II, and indicate that the water-cement ratio law may be depended on for mixtures containing very small amounts of cement.

Table III gives the shortenings of the specimens due to shrinkage. The readings for three test pieces representative of unrestrained mortar (C), tamped concrete (A) and vibrated concrete (D) are plotted in the accompanying figure. It is apparent that the decrease in cement-paste content made possible by placing by vibration results in material reductions of the contractions due to loss of water.

The test results suggest the following:

1. The water-cement ratio law appears to hold for very lean mixtures as long as a compact concrete can be produced.

2. The shrinkage of lean mixtures when compacted by vibration is considerably less than for richer mixtures of the same water-cement ratio.

It follows from the above conclusions that if shrinkage is an undesirable property in a building material, then the vibrated concrete of low cement content is superior to the tamped concrete of higher cement content.

Remarkable Series of Bridges on Oregon Coast Highway

Five structures under construction include concrete deck arches and girders, concrete bowstrings and steel cantilever, with interesting design and erection features

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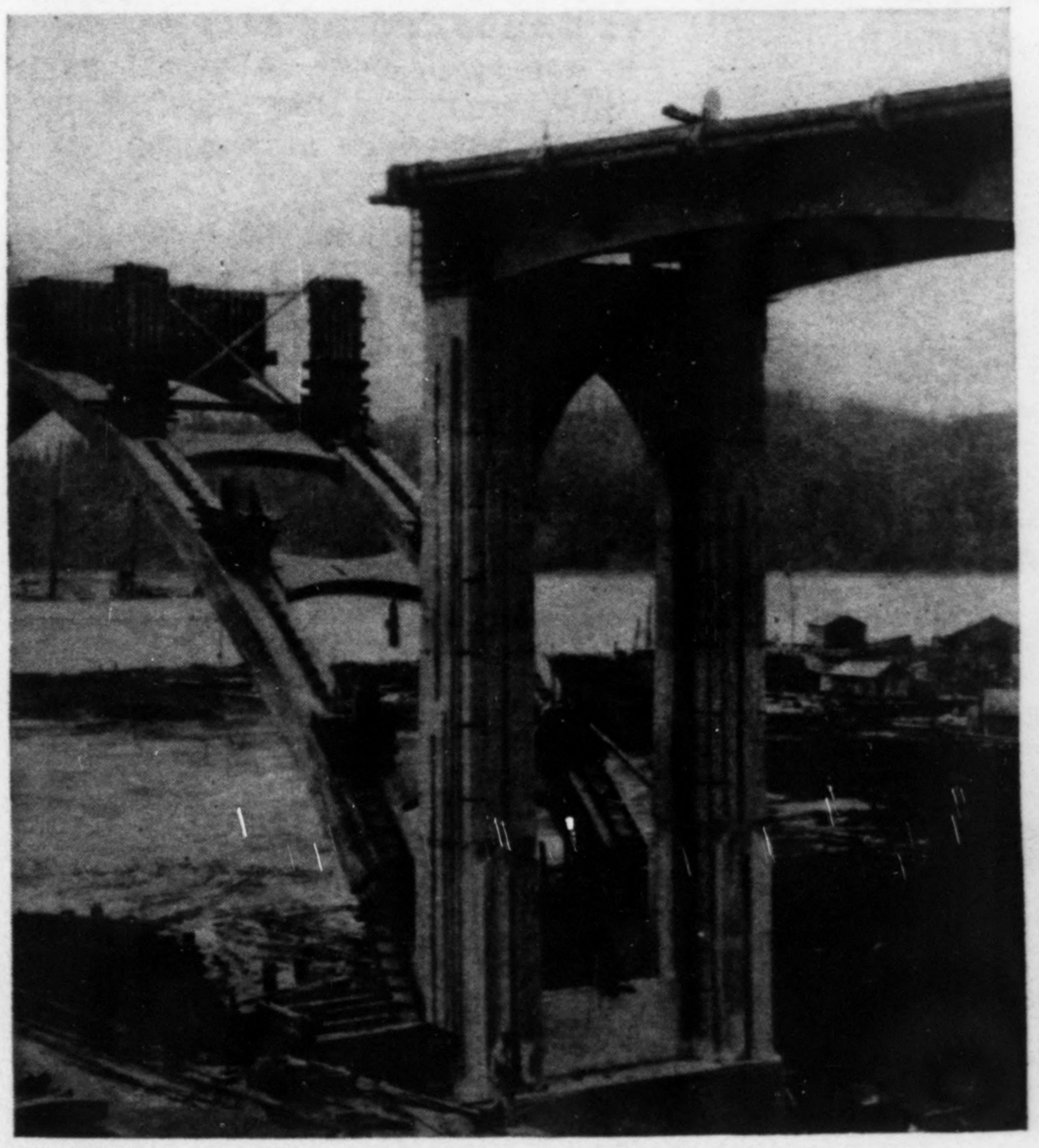
THE most ambitious bridge-building program ever undertaken by the state of Oregon is well under way along the Coast Highway. It is estimated that three of the five structures in the program will be ready for traffic early in 1936 and that the other two will be complete by September of that year. The bridges, financed by PWA on the basis of toll refunding (*ENR*, June 6, 1935, p. 814), are shown in Fig. 2. A number of interesting design and construction features are involved which may be outlined briefly.

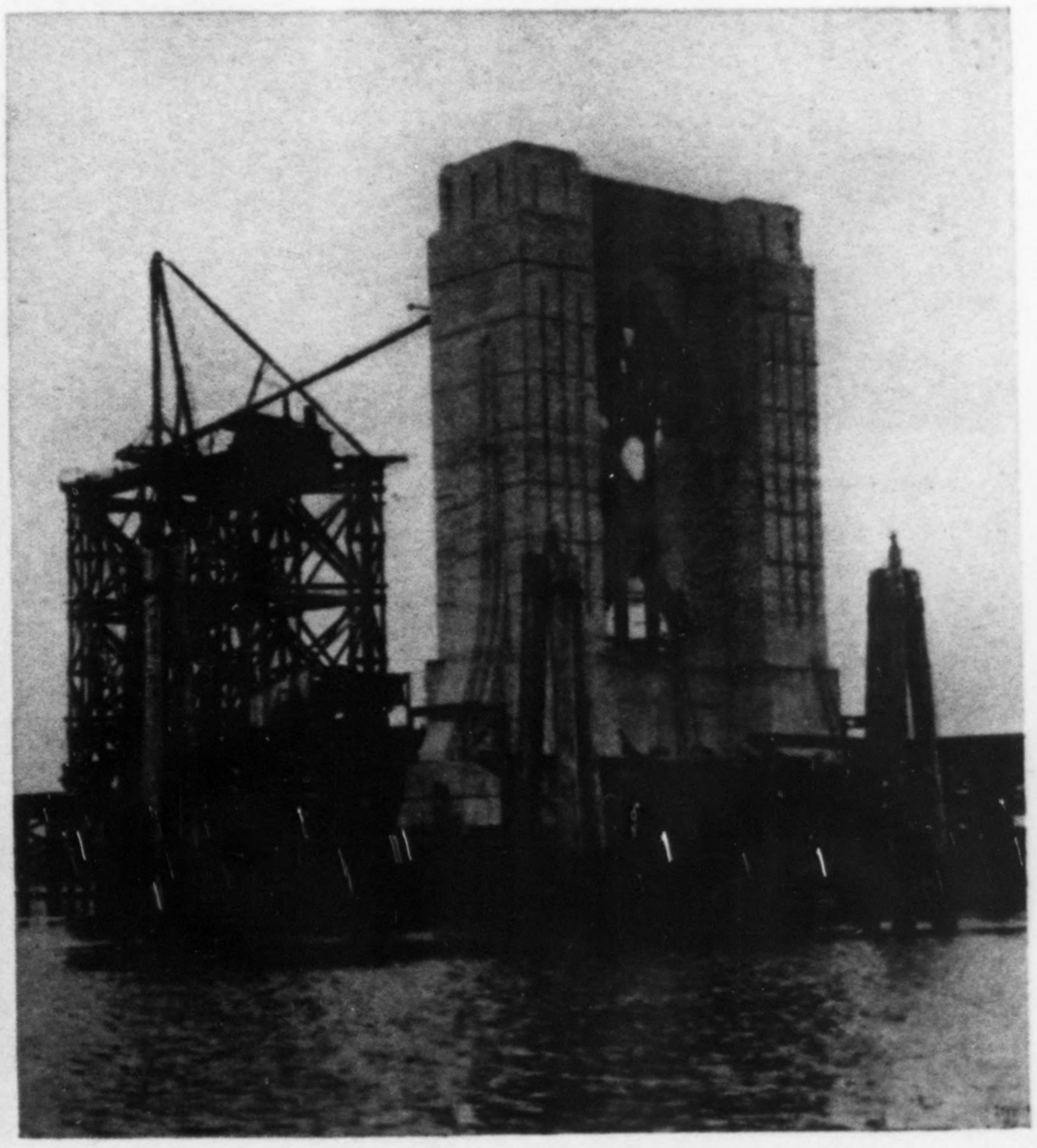
Construction Hinges—On all of the concrete deck arch spans temporary construction hinges of the Considere type are being used. This expedient results in a marked decrease in deformation stresses with a consequent saving in section. Fig. 3, showing one of the arch spans comprising the south approach to the Coos Bay Bridge, indicates the location of the skewback and crown hinges.

Concrete Bowstring Arches—The concrete bowstring arches in the Siuslaw River Bridge, the Umpqua River Bridge and Alsea Bay Bridge make use of structural-steel compression stubs and fabricated-steel tension ties, as shown in Fig. 4 for one of the spans of the Umpqua River Bridge. The compression stubs extend from the skewback pin 8 ft. up into the arch rib. They are designed in the form of a box section with suitable angle lugs proportioned to transmit the entire arch rib compression into the steel hinge pin and then into the tension bar. The skewback hinge pin and the entire tension-tie system will be encased in concrete so that the hinge will no longer act as such. The pinned arrangement was selected in order to insure complete and positive transmission of stress into the arch rib tie.

Steel Cantilever Erection—When the Rogue River Bridge (*ENR*, Nov. 26, 1931, p. 841) was constructed, the state of Oregon purchased a complete set of specially designed hydraulic jacks to be used in connection with the Freyssinet method of decentering employed for that structure. This equipment is being utilized to considerable advantage in the erection of the Coos Bay cantilever bridge, which has a main span of 793 ft. and anchor spans of 457½ ft. The erection procedure is as follows:

FIG. 1—ARCHITECTURAL treatment on Coos Bay Bridge, showing intermediate piers (left) and main channel pier (right).



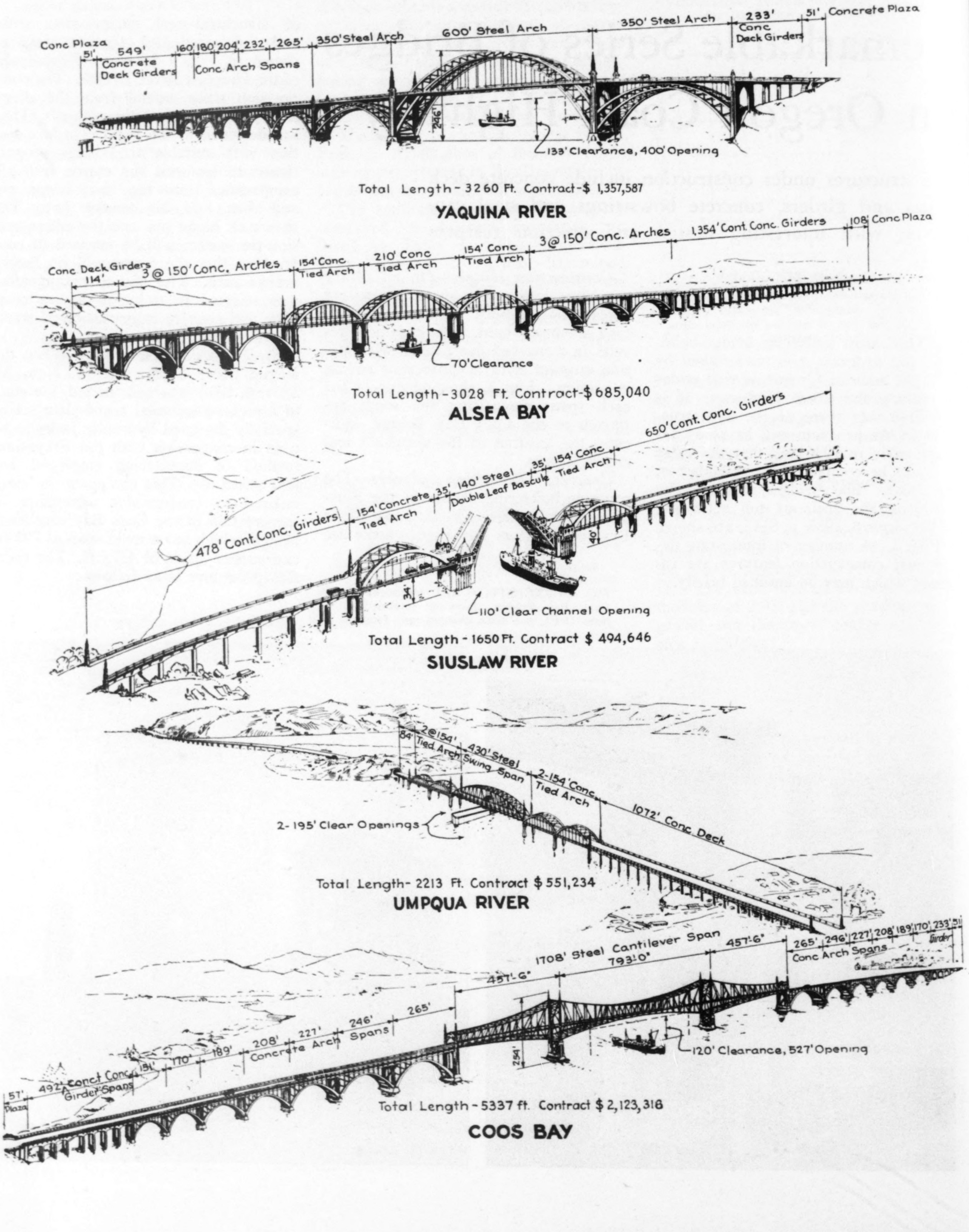


The main tower at the south end of the channel span was first erected to an elevation slightly above deck level by means of guy derricks. One bent of falsework was next placed under the second panel point toward shore as shown in Fig. 5.

The bottom-chord diagonals and deck system were then erected out to this point, and the guy derricks were moved up to deck level. The main tower was next completed, following which erection proceeded simultaneously on both the cantilever and anchor arms. With this method of erection the load must be balanced about the main pier with a slight excess at all times on the anchor arm, and it was in this connection that the hydraulic-jacking equipment was utilized.

Two 275-ton jacks, equipped with accurate pressure gages were placed under each truss on top of the shoreward falsework bent. By means of this equipment the excess load on the anchor arm was very accurately controlled. Erection proceded by cantilevering both ways

FIG. 2—FIVE LARGE BRIDGES UNDER CONSTRUCTION ON THE OREGON COAST HIGHWAY.



until the anchor arm was 275½ ft. from the main pier, at which point a second bent of falsework was placed, also provided with a battery of two hydraulic jacks under each truss. The anchor arm was then completed by cantilevering beyond this support until the end pier was reached. At the same time the cantilever arm was extended out to its junction with the suspended truss without the use of falsework. The same procedure will be followed for the north half of the structure.

Pier Architecture—The Coast Highway bridges are so tied in with the construcure of adjacent state parks that the underneath portions will be subjected to view to a much greater extent than otherwise. For this reason, considerable attention was paid to architectural treatment of the piers (Fig. 1).

Vibrated Concrete—Internal vibrators are being used to aid in the placement of all concrete. On four of the jobs electrically driven vibrators are being used, while the fifth is equipped with air-driven machines. Two types of electric vibrators have been employed, the first being a comparatively light machine equipped with a rigid tube containing an eccentric shaft directly connected to the motor; the second vibrator is a heavier machine in which the motor is connected by a flexible shaft to the vibrating element. Both of these types have given excellent service, the second type being peculiarly adaptable to beams where the distance from the top of the form to the bottom of the concrete is not greater than the length of the machine. The air-driven vibrator has also given very satisfactory service.

A marked improvement in concrete quality has been observed throughout the progress of the work. Gravel pockets have been practically eliminated, and by permitting the use of a stiff dry concrete there has been effected an average saving of about one sack of cement per cubic yard of concrete without any decrease in strength.

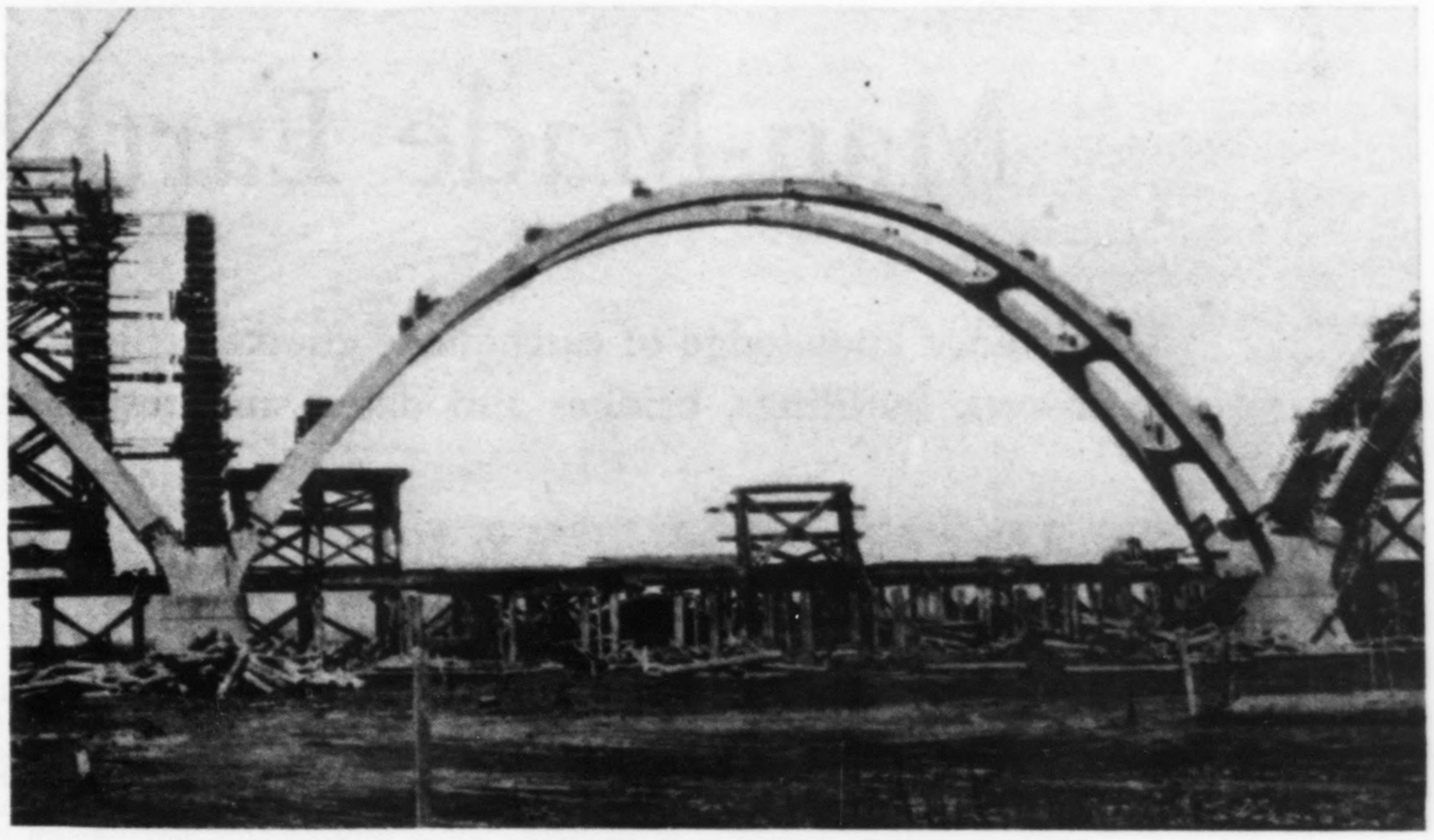


FIG. 3—TEMPORARY HINGES of Considere type at skewback and crown are used on all concrete deck arches.

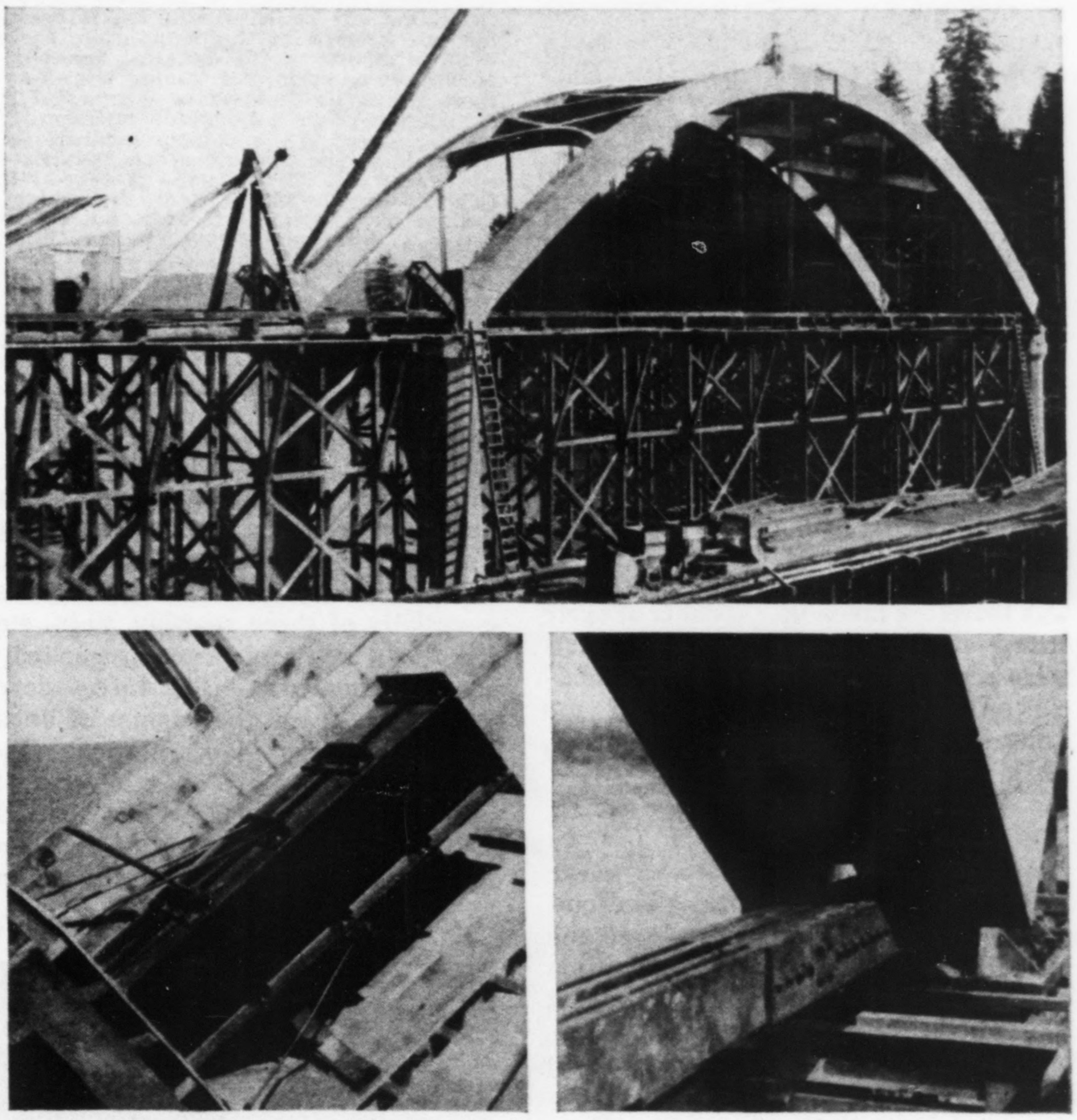


FIG. 4—BOWSTRING ARCHES (right) of concrete incorporate steel compression stubs at the skewback, pin-connected to steel tension ties. In the completed bridge the pinned connection is concreted in, to eliminate hinge action.

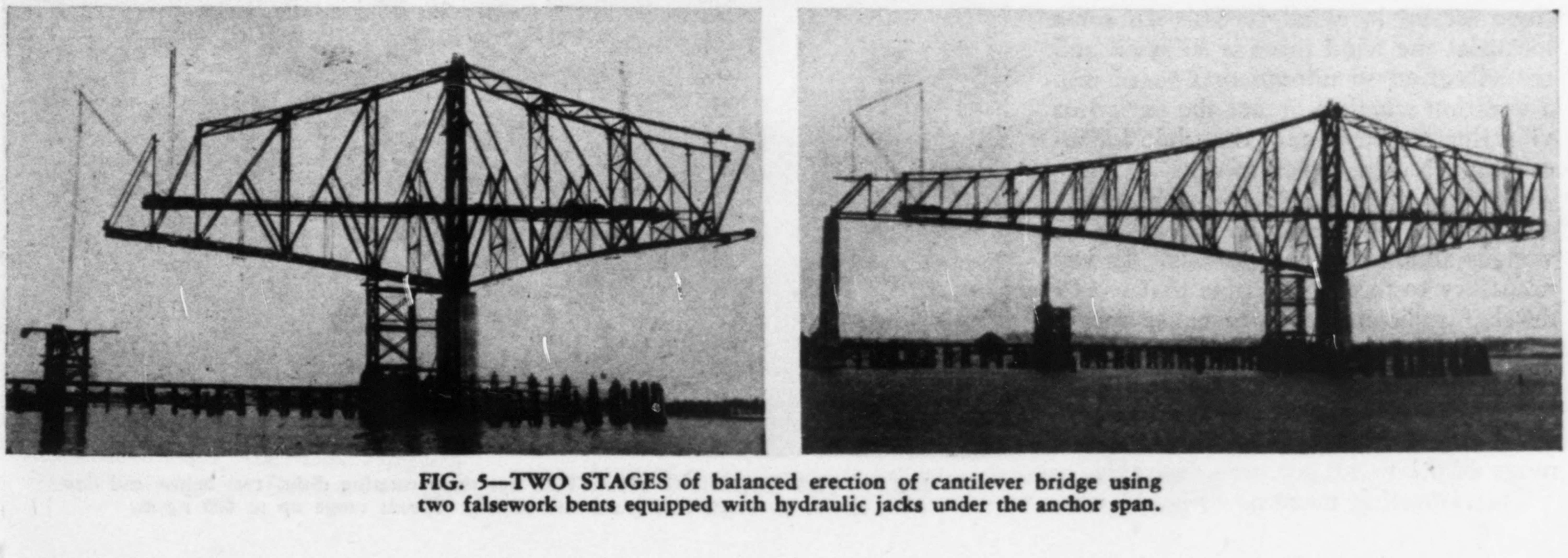


FIG. 5—TWO STAGES of balanced erection of cantilever bridge using two falsework bents equipped with hydraulic jacks under the anchor span.