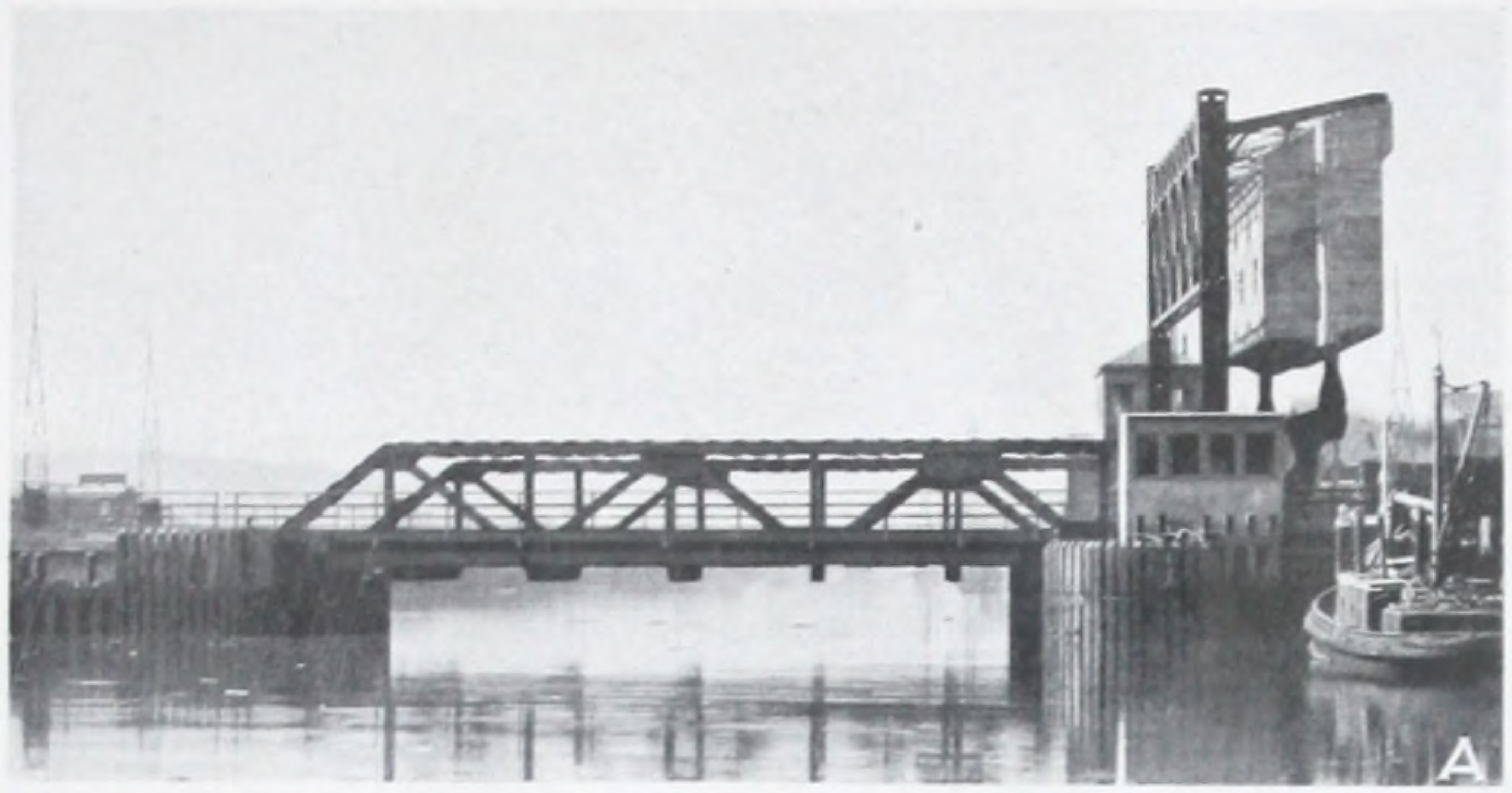
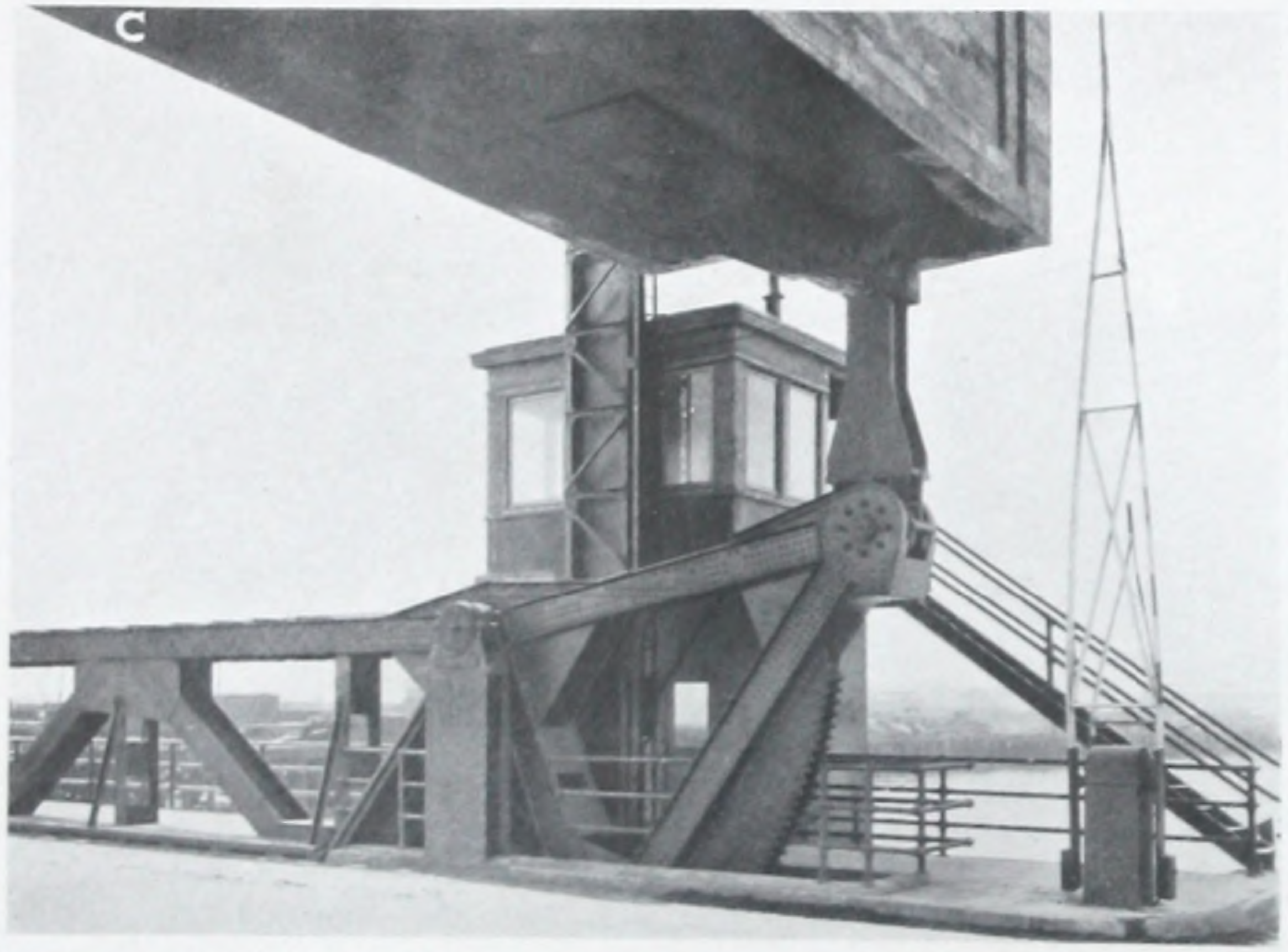
Group I. Vertical Overhead Counterweight Type

FIGURE 2, (a), (b) and (c), illustrates the Vertical Overhead Counterweight Type, showing views of the Fourth Street bridge, San Francisco, completed 1917.

The main trusses are each supported by means of a trunnion (short axle), secured to the top chord, mounted in a pair of symmetrical journal-bearings, which are secured to vertical structural steel posts (termed trunnion posts) supported on and anchored to the pier. The trunnions just referred to are termed the "main trunnions" and divide the bascule span into a "long arm," spanning the navigable stream, and a "short arm," extending back toward the shore, and serve as the fulcrum about which the bascule span, or leaf, rotates a quarter turn in opening or closing.

To make up for the discrepancy in weight between the two, the short arm is weighted by means of a concrete counterweight block located in an upright position (whence the term "Vertical Overhead Counterweight" type), above the traffic clearance line of the roadway. This counterweight bears down on the extremity of the short arm of the leaf by means of supporting structural steel columns in line with the main trusses, and pivotally connected thereto by trunnions, termed "counterweight trunnions," secured to the trusses, and journal-bearings secured to the column bases. The counterweight is held in an upright position by means of a rigid member termed the "counterweight link," one end being pivoted to the top of the counterweight and the other to a fixed tower, or gallows frame, built up from the outside trunnion posts. The center line of the counterweight link is parallel and equal in length to a line joining the main and counterweight trunnions, these two points and the two link pivots forming a parallelogram by virtue of which the counterweight is constrained to move parallel with its initial position and so establishes one of the conditions that maintains the leaf in equilibrium while the bridge operates. Further details concerning conditions for equilibrium are demonstrated in the following pages.





Length span, 94 feet. Width of roadway, 40 feet; sidewalks, 6 feet, completed 1917.

(A) Bridge closed. (B) Bridge open. (C) View showing details truss, main and counterweight trunnions.

Figure 2. Single Leaf Vertical Overhead Counterweight Highway Bridge, Fourth St. Over Channel St. Waterway, San Francisco, California

The span is opened and closed by two circular curved rack and pinion drives, the prime mover being electric motors. The curved racks are secured, one to each of the bottom chords of the short arm, whose centers are the main trunnions and are engaged by operating pinions keyed to shafts mounted in symmetrical journal-bearings secured to the base of the trunnion posts. These operating shafts are connected by means of transmission gears to electric motors which are controlled by the bridge tender in a suitable operator's house at the side of the bridge, supported by brackets at the end of the pier, over the sidewalk. When closed the bridge is locked to the rest pier by means of a motor-driven latch bar moving in guides attached to the front end of the bridge and engaging a suitable casting anchored to the pier, the lock motor and gear train being mounted on the end of the leaf beneath the floor. The lock motor is controlled from the operator's house and is electrically interlocked with the main operating motors so that neither can be operated except in correct sequence.

Other safety measures consist of automatic cutoffs which stop the operating motors in the nearly-open and nearly-closed positions of the leaf, setting the motor brakes at the same time; in addition a mechanically-operated emergency brake is provided. Emergency hand-operation is also provided, consisting primarily of a hand crank geared to the machinery at either side of the bridge. In some instances a central hand capstan, at the center line of the roadway a short distance back of the trunnion, is employed to effect operation.

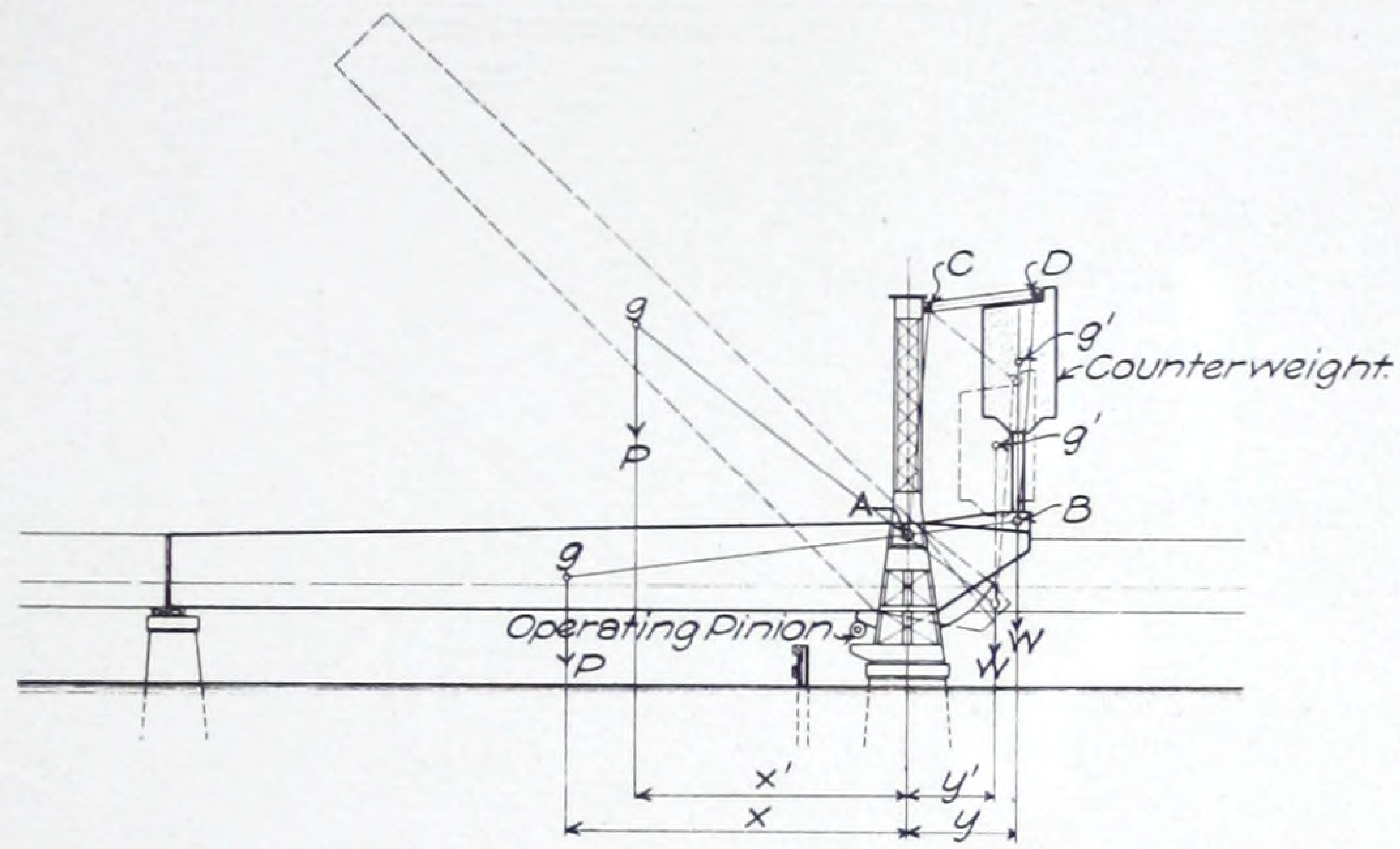


FIGURE 3. DIAGRAM VERTICAL OVERHEAD COUNTERWEIGHT TYPE

Figure 3 illustrates the conditions that maintain the leaf in equilibrium—(g) is the center of gravity of the moving leaf, whose moment is (Px), about the main trunnion (A), in which (P) is the weight of moving leaf considered concentrated at point (g). Point (g^1) is the center of

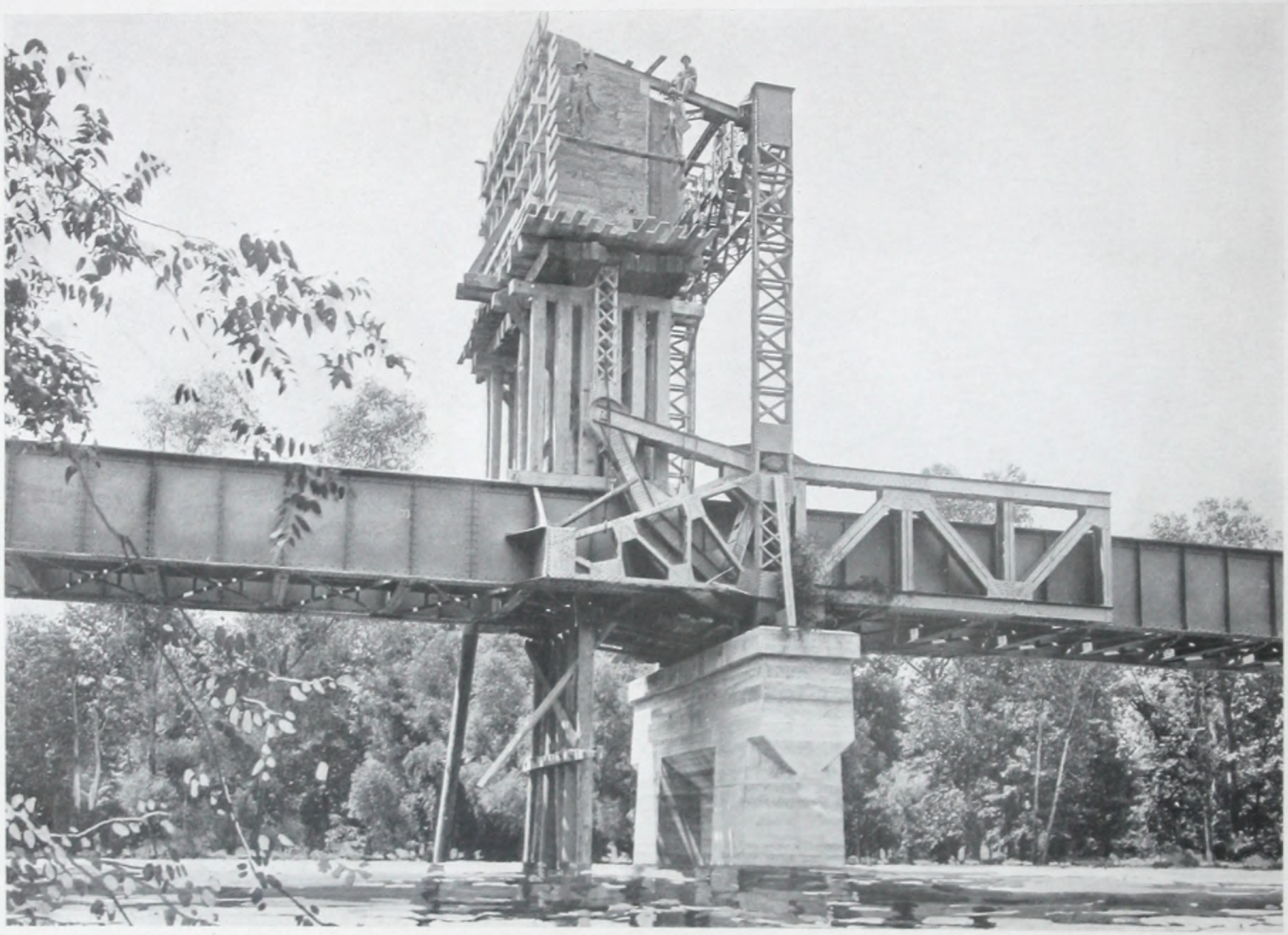


FIGURE 4. SINGLE LEAF OVERHEAD COUNTERWEIGHT BRIDGE, ILLINOIS CENTRAL RAILROAD. "LIFTING TRUSS DESIGN" OVER BIG BLACK RIVER, ALLEN, MISSISSIPPI

Length span, 77 feet. Single track. Completed 1917. (View shows counterweight forms and falsework before removal.)

gravity of the counterweight whose moment is (Wy), about (A), in which (W) is the weight of counterweight considered concentrated at (g), and applied vertically at (B). The moment (Wy) is made equal and opposite to the moment (Px), which condition balances all vertical forces about (A), and the structure is thus in equilibrium for the closed position of the bridge. For any other position of the bridge, such as indicated in dotted lines, it can be seen that the forces are also in equilibrium by virtue of the fact that the three points, (g), (A), (B), lie in a straight line, thus establishing a constant relation between the horizontal lever arms, about (A), of leaf and counterweight, and furthermore because the counterweight is pivotally attached to the leaf and moves parallel to its initial position as explained above.

From the foregoing it will be seen that the main trunnions support the weight of leaf and counterweight, and that *this weight*, termed the "*dead load*," thus supported, is *always* a *vertical* and *constant force on the pier*.

The great advantage of the pivotal connection of the counterweight will become apparent by comparison with the use of a fixed counterweight, that is, a counterweight which is an integral part of the moving leaf. In such an arrangement, the *actual* center of gravity of the counterweight must be located on the extension of the line joining the center of gravity of the long arm and the center of rotation, i. e., at point (B) (see Fig. 3), which will necessitate the use of a cast iron or heavier metal on account of the limited space available between the bridge and water level, or else an expensive watertight pit must be built in the pier. The only other alternative, with the fixed counterweight design, is to raise the center of rotation materially, so that the counterweight may be located above the traffic clearance line, which in fact is what is resorted to at the expense of stability and economy. In the STRAUSS design, however, since the counterweight trunnion is correctly located with respect to the center of rotation and center of gravity of the long arm, the actual mass of the counterweight may be located above the clearance line without impairing the stability or the economy of the design. That is, since the effect of the counterweight is applied vertically on the counterweight trunnion in the STRAUSS design, it is immaterial where the actual center of gravity of the counterweight block is located, so long as the correct total weight is provided, which is accurately and easily obtained by casting recesses, or pockets, in the counterweight, for the purpose of adding to or taking away small concrete blocks until an exact balance is reached.

Where it is necessary to convert an existing fixed girder span into a bascule, or to build a deck-plate girder span with counterweight overhead, this type is found very satisfactory. In this form the bridge is known as the "Lifting Truss" type, illustrated in Fig. 4. The main span is not directly mounted on trunnions but is supported on the piers at each end, as if it were a fixed girder span, and is in this case a duplicate of the series of approach spans at either side. It is counterweighted and made operative by two short bascule trusses, one outside of each main girder, and mounted on trunnion posts anchored to the pier at one end of the span and connected thereto by means of transverse beams framing to the vertical members of the lifting truss and the webs of the girders of the span.

The vertical overhead counterweight type is used for double leaf as well as for single leaf designs; there being no support at the ends of the leaves at the center of double leaf spans, means are provided to support the leaves under live load. The means usually devised for this purpose are quite similar to those employed for the underneath counterweight type described in the succeeding pages under Group II. In most cases the leaves under live load act as cantilever spans, but a notable example, where the two leaves form a three-hinged arch, is found in the highway bridge, across the harbor entrance in Copenhagen, Denmark, built by the Harbor Board in 1908, illustrated in Fig. 5. The roadway carries a double track electric railway line between the two main bascule girders. Two 10 ft. 3 in. sidewalks cantilevered from the main girders are also provided. The main girders are arched above the roadway and are provided with a compression lock at the center of the span near the top of the girders, where they meet, forming the center hinge. The end hinges are located near the bottom of the girders beneath the roadway, at the top of the piers near the channel lines. To insure proper bearing at the three hinges, the pressure of the counterweights at the tail ends of the girders is relieved by means of hydraulic cylinders when the bridge is closed.

The Copenhagen bridge also illustrates how the vertical overhead counterweight type lends itself to decorative or ornamental treatment. Fig. 6, being a portal view of the Federal Street bridge, Camden, N. J., completed in 1908, illustrates the same feature in somewhat different form. In this design the counterweight itself forms an ornamental portal over the roadway and, as the bridge operates, moves between two reinforced concrete operators' houses over the sidewalks. From the foregoing examples, it is seen that this type of bridge is capable of proper artistic treatment.

* * *

Summing up, the advantageous features of the Strauss Vertical Overhead Counterweight Type are as follows:

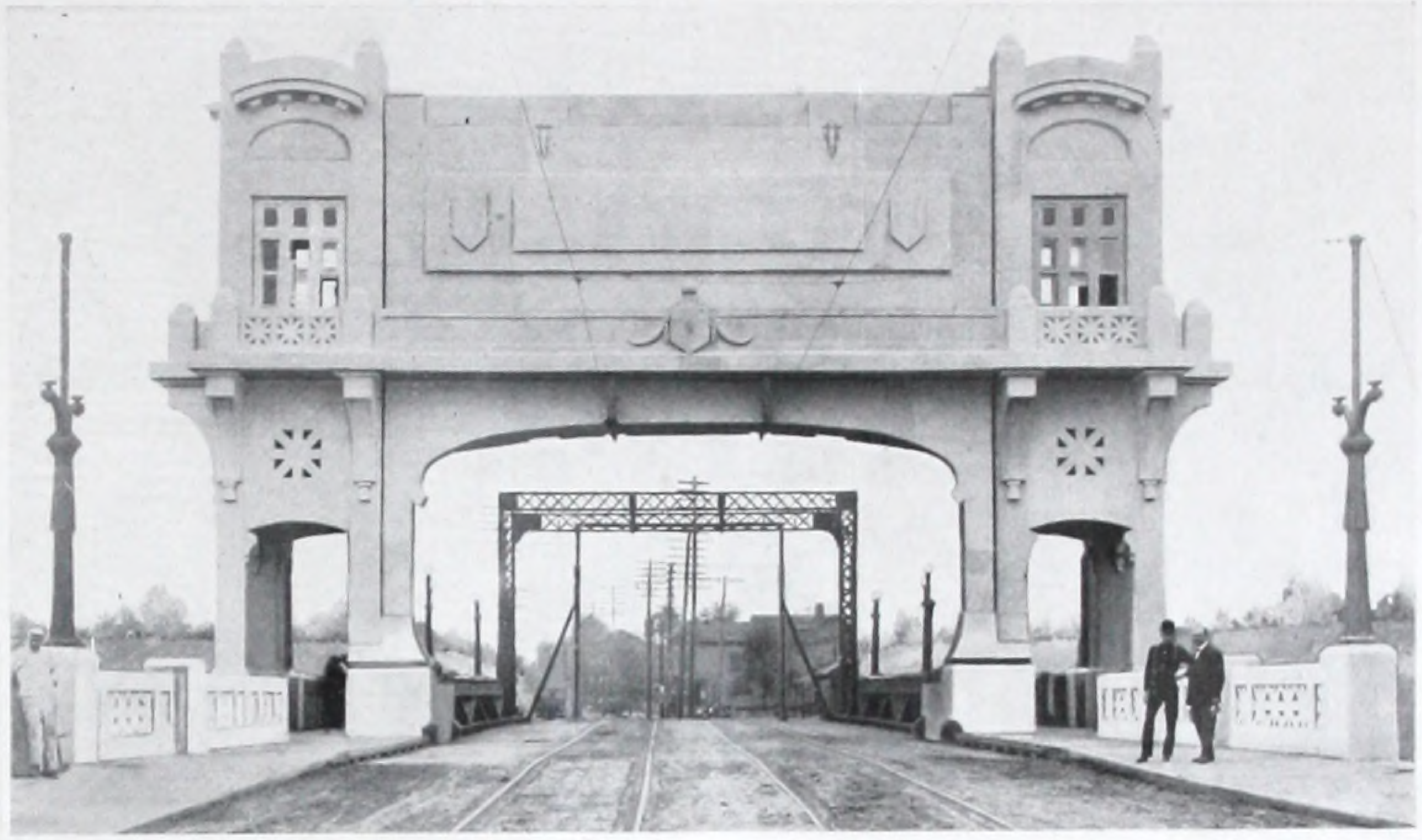
1. The entire dead load, leaf and counterweight, is supported directly over the center line of the pier and remains a constant vertical load during the operation of the bridge. Only one pier is required at trunnion end.

2. The points of support for the dead load, the main trunnions, are close to the pier top and positively connected to the pier by means of short steel posts anchored thereto.

3. Space for the counterweights is not cramped, allowing use of ordinary concrete; neither is its shape restricted by the location of the actual center of gravity of the counterweight mass, since

Figure 5. Double Leaf Overhead Counterweight Highway Bridge Over Inner Harbor Entrance, Copenhagen, Denmark

Length span, 109 feet 2 inches; width roadway, 22 feet 7 inches; double track St. Ry.; width sidewalks, 10 feet 3 inches. Completed 1909



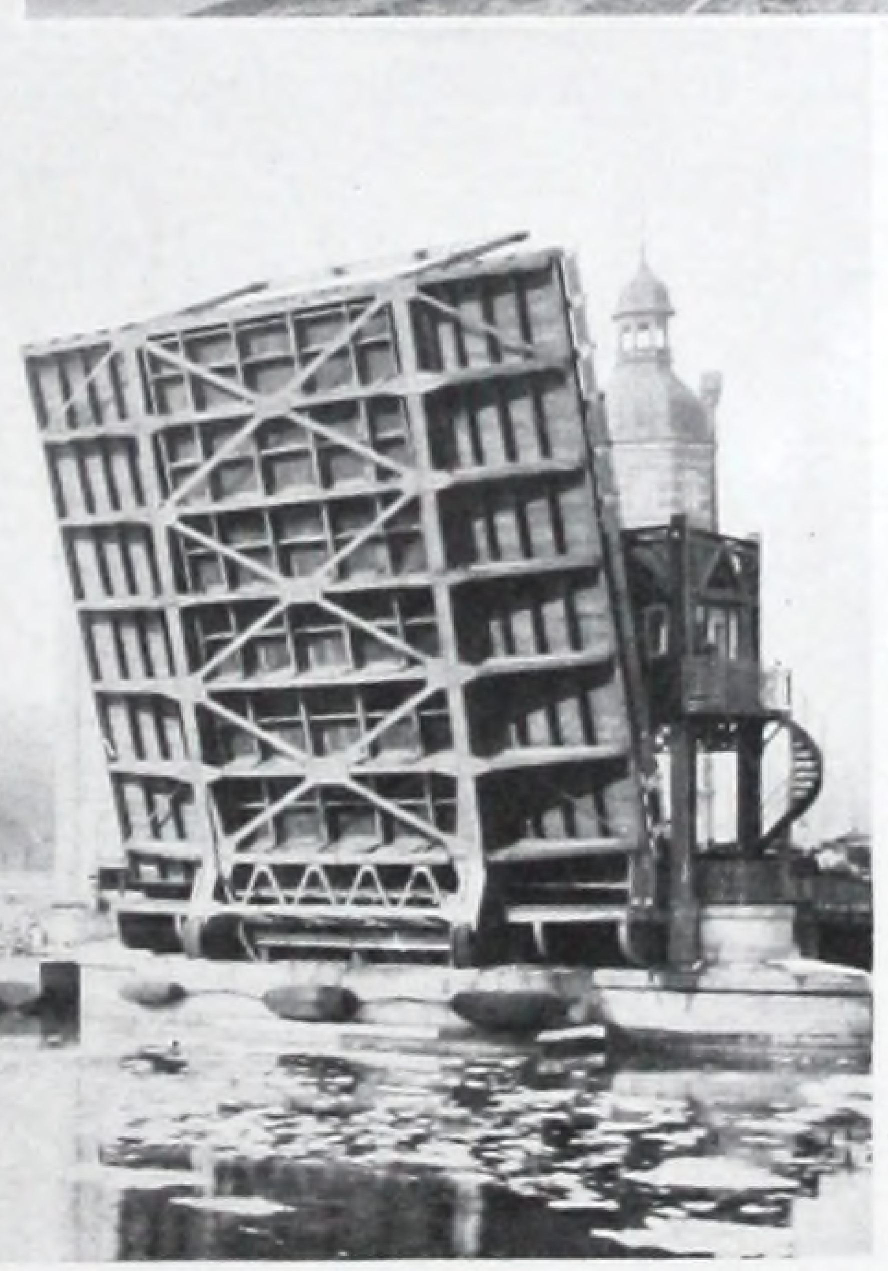


Figure 6. Single Leaf Overhead Counterweight Highway Bridge Over Cooper's Creek at Federal Street, Camden, New Jersey

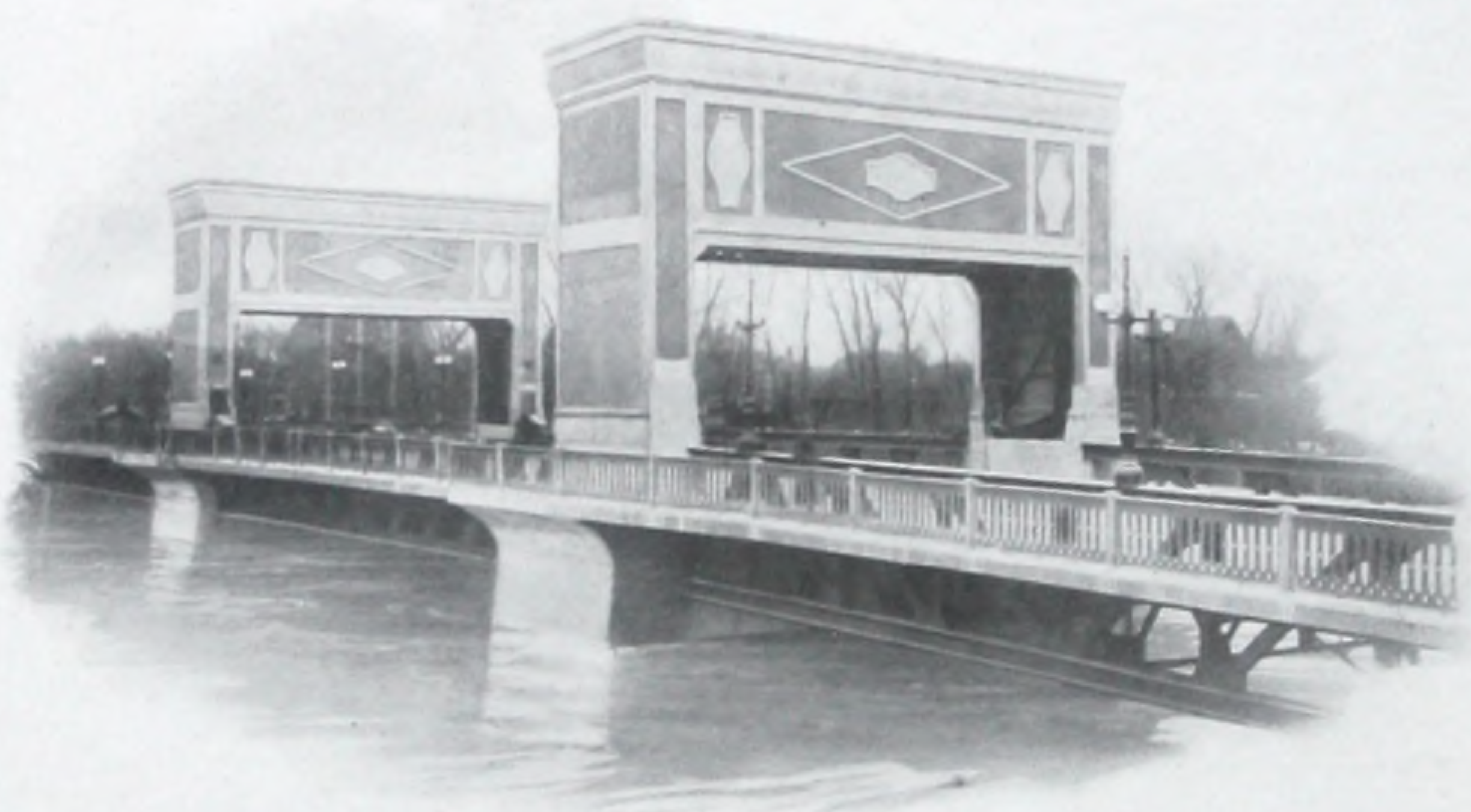
Length span, 78 feet; width roadway, 34 feet; double track St. Ry.; sidewalks, 7 feet. Completed 1908 the correct counterbalancing effect is applied to the leaf at the counterweight trunnions, which are accurately located in the shop, insuring correct balance irrespective of the location of the actual center of gravity of the counterweight.

4. Operating machinery and motors are not located on the moving leaf but are securely supported on fixed girders anchored to the pier, providing a rigid support free from distortion, thus facilitating electrical connections, lubrication, inspection and maintenance. Likewise, hand-operation is more convenient and efficient.

5. The vital parts of movement, the trunnions, are securely housed in journal bearings, lined with phosphor bronze bushings, well lubricated, reducing wear to a minimum, and giving protection against influence of weather, lodgment of dirt, etc. *Trunnions in their bearings give surface contact with pressure distributed over requisite area for safe unit load.*

6. Counterweighting and operating mechanism readily applied for converting fixed spans into bascule structure with minimum alteration to existing structure.

7. Design lends itself to artistic treatment since counterweight may be designed as ornamental portal.



Osborne St. Bridge, Winnipeg, Canada