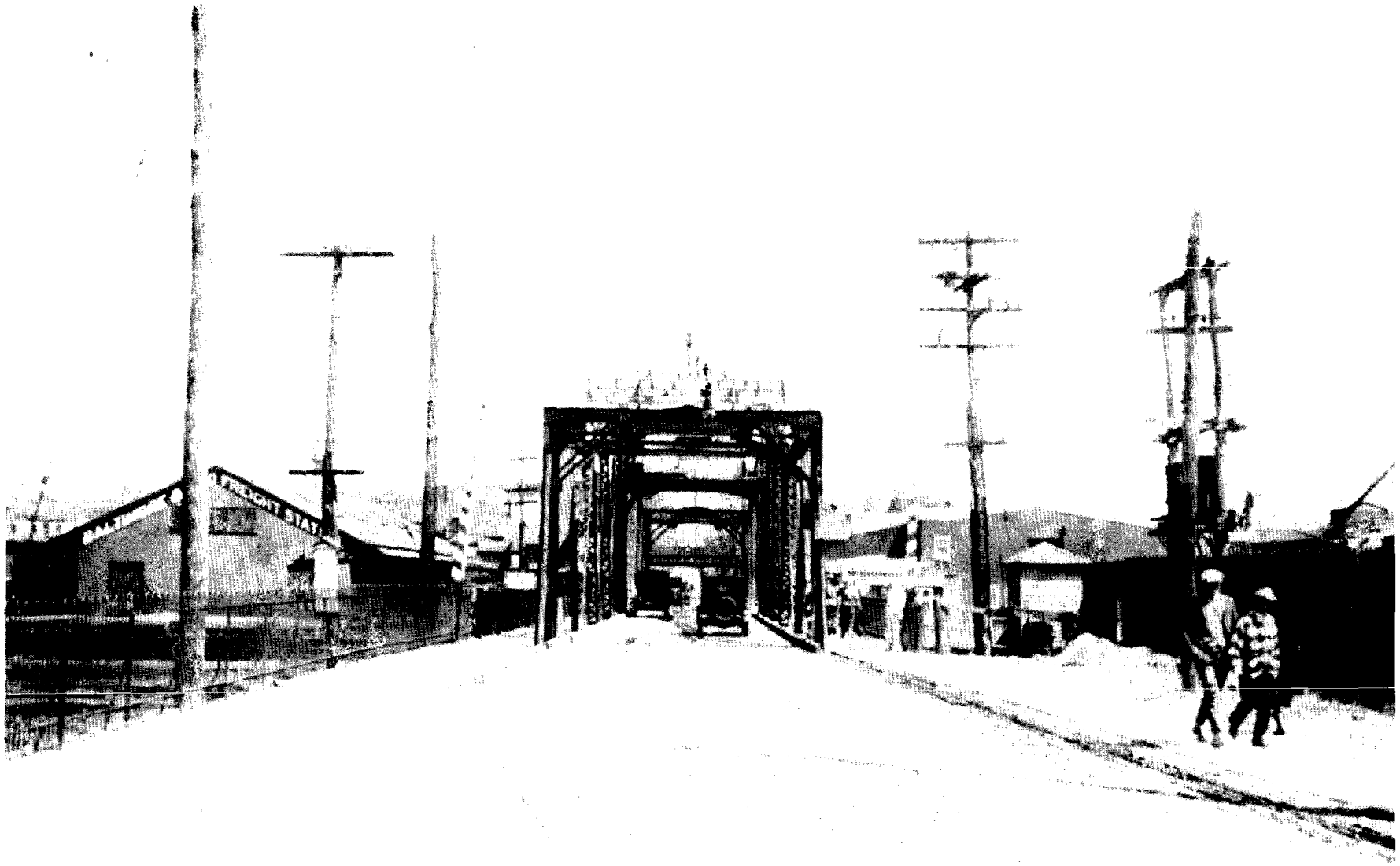
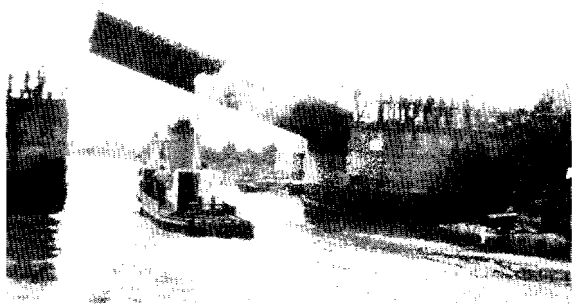
MOVABLE BRIDGES



South Market Street Bridge, Wilmington, before replacement in 1927.



Lewes Bridge, a bascule.

MOVABLE BRIDGES

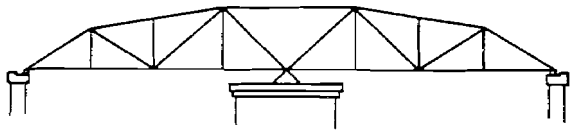
The engineering solution to crossing a navigable river is to build either a high bridge with adequate clearance to permit vessels to pass beneath it or a low bridge that can be moved to allow marine vessels to pass through. Bridges over navigable waters, then, fall broadly into the categories of fixed and movable bridges. Movable bridges are those which turn, move to the side, lift up and down, or in any way change positions to allow traffic to pass in the waters they span.

Descriptive terminology for the various types of movable bridges was not consistent in historical texts and periodicals, particularly those published during the nineteenth century. Patented types began to appear by the 1830s. There were numerous patents for a variety of movable bridges and their moving mechanisms by the 1870s, and the number increased by the early twentieth century. In a 1907 paper intended to open discussion and establish specifications for movable bridges, past president C.C. Schneider of the American Society of Civil Engineers classified movable spans in the following categories:

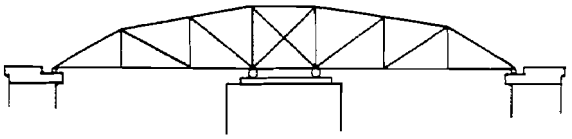
1. Swing bridges, which turn about a vertical axis.
2. Bascule bridges, which turn about a horizontal axis or roll back on a circular segment.
3. Lift bridges, which lift vertically.
4. Traversing or retractile bridges.
5. Transporter or ferry bridges.
6. Pontoon or floating swing bridges.

The latter three types were seldom used, so for the purpose of clarification, movable bridges can be classified as being of the bascule, lift or swing type. These primary types of movable bridges, shown below, are (a) a center-bearing swing bridge, (b) a rim-bearing swing bridge, (c) a vertical-lift bridge and, (d) a bascule bridge.

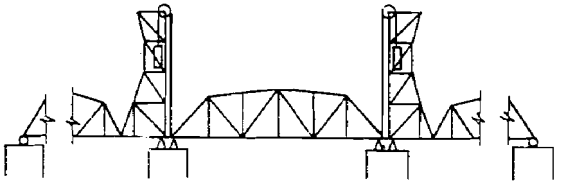
Low movable bridges were considered to have several advantages over high fixed bridges; initial costs are lower and less of the surrounding land is used. Their disadvantages are considerable, however. When the span is open, there is either an inconvenience to highway traffic or to



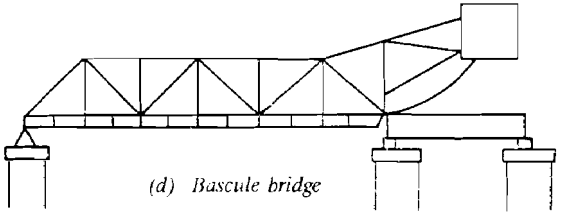
(a) Swing bridge, center-bearing



(b) Swing bridge, rim-bearing



(c) Vertical-lift bridge



(d) Bascule bridge

Types of Movable Bridges.

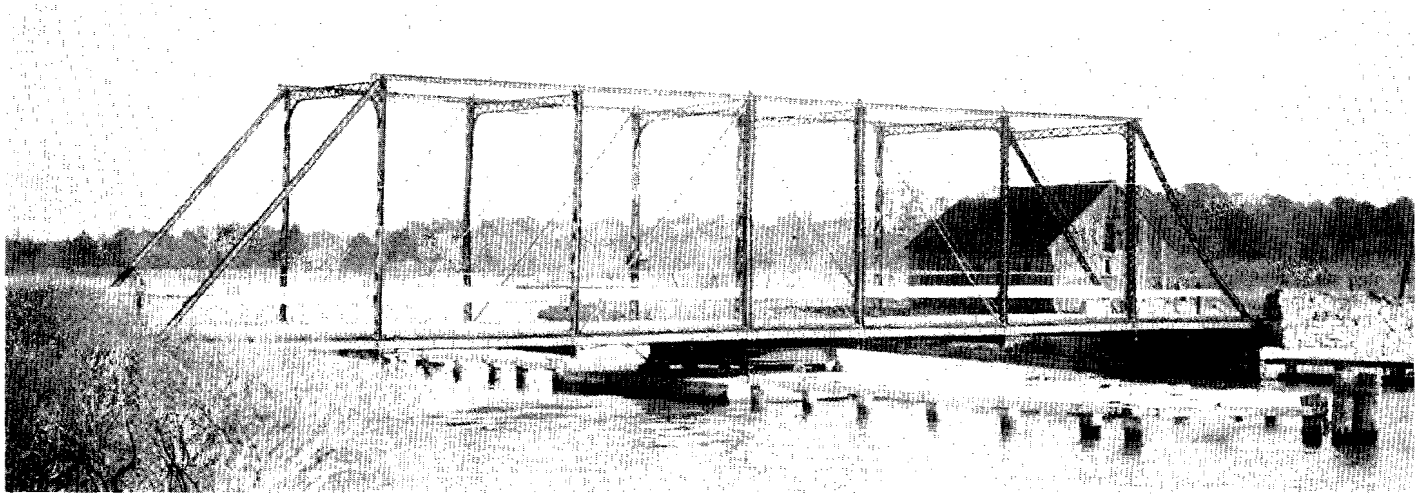
marine traffic. They require additional expense for machinery, power, and operators, and they are hazardous in case of emergency. The type selected depends on site conditions; criteria include character of channel traffic, subsoil conditions, foundations, and value of shore property.

Operation of the movable bridge evolved from simple hand-operated mechanisms to applied power through steam engines, gasoline engines and electrical motors. In 1916 J.A.L. Waddell cautioned, "every movable span should be provided with a means for operating it slowly by hand" in order to meet the possible emergency of power failure.

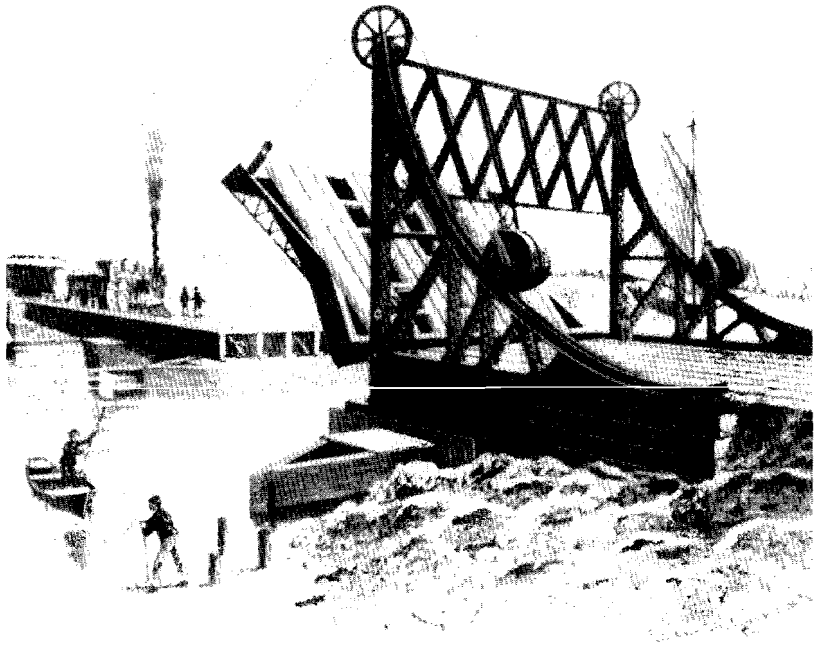
Although many of the remaining movable bridges in Delaware are inoperable, they have been permanently closed with operating equipment intact. Most of the six bascule spans house moving mechanisms in the bascule pier, below the deck. Of the two swing bridges, one was a hand operated span and the means for pivoting the bridge is intact and visible on the deck.

The operation of movable bridges is regulated by the U.S. Army Corps of Engineers which has been given authority over navigable waters by Congress. Regulations governing the operation of each bridge have been established based upon the navigation needs of the waterway. These regulations must be posted on upstream and downstream sides of the bridge. Some movable bridges had twenty-four hour service because the operator lived near the bridge and was able to respond to a boat whistle or horn blast; others required notice ranging from four to twenty-four hours. Some spans included operator's houses for the convenience of the tenders.

Included in Delaware DOT photo archives for New Castle County in the 1920s-1930s are eight movable bridges, all built prior to 1921. All are swing bridges: one through truss, three pony trusses, three cable stayed trusses and one cable stayed steel girder. According to a 1965 Wilmington "Morning News" article, there were sixteen operating movable bridges on state roads at that time. The results of this historic bridge survey indicate that there were eight extant movable bridges on Delaware highways in 1988; six are bascule bridges and two are swing bridges. There are two extant patented types: a Scherzer rolling lift and a Chicago trunnion bridge.



Broadkill River Swing Bridge. No longer in existence.



Early Bascule Bridge.

BASCULE BRIDGES

The earliest type of movable bridge used was the bascule bridge, a shallow deck which could be raised or lowered to a vertical or inclined position by means of an outhaul cable attached to the free end. It was constructed of timber, was hand operated, and was limited to small openings; typically, it was the medieval drawbridge. Bascule bridge design evolved over the centuries, and during the late nineteenth and early twentieth centuries, it was developed in numerous patented types. In general, these patented bascules were of a pivoting, or trunnion, variety or a rolling type. A bascule bridge was desirable when one large clear channel was necessary. The disadvantages of the bascule type were the difficulty of maintenance and the power necessary for operation when the span was opened and exposed to wind pressure.

Two types of bascule bridge were described by J.A.L. Waddell in his 1898 book De Pontibus; namely, the counterweighted bascule and the rolling bascule. A counterweighted bascule bridge contemporary with his description is illustrated in the adjacent drawing. Waddell revised the list of bascule types in his 1916 book Bridge Engineering to trunnion, rolling lift, and roller bearing bascule bridges. The differences among them are in the detailing of the moving mechanism. The trunnion bascule bridge moves about a fixed center of rotation located at the center of gravity of the rotating part. The roller-bearing bascule bridge also moves about a fixed center of rotation that coincides with the center of gravity, but the trunnion is eliminated and the load is carried by a segmental circular bearing on rollers in a circular track. The rolling lift bascule bridge continually changes its center of rotation and shifts its load application points as its center of gravity moves in a horizontal line.

To overcome features which were unsatisfactory, various sub-types were developed and patented. In the trunnion category were the Strauss (Strauss Bascule Bridge Company), Brown, Page, Chicago (Chicago Bascule Bridge Company), and

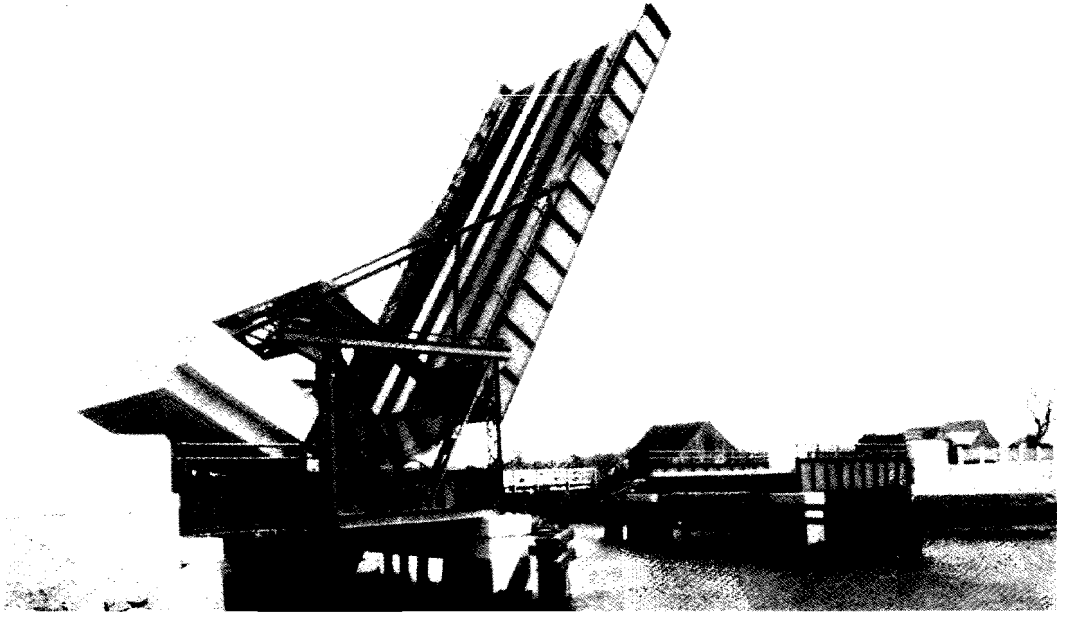
Waddell and Harrington types. In the roller-bearing category were the Montgomery, Waddell and Cowing types; and in the rolling-lift category were the Scherzer (Scherzer Rolling Lift Bridge Company) and Rall (Strobel Steel Construction Company) types.

Waddell's analysis of which type of bascule bridge was preferable reflected his sense of aesthetics. All were "inherently ugly" and "for all but comparatively short spans are uneconomic in comparison to the vertical lift." From an engineering perspective, he claimed, "they are scientific, and they represent, probably, the best and most profound thought that has ever been devoted to bridge engineering." In 1916, he pronounced the Scherzer rolling-lift bascule the most popular of all types. At that time the longest single-leaf Scherzer bascule spanned 200 feet on the Baltimore and Ohio Railroad in Cleveland, Ohio.

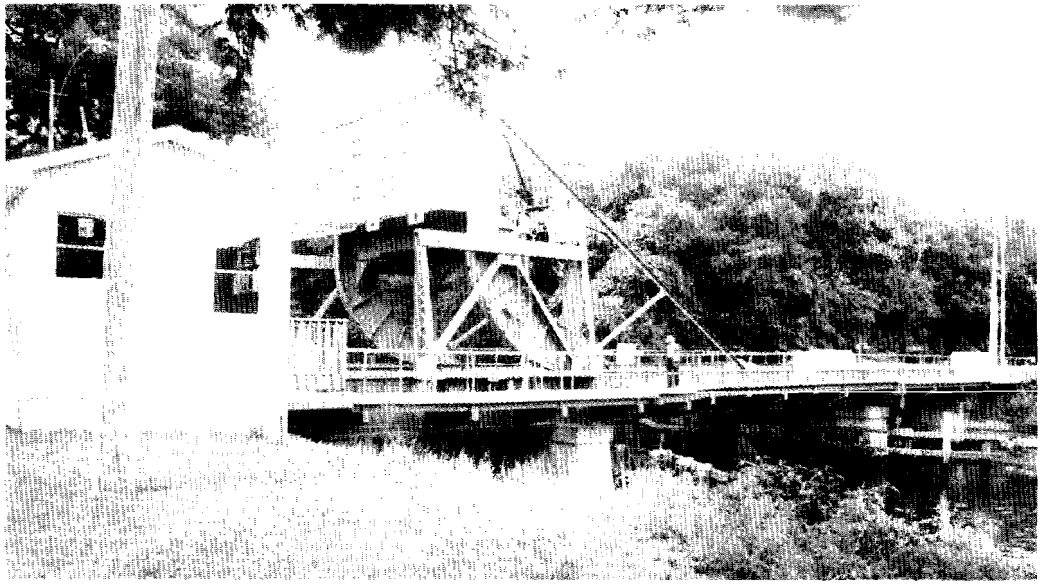
Between 1893 and 1921 the Scherzer Rolling Lift Company was granted twelve patents for variations in their rolling lift bascule design. This type of movable bridge was developed in 1893 by William Scherzer for the Metropolitan West Side Elevated Railroad Company of Chicago. Scherzer designed a four-track bridge across the Chicago River near Van Buren Street, which Waddell claimed ushered in the "modern era of bascule building."

A Scherzer rolling-lift bascule bridge is characterized by its large, concrete counterweight and segmental circular moving girder. These can be seen in the photograph below of the Broadkill River Bridge which is no longer in existence. The bridge's movement occurs as it rotates on a short circular segment along a horizontal track girder. The rectangular counterweight is attached to this short, shoreward section of the moving leaf. In the main pier, below the counterweight, is a pit that receives the counter weight when the bridge is open. For a simple, single-leaf, Scherzer rolling-lift bridge three piers are necessary: the main pit pier, the rest pier for the free end of the leaf, and a shoreward pier for the approach span.

The State of Delaware owns three single-leaf, rolling-lift bascule bridges, (21A, 152 and 159), two single leaf trunnion bridges (151, 577) and one double leaf trunnion bridge (688) carrying highway traffic over navigable rivers. Bridge 152 (Laurel Bridge) is a patented Scherzer rolling lift and Bridge 151 (Seaford Bridge) is a patented Chicago trunnion. All the bascule bridges are illustrated in the following pages.



Broadkill River Rolling Lift Bascule Bridge. Note overhead counterweight.



State Bridge 21A: Milford Bridge

STATE BRIDGE 21A

State Bridge Number 21A
Rehoboth Road over Mispillion River
Milford, Kent County, Delaware
1929

State Highway Bridge 21A (Milford Bridge) is a single leaf rolling lift bascule bridge with two plate girder approach spans. The moving leaf of the bascule span measures 56'-6", while the fixed span and the south approach span measure 26'-0". The bridge width includes a 24'-0" roadway with a 5'-7" walkway cantilevered off the west side. The walkway has an unadorned pipe railing. The rolling lift bascule type, like the patented Scherzer design, is characterized by an overhead counterweight, supported by segmental girders which roll along track girders when the moving span is lifted and lowered. The Milford Bridge consists of combination steel girder and steel truss construction. The steel girder which supports the deck is a plate girder on both the moving and stationary spans, while the lifting and counterweight trusses consist of riveted members. The substructure consists of concrete piers and abutments on timber piling. All machinery, including gears and motor, is mounted above the road. There is an operator's house with stuccoed walls and a hipped roof on the north end of the bridge. Ornamental light standards top each concrete endwall.

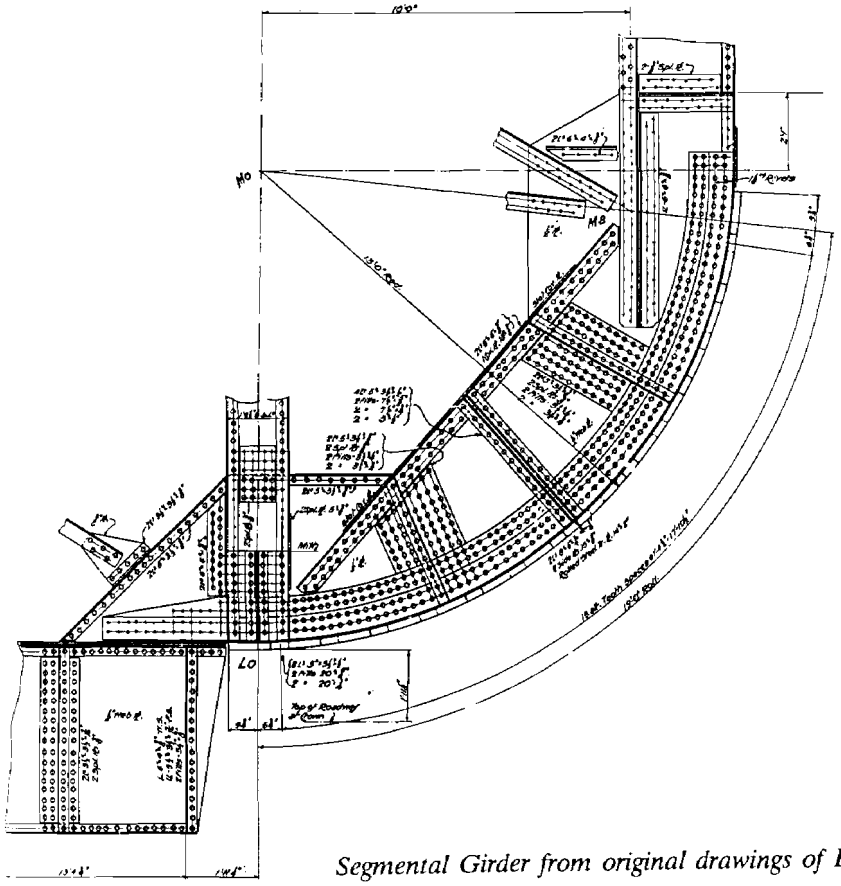
Delaware Department of Transportation records state that Bridge 21A was built in 1929 under State Highway Department contract 104 (Federal Aid Project # 50a). Similar in configuration to the patented Scherzer type, the Milford bridge was designed by Keller and Harrington, consulting engineers specializing in movable spans, and located in Chicago. Because the bridge crossed a navigable waterway, approval from the War Department was required prior to construction. Original plans on file at the Department delineate structural and mechanical details and also the operator's house. Notes on the drawings specify "A pleasing elevation, architecturally will be one of the requirements". An excerpt from these plans is presented below.

This bascule bridge was designed by Keller and Harrington, Consulting Engineers of Chicago, Illinois. Charles Lincoln Keller

received his degree in engineering from Lehigh University in 1893. He was involved in the design of numerous movable bridges throughout his career. From 1916 to 1922 Keller was president and chief engineer of the Scherzer Rolling Lift Bridge Company, located at 1616 Monadnock Block, Chicago. He later joined H.P. Harrington to form the Chicago-based engineering firm, Keller and Harrington, which specialized in movable bridges. This firm was responsible for other movable bridges in Delaware, including State Bridge #159 in Newport.

The operating machinery was fabricated by The Earle Gear & Machine Company of Philadelphia, and the structural members were fabricated by the Bethlehem Steel Company of Bethlehem, Pennsylvania. Local contractors were awarded separate contracts for the substructure and superstructure. Bridge 21A opened on August 1, 1930. The bridge was designed to AASHO Standard Specifications for Highway Bridges 1925, Live load: Class H15. Handwritten stress tables for bascule girders, truss members and floorbeams appear on the drawings. The total cost of the bridge amounted to $60,026.18, part of which was covered by the Federal Aid Program. The structure was refloored in 1952 under contract 1049, replacing timber flooring with open mesh steel.

State Bridge 21A was an important component of a project designed to relieve the congested streets of Milford's central business district by providing a bypass around the town. The new route also helped to serve the increasing traffic to beach resorts at Rehoboth. Such "cutoff" projects were among the types of major construction for which Delaware received federal aid during the 1920s and 1930s; they highlight the important role this assistance played in enabling the State Highway Department to accomplish its program of modernization and expansion of the state road network during this period.



Segmental Girder from original drawings of Bridge 21A.

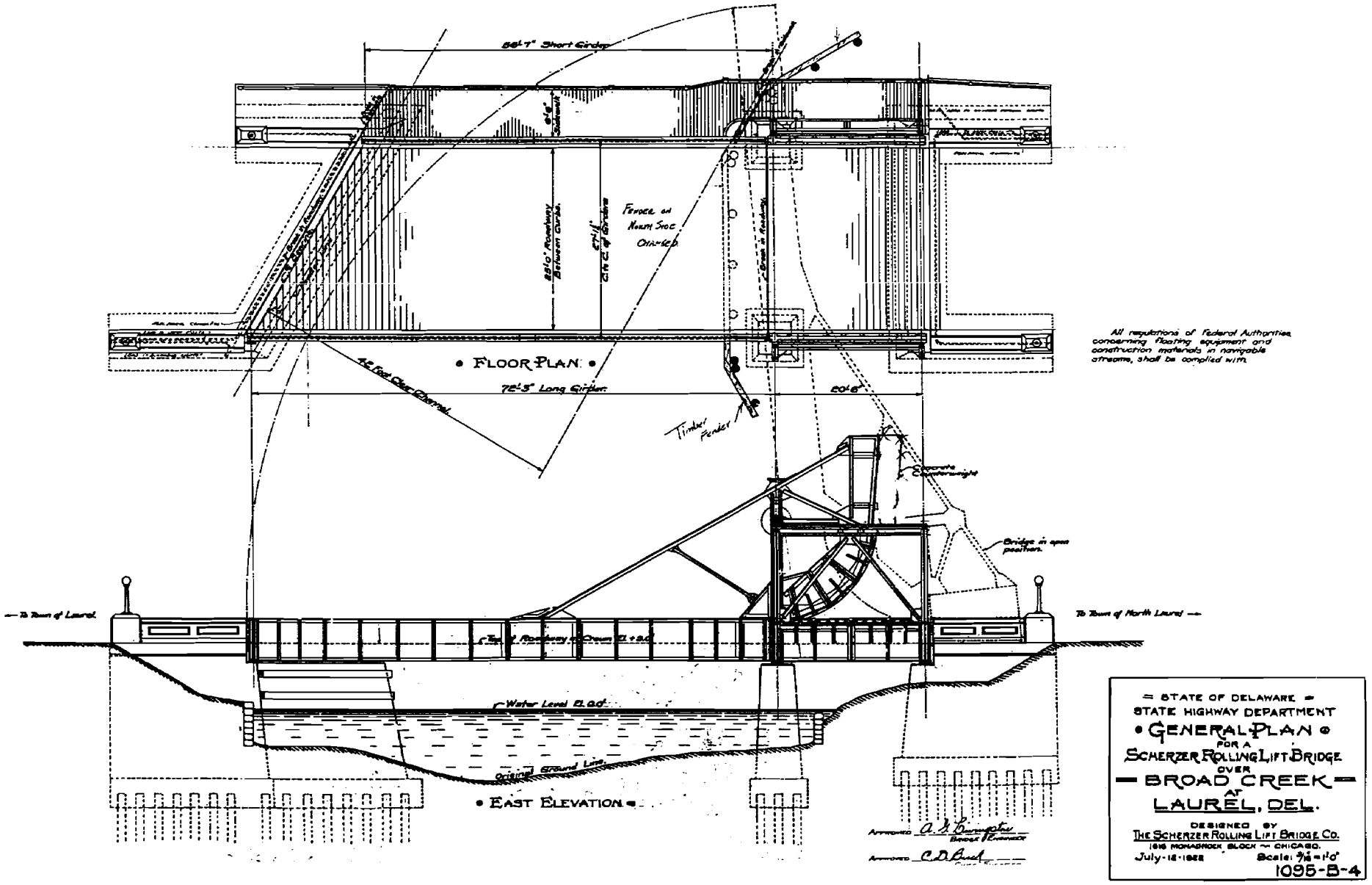
State Bridge 152: Laurel Bridge

STATE BRIDGE 152

State Bridge 152
Central Avenue (Route 13) over Broad Creek
Laurel, Sussex County, Delaware
1923

State Bridge 152 (Laurel Bridge) is a single leaf Scherzer rolling lift bascule bridge, designed by the Scherzer Rolling Lift Bridge Company of Chicago. The total structure length is 92'-9", with a skewed movable span varying in length from 56'-7" on the west side to 72'-3" on the east side; the fixed span measures 20'-6". The deck width is 25'-0" curb-to-curb with a 6'-6" sidewalk on one side. The Laurel Bridge consists of combination steel girder and steel truss construction. The steel girder which supports the deck is a plate girder on both the moving and stationary spans, while the lifting and counterweight trusses consist of riveted members. The substructure consists of concrete piers and abutments on timber piling. The south end of the movable span has a 20° skew, while the north end has a 0° skew. All machinery, including gears and a 20 HP motor, are mounted above the road. U-shaped, concrete wingwalls with incised rectangles are completed by endposts supporting simple globe lamps.

State Bridge 152 is the earliest bascule bridge surveyed in Delaware, constructed in 1922 under Delaware State Highway Department contract 41A. The movable span was designed by the Scherzer Rolling Lift Bridge Company of Chicago. It was erected by Al. S. Fox, contractor and builder, who later constructed the bascule bridge at Seaford (Bridge 151, built 1924). The DelDOT contract files note that Charles L. Keller was the consulting engineer on the project.



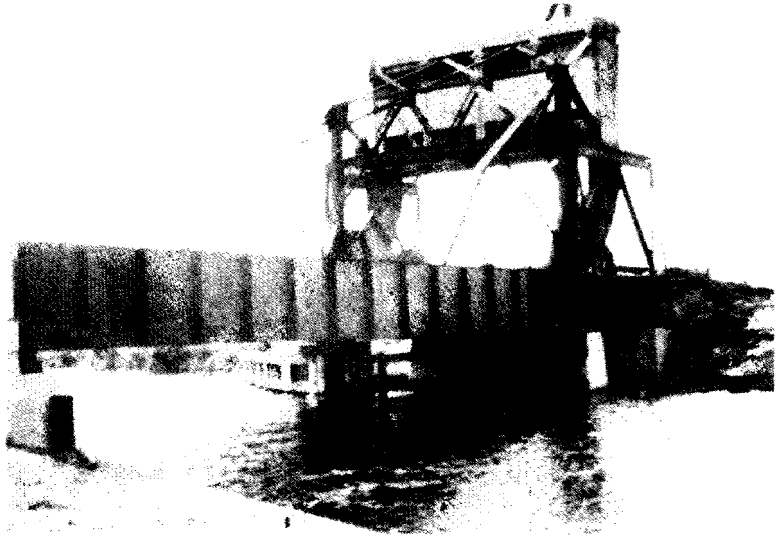
"General Plan" from original 1922 drawings for Bridge 152.

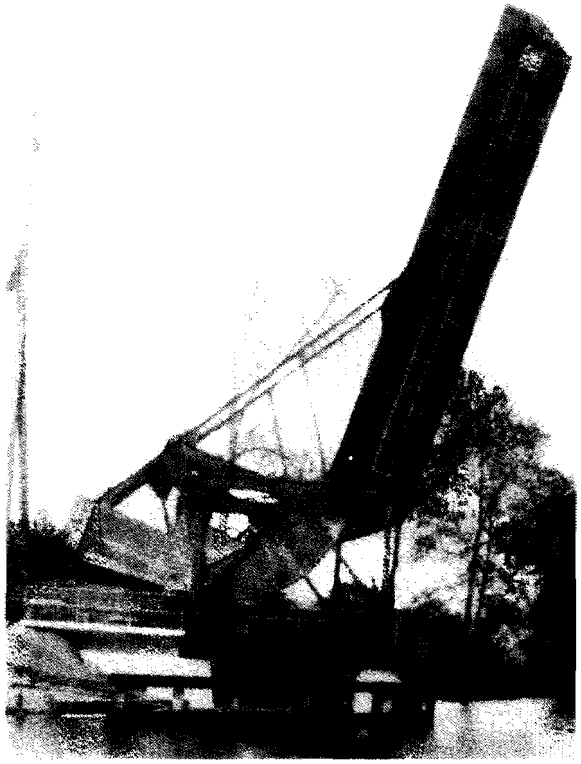
Charles Keller received his degree in engineering from Lehigh University in 1893. He was involved in the design of numerous movable bridges throughout his career. From 1916 to 1922 Keller was president and chief engineer of the Scherzer Rolling Lift Bridge Company, located at 1616 Monadnock Block, Chicago. He later joined H.P. Harrington to form the Chicago-based engineering firm, Keller and Harrington, which specialized in movable bridges. This firm was responsible for other movable bridges in Delaware, including State Bridge 159 in Newport.

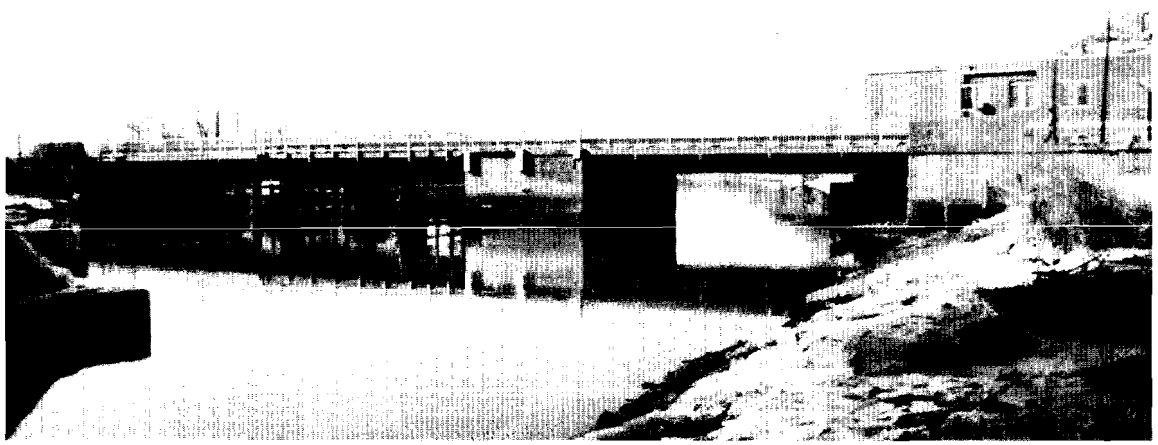
State Bridge 152 was highlighted in the 1924 Annual Report of the State Highway Department as "the most notable bridge construction of the year". Seen below are photographs from the 1924 Annual. This account reported that the substructure design was prepared in-house, and bids with plans were received for the steel superstructure. Original drawings, dated July - November 1922, illustrate the bridge's configuration and construction. A plan and elevation from these drawings are presented on the preceding page. Improvements were made in 1947 which included the addition of a walkway and the replacement of the original wood deck with a steel floor.

State Bridge Number 152 appears to be the first structure of its type built under the auspices of the State Highway Department. The Laurel Bridge is the only patented Scherzer rolling lift bascule surveyed and is a contributing element in the Laurel Historic District.

Bridge 152: "Bridge of the Year" from the 1924 Annual Report.







State Bridge 159: James Street / Newport Bridge.

STATE BRIDGE 159

State Bridge Number 159
James Street Bridge over Christiana River
Newport, New Castle County, Delaware
1929

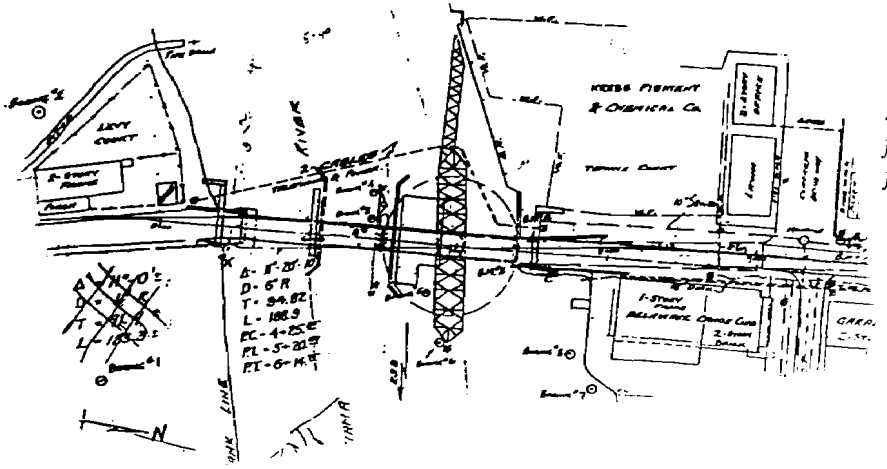
State Bridge 159 (James Street/Newport Bridge) comprises a 83'-3" single leaf, plate girder bascule span, and two plate girder approach spans measuring 63'-7" and 64'-4", for an overall length of 212'-1". The bascule span is currently inoperable. Designed by Keller and Harrington, the bascule movement occurs about a simple trunnion, with a track girder guiding the circular portion of the bascule girder within the bascule pier. The lifting mechanism is not visible; it is housed in the bascule pier below the deck, along with the counterweight. The draw span, when working, was operated by an electrically driven motor with rack and pinion gearing and a 480,000 pound concrete counterweight. The bridge carries two lanes of traffic on a 30'-0" wide roadway, flanked on each side by 7'-0" cantilevered sidewalks. There is an aluminum balustrade and handrail; ornamental light standards are located on the deck. The substructure includes concrete abutments with U-shaped wing walls.

Delaware Department of Transportation records state that Bridge 159 was built in 1929, Keller and Harrington of Chicago, Illinois, specialists in movable bridges, designed the Newport bascule bridge. Original drawings, dating from March to November 1928, document construction details for the bridge. Plan notes specified that a bascule span was the preferred type and "a pleasing elevation, from an architectural standpoint, will be required". The proposed elevation, from original drawings, is illustrated below. Original drawings indicate the bridge design included concrete balustrade and handrail, with matching steel railing over the bascule span. The notes further indicated estimates for the lift span opening were 300 times a year (60 openings for acid barges and 240 openings for ore barges), primarily providing service for barges from Krebs Pigment and Chemical Company, located a short distance northwest of the bridge. Area plans taken from the original drawings showing the old bridge and new bridge are presented on the following page. The bridge was opened to traffic on December

1, 1929; the total construction cost was $149,035.00.

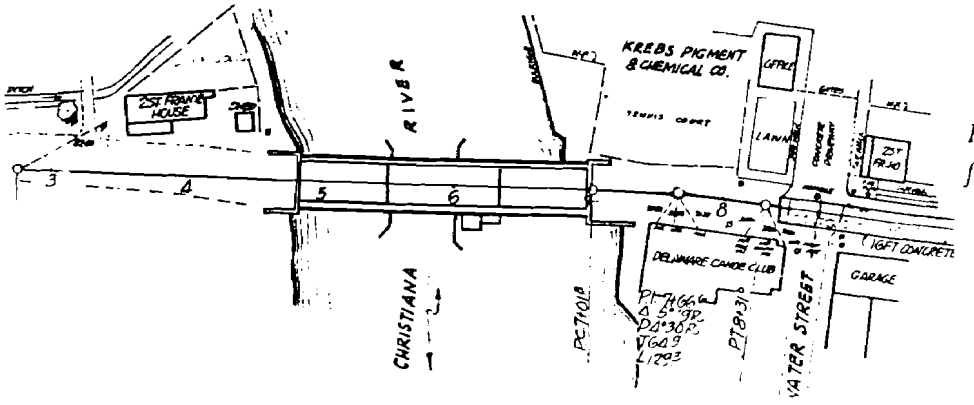
Additional drawings on file at the Delaware Department of Transportation document the replacement of the bridge floor and construction of a timber fender system in 1948-49. At that time, timber deck material was removed and replaced with a combination of 5" open and 3" I-beam interlock slab flooring. In 1966 extensive renovations were performed on the bridge and the draw span was permanently closed.

The James Street Bridge site has been a crossing for the Christiana River since at least the middle of the eighteenth century. A toll ferry operated out of Newport until 1790 at which time the Levy Court was petitioned to eliminate all fees. The New Castle Turnpike Company, chartered in 1811 by the General Assembly, was authorized to macadamize the Newport Road; the project included a bridge at this crossing. The present bascule bridge replaced an 1879 iron truss bridge built by the Edge-Moor Iron Works of Wilmington, Delaware. The 1879 bridge, seen adjacent, included a fixed 95'-0" pony truss span and a manually operated 92'-0" pony truss swing span. Rubble masonry piers supported the truss spans. The piers were reconstructed in 1920 and the swing span was reinforced.

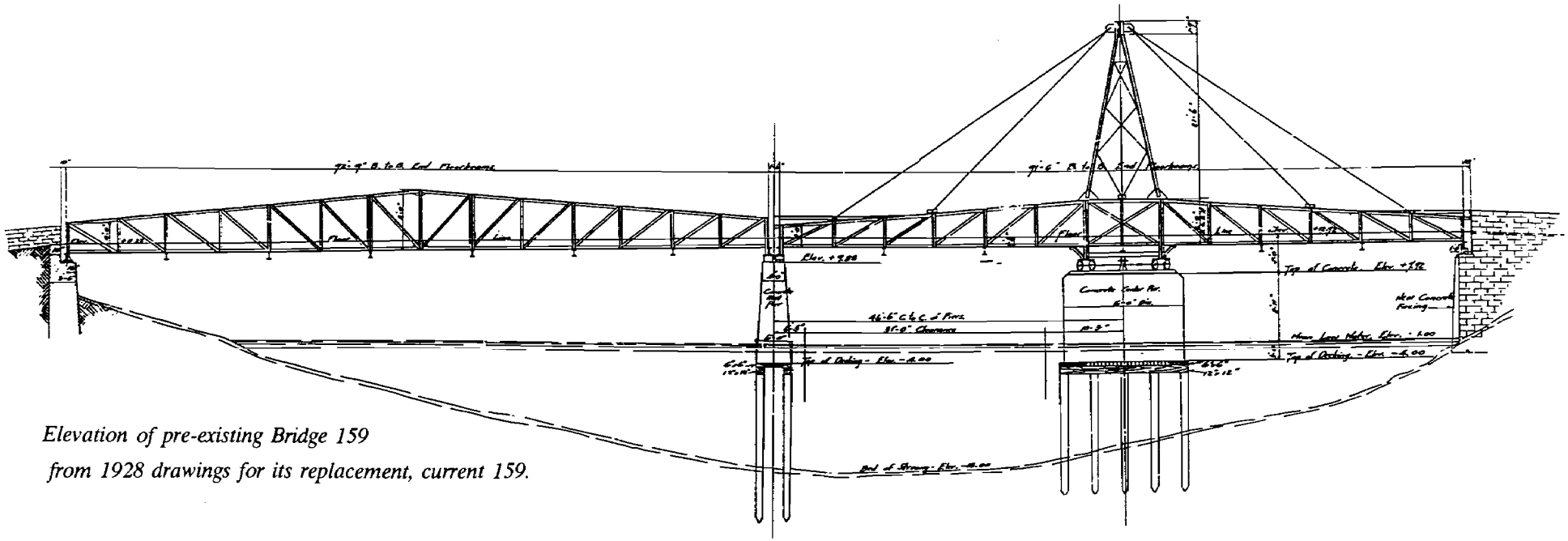


Plan of pre-existing Bridge 159 from 1928 drawings for current Bridge 159.

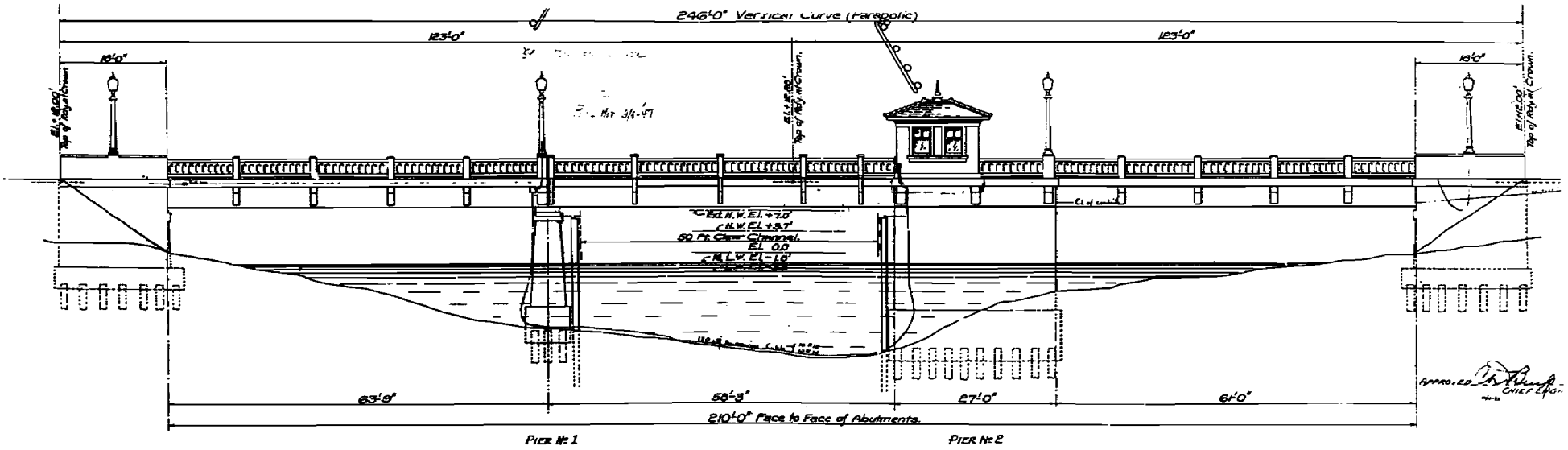
Photograph of pre-existing Bridge 159 from photo-archives of New Castle County.



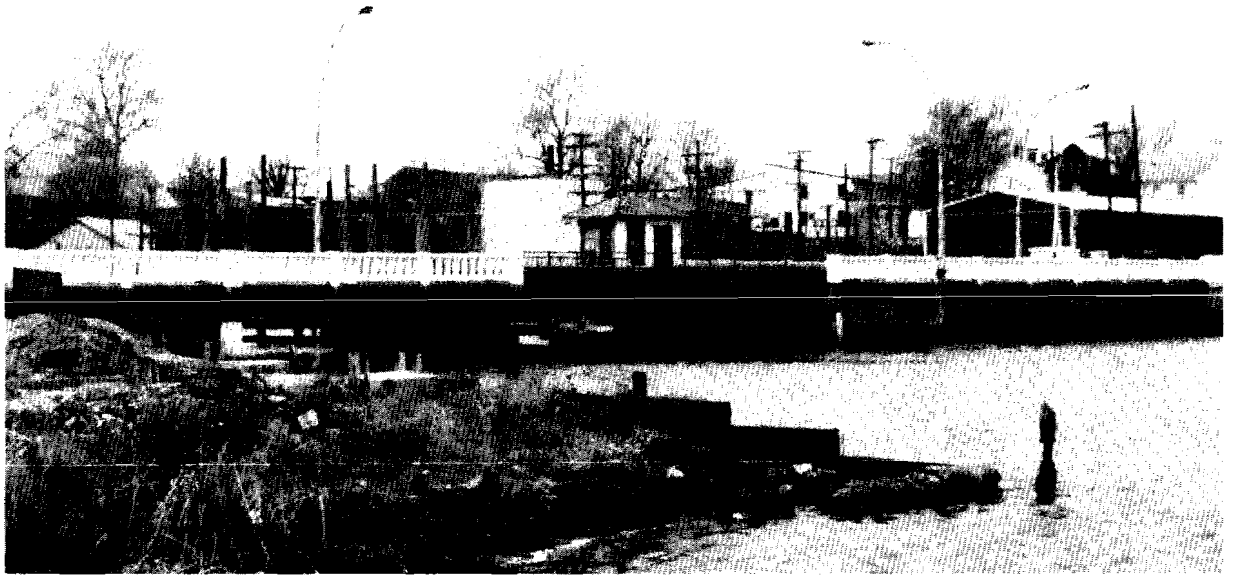
Plan of current Bridge 159 from original 1928 drawings.



Elevation of pre-existing Bridge 159
from 1928 drawings for its replacement, current 159.



East Elevation of Bridge 159 from original 1928 drawings. ~ EAST ELEVATION ~



State Bridge 151: Seaford Bridge

STATE BRIDGE 151

State Bridge 151
Front Street over Nanticoke River
Seaford, Sussex County, Delaware
1924

The main span of the Seaford Bridge is a single leaf through plate girder trunnion bascule bridge, of the Chicago type. The total structure length is 224' with a main span length of 55' and a clear waterway of 40'-9". The approach spans are concrete T-beam spans measuring 33'. The roadway is 24'-0" wide with 5'-0" sidewalks on either side. Ornamental, open concrete balustrades run the length of the bridge (except at the bascule span) with four lamp posts on either side setting on slightly larger posts. The bridge is powered by a KHP motor and the counterweight consists of 305,000 pounds of composition concrete with 12,000 pounds of adjusting blocks. All machinery is concealed below the road in the bascule pier. There is an operators house at the north end of the bascule span.

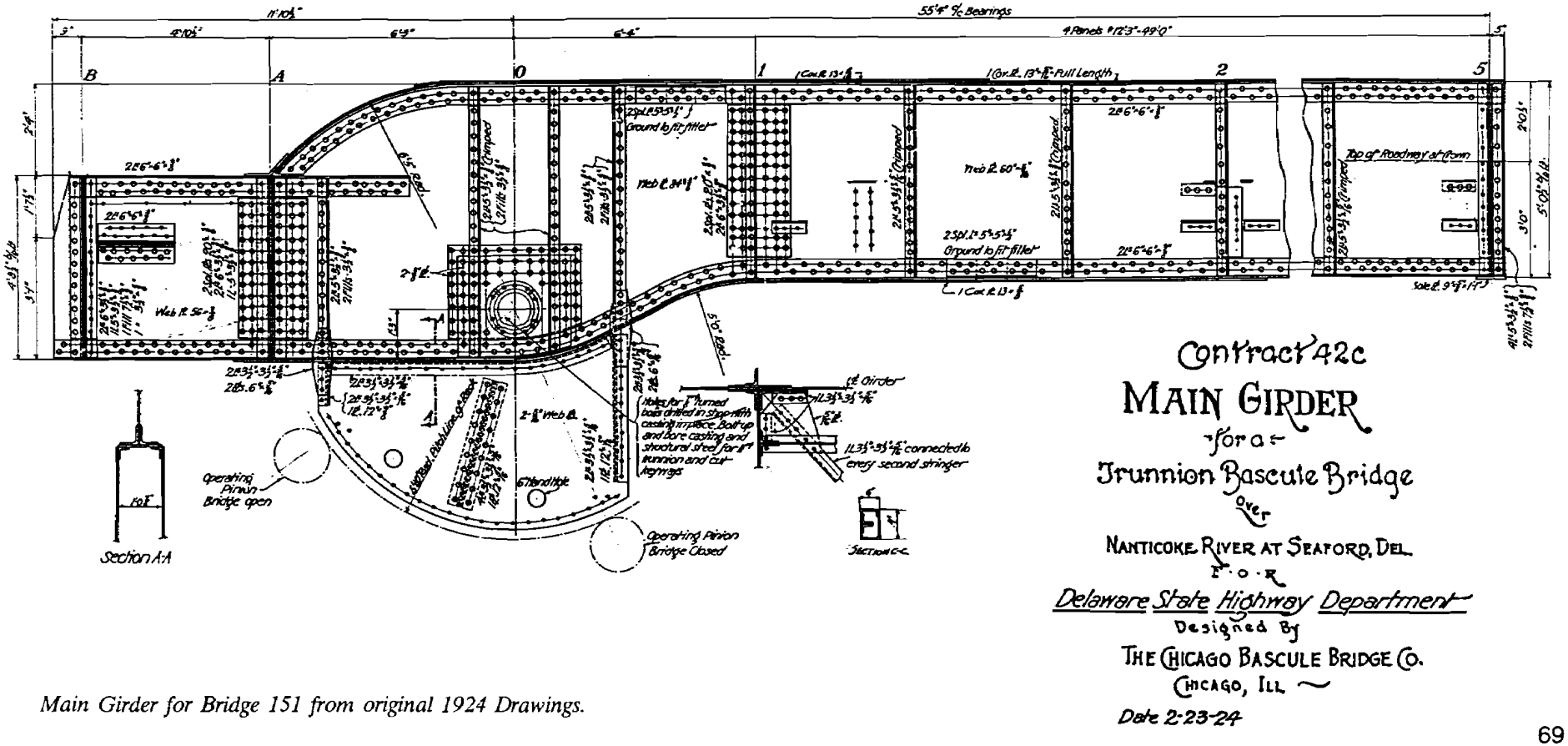
State Bridge 151 was constructed in 1924 and 1925. Original drawings and notes, dated 1923 and 1924, indicate that the bridge construction was authorized by Congressional Act SB 4346 on February 15, 1923 and that a War Department permit was issued June 30, 1923. The need for federal approval is standard procedure for bridges over navigational waters.

Bids for the substructure were received on December 19, 1923, and the contract was executed on January 8, 1924 with Imbach-Wozny-McCoy, Inc., of Baltimore, for the bid price of $69,447.00. Delaware records indicated that Henry G. Tyrell, noted bridge engineer and historian, was associated with this firm as consulting engineer at that time. Bids for the superstructure were received on April 9, 1924, and the construction contract was signed with Al. S. Fox on May 6 for $29,690.00. The bascule bridge was designed by the Chicago Bascule Bridge Company, Hugh E. Young, President, patent holders for the Chicago type bascule which

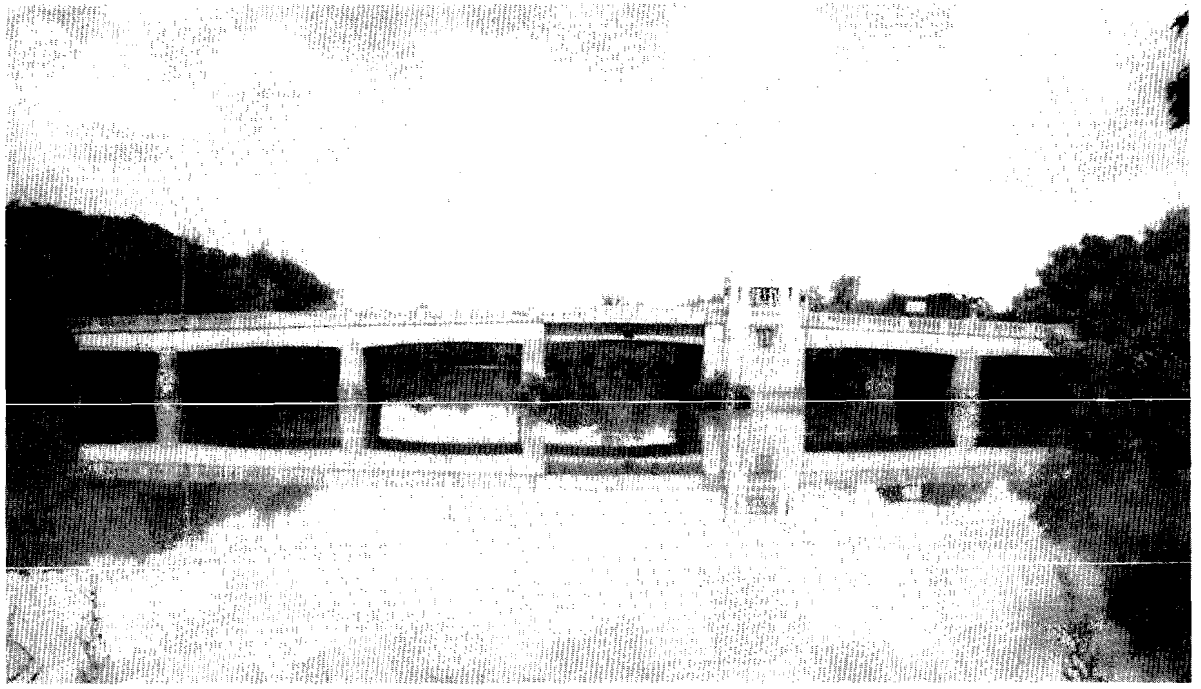
is shown below. Upon completion in 1925, it was inspected by C.L Keller, principal in the firm of Keller & Harrington; Keller wrote to A.G. Livingston, Bridge Engineer for the State Highway Department, that the construction was "well executed and is very satisfactory". Keller & Harrington designed the bascule bridges at Milford (Bridge 21A), and Newport (Bridge 159), both constructed in 1929.

The Seaford Bridge replaced a steel and timber swing span on the same location; a temporary fixed timber bridge was erected to accommodate traffic during construction. The bridge was completed and recommended for acceptance in March 1925. Improvements were made in 1951; these included the replacement of the original wood deck with a steel floor.

State Bridge Number 151 (Seaford Bridge) is one of two bascule bridges inventoried in Sussex County. The Seaford Bridge is the only extant trunnion bascule of the patented Chicago type.



Main Girder for Bridge 151 from original 1924 Drawings.



State Bridge 577: Church Street Bridge or Eleventh Street Bridge

STATE BRIDGE 577

State Bridge Number 577
North Church Street over Brandywine River
Wilmington, New Castle County, Delaware
1932

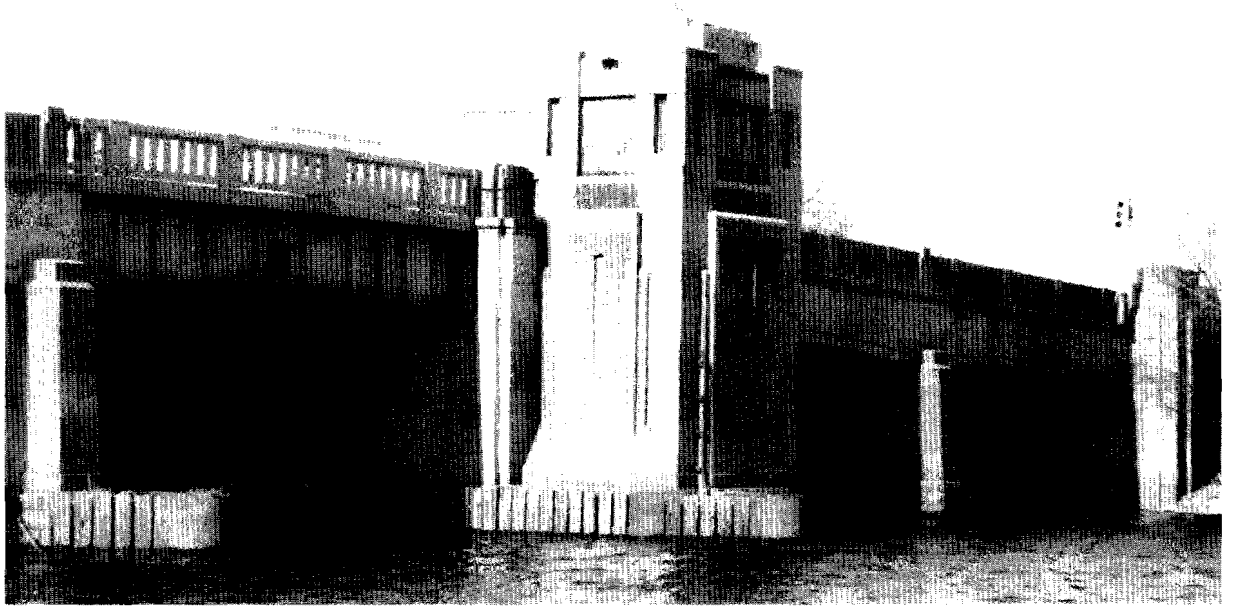
State Bridge Number 577 (Church Street or Eleventh Street Bridge) is a six span bridge, comprising a single leaf, deck girder trunnion bascule span and five reinforced concrete girder spans. The bridge features extensive Art Deco-influenced architectural detailing: the abutments, wing walls, piers, parapet, and operator's building feature a variety of battered, stepped, and striated motifs expressive of the "skyscraper style". The superstructure is supported by concrete piers with coursed ashlar bases, and concrete abutments with U-shaped wing walls. The abutments are marked by massive stepped end posts whose form is echoed in the bascule pier; the wing walls rise above grade to form an approach wall with stepped buttresses and end blocks. The piers are battered and feature vertical striations; the girders are curved to create the appearance of segmental arches between the piers. The parapet comprises a series of block forms spanned by a concrete balustrade with stepped openings. The bascule leaf is no longer operable. The bridge measures 332'-7" in length, and carries four lanes of traffic on a 44'-0" wide deck with an 8'-0" sidewalk on either side. Operating machinery is concealed below the roadway within the bascule pier.

Delaware Department of Transportation records state that Bridge 577 was built in 1932. This is confirmed by a bridge plate which also states it was built under jurisdiction of the Levy Court of New Castle County and also lists the members. The bridge replaced a steel drawbridge dating from 1869 located slightly downstream. Bridge 577 was designed by Ash, Howard, Needles & Tammen of Kansas City and New York City. The construction contract was awarded to Seeds and Derham of Philadelphia on November 10, 1931. The Concrete Steel Company, also of Philadelphia, supplied the

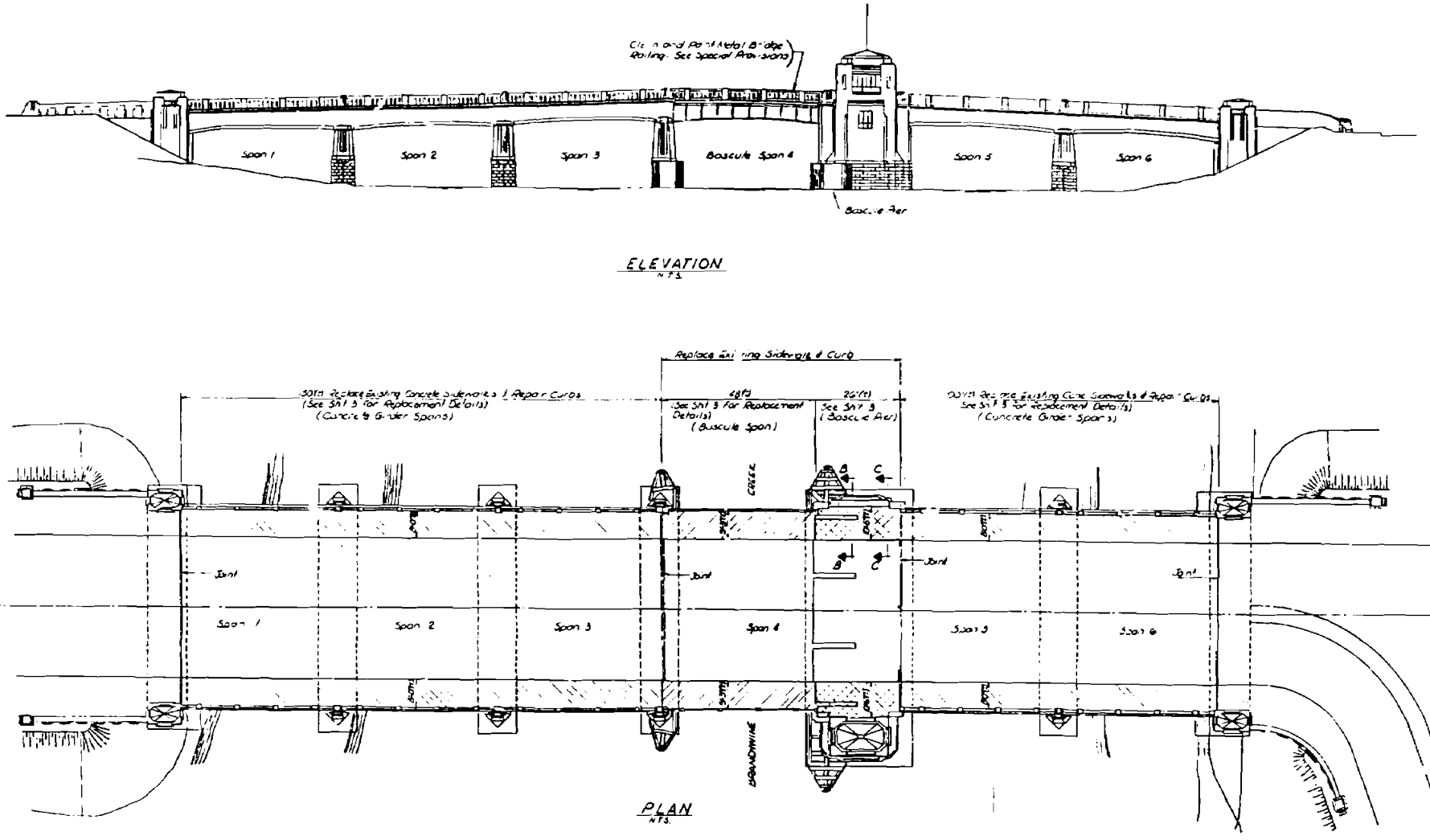
reinforcing steel; the structural steel and operating machinery for the bascule span were produced by the American Bridge Company of Ambridge, Pennsylvania. As promised by County Engineer, Shaw, the bridge project provided the opportunity to create much needed jobs for area residents suffering from the Depression.

The contract specifications note additional details of the bascule bridge. The counterweight, made of concrete, is offset by cast iron balance blocks. An electric motor operates the bascule leaf, supplemented by an auxiliary hand mechanism. The operator's house stands at one end of the bridge, finished in light gray brick "to match the color of the finished concrete surfaces" of the bridge. The specifications provided that the piers be embedded in solid rock and required that the contractor assume the cost of any change in the depth of the piers beyond that stated in the plans; such a change proved necessary, generating a cost increase of $6952.32. The concrete piers were required to be faced with ashlar masonry. The plan and elevation from original drawings are illustrated in the adjacent drawings. Notes on original drawings indicate the structure was designed for 60 ton electric railway cars, while notes on the 1968 repair drawings indicate that the trolley tracks and original timber roadway were removed, and the span was made a fixed span with all machinery left intact in 1952. Delaware Department of Transportation records indicate that repairs have occurred in 1952, 1963, 1968, and 1984.

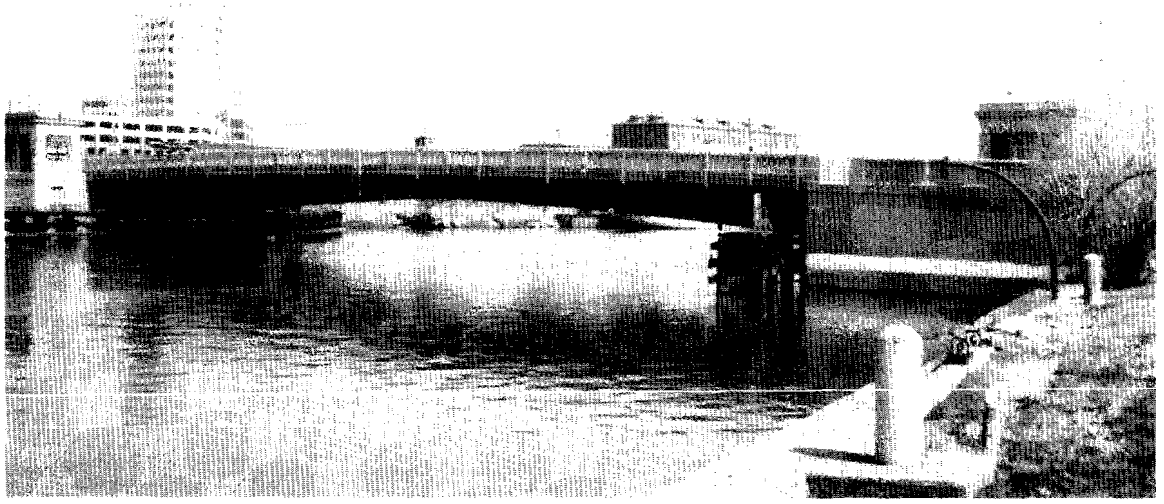
State Bridge 577 is one of six remaining historic bascule bridges carrying vehicular traffic in Delaware. Although it is no longer operable as a movable bridge, the machinery for the bascule is still in place in a pit below the deck within the bascule pier; this made possible an exterior design free of visible machinery, an appropriate choice for urban settings. The bridge also derives significance from its association with the prominent engineering firm of Ash, Howard, Needles & Tammen; this firm or its associates designed five of the eight movable highway bridges surveyed in Delaware. In addition to its significance as an extant bascule bridge, Bridge 577 is an exceptional example of an embellished long-span urban bridge.



Detail bascule span and pier, Bridge 577.



Plan and elevation from 1984 rehabilitation for Bridge 577.



State Bridge 688: South Market Street Bridge

STATE BRIDGE 688

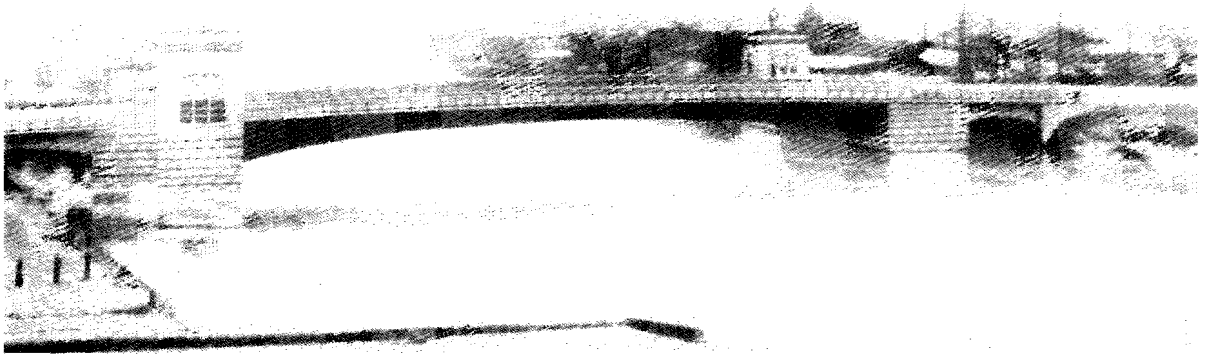
State Bridge Number 688
South Market Street over Christiana River
Wilmington, New Castle County, Delaware
1927

State Bridge Number 688 (South Market Street Bridge) is a 208'-0" double leaf trunnion bascule bridge of plate girder construction. It carries three lanes of traffic on a 38'-0" wide deck, and has a 6'-0" sidewalk with a simple metal railing cantilevered off each elevation. The underside of the bascule girders is curved to form a segmental arch. Plate girder floor beams support a deck of steel grating. There are two operator's towers constructed of tan brick with corbeling and rustication, featuring hipped roofs with sheet metal cornices and roof covering. The abutments and U-shaped wing walls are concrete; the wing walls support concrete parapets with incised panels and striations and a peaked coping. The operating equipment is concealed below the roadway in the bascule pier. A plaque indicates the bridge was constructed in 1927 and designed by the firm of Harrington, Howard and Ash. The State Bridge Engineer was listed as A.G. Livingston and the State Road Commissioners were listed.

Delaware Department of Transportation records state that Bridge 688 was completed in 1927 to replace an 1883 245'-0" pin connected Warren through truss swing span which can be seen in various construction photographs shown in following pages. Drawings dated August 1925 on file at the Delaware Department of Transportation document the configuration of the swing bridge which formerly existed at the site, and include specifications for the design of the replacement structure. The new bridge was required to be operated electrically and have a 38'-0" clear roadway with two 6'-0" sidewalks. It was to have a clear opening of 160 feet for the passage of boats, and was to be located at the center of the stream or to the south; a note indicated that the south opening was preferred by navigators, because of a bend in the river. The specifications advised that "the design submitted should give careful consideration to architectural features as the bridge is used by all North and South traffic and a pleasing structure to the eye is desired". A rendering published in the 1926 Annual Report illustrates the proposed bridge and is presented on the following page. Drawings for Bridge 688 are dated July 1926, and document the details of

construction, materials, machinery and operation of the bascule bridge. Excerpts from these drawings are presented at the end of this section. Harrington, Howard and Ash of Kansas City and New York were the structural consultants for the design. The span's steel was fabricated by the Bethlehem Steel Corporation. The balustrade shown in the plans incorporated lattice and scroll work. The final cost of the bridge amounted to approximately $545,000, about 8% over bid. Original specifications call for creosoted timber as the decking material; this was replaced with steel grating in 1946. A general rehabilitation was undertaken in 1981-82.

Historically, the crossing of the Christiana River at South Market Street has been an important component in Wilmington's transportation routes. The river was first bridged at the South Market Street location in 1808 when the Wilmington Bridge Company opened its toll swing bridge.



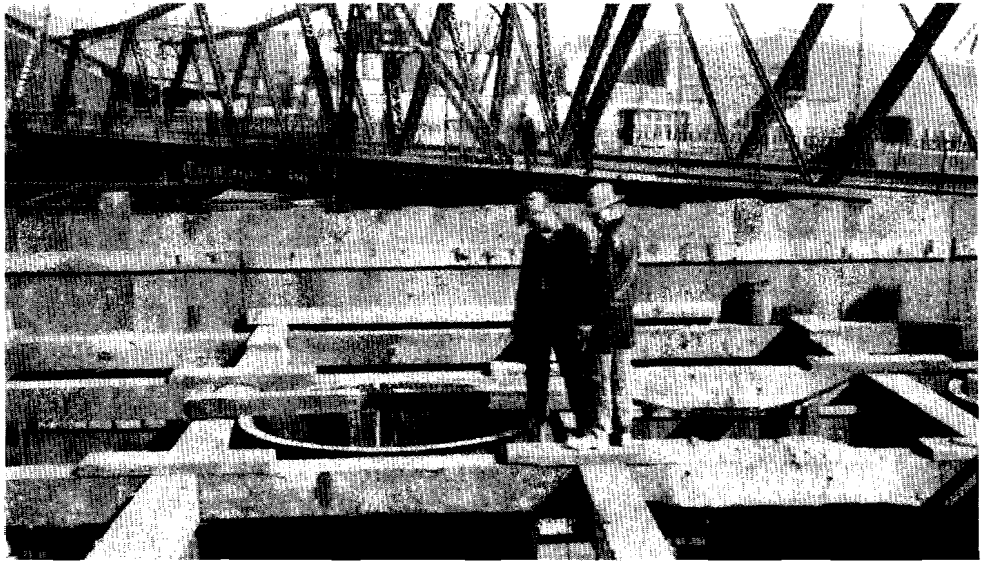
Rendering of proposed Bridge 688 from 1926 Annual Report.

Chartered by the General Assembly, the Wilmington Bridge Company was composed of private citizens who supported a bridge at this location and raised $15,000 for its construction. Prior to the construction of the first movable bridge at this site, people crossed the Christiana River by ferry. The wooden "turn bridge" initiated a long history of movable bridges at this site and operated as a tollbridge until 1851 when the county assumed control of the bridge. It was replaced in 1883 by a truss swing span and then in 1927 with the present double leaf trunnion bascule bridge.

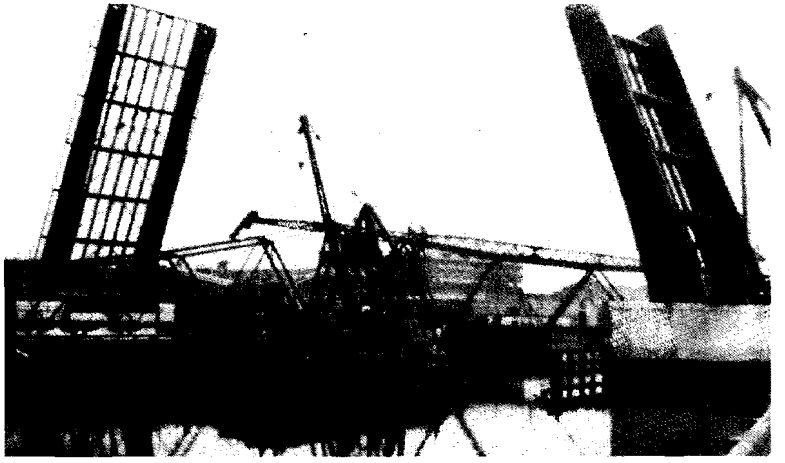
The South Market Street Bridge opened with a large, crowded ceremony on November 11, 1927, Armistice Day. Senator Tasker L. Oddie of Nevada addressed the audience with comments relating to the development of roads and bridges in Delaware and the nation. Activities such as a pageant were also held in honor of Armistice Day.

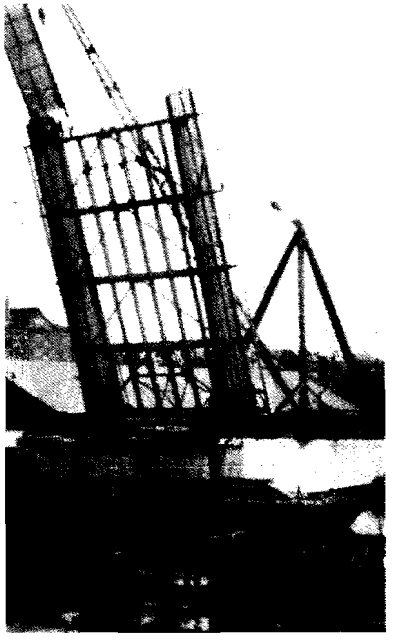
Bridge 688 was designed by the firm of Harrington, Howard and Ash of Kansas City, Missouri, who made movable bridges a specialty; several of the movable bridges surveyed in Delaware were designed by the principals of this firm or its successors. John Lyle Harrington and Ernest E. Howard both began their bridge-building careers in association with J. A. L. Waddell, whose

1892 design for a vertical lift bridge at South Halstead Street in Chicago had established his eminence as a pioneer of the type. Harrington went to work in Waddell's office in Kansas City, Missouri, after graduating from the University of Kansas in 1895; he left to pursue further education and worked for a succession of bridge companies until 1907, when he returned to Kansas City to enter a consulting practice in partnership with Waddell. It was there that he met Howard, who had been working with the firm of Waddell and Hedrick since 1901 as draftsman, designer, and resident engineer.



Construction progress photograph of Bridge 688. Note truss bridge left standing to carry traffic during construction.

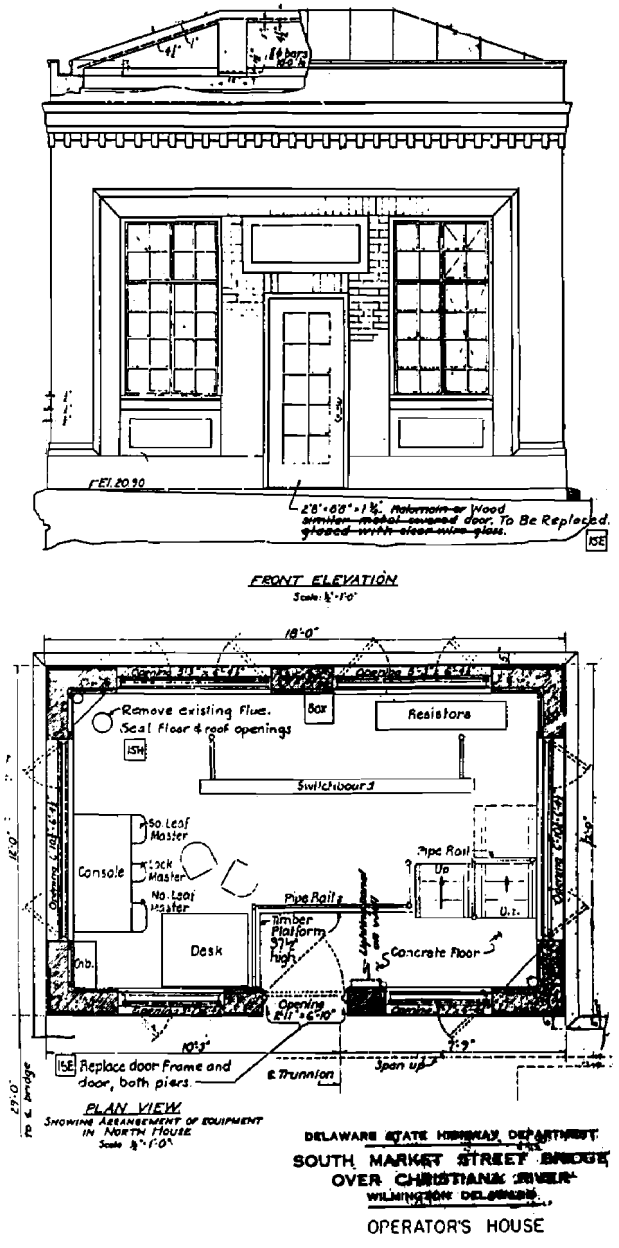


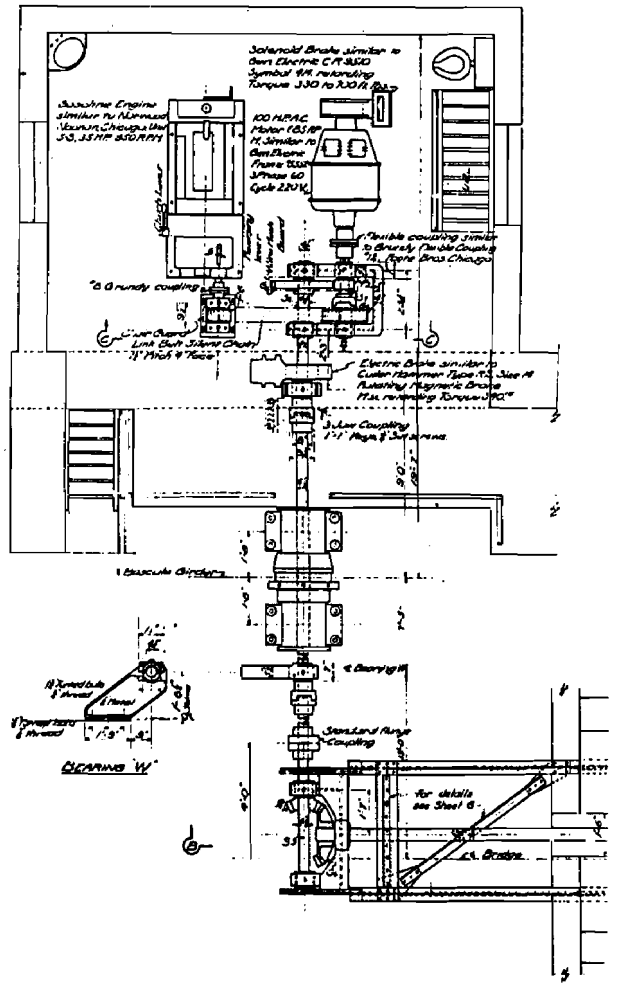


Bridge 688.
Construction photographs published in 1927 Annual Report.

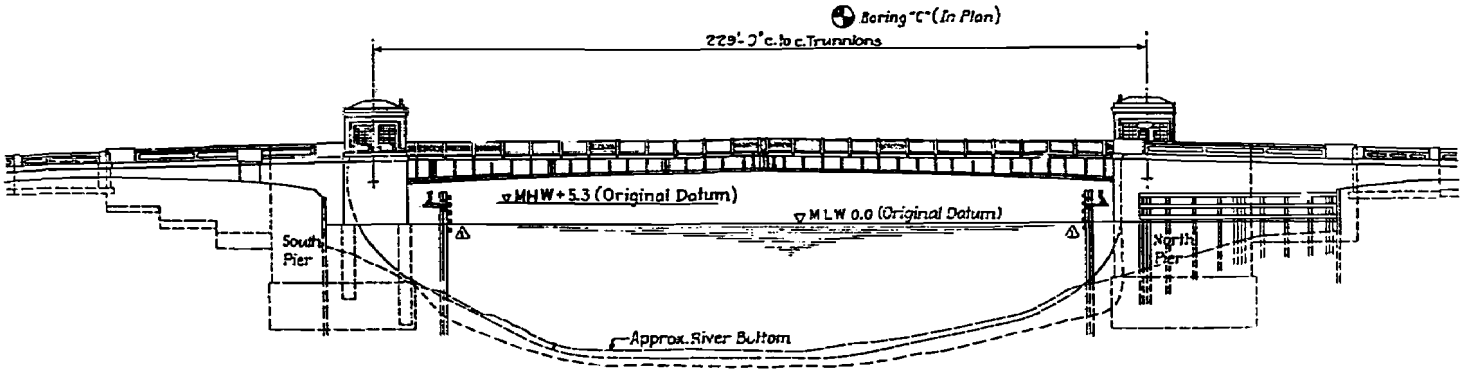
Upon the 1907 reorganization of the firm as Waddell and Harrington, Howard assumed the position of associate engineer. In 1914, Harrington, Howard, and Louis R. Ash formed Harrington, Howard & Ash which designed and constructed bridges until 1928. In addition to Bridge 688, their work in Delaware includes Bridge 393, a center bearing, plate girder swing span and one of two remaining highway swing bridges in Delaware. They also were consulting engineers for the Rising Sun Bridge over the Brandywine Creek (#1), the only remaining through truss highway bridge identified within the state. Howard and Ash became associated with the firm of Ash, Howard, Needles and Tammen which produced the bascule bridge carrying North Church Street over the Brandywine in Wilmington (Bridge #577, built 1932). Both Harrington and Howard patented numerous improvements to movable bridges; both held offices in national professional organizations, and Howard contributed several articles to professional journals.

State Bridge 688 continues to function as a movable bridge. In addition to its significance as an extant bascule bridge, Bridge 688 has technological significance and derives additional significance from its association with a prominent engineering firm, and as an example of an embellished urban bridge.





"Operator's House" from original drawings for Bridge 688, dated 1926.



ELEVATION
Scale: 1' - 20'

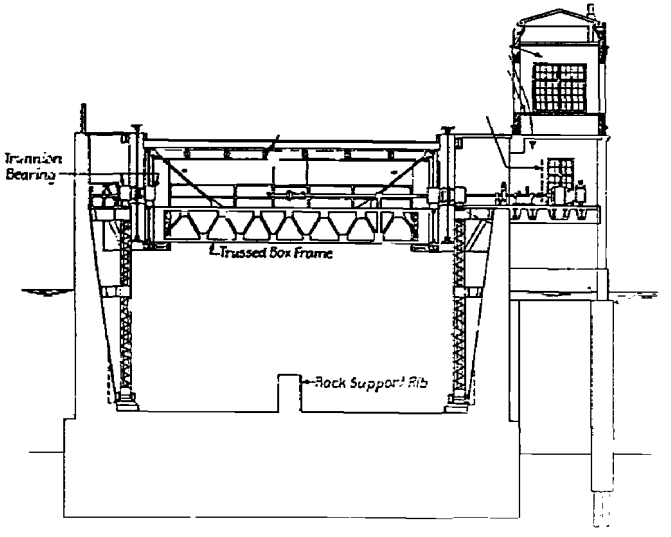
SYNOPSIS OF OPERATION

To Open the span

1 Close the gates, closing those to "oncoming" traffic first.
2. When all gates are closed the contactor in the lock circuit is closed and the lock can be opened.
3 When the lock is fully open the contactor in the control circuit is closed giving current to x + y. The controller must be brought to the "off" position to close the low voltage relay and complete the control circuit.
4 Move the controller to the 1st position and the circuit is made through bc and "a" and the brakes are released.
5 Move the controller to the 2nd position and the circuit is closed through 1 + x closing the directional switch in the motor circuit and current is applied to the motor circuits with full resistance in.
6. Move the controller to the 3rd position and one step of resistance is cut out. Each step of resistance is cut out as the controller is advanced. The speed of closing of the contactors is regulated by the definite time relays.
7. When the leaf is 4" from end of movement current is cut off by the limit switch and the Emergency brake is applied. To further operate the leaf the controller must be brought to the "off" position again, and the circuit is completed by closing the push button in the "limit switch" circuit and using the controller as before.

To Close the span

8 Proceed as in 4,5,6,+7, above, except move the controller in the reverse direction.
9 Close the locks.
10. Open the gates.

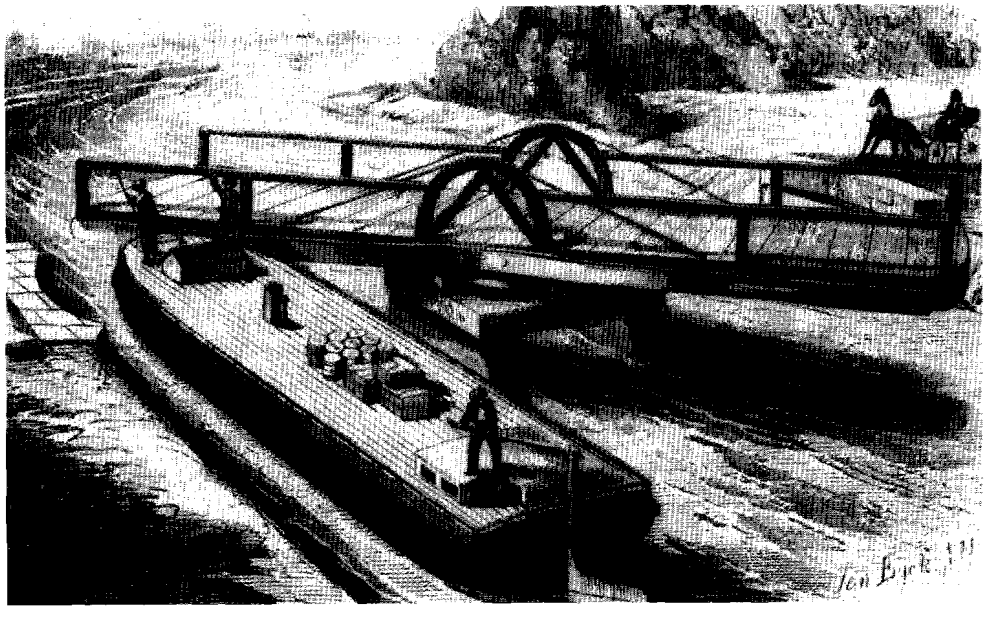


Details from original drawings for Bridge 688, dated 1926.

SWING BRIDGES

Swing bridges were the most common movable spans in use prior to 1916, according to Waddell. As mentioned above, photo archives for New Castle County show eight pre-1921 swing bridges of varying configurations, some of which are shown on the following page. No bascule bridges are recorded in these early photo archives. The earliest swing bridges were constructed of wood and were put into motion by the approaching vehicle, as illustrated by the adjacent drawing. As the rotating wooden bridge evolved to the metal swing span, its form varied. The main span could be made of plate girders, open-webbed, riveted girders, riveted trusses, or pin-connected trusses. Deck, pony and through trusses were all considered appropriate forms by Waddell. As cited in **De Pontibus**, his specifications in 1898 were:

Spans up to 140 ft	Plate girders
Spans 140 - 225 ft	Pin-connected Pratt trusses with parallel top chords and stiff diagonals in panels where stress reversal occurs.
Spans 225 - 300 ft	Pin-connected Pratt trusses with broken top chords
Spans greater than 350 ft	Pin-connected trusses with sub-divided panels



"Selser's Self-Closing" Early Swing Bridge.

In general, the 1898 design requirements complied with those for fixed spans. But by the early twentieth century, the need for simplicity and rigidity in the design of truss swing spans was emphasized.. All members subject to stress reversals needed to be stiff and have riveted connections. This was particularly noted in the end posts and lower chord connections, because the continued stress reversal due to lifting and lowering the ends of the bridge when initiating and terminating rotation caused serious wear on the pins and pinholes. Riveted connections alleviated the problem as no play in the joints was possible.

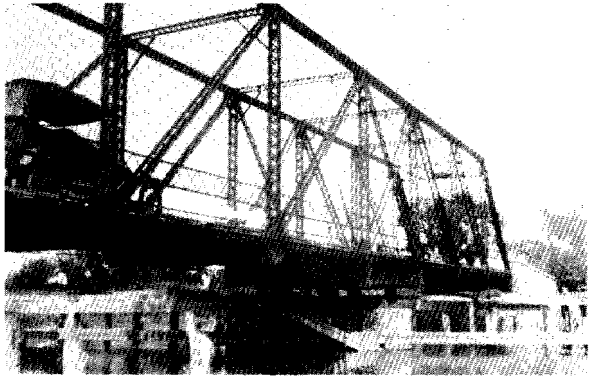
A swing-span bridge rotates on its central pier and rests in a position perpendicular to the roadway, thus opening two channels for passing marine traffic. Disadvantages of the swing-bridge type, in general, included the time required for opening and closing the bridge, the obstruction the pivot pier created in the waterway, and the uselessness of dock-front property adjacent to the opening span.

In addition to classifying swing spans by structural type, they can be differentiated

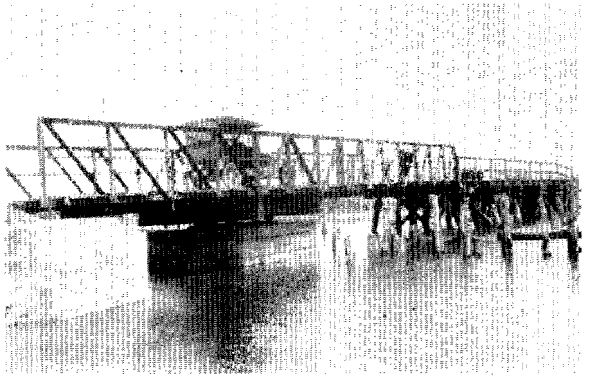
by the mode in which they rotate and are attached to the central pier. The span's weight is either supported at the center pivot (center bearing) or on small roller bearings or wheels that run on steel track a small distance from the center (rim bearing). Both of these types were in common use, each with its own advantages. Since the pivot bearing wears with use and is expensive and difficult to replace, parts which should serve only to steady the span, not carry loads, were frequently overloaded. Often a bridge designed to be center bearing would function in a rim bearing capacity. For this reason, it was recommended that center-bearing swing spans be used only for short, light spans. Long, heavy spans were designed as either rim-bearing swing bridges or combination rim-bearing and center-bearing. Solely rim-bearing swing spans had strong disadvantages and were not hastily recommended. The rollers and tracks necessary in rim-bearing spans required great care in their construction and delicate adjustments in their erection. Repair work was expensive and unequal settlement of the bridge disrupted the entire turning apparatus. The extant Delaware spans are center-bearing. Span length and site conditions controlled the choice of swing bridge form and mechanical design. Among the widely varying types of swing span bridges available, one of the most curious was the bobtailed swing span, represented in Delaware by State Bridge 393. This was a through truss that was not symmetrical about the centerline. One of the arms was shortened and counter-weighted to balance the structure about the principal planes containing the axis of rotation. It was not a common type of construction; unbalanced wind loads raised machinery costs and the counterweight added to the bridge's initial cost. The bobtailed swing bridge was used only when the pivot pier had to be on or near one of the banks and a shore arm of the usual length would interfere with the use of valuable waterfront property.

There are two remaining swing bridges carrying vehicular traffic on Delaware highways: Bridge 161, a hand-operated truss swing bridge, and Bridge 393, a plate girder swing bridge. They are both illustrated in the following section.

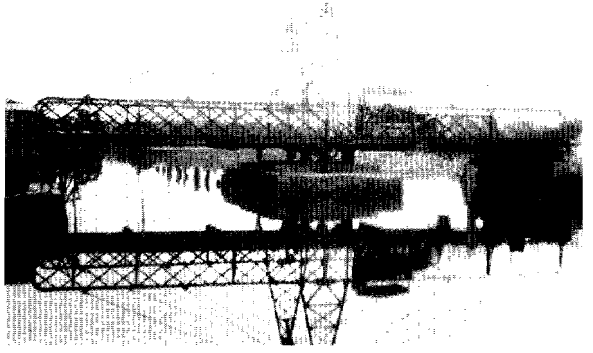
EARLY NEW CASTLE COUNTY SWING BRIDGES



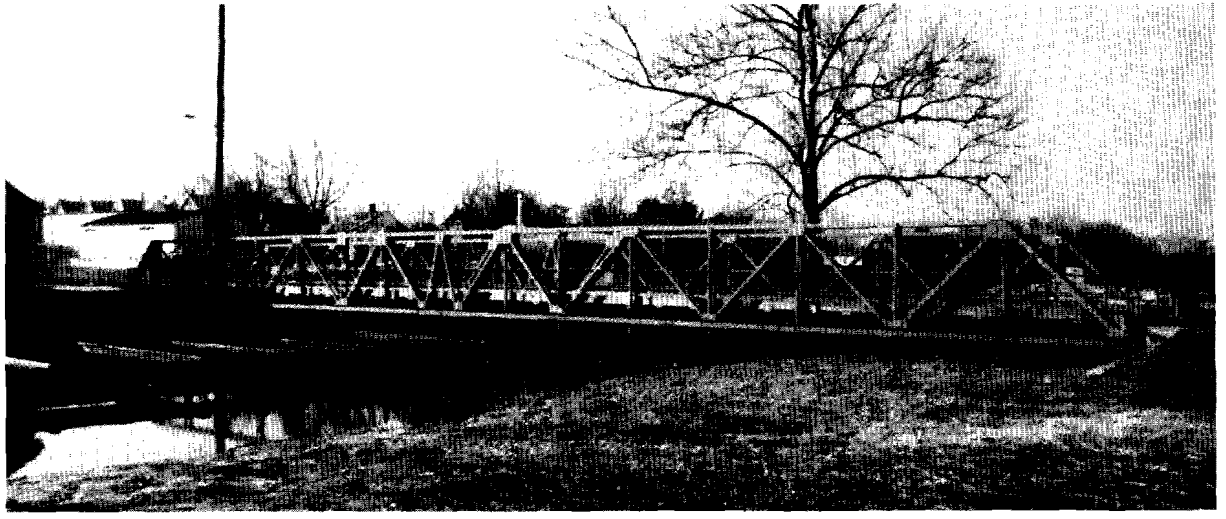
Through truss swing Bridge.
Fennimore's New Bridge, New Castle County
No longer standing.



Pony truss swing bridge.
Fennimore's Old Bridge, New Castle County
No longer standing.



Cable-stayed truss swing bridge.
Blackbird Landing, New Castle County
No longer standing.



State Bridge 161: Poplar Street Bridge

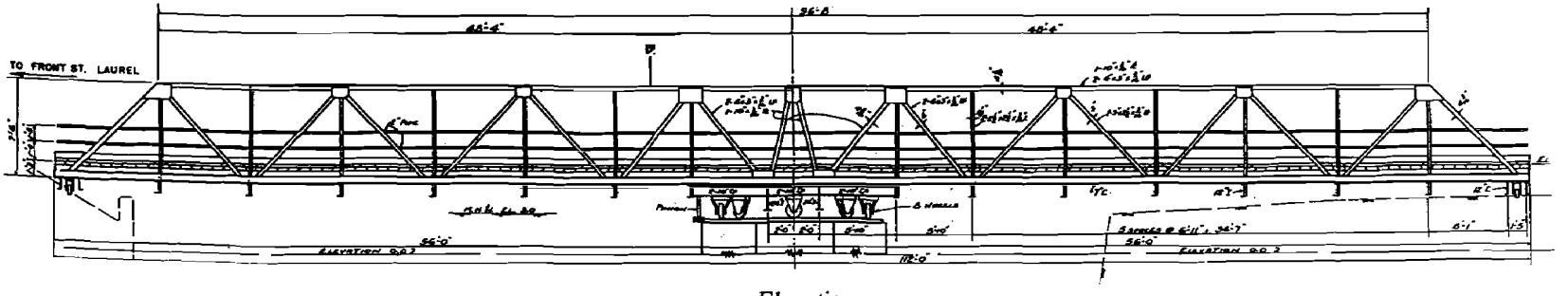
STATE BRIDGE 161

State Bridge 161
Road 28A, Poplar Street over Broad Creek
Laurel, Sussex County, Delaware
1915

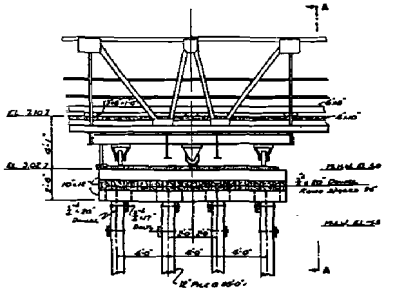
State Bridge 161 (Poplar Street Bridge in Laurel) is a hand-operated, center bearing, swing bridge consisting of Warren pony trusses. The swing bridge is 112 feet long, and consists of two 56 feet long spans. The substructure consists of a center pier of timber and concrete abutments. Measuring 14 feet wide from curb-to-curb, the bridge is considered a one lane bridge. The trusses have seventeen panel points. The top chord consists of two 4" x 3" x 3/16" angles with a 10" x 3/16" top plate. The bottom chord is a 7" channel. The struts are two 3" x 2½" x 3/16" angles and the verticals are two 2½" x 2½" x 3/16" angles. The floor system is formed by 12" I-beams at 6'-11" on center (corresponding to panel points) that run under the truss; 4" x 12" creosoted floor joists run longitudinally and are topped by 4" x 10" planking. Curbs are built up of 2" x 8" and 6" x 8" lumber. A 2" pipe forms two rows of railing. Although no longer operable, this swing bridge originally pivoted on a center bearing with eight balance wheels at the rim. The mechanism for hand-operation is visible on the deck.

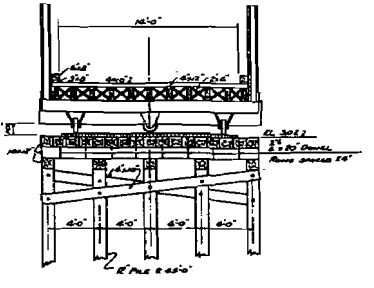
State Bridge 161 was built in 1915 as noted on 1946 plans for repairs to the Poplar Street Bridge, and on the original 1922 plans for an adjacent Laurel bridge (Bridge #152 over Central Avenue). The 1922 plans also reveal that two sets of repairs had been completed on the bridge by 1936, and that by 1943 it was in "bad shape". Repairs to improve the structural condition of Bridge #161 occurred in 1946, including the temporary removal of the truss so new timber bents could replace the original central concrete pier. Portions of the 1946 repair plans are included on the adjacent page. The contract for that work was awarded on February 27, 1946. The bridge reopened to traffic in November of the same year. Drawings from the repairs are on file with Delaware Department of Transportation (Contract No. 941) and note that the bridge opened about 100 times per year and could carry a load of 15 tons.

State Bridge Number 161 is significant as one of only two extant swing bridges surveyed on Delaware highways, and as the earliest swing bridge remaining in the state. In addition, it is a contributing element in the Laurel Historic District.

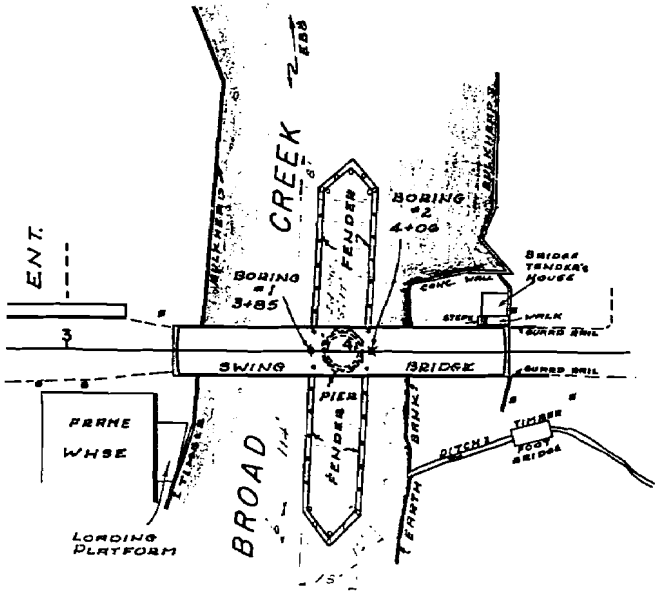


Elevation



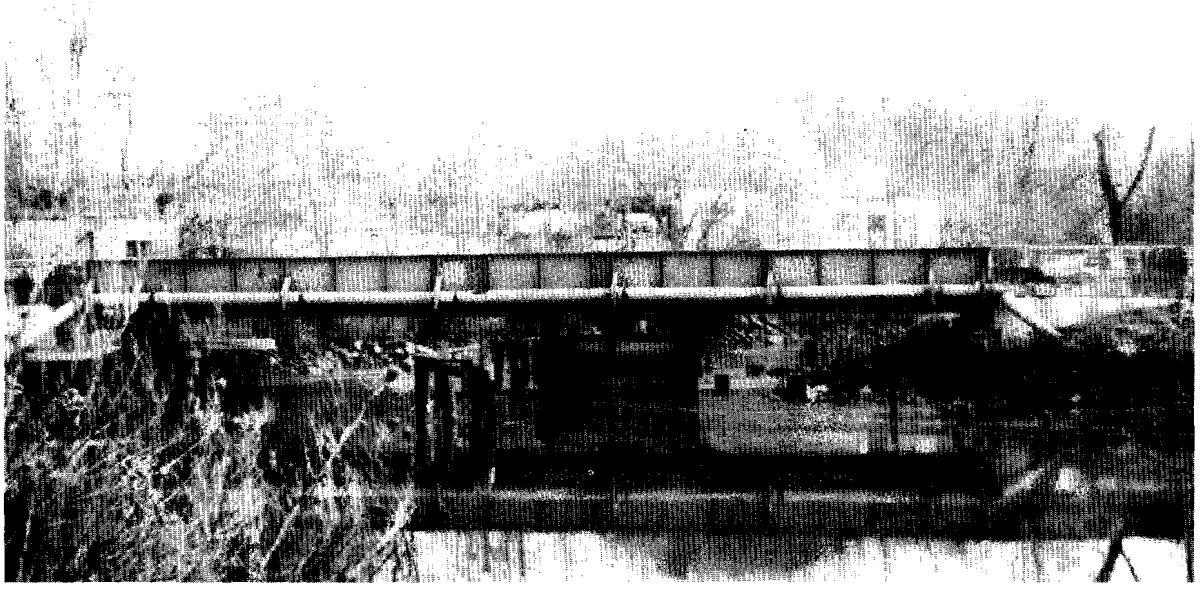


Center Pier Details



Plan

Excerpts from 1946 repair plans to Bridge 161.



State Bridge 393: Odessa Bridge

STATE BRIDGE 393

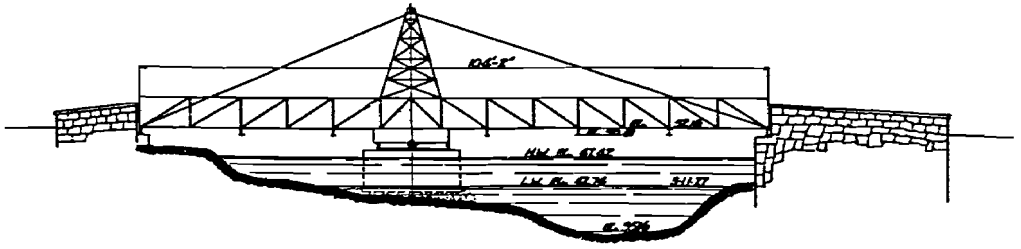
State Bridge Number 393
S. R. 299 over Appoquinimink River
Odessa, New Castle County, Delaware
1928

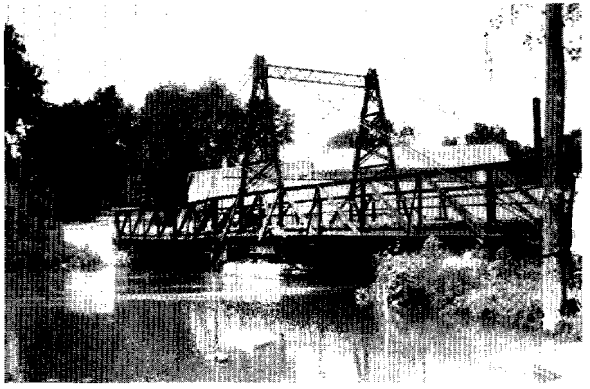
State Highway Bridge 393 (Odessa Bridge) is a 97'-1" plate girder swing bridge. This center bearing swing span has a "bob-tail" configuration; i.e, the pier is located off-center, with a 39'-4" span on the shorter, east end and a 57'-9" span on the west end. The short end thus requires a concrete counterweight to balance it. The plate girders are 6'-6" deep, with 5" x 3" angles acting as stiffeners. The concrete deck is supported on floor beams and measures 22'-6" wide; it carries two lanes of traffic. When closed the structure is supported on concrete abutments with U-shaped wing walls. The cylindrical center pier is concrete supported on timber piles. The wing walls are toped with concrete parapets, configured with solid end blocks and incised rectangular panels. A plaque indicates the construction date, 1928, and credits Charles E. Grubb, county engineer, the Selbyville Manufacturing Co., contractors, and Harrington, Howard, and Ash, consulting engineers. The members of the Levy Court are also named. The swing mechanism is no longer in use.

Delaware Department of Transportation records state that Bridge 393 was built in 1928. Photo archives at Delaware Department of Transportation indicate that the current Bridge 393 replaced an earlier, cable-stayed metal truss swing bridge. Preliminary drawings for the replacement also illustrate the previous bridge. The photograph and drawing of the earlier bridge is shown on the adjacent page. Original drawings on file at Delaware Department of Transportation, dated January 1928 show the configuration and construction details of the bridge. Excerpts from the original drawings are shown at the end of this section. According to these drawings the bridge was designed to carry two fifteen ton trucks with 30% impact. New Castle Engineer's Reports detail rural bridge bond funding for the construction of the bridge amounting to $43,236.67 and including the cost of advertising, blueprints, engineering and construction. Bridge 393

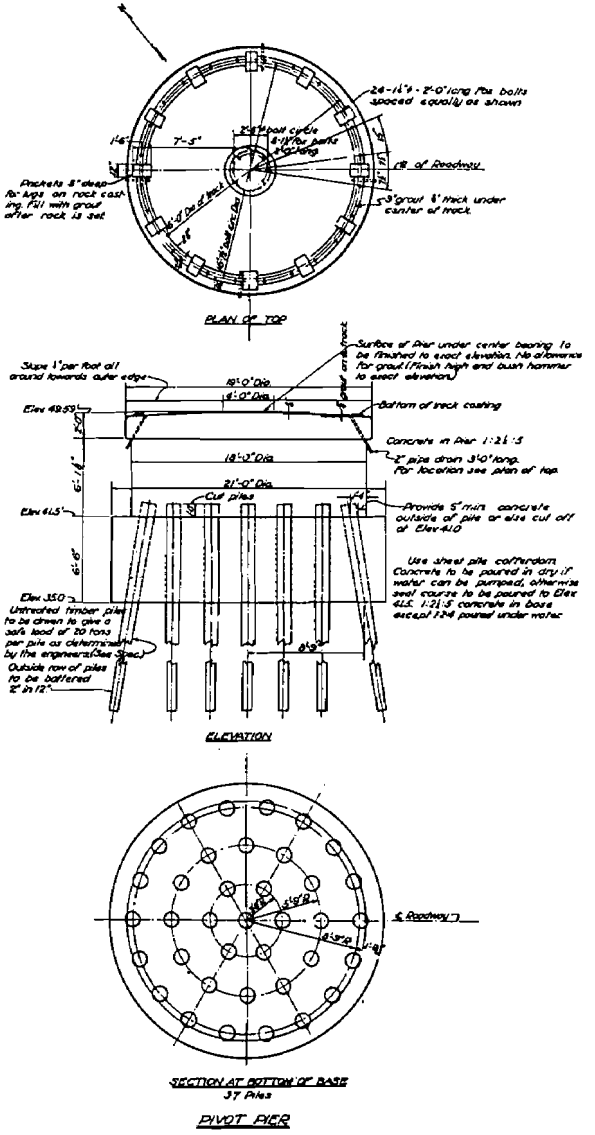
was designed by the firm of Harrington, Howard and Ash of Kansas City, Missouri, who made movable bridges a specialty; several of the movable bridges surveyed in Delaware were designed by the principals of this firm or its successors. More information concerning Harrington, Howard and Ash is presented in the section dealing with State Bridge 688, also designed by this firm.

State Highway Bridge 393 is one of two remaining historic swing bridges on Delaware highways. The Odessa Bridge is a plate girder, bobtailed swing bridge which rotates on a center bearing, appropriate to a relatively short, light span. The bobtailed form is relatively unusual.

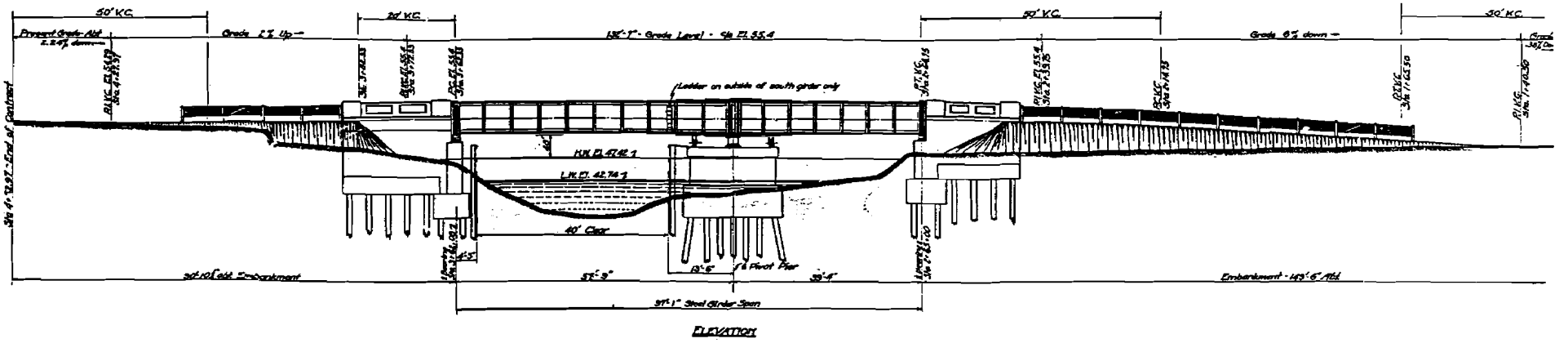


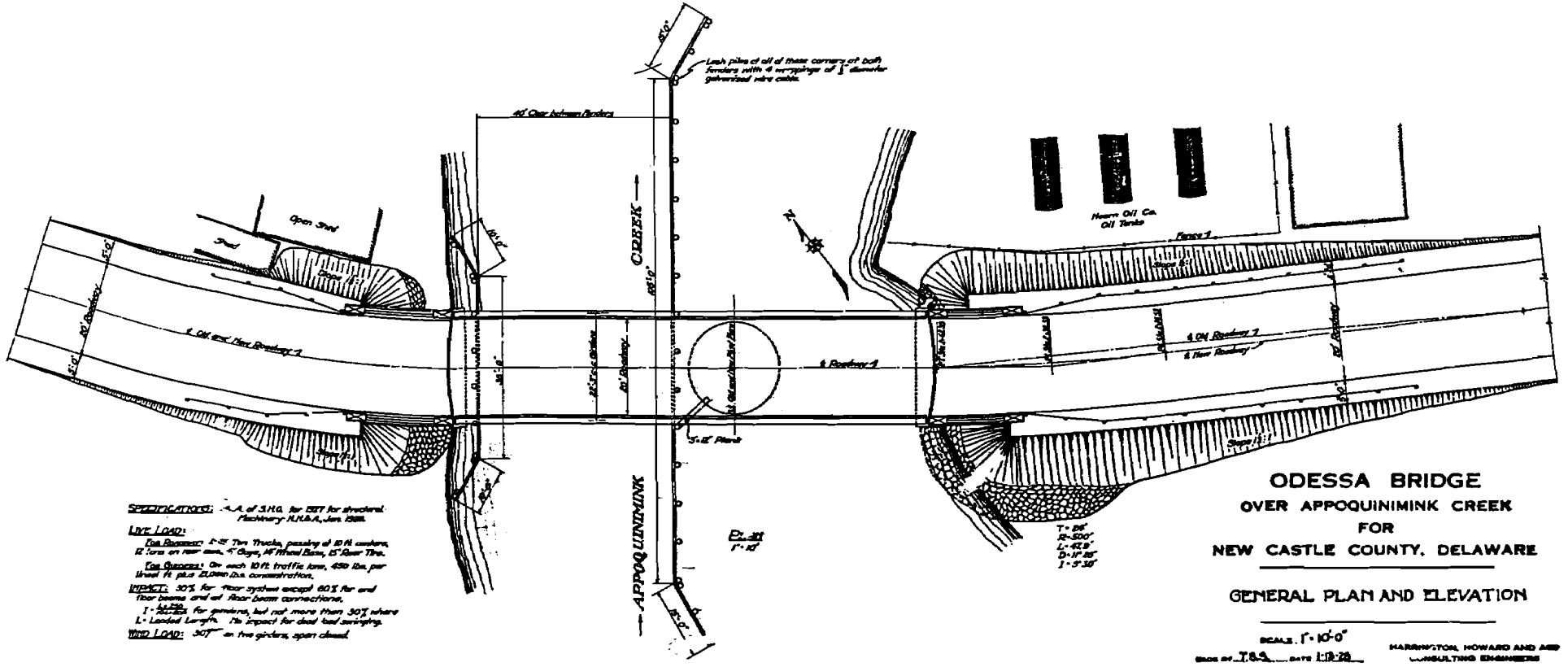


Drawing and photograph illustrating configuration of previous Bridge 393.



Center Pier Details from 1928 original drawings





ODESSA BRIDGE

OVER APPOQUINIMINK CREEK FOR NEW CASTLE COUNTY, DELAWARE

GENERAL PLAN AND ELEVATION

SCALE 1" = 10'-0"

DRAWN BY T.B.S. DATE 1-19-38

TRACED BY T.B.S. DATE 1-23-38

CHECKED BY [illegible] DATE 2-4-38

HARRINGTON, HOWARD AND AMD CONSULTING ENGINEERS

SHEET NO. 1