PENNSYLVANIA & NEW JERSEY RAILROAD, DELAWARE RIVER BRIDGE HAER No. PA-545
(Pennsylvania Railroad, Delaware River Bridge)
(Delair Bridge)
Pennsylvania Historic Railroad Bridges Recording Project
Spanning Delawere River, south of Betsy Ross Bridge (State Rt. 90)
Philadelphia
Philadelphia County
Pennsylvania

PHOTOGRAPHS

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HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
1849 C Street, NW
Washington, DC 20240

PENNSYLVANIA & NEW JERSEY RAILROAD, DELAWARE RIVER BRIDGE*

(Pennsylvania Railroad, Delaware River Bridge)
(Delair Bridge)

HAER No. PA-545

Location:	Spanning Delaware River, south of Betsy Ross Bridge (State Rt. 90), between Philadelphia, Philadelphia County, Pennsylvania, and Pennsauken vicinity, Camden County, New Jersey.
USGS Quadrangle:	Camden, New Jersey-Pennsylvania (7.5-minute series).
UTM Coordinates:	18/494035/4425635
Date of Construction:	1895-96.
Basis for Dating:	Plaque on bridge; secondary sources.
Dates of Alteration:	1958-59.
Designers:	Pennsylvania Railroad: William H. Brown, Chief Engineer, and William A. Pratt, Bridge Engineer, original; Hardesty & Hanover, consulting engineers (New York), vertical-lift span.
Fabricators:	A. & P. Roberts, agents for Pencoyd Iron Works (Philadelphia), original; U.S. Steel Corp., vertical-lift span.
Builders:	Pencoyd Iron Works, original superstructure; American Bridge Co., vertical-lift span superstructure; Charles A. Sims & Co. (Philadelphia), Drake & Stratton Co. (Philadelphia), and P. McManus Co., original substructure; John F. Casey Co., vertical-lift span substructure.
Present Owner:	Shared asset between CSX Transportation and Norfolk Southern Railroad.

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* For legal purposes, the bridge was owned by the Pennsylvania & New Jersey Railroad of New Jersey, and a similarly named corporation in Pennsylvania, which merged into the Delaware River Railroad & Bridge Company on 16 March 1896, shortly after the bridge's completion. See Coverdale & Colpitts, Consulting Engineers, *The Pennsylvania Railroad Company, Description of Important Bridges and Stations* (New York, 1945), 8, typescript in folder "PRR Office of Secretary, Studies by Consultants and Published Reference Materials, 1855-1958," Box 1, Penn Central Railroad Records, Manuscript Group 286, Pennsylvania State Archives, Harrisburg, Pa.

Present Use:	Railroad bridge.
Structure Type:	Riveted Warren truss vertical-lift span; pin-connected Petit through truss; riveted trestle bent; riveted deck girder.
Significance:	Because of its location on the lower Delaware River, the Delair Bridge has a collection of extremely long and heavy spans. These include the world's heaviest center-bearing swing span, completed in 1896, and longest double-track vertical-lift span, added in 1959. Both movable spans are still present, which is an unusual occurrence. The Delair Bridge is also significant as the first Delaware River crossing at Philadelphia, supplanting a ferry crossing for passengers and freight bound for southern New Jersey.
Historian:	Justin M. Spivey, April 2001.
Project Information:	The Historic American Engineering Record (HAER) conducted the Pennsylvania Historic Railroad Bridges Recording Project during 1999 and 2000, under the direction of Eric N. DeLony, Chief. The project was supported by the Consolidated Rail Corporation (Conrail) and a grant from the Pennsylvania Historical and Museum Commission (PHMC). Justin M. Spivey, HAER engineer, researched and wrote the final reports. Preston M. Thayer, historian, Fredericksburg, Virginia, conducted preliminary research under contract. Jet Lowe, HAER photographer, and Joseph E. B. Elliott, contract photographer, Sellersville, Pennsylvania, produced large-format photographs.

Description and History

The Pennsylvania Railroad (PRR) was the first to accomplish the goal, envisioned by many throughout the nineteenth century, of spanning the Delaware River between Philadelphia and Camden, New Jersey. In 1896, the railroad completed a bridge between the Philadelphia neighborhood of Bridesburg and Delair, New Jersey, just upstream from Camden. For three decades until the Benjamin Franklin Bridge opened to automobile traffic, the PRR's bridge (commonly known as the Delair Bridge) was the only crossing downstream of Trenton.[1] The lower Delaware's extreme width, tidal current, and soft bottom made foundation work difficult, meaning that a successful design would need extremely long spans. When completed, the Delair Bridge had 533'-0" Petit through truss spans. This was an impressive length for the time, albeit a few feet shorter than the Chesapeake & Ohio's 1889 Ohio River bridge at Cincinnati, the record-holder at 542'-6". Complicating the design further, heavy traffic on the lower Delaware required

a high bridge, or else a movable one. PRR engineers compromised by building the fixed spans 50'-0" above the water and providing a swing span for the tallest vessels. At 323'-0" in length, the swing span did set a record as the heaviest to bear on a center pivot (as opposed to a circular nest of rollers).[2] The Delair Bridge is also significant for having set records at two widely separated points in its existence. In the mid-twentieth century, PRR retained Hardesty & Hanover to design a 542'-0" vertical-lift span over a new navigation channel proposed by the U.S. Army Corps of Engineers. While setting a record for the longest vertical-lift bridge with two tracks, it was two feet shy of the overall record, set by the New York, New Haven & Hartford's single-track bridge at Buzzard's Bay, Massachusetts, in 1935.[3] As a result, the Delair Bridge hosts an unusual combination of two different movable spans in one structure (although the swing span was subsequently taken out of service).

Construction of the Delair Bridge in 1895 and 1896 held the interest of engineers around the world. What seems to be the most extensive description was in fact published by the German journal *Allgemeine Bauzeitung* (General Construction).[4] The structure was unusually long and heavy, and its construction proceeded at a remarkably rapid pace despite the difficult site. Foundation work required the efforts of three contractors, Charles A. Sims & Co. of Philadelphia, Drake & Stratton Co., and P. McManus Co.[5] Excavation work began on 15 January 1895 and the masonry piers stood complete on 1 November of that year. The year is commemorated by a plaque bearing Drake & Stratton's name on Pier No. 6, between the last main span and the New Jersey approach.[6] Erection of the superstructure by Philadelphia-based Pencoyd Iron Works progressed as the substructure was completed, and took but four months more. PRR officials and their guests rode a special train across the mostly completed span on 9 March 1896, but regular service did not begin until 19 April. The bridge eliminated a time-consuming ferry ride for Pennsylvanians heading to the New Jersey shore and an expensive transfer of freight as well.[7]

The Delair Bridge is 4,396'-0" long, of which 2,453'-0" is riveted deck girder approach trestles (see Table 1). A lengthy trestle was necessary on the Philadelphia side to carry the railroad over city streets while climbing an 0.7-percent grade to the high truss spans over the river; the New Jersey approach is mostly earthen embankment. The girder spans are mostly 40'-0", with some exceptions where the approach crosses Carbon Street (50'-3") and Delaware Avenue (77'-6") on the Philadelphia side.[8] Each trestle bent is supported by four stepped granite footings on a wooden pile foundation. The shore piers, Nos. 1 and 6, are also carried on wooden pile foundations with 190 piles in each group, driven to bearing in a sand and gravel layer and capped with a timber grillage at 30'-0" below water level.[9] All of the river piers, Nos. 2 through 5, were excavated by Drake & Stratton using timber caissons; these were rectangular, except for a hexagonal caisson accommodating the cylindrical swing span pivot pier, No. 4. Pier masonry consisted of a concrete core sheathed in large granite blocks 18" to 24" thick, or 30" in the coping, with some blocks weighing more than 20 tons.[10]

Table 1. Span table for Delaware River Bridge, original and altered configurations.

1896 configuration	Length (ft)	1959 configuration	Length (ft)
Pennsylvania approach trestle	2,129	Pennsylvania approach trestle	2,129
Petit through truss	533	Petit through truss	433
Pier No. 2	7	Pier No. 2A	52
Petit through truss	533	Warren through truss (lift span)	542
Pier No. 3	7	Pier No. 3A	53
Petit through truss (swing span)	323	Petit through truss (swing span)	323
Pier No. 5	7	Pier No. 5	7
Petit through truss	533	Petit through truss	533
New Jersey approach trestle	324	New Jersey approach trestle	324
Total	**4,396**	**Total**	**4,396**

Sources: Pennsylvania & New Jersey Railroad Co., "Bridge over the Delaware River at Philadelphia" (30 Nov. 1894), and Hardesty & Hanover, Consulting Engineers, "Delaware River, Philadelphia, PA, to Trenton, NJ, Alteration to Delair Railroad Bridge, General Plan and Elevation," (Dec. 1957); both in Conrail aperture cards.

The river spans originally consisted of three 533'-0" pin-connected Petit through truss spans, one on the New Jersey side of the 323'-0" swing span and two on the Pennsylvania side. Invented by a PRR bridge engineer, the Petit (or Pennsylvania) truss is a variant of the Pratt truss, with diagonal members in tension, a polygonally curved top chord, and intermediate floor beams hung from a secondary diagonal system. The intermediate floor beams reduce the length of longitudinal stringers between panel points, making a more efficient structure capable of spanning up to 600'-0".[11] The fixed trusses are 84'-0" deep at mid-span and divided into 66'-7-1/2" main panels, with intermediate floor beams at half that interval. In the swing span, a 60'-0"-deep pin-connected Petit through truss, the six main panels are each 53'-4", with intermediate floor beams at 26'-8". Pencoyd Iron Works used a traveling gantry crane to erect the fixed spans, each weighing 2,091 tons, on temporary wooden falsework. The swing span (931 tons including machinery) was erected in the open position, using the fender pier as a working platform.[12] Several sources, including PRR annual reports, describe the Delair Bridge as "an iron structure," but this is simply the persistence of a nineteenth-century paradigm for metal bridges; the specifications called for open-hearth steel.[13]

The Delair Bridge is most significant for its two movable spans, representing the state of the art in the late nineteenth and mid-twentieth centuries. The 1896 swing span has several innovative features, probably devised by C. C. Schneider, chief engineer of Pencoyd Iron Works' Bridge and Construction Department, who was known for his swing bridge designs.[14] At mid-span, two heavy floor beams deliver the truss's weight to the center bearing, an unprecedentedly large steel casting with a phosphor bronze bearing surface 27" in diameter. Another novel feature was the counterweighted latching mechanism, which failed to engage if the operator

closed the bridge too quickly. To Schneider's innovations, PRR signal engineers added a control system interlocked with the railroad's signal system, to prevent trains from approaching the swing span when open. The swing span was driven by a steam engine located above the clearance envelope at mid-span, designed and built by Cyrus Currier & Sons of Newark, New Jersey.[15] Records do not indicate if or when this may have been replaced by electric motors.

The Delair Bridge's vertical-lift span represents more than six decades of development in that type. A vertical-lift bridge is defined by a truss raised and lowered between two towers, balanced by counterweights falling and rising at either end. The U.S. had but one long-span vertical-lift bridge in 1896, at South Halsted Street in Chicago, designed by J. A. L. Waddell. Because of the prototype's expensive construction and questionable reliability, it was not immediately popular. John L. Harrington, Waddell's partner from 1907 to 1913, seems to have been responsible for developing the vertical-lift bridge into a practicable design.[16] Railroads subsequently embraced the design for long-span movable bridges. When, in the 1950s, the U.S. Army Corps of Engineers proposed widening and straightening the Delaware River channel to serve industry upstream, a vertical-lift span was PRR's only option for providing the necessary 500'-0" clearance. The railroad turned to New York-based consulting engineers Hardesty & Hanover, one of several descendants of Waddell & Harrington's partnership. They designed a riveted Warren through truss, 542'-0" long between bearings, to replace the fixed truss west of the swing span. Winding machinery atop each of the towers would lift the span up to 135'-0" above the high-water mark. John F. Casey Co., the substructure contractor, added a second shaft west of pier No. 3 for the east tower, and constructed an entirely new double-shaft pier No. 2A for the west tower. Because pier No. 2A was located west of No. 2, the westernmost fixed truss had to be shortened by 100'-0", resulting in its current asymmetry. American Bridge Co. shortened the truss and erected the towers around the existing bridge with minimal interruptions to traffic. Meanwhile, another crew constructed the lift span on falsework atop a barge anchored off the Pennsylvania shore. The spans were swapped out, using the rising tide to lift the fixed span off the piers and the falling tide to lower the lift span into place. Once cables were connected to the operating machinery and counterweights, the new vertical-lift bridge was ready for operation. Crews then demolished Pier No. 2 to clear the channel. The bridge remains in active service today, carrying Atlantic City-bound passenger trains as well as freight.[17]

Notes

1. "The Benjamin Franklin Bridge, 1926," in John R. Bowie, ed., *Workshop of the World: A Selective Guide to the Industrial Archeology of Philadelphia* (Wallingford, Pa.: Oliver Evans Press, 1990), 6.8.

2. Franklin Institute Committee on Science and the Arts, "Improvements in Bridge Construction," *Journal of the Franklin Institute* 150, No. 5 (Nov. 1900): 325-26; cf. "Erecting Three Notable Bridges," *Engineering Record* 42, No. 17 (27 Oct. 1900): 392.

3. David B. Steinman, "The World's Most Notable Bridges," *Engineering News-Record* 141, No. 24 (9 Dec. 1948): 92-94.

4. F. C. Kunz, "Die Brücke der Pennsylvania Eisenbahn über den Delaware bei Philadelphia," *Allgemeine Bouzeitung* 1 (1901): 5-15.

5. Coverdale & Colpitts, *Description of Important Bridges ond Stations,* 8.

6. See photograph PA-545-13. "The Delaware River Bridge at Bridesburg," *Engineering Record* 40, No. 26 (25 Nov. 1899): 594, states that foundation work progressed from January to November 1896, but this is clearly incorrect given that the bridge opened to traffic in April 1896.

7. "Completion of the New Delaware River Bridge," *Railroad Gazette* 28, No. 11 (13 Mar 1896): 184; Howard W. Schotter, *The Growth and Development of the Pennsylvania Railroad Company,* 2nd ed. (Philadelphia: Press of Allen, Lane & Scott, 1927), 240.

8. Hardesty & Hanover, Consulting Engineers. "Delair Bridge U. G. 2.07, General Plan and Elevation" (8 Feb. 1969), milepost 2.07, region/division/branch 111127, aperture card files, Consolidated Rail Corp., Philadelphia, Pa. [transferred to Norfolk Southern Railway Co., Atlanta, Ga.; hereinafter cited as Conrail aperture cards].

9. The timber grillage under Pier No. 1 was stabilized by pressure grouting in 1960; see Pennsylvania Railroad, "Philadelphia Region, Philadelphia District, D. R. R. R. & B. Co. Branch, U. G. Bridge No. 2.07, Delair Draw Bridge, Stabilizing Pier No. 1" (31 Jan. 1961), Conrail aperture cards.

10. Kunz, "Brücke der Pennsylvania-Eisenbahn," 5-6; cf. Drake & Stratton Co., "Plan of Timber Caisson and Grillage for Pier No. 4, Delaware River Bridge P. & N. J. R. R." (Jan. 1895), Conrail aperture cards.

11. See T. Allan Comp and Donald Jackson, "Bridge Truss Types: A Guide to Dating and Identifying," *History News* 32, No. 5 (May 1977): Technical Leaflet No. 95.

12. Paul L. Wolfel, "Substructure of the Delaware-River Bridge at Bridesburg, Philadelphia, for Pennsylvania and New Jersey R. R. Co.," *Proceedings of the Engineers' Club of Philadelphia* 14, No. 2 (Feb. 1897): 154-55; "Weight of a 533-ft. Span Railway Bridge across the Delaware," *Engineering-Contracting* 30, No. 23 (2 Dec. 1908): 380.

13. Pennsylvania Railroad, *Annual Report* (1896), 106; for an extract of the specifications, see "The New Delaware River Bridge of the Pennsylvania," *Railroad Gazette* 27, No. 14 (5 Apr. 1895): 216.

14. Otis E. Hovey, *Movable Bridges,* 2 vols. (New York: John Wiley & Sons, 1926), 2:36-37.

15. *Engineering Record,* "Delaware River Bridge," 595; cf. Pencoyd Iron Works, Bridge and Construction Department, "Delaware River Bridge, Penna. & New Jersey R. R., Double Track Draw Span 323'-0" c. c. end pins" (16 May 1896), Conrail aperture cards.

16. Frank M. Cortelyou et al., "Memoir of John Lyle Harrington," *Tronsactions of the American Society of Civil Engineers* 107 (1942): 1768-69, cited in U.S. Department of the Interior, Historic American Engineering Record (HAER) No. IL-156, "Pittsburgh, Fort Wayne & Chicago Railway, Calumet River Bridge," 2001, Prints and Photographs Division, Library of Congress, Washington, D.C.

17. Larry DeYoung, "Delair Bridge," in *Workshop of the World,* 14.9-14.10; "PRR Bridge Will Set a Record," *Railway Age* 145, No. 3 (21 Jul. 1958): 18-33.