Rock Island Arsenal
Rock Island Bridge
(Government Bridge)
Fort Armstrong Avenue
Rock Island
Rock Island County
Illinois

HAER No. IL-20-B

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, D.C. 20013-7127

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HISTORIC AMERICAN ENGINEERING RECORD

ROCK ISLAND ARSENAL
ROCK ISLAND BRIDGE
(Government Bridge)
HAER No. IL-20P

Location:	Fort Armstrong Avenue, Rock Island Arsenal, Rock Island, Rock Island County, Illinois UTM: 15.703050.4599300 Quad: Davenport East
Date of Construction:	1895-1896
Present Owner and Occupant:	U.S. Army
Present Use:	Railroad, vehicular, and pedestrian bridge
Significance:	The Rock Island Bridge was constructed in 1895-1896 to connect the arsenal with Davenport, Iowa. It was the first major bridge commission of Chicago engineer Ralph Modjeski, who subsequently established a reputation as one of the country's leading bridge designers. The bridge was equipped with a variety of innovative safety features, including pneumatic rail locks, which did not become widely used until two decades later. Part of the Rock Island Arsenal National Register Historic District, the Rock Island Bridge is the oldest surviving Mississippi railroad crossing in the Iowa-Illinois region.
Historian:	Jeffrey A. Hess, February 1985
Architectural Historian:	David Arbogast, February 1985

PART I. HISTORICAL INFORMATION

A. Physical History:

1. Date of erection: The six stone piers comprising the substructure of the present Rock Island Bridge were originally designed and built to support a previous bridge completed in 1872 (Flagler, p. 175; Riebe, pp. 73-74). During the construction of the present bridge, the old superstructure was dismantled and the original piers were remodeled to support a wider superstructure. The remodeling was accomplished by "[removing] the coping and top part of the old pier[s]. . .down to a point where by interrupting the batter of the old cutwater and extending it upward vertically the increased width obtained would be sufficient for the new conditions. For the old piers Joliet limestone had been used, but the new masonry was composed of Kettle River sandstone for the facing and coping and of Anamosa stone backing, laid in Alsen's Portland cement mortar" ("Double Deck Highway and Railway Bridge" p. 406).

   On March 2, 1895, Congress authorized the War Department to build the new Rock Island Bridge for a cost not exceeding $490,000. The War Department approved plans and specifications on June 27, 1895. Preliminary survey work began with an underwater examination of the original piers on September 12, 1895. The work of dismantling the old bridge and building the new superstructure commenced on October 25, 1895 (Robbins, pp. 17-18). The new bridge was opened to the public on December 5, 1896 ("Traffic Resumed").

2. Architect/Engineer: General Thomas Jefferson Rodman of the Ordnance Department designed the original stone piers in 1868-1869. At the time, Rodman was commandant of Rock Island Arsenal. On June 30, 1869, the project was transferred to the U.S. Army Engineer Department and "all drawings, surveys, plans, contracts, and other papers relating to the construction of the bridge were at once turned over to Major G. K. Warren" (Flagler, p. 175).

   Ralph Modjeski, a Chicago civil engineer, was responsible for remodeling the old substructure and designing the new superstructure in 1895 ("The New United States Rock Island Bridge -- Part 1," p. 181).

   Born in Cracow, Poland in 1861, Modjeski graduated with a degree in civil engineering from the Ecole des Ponts et Chaussees in Paris in 1885. That same year, he emigrated to the United States and went to work as an assistant engineer on the Union Pacific bridge in Omaha, Nebraska. Specializing in bridge work, he established his own engineering consulting practice in Chicago in 1892 (National Cyclopaedia, p. 68).

The Rock Island Bridge was Modjeski's first major bridge commission. It was followed by the reconstruction of the Bismarck, North Dakota, bridge across the Missouri River and the Thebes, Illinois, bridge across the Mississippi River. Subsequent commissions included the Columbia River and Williamette River bridges for the Spokane, Portland and Seattle Railway; the McKinley bridge across the Mississippi River at St. Louis; the Columbia River Bridge at Celilo, Oregon, and the Broadway bridge across the Williamette River in Portland, Oregon; and a series of bascule bridges in Chicago. By 1916, Modjeski was considered "one of the leading engineering authorities on bridges in this country" (National Cyclopaedia, p. 68). He died in 1940 ("Famed Designer of Government Bridge").

3. Original and subsequent owners: U.S. Army.

4. Builder, contractor, suppliers: Phoenix Bridge Company of Phoenixville, Pennsylvania served as general contractor for the project; Sooysmith & Company of New York was the subcontractor for the remodeling of the substructure; George P. Nicholas & Bro. of Chicago was the contractor for the operating machinery of the swing span ("Double Deck Highway and Railway Bridge," p. 408).

5. Original plans and construction: The Rock Island Arsenal Engineering Plans and Services Division has a comprehensive set of original drawings and specifications, dated 1895, as well as microfiche copies of the same material (R20000162-R20000274). The present structure conforms to an original elevation entitled "Bridge Across the Mississippi River Between Davenport, Ia. and Rock Island, Ill. / North Elevation / July 5, 1895" (microfiche cards R20000210-20000211). This elevation was published in 1897 ("The New United States Rock Island Bridge -- Part 1," p. 181; see "Supplemental Material" section of this report). The original construction is documented by a sheet of five photographic views published in 1898 (Tillinghast, p. 8), a copy of which is in the picture collection of the Rock Island Arsenal Historical Office (see HAER Photo No. IL-20P-26).

6. Alterations and additions: In 1908, the trackage on the upper deck was replaced by new rails of the same weight. In 1909, the wood flooring of the lower deck was replaced by creosoted wood flooring, on a contract basis, by the Kettle River Quarries Company for $35,515.00. At the same time, the Tri-City Railway

Company replaced their street car rails with new rails of heavier weight (Robbins, p. 19).

In 1922-1923, the stone piers were encased in cement (Riebe, p. 74). During 1931-1933, as part of the construction project of Locks and Dam No. 15, the central pier of the swing span was incorporated into the lower guide walls of both locks (Riebe, p. 74). The completed work is documented by a 1935 photograph in the picture collection of the Rock Island Arsenal Historical Office. The photograph is captioned, "U.S. Engineers / Mississippi River Lock #15 / Barge line boat, with tow, entering Main Lock / 473-121.41 / April 4, 1935."

During the late 1940s, wooden supports for the upper deck trackage were replaced with metal components (Riebe, pp. 76-77).

In 1957, connecting pins were replaced in the superstructure; the diagonal, reinforcing I-bars were tightened; the wood sidewalks were replaced with open steel gridwork; a concrete roadway was constructed on the lower deck; and electric power line towers were installed ("Government Span").

B. Historical Context:

When General Thomas Jefferson Rodman assumed command of Rock Island Arsenal in 1868, he informed the War Department that existing rail facilities were detrimental to the arsenal's expansion: "The present location of [the railroad] upon the island is not a suitable one. It cuts the island into two very inconvenient parts. . . . It is, therefore, proposed and recommended that this road be removed to the [western] extremity of the island" (Flagler, pp. 119-120).

The War Department concurred, and a new line was constructed across the island. This project included a new railroad-vehicular-and-pedestrian bridge, completed in 1872, that crossed the Mississippi River to link the arsenal with Davenport, Iowa. The bridge was a double-deck, single-track, swing-span structure supported by six stone piers. By the 1890s, however, the bridge was creating serious bottlenecks in traffic "[due] to the fact that it was a single track bridge in the middle of an important stretch of main line railroad that had been double tracked" (Riebe, p. 74).

On March 2, 1895, Congress authorized the War Department to reconstruct the arsenal bridge; plans and specifications were approved on June 27, 1895. The first major bridge commission of engineer Ralph Modjeski of Chicago, who subsequently became one of the country's foremost bridge designers, the new bridge was a double-deck, double-track, swing-span structure supported by the old bridge's stone piers, remodeled to accommodate a wider superstructure.

Powered by a direct-current, motor-driven, chain-and sprocket system, the swing span was engineered to revolve in either direction in order to reduce stress from oblique wind pressures, which were common at the site, and which had occasionally made it difficult to operate the unidirectional swing span of the previous bridge ("The New United States Rock Island Bridge," p. 384; Interview with Miller). The bridge was also equipped with a variety of innovative safety featurea, including pneumatic rail locks, which did not become widely used until two decades later (Interview with Muessig). Completed in December 1896, the Rock Island Bridge still preserves almost all of its original operating machinery and continues to serve its original function ("Traffic Resumed"). It is the oldest surviving rail crossing over the Mississippi River in the Illinois-Iowa region ("Interstate Bridges to Iowa"; for additional documentation, see HAER No. IL-20).

Prepared by: Jeffrey A. Hess
MacDonald and Mack Partnership
February 1985

PART II. ENGINEERING INFORMATION

The bridge (see HAER Photo Nos. IL-20P-1 and IL-20P-2) is a double-deck structure carrying two tracks of railroad traffic on its upper deck (see HAER Photo Nos. IL-20P-4 and IL-20P-10) and vehicular and pedestrian traffic on its lower deck (see HAER Photo Nos. IL-20P-3 and IL-20P-11) across the Mississippi River between Rock Island Arsenal and Davenport Arsenal. It intersects with the corner of Rodman Avenue and Fort Armstrong Avenue at the arsenal (see HAER Photo Nos. IL-20P-5 and IL-20P-6) and with the corner of Second Street and LeClaire Avenue in Davenport (see HAER Photo No. IL-20P-3). Passing east of Dam No. 15, it crosses Lock No. 15 (see HAER Photo No. IL-20P-1) on the south side of the river. It is above this lock that the swing span (see HAER Photo Nos. IL-20P-1, IL-20P-5, IL-20P-8, and IL-20P-9) is built.

There are eight spans resting upon a total of six piers and four abutments. From north (Davenport) to south (Rock Island Arsenal), the spans measure as follows:

Span A (fixed) . . . . 193 feet, 6 inches
Span B (fixed) . . . . 258 feet
Span C (fixed) . . . . 216 feet, 6 3/4 inches
Span D (fixed) . . . . 216 feet, 6 3/4 inches

Span E (fixed) . . . . 216 feet, 6 3/4 inches
Span F (swing) . . . . 258 feet
Span G (fixed) . . . . 365 feet, 7 inches
Span H (fixed) . . . . 98 feet, 9 inches

The piers and abutments (see HAER Photo Nos. IL-20P-1, IL-20P-2, IL-20P-7, IL-20P-12, IL-20P-14) are constructed of limestone with sandstone facing. Abutments support each end of spans A and H; piers support the ends of spans B through G in the river, as well as the midpoint of span G, the swing span. Except for the swing span pier, which is larger than the others, the various piers are relatively equal in size.

Spans A and H (see HAER Photo Nos. IL-20P-4, IL-20P-6, and IL-20P-20) serve as approaches to the bridge. They are substantially smaller and shorter than the other spans, rising from a level equal to the railroad bed. All other spans rise from a level equal to the lower vehicular road bed. The vehicular roadway has no approach spans, traversing only spans B through G.

Span A (see HAER Photo Nos. IL-20P-4, IL-20P-6, and IL-20P-20) has a riveted, steel, single-intersection Pratt truss along each side of nine panels demarcated by compression members and diagonal tension members. The two end panels have inclined end posts rising from the bearing points to the upper chords. Span H, the shortest span of all, is similar to span A, but has four panels instead of nine.

Spans B and F (see HAER Photo Nos. IL-20P-21, IL-20P-10, and IL-20P-12) are vitually identical to each other. Each has a riveted, steel, Baltimore truss along each side. Each truss has six panels demarcated by vertical compression members with additional vertical steel tension members at the midpoint of each panel. The end panels are similar to those of span A, rising diagonally to the upper chord. Between the railroad bed and the vehicular road bed are short, diagonal, steel, tension members. Above, the truss is reinforced by diagonal, steel, tension rods. Spans C, D and E (see HAER Photo No. IL-20P-7) are similar to spans B and F, although one panel shorter in length.

Span G, the swing span (see HAER Photo Nos. IL-20P-1, IL-20P-5, IL-20P-8, IL-20P-9, IL-20P-13, IL-20P-22, IL-20P-23, IL-20P-24, and IL-20P-25) has a center-supported, cantilevered, camelback, through-truss configuration. Each riveted steel truss is divided into nine bays demarcated by heavy compression members. The four outer panels of each truss are subdivided with an additional vertical member, a diagonal member extending from corner to corner of the panel, and a shorter diagonal member extending from the remaining lower corner to the center of the full-length diagonal. The lower chords are at the roadway level. Diagonal stability is provided by "X" bracing between the upper chords and between the upper parts of major vertical members. Pneumatic jacks (see HAER Photo No. IL-20P-15) on rollers support each end of the span, thus permitting the span to swing freely from its engaged position.

Capable of full rotation in either direction, the swing span is supported by a massive cylindrical pier at its center. Large, fixed sprockets are located in a ring just below the center of the pier. A heavy drive-chain (see HAER Photo Nos. IL-20P-16 and IL-20P-17) on each side of the bridge is powered by two sprocket wheels and drive shafts that extend to a power house on top of the span. The drive machinery is electric-powered. The swing span itself rests on a series of radially-tied wheels that follow a track around the top of the pier.

All trusses are tied at their top (see HAER Photo Nos. IL-20P-1, Il-20P-5, IL-20P-6, IL-20P-8, IL-20P-9, IL-20P-10, IL-20P-12, IL-20P-21, IL-20P-23, and IL-20P-24) with riveted steel members at each panel with diagonal cross members in each bay. A smilar set of steel members (see HAER Photo Nos. IL-20P-11 and IL-20P-13) is used to tie the two sides together under the railroad deck and under the vehicular road bed.

The control room (see HAER Photo Nos. IL-20P-1, IL-20P-5, IL-20P-8, IL-20P-9, IL-20P-18, IL-20P-19, and IL-20P-25), in the upper, center of the swing span, is reached from the vehicular roadway level by two, straight-run, open, steel stairs on the east side of the bridge, rising to the railroad track level with a shared steel deck landing, then continuing upward to the control room level. The room is surrounded by a narrow, steel walkway with a metal deck and pipe railing painted black. From the south walkway a steel cage ladder rises to a steel landing above the roof, which gives access to the steel ladder rising to the turntable for the upper swing span.

The control room is square in plan with a hipped roof covered with standing-seam copper roofing painted black. Roof, wall, and floor systems are all sawn wood members. There is a set of semi-circular metal gutters on all four sides of the roof. Decorative pressed-metal shingling painted black covers all four walls. The east elevation (see HAER Photo No. IL-20P-9) has a single doorway on its south end containing an original wood door with four lights over three panels and a modern raw aluminum storm door. To its north is a single window opening. Two single window openings are located on each of the south and west elevations. An octagonal bay window (see HAER Photo No. IL-20P-25) is centered in the north elevation with a single window opening in each of its three faces. All eight window openings contain one-over-one, double-hung, wood sash with plain interior and exterior, painted, wood casings.

The one-room interior (see HAER Photo Nos. IL-20P-18 and IL-20P-19) has wood floor covered with linoleum tile, overlaid with loose strips of carpeting. The walls are covered with horizontal, beaded, tongue-and-groove, board siding. In the northeast corner is a pair of cabinets made of vertical, beaded, tongue-and-groove boards. In the center of the west wall is a wood shelf, dating from the original construction. The walls, cabinets, and shelf are all painted cream. The cabinets each have a set of three butterfly hinges and single latches. The shelf is supported by two decorative, cast iron brackets. The ceiling is acoustical tile attached to the original, tongue-and-groove, board ceiling. Near the south wall an inclined wood ladder leads upward to the ceiling hatch giving access to an unfinished attic used for storage. Lighting is by flourescent and incandescent fixtures. There is an air-conditioning unit in the south window of the west wall. A modern electric heating unit supplies the necessary heat. An older electric heating unit survives along the west wall.

Along the south wall of the control room is an original, 550-volt, General Electric, motor-generator set, which converts alternating current to direct current in order to run a 50-horsepower motor, which, in turn, powers the drive train machinery for the swing span. A series of bull and bevel gears for the power train occupies the center of the room, surrounded by a polished brass guard rail (see HAER Photo Nos. IL-20P-18 and IL-20P-19). In addition to a control board on the north wall, the room also houses an alternating-current, motorized, direct-drive, air-compressor unit, which, at an undetermined date, replaced an original belt-driven unit. The air-compressor activates the pneumatic jacks underneath the swing span and the pneumatic rail locks on the railroad bed. The pneumatic system operates under 100 to 120 pounds per square inch of pressure, which is maintained by two original, riveted, steel, air-storage tanks located in the attic above the control room.

PART III. SOURCES OF INFORMATION

A. Original Architectural/Engineering Drawings:

The Rock Island Arsenal Engineering Plans and Services Division has a comprehensive collection of original specifications and drawings, dated 1895, which have been reproduced on microfiche cards (R20000162-R20000274). The following items are of particular interest:

"Rock Island Bridge Between Davenport, Iowa & Rock Island, Illinois / North Elevation," July 5, 1895 (R0000210-R0000211).

"Specifications for the Erection of Superstructure of the United States Bridge Across the Mississippi River Between Rock Island & Davenport," 1895 (R20000196-R20000208).

"Specifications for Machinery of Draw Span of the Superstructure for the Rock Island and Davenport Bridge," 1895 (R20000162-R20000170).

B. Early Views:

The picture collection in the Rock Island Arsenal Historical Office contains a photograph (see HAER Photo No. IL-20P-26), originally published in 1898 (Tillinghast, p. 8), that documents the original construction and shows the bridge in its present configuration. The same collection has a photograph, dated 1935, that documents the remodeling of the swing-span pier to accommodate the construction of Locks and Dam No. 15. The photograph is captioned, "U.S. Engineers / Mississippi River Lock #15 / Barge line boat, with tow, entering Main Lock / 473-121.41 / April 4, 1935."

C. Interviews:

Dorman Miller, Rock Island Arsenal Bridge Foreman, January 28, 1985. Verified that oblique wind pressures influence the operation of the swing span.

Hans Muessig, Vice President, Dennet, Muessig, Ryan & Associates, Iowa City, November 27, 1984. Assessed historical significance of bridge's original safety features, including pneumatic rail locks.

D. Bibliography:

1. Primary and unpublished sources:

Hess, Jeffrey A., and Mack, Robert C. "Historic Properties Report Rock Island Arsenal, Rock Island, Illinois". Prepared by MacDonald and Mack Partnership, and Building Technology Incorporated for the Historic American Buildings Survey/Historic American Engineering Record, National Park Service, U.S. Department of the Interior, 1985. The report, with accompanying inventory cards, is filed as field records in the Prints and Photographs Division, Library of Congress, under HAER No. IL-20.

"Interstate Bridges to Iowa: A Descriptive List of Bridges Over the Mississippi, Missouri, Des Moines and Big Sioux Rivers," prepared for Iowa Department of Transportation by Dennett, Muessig & Associates, 1982. Iowa State Historic Preservation Office, Iowa City.

Robbins, F. E. "Copy of History of the Rock Island Bridge," typescript, 1910. Rock Island Arsenal Historical Office. Specifications for the Erection of Superstructure of the

United States Bridge Across the Mississippi River Betweem Rock & Davenport," 1895. Rock Island Arsenal Engineering Plans and Services Division.

"Specifications for Machinery of Draw Span of the Superstructure for the Rock Island and Davenport Bridge," Rock Island Arsenal Engineering Plans and Services Division.

2. Secondary and published sources:

"Double Deck Highway and Railway Bridge Rock Island, Ill." Engineering News, 36 (December 17, 1896), 406-408. Detailed discussion of bridge's planning and construction.

"Famed Designer of Government Bridge at Rock Island Is Dead." Moline Dispatch, June 23, 1940. Modjeski's obituary.

Flagler, D[aniel] W[ebster]. A History of the Rock Island Arsenal from Its Establishment in 1863 to December 1876. Washington, D.C.: Government Printing Office, 1877. Outlines Rodman's participation in designing the 1872 bridge.

"Covernment Span, Closed April 22, to Be Opened Before First of Year." Moline Dispatch, November 12, 1957. Describes 1957 alterations.

The National Cyclopaedia of American Biography. Vol. 15. New York: James T. White & Company, 1916. Provides good biography of Modjeski.

"The New United States Rock Island Bridge," Engineering Record, 37 (April 2, 1898), 384-387. Excellent discussion of bridge's design; contains engineering drawings.

"The New United States Rock Island Bridge--Part 1." Engineering Record, 35 (January 30, 1897), 181. Reproduces elevation of bridge.

Riebe, William. "The Government Bridge." Rock Island Digest, 2 (1983), 68-79. Presents brief historical descriptions of the various Rock Island-Davenport bridges.

Tillinghast, B. F. Rock Island Arsenal: In Peace and in War. Chicago: The O. Shepard Company, 1898. Reproduces photographs showing bridge's original configuration.

"Traffic Resumed." Rock Island Weekly Union, December 5, 1896.

Announces opening of Rock Island Bridge.

E. Likely Sources Not Yet Investigated:

Modjeski and Masters, Consulting Engineers, of Harrisburg, Pennsylvania, has project files on the construction of the bridge.

Record Group 156 at the National Archives contains correspondence on the construction and operation of Rock Island Arsenal from 1871 to 1903. This material is also available on 216 reels of microfilm at the Browning Museum, Rock Island Arsenal.

F. Supplemental Material:

Photocopies of the following engineering articles on the bridge's construction are attached at the end of these Data Pages:

"The New United States Rock Island Bridge," Engineering Record, 37 (April 2, 1898), 384-386.

"The New United States Rock Island Bridge--Part 1," Engineering Record, 35 (January 30, 1897), 181.

PART IV. PROJECT INFORMATION

This project was part of a program initiated through a memorandum of agreement between the National Park Service and the U.S. Department of the Army. Stanley J. Fried, Chief, Real Estate Branch of Heaquarters DARCOM, and Dr. Robert J. Kapsch, Chief of the Historic American Buildings Survey/Historic American Engineering Record, were program directors. Sally Kress Tompkins of HABS/HAER was program manager, and Robie S. Lange of HABS/HAER was project manager. Building Technology Incorporated, Silver Spring, Maryland, under the direction of William A. Brenner, acted as primary contractor, and MacDonald and Mack Partnership, Minneapolis, was a major subcontractor. The project included a survey of historic properties at Rock Island Arsenal, as well as preparation of an historic properties report and HABS/HAER documentation for 38 buildings. The survey, report, and documentation were completed by Jeffrey A. Hess, historian, Minneapolis; Barbara E. Hightower, historian, Minneapolis; David Arbogast, architectural historian, Iowa City, Iowa; and Robert C. Mack, architect, Minneapolis. The photographs were taken by Robert A. Ryan, J Ceronie, and Bruce A. Harms of Dennett, Muessig, Ryan, and Associates, Ltd., Iowa City, Iowa. Drawings were produced by John Palmer Low, Minneapolis.

THE NEW UNITED STATES ROCK ISLAND BRIDGE.

PART I.—HISTORY AND DESCRIPTION—GENERAL DATA, REQUIREMENTS, MANUFACTURE AND ERECTION.

THE construction of the first bridge across the Mississippi River was long and earnestly opposed, but it was finally built between Rock Island and Davenport for the purpose of connecting the Chicago and Rock Island Railroad in Illinois with the Mississippi and Missouri Railroad in Iowa. The contract for constructing the masonry was let September 26, 1853, and on April 21, 1856, the structure was completed. In 1856, one 250-foot span was destroyed by fire communicated by the steamboat Effie Afton, which collided with and was burned at one of the piers. In the litigation which followed, and which was brought by the owners of the boat, Abraham Lincoln, of Springfield, Ill., appeared as one of the counsel for the railroad company. In 1860, in a suit brought in the District Court of the United States Judge Love declared the bridge "a nuisance," and ordered "all the piers within the State of Iowa, together with the superstructure thereon, removed, because if this bridge were permitted to remain, we shall probably in no great period of time have railroad bridges upon the Mississippi River at every 40 or 50 miles of its course"; so "that the loss involved in the removal of this bridge would be but trifling compared with the great mischief which must inevitably flow (to the commerce of the river) from the precedent of maintaining it."

The Supreme Court of the United States reversed this decree, principally on the ground that the removal of the three piers in the State of Iowa would not remedy the obstruction, while it would destroy the bridge. In March 1868, the first pier from the Iowa shore was pushed bodily down stream some 20 or 25 feet by the ice; and in April of the same year, during a severe wind storm, the draw span was lifted from its masonry and blown over on its side up stream, so that it hung supported only by the draw pier, with both ends free in mid-air. In 1866 and 1867 two acts were passed by Congress, authorizing the construction of a new bridge over the Mississippi River, between Rock Island and Davenport, providing for a new location of the railroad track on the Island of Rock Island, and the removal of the original bridge from the river. A contract for the masonry of a new single track bridge of which the late C. Shaler Smith was Chief Engineer, was let in 1869; the superstructure was built by the Phœnix Bridge Company, completed and opened in 1872. In 1891 the wooden upper or railroad deck was replaced by iron by the Phœnix Bridge Company. In the winter of 1894 and 1895 an entirely new superstructure and partially new masonry were authorized, and the necessary appropriation made by Congress for the construction. Mr. Ralph Modjeski, M. Am. Soc. C. E., Chicago, was appointed Chief Engineer, tenders for the work were received on August 12, 1895, at Rock Island Arsenal, by Col. A. R. Buffington, U. S. A., commanding, and the contract subsequently awarded to the Phœnix Bridge Company. John Sterling Deans, Chief Engineer.

The reason for the present reconstruction of this bridge was that the old single-track structure was inadequate for the traffic, and was not considered strong enough for the increased loads.

Figures 1 and 2 show the general elevations and principal dimensions of the bridge which comprises eight spans of a total estimated weight of 8,770,000* pounds, and about 900 cubic yards of substructure masonry in piers and abutments. The superstructure consists of:

	Pounds.
"A." One draw span 365 feet 7 inches long between centers of end pins......	2,468,271
"B." Two fixed spans 258 feet..........	3,298,955
"C." Three fixed spans 216 feet 6¾ inches..............................	3,600,815
"D." One fixed span 193 feet 3 inches...	789,142
"E." One fixed span 9? feet 9 inches....	337,779
	10,582,062**

The letters A, B, C, D and E are used in the strain sheets and working drawings and specifications to designate the respective spans. The strain sheets have on them every detail of loading, of unit stresses and of the methods of calculation. Spans A, B and C are 29 feet wide between centers of trusses; B and C are 50 feet high, center to center of chords; A is 62 feet high at the center, and 50 feet high at the ends. They carry a double-track railroad floor, a 26-foot roadway, and two 6-foot sidewalks. The roadway and sidewalks are placed at lower chords; the railroad floor placed above the roadway. D is 29 feet wide and 30 feet high, E is 28 feet wide and 25 feet high; D and E carry a double track railroad floor. The trusses are calculated to carry a total moving load of 11,360 pounds per lineal foot, of which 8,000 pounds are on the railway floor and 3,360 pounds on the roadway floor. The solid corrugated steel railway floor, together with the guard angles and rail plates, weigh about 940 pounds per lineal foot of the bridge. All steel is made by the open-hearth process with the percentage of phosphorus limited to 0.08 for acid and 0.04 for basic process. Steel for pins above 4 inches diameter is hammered.

The bed plates and portions of machinery for the draw are of cast iron. The pedestals for fixed and expansion bearings, the wheels of the turntable, and other portions of the machinery are of cast steel. The expansion rollers and rail-plates are of Bessemer steel. The spider rods of the turntable and the sleeve-nuts for counters are of wrought iron. The rivets are of soft, open-hearth steel. All other parts of the structure are of medium open-hearth steel.

*Exclusive of corrugated steel floor.
**Inclusive of corrugated steel floor.

Tests were required to be made at such places and on such machines as directed by the commanding officer of the Rock Island arsenal, and when tests were made on other machines than the United States testing machine at the Watertown arsenal, Massachusetts, then the contractor was liable to be required to furnish specimens for such tests on the Watertown machine as would serve to standardize the machine used by him in comparison with the government testing machine at Watertown arsenal. Test specimens being provided in ample time to make the comparison, and the results obtained with the Watertown

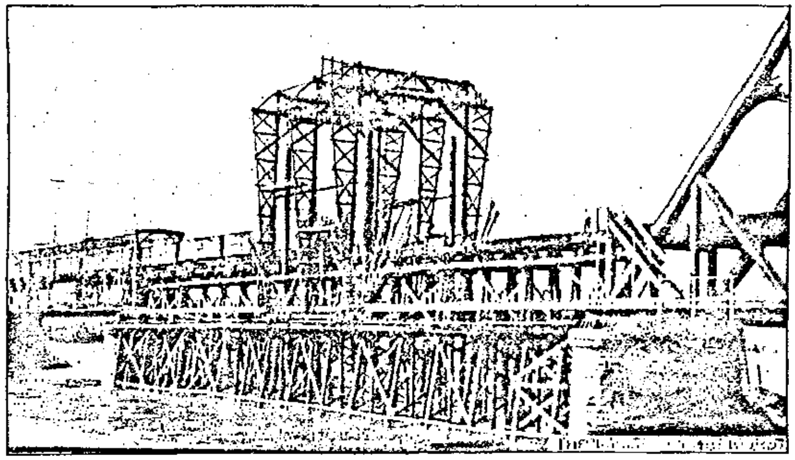


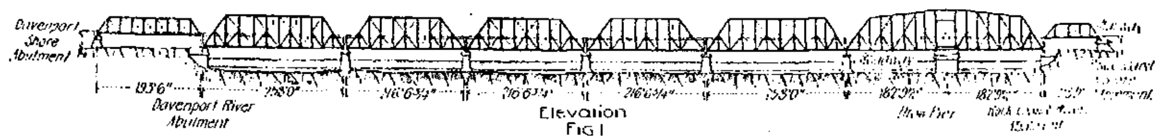
FIG. 4.

machine taken as standard for the correction of results obtained on other machines.

The specifications showed special provision to secure accuracy and perfection of workmanship and required, besides ordinary provisions for standard high-class work, that after reaming every hole should be gone over with a countersinking tool, cutting off the sharp edges of the hole and making a fillet of about one-sixteenth of an inch under each rivet head. The members should then be taken apart and cleaned, the surfaces in contact painted, and the members carefully reassembled and riveted up before the paint is dry, that the chord sections should be fitted together at the shops in lengths of at least 130 feet, and that when so fitted together there should be no perceptible wind in this length; that the reaming of the splices, as well as all other field connections, should be done with the different parts assembled and when this is impracticable, that the connections should be reamed through iron templates at least 1½ inches thick.

Roughness in a pin-hole was specified to be sufficient reason for the rejection of the whole member. The main truss pins and all others in the structure were required to fit their respective holes within the one-fiftieth part of an inch. All iron-work was painted with hot boiled linseed oil after completion before leaving the shops.

Tests to destruction were required of 12 full-sized eyebars without visible defects, which were required to develop a minimum ultimate strength of 60,000 pounds, a minimum elastic limit of 33,000 pounds, a minimum elongation for each bar of 10 per cent., and an average elongation for a group of three tests of 12 per cent., the elongation being measured in 20 feet, including the fracture,



Elevation
FIG 1

THE ENGINEERING RECORD

THE UNITED STATES BRIDGE, ROCK ISLAND, ILL.
MR. RALPH MODJESKI, M. AM. SOC. C. E., CHIEF ENGINEER, CHICAGO, ILL.

The bars were required to break in the body. If a bar broke in the head, but developed 10 per cent. elongation, another bar of the same size and lot was to be tested, the two tests being counted as one. If the average elongation of these two tests attained 12 per cent., the test was to be considered satisfactory, provided, however, that no more than one bar of each group of three tests broke in the head. If, in a group of three tests, more than one bar broke in the head, all bars represented by this group of tests were to be rejected. If a test bar proved too long for the machine, it was to be cut in two and both halves reheaded, annealed and tested, the two tests counting as one. If the cross section of a test bar proved too great for the capacity of the machine, it was to be planed down on a length of 10 feet to a section equal to the capacity of the machine in pounds divided by 75,000 and then tested to destruction, care being taken to have all corners and angles at the places of change of section carefully rounded off. The elongation was then measured in eight feet. The cast-steel pedestals were required to be free from large blowholes. Planed and finished bearing surfaces were not permitted to have blowholes visible exceeding one-half inch in either dimension, not exceeding one-fourth square inch in area. The length of blowholes cut by any straight line laid in any direction was not allowed to exceed one inch in any one foot. The pin bearings were perfectly free from blowholes. The masonry under the rim for the turntable was rubbed down to a uniform plane and the cast-iron track set with anchor bolts directly on the masonry. The cast-iron bed-plates under the fixed span were set on rust cement.

The draw span is swung by a novel arrangement of sprocket wheels and chains that are operated by a 50 horse-power electric motor; another 12 horse-power electric motor drives an air compressor that furnishes power for the operation of the pneumatic cylinders commanding the rail locks and end lifting toggles, these are automatically interlocked with the signaling and controlling apparatus, and the whole bridge controlled by four levers in the operators' room. The erection of the superstructure was under the general supervision of Supt. A. B. Milliken and Foreman J. W. Simmons.

Traffic was discontinued on the roadway floor during erection, but the work was subjected to difficulties from various causes, among which were the facts that trains had to be carried without interruption, and another difficulty not quite so serious, was that piles could not be driven in the bottom of the river for falsework, as the bottom is rock with about 15 feet of water above it at the stage shown in Fig. 3. The grade of the railroad floor on the new bridge is about two feet higher than the present grade. The contractor was required to effect this change of grade in a manner not to disturb the trains or introduce heavy inclines. All rivets in the tension splices and connections of floor beam to post were driven by power. Under these conditions, Mr. Dean writes, "During one month we have removed one 216-foot span and one 258-foot span, and replaced same with new structures; this work of course, also includes the putting in of falsework under both spans. During this same month 925 steamers passed through the drawbridge which broke our line of connection with yard, and 1590 trains passed over the bridge."

Figure 4 is made from a progress photograph showing the construction of the falsework and comparative design and position of the old bridge. Figure 3 shows details and dimensions of the erecting traveler used.

The description and illustrations have been prepared from data furnished us by the Chief Engineer and the contractors and authorized by Colonel Bullington, Commanding. Mr. E. H. Connor was Resident Engineer and Byron B. Carter Mechanical Engineer. The substructure was built by Sooysmith & Co., of New York, and the swing span operating machinery by Messrs. G. P. Nicholas & Bro., Chicago, Ill.

[To be continued.]

A WOMAN ENGINEER.

FEMALE draughtsmen have for several years been employed in architectural and other offices, but they have probably been engaged on clerical and copying work chiefly. There seems no good reason why they should not excel in many kinds of drawing that does not require outside service or practical or mechanical knowledge or involve accuracy and responsible judgment. One woman, at least, has been in the engineer's office of the Chicago Drainage Canal and seemed to do creditable map and color work, which, with tracing and lettering, would appear very suitable fields in which feminine nimbleness, neatness and taste might profitably be applied. An instance has, however, been recently noted in which this latitude is considerably exceeded by a firm of architectural engineers in New York, who, among their force of a dozen or two of graduate civil engineers, employ one young woman who has graduated from an engineering school and shares the ordinary duties of her associates, though, of course, at a disadvantage concerning shop, mill and field work.

Every encouragement should, of course, be given to extending and developing the scope of suitable female employment, but it should not, in the novelty of a new field, be forgotten that the profession of engineering is a most jealous mistress and exacts the utmost effort and eternal enthusiasm, together with indomitable perseverance and persistence and superior special qualifications and sound judgment from those who are to secure a permanent foothold or acceptably to perform the responsible duties assigned the engineer. No transient occupation or dividedaim is tolerable. The profession must be supreme, and, further, to be truly a competent engineer involves the necessity of intimate acquaintance with all the practical sides of the work; the reconnaissance, the location, trial surveys, years of patient study and laborious physical work in the mines, mills and shops, life in camp and in the field, hazardous duties faithfully performed on the dizzy heights of lofty falsework for erection, handling of iron and machinery in tunnels and excavations, blasting and building as well as drawing or even calculating a plan, and these lessons are not only necessary to success, but for the safety of lives and property always dependent upon the engineer's constructions.

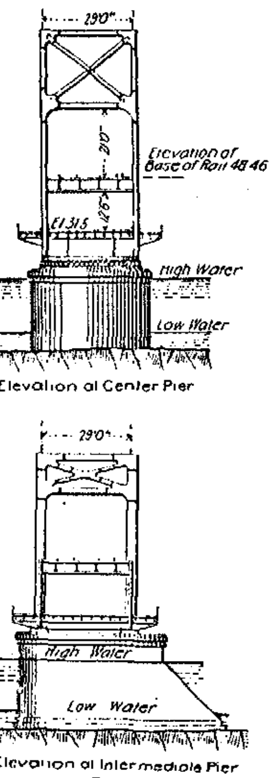


Fig. 2

THE ENGINEERING RECORD.

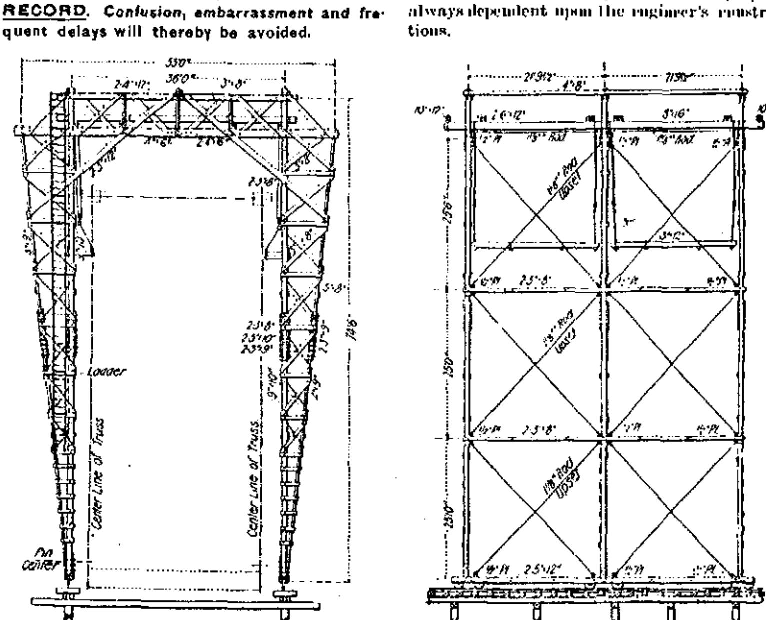


Fig. 3

THE UNITED STATES BRIDGE, ROCK ISLAND, ILL.

MR. RALPH MODJESKI, M. A. M. SOC. C. E., CHICAGO, ILL., CHIEF ENGINEER.

simple statement of the facts that an extraordinary manufacturing economy has been effected by very simple means, to wit, by keeping all parts of the machinery running free on suitable material.

The separators are 10 inches wide and are inclined about 45 degrees. The top cover is placed quite near the screen, so that the coarse material in falling will alternately strike the top and rebound on the screen. Both top and bottom are lined with sheet iron. The mills are French burr stones 4½ feet in diameter, the top stones being driven. The crushers employed are of the coffee mill pattern, such as are commonly employed for this purpose.

The power plant consists of a 50 horse-power Allis-Corliss engine for driving the hoist on the kiln tops and a 350 horse-power Allis-Corliss engine for driving the mill. This latter engine is now only taxed to about two-thirds its capacity, owing to the fact that only six stones out of 16 are driven in the mill.

There are four 100 horse-power return tubular boilers (also built by the Edward P. Allis Company) supplying steam for the engines. There is a siding just back of the boiler house on a high level trestle under which the coal supply is stored for the boilers.

The works have excellent facilities for shipping, having tracks connecting with all the roads entering Milwaukee, and have a large market throughout the Northwest and in the lake cities.

THE NEW UNITED STATES ROCK ISLAND BRIDGE.

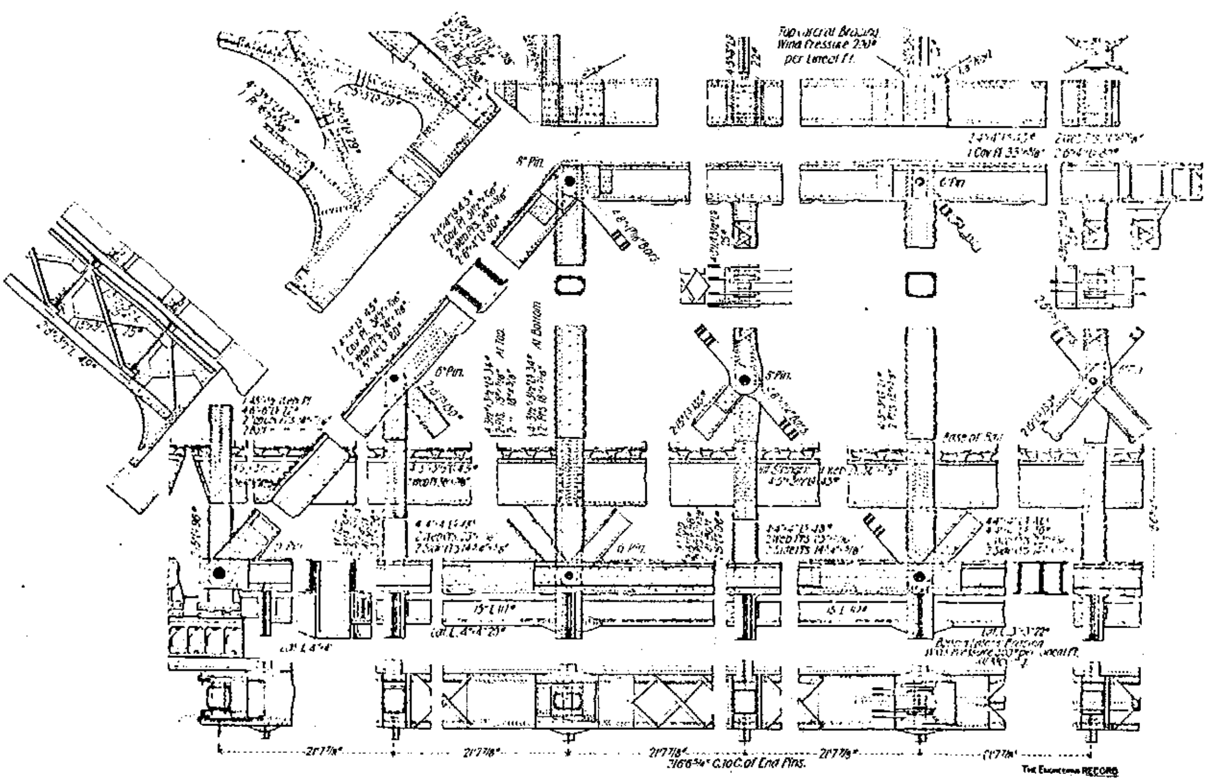
The history of the United States bridge at Rock Island, Ill., of which Mr. Ralph Modjeski, M. Am. Soc. C. E., is Chief Engineer, was published in our issue of January 30, 1897, and some general data of the requirements and manufacture of the structure were then given. The general statement of the design there given may be supplemented by the details now available of the connections of the fixed and draw spans, the details of the swinging mechanism, the locks, jacks and interlocking and hand machinery. The following data and requirements were among the principal considerations determining the design of the operating machinery, including the interlocking safety devices, electric annunciators, signals, etc.

The bridge was required to be able to make an entire revolution on the center, in either direction, continuously or alternately; for the purpose of avoiding or taking advantage of unequal wind pressures on the ends of the draw. The situation of the bridge was such that these unequal wind pressures were frequent, as was experienced on the old bridge.

The speed of operation required was 90 degrees in 1½ minutes, or at the rate of a complete revolution in 6 minutes. The estimate of the power necessary to apply tangent to the outer diameter of the drum, to operate the bridge, was 100,000 pounds, and the motive power was to be electricity at 500 volts pressure. The estimated maximum deflection at each end of the draw span was 1¾ inches. The load on each end of the bridge when raised is 360,000 pounds, or 180,000 pounds on each corner. The operation of trains over the bridge was to be entirely under control of the bridge operator with signals so arranged as to prevent trains entering on the draw span unless it was safe so to do. And the operation of the devices on the bridge was to be so interlocked as to prevent damage by incorrect operation.

The corrugated solid floor was designed, first to protect the lower roadway floor from any refuse of the trains, and second to provide a thorough lateral system for the bridge, the longitudinal plates under the rails taking the chord strains due to wind stress. The railway floor is the level at which the greatest wind strain is transmitted to the bridge, and the advisability of such a stiff bracing is due to the peculiar position in which this floor is placed in the Rock Island bridge.

A 50 horse-power electric motor in the operating house drives a horizontal cross shaft, transverse to the main axis of the bridge and through its center point. At each end of this cross shaft double miter gear wheels connect it to the vertical main shafts that have bearings on the outside of the turntable drum, diametrically opposite to each other. The turning mechanism is duplicated, a complete set being driven from each of these shafts as herewith described for one. The main shaft A, shown in the diagram of power connections, carries at its foot two sprocket wheels II, which engage opposite balanced chains BB. These through sprocket wheels HH, attached to the tops drive the two shafts DD. CC are idlers introduced to offset the chain from the drum and prevent interference with II. The driving shafts DD run in massive rigid suspended bearings, and carry twin sprocket wheels FF on their lower ends. As these wheels are driven uniformly, simultaneously, and at the same speed in the same direction, they act in unison to operate the driving sprocket chain E, the inner line of which engages the 12-inch teeth of the rack and pulls the turntable around it in either direction. A heavy adjustable tie K, is provided to brace the foot of each shaft D, and take the pull of the driving sprocket chain E, the outer line of which is carried in a trough H that also serves as a guard to shield it from injury and obstructions. This guard and brace are shown at the right of the lower figure in the diagrams only, and are elsewhere omitted to avoid confusion. Attached to the tread bearing castings on the pier, is a cast steel sprocket rack 33 feet 8¾ inches pitch diameter, made in segments with 108 teeth, 12-inch pitch and 4-inch face. The center of strain is low, and very close to the attachments to the tread castings. The distribution of metal is such that the long axis of the rectangular sections of the



ASSEMBLED CONNECTIONS OF A 216-FOOT FIXED SPAN,
THE NEW UNITED STATES BRIDGE, ROCK ISLAND, ILL.

teeth is in the direction of the strain. The flanks of the teeth are circular, with the describing center on the pitch line. The teeth are thus stronger for a given weight of metal than any other form of rack that could have been used.

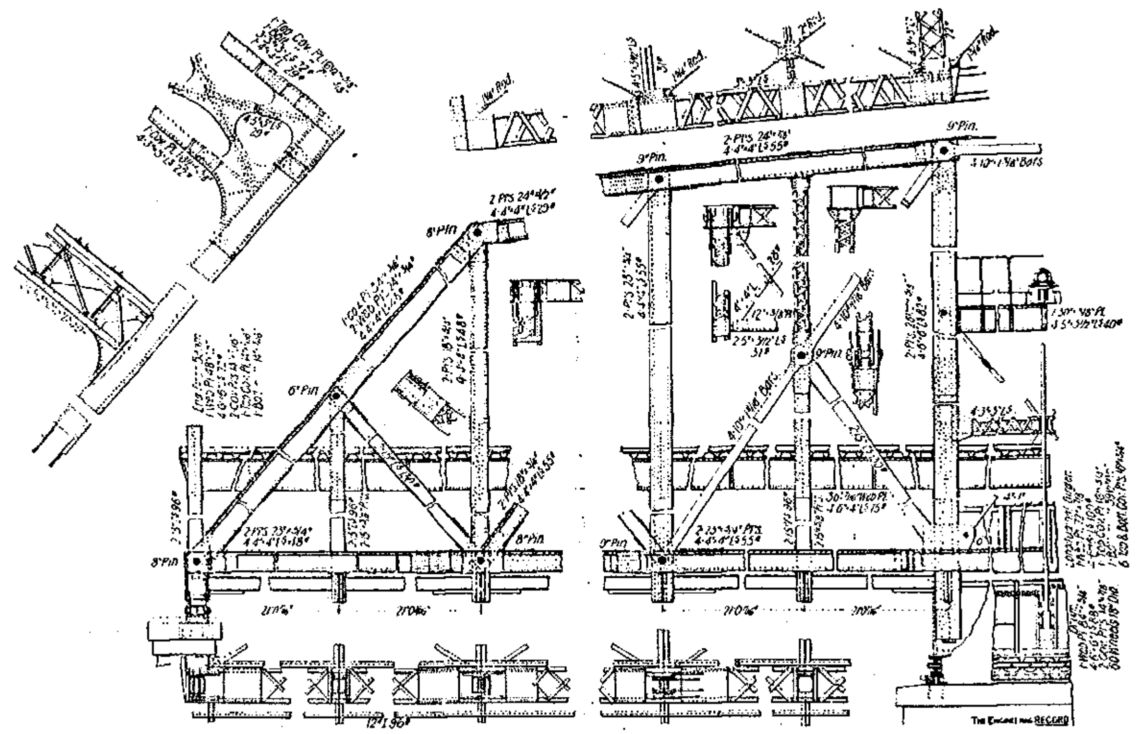
On each side of the longitudinal center line of the bridge, and attached rigidly to the drum, are heavy brackets, carrying vertical shafts, reaching from just above the top of the pier to about the top of the drum. Keyed to the lower end of each shaft is a cast steel sprocket pinion, with six teeth 12 inches pitch, with teeth corresponding to the rack. These sprocket teeth are elevated ¼-inch above the rack teeth, to compensate for the settling of the bridge by the wear of the turntable rollers. Around these sprocket pinions and on the rack runs a steel chain made of eye bars alternating in and out, and pins with separating rollers. The pins are 3½ inches in diameter, and the bars are 3½x 1-inch. These chains are calculated to stand a maximum accidental stress of 100,000 pounds, and when thus strained will have a fiber strain nearly 15,000 pounds per square inch. The total calculated working stress is 50,000 pounds. A rib is cast on each alternate tooth in the rack and pinion to match the links. By this chain arrangement there are always at least three teeth of the pinion in mesh, and from seven to eight on the rack; and on either a tooth could be broken without interfering in any manner with successful operation. The whole weight of the shafts, and both gears and chains, is carried on ball step bearings against the lower brackets. These bearings have 25 1½-inch steel balls. The plates are grooved so that each ball travels in a circle with no twisting action.

On the upper ends of these pinion shafts are sprocket gears for the secondary chains, running to the vertical shafts in the transverse vertical plane. Between these center vertical shafts and the pinion shafts is a reduction of 4 to 1. The secondary chains are of same design as the main chains, but smaller and are calculated to carry a maximum accidental stress of 25,000 pounds and a working stress of 12,500 pounds. The vertical shafts are carried, from a bracket on the drum, to bevel gearings on the operating room level. The weight and thrusts on these shafts are also carried on ball step bearings having two circles of 15 and 25 1½-inch steel balls respectively. The grooves are made as in the other bearings. On the upper end of these shafts are machine molded cast-iron bevel gears meshing into pinions on horizontal shafts, through the operating room, with pinions above and below as usually arranged. The reduction here is 2.1 to 1, the horizontal shaft being separated in the equalizer.

Mounted in a heavy bed plate on the middle of the horizontal shafts is an equalizer so constructed that half the strain in operating is carried to each side of the bridge and to the main chain on each side of the drum, thus eliminating unbalanced side strains on the turntable center from operating. It differs from the gear form of equalizer, in the substitution of lever arms with ball joints on the ends, for the bevel gears. As in this case only the differential of pitch in the various connections to the rack must be compensated for, there is only necessity for a limited movement here. By projections on the hubs of the shaft arms and the gear, jaw clutches are formed which rigidly lock the shaft sections together if from any cause there should be an excessive movement of the equalizer levers. The bed plate carrying the equalizer also carries the bearings for a train of cut gears connecting to a 50 horse-power street railway type motor. The motor is wound for a 500 volt current, and runs from 500 to 550 revolutions per minute. Mounted on one of the shafts for the gears is a large band brake.

Each rail, on each end of the bridge, and also the corresponding rail on the approach has a portion of the head cut away. A plate fastened to the bridge on the outer side of the track forms a guide for a key to slide beside the rail. This key is about 5 feet long and when the bridge is closed, is moved across the gap between the draw span and adjoining fixed spans, bearing on each. Over the gap the key is about 5-16-inch higher than the rail and tapers from here each way to a little below the rail top. The key is in position to strike the tread of car wheels outside the rail. Hence when a train passes over the draw span it runs over the necessary gap without noise or jar. For operating these keys an 8 inch pneumatic cylinder is located between the tracks on each end of the bridge, and by levers and connections to the keys the movement of the piston operates the keys for each rail of both tracks. An arrangement is made that in case of accident a hand bar may be put on the main center lever and each track operated by hand independently. Both ends of the tracks on the draw span are operated practically simultaneously. Special check valves are used here to control the movement of the device. The end jacks are of the semi-toggle type consisting of two parallel pair of bars, pin-connected to the end beams directly under the chords so as to turn freely, while on the lower end are rollers, which rest on bearing plates on the shore abutment as shown in the figure. By means of a pneumatic cylinder, a center crank and struts connected to the roller pins, these jacks are forced to a vertical position when the bridge is closed and drawn in to release the bridge when it is to be opened. A feature of the end lift device is a certain specific movement, enough to do the desired work, and so arranged that no damage can be done by continuing the application of power to the device after the movement is complete. Another feature is that when the toggles have finished the movement raising the bridge the center of the crank pin moves ¼-inch beyond a line joining the centers of the strut pin at the rollers and the shaft in the end beam. Thus when down the jacks are self locked and no amount of power applied in any direction at the rollers can possibly unlock and lower the bridge. Hence after the jacks are locked the air pressure is cut off from the cylinder.

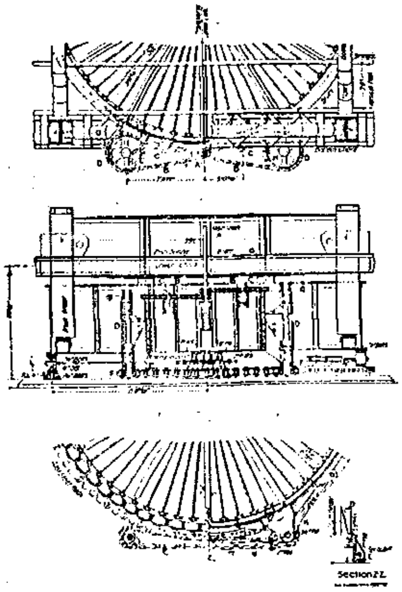
The electric current to operate the motors is taken from the power station of the Tri-City Railway Company through cables carried over the top of the bridge on the turntable. There are two distinct sources of power which, with



ASSEMBLED CONNECTIONS OF THE 365 FOOT 7-INCH DRAW SPAN.
THE NEW UNITED STATES BRIDGE, ROCK ISLAND, ILL.

other currents for lights, signals, etc., are brought down through an electric turntable over the center of the draw span. The wires from overhead are attached to stationary insulated rings and the current is taken from these by movable brushes attached to the draw span. From here the wires are carried in iron insulated conduits to the attic of the operating room and from there to the switchboard. The two main currents are carried into a double-throw switch. If from any cause the current should fail, the change to the other could instantly be made by reversing the switch. From the middle points of this switch the current passes through the main motor cutout switch and air compressor motor cutout switch and thence through the respective controllers. The switchboard carries besides these switches a switch for the illuminating lights in the operating room, by which the room may be instantly darkened when operating at night, an air pressure gauge, clock, automatic controller for the air compressor motor, and two push buttons for the signals. The board is near the operating stand at one side of the room. The main controller was especially made for this place and is operated by a lever in the operating stand.

A Hall signal is placed on each of the fixed spans within a few feet of the ends of the draw and stands normally at danger. Connected to each of the jacks and rail locks are electric switch boxes from which wires run through insulated pipes to an indicator in the machinery room. When any one or all of the jacks or rail locks are in a closed position a red lamp is lighted in the indicator, one lamp for each jack or rail, and when they are released for the bridge to swing a corresponding white lamp is lighted, replacing the red. By a combination of electric connections, the man in



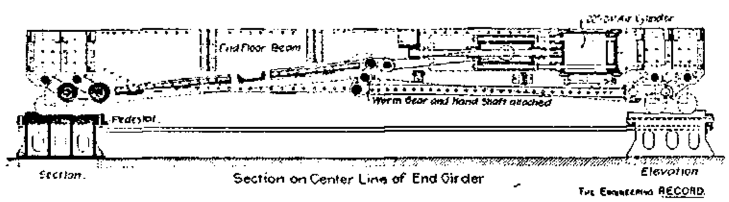
POWER CONNECTIONS TO THE TURNING GEAR.

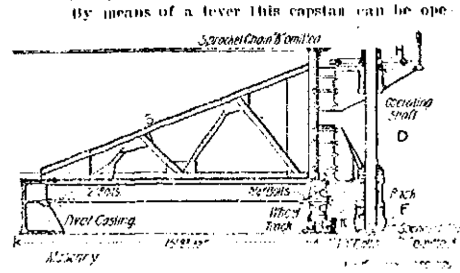
charge of the bridge can set the signal to safely only when the end jacks and rail locks are set. Should the bridge, for any reason, not be properly locked, the engine runner cannot receive his signal to enter upon the draw. The first movement of any part of the mechanism toward the condition for swinging the draw will drop the danger signal even should the operator on returning to the room neglect to open his clearing switch. Hence it is impossible for a train to pass upon the draw span, unless it is safe for the train to cross.

At the front end of the machinery room in a bay window from which the operator has a clear view of the tracks and river, is placed an interlocking controlling stand, having four levers. The first lever to the right operates a band brake. The second lever controls the rail locks through an air valve and can be moved at will; this being thrown forward the end jack lever, which previously has been locked, is released. This movement unlocks the motor controller lever, which now can be moved for operating the bridge. This system makes it impossible for the operator to swing the bridge until first the rail locks and then the end jacks have been released, the indicator above referred to announcing to the operator that these various devices have properly responded.

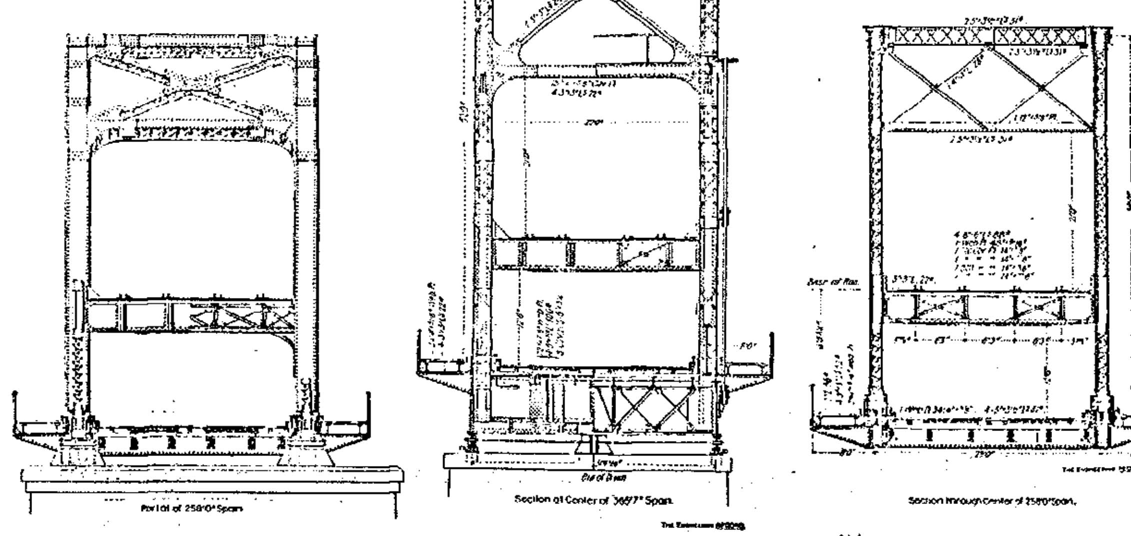
In the machinery house is also an air compressor driven by an electric motor, and in the attic above the machinery room are two steel reservoirs of a combined capacity of 200 cubic feet, from which air is drawn to operate the various cylinders. A uniform pressure of 120 pounds is maintained by an automatic device whereby the pump is started when the pressure falls below 120 pounds and stops when it reaches 120 pounds.

To guard against the possibility of the bridge becoming inoperative a supplementary hand connection has been made for each separate device. To swing the bridge a capstan is placed underneath the roadway deck at each end and attached to the floor beams. Eye bolts are fastened in the masonry at the abutment and at the ends of the stone protection. A heavy hawser stored on a platform near the capstan is attached to these eye bolts in case of emergency and the rope reeved around the capstan. By means of a lever this capstan can be ope-





RADIAL PARTIAL ELEVATION AND SECTION OF DRUM.



THE NEW UNITED STATES BRIDGE, ROCK ISLAND, ILL.

COL. A. R. BUFFINGTON, COMMANDING ROCK ISLAND ARSENAL; RALPH MODJESKI, M. AM. SOC. C. E., ENGINEER.