~~Addendum to~~
Pacific Short Line Bridge
(Combination Bridge)
Spanning Missouri River
Sioux City
Woodbury County
Iowa

ADDENDUM
FOLLOWS...

~~REDUCED COPIES OF MEASURED DRAWINGS~~

PHOTOGRAPHS

~~WRITTEN HISTORICAL AND DESCRIPTIVE DATA~~

Historic American Engineering Record
National Park Service
Department of Interior
Washington, D.C. 20240

Addendum to
Pacific Short Line Bridge
(Combination Bridge)
Spanning Missouri River
Sioux City
Woodbury County
Iowa

HAER IA-1

HAER
IOWA,
97-SIOCI
1-

REDUCED COPIES OF MEASURED DRAWINGS
PHOTOGRAPHS
WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of Interior
Washington, D.C. 20240

THE PACIFIC SHORT LINE BRIDGE

SIOUX CITY, IOWA

An Historic American Engineering Record
Documentation Project

completed by

Dennett, Muessig & Associates, Ltd.
Iowa City, Iowa

for

Iowa Department of Transportation
Ames, Iowa

1980

HISTORIC AMERICAN ENGINEERING RECORD

Pacific Short Line Bridge

(U.S. 20 or Combination Bridge)

Location: Spanned the Missouri River between Sioux City, Iowa and South Sioux City, Nebraska, carried U.S. Highway 20.

UTM: North end: 15. 712660. 4707300
South end: 15. 712665. 4706830

Quad: Sioux City South

Date of Construction: 1890-1896. North approach replaced 1907, Nebraska swing span machinery electrified 1919. South approach replaced 1922. North approach rebuilt 1929. Rehabilitated 1937. Iowa swing span removed 1957. Cantilevered roadways widened 1961-62. Replaced 1980.

Owner: Iowa Department of Transportation
800 Lincoln Way
Ames, Iowa 50010

Use: Vehicular and pedestrian bridge

Significance: The Pacific Short Line Combination Bridge was the work of three prominent names in the late 19th century American engineering: J.A.L. Waddell (chief engineer), Charles Sooysmith's Sooysmith & Company (foundations and piers), and the Phoenix Iron and Bridge companies (fabricators and erectors). The dates of the Pacific Short Line Bridge (1890-1896) make it among the early large-scale works of both Waddell and Sooysmith. It is also one of Waddell's and Phoenix's earliest efforts in steel bridge design and construction, at a time when the use of steel was still not universally accepted, particularly for spans of the size of the Pacific Short Line bridge. As constructed, the bridge consisted of two 470' rim-bearing through Pratt swing spans and two 500' Pennsylvania through trusses. All spans were pin-connected. The bridge was built at least partially as Sioux City's response to changing developments in Upper Missouri transportation systems, as westward running railroads supplanted steamboats, which were instrumental in the city's early growth, as the principal carriers of people, goods and raw materials during the 1880's. The bridge also stands as a rather spectacular relic from a late 19th century speculative scheme to build a transcontinental "short line" from Sioux City to Ogden, Utah. Although the Pacific Short Line failed after two years (a lifespan common to other railroad ventures of its kind), businessmen of Sioux City saw the bridge through to completion. The transcontinental plans were not realized, but the bridge provided needed competition for the 1888 Union Bridge at Sioux City, controlled by the Chicago and North Western Railroad, and gave Sioux City businessmen access to potential markets in northeastern Nebraska. Perhaps the most long-lasting impact of the Pacific Short Line bridge was that its wagon, streetcar and pedestrian paths, eventually expanded to a full four lanes of highway, served to connect Sioux City physically -- and psychologically -- to areas to the west and south, resulting in the development of South Sioux City and environs as part of Sioux City's market and metropolitan area.

Project Information: The Pacific Short Line Bridge was documented by Dennett, Muessig & Associates, Ltd., Iowa City, Iowa, for the Iowa Department of Transportation. The documentation fulfills the obligations of the Iowa Department of Transportation, the Nebraska Department of

Roads, and the Federal Highway Administration under a Memorandum of Agreement between the Federal Highway Administration, the States of Iowa and Nebraska, and the Advisory Council on Historic Preservation, pursuant to 36 CFR 800. The bridge was photographed in May 1980 and measured in August 1980. The project team consisted of Martha H. Bowers, Historian; John Hotopp, Project Assistant; Hans Muessig, Engineering Historian and Photographer; and Robert Ryan, Photographer and Project Assistant.

CONTENTS

HISTORY OF THE PACIFIC SHORT LINE BRIDGE

The Pacific Short Line combination bridge was the later, and larger, of two railroad bridges built over the Missouri at Sioux City during the late 1880's and early 1890's.

Until this time, there appeared to be no pressing need for a Missouri crossing here. Beginning about 1858, Sioux City's economy developed around wholesale merchandising based on the Missouri River steamboat trade.[1] During the late 1860's, Sioux City's principal markets were in the Montana gold fields: Sioux City merchants obtained goods from St. Louis, then shipped them north, all transportation via Missouri steamboats. The arrival in 1868 of the Sioux City and Pacific Railroad, and of the Illinois Central in 1870, gave Sioux City a direct rail link to eastern manufacturers. This eliminated the city's dependence upon river transportation from the south, and, until the railroads built north to Yankton and Bismarck in the 1880's, gave Sioux City a pivotal role in the Upper Missouri steamboat trade, which in the 1870's and early 1880's supplied miners in the Black Hills, and also the US Army during its Dakota campaigns against the Sioux.[2]

As Sioux City gradually lost business during the 1880's to towns upriver, local merchants were forced to reconsider their long-time orientation toward the north, and to seek new markets in the slowly-developing areas of northeastern Nebraska. Sioux City's rail transportation system, however, had no direct access across the Missouri, as the nearest railroad bridge was some 60 miles south at Missouri Valley. Local businessmen had recognized this problem as early as 1872, the year the Central Pacific bridge was completed between Council Bluffs and Omaha. They organized the Sioux City Bridge Company and began seeking a railroad company willing to build a bridge over the Missouri at Sioux City. "Each railroad company turned a deaf ear" however, because the bridge charter, granted in 1877, provided for access by all railroads upon payment of "reasonable compensation".[3] The search continued well into the 1880's, until A.S. Garretson, a man of considerable economic standing and political influence, forged an agreement with the Chicago and North Western in 1887. The "Union Bridge" at Sioux City, designed by George S. Morison, opened 4 December 1888.

> "It is a wonderfully rich domain which is now opened in Sioux City. North Nebraska is a garden spot, and in the production of corn and grass is a world beater. It is a great stock country and its people are prosperous. Sioux City jobbers count it as among their best and most satisfactory trade territories. But this is not all the benefits to be derived by the opening of this union bridge....It decides the destiny of Sioux City and makes it sure that we are to have 100,000 people."[4]

These hopes, so fulsomely proclaimed in the exaggerated newspaper prose of the time, were but uncertainly realized. True to the letter of the charter, and of its agreement with the Sioux City Bridge Company, the North Western did operate a "union bridge", but its standards for "reasonable compensation" were viewed by other railroads in the city as prohibitive. As a result, Sioux City now had a railroad bridge, but the

North Western's charges effectively discouraged the kind of railroad growth so eagerly sought by city merchants, and limited their plans for developing trade territory in northeastern Nebraska.[5] Given these circumstances, local businessmen were understandably pleased to learn, in November 1889, of the Pacific Short Line plans to build a bridge at Sioux City and to develop a new transcontinental line to Utah.

The Pacific Short Line was but one of the many promotional schemes that accompanied the actual building of railroad lines across the continent. Its originator was Donald McLean, "a railroad adventurer of no special means" who "had the peculiar facility of getting capital."[6] McLean proposed a new line from Sioux City to Ogden that would "run through rich oil regions and coal mining districts", and that would be all of 120 miles shorter than the existing transcontinental line from Council Bluffs/Omaha.[7] McLean and his fellow incorporators, among them "railroad man" David MacKinzie, bridge contractor Leverett Clark, attorney Craig Wright, and Sioux City businessman and promoter John Peirce, organized a series of paper companies to handle shipping, warehousing, roadbuilding in Nebraska and further west, townsite promotion along the line, and to build the bridge at Sioux City.[8]

The Sioux City Journal published word of the proposed bridge on 15 November 1889. The project's chief engineer was J.A.L. Waddell, who at that time acted as the western agent for the Phoenix Bridge Company of Phoenixville, Pennsylvania, while conducting his own business out of Kansas City. At this early stage, both draw and high truss designs were under consideration.[9] The plans Waddell finally submitted to the Secretary of War early in 1890 were for a low bridge with a single draw span. According to a later account[10] the Secretary agreed to approve the plans only if a second draw span were included in the design. Although the Journal described this as "unfortunate", the use of two draw spans was actually a practical way to deal with problems of permanent or semipermanent river channel shift[11] for which the Missouri River was notorious.

By the end of November 1889, Lee Treadwell, an engineer with Waddell's office, had begun soundings to determine the nature of the river bottom and the depth of bedrock below the low water line -- a task which followed preparation of a hydrographical and topographical map of the river for a mile above and below the proposed bridge site. In place by this time, also, was a temporary railroad bridge, built by the Pacific Short Line to handle construction materials to the Nebraska side, since the North Western's high charges prohibited the use of the Union Bridge.[12] By the summer of the following year, the Pacific Short Line Bridge Company had executed construction contracts with the Phoenix company (for the superstructure) and with Sooysmith and Company of New York (for the foundations and piers).[13] The location of the bridge was announced in the Sioux City Journal on 13 September 1890, and on the following day the paper reported the arrival of "several carloads" of material, including "machinery for use in the dredging operations by which the piles will be sunk.[14] Late in 1889, work had begun on a rail line from South Sioux City to O'Neill, known as the Nebraska and Western, which was completed in August 1890.[15] In May of that year, the Wyoming Pacific Improvement Company of New York awarded to Scollen and Steacy, St. Louis, an $8 million contract to continue the Pacific Short Line the 830 miles from O'Neill to Ogden.[16]

With work on the bridge under way, McLean turned to other promotional efforts. In Sioux City, the Pacific Town Site Company opened an office in the Chamber of Commerce and ran advertisements asking readers to "investigate the possibilities of growth in the Pacific Short Line towns," which were a series of largely paper communities in Nebraska located along the Nebraska and Western between South Sioux City and O'Neill.[17] Land speculation was further encouraged by announcements that O'Neill was "growing handsomely", and that settlement of northeastern Nebraska was proceeding at a rapid rate.[18] To prove this, and to draw buyers, the Pacific Short Line planned an excursion to Osmond, Nebraska, to coincide with a town lot auction scheduled for October 29.[19] South Sioux City advertised its own small boom, based on its hopes for the bridge and upon the fact that the Pacific Short Line would locate its railroad shops there (after having received a $60,000 "bonus" from local promoters operating as the South Sioux City Land Company).[20] And the Pacific Short Line Express Company, with an office at 609 4th Street, Sioux City, opened for business for "all points between Sioux City and O'Neill".[21]

By November, 1890, stabilization of the south bank of the

Missouri was about finished, and the first pier caisson was soon to go down.[22] But there were rumors, which McLean at first denied, that the Pacific Short Line was in financial straits. On 15 November the Journal reported that the Line had been operating recently "at least with no profit to its owners."[23] A week later the paper was more specific. The Pacific Short Line "is not paying", is "losing money", and bridge work is -- or will be -- shut down.[24] Construction did go on into December, but only slowly, and by the 20th, work on the caisson for pier 3 had stopped and the number of men on the job was down to just those needed "to keep up appearance".[25] Also by the 20th, the Pacific Short Line had gone into receivership, following "a quarrel between Sioux City and New York stockholders," presumably over the company's finances.[26] The receiver was E.L. Bierbower of Omaha, a "friend" of McLean.[27]

The Sioux City interests, however, were determined to take control. Even if the Pacific Short Line's transcontinental plans failed, construction of a bridge would significantly aid Sioux City's development of Nebraska markets. In April, 1891, A.S. Garretson, a Pacific Short Line investor who had 3 years earlier achieved the erection of the Union Bridge, declared the combination bridge "will be built".[28] Indeed, work began again on the bridge in May, 1891. Pier #3 was sunk, and #2 came close to completion.[29] On September 1, however, the mortgage on the Pacific Short Line was foreclosed and all construction ceased. On 23 October, Garretson (who had unsuccessfully tried to buy the line a year before)[30] and George Wickersham bought the

Pacific Short Line, including the bridge company and the Nebraska and Western Railroad, for $2 million.[31] The 129 miles of the Nebraska and Western line Garretson renamed the Sioux City, O'Neill and Western.

Bridge work did not resume until December of 1892, delayed at least in part by problems between the Pacific Short Line Bridge Company and the builders, Phoenix and Sooysmith.[32] Once at work, however, Sooysmith's western manager George Adgate intended to proceed rapidly, building 2 and 3 piers simultaneously. Pier 3 (for the Iowa draw span) was to be completed "at once", the caisson for #4 begun at the same time, and, as soon as that caisson was ready, workers would begin #5. Adgate dismissed rumors to the effect that plans for a combination bridge had been shelved in favor of a straightforward railroad structure, saying "we are putting in piers that will carry a combination bridge".[33] Construction was aided by the organization, early in 1893, of a "new" bridge company, the Missouri River Bridge Company, which held "all the rights and franchises" of the former company.[34]

In April 1893, Adgate was on schedule, with masonry laid for pier #3, and caissons for piers 4 and 5 sunk.[35] Work was abruptly halted on the 21st, when the current of the Missouri's springtime high water washed away the tramway between piers 4 and 5. Before the damage could be repaired, the entire project folded -- a victim of the national financial panic triggered by a combination of agricultural depression, monetary problems, and overspeculation. On 28 April, Garretson announced that bridge work would not be resumed in the near future, "and he could not say when it would be".[36]

The impact of the panic on Sioux City businessmen, whose economic and transportation systems were basically "defined by a commercial network whose centers of power remained beyond their control,"[37] was severe. Within a few days in late April, many of the city's largest businesses closed.[38] Perhaps most illustrative of the panic's effect on Sioux City was the fact that the town's population, which had grown from 19,060 in 1885 to over 37,000 in 1890, had fallen to just over 27,000 5 years later.[39] Among the failures was the Union Loan and Trust Company, the "railroad syndicate" backed heavily by New York's Manhattan Trust Company and controlled locally by A.S. Garretson, Edward Haakinson, John Hornick and James Booge.[40]

The syndicate counted among its holdings the newly-formed Missouri River Bridge Company, and the Sioux City and Northern and Sioux City, O'Neill and Western railroads.

To protect their investments, "over 200 creditors" of the Union Loan and Trust, including many with Sioux City interests, met in Chicago in June 1893. They organized the Credits Commutation Company, "the main object of which was to save from the wreck whatever could be saved".[41] Over the next few years, Credits Commutation Company was occupied principally in settling debts, fending off lawsuits, and otherwise trying to put Sioux City enterprises back on a firm financial footing.[42]

One of the company's projects was the organization in May, 1894, of the Combination Bridge Company.[43] Although many of

Credit Commutation's members were indifferent, and even opposed, to the bridge project, Sioux City promoters had two strong allies in Frederick L. Eaton, Credit Commutation's secretary and general manager, and Colonel J.C. Elston, a member of Credit Commutation's executive committee and a director of the Bridge Company.[44]

Despite the failure of Donald McLean's transcontinental scheme, and of Garretson's attempt in 1892-3 to keep the bridge construction going, Sioux City people had not given up hope for a second bridge across the Missouri.

> "First and immediately, Sioux City was shut off for the greater part of the year from the trade of the fertile region lying at its door across the river. Second, the river interposed an almost impassable barrier to any railroad seeking to come from Iowa into Nebraska. Third, one bridge without competition, the tolls of which at any time could be made prohibitory, and the powers of Sioux City to compete with other markets for Nebraska business being in the hands of one company and dependent on that company's friendship, formed another serious obstacle to the city's rapid advance in the commercial world. In addition to these reasons it appeared to the Credits Commutation company that the bulk of the trade naturally would pass over the bridge and the chance of growth of the company's allied enterprises be greatly increased, and, taking into consideration the work already done, it would be only good business to complete the structure. It was figured that it would bear a fair rate of interest on the investment and would be a valuable property in the course of time.[45]

These arguments persuaded Sioux City voters on 26 June 1894 to approve, three to one, a 2% tax (amounting to about $300,000) to assist in completion of the bridge.[46] They also were used effectively by Eaton and Elston a year later, when during May and June 1895 they went before the Credits Commutation membership, gathered again in Chicago, and forced through a 10% assessment on the company's $4 million worth of stock -- a move that ensured that the bridge, so long delayed, would at last be built.[47]

On 12 June 1895, the Combination Bridge Company rehired J.A.L. Waddell and Lee Treadwell (the latter the resident engineer for the project), and negotiated new contracts with Sooysmith and Phoenix.[48] The negotiations took 4 days, perhaps because the building firms were being asked, according to Waddell, "to do a piece of work unprecedented in the history of civil engineering, viz: to build a larger bridge than any yet built across the Missouri River, and complete it in... eight months."[49]

The final push to build the bridge began in late June. The construction site was occupied day and night, seven days each week[50] as Sooysmith's crew rushed to finish the piers (5,6,7,&8) toward the Nebraska shore while Phoenix men erected falsework for the superstructure from the Iowa side.[51] The Iowa draw span was the first built, begun about 11 September and "coupled up" by the 24th of that month.[52] The first fixed span went up in 9 days, between the 4th and 13th of October[53] and the second was underway by the 20th.

As the autumn progressed, the bridge builders encountered weather problems. High winds occasionally prevented work on the superstructure[54], and the Nebraska draw span was briefly delayed due to ice and frost in November.[55] As the bridge itself went up, the Sooysmith company worked on the Nebraska approach, and in early November received the contract for the Iowa approach as well. These were timber pile, rather than girder, approaches, and represented a rather late change in plans due to budget problems - Lee Treadwell was working on new design for the Iowa approach in October.[56]

On 18 November 1895, the Phoenix Bridge Company inserted the last pins in the connections, and "rested" the following day.[57] Riveters and painters worked through Thanksgiving Day, and during most of December. These last 2 months of 1895 also saw the completion of the d ck, placement of the cantilevers, laying of track, removal of the falsework and pilings, completion of the Nebraska approach and, toward Christmas, final work on the Iowa approach.[58] The last major work came in January 1896. Track from the bridge was connected to the Pacific Short Line line on the Nebraska side on the 13th.[59] The Sioux City Traction Company (operators of the streetcar line) joined its stub line from the bridge to West 3rd Street and Perry Creek on the evening of the 19th, although its track gangs, and those of the Sioux City and Northern (which was responsible for laying the railroad line), continued to work steadily for the next several days.[60]

Throughout January the Sioux City Journal reported on plans for the opening ceremonies, scheduled for 21 January 1896. On the appointed day, officials from Sioux City and South Sioux City joined bridge company officers and Engineer Waddell in "expressions of good will and gratification."[61]

"The combination bridge, which from the start has been known as the Pacific Short Line bridge, is completed. It is ready for use and is in use."[62] As proof that the task was indeed finished, one of the Sioux City Traction Company's streetcars crossed the bridge at 11AM, followed by locomotives of the Pacific Short Line (with Sooysmith manager Adgate on the cowcatcher) and the Sioux City and Northern. At noon, Lee Treadwell opened the Nebraska span, to the general gratification of the crowds that had filled the pedestrian walks since 9AM. In the afternoon, the first train pulled out of Sioux City's Union station to the music of the Fourth Regiment Band. It was cheered across the bridge by the crowds, and met on the Nebraska side by South Sioux City dignitaries and townspeople who had gathered to "show by this formality their gratification at the completion of the bridge."[63]

There were many speeches that day on both sides of the Missouri River. John Davies, president of South Sioux City's town board, declared "the completion of the Pacific Short Line bridge marks an epoch in the history of South Sioux City. It makes its [sic] possible for us [South Sioux City and Sioux City] to work together. It means the development of new lines of railroad and the development of the resources on this side of the river."[64] Sioux City Mayor C.W. Fletcher promised "a new era of prosperity for northeastern Nebraska and northwestern Iowa" and "for the whole of these states and adjacent states."[65]

When called upon to speak, J.A.L. Waddell said simply that "he was very glad the bridge was completed."[66]

* * * * * *

For fourteen years the bridge served largely as intended. The structure's principal user was the Great Northern Railroad, which eventually took over both the Sioux City, O'Neill and Western, and the Sioux City and Northern roads. Although the old Pacific Short Line rail line never did become part of a "new route to the Pacific", cars of the Sioux City, O'Neill and Western brought to Sioux City grain and livestock from northeastern Nebraska, and took on coal and lumber from connecting lines.[67]

In 1910 however, the Great Northern was rerouted over the old Union Bridge, probably because that bridge was located closer to Sioux City's stockyards and packing houses, which beginning in the 1890's grew to rival those of Chicago. The Pacific Short Line bridge trackage became the exclusive domain of the streetcar system (until buses took over in 1937), binding South Sioux City ever more closely to Sioux City's metropolitan development.

Financial problems continued to be a part of the bridge's history. $500,000 in bonds issued by the Combination Bridge Company toward construction costs never paid off, and purchasers were forced to take heavy losses on their investments. Loss of railroad fees after 1910 created additional financial strains, and in 1916 the bridge was sold at a receiver's sale for only

$288,000. The Missouri River Bridge Company was organized to bond the bridge for $1.3 million.[68]

Within a few years, the issue of bridge tolls became prominent in local thinking. The Pacific Short Line bridge had not been intended as a free crossing, but rather was a second attempt to achieve a crossing available to a variety of railroad users. Correctly or not, however, people on both sides of the Missouri River began to see bridge tolls as an obstacle to commerce and, later, tourism. In response came a series of efforts, lasting over 30 years, to achieve a free crossing.

Because the Pacific Short Line bridge was privately owned, and in no condition financially to operate without charges, the only alternative seemed to be construction of yet another crossing. A petition circulated in 1919 to bring the new bridge question to a vote in Sioux City failed for want of signatures, but the issue remained active. Five years later, a bond issue for a new bridge came before Dakota County voters in Nebraska, but this also was rejected.[69]

The unsuccessful petition and bond issue did, however, focus more public attention on the bridge problem. The next year, 1925, saw the organization of an Iowa-Nebraska bridge commission. The commission's practical recommendations were (1) to build a new bridge, or (2) to have the two states purchase, jointly, one or both of the existing bridges and run them without charge. The latter proposal seemed the more popular: although in 1927 the Iowa Senate rejected a House bill setting aside highway funds for bridge purchase, the Nebraska legislalittle advertised, passed overwhelmingly in 1940, and the city hired the St. Louis engineering firm of Sverdrup and Parcel on a contingent basis to prepare plans and specifications. World War II halted the project, however, as the cost of steel and labor "rose sky high" and threatened to double the price of the structure originally estimated at about $1 million.[74]

Despite these reverses, support for a new bridge continued strong, during the war and after. In 1949, Dakota County applied for a Corps of Engineers permit to make repairs on the Pacific Short Line bridge. The county said it planned to seek state and federal monies to pay for the work, but Ward Evans and other free-bridge advocates refused to believe this. They were convinced that the County was really intending to issue revenue bonds, which would require bridge tolls to remain in force for many years. The city council and Chamber of Commerce in Sioux City did not fully subscribe to Evans' argument, but their recommendations were that Dakota County should wait until the bridge was free of existing bonded indebtedness before considering major and costly improvements. In the face of all this controversy, Dakota County withdrew its application to the Corps.[75] As it happened, only about a year passed before Dakota County was able to retire the last of its $1.5 million in revenue bonds on the bridge. On 2 November 1950 came the announcement that the bridge would be turned over to the states of Iowa and Nebraska, and would henceforth operate as a free bridge.[76] The transfer was accepted by the Iowa Department of Transportation on 21 November. The Dakota County board of commissioners formally approved a measure declaring the bridge free of bonded indebtedness on 8 February 1951. The bridge was until the present operated under the joint ownership of Iowa and Nebraska, with Iowa handling all maintenance and repair, and Nebraska reimbursing that state for a percentage of the costs.[77]

FOOTNOTES

[1]William Silag. City, Town and Countryside: Northwest Iowa and the Ecology of Urbanization. Ph.D. Dissertation, University of Iowa, 1979, p. 47.

[2]Hiram M. Chittenden. History of Early Steamboat Navigation on the Missouri River. Minneapolis: Ross & Haines, 1962. Reprint of 1903 edition, p. 419; William E. Lass. A History of Steamboating on the Upper Missouri River. Lincoln: University of Nebraska Press, 1962, pp. 21ff.

[3]"Story of a Bridge". Typescript of newspaper article (n.d.) from S.T. Davis scrapbook, Sioux City Public Museum. Works Progress Administration, Iowa Historical Records Survey Report, 1940.

[4]Ibid.

[5]John F. Schmidt, A Historical Profile of Sioux City. Sioux City: Sioux City Stationery Company, 1969, p. 83.

[6]Sioux City Journal, 22 January 1896, p. 10:1.

[7]Ibid.

[8]Ibid.

[9]Sioux City Journal, 15 November 1889, 6:1.

[10]Sioux City Journal, 22 January 1896, 15:1.

[11]J.A.L. Waddell. Economics of Bridgework. New York: John Wiley & Sons, 1921, p. 122.

[12]Sioux City Journal 27 November 1889, 3:3; Railroad Gazette 22 (29 August 1890), p. 611.

[13]Sioux City Journal 22 January 1896, 10:1.

[14]Sioux City Journal 14 September 1890, 8:3.

[15]Railroad Gazette 22: 17 January 1890, 49; 28 February 1890, 151; 28 March 1890, 224; 9 May 1890, 329; 23 May 1890, 396; 25 July 1890, 533; 29 August 1890, 611.

[16]Railroad Gazette 22: 16 May 1890, 348.

[17]Sioux City Journal 15 September 1890, 3:3-5.

[18]Sioux City Journal 16 September 1890, 4:4; 17 September 1890, 4:2.

[19]Sioux City Journal 19 October 1890, p. 13.

[20]Sioux City Journal 26 September 1890, p. 3; 17 September 1890, 5:1.

[21]Sioux City Journal 7 October 1890, 5:5.

[22]Sioux City Journal 15 November 1890, 5:2.

[23]Ibid., 5:1.

[24]Sioux City Journal 21 November 1890, 2:1.

[25]Sioux City Journal 20 December 1890, 5:2.

[26]Railway Review 31 (7), 14 February 1891, 110.

[27]Sioux City Journal 19 December 1890, 2:1; 25 December 1890, 2:5.

[28]Sioux City Journal 22 April 1891, 5:4.

[29]Schmidt, p. 84.

[30]Railroad Gazette 22, 8 August 1890, p. 563.

[31]Ibid., 23, 30 October 1891, 774.

[32]Sioux City Journal 21 December 1892, 4:6.

[33]Ibid.

[34]Sioux City Journal 22 January 1896, 10:1.

[35]Schmidt, p. 84.

[36]Sioux City Journal 21 April 1893, 3:2; 28 April 1893, 3:2-3.

[37]Silag, p. 4.

[38]Schmidt, p. 86; Sioux City Journal 28 April 1893, 3:2-3; 22 January 1896, 15:5-7.

[39]Silag, p. 145.

[40]Sioux City Journal 22 January 1896, 15:5-7.

[41]Ibid.

[42]Schmidt, p. 85; Railroad Gazette 26, 21 December 1894, p. 862; 27, 25 January 1895, p. 62; 14 June 1895, p. 398;

Sioux City Journal 22 January 1896, 15: 5-7. The crash also revived rumors, first circulated in early 1891, that J.J. Hill's Great Northern Railroad was interested in acquiring both the Sioux City and Northern and the Sioux City, O'Neill and Western. Although these rumors were quite premature, the Great Northern was to operate over the combination bridge until 1910. (Railway Review, 31(7) 14 February 1891, p. 110; Sioux City Journal 28 April 1893, 3: 2-3).

43 Sioux City Journal 22 January 1896, 15: 5-7.

44 Ibid., p. 14: 1-5.

45 Ibid., p. 10: 1-2.

46 Sioux City Journal 23 June 1894, 5: 1-3; 27 June 1894, 3:5.

47 Sioux City Journal 22 January 1896, 10:2.

48 Ibid.

49 Sioux City Journal 22 January 1896, 4:1.

50 Sioux City Journal 22 September 1895, 3:2; 24 September 1895, 7:3.

51 Sioux City Journal 1 August 1895, 8:3; 10 August 1895, 8:3; 19 August 1895, 8:4; 23 August 1895, 8:4; 6 September 1895, 8:4.

52 Sioux City Journal 25 September 1895, 6:1.

53 Sioux City Journal 20 October 1895, 11.

54 Sioux City Journal 28 October 1895, 8:4.

55 Sioux City Journal 9 November 1895, 8:4.

56 Sioux City Journal 19 October 1895, 5:5; 6 November 1895, 7:4.

57 Sioux City Journal 20 November 1895, 8:4.

58 Sioux City Journal 24 November 1895, 3:1; 28 November 1895, 8:3; 29 November 1895, 8:3; 4 December 1895, 8:4; 8 December 1895, 6:1; 9 December 1895, 8:4; 10 December 1895, 8:3; 14 December 1895, 5:3; 16 December 1895, 8:4.

59 Sioux City Journal 13 January 1896, 8:3.

60 Sioux City Journal 20 January 1896, 8:3.

[61]Sioux City Journal 22 January 1896, 1.

[62]Ibid.

[63]Ibid.

[64]Ibid., p. 2.

[65]Ibid.

[66]Ibid.

[67]Nebraska Board of Transportation, Annual Reports. Lincoln: State Journal Co. (printers). 6th Annual Report, for 1892 (1893), pp. 456-468; 9th Annual Report, for 1895 (1896), pp. 490-504; 10th Annual Report, for 1896 (1897), p. 552. Subsequent annual reports were published in a different format, using aggregate statistics.

[68]Sioux City Journal 25 July 1954 (Centennial Issue), p. 20:6-7.

[69]Ibid.

[70]Ibid., 20:8; p. 21:1.

[71]Sioux City Journal 1 May 1937, 1:1; 2 May 1937, A15:2, B16:1; 8 May 1937, 11:1-3; 11 May 1937, 14:2-3; 13 May 1937, 16:6; 14 May 1937, 8:7.

[72]Sioux City Journal 1 May 1937, 11:3-7.

[73]Sioux City Journal 10 January 1938, 1:8; 3:1-3.

[74]Sioux City Journal 25 July 1954, 21:2-5.

[75]Sioux City Journal 10 August 1949, 2:2-3; 11 August 1949, 5:1; 13 August 1949, 7:4; 14 August 1949, II 6: 5-6; 17 August 1949, 11:2; 18 August 1949, 1:4, 7:4.

[76]Sioux City Journal 3 November 1950, 7:6-8; 9 February 1951, 1:4, 6:1.

[77]Iowa Department of Transportation, Maintenance and Inspection Files for U.S. 20 Combination Bridge, Sioux City.

CONSTRUCTION HISTORY AND TECHNIQUES

After he was engaged by the Pacific Short Line Bridge Company, one of James Waddell's first acts was to send Lee Treadwell to Sioux City in November, 1889 with a party of surveyors. Treadwell's assignment was to complete a topographic and hydrologic survey of the Missouri River for a distance of a mile above and below the proposed bridge site. As part of his survey, Treadwell completed a series of twenty borings to determine the depth to, and the character of, the bedrock upon which the piers would rest.

The borings were accomplished by driving a 2" pipe, open at both ends, through the sand and river gravel until it struck bedrock. Driving the pipe through the river gravel was accomplished in stages. First the pipe was driven a few feet, and then a one inch pipe was inserted into the 2" pipe until it struck bottom. A stream of high pressure water was then directed down the smaller pipe to clean out the sand and gravel that had filled the larger pipe during driving. The water pipe was removed, and the larger pipe driven a few more feet. Once the pipe stem reached bedrock a drill was inserted that bore a 10 to 20-inch hole to determine the character of the rock.[1]

The surveys and borings were completed toward the end of January, 1890, and with the information they provided, Waddell set about designing the bridge. After receiving approval for his design - with the addition of a second swing span - Waddell drew up detailed plans and specifications.

Work on the substructure of the bridge began in August of 1890 with the construction of a pile trestle out from the Iowa shore to the site of pier 3 (Historic Photograph HP-4). Work on the pier itself began November 23 (a Sunday) with the sinking of the pneumatic caisson and its pressurization. The caisson was 38'6" in inside diameter and was equipped with electric lights. On the site of the pier there was a power-house with three air compressors and an electric generator for the caisson. This equipment was powered by four boilers and a series of donkey (steam) engines.[2]

In mid-December the railroad's financial problems became critical and all work on the bridge ceased. At this point the caisson for pier 3 had been sunk 35' and the caisson for pier 4 had been partially framed. Work was resumed in May, 1891. When the money ran out that September, pier 3 had been finished except for the masonry, and pier 2 was nearly complete.[3]

Work resumed again in December. The caissons for piers 4 and 5 were framed and placed, with crews working three shifts, seven days a week. The steel for the caissons for piers 6 and 7 arrived in Sioux City and framing was started for these caissons.[4]

In early April 1893, floodwaters destroyed the pile trestle leading to the piers and all work on the piers stopped. By late April, the nationwide financial panic reached Sioux City and the failure of a number of the city's major financial businesses, including some owned by bridge and railroad investors, precluded any further work on the bridge.[5]

A considerable amount of work had been completed. The Engineering News and Railroad Journal reported that piers 2 and 3 were complete except for some masonry work. Piers 4 and 5 had been sunk 45' and 65' below low water respectively. The caisson for pier 7 had been built on shore and was ready to be floated to the pier site. The steel for the caisson for pier 6 had been delivered. Some work had also been accomplished on pier 2. The Journal added that "Nearly one-half the steel for the superstructure had been rolled and a small portion of it manufactured" by the Phoenix Bridge Company.[6]

* * * * * *

Sooysmith and Company used several methods to built the piers of the Pacific Short Line Bridge. Piers 2 and 8 (the latter completed in 1895) each consisted of a pair of Lally columns. These were built in sections and sunk by open dredging. When the columns could be sunk no deeper, a series of piles was placed inside the columns and driven to bedrock. The columns were then filled with Portland Cement grouting to the top of the piles and from there up with American National Cement concrete (Historic Drawings 79, 80, 81A).

Piers 3, 4, and 5 (under construction 1890-91, 1892-93) were sunk using pneumatic caissons of steel. The diameter of the caisson for pier 3 was 38'6"; the caisson for pier 4 was 19' x 44', for pier 5 20' x 46'. A chamber 8' high formed the bottom section of each caisson. This chamber had no bottom and was pressurized to keep out water, mud and gravel from the river bottom. A group of men, called "sandhogs", worked in this bottom chamber removing the gravel, sand, and mud under the caisson so it could slide through this muck to bedrock. Near the bottom rim - the cutting edge - of each caisson was a series of 5" pipes for blowing out the sand, gravel, and mud. The sandhogs shoveled the muck around the open ends of these pipes and the pressure of the caisson forced it up the pipes and outside. Access to the bottom chamber was through a 4' shaft and airlock for men, and a 3' shaft and airlock for equipment and materials. A series of small pipes into the bottom chamber brought air in and removed it.

In general, as the caisson sank deeper additional sections, or rings, were added to the outer shell, the access shafts, and the blowout and air pipes. The additional caisson sections served to keep the river from spilling into the caisson and also as forms for the concrete which was poured into the caisson above the bottom chamber. When the concrete reached a certain height above the foot of the caisson, work on the masonry shell began. Once the cutting edge of the caisson touched bedrock, it was sealed, the bedrock prepared, and the bottom chamber and the access shafts filled with concrete, thus forming an essentially solid concrete column, or pier, with a steel shell. By this time, some, if not all, of the masonry for the top portion of the pier was in place.

Piers 6 and 7 (sunk in 1895, see below) were completed using the open dredging method rather than the pneumatic method. Open dredging consisted of removing material from the bottom chamber of the caisson through an open well in the caisson with a clamshell bucket (Historic Photographs HP-31,32,33). As the caisson sank additional sections were added to the shell and to the open well. As with the pneumatic caissons these sections served as forms for the concrete which made up the lower portion of the piers. The masonry portion of piers 6 and 7 was constructed in the same manner as the other piers.

* * * * * *

When work resumed in June, 1895 it was resumed on many fronts. Pier 4 was finished in mid-July and steel for the superstructure began arriving in late-July.[7] The caisson for pier 7 was launched July 23rd (see Historic Photographs HP-11,12). The piles and other lumber for the falsework arrived August 2nd.[8] (This falsework, or scaffolding, served as a platform to work from and supported the steel of the trusses until they were completed and able to support themselves.) The next day the caisson for pier 5 reached the bottom and "work at cementing [was] commenced". By August 6th the last of Sooysmith's "sandhogs" were paid off; some of them remained in town to work for Phoenix when the erecting began.[9] By mid-August the falsework extended beyond pier 3 and pier 6's caisson was down 40'.[10]

In late August A.B. Milliken, Phoenix's Superintendent for Construction, began the process of placing the rails, rack, rollers, and radial rods for the Iowa swing span turntable. On August 31 the first section of the drum was placed (Historic Photograph HP-17). Two days later the "main traveler" was framed.[11] This erecting frame consisted of a series of derricks and overhead cranes that ran on rails laid on the falsework. The traveler weighed 120,000 pounds and stood 84 feet high. It was the largest piece of equipment used in the erection of the bridge.

The first steel for the Iowa swing span was placed September 8th. The central tower was framed and several members of the north arm of the span were placed by September 14 (see Historic Photograph HP-19,20). Five days later the north arm was complete. Work then commenced on the south arm (Historic Photographs HP-22,23,24) which was 'coupled up' (meaning that the top chord, bottom chord and web were completed and the last pin hammered into place on the 24th).

Because work progressed day and night, the Pacific Short Line yards in Sioux City, which served as the marshalling yard for the steel of the superstructure (Historic Photograph HP-22) were illuminated with arc lights. Although the "superstructure gang" did not work at night, it was then that structural pieces needed for the next day's work were loaded and taken onto the bridge, either on rails laid on the completed portions of the bridge and the falsework, or on the trestle running out to the piers. The masonry on pier 6 was started on September 26 and the caisson for pier 7 was down 84' by that date. The next day twenty-five car loads of steel for the north fixed span arrived. (Historic Photograph HP-33 showing work on piers 6 and 7, was taken about this time.)[13]

Work on the superstructure of the north fixed span began on

October 4th even before the falsework at the south end of the future span was complete.[14] As the traveler moved toward the center of the falsework, the superstructure gang used it to place the bottom chord eyebars and hangers on the falsework. When the traveler reached the center it was used to erect the center panels of the bridge. The traveler then moved north as this half of the span was erected. The north half was finished on the 9th and the traveler moved back to the center so that the superstructure gang could work toward the south abutment (pier 5). The main structure - top and bottom chords and webbing - of the span was completed October 12 and work began on placing the floor beams and stringers.

Pier 7 reached bedrock while the north fixed span was being built and work on the masonry began. Preparations were underway for pier 8 and the Iowa swing span was given its first coat of red paint.[15]

Work on the south (second) fixed span began on October 20. As the traveler was moved toward the center of the span the eyebars and hangers for the north half were laid out. The center panel was started on the 21st and work proceeded rapidly toward the south end (pier 6 with the fixed abutment). Work was halted on Sunday, October 27th because of high winds, but the span was finished the next afternoon. In all the "iron [sic] erection took 55 hours", and this was "said to be the fastest time on record" for a 500' span. Placement of the floor beams and the stringers was finished October 31st. Including the erection of the falsework, the two fixed spans were completed in 24 days.[16]

* * * * * * *

The erection of the two fixed spans started at the center panels because these were capable of standing alone. The traveler, placing web and top chord members, proceeded toward the end of the span with the fixed abutment. When this half of the span was complete the traveler was brought back to the center of the span, and work proceeded toward the abutment with the sliding pedestal (these pedestals, set on rollers as a provision for the expansion and contraction of the fixed spans, are located on pier 5). During the erection of both fixed spans, the traveler was used to place the lower chord eyebars and the hangers as it was moved toward the center of the span. On the north fixed span the traveler was then moved back toward pier 4 (with the fixed pedestal) and the web and top chord were built atop the previously placed bottom chord members. For the south half of this span the lower chord members were placed as the web and top chord were built.

On the south fixed span the bottom chord members on the north half were laid out as the traveler moved on the falsework toward the center from the north fixed span. Erection of the center panels and the south half of the span was then completed, and the traveler returned to the center and worked north. (This sequence is shown very well by Historic Photographs HP-25-30 for the north fixed span and HP-36-42 for the south fixed span.) Once the top chord and the web were complete (i.e. the last pin was placed and the span "coupled up") and the truss was capable of supporting itself rather than resting on the falsework, the traveler was used to place the floor beams, bottom lateral bracing, and the stringers (Historic Photograph HP-30, taken 13 Oct. 95 shows floor beams and stringers being placed on the north fixed span). Small derricks placed the cantilever brackets and outside stringers after the traveler had finished on a span.

* * * * * * *

While work on the second fixed span proceeded, the flooring (deck) on the Iowa swing span was completed. Workmen also started building the blinds between the railroad track and the roadways.[17] Sooysmith's crews were hard at work on the Nebraska approach (Historic Photograph HP-45) and pier 8. In October, Treadwell designed the timber trestle for the north approach. A contract for the north approach was awarded to Sooysmith on November 5th.[18]

Work on the Nebraska swing span started on November 4th with the erection of the central tower. The north arm was begun, but its construction was slowed by frost and ice.[19] As on the Iowa swing span, everything but the floor beams and stringers were placed as the traveler worked out from the pivot pier. Once the arm was complete and able to support itself the floor beams and stringers were placed using the traveler. The north arm was "coupled" on the 9th and finished on the 12th.

Completion of the south arm of the Nebraska swing span must have been an interesting proposition, with the pile drivers for the falsework moving only slightly ahead of the traveler itself (see Historic Photograph HP-46). Nonetheless the south arm was "coupled" and finished on November 18th.[20] In erecting the south arm, the floor beams and stringers were placed as the top chord and web were erected. This was possible because the completed north arm acted as a counterbalance.

During the next five weeks the remaining cantilever brackets and outside stringers were riveted in place, the railings and deck finished, and the bridge painted. By the end of November many of the Phoenix men had left. Sooysmith's crew was still working on the Nebraska approach, which it finished in mid-December. Work on the north approach began December 7th. On December 28, 1895 the Phoenix Bridge Company announced that the bridge would be finished in two or three days. By this time Phoenix men who were not laying rails had left for Rock Island to work on the Government bridge across the Mississippi River to Davenport, Iowa.[21]

The bridge itself was finished on January 1, 1896, but the rails on the north approach were not finished until shortly before the opening ceremonies on January 22, 1896.

* * * * * * *

In the eighty-four years since it was opened the Pacific Short Line Bridge has been renovated and repaired several times. The first major modification came in 1907. The Combination Bridge Company asked Waddell and Harrington (Kansas City, Missouri) to prepare plans for replacing the timber trestle approaches with steel deck girder approaches. The north approach was rebuilt but, for whatever reason, the south approach was not.

In 1919 electric motors were installed in the Nebraska swing span. These motors ran off the 500 volt DC for the streetcars. In all there were three motors: one for each of the two pinion gears and one for the locking gear at either end of the swing span. The engineering firm of Waddell & Son, Inc. (New York City and Kansas City) prepared the drawings and specifications for the Missouri River Bridge Company.

The south approach was finally replaced in 1922 as a deck girder trestle. The American Bridge Company fabricated, and probably erected, the approach which followed the 1907 proposed drawings quite closely. It is highly likely that Waddell was involved but this cannot be confirmed.

The Chicago, Milwaukee, St. Paul & Pacific Railroad rebuilt the north approach in 1929. The work, designed by the Engineering Department, consisted of replacing and re-enforcing the deck girders under the streetcar tracks and replacing the wooden deck with a concrete one.

The removal of streetcar service across the bridge in 1937 led to the first major alterations to the main spans. The streetcar/railroad rails were removed and the center was converted to a two lane roadway; the westside roadway was then converted to a walkway. The center deck was replaced with an open steel grate; the deck on the cantilever bracket remained wood. The Nebraska swing span machinery was rebuilt also. The work consisted of replacing several sections of the rack, totally replacing the two pinion gears and associated supports on the drum, rebuilding the locking/lifting jacks at the ends of the span and adding a locking bolt. Because the 500 volt DC service was removed from the bridge along with the streetcars a gasoline powered generator was installed to provide power to the three motors that operated the swing machinery. Waddell and Hardesty of New York served as consulting engineers for the project.

In August, 1957 the Iowa swing span was opened for the first time since 1929 - the river having long since abandoned the channel on the Iowa shore. It was swung so that Interstate 29 could be finished. Since a cloverleaf interchange was designed to occupy the land occupied by the span, the August swinging was the last for the Iowa span.

Because the Pacific Short Line Bridge was the only bridge over the Missouri for 40 miles up or downstream it carried increasing numbers of automobiles and trucks as these became the normal transportation for Americans. In response the Nebraska Department of Roads prepared plans for widening the roadway on the east cantilever and converting the walkway on the west cantilever to a roadway. To accomplish this the cantilever brackets were lengthened by 5'3" on the east side to accomodate a 12' roadway and by 11'3" on the west side for the 12' roadway and a 4' walkway. A steel grate deck was installed on the new roadways. An interesting aspect of the widening is that the existing floor stringers placed in 1895 were reused once the cantilever brackets were lengthened: the exterior stringer was placed on the existing seat for the interior stringer and the interior stringer was placed on the bracket extension.

Since the widening in 1961, the most serious problem the bridge suffered was with the grate decking. It was improperly installed and was prone to come loose from the subfloor. The annual inspection report for 1965 noted that the bridge was in good condition but added "the maintenance of the grid floor will continue to be an expensive and time consuming item." The annual inspection reports did say that rust was beginning to take its toll, but this was never noted as a serious problem. In April, 1967 the Iowa Department of Transportation had problems with the motors that operate the Nebraska swing span; the bridge had to be closed manually. Concern over the reliability of the motors (incorrectly thought to date from 1893) lead to their replacement in November, 1968. By the mid-1970's the bridge was carrying upwards of 40,000 vehicles a day and it had a high accident rate because of the narrow lanes and grate deck. Replacement of the bridge became inevitable. It is scheduled for late 1980.

FOOTNOTES

[1]Sioux City Journal, 22 January 1896, p. 5:1.

[2]Sioux City Journal, 25 November 1890, p. 5:1; 22 January 1896, p. 5:2.

[3]Sioux City Journal, 4 December 1890, p. 2:6; 22 January 1896, p. 5:2.

[4]Sioux City Journal, 21 December 1890, p. 4:6; 7 January 1893, p. 5:3; 17 January 1893, p. 5:3; 28 January 1893, p. 6:3.

[5]Sioux City Journal, 11 April 1893, p. 3:2; 28 April 1893, p. 3:2-3.

[6]Engineering News and Railroad Journal, 30(3)45 (20 July 1893). The December 5, 1895 issue (34(28)726) of Engineering News and Railroad Journal stated that 600,000 pounds of steel had been rolled for the bridge and that 25,000 pounds of metal work was riveted up and ready to ship.

[7]Engineering News and Railroad Journal, 34(28)726 (5 December 1895).

[8]Sioux City Journal, 2 August 1895, p. 8:3.

[9]Sioux City Journal, 6 August 1895, p. 8:4.

[10]Sioux City Journal, 13 August 1895, p. 8:4; 19 August 1895, p. 8:4.

[11]Sioux City Journal, 2 September 1895, p. 8:4.

[12]Engineering News and Railroad Journal, 34(28)726 (5 December 1895); Sioux City Journal, 20 September 1895, p. 8:8; 25 September 1895, p. 6:1.

[13]Sioux City Journal, 16 September 1895, p. 8:3; 26 September 1895, p. 8:8; 25 September 1895, p. 6:1.

[14]Sioux City Journal, 5 October 1895, p. 5:1.

[15]Sioux City Journal, 5 October 1895, p. 5:1; 10 October 1895, p. 5:1.

[16]Sioux City Journal, 28 October 1895, p. 8:4; 29 October 1895, p. 5:3; 1 November 1895, p. 8:3; Engineering News and Railroad Journal, 34(28)726 (5 December 1895).

[17]Sioux City Journal, 25 October 1895, p. 8:4; 27 October

1895, p. 3:2.

18 Sioux City Journal, 19 October 1895, p. 5:3-4; 6 November 1895, p. 7:4.

19 Sioux City Journal, 5 November 1895, p. 8:3; 9 November 1895, p. 8:4.

20 Engineering News and Railroad Journal, 34(28)726 (5 December 1895); Sioux City Journal, 20 November 1895, p. 8:1.

21 Sioux City Journal, 20 November 1895, p. 8:4; 24 November 1895, p. 3:1; 28 November 1895, p. 8:3; 29 November 1895, p. 8:3; 30 November 1895, p. 8:4; 4 December 1895, p. 8:4; 8 December 1895, p. 6:1; 10 December 1895, p. 8:3; 16 December 1895, p. 8:4; 17 December 1895, p. 3:1; 19 December 1895, p. 8:4; 29 December 1895, p. 8:3.

ENGINEERING DESCRIPTION

The Pacific Short Line bridge was designed by J.A.L. Waddell as a "combined" bridge: that is, it was planned to carry wagon and pedestrian, as well as rail, traffic. As constructed, the bridge consisted of four spans: two 500-foot fixed Pennsylvania through trusses with a 470-foot rim-bearing Pratt through truss swing span at either end. The north swing span was removed in 1957. There were two walkways and a single, dual gauge railroad/streetcar track within the trusses. "In the plane of the trusses there is a solid screen 9 feet high, its purpose being to separate the driveways from the railroad track so that horses on the bridge cannot see a passing train and become frightened by it."[1] The original designs called for deck girder approach spans, giving the entire structure a total of nine piers (numbered 1 through 9 north to south). Lack of funds toward the end of construction resulted in the substitution of timber pile trestle approaches for the girder approaches, with a concomitant loss of the first and ninth piers.[2]

The four spans thus rested on a total of seven piers. Piers 2 and 8, at the shoreward ends of the swing spans, are each a pair of eight foot diameter concrete-filled Lally columns founded on 60 foot piles. The two columns of each pier are tied together above the water with lattice frame bracing. Piers 3 and 7 are the pivot piers for the Iowa and Nebraska swing spans respectively. Both rest on bedrock. The lower portion of each is a concrete-filled circular steel caisson having an inside diameter of 38'6". At a point 5 feet below low water, a limestone masonry shell begins inside the caisson. The shell rises 27'6", with courses varying from 2'6" to 2'0". (The rim of the caisson extends only slightly above the water.) The interior of the shell is filled with concrete. Pier 3 is 110' from footing to coping; pier 7 is 126', the deepest of all the piers.

Pier four is common to the Iowa swing span and the north fixed span; pier six is common to the Nebraska swing span and the south fixed span. Their construction is identical to the pivot piers, with the exception that the masonry portion of each is 32'6" high. These piers are rectangular with semi-circular ends. The concrete portion of each is 19' x 44' and the size of the coping is 12' 2½" x 37' 2½". Pier five, common to the two fixed spans, is slightly larger than four and six. The concrete portion is 20' x 46'; the size at the coping 14' 2½" x 40' 2½". (See the Pier Schedule (Table 1) and Historic Drawings 76, 81A, 81B.) All of the bridge spans are pin-connected and are constructed principally of steel.

Each of the two fixed spans consists of sixteen panels, 31' 3" pin to pin. At the center of the spans the truss depth is 72' pin to pin; 60' at the hip. The existing swing span (the removed north swing span was identical) is made up of 13 panels, the panel over the drum being 28', the others 31'7", pin to pin. The central tower of the swing span is 72' high. The truss depth at the intermediate hip is 53' and at the outer hip 33'. On all three spans the distance between the

TABLE I

Pier Schedule

Low water = 667' above sea level

	#2	Iowa pivot #3	#4
Pier size at coping	2 8' dia. Lally Columns	35'6" dia.	12'2½" x 37'2½"
Inside dimensions of caisson	n/a	38'6" dia.	10' x 44'
Elevation at bedrock	n/a	579'6"	589'
Total height of concrete portion of pier	n/a	82'6"	70'6"
Total height of masonry	n/a	27'6"	32'6"
Total pier height, bedrock to coping	n/a	110'	103'
Elevation at top of coping	692'	689'6"	692'
Method of construction	open dredging & pilings	pneumatic caisson	pneumatic caisson

Sources: "Plan of Coping and Pedestal Blocks, July 3rd., 1895, J. A. L. Waddell, Chief Engr. by Lee Treadwell, Engr. in Chg.", Historic Drawing # 76 and "Piers for the Pacific Short Line Bridge Co's Bridge over the Missouri River at Sioux City, June 6th, 1890, J. A. L. Waddell, Chief Engineer", Historic Drawings #81A, 81B.

TABLE I (Con't)

#5	#6	Nebraska pivot #7	#8
14'2½" x 40'2½"	12'2½" x 37'2½"	35'6" dia.	2 8' dia. Lally Columns
20' x 46'	19' x 44'	38'6" dia.	n/a
579'	565'	563'6"	n/a
81'6"	94'6"	28'6"	n/a
32'6"	32'6"	27'6"	n/a
113'	127'	126'	n/a
692'	692'	689'6"	692'
pneumatic caisson	open dredging	open dredging	open dredging & pilings

truss planes is 25' and the cantilever brackets are 15' from truss plane to end. Although steel is the principal material in all the trusses, iron is used for the lattice bars and batten plates on the major web compression members on all three spans, the transverse and diagonal top chord struts on the swing span, the diagonal top chord struts on the fixed spans, several secondary vertical compression members on all three spans, and many of the web tension members on all three spans. (See Historic Drawings 73A,73B,74 for material and stress calculations.)

All structural members except the eyebars and tierods are built up. The top chord members are made of two long steel plates with angle stock riveted along the top and bottom edges of each to form two channel beams. A top cover plate and bottom lattice bracing are riveted to the flanges of the channel beams. The major vertical and diagonal compression members are pairs of built-up channel beams with lattice bracing on both flanges. The minor compression members, the transverse and diagonal top chord bracing, the bottom chord diagonal bracing, and the sway bracing between the top and bottom chords and the two truss panels are built-up lattice (open) I-beams of various sizes. The bottom chord members of the swing span are built-up channel beams with lattice bracing of angle stock riveted to the top and bottom flanges. These members serve both as compression and tension members (span open and closed, respectively), and thus are larger than those major members subject only to compression. The bottom chords of the fixed spans consist of eyebars. The size and number of eyebars per panel depend on the forces calculated for a particular segment of the lower chord. The floor beams consist of a series of plates spliced together. Angle stock is riveted to the top and bottom of these plates to form a tall I beam; vertical angle stock is riveted to the beam as a stiffener. The floor stringers are built up in a similar manner. All structural members have additional plates riveted around pin connection holes. (See Phoenix Bridge Company fabricator's drawings, for example 9, 22 .)

At each panel point on the lower chord of each span there is a built-up floor beam. The ends of this floor beam are either riveted to a vertical compression member or are riveted to a vertical built-up I beam hanger or a flat hanger which has a pinned connection at its top for a vertical tension member. At the bottom of the hanger or the bottom of the vertical compression member is a pinned connection for the bottom chord members and the diagonal compression or tension members. The cantilever brackets are riveted to the hanger or compression member as are the diagonal lower chord braces. Attached to the floor beams and cantilever brackets are the built-up floor stringers that supported the wood deck and rails. It is interesting to note that the arrangement of members at the panel points, described here for the Pacific Short Line Bridge, is almost identical (except for the size of the members) to the lower chord panel points on Waddell "A" trusses. (See HAER drawings for the Waddell "A" truss, Trimble Vicinity, Clinton County, Missouri, HAER-MO-2; See Historic Photos UP-21,48 , Contemporary photos 20,26,41,43-46, Drawing sheet 3 for the Pacific Short Line Bridge.)

The swing span pivots on and is supported by rollers that run on two circular tracks. The lower track consists of 20 cast iron segments, bolted together to form the circular track and anchored to the masonry of the pivot pier. The upper track (also cast iron) consists of 18 sections, and is bolted to the base of the 30' diameter, 4' 8½" high drum. Between the upper and lower tracks there are 45 rollers, each 24" in diameter and 14" wide. (Phoenix Bridge Company drawings 90,95-97,99-103,112.) The design of the rollers and track for the Pacific Short Line Bridge is an example of the style recommended by Waddell in Bridge Engineering (1916):

> All rollers, and the faces of the upper and lower tracks which are in contact with the rollers, are to be turned smooth to the forms of right frustums of cones the vertices of which intersect at the center of the drum, so that the rollers will have perfect contact with the tracks throughout their travel around the entire circumference. A bearing is to be turned in the center of each roller for the radial rod; and oil-holes are to be provided on both the interior and exterior ends of the rollers, so that these bearings can be kept well lubricated. Turned bosses must be provided on both the inner and the outer ends of the roller, to bear against the collars and the friction-washers. The outer ends of the radial rods are to pass through the rollers, and the inner ends are to attach to a circular plate fitting closely around the center casting. These radial rods are to be provided with nuts for adjusting the [radial] position of the rollers.[2] (See Contemporary Photographs 31,33 and Historic Photographs HP-17.)

The span turning mechanism is a rack and pinion system. The rack is built of 24 cast iron sections bolted to the outside of the lower track and anchored to the pier. There are two pinion gears at opposite points on the outside of the drum. These are driven, via several reduction gears, by two capstans, each originally operated by four men. The Nebraska span, in addition, was designed to have two additional pinions driven by a pair of steam donkey engines mounted on a platform in the central tower. This power turning system was omitted on June 15, 1895, shortly after the negotiations for resuming construction on the bridge were completed between Phoenix Bridge Company and the Combination Bridge Company (see Phoenix Bridge Company erector's drawings, Historic Drawing #90, dated April 17, 1893 and revised June 15, 1895). In addition to carrying notes on the omission of the power turning machinery for the Nebraska swing span, two of the Phoenix Bridge Company fabricator's drawings carry the following note:

> <u>Calculated Time of Operating Draw</u>
>
> Assuming a pressure of 20,000 lbs. upon the teeth of each one of the two rack pinions, and placing four men at each capstan, using therefore eight (8) men in all, it will take them about 20 minutes to turn draw 90 degrees. The locking can be done by two men in 2 minutes easily July 10/95 F.G.L.
> (Historic Drawing 90, 29)

At the ends of the swing span there are locking mechanisms which consist of a block in a guide, and lifting jacks. The block is raised and lowered by a threaded shift operated from the center of the span by a third capstan. Connected to the block and actuated as it was raised or lowered is a pair of lifting/locking jacks and a mechanism for lifting the track ends (Historic Drawings #91, 98, 108). Local lore has it that in early years the swing spans were opened by drunks recruited out of the bars. The incentive for closing the span must have been great indeed!

BIOGRAPHICAL: J.A.L. WADDELL

James A.L. Waddell (chief engineer and designer of the Pacific Short Line bridge) was born in Port Hope, Ontario in 1854. He studied civil engineering at Rensselaer Polytechnic, graduating in 1875. Waddell's first engineering work was with the Canadian Pacific, during 1876-78. In the latter year, he returned to Rensselaer as a faculty member, the start of an interest in engineering education that would parallel his work as an engineer and designer.

Waddell traveled to the Orient in 1880, then came back to the U.S. for a 2-year (1881-2) job as chief engineer with the firm of Raymond & Campbell in Council Bluffs, Iowa. In 1882, he returned to Japan, as Professor of Engineering at the University of Tokyo.

In May 1886, Waddell was back in America. For the remainder of that year, he worked in the offices and shops of the Phoenix Bridge Company, Phoenixville, Pennsylvania, gaining first-hand knowledge of the mechanics and processes of bridge fabrication and construction. The following year, Waddell went to Kansas City, Missouri, as western agent for Phoenix and also to set up an engineering practice of his own. Lee Treadwell, later resident engineer for the Pacific Short Line bridge, joined Waddell's staff in 1888.

Phoenix's Kansas City office closed in 1892, when Waddell resigned from his position as the company's agent. Until 1899 he practiced alone. Subsequent partners were Ira G. Hedrick

(1899-1907) and John Lyle Harrington (1907-1917). In 1920 Waddell moved to New York City. He formed a partnership with Shortridge Hardesty in 1927, which lasted until his death in 1938.

Waddell is rightly known as one of America's foremost bridge engineers, in the era of long-span structures and the refinement of steel as a building material. The Pacific Short Line bridge, with its two swing spans, was among his earliest designs (1889-90). Lessons learned at Sioux City were applied to the double track bridge over the Missouri at East Omaha (1893), which was also a double-swing bridge, but with swing spans 50' longer than those of the earlier structure. Another of Waddell's early bridges was the Atlantic & Pacific Railway bridge over the Colorado (1889) which featured a 660' cantilever.

Waddell is particularly known for the development of the modern vertical-lift bridge, his first being the Halsted Street Bridge in Chicago (1895). He also served as consulting engineer (1896) for Chicago's El, which today defines (and indeed, created) the Loop and is still a major-element of the city's public transportation system. Later bridges include the Newark Bay Bridge (1926), the 3720' cantilever bridge at Cairo, Illinois (1929), and the Anthony Wayne High Level Bridge at Toledo, Ohio (1931).

Waddell also found time to write extensively about the mechanics - and particularly the economics - of bridge building. Among his publications were: Designing Ordinary Highway Bridges (1884), De Pontibus (1898), Bridge Engineering (1916), and

Economics of Bridge Engineering (1922).

BIBLIOGRAPHY

Civil Engineering, 7 (January 1937), p. 77; 8 (April 1938), p. 286.

New York *Times*, 3 March 1938, 21:3.

Plowden, David. *Bridges: The Spans of North America*. New York: Viking Press, 1974.

Schuyler, Robert L. (ed.) *Dictionary of American Biography*, Vol. XI. New York: Charles Scribner's Sons, 1944.

Sioux City *Journal*, 22 January 1896, p. 14.

Who's Who in Engineering. New York: Lewis Historical Publishing Company, Inc., 1937.

BIOGRAPHICAL: CHARLES SOOYSMITH

Two men prominent in late 19th and early 20th centuries foundation engineering and construction were William Sooy Smith (1830-1916) and his son, Charles Sooysmith (1855-1916).[1]

Charles Sooysmith was born in Buffalo, New York, two years after William graduated from West Point. During Charles' youth, his father worked for the Illinois Central Railroad, and in 1857 organized the firm of Parkinson & Smith, whose early work included surveys for an international bridge at Niagara. In 1859, William introduced the pneumatic caisson, developed in France, for the foundations of the Charleston & Savannah Railroad bridge over the Savannah River.

During the Civil War, William achieved the rank of brigadier general, serving on the staffs of both Grant and Sherman, who fought "engineering wars" and thus made good use of men like Sooy Smith and William Le Baron Jenney.[2] William retired in 1864, following a severe bout with rheumatism, and in 1866 opened his own engineering practice. His refinements, over the next ten years, of the pneumatic process, earned him a prize at the American Centennial Exhibition in 1876. Two years later (1878) William designed a railroad bridge at Glasgow, Missouri, the first all-steel bridge in the U.S.[3]

In 1876, Charles Sooysmith graduated from Rensselaer Polytechnic (one year after J.A.L. Waddell). Like his father, Charles received early experience by working on railroads. In the latter's case it was the Atchison, Topeka & Sante Fe, for whom he served from 1879-1881 as assistant superintendent of the Maintenance of Way Department.

In 1881 Charles joined his father in the firm of William Sooy Smith & Son, Engineers and Contractors. The partnership lasted until 1887, and during that time Charles developed an interest in subaqueous foundations that was to dominate his subsequent career.

Charles Sooysmith went out on his own in 1887. Over the next ten years, his firm, Sooysmith & Company, Contractors, of New York, participated in "many of the most difficult and important foundation projects in the country."[4] Among Sooysmith's earliest "solo" efforts was the Pacific Short Line bridge at Sioux City. It was followed by the East Omaha bridge (also by J.A.L. Waddell), of 1893. Other midwestern projects included bridges at Fort Madison, Iowa; Keithsburg, Illinois; Kansas City; and Sibley, Nebraska, all of which spanned major rivers.

During the 1890's, William and Charles, pursuing their separate careers, also addressed the problems of foundations for tall buildings. In 1890, William began a new career in Chicago, then the focus of some of the most innovative architectural and engineering work in the nation. To these efforts Sooy Smith contributed foundations for Adler & Sullivan's Auditorium (1891-2) (whose 17-story office tower presented particular challenges)[5] and used the pneumatic caisson for the same architects' Chicago Stock Exchange of 1893-4. During 1890-1910, he was "consulted in regard to the foundations of nearly all the larger buildings" going up in Chicago, and was credited with being the first to carry the piers of high buildings there to bedrock, rather than supporting them on unstable ground with rafts or grillages.[6]

While his father worked in Chicago, Charles Sooysmith turned to New York, where he built the foundations of large office buildings, most notably the American Surety (1896), Washington Life & Manhattan Life. In 1898, Charles retired from the contracting business, and opened a consulting office in the city. One of the larger projects - which, like Waddell's Elevated in Chicago had a profound impact on 20th century center-city transportation - was New York's Underground Rapid Transit system.

Although Charles Sooysmith was widely known for his use of the pneumatic caisson, his major contribution to American building was the "freezing process," which used a chemical coolant to render solid particularly fluid soils. Once the soil was "frozen", a hole the size of the pier was blasted out, and the pier then built up from bedrock. This process was not used at Sioux City, but, according to the New York Times, was in the foundation work for the American Surety, Manhattan & Washington Life buildings.[7]

Charles Sooysmith died in June 1916, two months after his father, who had retired to Medford, Oregon in 1910.

FOOTNOTES

[1]Dumas Malone (ed.) Dictionary of American Biography. New York: Charles Scribner's Sons, 1935. Vol. IX, pp. 367-68, 397.

[2]Hugh Dalziel Duncan, Culture and Democracy. Totowa, New Jersey: Bedminster Press, 1965, p. 330.

[3]David Plowden, Bridges: The Spans of North America. New York: Viking Press, 1974, pp. 136-137.

[4]Malone, Dictionary of American Biography, p. 397.

[5]Carl W. Condit, American Building. University of Chicago Press, 1968, pp. 127-129.

[6]Malone, Dictionary of American Biography, p. 368.

[7]New York Times, 2 June 1916, 11:5; Sioux City Journal, 22 January 1896, 15:3.

BIOGRAPHICAL; PHOENIX BRIDGE COMPANY

The Phoenix Bridge Company, Phoenixville, Pennsylvania, has been described as "one of the foremost and influential bridge manufacturing concerns in America."[1] The company was organized in the 1860's as Clarke, Reeves and Company, and reorganized as the Phoenix Bridge Company in 1884.[2] The Reeves family were developers of the Phoenix Iron Works, established 1783[3] and taken over by the Reeves brothers in 1827.[4] With the Phoenix Bridge Company, the Reeves had a "vertical operation" that controlled all aspects of bridgework from smelting ore, to fabrication, and finally erection.[5]

By 1855 the Phoenix Iron Company was a "leading structural iron producer," and could produce I-beams 9 inches deep. The firm's ascendancy was further assured by the patenting in 1862 of Wendel Bollman's innovative wrought-iron column, known subsequently as the Phoenix column and a hallmark of Phoenix bridge construction.[6] The company first produced steel in 1889;[7] thus the Pacific Short Line bridge at Sioux City must be considered one of Phoenix's very first projects involving the use of that metal.

A principal factor in the choice of Phoenix as fabricator and erector of the Pacific Short Line bridge was very probably the fact that the bridge's chief engineer, J.A.L. Waddell, was then agent of the company's "branch office" in Kansas City. This "office" was open from 1887 to 1892, when Waddell dissociated himself from the firm.[8]

FOOTNOTES

[1]David Plowden, Bridges: The Spans of North America. New York: Viking Press, 1974, p. 65.

[2]William T. Hogan, Economic History of the Iron & Steel Industries in the United States (5 vols.). Lexington, Massachusetts: D.C. Heath & Co., 1971. Vol. I, p. 94; Dan Grove Diebler, Metal Truss Bridges in Virginia, 1865-1932 (6 vols.). Charlottesville: Virginia Highway and Transportation Research Council, 1976. Vol. I, p. 41.

[3]Kenneth Warren, The American Steel Industry 1880-1970: A Geographical Interpretation. Oxford: Clarendon Press, 1973, pp. 156-7.

[4]Hogan, p. 94.

[5]Diebler, p. 41.

[6]Hogan, p. 94; Diebler, p. 41; Plowden, pp. 65-66.

[7]Warren, p. 156-7.

[8]Sioux City Journal, 22 January 1896, 10:1.