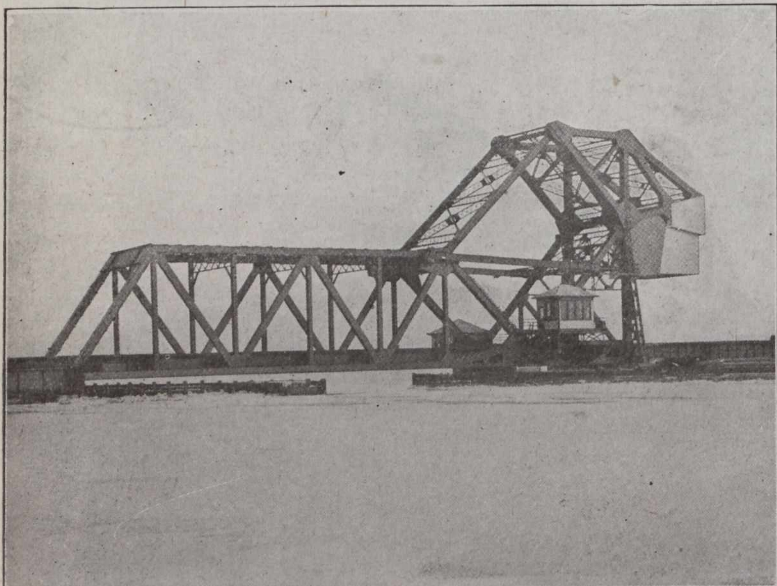
each shore, the deck of which is at a higher level. The chief merit of Mr. Breithaupt's design is that, for tugs and small craft the bascule floor only need be raised without opening the arch. The arches and bascule floor had separate counterweights consisting of chains, each link of which weighed two tons.

A patent was granted to Mr. Montgomery Waddell and filed April 6, 1897, for a somewhat similar type of bridge with lenticular or cigar-shaped arch ribs meeting at the centre when closed. The platform, instead of being suspended, as in Mr. Breithaupt's design, was in this case hinged to the arch ribs. Another patent granted to Mr. Waddell at the same time shows double bascule trusses hinged at the foot of the shore towers and supported underneath by diagonal struts bracing back to the abutments.

Suspended Series of Falling Counterweights.—Another system of compensating counterweights was invented by William Burdon and described in the Scientific Canadian of February, 1879. The lifting was accomplished by ropes



Strauss Trunnion Bascule Bridge, Hackensack River, Erie Railroad.

from hydraulic pistons, and the leaves were balanced by cables from their outer end passing over sheaves at the top of shore towers in which a series of weights were suspended, which came to a bearing on the ground as the leaf ascended. A somewhat similar type of small bridge was used many years ago at the Liverpool docks, the chains going down inside the shore columns to the hydraulic machinery below. In 1892, a plan on a larger scale was proposed by Mr. Charles Steiner, of Minneapolis, in which double leaves, each 25 feet long, were used over a 250-foot channel, the leaves being supported by chains passing over pulleys on shore towers and fastened to hydraulic rams. Another bridge at Birkenhead, over the Great Passage at Granaries, carried two tracks of railroad on double leaves over a 30-foot opening. When in their lowered position, the girders were strengthened by hinged struts supported by chains which guided the ends of the struts into sockets on the abutment faces. The bridge was raised by chains passing over pulleys on vertical pillars 10 feet high, set 8½ feet back from the abutment face. It was very light, had no tail end or balance and occupied a very small dock space.

Bridges of this type were brought into active use in America in 1890, when one over the Harlem River was completed for the New York Central Railway, near 135th Street and 4th Avenue. It was designed by Mr. G. H. Thomson, assisted by Mr. J. D. Wilkins. The principle involved is identically the same as that which is so commonly used in crossing gates, which, when open, fold up at each side of the street against their weight cases. The bridge was 106 feet long and 32 feet wide, with four tracks, the two outer ones curving in at the bridge and making it possible for only two trains to cross at one time, notwithstanding the heavy travel of more than five hundred trains daily. Switches were not used. The sheaves at the tower tops were quite unusual, being made of old locomotive driving wheels, 6 feet 10 inches diameter grooved out for the cables. Three years after its completion the bridge was removed and re-erected over the Harlem at Spuyten Duyvil. In 1897 there was a similar one on the Wisconsin Central Railway at Manitowoc, Wis., and another was proposed about the same time by Mr. C. E. Bidell for crossing Newton Creek. The clear opening in the latter case was 150 feet, and towers 112 feet high on each shore support 9-foot drums, over which the cables pass, holding the 65 tons of counterweight in several separate blocks. It was provided with a 36-foot road and 11-foot walks outside the trusses, the whole bridge being supported on cylinder piers. When the leaves were lowered they were to be supported by eye bars from the towers, the bars being hinged at the centre to fold up as the leaf was raised.

One of the last bridges of this kind, completed in 1905, crosses the New Basin Canal at New Orleans. It has an effective span of 70 feet over a 63-foot channel, crossed by through plate girders 9 feet deep, for double track. Towers are 104 feet high, inside of which hang the counterweights in successive blocks weighing 3,000 pounds each. It is operated by a 35-horse-power electric motor, but also has an auxiliary 10-horse-power gasoline engine.

Between the years 1897 and 1900, designs for several bridges of this type were made by I. G. Tyrrell, including those at Elizabeth City, N.C., with a span of 24 feet; Chatham, Mass, with span of 25 feet; Charleston, S.C., with span of 60 feet, and Kennebunk with span of 81 feet. A small one for single track, designed by the writer in December, 1899, had a 21-foot clear opening, and was founded on piles. It was proportioned for light locomotives equal to Cooper's specification E.30, and had hand machinery only. The estimated quantities for superstructure only, without foundation or floor, are:—

Structural steel	20,000 lbs.
Machinery	3,000 lbs.
Counterweight	16,000 lbs.
Total	39,000 lbs.

If the clear opening were increased to 30 feet, the estimated quantities would then be:—

Structural steel	30,000 lbs.
Machinery	3,500 lbs.
Counterweight	24,000 lbs.
Total	57,500 lbs.

A patent was filed February, 1908, in favor of Louis H. Shoemaker, of Sewickley, Pa., for a counterbalanced lift bridge, in which the pull on the cables from the bridge and fixed counterweight is equalized. As the bridge rises, the angle of the cable changes, making a nearly constant pull in the cables from the girders at all times.

Poncelet Bascule System.—This was evolved by M. Poncelet, in France, prior to 1840, and is a modification of the Derché draw. It was revived in 1896 during the Newton