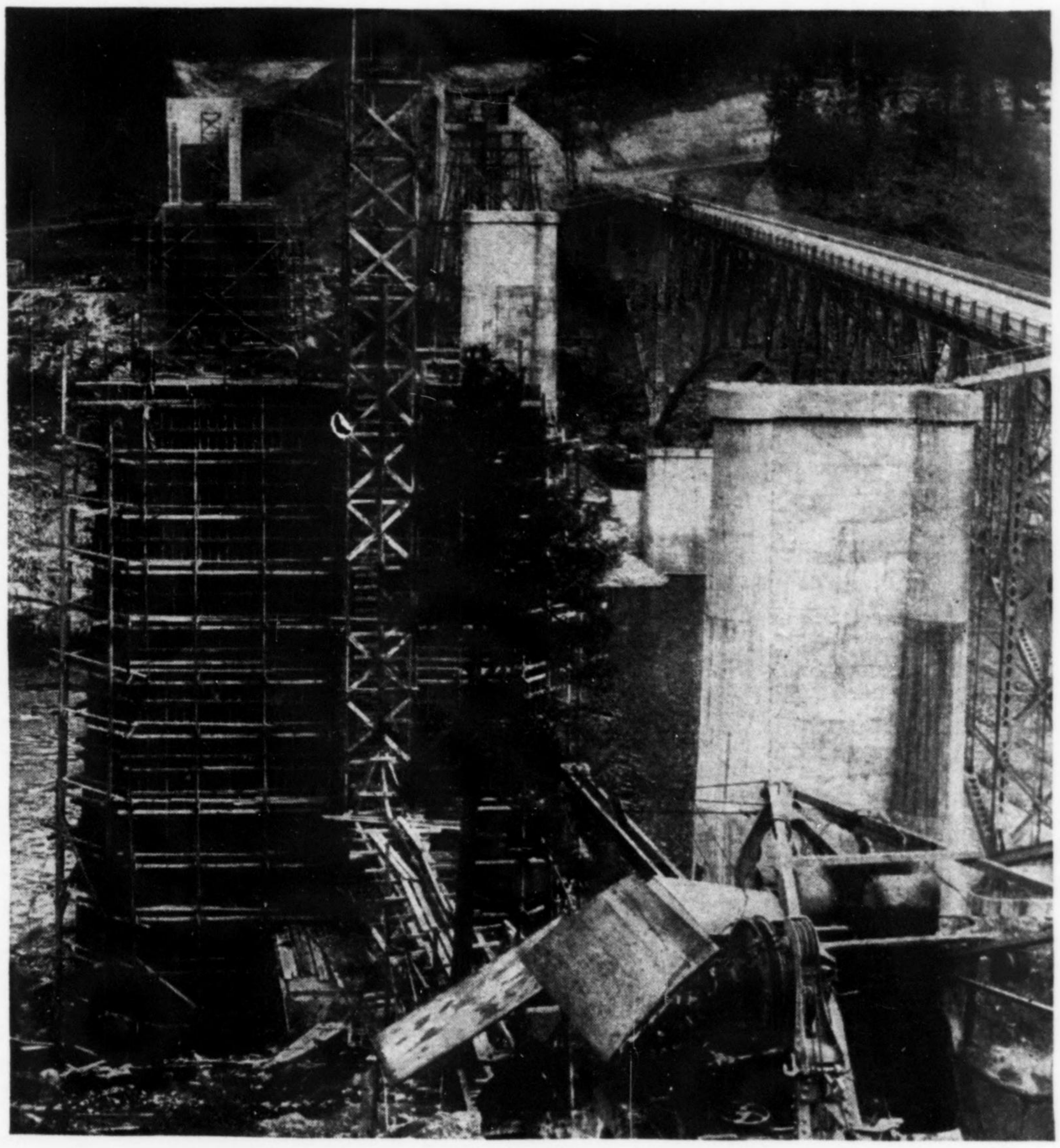


Fig. 3. Old Kettle Falls highway bridge, which will be abandoned, is shown at right. Completed piers and abutments for the new highway crossing are in the center, while at left construction is in progress on railroad bridge piers.

Determining central span length

As the length of the span crossing the stream would have a major influence on the structure's total cost, the length of this span was, therefore, held to a minimum. After a careful study of the profile, topography, and geology, the piers were located as near the stream bank as was deemed advisable or the length of the span crossing the river established at approximately 600 ft.

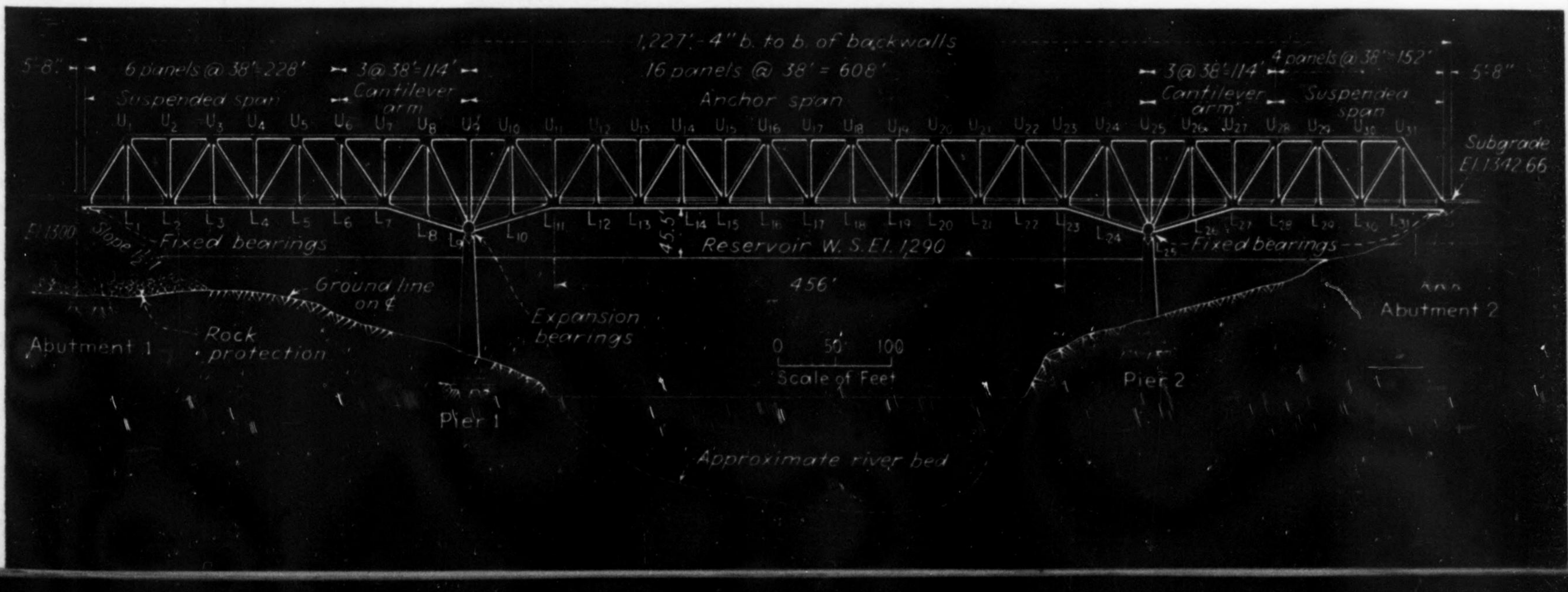
The bridge's height above the river bed and the stream's depth and velocity made the use of erection falsework impracticable. Since a cantilever bridge, more than any other type, can generally be readily and economically erected without the use of falsework, this type of structure was chosen.

After the type of structure and center-span length were determined, various economic studies were made in which the length of the side or anchor spans were varied. First, anchor spans of medium length, to extend from the piers to the approach embankment were investigated, but it was found that for such spans under passage of live load a reversal of stress would occur at the end bearings. As past experiences with railroad bridge bearings under similar conditions have not been satisfactory, anchor spans of medium length were considered undesirable. (On the highway bridge, reversal of stress at the end bearings of medium-length anchor spans did not occur and the conventional type cantilever structure appeared suitable.)

Unusual cantilever selected

As part of the railway bridge studies, side spans where reversal of stress would not occur were considered and short spans were found to cost considerably less than long spans, as the approach embankment could be con-

Fig. 4. Unusual design for railroad bridge in which center span is fixed and suspended spans are at the ends.



structed cheaply. However, the more economical short anchor spans required three girder approach spans between the anchor span and the end of the embankment to keep the embankment's toe at a safe distance from the steeper river banks. Such a structure, consisting of truss spans and girder spans, seemed to lack continuity of design and appearance; and it was felt that trusses, in place of girders, should be used throughout the side spans. Further studies revealed that by placing the suspended spans at the ends and making the river or main span the anchor span of the cantilever structure, trusses could be used for the side spans and stress reversal at the end bearings avoided. Thus, this rather unusual arrangement seemed to be the most desirable design from the standpoint of maintenance, economy and appearance.

The bridge decided upon (Fig. 4) has a 608-ft. center span, a 114-ft. cantilever arm extending landward from each of the two main piers and then ends with a 152-ft. suspended span at the west end and a 228-ft. suspended span at the east end. Trusses are 30 ft. center to center and a 22-ft. minimum clearance between top of rail and lowest steel of the portal and sway bracing was required.

In preparing the design it was realized that the method of erection would be a determining factor for a number of the truss members. If erection stresses were not considered in the design at the start they would involve changes in design and details at a later date, and would consequently cause delays in fabrication and construction. Therefore, erection stresses were calculated, and proper allowance was made for these throughout the bridge as the design advanced. This procedure proved to be very satisfactory, as the contractor's method of erection required only minor changes in details for the jacking devices.

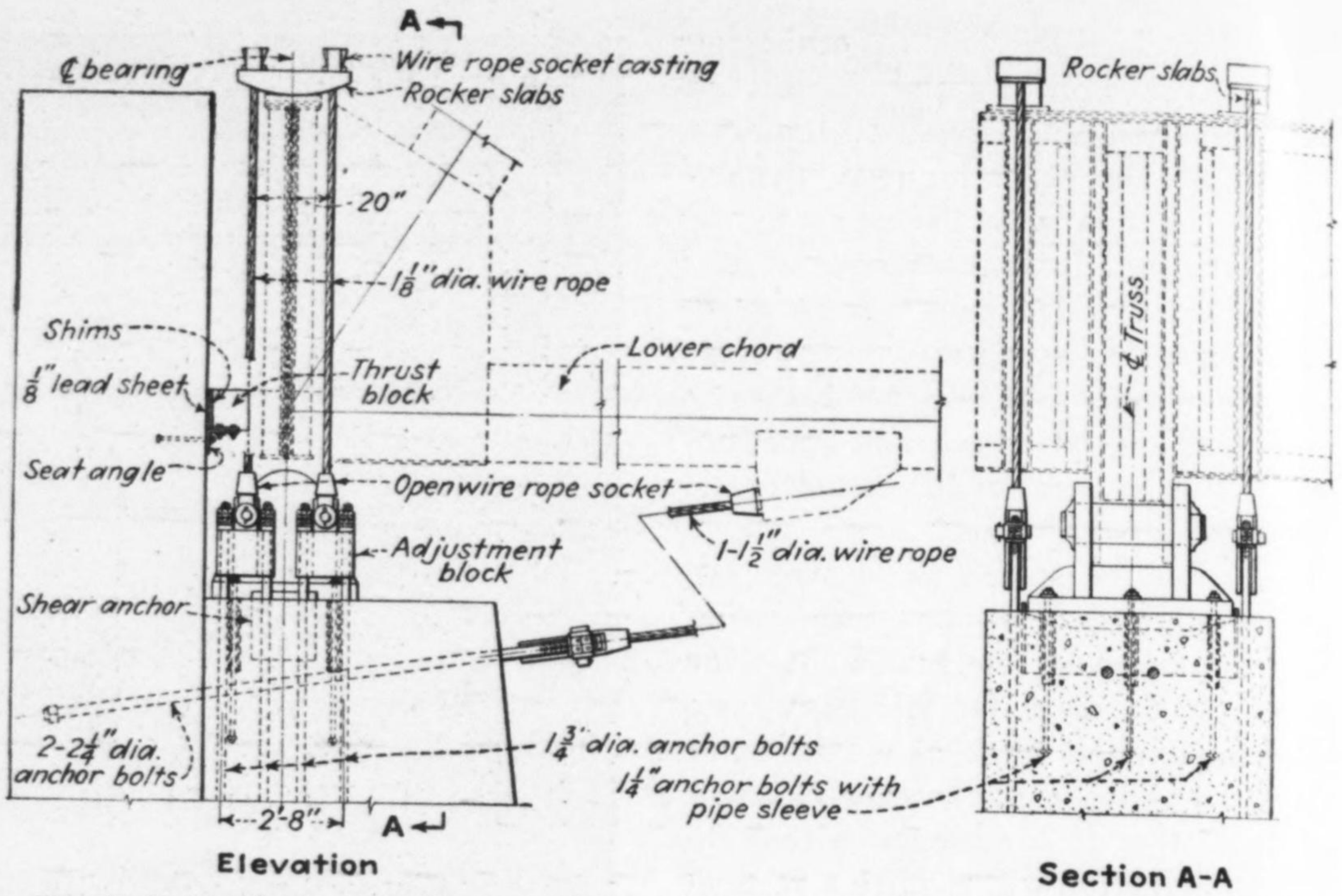


Fig. 5. Uplift during erection required anchors at Abutment 1. At Abutment 2 the thrust blocks, seat angles, and ties to the bottom chord are not required.

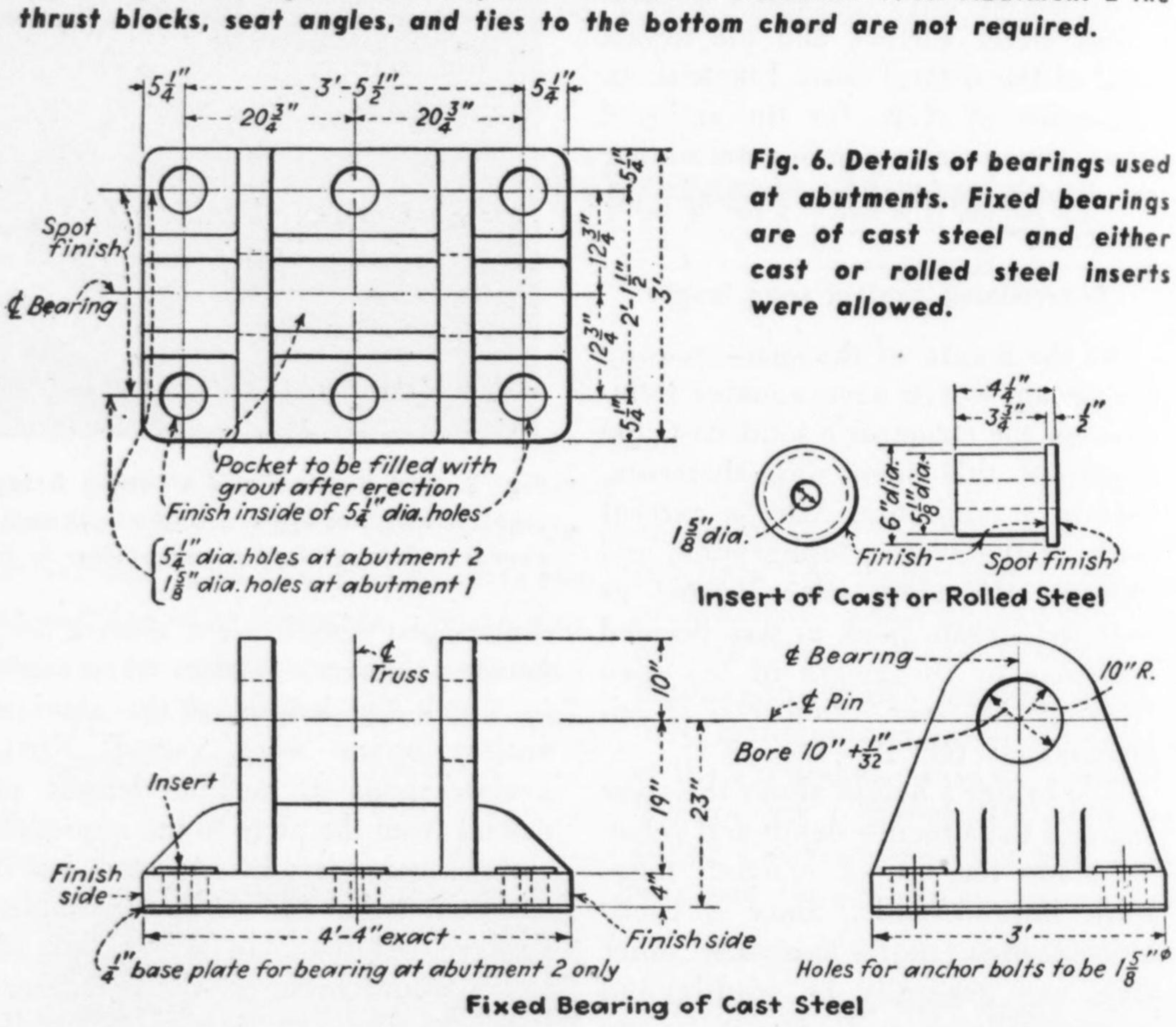


Fig. 6. Details of bearings used at abutments. Fixed bearings are of cast steel and either cast or rolled steel inserts were allowed.

Erection procedure

The erection procedure was essentially as follows: Steel in the two side spans was supported by falsework until the bearings at Piers 1 and 2 (Fig. 4) were placed. This falsework was then removed and steel in the center span cantilevered from each pier until closure at the center was complete. After closing the main span, jacks in the idle members U_5–U_6, L_6–L_7, U_{28}–U_{29}, and L_{27}–L_{28} were removed and the structure attained its final position.

At Abutment 2, the bearings remained fixed until the fixed bearings at Pier 2 had been placed, after which the bearings on the abutments functioned as expansion bearings. This was accomplished by removing the steel inserts that fitted into the oversized anchor bolt holes of the abutment bearing (Fig. 6), thus permitting longitudinal movements due to temperature changes and jacking operations during the center span's erection. Steel plates were embedded in the abutment along the sides of the bearings to take any lateral thrust without preventing longitudinal movement.

During the latter stages of erection it was necessary to restrain the bearings at each abutment against uplift by using wire rope ties between the end floorbeam and the abutment (Fig. 5). The length of these ties at Abutment 2 was adjusted so that the bottom of the bearings would raise a small distance off the abutment and eliminate any frictional resistance against longitudinal movements. A rocker and plate bearing on the end floorbeam's top flange transferred the uplift of the truss to the wire rope ties, which were connected at their lower ends through adjustment blocks to special anchor bolts in the abutment. Wire rope ties were used because they are sufficiently flexible to permit longitudinal movement without undue overstress. After the center span had been closed, the suspended span was moved until the steel inserts could again be put in place and the bearings at Abutment 2 were fixed in their final positions.

At Abutment 1 the bearings remained fixed throughout the entire erection procedure. This was made possible by the use of the expansion bearings at Pier 1, and steel inserts, as used on Abutment 2, were unnecessary. Further, the bearings were fixed against longitudinal movement by using a thrust block between the back wall of the abutment and the end of the truss, and by a wire rope tie from the abutment to the bottom chord.

The piers and abutments were constructed by A. A. Prendergast & Associates and Industrial Contracting Co., Minneapolis, Minn. The steel was fabricated and erected by the American Bridge Co. The plans and designs were prepared in the Denver office of the Bureau of Reclamation under the direction of R. Sailer, bridge engineer, and the supervision of H. R. McBirney, principal senior engineer of canals, and J. L. Savage, chief designing engineer. Construction of the bridge was supervised by Field Engineer A. J. Thomas under the direction of F. A. Banks, supervising engineer, Columbia Basin Project. All activities for the Bureau are under the direction of S. O. Harper, chief engineer, and John C. Page, commissioner.

Moving a 200-ton Dredge Overland To the New Panama Canal Lock Site

PICKED UP BODILY and placed on shore, then skidded 1,800 ft. overland into an artificial pool, to begin excavating for the additional locks for the Panama Canal, the 22-in. hydraulic dredge *Grand Lake* recently completed a long trip begun weeks ago near Kansas City, Mo.

Towed to New Orleans, the dredge was stripped of its machinery and provided with a superstructure for its ocean trip to the Canal Zone. Upon arrival at the Isthmus, the dredge was moored along the canal bank while the superstructure was removed. Then the 100x35-ft. hull, weighing 220 tons, was picked up by the floating crane *Ajax* and placed on a skidway. Sliding on two timber ways, the dredge was slowly moved overland, crossing a highway and three railroad tracks (see illustration), including the main line of the Panama Railroad. Motive power was supplied by a tractor, using cables and blocks.

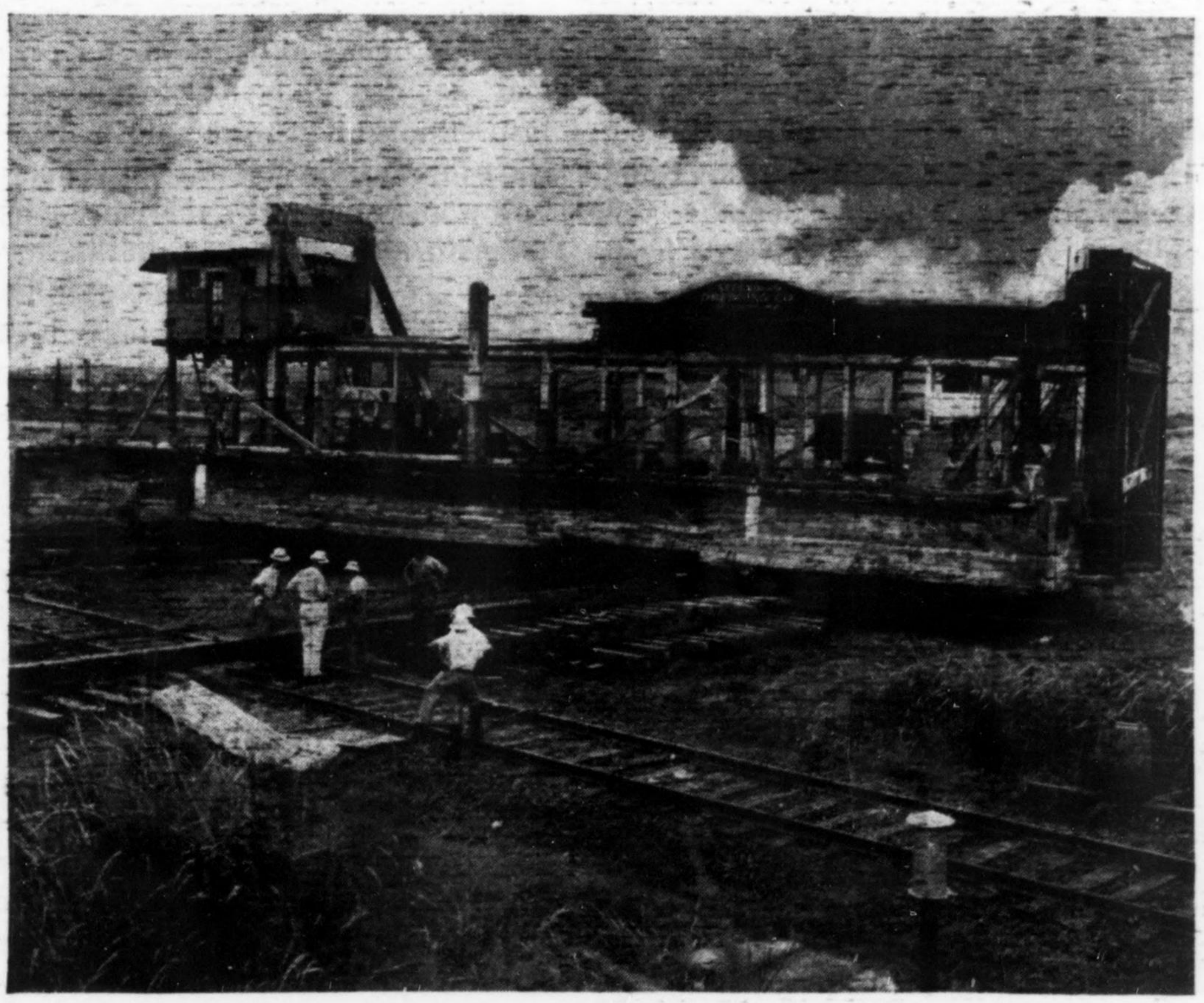
About Sept. 1, the dredge was floated into the pool and its machinery re-installed, for the removal of about 2,000,000 cu.yd. of material at the north end of the new Gatun Locks site. As the pool is not yet connected with a waterway, water is being supplied from the canal through a 2,000-ft., 22-in. pipe, fed by two 16-in. pumps, each driven by a 250-hp. motor. To permit dredging to the required 65-ft. depth, the pool surface will gradually be lowered as excavation progresses. The final use of the dredge will be to unwater the pool, in order that hard material that underlies the muck may be excavated and the locks built in the dry.

The Sternberg Dredging Co. of St. Louis, Mo., owner of the *Grand Lake*, has subcontracted for the dredging from Martin Wunderlich Co. and Okes Construction Co., principal contractors for excavation of the new Gatun Locks site. Of the 12,000,000 cu. yd. of excavation required by the basic contract, approximately 2,400,000 yd. had been removed by Aug. 1.

To lift and transport the material to the spoil areas, which will be up to a maximum distance of about 10,000 ft. from the cut, the *Grand Lake's* 1,200-hp. pump will be supplemented by a 1,000-hp. fixed land booster pump. In order that 25-cycle Canal Zone power may be used by the 60-cycle dredge machinery, a frequency changer had to be installed.

Operations of the prime contractors are supervised by Martin Wunderlich and Day Okes. H. J. Sternberg personally supervised the moving of the *Grand Lake*, aided by Harry Gray and Roy F. Keller.

Col. T. B. Larkin, Corps of Engineers, is supervising engineer in charge of this project of the Panama Canal; Lt. Col. Hans Kramer is construction engineer; and E. B. Fontaine is area engineer in immediate charge of work in the Atlantic area.



The Week In Engineering and Construction

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Order halting non-essential construction drafted by WPB

Residential construction under $1,000 and other work under $25,000 exempted. No dearth of construction activity seen as officials seek means of speeding tempo.

The long-expected, constantly postponed stop-order on non-essential construction will probably be issued this week. Issuance of the order has been directed by top WPB officials, but questions of language are still in dispute, however, and this might again delay its issuance. Already drafted, it will forbid initiation of any construction project which does not carry a priority rating.

However, the order will exempt residential construction costing less than $1,000 and non-residential construction costing less than $25,000. It is over these exemptions that dispute still rages. The exemptions are supported, in general, by the production division of WPB but are opposed by important officials in the division of industry operations—priorities—who feel that any such exemption would be an invitation to evasion. By splitting projects and by making deliberately low advance estimates of cost, altogether too many jobs could be brought in under such exemptions, it is felt.

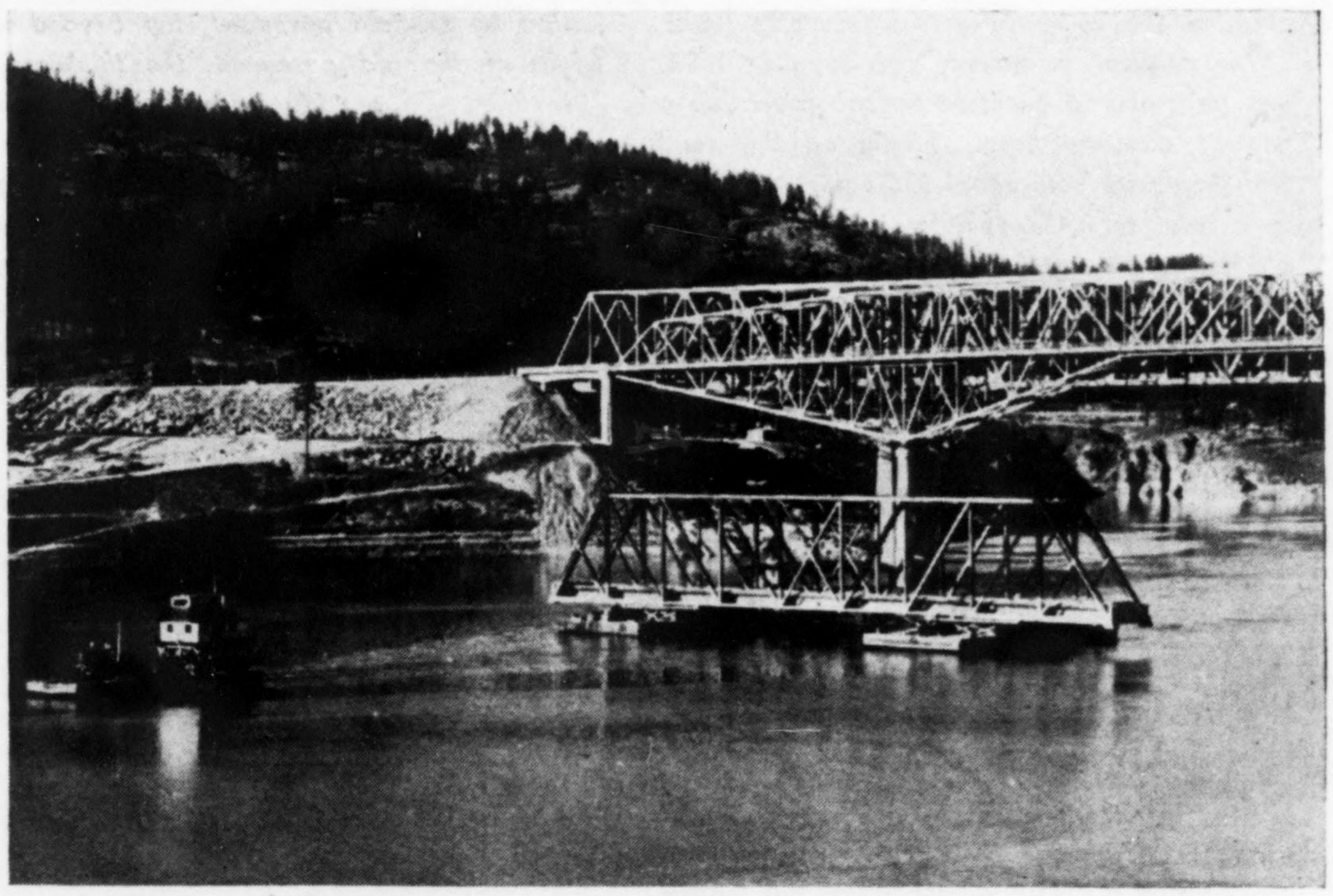
Industry operations officials are still fighting for an order which would exempt nothing except reconstruction and rehabilitation using no critical materials.

The forthcoming order is designed to end widespread evasion of priority controls over construction materials. The famous order SPAB 9, issued last October, warned that priority aid would only be granted to projects essential to defense or maintenance of the civilian economy. Belief then was that it would soon become impossible to build anything without priority assistance.

This would now be the case if priority rules were universally observed. But—and the situation is not confined to construction—they are not observed. A builder who knows the ropes and is willing to pay a price can still get almost anything he needs. So much is this the case that some housebuilders who have been granted ratings under the defense housing priority plan have decided they don't need the rating and have turned it back, thus escaping the $6,000 cost limit imposed on private defense housing.

The stop order, when issued, will certainly not mean that there will be any dearth of construction activity this year. In fact WPB officials are now anxious to find ways of speeding up the rate of construction. According to the latest official estimates, nearly fourteen and a half billion dollars worth of construction is lined up for 1942. In the face of this demand, construction expenditures in January amounted to $500,000,000, in February to $520,000,000. March expenditures are estimated at $580,000,000, and April at perhaps $610,000,000, far below the needed rate.

Private housebuilding, too, will continue at a greater than normal rate, though it will be restricted to certain areas and to houses costing less than $6,000 or renting for less than $50 a month. WPB this week decided to grant priorities to 200,000 more privately-financed dwellings. Priorities have now been granted to the full 200,000 units approved last September, and ratings are already being granted from the new allotment.



Bridge displaced by Coulee Lake floated to new duties

Sections of an old steel railroad bridge floating under the spans of a new structure are a unique sight on Grand Coulee Dam reservoir as Bureau of Reclamation crews move the old bridge from its former location at Marcus, Wash., to the dam's powerhouse site. Steel in the old span will be used as a framework for a large equipment, storage and fabricating plant.

The floating span above is one of the seven sections of the old Great Northern Railway bridge at Marcus, near Kettle Falls, which has been replaced by a new structure well above the estimated maximum height of reservoir water. Built in seven sections, the old bridge contains 965 tons of structural steel, 306,000 board-feet of timber, and 150 tons of miscellaneous metals. Sections are placed aboard Bureau of Reclamation barges and towed by a motor barge to the foot of the lake. The journey down the reservoir requires about 22 hours.