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 Willamette 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 Willamette 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").


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 features, 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.

Span 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 virtually 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 similar 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 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 fluorescent 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).

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, Dennett, 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:


"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.

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


Secondary and published sources:


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


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

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:


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 Headquarters 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 A.—DESCRIPTION—GENERAL

The construction of the first bridge across the Mississippi River was begun and completed as early as 1867, but it was finally built between Rock Island and Davenport for the purpose of connecting the Chicago, Rock Island and Pacific Railroad in Iowa, with the Mississippi and Missouri Railroad in Iowa.

The contract for constructing the bridge was let September 28, 1863, and on April 21, 1868, the structure was completed. In 1862, the 590-foot span was destroyed by fire communicated by the steamer Pittsford, 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 1890, in a suit brought in the District Court of the United States Judge Love declared the bridge "a nuisance," and ordered the piers within the State of Iowa, together with the superstructure thereof, removed.

In 1891, the Department of the Interior was authorized, and the removal of the three piers in the State of Iowa would not remedy the obstruction, while it also would be relieved. In March 1868, the first pier from the Iowa shore was pushed bodily downstream some 20 or 25 feet by the ice, and in the fall of the same year, during a severe winter storm, the draw span was lifted from its masonry and blown over on its side upstream, so that it would not remedy the obstruction, while it also would be relieved. In 1890, the iron-work was painted with hot boiled linseed oil after completion before leaving the shops.

The United States testing machine at Watertown, Massachusetts, was used by the contractor and tested for the government testing machine at Watertown Arsenal. Test specimens being provided in ample time to make the tests, and the results obtained with the Watertown machine taken as standard for the correction of results obtained on other machines.

The specifications allowed special provision to secure accuracy and perfection of workmanship required, besides ordinary provisions for standard high-class work, that after running every layout should be gone over with a contrivance, cutting off the sharp edges of the holes and making a file of about one-sixteenth of an inch under each rivet head. The numbers should then be taken apart and cleaned, the surfaces in contact painted, and the members carefully assembled and riveted up before the paint is dry, that the shed joints should be lifted together at the shops in lengths of at least 120 feet, and that when so fitted together there should be no perceptible wind in this length; that the running of the option, as well as all other field connections, should be done with the highest parts assembled and when this is impracticable, that the connections should be removed through iron templates at least 14 inches thick.

The United States Bridge, Rock Island, Ill.

Mr. Ralph Modjeski, M. Am.

The plate and portions of machinery for the draw are of cast iron. The pedestals for fixed and expansion bearings, the webs of the truss, and the other portions of the machinery are of cast steel. The expansion rollers and roller plates are of box-section steel. The spindles of the turntable and the lather-plate for runners are of wrought iron. The rivets are of soft wrought steel. All other parts of the structure are of medium open-hearth steel.

The results 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 work found in the method of calculation. Spans A and C are 25 feet wide between centers of trusses; B and D are 25 feet wide, center to center of church; A is 62 feet high at the center, and 30 feet high at the ends. There are a double-track railroad floor, a 25-foot roadway, and 30 feet wide. The draw and side walks are placed at lower church; the railroad floor placed above the roadway. D is 25 feet wide and 30 feet high. E is 25 feet wide and 32 feet high. D and E carry a double track railroad floor. The trusses are cast in a temporary mold of linseed oil, which is removed and the trusses placed on the trusses on the roadway floor. The trusses on the roadway floor. E is 25 feet wide and 32 feet high. D and E carry a double track railroad floor. The trusses are cast in a temporary mold of linseed oil, which is removed and the trusses placed on the trusses on the roadway floor. E is 25 feet wide and 32 feet high. D and E carry a double track railroad floor. The trusses are cast in a temporary mold of linseed oil, which is removed and the trusses placed on the trusses on the roadway floor. E is 25 feet wide and 32 feet high. D and E carry a double track railroad floor.
The Burr were required to break in the body. If a bar broke in the head, but developed 10 per cent. elongation, neither bar of the same size and lot was to be tested, but two bars being counted as one. If the average elongation of these two tests exceeded 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, none 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 machined, it was to be cut off; and both halves remachined, annealed, and tested. The two tests counting as one. If the result of a single test bar proved too great for the capacity of the machine in pounds divided by 73,000 and then tested in destruction, being taken to have all corners and edges at the places of change of section materially rounded off. The elongation was then measured in eight feet. The rust-steel pellets were required to be free from large blowholes. Primed and laked bearing surfaces were not permitted to have blowholes visibly containing two half-inch in either dimension, and exceeding one-fourth square inch in area. The length of blowholes cut by any straight line laid in any direction was divided by 73,000 and then measured in eight feet. The cast-steel pellets were required to be free from blowholes containing one-fourth square inch in area. The length blowholes cut by any straight line laid in any direction and touching one or more blowholes, were counted as one. If the cross section of a test bar proved too great for the capacity of the machine in pounds divided by 73,000 and then tested in destruction, being taken to have all corners and edges at the places of change of section materially rounded off. The elongation was then measured in eight feet. The rust-steel pellets were required to be free from large blowholes. Primed and laked bearing surfaces were not permitted to have blowholes visibly containing two half-inch in either dimension, and exceeding one-fourth square inch in area. The length of blowholes cut by any straight line laid in any direction was divided by 73,000 and then measured in eight feet. The cast-steel pellets were required to be free from blowholes containing one-fourth square inch in area. The length blowholes cut by any straight line laid in any direction and touching one or more blowholes, were counted as one. If the cross section of a test bar proved too great for the capacity of the machine in pounds divided by 73,000 and then tested in destruction, being taken to have all corners and edges at the places of change of section materially rounded off. The elongation was then measured in eight feet. The rust-steel pellets were required to be free from large blowholes. Primed and laked bearing surfaces were not permitted to have blowholes visibly containing two half-inch in either dimension, and exceeding one-fourth square inch in area. The length of blowholes cut by any straight line laid in any direction was divided by 73,000 and then measured in eight feet. The cast-steel pellets were required to be free from blowholes containing one-fourth square inch in area. The length blowholes cut by any straight line laid in any direction and touching one or more blowholes, were counted as one.
simple statement of the facts that an extraordinary manufacturing company has been effected by very simple means, to wit, by keeping all parts of the machinery running free on suitable materials.

The separators are 10 inches wide and are facilitated about 45 degrees. The top cover is placed quite near the screen, so that the waste material in failing will alternate strike the top and return on the screen. Both top and bottom are lined with sheet iron. The mills are French type about 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-Collis engine for driving the hoist on the kiln and a 350 horse-power Allis-Collis 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 18 are driven in the mill.

There are four 100 horse-power return mixer boilers also built by the Edward P. Allis Company, supplying steam for the engines. There is a sliding joint lock of the boiler house on a high level trench under which the coal supply is stored for the boilers.

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

THE NEW UNITED STATES ROCK ISLAND ARSENAL.

The history of the United States bridge at Rock Island, Ill., of which Mr. Ralph Mock, M. A. D. D. E., is Chief Engineer, was published in our issue of January 30, 1897, and some general data of the requirements and manufacturers of the structure were then given. The present statement of the design here given may be supplemented by the detailed new map of the connections of the fixed and draw spans, the details of the swinging mechanism, the locks, locks and interlocking and signal mechanism. The following data and remarks 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, continuous as a single unit. 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 in the old bridges.

The speed of operation required was 30 degrees in 4½ 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 wind pressure on each end of the draw span was 1½ inches. The load on each end of the bridge when raised is 360,000 pounds, or 180,000 pounds on each corner. The estimate maximum deflection at each end of the draw span was 100,000 pounds, and the motive power was estimated to be electricity at 500 volts pressure. The estimate 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 bridge is now only taxed to about two-thirds its capacity, owing to the fact that only six stones out of 18 are driven in the mill.

The separator drum was designed, first to prevent the lower carriageway from any release of the trains, and second to provide a thorough lateral system for the bridge, the longitudinal plates under the rails taking the greatest strain from wind stresses. The railway floor is at the level at which the greatest wind stress is transmitted to the bridge, and the advisability of such a mill bearing 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 worm shaft, transmitting the main shaft of the hoist and through its center point. At each end of this worm shaft double nil drums which control it in the vertical main shafts that have bearings on the outside of the turntable drums diametrically opposite to each other. The turning mechanism is duplicated, a complete set being driven from each of these electric motors, as described for one. The main shaft A shown in the diagram of power connections, carries at its front two sprocket wheels B which engage opposite balanced chains C. These through sprocket wheels D, attached to the top drive the two shafts E, F, and are later introduced to offset the chain from the drum and prevent interference with it. The driving chucks H run in massive rigid suspended bearings, and carry twin sprocket wheels F on their lower ends. As these wheels are driven uniformly, simultaneously, and at the same speed in the same direction, they are in position to operate the driving sprocket chain I. The inner line of which engages the 12-inch teeth of the rack and pinion the turntable around it in either direction. A heavy adjustable K is provided to brace the foot of each shaft L and take the pull of the driving sprocket chain I, the outer line of which is carried in a trough L which also serves as a guard to shield it from hangers and obstructions. This guard and brace are shown at the right of the lower hanger in the diagram only, and are elsewhere omitted to avoid confusion. Attached to the lower hanger castings on the pier, is a cast steel sprocket rack 33 feet 6½ inches pitch diameter, made in segments with 12-inch teeth, 18-inch pitch and 2-inch face. The center of the driving shaft M, and very close to the attachments to the trunnions. The distribution of metal is such that the long axis of the rectangular sections of the
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 pivot pin, with six teeth 12 inches pitch, with teeth corresponding to the rack. Three spoked teeth are elevated 1½ inches above the rack teeth, to compensate for the settling of the bridge by the wear of the tumbler rollers. Around these spoked 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 2½ inches in diameter, and the bars are 2½ inches thick. These chains are calculated to stand a maximum accidental stress of 100,000 pounds, and when thus strained will have a strain nearly 15,000 pounds per square inch. The total calculated working stress is 51,000 pounds. A fifth is used on each alternate tooth in the rack and pinion to check 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 not either a tooth could be broken without interfering in any manner with successful operation. The whole weight of the shafts, and both gears and chain, is carried on ball step bearings against the heavy brackets. Those bearings have 2½-inch steel balls. The plates are grooved so that each ball travels in a circle with no twisting motion.

On the upper ends of these pinion shafts are spur gear-gears for the secondary chains, running in the vertical shafts in the transverse vertical plane between the center vertical shafts and the pinion shafts in a reduction of 1 to 1. The secondary chains are of the 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 level gears 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 2½-inch steel balls respectively. The grooves are made as in the other bearings. On the upper end of these shafts are made molded rust-resistant level gears meshing into pinions on horizontal shafts, through the operating room, with pinions above and below and normally arranged. The reduction here is 2½ 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 in each side of the drum and to the main chain on each side of the drum, thus eliminating unbalanced side strains on the movable 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 level gears. As in this case only the differential of pitch in the various connections in the rack must be compensated for, there is only necessary for a limited movement here. By projection on the hub of the shafts and arms the gear, jaw clutches are formed which rigidly connect the shaft sections together if an excessive movement of the equalizer occurs. The best 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 360 volt current, and runs from 500 to 550 revolutions per minute. Mounted on one of the shafts for the gears is a large brake, incased.

Each rail, on each end of the bridge, and also the corresponding rail on the approach has a part of the hand car 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 1 foot long and when the bridge is closed, it is moved across the gap between the draw span and adjoining fixed span, bearing on both. Over the gap the key is about 1½ inches higher than the rail and imparts from here each way a little below the rail top. The key is in position to strike the front of our 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 trucks 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 rail 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-toggles type consisting of two parallel pairs of bars, pins connected in the end boxes directly under the wheels so as to turn freely, while on the lower end are rollers, which rest on bearing plates on the above abutment as shown in the figure. By means of a pneumatic cylinder, a center crank and levers connected to the roller pins, these jacks are turned to a vertical position when the bridge is closed and drawn back, and when released when the bridge is to be opened. A feature of the end lift device is a certain specific movement, enough to do the statistical work, and an arrangement 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 jacks have finished the movement raising the bridge the center of the trunk pin moves 1 inch beyond the frame joining the centers of the trunk pin at the rollers and the shaft in the end beam. There is, when then the jacks are self locked and no amount of power applied in any direction or the rollers can possibly unlock the larger. Hence the jacks are held the air pressure is cut off from the cylinder.

The electric current to operate the motors (taken from the power station of the Tri-City Railway Company through cables carried over the top of the bridge on the trusses 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 rail 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-toggles type consisting of two parallel pairs of bars, pins connected in the end boxes directly under the wheels so as to turn freely, while on the lower end are rollers, which rest on bearing plates on the above abutment as shown in the figure. By means of a pneumatic cylinder, a center crank and levers connected to the roller pins, these jacks are turned to a vertical position when the bridge is closed and drawn back, and when released when the bridge is to be opened. A feature of the end lift device is a certain specific movement, enough to do the statistical work, and an arrangement 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 jacks have finished the movement raising the bridge the center of the trunk pin moves 1 inch beyond the frame joining the centers of the trunk pin at the rollers and the shaft in the end beam. There is, when then the jacks are self locked and no amount of power applied in any direction or the rollers can possibly unlock the larger. Hence the jacks are held the air pressure is cut off from the cylinder.

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ASSEMBLED CONSTRUCTIONS OF THE 325 FOOT TINKER DRAW SPAN.
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other currents for lights, signals, etc., are brought down through an electric conduit 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. From any cause the current should fail, the change to the other could instantly be made by operating the switch. From the middle points of this switch the current passes through the main motor contact switch and air compressor motor contact switch and thence through the respective controllers. The switchboard carries besides these switches a switch for the illuminating lights to the operating room, in 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 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 bell signal is placed on each of the draw spans within a few feet of the ends of the bridge and stands normally at dinner. Connected to each of the jacks and rail locks are electrical connections 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 lit in the indicator, one lamp for each jack or rail, and when they are released for the bridge to swing the corresponding white lamp is lighted, replacing the red. By a combination of electric connections, the man in

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Section on Center Line of End Span

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HALF HORIZONTAL SECTION OF BEAMS.

HALF PICTURES CONCERNING TO THE TURNING BEAM.

The change of the bridge can set the signal to safety only when the end jacks and rail locks are set. Should the bridge, for any reason, not be properly locked, the engineer 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 and should the operator on returning in the room neglect to open his closing switch, then 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 is a bay window from which the operator has a clear view of the tracks and river, placed an interlocking controlling signal, having four levers. The first has to the right movement, main brake. The second lever controls the rail locks through an air valve and can be moved at will; this being thrown forward the rail 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 unless the rail locks and then the end jacks have been released, the indicator above referred to assuming 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 four steel reservoirs of a combined capacity of 282 cubic feet, from which air is drawn to operate the various cylinders. A uniform pressure of 125 pounds is maintained by an automatic device whereby the pump is started when the pressure falls below 120 pounds and stops when it reaches 125 pounds.

To guard against the possibility of the bridge becoming inoperative a supplementary hand reserve has been made for each respective device. To swing the bridge a capstan is placed underneath the capstan dock at each end and surrounded by the capstan. Eye bolts are fastened in the masonry at the abutment and at the ends of the stem protection. A heavy batter is placed on top of the capstan to prevent it from moving. The capstan can be operated by means of a lever this capstan can be operated.