HISTORIC AMERICAN ENGINEERING RECORD

# CHICAGO, MILWAUKEE & ST. PAUL RAILWAY, BRIDGE No. Z-6

HAER No. IL-162

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| Location: | Spanning N. Branch of Chicago River, S. of Cortland St., Chicago, Cook County, Illinois. |
| USGS Quadrangle: | Chicago Loop, Illinois (7.5-minute series). |
| UTM Coordinates: | 16/444985/4640400 |
| Dates of Construction: | 1898-1899. |
| Designer: | Onward Bates (Superintendent of Bridges and Buildings for Chicago, Milwaukee & St. Paul Railway). |
| Fabricator: | American Bridge Works (Chicago). |
| Builder: | Chicago, Milwaukee & St. Paul Railway. |
| Present Owner: | Canadian Pacific Railroad (Calgary, Alberta). |
| Present Use: | Railroad bridge. |
| Significance: | The Milwaukee Road's Bridge No. Z-6 may be the only one of its kind ever built, defying the conventional categories of center-bearing and rim-bearing swing bridges. This ingenious design answers the constraints of a small site on a bend in the river. The 175'-2"-long plate-girder span bears on a short segment of roller nest turning at one-half the span's rate. This is accomplished by an unusual drive mechanism with two parallel racks. As a result, the roller nest need only turn through an arc equivalent to half of the span's rotation, reducing the bridge's footprint accordingly. |
| Historian: | Justin M. Spivey, January 2001. |
| Project Description: | The Chicago Bridges Recording Project was sponsored during the summer of 1999 by HABS/HAER under the general direction of E. Blaine Cliver, Chief; the City of Chicago, Richard M. Daley, Mayor; the Chicago Department of Transportation, Thomas R. Walker, Commissioner, and S. L. Kaderbek, Chief Engineer, Bureau of Bridges and Transit. The field work, measured |

drawings, historical reports, and photographs were prepared under the direction of Eric N. DeLony, Chief of HAER.

## Introduction

In the final years of the nineteenth century, the Chicago, Milwaukee & St. Paul Railway (Milwaukee Road) replaced its Bridge No. Z-6, a wooden swing span across the North Branch of the Chicago River. The new structure, a steel plate-girder swing span of unique design, was constructed at the end of an era in Chicago railroad engineering. Swing bridges, nearly ubiquitous among Chicago's river crossings during the nineteenth century, became rare in the twentieth. Old age and structural inadequacy contributed to the need for replacing swing bridges, but more importantly, their mid-channel piers created an increasingly unacceptable obstacle to navigation on Chicago's narrow, winding rivers. With the River and Harbor Act of 1899, the U.S. War Department, through its Army Corps of Engineers, could demand the removal of obstructive bridges over navigable waterways.[1] In the twentieth century, swing bridges' slow operation and interference with dock space ensured their replacement with recently developed alternate forms.

The Milwaukee Road's wooden swing bridge, however, reached the end of its useful life in 1898, before the era of regulation and innovation. Three factors made it logical to replace one swing bridge with another. The Army Corps had yet to achieve its full regulatory role. Patented movable bridge designs, although available at the time, lacked the economy and reliability that earned their widespread use in the first decades of the twentieth century. Finally, the Milwaukee Road's Bridge and Building Department was biased toward in-house design and construction, and therefore persistent in using familiar forms.[2] The steel replacement for Bridge No. Z-6, while certainly an ingenious design, marks a limit to which swing bridge technology could be pushed.

## Context and Site

Throughout the twentieth century, a predominantly industrial area has existed northwest of Chicago's skyscraper core. Seeking new sites with direct access to water transportation, lumber, metal, and fuel trades spread up the North Branch of the Chicago River during the late nineteenth century. Although the advancing front of development had yet to reach the area, the North Branch Canal opened up additional water frontage in the 1850s. This man-made channel cut off a series of bends in the river and isolated the land mass known as Goose Island, which in

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[1] "An Act Making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," 3 Mar. 1899, *Statutes at Large* 30 (1899), 1121 et seq.

[2] This persistence continued into the twentieth century; for a structure completed in 1902, see Justin M. Spivey, "Chicago, Milwaukee & St. Paul Railway, Bridge No. Z-2," HAER No. IL-143, Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior.

the 1880s became home to rail yards, manufacturers, and bulk commodity distributors.[3] Throughout its existence, Bridge No. Z-6 has formed a critical link in the railroads serving these industries.

One railroad served land along the North Branch in 1855, the Chicago & Milwaukee Railroad (later Chicago & North Western Railway) line on its west bank.[4] Competition did not arrive until 1871, when the Atlantic & Pacific Railroad began constructing a line westward from Goose Island; the name was changed to Chicago & Pacific (C&P) the following year. As with many Midwestern railroads, insufficient local capital meant that eastern investors purchased most of the construction bonds issued by the line. Lackawanna Iron & Coal and the Delaware, Lackawanna & Western Railway, both Pennsylvania companies, backed the C&P — and took a hit when it declared bankruptcy in 1880.[5] The Milwaukee Road then had sufficient financial resources to purchase the C&P from its creditors. Local freight traffic from Goose Island, on the Milwaukee Road and its successors, has used the C&P line ever since.[6]

Even though shipping on the Chicago River and its branches declined in favor of year-round connections provided by railroads, industry remained along the rivers. According to geographer and Chicago regional planner Harold M. Mayer, the Chicago River's North and South branches remained important industrial areas "long after navigation on the rivers became relatively unimportant as a factor in the localization of industry."[7] This is certainly true in the vicinity of Goose Island, where tracks paralleled both river and canal, providing rail service to virtually every site with water access. Once crowded with industry, the island still supplies a limited amount of freight traffic today, from companies such as Akzo Salt, Big Bay Lumber, and Midwest Industrial Metals. Other customers on the North Side "mainland" include Peerless Confectionery, Aetna Plywood, and several metal industries.[8] When the Milwaukee Road's other North Branch bridge near Kinzie Street was demolished in the mid-twentieth century, Bridge No.

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[3] For more on Goose Island, see Perry R. Duis and Glen E. Holt, "Chicago's Only Island," *Chicago* (Feb. 1979): 170-72, Milwaukee Road Collection, Milwaukee Public Library, Milwaukee, Wis. (hereinafter cited as MRC).

[4] The Illinois & Wisconsin Railroad shared this line, built in 1854, between Chicago and Clybourn Junction; see Harold M. Mayer, "The Railway Pattern of Metropolitan Chicago" (Ph.D. diss., Univ. of Chicago, 1943), 80.

[5] John W. Cary, *The Organization and History of the Chicago, Milwaukee & St. Paul Railway Company* (Milwaukee: Press of Cramer, Aikens & Cramer, 1892; reprint, New York: Arno Press, 1981), 253-54.

[6] Mayer, "The Railway Pattern of Metropolitan Chicago," 82.

[7] Mayer, "The Railway Pattern of Metropolitan Chicago," 89.

[8] Tom Burke, "Milwaukee Road: Knocking at Chicago's Back Door," *Milwaukee Railroader* (3rd Quarter 1995): 16-18, MRC.

Z-6 became the only rail connection between the North Branch industrial area and the outside world.[9]

The site of Bridge No. Z-6 was an unusual and troublesome one. Meandering southeast toward the Loop, the North Branch of the Chicago River bends southward at Webster Street, then eastward again after Cortland Street. The C&P line, heading roughly southwest toward Clybourn Junction, crossed the river in the middle of the latter bend on a wooden swing bridge 161'-0" long with a mid-channel pier. Although such a structure ordinarily would provide two passages for boats, silt tended to accumulate between the pier and the outside of the bend. The remaining narrow inside channel made an already difficult right-angle turn nearly impossible to navigate. As stated in an 1897 analysis of obstructions in the Chicago River, "One of the worst places on the north branch is the sharp bend ... south of Clybourn Place ... and nothing but the most radical alterations can make this part of the river, or that above, accessible to vessels...."[10] The report, presented to the Western Society of Engineers in June 1898, carried the weight of more than opinion. The speaker was G. A. M. Liljencrantz of the U.S. Army Corps of Engineers' Chicago District, which was on its way to becoming the powerful federal ally of Chicago industries shipping on the river. The district engineer's recommendations against new bridges with mid-channel piers appear to have effectively prevented their construction after 1890.[11] Nonetheless, until the River and Harbor Act of 1899 imposed the Secretary of War's approval as a necessary step in constructing bridges over navigable waterways, the Army Corps had only limited control over their design.

The Milwaukee Road's solution was likely not the "radical alteration" that Liljencrantz had in mind. The old western abutment and mid-channel pier were to be left in place, and the distance between them covered by a 70'-0" fixed plate-girder span. The old eastern abutment was removed to provide a wider channel with a gentler bend. A second plate-girder span would swing on a pivot located on the inside of the bend, opening to provide a clear channel of about 100 feet. This would be a "bob-tail" swing bridge, with a counterweight arm much shorter than the arm overhanging the river. At 175'-2" in overall length with a river arm of 141'-6", its dimensions would exceed practical limits for plate girders suggested by contemporary design manuals (150'-0" long with two equal arms).[12] The replacement bridge would handle heavier trains and improve navigation, but retained a technology with several undesirable aspects. The Milwaukee Road's bridge engineers had to consider the inherent disadvantages of swing bridges: a large footprint, less economical use of material, and slow operation. But given the limited

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[9] The bridge is described below and in Otis E. Hovey, *Movable Bridges,* 2 vols. (New York: John Wiley & Sons, 1926), 2:55.

[10] G. A. M. Liljencrantz, "Obstructive Bridges and Docks in the Chicago River," *Journal of the Western Society of Engineers* 3, No. 3 (June 1898): 1070.

[11] U.S. Army, Corps of Engineers, *Annual Report of the Chief of Engineers to the Secretary of War for the Year 1900* (Washington, D.C.: U.S. Government Printing Office, 1901), 5:3869.

[12] Charles H. Wright, *The Designing of Draw-Spans,* 1st ed. (New York: John Wiley & Sons, 1898), 90.

territory covered by the old C&P line, the expense of patented movable bridge designs, and the abilities of the railroad's Bridge and Building Department, their decision seems reasonable.

## The Milwaukee Road's Bridge and Building Department

*Railway Age,* always thorough in crediting all parties responsible for a project, does not name an erection contractor for Bridge No. Z-6. This is no omission; the Milwaukee Road's own bridge department performed the work. Herein lies the most influential reason for the technological inertia of swing bridges. Because the railroad's Bridge and Building Department had experience in designing, erecting, and maintaining swing bridges, it was easier to push the limits of an existing form than to begin using a new one.

Many of the Milwaukee Road's administrative departments demonstrated an almost stubborn independence. One railroad historian noted that the company continued to build its own cars long after other railroads began buying standard cars from manufacturers.[13] Railroad and engineering periodicals repeatedly reminded their readers of this policy, to which the Bridge and Building Department was no exception. An editor's note appended to one article stated, "The Chicago, Milwaukee & St. Paul Ry. does practically all its bridge work by its own forces."[14] Equipment used by the department was largely of its own design. While researching this report, the author found articles describing custom-made derrick cars and cement mixers used for bridge construction.[15] When the Bridge and Building Department confronted the task of replacing Bridge No. Z-6, it may not have even considered paying royalties for patented designs before making plans for a bob-tail swing bridge.

Given the Milwaukee Road's penchant for designing and erecting its own bridges, one might expect the railroad to have fabricated them, too, but this was not the case. Although a railroad might obtain favorable rates for steel shipped along its lines, as the Pennsylvania Railroad learned from its vertical integration with the Pennsylvania Steel Company, the net cost of a "captive" mill's produce could end up higher than purchases made from independent mills.[16] For whatever reason — competitive pricing, intermittent demand, or the difficulties of making steel — the Milwaukee Road chose to pay the lowest bidder on a bridge-by-bridge basis rather than integrate a steel mill into its operations. According to an article in *Railway Age,* the railroad chose the American Bridge Works of Chicago to fabricate the steel members for Bridge No. Z-6.

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[13] Nick Callas, president of Illinois Railway Museum, telephone conversation with author, 30 July 1999.

[14] Editor's note in H. C. Lothholz, "Replacing Worn Bridge Pins in the Field," *Engineering News* 67, No. 4 (25 Jan. 1912): 153.

[15] "New Bridge Derrick Cars; Chicago, Milwaukee & St. Paul," *Railroad Gazette* 44, No. 11 (13 Mar. 1908): 362-63; "A Counterbalance Swing Bridge on the Chicago, Milwaukee & St. Paul,"*Railway Age* 33, No. 10 (7 Mar. 1902): 291; see also Lothholz, "Replacing Worn Bridge Pins in the Field," 153, for modifications to stock equipment.

[16] Thomas J. Misa, *A Nation of Steel: The Making of Modern America, 1865-1925* (Baltimore: Johns Hopkins Univ. Press, 1995), 22n.

The railroad also contracted out dredging and dock work, indicating further exceptions to the in-house rule.[17]

## Description

The bob-tail swing bridge concept was at least four centuries old when it arrived in Chicago; sketches of two bob-tail swing bridge designs appear in da Vinci's *Codice Atlantico*.[18] Timeless as it may be, this variant has most of a symmetrical swing bridge's disadvantages, as well as some of its own. Nonetheless, the Milwaukee Road used the bob-tail form to great success twice in Chicago, on sites which forgave some of these technical defects. Bridge No. Z-6 is described here.[19]

Bridge No. Z-6's plate-girder bob-tail swing span rotates about a vertical axis located on the east shore at a bend in the river. The arm extending over the river is long enough to provide the required clear channel of about 100 feet, but the opposite arm is kept as short as possible. To compensate for the river arm's greater length, the shorter arm contains a counterweight of 56.65 tons of iron, cast into shapes that fit against the girders to which they are attached.[20] As with all bob-tail swing bridges, a short counterweight arm consumes less space on shore. At this particular site, the pivot's location on the inside of a bend makes a short counterweight arm all the more necessary. If the arms were of equal length, rotating the river arm to clear the channel would cause the shore arm to obstruct the channel! To fit into the peculiar geometry of this site, the counterweight arm measures less than a quarter of the river arm's length.[21]

The designers of Bridge No. Z-6 did not equivocate about its size. When describing the structure to the Western Society of Engineers, engineer Albert Reichmann said straightforwardly, "This is probably the largest plate girder counter-balanced swing bridge ever built." The movable span is 175'-2" in overall length, 141'-6" of which is cantilevered over the river in the

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[17] "A Counterbalance Swing Bridge," *Railway Age* 29, No. 7 (16 Feb. 1900): 142-43.

[18] Leonardo da Vinci, *Il Codice Atlantico nella Biblioteca Ambrosiana di Milano* (riprodotto, Milano: Regia Accademia dei Lincei, 1894), cited in Hovey, *Movable Bridges,* 1:5. Another interesting example is a self-closing "counterbalanced" design used over a canal in Bordentown, N.J.; see H. S. Prichard, et al., "Lift Bridges — a Discussion," *Proceedings of the Engineers' Society of Western Pennsylvania* 25, No. 1 (Feb. 1909): 14.

[19] The other, Bridge No. Z-2, is the subject of Spivey, "Chicago, Milwaukee & St. Paul Railway, Bridge No. Z-2," HAER No. IL-143.

[20] This figure is from Albert Reichmann, "Design of a 175-Ft. Counter Balanced Plate Girder Swing Bridge," *Journal of the Western Society of Engineers* 4, No. 6 (Dec. 1899): 487. A recent inspection by the author discovered that discarded gears and rollers, likely removed from elsewhere on the bridge, have subsequently been added to a bin between the girders of the counterweight arm.

[21] In contrast, this ratio is more than one-half for both of the Milwaukee Road's proposals for the bob-tail swing bridge at Goose Island; see Spivey, "Chicago, Milwaukee & St. Paul Railway, Bridge No. Z-2," HAER No. IL-143.

open position.[22] Although contemporary design texts recommended trusses for spans longer than 150'-0", the railroad may have selected a plate girder to simplify erection.[23] Vertical stiffeners divide the girder into ten panels. To support the 108'-0" cantilever from roller nest to free end, the plate girder is 9'-0" deep, tapering to 6'-0" in the last two panels. The web splices that occur mid-way in each panel reflect the sizes of rolled steel plate then available. But this bridge did not push the limits of plate-girder construction so much as it included an unusually large plate girder in a movable span.

Bridge No. Z-6 truly breaks new ground with its means of support and movement. It does not fit into existing categories of swing bridges, i.e., center-bearing and rim-bearing. The structure surrounding the pivot lacks the members needed to concentrate the load there, so it is not center-bearing. The span does have a sturdy roller nest similar to that found in rim-bearing bridges, but the rollers do not form a complete circle. Instead the twenty-four rollers cover about sixty degrees of arc beneath the river arm, at a radius of 33'-6" from the pivot. The counterweight arm, in contrast, is equipped with four insubstantial balance wheels under its extreme end, which ride on a track at a radius of 33'-8" from the pivot. The rollers and balance wheels, because of their difference in strength, obviously do not carry equal loads. These two arcs therefore do not resemble portions of a rim-bearing bridge's circular drum, over which the span's weight is more or less symmetrically distributed. Upon further inspection, one notes that the counterweight sits inside the rim's diameter and is not heavy enough to balance the bridge on its pivot. Also, the plate girders' flanges are thickest over the roller nest, indicating that the highest bending moment occurs there. As it turns out, "almost the entire dead weight of the bridge" bears on the rollers beneath the river arm. According to Reichmann, "If a complete drum has [sic] been used, the effective length of this short arm would have been reduced by nearly the length of the diameter of the drum."[24] The bridge is neither center-bearing nor rim-bearing. A new term, perhaps "arc-bearing," must be coined to accurately describe this system of support.

Bridge No. Z-6's rollers depart further from convention in their method of operation. In a rim-bearing swing bridge, each roller in the nest is often tied to the center pivot by axles, which are called "spider rods" because of their radiating configuration. Each roller rotates about its own axle, but revolves at the same rate as the span itself. The roller nest on Bridge No. Z-6, in contrast, is not directly attached to the span and moves at only half the span's rate of rotation. Thus, while the bridge moves through 57 degrees of arc, the roller nest revolves only 28-1/2 degrees.[25] As a consequence, the fixed bearing beneath the rollers occupies a significantly shorter length of arc than it would with the rollers directly attached to the span. To control the radial position of the roller nest while allowing its differential rotation against the span, the roller

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[22] Reichmann, "Design of a ... Plate Girder Swing Bridge," 481.

[23] Wright, *The Designing of Draw-Spans,* 90.

[24] Reichmann, "Design of a ... Plate Girder Swing Bridge," 487.

[25] The precise figures are 57°-7'-0" and 28°-33'-30"; see Reichmann, "Design of a ... Plate Girder Swing Bridge," 485.

nest is attached to a triangular truss, also called a spider in published descriptions of the bridge. The spider truss lies in a horizontal plane with its apex centered on the pivot, about which it rotates.[26]

According to an article in *Railway and Engineering Review,* the Milwaukee Road's Superintendent of Bridges and Buildings, Onward Bates, devised this ingenious turning mechanism.[27] The improved version found in Bridge No. Z-6, however, clearly results from the sharing of information within Chicago's civil engineering community. Bates's turning mechanism was first used — unsuccessfully — on a different Milwaukee Road bridge spanning the North Branch of the Chicago River, at an extreme skew, north of the city's Kinzie Street Bridge. This highly unusual span originally pivoted about the midpoint of its western truss, but after frequent operating problems was rebuilt with a more conventional center pivot. When, in 1898, the competing Chicago & North Western Railway (C&NW) completed a nearby bridge with a similar eccentric pivot and turning mechanism, Chicago civil engineers naturally raised their eyebrows. At the Western Society of Engineers meeting on 21 December of that year, C&NW Assistant Chief Engineer William H. Finley was defended by his peers, who cited reasons for the Milwaukee Road bridge's failure: lack of radial restraint on the rollers, lack of bushings in the roller bearings, and uneven pier settlement.[28] The eccentric-pivot and double-rack concepts were nonetheless solid, and Finley had solved the largest problem by providing a spider truss to keep the roller nest in place on the C&NW bridge. Despite their employers' competition for traffic in the upper Midwest, Finley and Bates apparently met to exchange ideas on bridge design. Finley, for example, had been given the opportunity to inspect the old pivot removed from the Milwaukee Road's bridge at Kinzie Street.[29] It is therefore not surprising that Bates's design for Bridge No. Z-6 includes a spider truss similar to Finley's.

Bridge No. Z-6 also differs from its contemporaries in its lifting, locking, and rotating mechanisms. Before these can be described, their place in the operating procedure must be understood. First, the operator retracts the draw-bar which locks the span in its closed position. Because the rails on the bridge have scarfed ends that extend past the ends of the movable span, they must be lifted slightly when the bridge is moving or open. Rail lifts push the rails from

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[26] The spider truss appears to sag a bit, likely because its designer was primarily concerned with radial control and did not consider vertical deflection as an important factor.

[27] "New Form of Plate Girder Swing Bridge, C. M. & St. P. Ry.," *Railway and Engineering Review* 39, No. 43 (28 Oct. 1899): 604. The limited scope of this study did not permit detailed biographical research on Bates, but Wright, in *The Designing of Draw-Spans,* 226, did mention that Bates and J. N. Warrington entered the Duluth Ship Canal bridge design competition. Their losing entry was a swing bridge pivoted from one end on shore, with the free end resting on a pontoon.

[28] William H. Finley, "Rebuilding of the Kinzie Street Drawbridge of the Chicago & Northwestern Ry.," *Journal of the Western Society of Engineers* 4, No. 1 (Feb. 1899): 66-67.

[29] Finley, "Rebuilding of the Kinzie Street Drawbridge," 66. Hovey stated that the C&NW's bridge actually incorporated the Milwaukee Road's old pivot, but a careful reading of the discussion makes this claim suspect; cf. *Movable Bridges,* 2:55.

beneath to a height at which they clear the scarfed ends of the fixed rails on the abutments. (Scarfed joints allow thermal expansion and contraction, forming a smooth transition between fixed and movable rails in any weather.) The same gears which operate the rail lifts also rotate the end lift shoes clear of their seats, allowing the span to dip slightly toward its free end. The operator then engages the rotating mechanism, cutting power as the bridge nears its open position, and applying the brake if necessary. This procedure is reversed to close the bridge: rotate, brake, rotate the end lift shoes onto their seats while dropping the rails, and lock the span.

The Milwaukee Road's engineers devised a unique arrangement for Bridge No. Z-6's lifting and locking mechanisms. While contemporary textbooks on movable bridge design showed wedges driven to lift the end of the bridge to its proper elevation and to lock it in place, the Milwaukee Road's swing bridges have separate mechanisms for these two functions.[30] At the free end, cam-shaped end lift shoes rotate about an axis perpendicular to the tracks. Because the profile of the end lift shoe is eccentric to its axis of rotation, turning the shoe raises or lowers the end of the span. In the bridge's closed position, the end lift shoes rest on seats that are bolted to the abutment. When resting on the seat, the shoe acts as a rocker bearing, with small rotations accommodating thermal expansion and contraction of the span, which "is a feature but few end lifts possess," according to Reichmann. The Milwaukee Road was probably the first American railroad to use this arrangement.[31] The rocker might not exert enough frictional force to keep the bridge from rotating, however, so Bridge No. Z-6's designers provided a latch to lock the end in place. A spring-loaded draw-bar slides horizontally from the movable span into a slot on the fixed span, and must be retracted manually by attaching a handle to a crank in the bridge deck.

The bridge machinery was originally controlled from a wooden operator's house attached to the movable span, supported on brackets extending from the north side of the counterweight arm. These brackets still remain, although the operator's house has been removed and replaced by a modern aluminum-siding-clad structure attached to the north side of the river arm. The arrangement of machinery has been altered accordingly, but retains many of its original components. A longitudinal shaft running the full length of the bridge transmits power to transverse shafts operating the rail lifts at either end. At the free end, the end lifts are geared to the same transverse shaft as the rail lifts. Hand cranks located in the deck near either end of the span engage bevel gears on the longitudinal shaft for emergency manual operation. In the original design, a single 25-horsepower electric motor was located under the deck just outside the roller nest; it drove both the longitudinal shaft and the pinions which engage the rack. As explained by Reichmann,

> The pinion of the motor engages a large spur gear, which latter is movable on its shaft axis and has a clutch connection on each end of its hub. When this spur gear is moved in one direction, one clutch engages the gearing of the end lift, and when

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[30] See, for example, the machinery cuts in Wright, *The Designing of Draw-Spans.*

[31] Quote from Reichmann, "Design of a ... Plate Girder Swing Bridge," 485.; cf. Hovey, *Movable Bridges,* 2:291.

moved in the other direction, the other clutch engages with the gearing of the operating machinery.[32]

The spur gear and clutches still remain on the longitudinal shaft, although it has since been separated from the operating pinions and given its own electric motor. A second, presumably more powerful, electric motor was installed under the operator's house to power the operating machinery. At present, the operating gears are similar to the configuration described in Reichmann's article, although fasteners of a more recent vintage suggest reconditioning or replacement of some components. Through a gear reduction, the motor turns a separate shaft to which the brake is attached. A bevel gear then transfers the power to a vertical axis, where a reduction gear turns a large drive gear. (In case of motor failure, the large drive gear can also be turned with a hand crank from the bridge deck.) The large drive gear and an equalizing gear for the upper pinion are attached to a shaft which drives the lower pinion directly. Because it must turn at twice the rate as the lower pinion, the upper pinion is located on a parallel shaft, driven by the equalizing gear through a one-half reduction in gear ratio. These two pinions engage the racks, turning the bridge as described above.

**Conclusion**

The Milwaukee Road's Bridge No. Z-6 has since changed owners, but still operates as a movable bridge on an active rail line. In 1985, the Minneapolis, Sault Ste. Marie & Atlantic Railway (Soo Line) acquired the C&P line, among other Milwaukee Road properties in Chicago.[33] The Canadian Pacific Railroad (CP) had acquired the Soo Line as its U.S. division in 1888, an arrangement which continues at present.[34] Locomotives with either Soo Line or CP markings continue to move local freight trains across the bridge. Clearance under the bridge is too low for scrap metal barges plying the North Branch of the Chicago River. Rather than staff the bridge full-time, CP leaves the movable span open, using a rotating crew to close it for the infrequent train to cross.

The neighborhood today contains active industry, albeit among abandoned industrial buildings since remodeled for housing and retail. Working steel mills and scrap yards line Elston Avenue and Cortland Street, and the latter is decorated with landscaping and street furniture, indicating some investment by the city in improving neighborhood's appearance. Southeast of the site, a branch of the Old Navy clothing store has appropriated a smokestack for a high-rise advertisement, a sign that industrial land use is on the wane. Throughout the neighborhood,

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[32] Reichmann, "Design of a ... Plate Girder Swing Bridge," 487.

[33] Gary U. Mentjes, Manager of Public Works for Soo District of Canadian Pacific Railway, telephone conversation with author, 15 June 1999.

[34] James E. Vance, Jr., *The North American Railroad: Its Origin, Evolution, and Geography* (Baltimore: Johns Hopkins Univ. Press, 1995), 278.

heavier industries have been abandoned or demolished, and replaced by high-tech and light industry.

Amidst all this change, Bridge No. Z-6 sits rusting, visited by the occasional freight train. Although the operating mechanism has been altered, the remaining fabric provides a fairly complete picture of how the bridge originally worked. Its unusual bob-tail design remains a testament to the ingenuity of the Milwaukee Road's bridge engineers. Furthermore, as one of a declining number of railroad bridges in downtown Chicago, it serves as a reminder of the city's industrial past.

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