HISTORIC AMERICAN ENGINEERING RECORD

BROADWAY BRIDGE

This report is an addendum to a 7-page report previously transmitted to the Library of Congress in 1992

Location:	Spanning the Willamette River on Broadway Street, Portland, Multnomah County, Oregon UTM: 10/525560/5041900 Quad: Portland, Oregon
Structural Type:	Steel through truss bascule bridge, Rall type
	1912-1913
Engineers:	Ralph Modjeski; Rall Patent Bascule Span by Strobel Steel Construction Co., Chicago, Illinois
Builder:	Pennsylvania Steel Company, Steelton, Pennsylvania Superstructure; Union Bridge and Construction Co., Kansas City, Missouri, Substructure
Present Owner:	Multnomah County, Oregon
Present Use:	Vehicular and pedestrian bridge

Significance:	The Broadway Bridge is the first bascule span built in Portland and, at the time constructed, the longest in the United States. Its completion resulted in a dramatic shift in land values and business concentration in Portland. Those consequences profoundly influenced subsequent Willamette River bridge construction decisions. Ralph Modjeski, a premier American bridge engineer, designed the Bridge, incorporating the largest Rall-type bascule ever built, now one of the few surviving Rall mechanisms. Its Lovejoy Ramp, designed by Gustav Lindenthal in 1926-27, was removed during this recording project.
Historian	Researched and written by Judith A. McGaw
Project Information:	Documentation of the Broadway Bridge is part of Information: the Willamette River Bridges Recording Project, conducted during the summer of 1999 under the co-sponsorship of HAER and the Oregon Department of Transportation in cooperation with Multnomah County. It extends preliminary work conducted under the Oregon Historic Bridge Recording Project with the same co-sponsors in the summer of 1990.
Related Documentation:	See also HAER No. OR-20 and HAER No. OR-21

Introduction

In the afternoon of 22 April, 1913, a crowd converged at Portland's new Broadway Bridge that spans the Willamette River. The Bridge's two huge bascule leaves stood up at 80 degree angles, allowing spectators to see the opened structure. As they watched, Mayor Rushlight, standing at the base of the raised east leaf, pressed a small porcelain button and in the words of the *Oregon Journal,* published that evening, "An electric impulse sped to the two huge motors controlling each draw leaf, there came the hum of machinery, and, ponderously, the towering steel segments settled to their places." A few moments later, attendants swung open the traffic gates allowing three girls dressed in white to rush toward the center of the Bridge and clasped hands. Mary Evelyn Munley and Henrietta Heppner approached from the east and while Caroline Levy came from the west joining both sides. Eight other white-clad maidens proceeded to join them in scattering red roses across the bridge span. Brief remarks from a few politicians followed, but the span's opening was largely celebrated symbolically. Fittingly, a motorcade drove across the bridge and concluded the festivities.[1]

The Bridge captured in steel a vision of Portland's future that had emerged from more than six years of intense communication. As had become customary, roses served to represent the City's resolve of the building of Broadway Bridge. The pageantry served to glorify the structure's quick mechanism: the huge, complex, mass of metal seemed to respond at the touch of a button.[2]

Shaping the Bridge: Politics and Engineering, 1907-1912

The decision to build the Broadway Bridge provoked far more than the usual political battles that accompany any large, expensive public works project in the center of a city. Choosing to build it represented a major departure. When it opened in 1913, it was Portland's first Willamette River bridge built at a new location in nearly two decades. The City's first generation of bridges had encouraged dramatic population growth in the newer East side neighborhoods, now within easy travel of the older West side business center. Any new bridge would carry substantial traffic along new routes, promising lucrative new commercial and real estate opportunities. As had been the case with Portland's first Willamette bridge, completed in 1887, proponents and opponents engaged in a prolonged series of battles over the Broadway

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[1] "New Span Is Designed to Last 100 Years," *Oregon Journal*, 4/22/1913, 1-4; "Broadway Bridge: Editorial," *Oregon Journal* 4/22/1913, 8; "Five Hundred Autos to Move in a Parade over the New Bridge," *Oregon Journal*, 4/20/1913, 1-2; "Northeast Now Is Linked to City by Great Bridge," *Oregon Journal*, 4/22/1913, 1-2; W. P. Hardesty, "The Broadway Bridge over Willamette River, Portland, Ore., with Rail Bascule Span," *Engineering News*, 10/9/1913, 707.

[2] My reading of the festivities depends in part on the newspaper accounts cited above. A fuller account of the political battles and technological choices follows. I am indebted to Matt Roth for reminding me that in order to understand what is behind a structure, one needs to pay attention to "who gave the party."

Bridge's erection. The conflict took place in newspapers, public hearings, neighborhood organizations, and the courts. Again, as with Portland's first bridge, it took a U. S. Supreme Court decision to help resolve the issues.[3]

A prolonged debate about a city's bridge future inevitably involves diverse personalities, complex and shifting professional alliances. Of necessity, this brief account simplifies the intricate process by which the Broadway Bridge came to serve as one important path to Portland's future. Bridges has fostered continued growth in Portland. In 1885, before the first Willamette span was erected, Portland's population had registered 31,990; twenty years and four bridges later, it numbered 149,200, making it one of the nation's fastest growing cities. Because the Tualatin Mountains, known locally as the West Hills, blocked easy westward expansion, most city growth took place on the East side. The east side had been incorporated into Portland only after the first three bridges had been created. Rapid population and traffic growth had prompted replacement of all three City-owned Willamette vehicular crossings by 1905.[4]

But the City's growth had also shifted population and commerce in ways that rendered new bridges at existing locations a less and less satisfactory solution. On the East side, the northern reaches of the City, generally referred to as "the Peninsula," sprouted new industrial, commercial, and residential structures, linked to the Peninsula's rapidly developing rail and port facilities. On the West side, new settlements and a new commercial center several blocks west of the waterfront streets where early business had clustered were developed. Not surprisingly, all this growth created considerable unease among those owning real estate in established areas and those who had secured power in an earlier economy. Established figures, often allied with the *Oregonian*, stood to benefit from keeping transportation flowing along accustomed routes, so they favored limiting river crossings to existing locations. Newly successful businessmen and their allies, often supported by another local newspaper, the *Journal*, wanted a bridge north of those currently in place, one that, given the physical configuration of Portland's west bank, would

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[3] The only Willamette crossing not owned by the City was the Steel Bridge, a railroad bridge with an upper vehicular deck.

Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Steel Bridge," HAER No. OR-22. and Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Morrison Bridge," HAER No. OR-100, and Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Burnside Bridge," HAER No. OR-101 recount the histories of the first generation of Portland Bridges and their successors. For a brief synopsis see, Sharon Wood, *The Portland Bridge Book* (Portland: Oregon Historical Society Press, 1989), 92. See also, Hardesty, "The Broadway Bridge," 704; Fred Lockley, *History of the Columbia River from The Dalles to the Sea* (Chicago: S. J. Clarke Publishing Company, 1928) I, 534-538; Carl Abbott, *Portland: Planning, Politics, and Growth in a Twentieth-Century City* (Lincoln: University of Nebraska Press, 1983), *passim*; E. Kimbark MacColl, *The Shaping of a City: Business and Politics in Portland, Oregon, 1885 to 1915* (Portland: The Georgian Press, 1976) *passim*; "Vale Kiernanism," *Oregon Journal*, 2/20/1912, 6.

[4] MacColl, *Shaping of a City*, 225, 492, and passim; Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior "Hawthorne Bridge," HAER No. OR-20.

also shift West side traffic to the west.[5]

Conflicts between Portland Progressives and old-style politicians also helped define the Broadway Bridge. Given the economic power of local railroads, manifested in their control of substantial riverfront real estate, local Progressive politics especially expressed itself in attempts to reduce railroad influence. The locals also at least tried to extract more public benefits in exchange for the grants of right-of-way and other favors the railroad periodically sought. For example, the earliest attempt to solve the Peninsula bridge problem was a short-lived campaign to require the Northern Pacific to include a highway deck on its Willamette railroad bridge, one component of the 4.75 mile Vancouver [Washington]-Portland Bridges created to provide the first complete railroad link between Oregon and Washington. That attempt was defeated when Ralph Modjeski, the nationally prominent engineer employed by James J. Hill's railroad to design the spans, testified that such a move would abrogate a Port of Portland Commission agreement that the railroad could not be required to "build a larger draw span than the largest in existence." Adding a vehicular deck to a railroad bridge already slated to have the nation's longest swing span would make for a draw span "30 to 40 percent heavier than anything else in existence. With the requirement for very frequent, rapid and reliable operation of the draw span we are put against the proposition of extraordinarily heavy machinery and the entire draw span becomes an experiment because nothing as large as that has ever been built before."[6]

Progressive political debates continued to influence decisions about a North Portland bridge. By the time the Portland City Council began preliminary discussions of building such a bridge, the Oregon Railroad & Navigation Company (O.R.& N.), a Union Pacific subsidiary which owned Portland's downtown railroad bridge, had decided it needed to replace its existing bridge to accommodate heavier railroad traffic. To connect with new lines leading north to the new Willamette and Columbia River bridges, the O.R.& N. needed to relocate its bridge's eastern terminus, requiring changes in right-of-way and modification of some city streets. Progressive politicians exploited these railroad requests with considerable rhetorical vigor. When it became

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[5] Some of these political alignments are discussed more fully in Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Steel Bridge," HAER No. OR-21. Hardesty, "The Broadway Bridge," 704; "New Bridge Wins after Years of Hard Struggle," *Oregon Journal*, 4/22/1913, 4; MacColl, *Shaping of a City*, 310-313; Abbott, Portland, 52-57.

[6] Historic American Engineering Record (HAER) National Park Servive, U. S. Department of the Interior "Hawthorne Bridge," HAER No. OR-21discusses Progressive politics and local railroad history more fully. See Ralph Modjeski, *The Vancouver-Portland Bridges: A Report to Mr. Howard Elliot, President of the Northern Pacific Railway Company and to Mr. John F. Stevens, President of the Spokane, Portland & Seattle Railway Company* (Chicago: H. C. Sherman & Co., 1910) and Historic American Engineering Record (HAER) Natioanl Park Service, U.S. Department of the Interior "HAER No. OR-7 for fuller treatment of the Modjeski railroad bridges. Ralph Modjeski to J. C. Flanders, 4/4/1906, Modjeski Letterbooks, Division of Engineering and Industry, National Museum of American History, Smithsonian Institution. I am indebted to Kate Larson, HAER Staff Member for reviewing these letterbooks and transmitting copies of relevant correspondence.

clear that a new north bridge would require city acquisition of railroad land along the Willamette as well as easements to permit approaches to pass over Union Station land, Progressives at first postured and threatened condemnation proceedings, especially after the new mayor, Joseph Simon, a former railroad attorney, attempted to smooth the way for the O.R.& N. Bridge. Ultimately the City arranged a land exchange with the railroad, permitting both bridges' construction. In the interim, though, these negotiations combined with ongoing lawsuits challenging the City's right to build a new bridge to delay and create uncertainty about final plans for the Broadway Bridge.[7]

A final major conflict influencing the Bridge involved those who espoused and opposed city planning. As in many early twentieth-century American cities, some Portland promoters sought to channel and encourage their city's growth by deciding in advance where public amenities and utilities should be located. Building on an earlier report by John Olmsted that envisioned a citywide park system, a group of local business and professional men organized a Civic Improvement League to bring famed Chicago planner Daniel Burnham to Portland. When Burnham's busy schedule precluded his personal involvement, the League accepted his chief assistant, Edward H. Bennett, instead. Bennett's work coincided with continuing debates over a Broadway Bridge. His central concern with planning street and railroad traffic and directing specific economic functions to particular locations meant that Bennett necessarily took a stand on the proposed bridge; his 1911 report incorporated a Broadway bridge. Neighborhood associations and other civic organizations immediately joined the Civic Improvement League to form a new Greater Portland Plan Association to promote all aspects of the Bennett plan, including the Bridge.[8]

These various overlapping and competing contests over Portland's future did not always translate into consistent alliances. For example, Judge M. G. Munley, president of the Northeast side association, and H. A. Heppner of the Greater Portland Plan Association served as the Bridge's most active promoters, regularly relaying information and advice to consulting engineer, Ralph Modjeski, and running local interference for him. Their important role was dramatized when their daughters, Mary Evelyn Munley and Henrietta Heppner, ran side by side in the new bridge's opening ceremony. But Munley also became one of the City's most vocal opponents of planning and zoning. J. C. Beck, the lawyer whose niece represented the West side, shared even less with these fellow Bridge promoters. He supported the Bridge because it would forward his pet cause, the development of Seventh Avenue, a street he was instrumental in having renamed "Broadway." Likewise, although the *Oregonian* supported the legal challenges to the Bridge, hardly surprising since Ralph Duniway, the lawyer involved, was nephew to its powerful editor,

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[7] HISTORIC AMERICAN ENGINEERING RECORD (HAER) NATIONAL PARK SERVICE, U. S. DEPARTMENT OF THE INTERIOR "STEEL BRIDGE," HAER NO. OR-21; MODJESKI LETTERBOOKS, PASSIM; MACCOLL, SHAPING OF A CITY, 387-388 AND PASSIM.

[8] Abbott, *Portland*, 57-66.

Harvey Scott, the newspaper also joined the rival *Journal* in helping to fund Bennett's work in Portland. Given the complexities and unpredictability of the alliances involved, it is well that Portland found a masterful politician for its consulting engineer.[9]

Ralph Modjeski: The Engineer As Diplomat

When the City of Portland asked Ralph Modjeski to study potential locations for a "proposed high bridge" over the Willamette River somewhere north of the O.R.& N. Bridge and to offer preliminary plans and estimates, it represented an important departure. Previous local bridges had engaged regional engineering talent. Modjeski was the first nationally prominent figure to consult on a Portland highway bridge. Shortly thereafter the recognized inadequacy of earlier structures motivated the City to seek out Waddell & Harrington, another leading national firm, to replace its Madison Street Bridge with a more substantial structure. But the selection of Modjeski was motivated as well by the unprecedented scale a potential high bridge might assume. Modjeski's local presence as Consulting Engineer for James J. Hill's Vancouver-Portland Bridges initially brought him into contact with Portland civic leaders. His talents as a bridge engineer willing and able to take on structures of unprecedented proportions made him a fine choice.[10]

Ralph Modjeski began life in 1861 as Rudolphe Modrzejewski in Bochnia, a town in Austrian Poland near Krakow. His father, a wealthy Austrian named Gustav Sinnmayer, used

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[9] Abbott, *Portland*, 83-84, 102; Modjeski Letterbooks, *passim*; "Five Hundred Autos to Move in a Parade over the New Bridge," *Oregon Journal*, 4/20/1913, 2; "New Bridge Wins after Years of Hard Struggle," *Oregon Journal*, 4/22/1913, 4; J.C. Beck Obituary, *Oregon Journal*, 2/5/1936, 2.

[10] Although Waddell & Harrington became the first nationally prominent consulting engineers hired to design and supervise the construction of a Portland highway bridge, Modjeski was hired by the City to study the "high bridge" option more than a year earlier making him the first nationally prominent engineer to consult on a Portland highway bridge. George S. Morison, Modjeski's mentor, designed the first Portland Steel Bridge, but he worked for the railroad. The timing of these developments is spelled out is Historic American Engineering Record (HAER), National Park Service, United States Department of the Interior, "Hawthorne Bridge," HAER No. OR-20 and Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Steel Bridge," HAER No. OR-21.

Ralph Modjeski, *A Report to the Mayor and City Council with Plans and Estimates for the Proposed Bridge across the Willamette River at Portland, Oregon* (Chicago: Fred S. Miller & Co., 1908), 3; D. W. Taylor, City Engineer, to Honorable Mayor and Executive Board of the City of Portland, 4/27/1908, Council Documents: Improvements-Bridges, 1908, City Archives, Portland, Oregon; William E. Worthington, Jr., "Ralph Modjeski," in John A. Garraty and Mark C. Carnes, *American National Biography* (New York: Oxford University Press, 1999), 651-653; Historic American Engineering Record (HAER) National Park Service, U. S. Department of the Interior "HAER No. OR-7, 6.

Jim Carmin, Reference Librarian, Humanities, Multnomah County Library made my work with the various original Modjeski reports more productive and enjoyable. The County's superb Library and its remarkably helpful employees assured that library research for this project was a genuine pleasure.

the name Modrzejewski when working in the theater and his mother, Helena Opid, who had been trained as an actress by Sinnmayer, adopted the name on her theatrical debut. It remains unclear whether Modjeski's parents ever married. In any event, by 1865 Helena had left Sinnmayer to begin a successful acting career on her own and in 1868 she married Karol Chaplowski, a Polish aristocrat and revolutionary. She continued what ultimately became an internationally acclaimed acting career.[11]

She and her adolescent son first arrived in America in 1876 together with Chaplowski and several other Polish radicals. When their attempt to create a utopian Polish agricultural community near Anaheim, California, failed, Helena returned to the stage, shortening her name to Modjeska in deference to her American audience's difficulties with long Polish names. Her son followed suit by adopting the masculine variant, Modjeski, as well as substituting the more Americanized "Ralph" for his given name. The young man displayed remarkable versatility. He quickly mastered English and resumed his studies, served as his mother's stage manager, and continued the piano lessons in which he had excelled since early childhood.[12]

Given his diverse talents, Modjeski's decision to become an engineer clearly represented a choice, one to which he was deeply committed from the outset. When he failed the admission examinations after traveling to Paris in 1878 to enroll at the Ecole des Ponts et Chaussees, probably the premier civil engineering school at the time, he settled down for a three-year course of study that garnered him admission in 1881. He graduated first in his class in 1885, returning immediately to practice in the United States, where he had become a citizen two years earlier. His continuing desire for excellent training manifested itself when he chose to become an assistant to George S. Morison, America's foremost bridge engineer and the nation's pioneer steel bridge designer. After eight years of increasingly responsible work with Morison, he established his own Chicago consulting practice. Over the ensuing years, he alternated between working independently and joining in partnership with other leading engineers.[13]

Like most of his contemporaries, much of Modjeski's early work involved railroad bridges. Before coming to Portland, he especially demonstrated a capacity to use his creativity in finding cost-effective solutions for his clients. For example, he designed a series of standard steel bridges for the Northern Pacific to use as it faced the need to replace many of its bridges to handle new and heavier rolling stock. Likewise, when he served as chief engineer for the Southern Illinois and Missouri Bridge Company, designing and building a huge double-track railroad bridge across the Mississippi at Thebes, Illinois, he created a pin-connected through truss that allowed quick field assembly of prefabricated components. His highly visible success at Thebes brought him the Vancouver-Portland Railroad Bridges contract and introduced him to

[11] Felicia Hardison Londre, "Helena Modjeska," in Garraty and Carnes, *American National Biography*, 649-651; Worthington, "Ralph Modjeski," 651.

[12] Worthington, "Ralph Modjeski," 651; Londre, "Helena Modjeska," 649-650.

[13] Worthington, "Ralph Modjeski," 651.

Portland's business and political leaders.[14]

The details of Modjeski's initial recruitment have not survived, but it is clear that political rather than engineering support was crucial. In April 1908, City Engineer D. W. Taylor had to notify the Mayor and Council that while the Council had recently appropriated funds to hire Modjeski, Taylor had previously engaged J. B. C. Lockwood, a local consulting engineer affiliated with the Port of Portland, to perform much the same task. Evidently the novel proposition of a tunnel had motivated the selection of the distinguished outside expert; Taylor's letter describes that as his principal task. But reviewing a high bridge alternative was also part of his mandate. Fortunately, Lockwood, who had worked with Modjeski during the Port of Portland review of the Northern Pacific Bridges, was happy to allow Modjeski to assume the job and willingly passed on the results of his work.[15]

Modjeski's success in Portland rested on a highly developed sense of when to press his case and when to defer to his client, a flexibility that might well have derived from an early life spent continuously adjusting to the combined unpredictability of theatrical life and revolutionary politics. The fact that his mother was dying of kidney disease in California during his initial years' work for Portland (1908-09) must simultaneously have made continued work on the West Coast attractive and helped put mundane problems with his client in perspective. Throughout the period, as the Broadway Bridge weathered voter scrutiny in a charter change referendum that authorized up to $2,000,000 indebtedness for the structure, only to be immediately waylaid by a lawsuit, Modjeski kept his name and interest before political leaders while simultaneously seeking guidance from the Bridge's principal supporters.[16]

Modjeski's original, 1908 task for the City was to examine the possibilities for building a "high bridge" north of the northernmost downtown crossing, the O.R.& N. Bridge. He was to report on locations; offer preliminary plans showing alignment, pier location, and general shape; offer cost estimates; and provide a discussion of the options. He was also asked to assess a tunnel alternative. His report gave a good sense of his preferences, but distinguished them from recommendations founded on his engineering expertise. His text consistently recognized that

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[14] Worthington, "Ralph Modjeski," 651-652; Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, " No. OR-7, 6-7. Modjeski was already well enough known by the late nineteenth century to be appointed to a Board of Consulting Engineers to help the City of Chicago choose a new type of movable bridge. Donald N. Becker, "Development of the Chicago Type Bascule Bridge," *Proceedings of the American Society of Civil Engineers* (February, 1943), 271.

[15] D. W. Taylor to Honorable Mayor and Executive Board, 4/27/1908, Council Documents, Improvements-Bridges, 1908, City Archives; "Service Set for Engineer," *Oregonian*, 12/4/1945, 7; Modjeski to J. C. Flanders, 2/2/1906, Modjeski Letterbooks.

[16] Londre, "Helena Modjeska," 650; Modjeski Letterbooks, *passim*; "Report of the Special Committee on Bridges, City of Portland," 11/11/1908, including text of Charter Change Act, City Council Documents, Improvements to Bridges, 1908, City Archives. Interestingly, the text of the Committee recommendation refers to its consulting engineer as Ralph Modjeska. Indeed, local press coverage of the Bridge opening made sure to identify Modjeski as "the son of the famous actress, the late Helena Modjeski."

there were legitimate grounds upon which local decision makers might prefer other options.[17]

Modjeski clearly dismissed the tunnel option. While acknowledging its advantage in not interfering with navigation, he underscored the local environmental constraints that made it a poor choice for Portland: sandy soil quite "unfavorable to . . . tunnel construction" and topography requiring a descent of at least 91 feet on the west and 200 feet or more on the east, constituting a "heavy tax on the public" through the work required to travel the route. He also emphasized the unattractiveness of dark, damp places, a view that he took to be widely shared. Finally, he calculated that these various problems would combine to make a tunnel more than twice as costly as the most costly bridge option.[18]

Modjeski also proffered two bridge alternatives, each meeting the "high bridge" criterion in that they would rarely interrupt traffic to accommodate navigation. The first alternative crossed the Willamette well north of the city center, a location chosen so as to keep manageable the substantial potential cost of the long approach ramps it required. The bridge would arch over the river using a 1,000 foot span between centers on piers, affording an 170 foot clearance over low water, 135 feet over high water. Neither piers nor span would obstruct navigation. The principal cost from Modjeski's perspective would come in the very long ramps necessary to keep grades reasonable. The longer drive and steeper grade than for a lower bridge would "represent a constant tax on people using the bridge in the form of additional and unnecessary work performed." Added to its substantially greater costs than for a lower span, including nearly four times the expense for ramp construction (exclusive of real estate costs) and more than twice the cost for the span itself, Modjeski found its disadvantages far too great to justify the structure's few advantages: the absence of piers in the river and the elimination of bridge openings. Nonetheless, he took pains to sketch what he considered an acceptable possibility should City Council prefer the high bridge. He chose an arch for of the truss to "suggest . . . a gateway or an entrance to a city," rejecting a cantilever alternative as less attractive and harder to construct.[19]

Modjeski's preference, though, was a bascule bridge built closer to the City's center and spanning the river high enough to make openings comparatively rare. He had carefully reviewed the navigation data he had requested and could specify probable opening frequencies at high and low water. In essence, his proposal sketched the Broadway Bridge. Its through truss spans, like those of Modjeski's recently completed Willamette River railroad bridge, would be Parker trusses

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[17] Modjeski, *A Report to the Mayor*, 3 and *passim*.

[18] Modjeski, *A Report to the Mayor*, 12-15. Modjeski also emphasized the absence of good precedents for such a structure; the only roughly comparable structures were British and had to carry only a fraction of Portland's expected traffic. His estimated cost for a tunnel was $7,800,000.

[19] Although the proposed high bridge's ramp began at Eighth and Davis, it turned and crossed the river at Northrup, placing its overpasses and piers farther from businesses and other structures. Its east approach ended at Wheeler and Hancock, placing it in a locale sufficiently underdeveloped that Modjeski called for construction of an additional approach street. Modjeski, *A Report to the Mayor*, 4-7, 9-12. His estimated cost for a high bridge was $3,250,000 of which $70,000 would go to acquire the land and $186,415 would cover approach construction.

of the Pennsylvania Petit type. The movable span, placed at the center of the river superstructure in line with the draw of the Steel Bridge one-quarter mile upstream, would be a bascule, a more modern choice than the swing spans with which Portland was familiar, but one that Modjeski judged less experimental than a vertical lift bridge, the other possible alternative. Because Modjeski was not a bascule designer and because the technology was a rapidly evolving one at the time, he left the specific type of bascule open. He sketched a deck truss with an arched lower chord, but suggested the alternative of a through truss with a straight lower chord which would provide a 65 foot clearance over high water the full width of the bascule span, although at added expense. He also observed that a through truss bascule would be less attractive and harder to operate.[20]

Modjeski clearly recognized that cities faced more serious financial limitations than did the railroads, his usual clients. His proposal cannily offered a bridge of modest dimensions while indicating that its size might be increased at increased expense. So, for example, he limited the bascule opening's clear width to 200 feet and specified a deck width of 60 feet, including a 40 foot roadway and two 10 foot sidewalks. Recognizing the high real estate costs for a bridge closer to downtown, he took pains to specify the parcels of West side real estate required. His sketch also kept these costs down by calling for the approach to begin at Sixth and Irving, about a block north and east of the Bridge's final route; in other words, he accepted a slightly steeper approach ramp in exchange for lower cost. By contrast, on the East side where land was cheaper and bridge supporters had a clearer sense of the Bridge's role in local development, Modjeski simply stated Broadway and Larrabee as the expected eastern approach terminus, a specification embodied in the final structure. He also demonstrated a sense of the difficulties between the City and the railroads when he planned a 441 foot span over the Terminal Company tracks where the west end of the Bridge passed near Union Station.[21]

Modjeski's report was ready for submission in September, 1908. He simultaneously tendered an offer to prepare plans and supervise construction at a 4 per cent commission on total construction costs. Intervening delays meant he needed to write to the Mayor and renew the offer once again in August, 1909, at the same time dispatching twenty-five more copies of his report and keeping his local supporters posted on his activities. They had evidently alerted him

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[20] Modjeski, A Report to the Mayor, 5-7; Modjeski to H. A. Heppner, 9/29/1909, and Modjeski to Spurgeon Bell, Secretary, Chicago Commission of City Expenditures, 2/23/1910, both in Modjeski Letterbooks.

Interestingly, at this juncture, Modjeski failed to note that using a through truss would permit savings in approach costs, or, alternatively, lower grades, making his report somewhat more favorable toward a deck truss, clearly his aesthetic preference. On the other hand, at least for the Rall bascule that was chosen, his assertion that a through truss would complicate the operating mechanism was certainly warranted. See the discussion of the Rall below.

[21] Modjeski, *A Report to the Mayor*, 6, 9. Although the approaches at the proposed Broadway location were much shorter, Modjeski estimate real estate costs to be higher than for the more northerly high bridge: $85,000. By contrast, the approaches themselves would cost only $47,855. His total estimate for a bascule was $1,380,000.

that a decision was imminent; in late August, Modjeski noted in a letter to Heppner, "I would try to be in Portland at the right time if you could kindly advise me when that time would be." But events moved too rapidly for Modjeski's busy schedule; as the City prepared to choose its engineer in mid-September, 1909, Modjeski dispatched W. E. Angier, his principal assistant, to discuss his proposal with Mayor Simon and others. Again, the details are sketchy, but there was at least one other major contender for the contract: Waddell & Harrington, a firm with high national visibility and one that the City had hired in April, 1909, to prepare plans for and supervise construction of a Hawthorne Street vertical lift bridge. At roughly the same time, the O.R.& N. had also decided to use the new vertical lift technology, challenging Waddell & Harrington to create a unique variation with two independently moveable decks.[22]

The decision to employ Modjeski, made later that fall, came only after City leaders consciously chose not to employ vertical lift technology on the Broadway Bridge. Modjeski saluted the decision as technologically astute, calling the lift bridge "a very complicated piece of machinery and [one that] has not been sufficiently tried and which, at best, only provides limited head room," an apt assessment at a time when Chicago's South Halsted Street Bridge, a mechanically cumbersome early version of the type, was the only modern high-clearance vertical lift bridge available to assess. Modjeski's preferences also rested on his prognostication that "modern warships with the new type of 'indestructible towers' or, as they are sometimes called 'antenae'" and "further development of wireless telegraphy on boats" would increasingly favor bascule bridges because, once open, they offered unlimited vertical clearance.[23]

In contrast to the limited evidence that vertical lift bridges were a viable alternative, Modjeski's experience in Chicago gave him familiarity with a number of successful bascule bridges. By 1909, the City had erected nine simple trunnion bascules, structures whose leaves lifted and lowered as they rotated around a fixed axle. Another version of the fixed trunnion bascule, patented by Joseph B. Strauss and manufactured by the Strauss Bascule Bridge Co. of Chicago, had first been built in 1905; by 1909, two additional Strauss bascule had been or were being constructed. Although Strauss built these bridges outside the Chicago area, Modjeski had

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[22] The Modjeski Letterbooks offer the most detailed picture of the process. See in particular Modjeski's letters to: M. G. Munley, 8/18/1909; Hon. Joseph Simon, 8/27/1909; H. A. Heppner, 8/27/1909; Hon. Joseph Simon, 9/15/1909 (2); Hon. Joseph Simon, 9/21/1909; H. A. Heppner, 9/29/1909. On Waddell & Harrington's other Portland ventures see Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Hawthorne Bridge,", HAER No. OR-20 and Historic American Engineering Record (HAER), National Park Service, "Steel Bridge," HAER No. OR-21. That Modjeski's schedule did not permit a last minute visit is hardly surprising. His mother had died in July; August and September must have been crowded with rescheduled business trips.

[23] Modjeski to H. A. Heppner, 9/29/1909 and Modjeski to George W. Brown, 11/27/1909, Modjeski Letterbooks. On the state of vertical lift bridge technology in 1909 see Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Hawthorne Bridge," HAER No. OR-20.

good cause to be aware of his work; the younger engineer had formerly served as his assistant.[24]

Among bascules, "rolling-lift" bridges were a somewhat more established alternative. Again, the technology had first gained visibility in Chicago, where, in 1893, William Scherzer completed plans for a bascule leaf whose shoreward end took the form of a quadrant. As the quadrant rolled along a horizontal track, the leaf's river end simultaneously lifted and moved shoreward, providing greater horizontal clearance relative to the span's length than did fixed trunnion bascules. At least sixteen such bridges had been built by the time Portland hired Modjeski. Theodor Rall of Chicago offered another version of the rolling lift type, patented in 1906 and controlled by Chicago's Strobel Steel Construction Company. After its initial trial in Peoria, the type was just gaining visibility with the completion of four double-track Rall railway bridges over the East Chicago Canal. Although these were the principal bascule options, the late nineteenth and early twentieth century was a time when many prominent engineers spent time developing patent bridges, so a variety of additional bascules were also theoretical possibilities.[25]

Modjeski clearly appreciated the virtues of the bascule type, but he made no pretense of expertise in the technology. Although bascules were rapidly gaining favor over swing spans, they were mostly preferred for highway bridges and Modjeski had been primarily a railway bridge builder. Most recently, as Consulting Engineer for the Vancouver-Portland Bridges, he had arranged a Chicago expedition for members of the Port of Portland Commission to acquaint them with the new bascule technology. But when his guests nonetheless decided they preferred a swing span, Modjeski acceded to their wishes. He showed a similar willingness to be governed by the City of Portland when it came to choosing the Broadway Bridge bascule span, but that decision came relatively late in the game.[26]

A number of other decisions began to refine Modjeski's sketch during the months immediately following his appointment as Consulting Engineer. Those acquainted with Modjeski's love of impressive masonry piers will be unsurprised to learn that one of his earliest inquiries asked whether the Index, Washington, quarry that had supplied granite for the Vancouver-Portland Bridges' piers could quickly come up with the stone to accommodate a last-minute decision. Recognizing the Portland Bridge Committee's cost consciousness, Modjeski was both anxious to urge a practice he deemed superior and prepared to compromise. The actual bridge embodies the compromise. The less visible shoreward river piers are pairs of concrete-filled twelve-foot diameter steel cylinders strongly braced together by riveted steel. The

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[24] Becker, "Chicago Type Bascule," 270-279, 292; Otis Ellis Hovey, *Movable Bridges*: Volume I.--Superstructures (New York: John wily & Sons, 1926), 28-29, 102, 115-116, 127, 143-145, and *passim*; Worthington, "Ralph Modjeski, 653. Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior "Morrison Bridge," HAER No. OR-100 and Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Burnside Bridge," HAER No. OR-101 offer fuller discussions of the Chicago and Strauss bascules.

[25] Hovey, *Movable Bridges*, 101-115.

[26] Hovey, *Movable Bridges*, 28; Modjeski to J. C. Flanders, 2/2/1906, Modjeski Letterbooks.

more prominent bascule piers are granite faced, with careful provision made for diminishing thickness of the stone so as to preserve a uniform appearance as the pier becomes narrower toward its top. Then, the final three courses, belt course, and coping are comprised entirely of granite, assuring more even distribution of superstructure weight.[27]

Several decisions needed to be made early so as to permit the Army Corps of Engineers, acting on behalf of the War Department, and the Port of Portland Commission, exercising the State's approval powers, to review the structure, a legal requirement where a bridge potentially interfered with navigation. Approval hearings could take place only after the City had fixed the basic dimensions of the Bridge, those that would define pier placement and the width of the horizontal opening. In the process of reaching this agreement, Modjeski's modest sketch became a more substantial structure. By late November, when Modjeski submitted a map and cross section of the river portions of the Bridge for Bridge Committee and Port of Portland Commission approval, he showed a clear horizontal opening of 225 feet. By early December, Modjeski had visited and heard some Bridge Committee and Port Commission members propose a 300 foot opening. Preferring, as always, to undertake realistic rather than experimental projects, Modjeski urged approval of his 225 foot plan or, if that was impossible, a compromise at some width less than 300 feet. Again, the final structure embodies Modjeski's ability to accept and encourage compromise. The clear horizontal opening is 250 feet between pier foundations, an increase necessary to gain Corps of Engineers approval. Achieving that meant building a 278 foot bascule span (center to center of the Rall wheels in closed position), making it by far the longest bascule span in the nation. The Bridge's height remained that sketched in 1908: 65 feet above extreme high water at its bascule span. It lessened only slightly to 56 feet at the harbor lines, reflecting another compromise; as signalled in Modjeski's earlier report, he was willing to accept a through truss, permitting a lessened East side approach grade as well as straight bottom chord. Perhaps to balance this change, the Committee and Modjeski agreed to extend the West

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[27] Here and in what follows I use the shorter term "Bridge Committee," to refer to the "Bridge Committee of the Executive Committee of the City of Portland." Modjeski to John A. Soderberg, 11/22/1909, and Modjeski to H. A. Heppner, 11/27/1909, in Modjeski Letterbooks; Hardesty, "The Broadway Bridge," 704-705. The steel cylinder piers are numbers 7 (on the east side), 2, 3, and 4 (all on the west side). Piers 5 and 6 are the bascule piers.

Modjeski's unsuccessful proposal for the Columbia River Interstate Highway Bridge, drafted while completing the Broadway Bridge, elaborates further concerning his pier face preferences. With cost even more an issue on the Interstate Bridge, he accepts that stone will be too expensive and proposes all concrete-filled steel cylinder piers. He confesses that he has "never had complete confidence in concrete for important river piers, and has, with one exception, always built them of stone backed with concrete." Modjeski, *To the Joint Pacific Highway Bridge Committee of Portland and Vancouver Commercial Clubs: A Report with Plans and Estimates for the Proposed Bridge Across the Columbia River between Portland, Oregon, and Vancouver, Washington* (Chicago: H.C. Sherman & Co., 1912), 9-10. Modjeski did not get the job because Washington votes defeated the approach to Seventh and Hoyt, lessening the West approach grade.[28]

Such agreements did not happen without sustained effort on Modjeski's part. Reliance on long distance written communication especially left room for misunderstanding. In mid-December, for example, Modjeski took time to explain in a letter to R. E. Menefee of the Bridge Committee that a telegram Modjeski had sent him in mid-November had miscarried because he had used the wrong middle initial and because the telegram had gone out via Western Union rather than the Postal Company. Modjeski even tracked down the actual recipient of the telegram and reported his findings to Menefee. He concluded, "I trust the above will square me with you." Similarly, a late January 1910 letter alerted Mayor Simon that Henry L. Corbett, one of Portland's wealthiest and most influential businessmen as well as a member of the Bridge Committee, had written independently to Modjeski asking that he narrow the Bridge. Modjeski had previously gotten the Mayor and others to agree to a 70 foot bridge with a 50 foot roadway and two 10 foot sidewalks rather than the narrower structure he had originally sketched. He quickly responded to Corbett's potential ability to cause trouble if not to undo a carefully crafted agreement. In February, he dispatched his assistant, Angier, to resolve these and other pending matters. The final bridge reflected the success of Modjeski and Angier as negotiators. The main superstructure was 70 feet wide (50 feet center to center of its trusses), permitting a 46.5 foot roadway between curbs and two 9 foot sidewalks once space devoted to light fixtures, railings, and trusses had been subtracted. As a culmination of this period of long-distance negotiation, in March, 1910, Angier managed to get the Mayor's support for creosoted timber flooring on the bascule deck, something Heppner and Modjeski had agreed on as a preference almost as soon as Modjeski was hired.[29]

The frequent, amicable correspondence passing between Modjeski and Mayor Simon and the evidence that their face-to-face interchanges were equally cordial helps explain a final belated change of little structural, but considerable symbolic importance. All of the drawings of the bascule through trusses show a configuration of structural members that terminates on the channel ends with a diagonal slanting down toward the river end of each leaf. The result, depicted in the cover sketch for Strobel's drawing set, is a wide V-shaped opening between the trusses at the center of the bascule span. By contrast, the actual bridge shows the trusses' top

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[28] Modjeski to George W. Brown, Chairman Bridge Committee, 11/27/1909; Modjeski to Judge M. G. Munley, 12/11/1909; and Modjeski to Hon. Joseph Simon, 1/17/1910, Modjeski Letterbooks; Hardesty, "The Broadway Bridge," 704-706. Tables of bascules' dimensions in Hovey, *Movable Bridges*, show the Broadway Bridge to have remained the longest U. S. bascule for at least a decade.

When Port of Portland Commission members joined with their fellow leaders of Portland's establishment to oppose the Bridge, the Commission's jurisdiction over bridge building, increasingly suspect among Progressives, was successfully challenged in the Oregon Supreme Court. "New Bridge Wins after Years of Hard Struggle," *Oregon Journal*, 4/22/1913, 4.

[29] Modjeski to R. E. Menefee, 12/17/1909; Modjeski to Hon. Joseph Simon, 1/28/1910; W. E. Angier to Hon. Joseph Simon, 3/3/1910; and Modjeski to H. A. Heppner, 11/27/1909; Hovey, Movable Bridges, 112. The width of roadway and sidewalks differed slightly on various sections of the Bridge.

chords descending only slightly from their highest point when they reach center of the bascule span.[30]

Sometime after the 1912 selection of a bascule designer and the subsequent receipt of preliminary plans, Mayor Simon voiced concern about the bascule trusses' appearance. At a time when Portland's citizens were used to crossing swing spans and growing accustomed to the new vertical lift bridge, bascules remained unfamiliar. Unlike other movable bridges, the channel ends of their leaves must have looked dangerously unsupported; if they could freely lift, some must have wondered, what kept them from falling toward the river just as freely? Functionality to the contrary notwithstanding, the wide open V above the place where the closed leaves met made them look even less well supported. At the Mayor's request, "to give a greater effect of security in appearance" Modjeski added a series of false members, making the channel ends of the bascule trusses appear as substantial as they in fact were.[31]

Anyone who thinks that the massive industrial-style truss bridges of the early twentieth century lack an aesthetic dimension need look no further than the Broadway Bridge to see evidence to the contrary.. An aesthetic of massive industrial strength provided crucial reassurance at a time when bridges such as Portland's Broadway Bridge reached across unprecedented distances using relatively novel technology. Modjeski's ability to hear and his willingness to accommodate Simon's concern clearly recognized that politicians performed an important task: expressing popular will. Modjeski's respect for that expression made him a truly exceptional engineer.

Choosing A Bascule: How Portland Got its Rall and What It Got

Of all the choices that shaped the Broadway Bridge, the most dramatic decision and the one with the most far-reaching consequences was the selection of the bascule type. Although from the outset Modjeski expressed clear preference for a bascule, he evidently remained silent as to type for most of the roughly three years that elapsed between his initial sketch of the Bridge and the end of the court battles that delayed its construction. In part, his silence reflected the state of bascule art: the technology was developing rapidly and premature commitment to a particular type might have been imprudent. Even more caution was warranted because the Broadway Bridge bascule span would be more than 70 feet longer than any previous American bascule and more than one and two-thirds times the length of the longest bascule built under any

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[30] Modjeski Letterbooks, *passim*; the various Broadway Bridge drawings are housed in the Bridge Engineering and Maintenance Office, Multnomah County. Unfortunately, the Strobel drawings are of such poor quality that they cannot be adequately reproduced to illustrate this report.

[31] Hardesty, "The Broadway Bridge," 705-706. Even today it takes a leap of faith to believe that the huge, heavy through truss leaves of the open Broadway Bridge will not fall into the Willamette. Without seeing the Bridge in action, the sensation is difficult to appreciate. The note mentioning the mayor's request for redesign also refers to making the outline more symmetrical, which was not the case since the Bridge was equally symmetrical before and after the addition of the false members.

of the patents Portland considered. Modjeski lacked the intimate acquaintance with bascule technology that permitted trustworthy extrapolation from known examples to a precedent-setting new case. As he wrote to one Chicago official, "My experience with bascule bridges has been mainly in designing outlines, checking over details submitted by the contractors and superintending the construction. I have had no experience to speak of in drawing up detail shop plans for the work nor for maintenance of bascule bridges." In early 1910 when he penned these words, he named Strauss and Scherzer as obvious firms to contact and added, "Possibly the Strobel Steel Construction Co. can also give you some information," suggesting less confidence or familiarity with the newer Rall technology and its owner.[32]

The Supreme Court decision did not clear the way for the Broadway Bridge until February 1912, but planning proceeded so as to permit construction to begin as soon as possible. By November, 1910, Modjeski completed specifications for the substructure and by September, 1911, he completed superstructure specifications. Under "Patents and Royalties," provision 11 specified that "The bascule span shown by the accompanying drawings and described by these specifications, is a two-leaf, through, highway, bascule bridge, designed under the 'Stauss' patent, controlled by the 'Strauss Bascule Bridge Company,' of Chicago, Illinois." Provision 13 of the same section permitted a Contractor to substitute another patent mechanism if the Contractor assumed liability. As late as 1911, then, Modjeski evidently saw the Strauss patent as the best option, a choice that might be deemed prescient; over the ensuing decades, Strauss bascules quickly surpassed all other patent bascules to become the nation's most widely used.[33]

Whatever the case in September 1911, January 1912 found Modjeski in Portland to attend Bridge Committee hearings called to determine what sort of bascule Portland would have. Four superstructure contractors had submitted bids and each of them had offered the same four options at different prices: a Rall, a Scherzer, and two different Strauss options. Pennsylvania Steel Co., the low bidder on all of the designs, won the contract, but all of the bids showed the Rall to be the cheapest option and the Stauss to be the most expensive. Probably because the Rall was less established, Strobel charged only $12,000 in royalty, whereas Strauss's and Scherzer's fees were $17,000. The Strauss option also cost more for heavier steelwork and counterweights, more than offsetting its slightly lower cost for operating machinery as compared to the other bascules.[34]

By January 1912, the Scherzer bascule was evidently not a serious contender; after garnering a large initial market it was beset by problems of wear that made it less and less

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[32] Modjeski to Spurgeon Bell, 2/23/1910, Modjeski Letterbooks and *passim*. According to Hovey's data in *Movable Bridges*, passim, the longest prior bascule was a 1903 Chicago-type of 206 feet. The longest prior Strauss was 165 feet; Scherzer, 160 feet; and Rall, 142 feet.

[33] "Vale Kiernanism," 6; "Specifications: Broadway Bridge," Job No. 8898, Modjeski and Masters Files; Hovey, *Movable Bridges*, 116. My thanks to Eric DeLony for arranging for me to receive the specifications from Modjeski and Masters.

[34] "Draw Span Type Exponents Here," *Oregonian*, 1/15/1912, 14; Hardesty, "The Broadway Bridge," 706-707.

attractive and probably better suited to shorter crossings. P. L. Kaufman and Joseph B. Strauss both came to Portland to make the case for the Strauss bascule, while a Mr. Haupt represented Strobel, holder of the Rall patent. Modjeski also spoke on behalf of a particular bascule: he endorsed the Rall, principally because of its lower cost. Judging from an interview reported in the press, though, Modjeski was extremely comfortable at the prospect of intense City Bridge Committee debate. According to the *Oregonian*, he saw the local controversy as "merely a repetition of what occurs in every city where a bridge with a patent span is built" and that it would "seem very unnatural if a contract were let without being preceded by a fuss."[35]

The size of the Broadway Bridge especially fueled the controversy because the winner expected the high visibility of the span to make it good advertising for the winning patent. In a sense this expectation proved true. The Broadway Bridge figured prominently in subsequent discussions of the Rall, receiving the lion's share of attention in engineering textbooks. On the other hand, Rall mechanisms remained the least common of the four principal bascule types and rolling lift bascules progressively lost ground to their fixed trunnion competitors. The Broadway Bridge remains the largest Rall ever built. It is now also one of the few surviving Rall mechanisms.[36]

Looking closely at the Bridge's Rall mechanism offers a rare chance to see how Rall's design worked in practice. Moreover, the scale of the Broadway Bridge's bascule as well as constraints established by Modjeski, notably his provision that the trusses of the bascule line up with those of the fixed spans, combined to required Strobel to exercise considerable ingenuity in its design. The resulting bridge differs significantly from Rall's 1906 patent specifications. It also behaves differently than descriptions of it in the technical literature state. Thus, it offers a splendid illustration of why documentary evidence does not suffice to preserve our engineering history.[37]

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[35] Jeffrey A. Hess, "The Development of Wisconsin Movable Highway Bridges," in Jeffrey A. Hess and Robert M. Frame III, *Historic Highway Bridges of Wisconsin: Volume 3, Historical Survey of Wisconsin Movable Bridges* (Wisconsin Department of Transportation, 1996), 21-29; "Draw Span Type Exponents Here," 14.

[36] "Draw Span Type Exponents Here," 14; Hovey, *Movable Bridges*, 105-115, 116; George A. Hool and W. S. Kinne, eds., *Movable and Long-Span Steel Bridges* (New York: McGraw-Hill Book Company, 1943), 15-19, 38. The 1943 edition of Hool and Kinne specifies the four most common types of bascules as Scherzer, Strauss, Chicago, and Rall.

[37] Provision 37 of Modjeski's specifications stated: "The trusses of the bascule span are placed the same distance apart, center to center, as the trusses of the adjacent spans, being in line with them, and this arrangement must be used in any alternative plan, if submitted, to provide a continuous roadway without offsets." "Specifications: Broadway Bridge," Superstructure. Hovey, *Movable Bridges*, 114-115, notes that this provision "necessitated special recesses in the counterweight boxes and their supports to enable them to pass between the trusses of the approach spans, and rendered the design of the bracing rather difficult." When Strobel designed the Broadway Bridge it did so under two existing Rall patents, No. 817,516 issued 10 April, 1906 for a through truss version and No. 12,570 issued 27 November, 1906 for a deck truss version. The Broadway Bridge includes elements of each and also elements shown in neither. It no doubt helped inspire a final Rall bascule patent, No.

Figures A and B illustrate the principal components of the Broadway's Rall mechanism in open and closed positions. The Rall mechanism supplies each bascule leaf with a combined rotary motion around a shaft passing through the centers of the Rall wheels and retracting motion along the length of the Rall wheel track. The Rall wheels, one on either side of each bascule leaf, are cast nickel-chrome-steel rollers 100 inches in diameter and 40 inches in face. The rollers' axle is a hollow, forged steel shaft 28 inches in outside diameter and 16 inches in inside diameter. When the Bridge is operating, the ends of the roller shafts support the entire weight of the leaf, about 2,000,000 pounds per roller. As the Bridge opens, the rollers rotate on their shafts and roll back toward the shore ends of the Bridge. Each Rall wheel rolls on a 32.67 foot long cast nickel-chrome-steel track that is 40 inches wide and 20 inches deep, attached to and supported by a box girder. When combined with the leaf's rotation, this retraction results in a greater horizontal opening relative to leaf length than is possible with a fixed trunnion mechanism.[38]

Operating struts serve to transmit power from the span drive machinery to the bascule, overcoming inertia and the considerable friction that results from the Rall's combination of trunnions and rolling lift linkages. Four operating struts, two on each leaf, are placed 12 feet to either side of the leaves' longitudinal center line. On the underside of each operating strut is a rack whose teeth mesh with the teeth of a pinion at the river end of the span drive gear train. Each strut's 21 ton weight is supported at its pinion end by side cylindrical surfaces, integrally forged parts of the main pinion gear and shaft. Rack guides, one on either side of each strut and also supported by the pinion shaft, provide some lateral alignment for the operating strut through rollers (two per rack guide; four per operating strut) that travel along flanges atop the strut; the rack guides serve principally to help support the strut during seating. When the Bridge operator activates the machinery, the pinion gear teeth move within the operating strut rack, drawing the strut shoreward. Each operating strut is 91 feet long and travels up to 65 feet. At its river end, the strut is pin-connected to the top of the bascule leaf on the channel side of the trunnion so that as the pinion end of the strut is drawn shoreward, the strut draws the bascule span up and away

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1,094,473, issued a year after the Bridge's completion on 28 April, 1914. Hovey, *Movable Bridges*, 144; Hool and Kinne, *Movable and Long-Span Steel Bridges*, 28. My thanks to Justin Spivey of the Chicago HAER bridge project for copies of the 1906 Rall patents.

[38] Here and in what follows I am indebted to John Muenchow, Project Manager for the Broadway Bridge Mechanical Renovations and Engineer Technician Principal, and Ed Wortman, Engineering Services Administrator, both of the Department of Environmental Services, Division of Transportation - Bridges, Multnomah County. They provided a tour of the Bridge, met with me to review aspects of its operation, and fielded numerous additional questions. Sharon Wood Wortman's tour for County employees provided me with my initial introduction to the span and Pam Patrie, Broadway Bridge Operator, supplied an invaluable perspective. Hool and Kinne, *Movable and Long-Span Steel Bridges*, 19; Hovey, *Movable Bridges*, 110, 113; Hardesty, "The Broadway Bridge," 707.

from the river.[39]

Counterweights attached to the shoreward ends of the bascule leaves assure that relatively slight pressure is required to make the leaf rotate around the roller shaft. As the counterweights descend, their weight counterbalances that of the river ends of the leaves, which rise. Because the west leaf included the centerlock mechanism, its counterweight was poured using a somewhat richer mixture of concrete to weigh about 2,325,000 pounds; the east counterweight originally weighed about 2,281,000 pounds. Each counterweight is 26.5 feet high by 44 feet wide by 15 feet thick (the dimension paralleling the path of the Bridge), but each counterweight's volume is only 15,550 cubic feet because Strobel left room for open pits in which concrete weights can be placed to adjust for increases in the leaf's weight and provided slots that allow passage of the operating struts (see Figure B). Originally, the leaves opened to an 89 degree angle, bringing the counterweight within 7 inches of the floor, but more recent safety provisions (guard rails and walkway hand rails) interfere with counterweight movement and prevent full opening; the leaves now open to a maximum of 63 degrees.[40]

As the Rall wheel rolls, adding a shoreward motion to the leaf's lift, a control strut guides it. The control strut, generally referred to as a "swing" or "swinging" strut in published accounts of the mechanism, is pin-connected to the counterweight box at one end and to the inside of the Rall track girder at the other. The strut measures 23 feet between centers of pins. During the Bridge's opening, the counterweight end of the control strut describes a circular curve of up to

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[39] Consulting Engineers' Reports and internal evaluations have examined the Bridge's mechanical components repeatedly, beginning with a 1978 crack in one of the Rall wheels after sand was allowed to build up on a Rall wheel track during maintenance painting of the Bridge. My understanding of its operation is informed by this extensive documentary collection. Especially valuable are Muenchow to Norman, Oregon Department of Transportation, 6/18/1999; Hardesty & Hanover Report, 6/7/2000; and various documents produced for a planned 1991 mechanical renovation and an ensuing 1993 lawsuit, all in Broadway Bridge Files, Yeon Annex Records Center, Multnomah County Department of Environmental Services, Division of Transportation, Portland, Oregon (hereinafter Yeon Records Center).

"Broadway Bridge Mechanical Work Items," Broadway and Burnside Bridge: Mechanical/Electrical Renovations, 9/88, Sheet 5 of 43 Drawings, Broadway Bridge Files, Yeon Records Center; Muenchow to Norman, 6/8/1999, 3-4; Hardesty & Hanover Report, 6/7/2000, 5-7; Hardesty, "The Broadway Bridge," 707; Hovey, *Movable Bridges*, 113. The great length of the operating struts and the fact that they operate as cantilevers required them to be stiffened through the attachment on the strut's top side of a girder varying in depth from nothing to 3.25 feet. This accounts for some of the strut's substantial weight.

As noted below, the Bridge can no longer perform a full opening. Here and elsewhere, then, I indicate the maximum potential movement of components of the Rall mechanism although their actual movement is now less.

[40] Figures for the weight of counterweights are inevitably estimates. My understanding of this and of changes in the ability of the Bridge to open comes from discussions with Ed Wortman, Engineering Services Administrator, Multnomah County and John Muenchow, Engineering Technician - Principal. Muenchow to Norman, 6/18/1999, 2; Hardesty, "The Broadway Bridge," 706-707.

105 degrees, limiting the Rall wheel's movement shoreward along its track.[41]

A final major component of the Rall mechanism is its anchor strut, more properly called an anchor tie because it carries live load in tension, not compression. Nonetheless, I use the term anchor strut here because it is used in all documentary and local discussions of the Bridge. The primary role of the anchor strut is to transmit the horizontal component of the span's live load to the fixed span or, more colloquially, to keep the bascule leaves from falling into the river when traffic moves over them. The anchor struts are 52 feet long and travel up to 35 feet. A 13 inch pin attaches each anchor strut to the bascule leaf. A slot within the strut moves on a 10.5 inch pin attached to an extension of the fixed span's top chord (pin location labeled "guide wheel" in Figure A). When the Bridge is closed, the shoreward end of the anchor strut slot comes to bear on the 10.5 inch pin so that the live load is taken by the fixed span. Originally, hydraulic buffers were installed in the anchor strut slots to assure that the slot end came to bear without shock. Construction drawings suggest that these buffers caused trouble from the outset; they have not been part of the Bridge's operation for many years. They may never have been necessary because the Bridge is counterweight heavy. Indeed, the anchor struts perform a secondary function of pushing the span into its closed position.[42]

The anchor struts are the weakest component of the Rall mechanism, hardly surprising since they were evidently newly and hastily devised to meet the challenge this bridge posed. They do not appear in the 1906 Rall patents or in discussions of earlier Rall bascules. Each anchor strut moves by rolling against two guide wheels that rotate about the pins on the fixed span's top chord. As the anchor strut moves, the guide wheels press against the underside of angles on the strut's top flange. This design has posed problems from the start, largely because the guide wheel tracks are made of conventional hot-rolled structural steel and lack the ability to withstand the stresses to which they are routinely subjected. As the tracks have deformed, the wheels and their bushings have also deformed, a process aggravated because the wheel hubs are narrow relative to the wheels' diameter. Replacement of individual components and patchwork strengthening has failed to solve the problem; new anchor struts with a redesigned guide wheel

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[41] Hool and Kinne, *Movable and Long-Span Steel Bridges*, 19; Hovey, *Movable Bridges*, 108; Hardesty, "The Broadway Bridge," 708.

[42] Conversations with Ed Wortman and John Muenchow proved essential in understanding these components. Hardesty, "The Broadway Bridge," 708; Hovey, *Movable Bridges*, 113; Muenchow to Norman, 6/18/1999, 2-3; Hardesty & Hanover Report, 6/7/2000, 4-5, 8; "Revisions on Hydraulic Buffer Cylinder, Valve-Head, and Plunger," Broadway Bridge Drawing C4159/R referenced to Drawings C4159/46 & 50, all at the Multnomah County, Bridge Maintenance and Engineering Office. The drawings for this bridge are incomplete and occasionally impossible to read; Strobel never provided the City or County with a full set of as built drawings.

Because the actual span is counterweight heavy, its actual center of gravity is not at the center of the Rall wheel trunnion as routinely stated in published descriptions, but somewhat closer to the counterweight end of the leaf.

system are slated for installation within the next few years.[43]

Perhaps because building the Broadway Bridge required changes in the patented Rall design such as the addition of anchor struts and the modification of operating strut positioning, the Broadway Bridge's Rall also behaves differently than published accounts would have us believe. According to the 1906 patents and to every published description of the Rall mechanism, the heel bearing (identified in Figure B as the "bridge seat"), a cast pintel type, takes all dead load plus the vertical component of the live load. Thanks to the heel casting, these accounts claim, when the bridge is seated, the Rall wheel is lifted free of its track and carries no load. Indeed, one account reports this feature as making the Rall easy to repair: "the rollers can be removed, for repairs or replacement, when the bridge is in its closed position, for they are relieved of all load." In actuality, though, the operating strut is in compression when the span is seated, forcing the Bridge onto the heel bearing, but leaving some dead and live load on the Rall wheel. The complexity and uncertainty of this load division disconcerts those seeking to quantify the Bridge's behavior, but poses no problem for its routine operation.[44]

The 1913 Broadway Bridge

I have already described important features of the Bridge in recounting its development and explaining its mechanism. What follows is a survey of its other salient aspects as of Opening Day, 1913. The Bridge extended from Seventh (Broadway) and Hoyt on the West side to Broadway and Larrabee on the East. Fixed Pennsylvania Petit truss spans of 297.213 feet flanked the central 278 foot bascule span. The Rall's roller track girders and operating machinery were supported in the long rivermost panel of these anchor spans. Thus, during a Bridge opening the weight of the bascule leaf was taken by the trusses of the anchor span and carried to its piers, obviating the need for two pairs of bascule piers or four-cornered pier bascule piers as was customary. Modjeski's 1908 bascule sketch had included the provision of a second set of bascule piers. He must have been pleased to be able to use the individual massive granite piers he strongly preferred, a preference that no doubt encouraged the innovative Rall placement. The

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[43] My conclusions about the novelty of the Broadway Bridge's anchor struts rest on an examination of the two 1906 Rall patents and of earlier designs described and illustrated in Hovey, *Movable Bridges,* 105-112 and Hool and Kinne, *Movable and Long-Span Steel Bridges,* 16-19. Muenchow to Norman, 6/18/1999, 2-3; Hardesty & Hanover Report, 6/7/2000, 4-5. Replacing the struts in their entirety also makes sense because several have become twisted over their years of operation.

[44] It is worth underscoring in this context that Strobel received the nod only fourteen months before the Bridge was completed. After the long court battles were resolved, there was strong pressure to complete the Bridge promptly. That Strobel's innovations were less than perfect is hardly surprising.

Again, I am indebted to Ed Wortman and John Muenchow for my understanding of the Bridge's actual behavior. Hovey, *Movable Bridges,* 108-110; Hool and Kinne, *Movable and Long-Span Steel Bridges,* 18; Hardesty, "The Broadway Bridge," 708; U. S. Patents numbers 12,570 and 817,516; Hardesty & Hanover Report, 6/7/2000, 9; "New Span Is Designed to Last 100 Years," 1, 4.

anchor spans also carried the operators' and gate tenders' houses on pedestals outside the trusses.[45]

The Bridge continued with a 285.989 foot Pennsylvania Petit span that carried the west end onto land, where an additional 269.785 foot Pennsylvania Petit span followed by a 125.4 foot Pratt truss span completed the through portion of the West approach over the rail terminal and tracks. The Bridge's West approach then turned and descended to Seventh Avenue (Broadway), supported by steel plate-girder, concrete, and retaining wall spans, a total distance of 914.7 feet. A 182.899 foot Pratt truss span carried the Bridge to its east abutment; retaining wall supported the shorter East approach for its remaining 342.53 feet. Total Bridge length from the center of Hoyt Street to the center of Larrabee Street came close to 3,000 feet. Modjeski's continuous effort to reduce demands on those using the Bridge resulted in final grades of 2.25 per cent on the anchor spans and 3.8 per cent on the remaining fixed through spans. As a result, Bridge clearance at the harbor lines was only 9 feet less than at the center where it rose 65 feet over high water and 93 feet over low.[46]

The Broadway Bridge differed from other downtown Portland bridges in having its piers rest on pneumatic caissons, a technique Modjeski preferred despite its somewhat greater cost. The caissons' cutting edges varied from 85.25 feet (Pier 4) to 32.64 feet (Pier 7) below low water. The westernmost of these piers (4) and the easternmost (7) had caissons 20 by 68 feet, topped by two reinforced concrete pedestals 50 feet apart (center to center) and 14 feet square. Reinforcing bar projected into a reinforced concrete coping and into the concrete-filled steel cylinders set atop the coping. The two 12 foot diameter steel cylinders were each capped by a 3 foot coping that ended 80 feet above low water. As discussed earlier, the bascule piers (5 and 6) were granite-faced concrete. They rested on caissons 33 by 90 feet and 50 feet high. The bascule piers were 10 feet wide under the belt course and 56 feet long between shoulder points. Their coping topped at 87 feet above low water. Piers 2 and 3, on the West approach, rested on timber

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[45] Ed Wortman helped me recognize the relationship between the Rall placement and the pier innovation. On span lengths see the discussion in the next footnote. Hardesty, "The Broadway Bridge," 708; Modjeski, *A Report to the Mayor*," Figure 3; Broadway Bridge Drawings, Bridge Engineering and Maintenance Office.

[46] All span length figures in the text are for horizontal distance except for the east retaining wall section, which is from the center of the east abutment to the center of Larrabee Street. From west to east the through truss span lengths center to center on pins are: 123' 7/8"; 267'; 282' 3/4"; 295' 2.5"; 278' 7/8"; 295' 2.5"; and 180' 3 7/8". I include both sets of figures because published accounts and consultants reports often mix the two sets of figures. My thanks to Cheryl Strubb, Engineer Technician Senior, Department of Environmental Services, Division of Transportation - Bridges, Multnomah County, for help in obtaining and understanding these figures. "Broadway Bridge: Location of Bearings," As Built Drawing Number 10, 1911, Microfilm Copy, and "Detail of Floor and Sidewalk," Broadway Bridge Drawing Number C4161/2A, Bridge Engineering and Maintenance Office; "Broadway Bridge Specifications," Superstructure; Hardesty, "The Broadway Bridge," 704-705; Hovey, *Movable Bridges*, 112-113; Gustav Lindenthal, Consulting Engineer, to Board of County Commissioners, 1/24/1927, Broadway Bridge 1920s Renovation Files, Yeon Records Center.

Modjeski's original sketch included only four Pennsylvania Petit fixed through truss spans; the two Pratt trusses were added later.

piles and were made up of concrete-filled steel cylinders like those used for piers 4 and 7. Pier 1, the plate girder span pedestals, and the approach retaining wall counterforts rested on driven reinforced concrete piles.[47]

As with other major river crossings of its era, the Broadway Bridge was built to carry relatively heavy loads. This was largely because bridges of the era carried street railway traffic. The Broadway Bridge brought this era to a close locally; it was the last Willamette River bridge built to carry streetcars. Its floor was designed to support on its two streetcar tracks continuous trains of 51.6-ton cars, each 51 feet 4 inches long. On its two roadways the floor could support a live load of a 24-ton truck, with 100 pounds per square foot on its remaining surface. The trusses were designed for a load of 2,000 pounds per linear foot of streetcar track, 1,000 pound per linear foot of roadway, and 90 pounds per square foot of sidewalk. They could also sustain a wind pressure of 30 pounds per square foot of exposed surface, a more important concern with bascules than with vertical lift or swing bridges. As Lindenthal's Resident Engineer noted in 1926, when plans for Broadway Bridge renovation required him to convey these data to Lindenthal, the live load requirements of early twentieth century bridges were impressive; they were heavier than those used for the three new Portland bridges whose completion Lindenthal had recently supervised.[48]

In fact, the trusses were strong enough that Lindenthal readily substituted concrete for the original wooden decks of the fixed truss spans as part of his 1927 Broadway Bridge work. When built, the fixed truss span had a floor of creosoted 8 by 8 inch ties supporting creosoted pavement of 4 by 4 by 8 inch wood blocks covered with paving pitch to fill the joints. A patent Shuman wood block flooring paved the bascule span. The bascule also had creosoted wood block sidewalks; reinforced concrete sidewalks served the rest of the Bridge.[49]

Two 75 horse power General Electric motors powered each leaf. The 600 volt motors running at 650 revolutions per minute activated gear trains, one for each operating strut, that multiplied the power roughly five times before the main pinion delivered it to the operating strut. Differential gearing equalized the torque delivered to each leaf's two operation struts. Lever-activated friction brakes with wood-block wearing surfaces could slow the machinery if necessary. Small machinery houses placed atop the river ends of the anchor spans afforded protection only to the electric motors; all other operating machinery remained outdoors, exposed to the weather. The operating machinery also included a capstan connected to shafting to supply

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[47] "Broadway Bridge Specifications," Substructure; Hardesty, "The Broadway Bridge," 704-705; Modjeski, Interstate Bridge Report, 9.

[48] Hardesty, "The Broadway Bridge," 705-706; Resident Engineer to Gustav Lindenthal, 4/7/1926, Broadway Bridge 1920s Renovations File; Wood, *Portland Bridge Book*, 16. Mass transit users made an unsuccessful rear guard effort to have trolley tracks place on the 1958 Morrison Bridge. Morrison Bridge Construction Files, Yeon Records Center.

[49] Resident Engineer to Lindenthal, 4/7/1926; Hardesty, "The Broadway Bridge," 705-706.

human power should the electricity fail, a provision often made at a time when electric motors remained relatively novel on bridges.[50]

When closed, the bascule leaves functioned as cantilevers. Two lock bolts and a 5 horse power motor and driving mechanism mounted under the channel end of the west leaf were controlled by the bridge operator. Once the bascule was seated, the operator shot the lock bolts which entered sockets mounted under the east leaf end. This assured a rigid connection between the closed leaves. Operators performed this and other functions from the primary operator's house, which stood on a steel pedestal on the downstream side of the west anchor span. It held an array of switches, controls, and indicators that permitted control of both leaves from a single location. A secondary operator's house mounted on a pedestal on the upstream side of the east anchor span permitted operation of the east leaf only. Gatekeepers' houses were mounted on similar pedestals on the upstream west and downstream east sides of the anchor spans.[51]

Building the Bridge

Union Bridge and Construction Co. of Kansas City, Missouri, won the Broadway Bridge substructure contract. Thomas Alexander served as Union's engineer in charge. The firm had come to Portland, probably at the behest of Kansas City-based Consulting Engineers, Waddell & Harrington, to construct the Steel Bridge substructure, one-quarter mile upstream from the Broadway Bridge site. Combined with their recently acquired familiarity with the deep sand underlain by gravel that formed the Willamette riverbed at the Bridge site, Union Bridge evidently brought more extensive experience with substructure technology than local firms possessed. The Railroad had already footed the bill to bring Union's men and equipment to Portland, although its Assistant General Manager alerted the company that tools and equipment used on the Broadway Bridge would not qualify for free transportation back to Kansas City.[52]

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[50] Hardesty, "The Broadway Bridge," 708; Hardesty & Hanover Report, 6/7/2000, 3; "Hand Machinery: Bearings, Shafting, Etc.," Broadway Bridge Drawing Number C4159/51, Bridge Engineering and Maintenance Office; Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Hawthorne Bridge," HAER No. OR-20 and Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Steel Bridge," HAER No. OR-21; "New Span Is Designed to Last 100 Years," 1. Unlike the nearby Steel Bridge's capstan which was supplied with wooden handles to be inserted when it was used, the Broadway Bridge's handles, since lost, were wrought steel. As was customary on bridges of the era, the system was also designed so that a single motor could power the bridge if one motor failed.

[51] Hardesty, "The Broadway Bridge," 708-709; Broadway Bridge Drawings, Bridge Maintenance and Repair Office.

[52] Hardesty, "The Broadway Bridge," 710; Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior "Steel Bridge," HAER No. OR-21; James G. Wilson to Assistant General Manager, 11/28/1911, O.R.& N. Letter Press Books, 1911-1912, Union Pacific Collection, Oregon Historical

The use of pneumatic caissons for the four river piers presented challenges, especially near the west shore (Pier 4) where low-lying areas had been filled, creating an especially thick layer of fine sand. The West river pier excavation had to go to 73 feet below the river bed, making the caisson immersion 101 feet and the pressure 44 pounds. At the time, the record depth for pneumatic caisson work was only 10 feet greater. As a precaution, Union used 2-hour shifts for its caisson workers. Although borings to a depth of 130 feet found nothing harder than gravel, some blasting was required in the cemented gravel near the east shore (Pier 7). The final contract cost of the substructure, $607,828, nonetheless showed that Modjeski's granite-clad bascule piers ate up a disproportionate share of the budget. Contract prices of $190,290.10 and $181,694.17 for piers 5 and 6 represented 61 per cent of substructure cost.[53]

The Pennsylvania Steel Co. of Steelton, Pennsylvania, fabricated and erected the superstructure. H. E. Trout served as engineer in charge. A long-established firm, Pennsylvania Steel had manufactured steel since 1867 and began bridge fabrication about 1891. Ironworkers assembled the bascule span in open position, 80 degrees from the horizontal, using a specially designed traveller that workers could anchor to the spans' top chords and then move as the work progressed. They poured the counterweights in stages as bascule leaf construction progressed, keeping the heel of the bascule leaf somewhat heavier than the channel end. In addition, braces of 16 by 16 inch timbers set between the pier tops and the undersides of the leaves helped hold the leaf in position. Most of the Shuman flooring was also attached while the leaves stood open. Two workmen positioned and nailed the wooden blocks to the subplanking as helpers working on the pier hoisted materials to them.[54]

The other truss spans used conventional falsework. A line of timber bents supported each truss on the dry land portions of the Bridge. For the anchor spans and span 3, just west of the west anchor span, workmen drove piles to create parallel lines of supporting bents for the trusses, then braced each parallel pair of bents together. The land bents consisted of four 10 by 12 or 12 by 12 inch posts, but the anchor spans generally required 13-pile bents and used 19-pile bents under panel points that would support the erection traveler when it lifted especially heavy loads.[55]

On the west side, proximity to rail lines allowed rail cars to deliver materials directly to a siding next to the Bridge site. A yard traveler as wide as the Bridge roadway traveled on rails atop the two lines of girders to deliver material to the erection traveler. The yard traveler operator stored material temporarily on the deck of the west viaduct, where an 18-foot space

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[53] Hardesty, "The Broadway Bridge," 704-705.

[54] Hardesty, "The Broadway Bridge," 709-710; Victor Darnell, *Directory of American Bridge Building Companies, 1840-1900* (Washington, DC: Society for Industrial Archeology, 1985), 70.

[55] Hardesty, "The Broadway Bridge," 709-710.

under the traveler left ample room. The yard traveler had a 25-ton capacity front boom and a 10-ton capacity rear boom. Specially built four-wheeled cars ran on standard-gauge track along the upstream side of the Bridge to deliver material to channelside. Lines running over sheave blocks to a hoisting engine on the erection traveller powered the cars.[56]

The erection traveler was a square mule type (a two-boom gantry). Its steel-cable front booms had capacities of 25 tons and 15 tons; the larger boom reaching up to 60 feet. A 10-ton rear boom operated using manila rope. The erection traveler was thus capable of handling the Bridge's heaviest members, 26 steel pieces comprising parts of the bascule and anchor spans, weighing from 27 to 40 tons each. Ironworkers simply moved the traveler to the east side when they began work on the eastern spans. Instead of using a yard traveler, though, material for the east anchor span and bascule was hoisted directly from barges in the river.[57]

Pennsylvania Steel began preliminary work for erection slightly more than a year before the Bridge stood open to vehicular and pedestrian traffic. The city's only substantial complaint with their work involved defective wood block paving, a problem that Pennsylvania Steel acknowledged and worked to rectify the following year. Responsibility for completing streetcar tracks across the Bridge lay outside Pennsylvania's contract. Conflict between the City and the local traction monopoly, the Portland Railway, Light & Power Company, fueled by the Progressive politics that had originally helped delay the Bridge, also delayed installation of rail tracks. The issue involved a change in the required gauge of track. Within a few months, commuters from the City's northeast section finally rode along the new, substantially shorter streetcar route.[58]

The Bridge Since 1913

Immediately after the Bridge opened, the City of Portland complied with a new State mandate and turned Bridge maintenance and operation over to Multnomah County. Thus, most subsequent changes in the Bridge have followed County decisions, although the City's continued responsibility for traffic and mass transit operations has given it continued influence. State inspections and the State's role as a conduit for Federal regulations and funds have also influenced decisions as have direct Federal mandates associated with navigation in particular. In

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[56] Hardesty, "The Broadway Bridge," 709.

[57] Hardesty, "The Broadway Bridge," 709-710.

[58] Hardesty, "The Broadway Bridge," 710; "Compromise Offer for Repairing Span Is Not Acceptable," *Oregon Journal*, 3/25/1914, 2; "Means 5 Months' Delay to Cars on Broadway Bridge," *Oregon Journal*, 4/17/1913, 1, 17; Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Hawthorne Bridge," HAER No. OR-20 and Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior "Steel Bridge," HAER No. OR-21.

what follows, I simplify these issues by talking in terms of County activities. In the interest of time and space I will also necessarily reduce an extraordinarily rich and well-documented story to a brief sketch.[59]

The major modification of the Broadway Bridge took place in 1927 under Gustav Lindenthal. The nationally distinguished engineer originally came to Portland to complete the Burnside, Ross Island, and Sellwood Bridges. Most Portlanders agreed that the City also needed a new North bridge. But a proposed new bridge from Twentieth Street on the west to Interstate Avenue on the east met defeat at the polls in 1926. The Broadway Bridge, whose heavy traffic had signaled the need for another bridge, also ironically helped defeat a new North bridge. As originally feared by its opponents, the Broadway Bridge had "caused the greatest shifting of land values and business ever seen in a city Portland's size in a short time." Equally important, components of the change were unanticipated, especially the north-south widening of the West side retail core. Thus, although most agreed that North Portlanders lacked adequate routes across the Willamette, fights over a new bridge's location not only defeated the 1926 proposal, but postponed its realization until 1973 when the Fremont Bridge completed downtown freeway connections. Because the Fremont is part of the limited-access, Interstate Highway system, the demand for its construction combined with the built-in constraints on its capacity to alter local traffic flow and overcame opposition to a new North bridge that originated in the City's Broadway Bridge experience.[60]

Lindenthal was clearly dismayed when voters defeated the 1926 bond issue for a new bridge he had expected to design. "In view of the already prevailing congestion of the downtown streets," he saw no reason "to congest these streets further by feeding still more traffic through them, to and from existing bridges. The better policy would be to carry not only additional traffic in the years to come, but also part of the present traffic away from the congested district and over a new bridge." His correspondence shows Lindenthal much less at ease with the realities of bridge politics than was Modjeski. He reluctantly undertook modifications of the Broadway Bridge to better suit it to heavy traffic. Working with a limited ($750,000) budget, he chose to replace the existing wooden decks of the fixed truss spans with concrete decks rather

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[59] "Bridge Accepted by County Court," *Oregon Journal*, 4/22/1913, 4.

[60] Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior, "Morrison Bridge," HAER No. OR-100 and Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior "Burnside Bridge," HAER No. OR-101; MacColl, *Shaping of a City*, 15; Gustav Lindenthal to Board of County Commissioners, 2/5/1927, Broadway Bridge 1920s Renovation Files, Yeon Records Center; Abbott, Portland, 99-100; Wood, *Portland Bridge Book*, 7-12. Indeed, Portland has been reluctant to build any downtown bridges at new sites since the Broadway Bridge experience. The sole exception before the two limited-access Interstate Highway Bridges was the Ross Island where, arguably, local topography guaranteed that new approaches would not become major commercial avenues.

than to modify the Bridge to carry five or six lanes of traffic.[61]

Lindenthal recognized that existing approach streets and ramps could not deliver a steady stream of traffic to the Bridge. As a result, the Bridge carried less traffic on its existing four lanes than it might have. He explained to the County Commissioners that new approaches offered a cheaper and better way to increase Bridge traffic. Lindenthal's most visible alteration of the Bridge was his addition of a new ramp, the Lovejoy viaduct, that carried traffic to and from an additional west side location, Tenth and Lovejoy Streets. To permit this modification, the westernmost truss span was removed. A box girder span replaced the Pratt truss, creating a wider roadway to handle traffic merging from the two ramps. Lindenthal also widened the retaining wall section at the entrance of the original Broadway ramp to smooth traffic feeding onto and off of the ramp. All spans but the bascule got new rails along with new concrete decks and the bascule span got a new timber deck. New light fixtures were added and new fire protection devices installed. Subways and safety islands to serve pedestrians completed the modifications. The major component of this system, the Lovejoy viaduct, arguably the only Portland bridge fully designed by Lindenthal, was demolished by the City of Portland during the 1999 HAER-ODOT study of Portland bridges. Despite repeated requests by the project's two full-time historians, no attempt was made to document this important structure in drawings or photographs.[62]

Lindenthal also proposed redesign of the East approaches to speed traffic, but costs and concern among East side real estate interests eventually limited changes to widening the East side approach streets. Reconfiguration of the East approaches waited until 1951, when it took into account a proposed East bank freeway.[63]

An open steel grating finally replaced the wooden deck of the bascule span in 1948. Over the years, numerous other repaving jobs have resurfaced both roadways and sidewalks; no original flooring remains on the Bridge.[64]

The Broadway Bridge has been painted a number of times. Its original shop coat was

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[61] Lindenthal to Board of County Commissioners, 1/24/1927 and 2/5/1927, Broadway Bridge 1920s Renovation Files, Yeon Records Center. The added lanes were to come by eliminating one sidewalk, but Lindenthal concluded that the trusses would be overstressed by the combined addition of concrete decks and additional traffic lanes.

[62] Broadway Bridge 1920s Renovation Files, Yeon Records Center. The Multnomah County portion of the Lovejoy viaduct ended at Ninth Street; the City completed it to Tenth.

[63] Broadway Bridge 1920s Renovation Files, Yeon Records Center; 1951 Broadway Bridge East Approach Drawings at Bridge Engineering and Maintenance Office.

[64] 1948 Steel Deck and other Broadway Bridge Paving Files, Yeon Records Center. See Historic American Engineering Record (HAER), National Park Service, U. S. Department of the Interior "Hawthorne Bridge," HAER No. OR-20 for a fuller discussion of the slightly earlier replacement of the Hawthorne movable span's wooden deck with steel grating.

specified as one or two coats of Detroit Graphite Marine Brown #501 followed by a heavy coat of red lead in linseed oil. Its next documented paint job occurred in 1949 and included a priming and intermediate coat meeting United States Maritime Specifications 52-MC-29 for Metal Primer, followed by a finish coat of Graphite-Synthetic Black Finish. A 1963 paint contract carried out a recently devised scheme to add color and diversity to Portland bridges. The Broadway Bridge, abutting the red roof tiles of Portland's Union Station, was chosen to be painted red, including roadbed, trusses, railings, operators' houses, and south pedestrian stairs. Piers and the west approach remained black. The most recent paint job took place in 1978-1979. It retained the red and black color division, but required that all bare metal receive three coats of basic lead silico-chromate primer, that red lead sealer be used to fill all cracks and crevices, and that the finish coat, "Broadway Bridge Red," for most of the structure include an array of pigments and vehicles specified in a page-long document. This paint job eventuated both in damage to one of the Rall wheels and in a lawsuit.[65]

When Modjeski speculated about the Bridge's expected longevity, he noted that its electrification was novel enough that it might shorten the structure's life. It is not surprising, then, that many changes have been necessary to modernize the Bridge's early electrical system and the structures that housed it. Essentially only its original electric motors remain. New lighting and wiring was installed on the Bridge and ramps in 1958. In 1961 the original gatehouses and operators' houses were demolished and the steel pedestals supporting the gatehouses were removed. New operators' houses replaced the original structures at the northwest and southeast locations. Automatic traffic control gates were installed in 1972. In 1976, because the local electric company would no longer supply DC current, the County installed silicon power rectifiers and related AC/DC conversion equipment on the Bridge. In 1977, the County replaced the original electrical control equipment including drum controllers, relay and switchgear panels, and resistor banks in the machinery houses and operators' houses. In 1979, new hydraulic centerlocks replaced the original spanlocks. Over the years, the original submarine cables carrying power to the bridge have also been replaced on several occasions.[66]

It remains uncertain when the original small machinery houses were replaced by the present ones, which afford protection to the shafting and gearing as well as to the motors. The enlarged machinery houses include "windows" through which the operating struts travel. A request for an estimate to replace the original wooden machinery houses with sheet metal structures appears in Lindenthal's correspondence, but the item is not listed in work performed. By the late twentieth century, the machine room interior was even more colorful than the bridge.

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[65] Original Broadway Bridge Drawings at Bridge Engineering and Maintenance Office; Broadway Bridge Painting Contract Awarded 3/24/49, Broadway Bridge Files, Yeon Records Center; 1963 Painting Contract and Associated Documents in Broadway Bridge Files, Yeon Records Center; Broadway Bridge Maintenance Painting, 1978-1979, Broadway Bridge Files, Yeon Records Center.

[66] "New Span Is Designed to Last 100 Years," 1. Documents associated with these various jobs are filed in chronological order in the Broadway Bridge Files, Yeon Records Center.

Bright red, yellow, white, and black paint made various operating and safety components stand out from one another. The operating struts had also been painted bright white.[67]

As early as 1928, Gustav Lindenthal evidently saw reason to encourage a careful examination of the Rall mechanism. The many studies of its components over the last two decades have identified a number of deformations and piecemeal repairs that suggest problems over the years, although the first documented repair was replacement of the anchor strut bushings in 1970. Thereafter, two major events have dominated the Rall's repair history: a 1978 crack in one Rall wheel caused by a poorly executed painting contract and a planned 1990 major mechanical overhaul that had to be jettisoned when the contractor proved ill-prepared to carry out the work.[68]

In 1978, the maintenance painting contractor allowed sand to build up on the northwest Rall wheel track. The Rall wheel ended up operating when out of alignment and span weight was taken on its guide flange. The result was a 9-foot crack on the wheel face running parallel to the face and a broken inner guide flange. When in-house attempts at a weld repair proved unsuccessful, the County turned to MEI-Charlton, a local firm specializing in the relatively new study of fractures and in metallurgical diagnosis and repair. Various tests showed that the Rall wheel's steel conformed to the original specifications, containing .42 per cent carbon, 1.44 per cent nickel, and .53 per cent chromium. It also possessed the high tensile strength crucial to its function, but, as a trade-off, had reduced ductility. To weld a large cast steel piece with these characteristics required extreme care in heating and cooling to prevent further cracking through differential cooling and/or differential changes in volume associated with the transformation of some steel to martensite, the hard constituent of heat-treated steel. By following MEI's detailed prescription for welding, the County managed a more successful repair, but additional cracking eventually required the installation of bolts running through the roller to provide structural support. This repair was performed in 1983.[69]

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[67] Broadway Bridge 1920s Renovation Files, Yeon Records Center; 1999 Bridge Tours.

[68] "Broadway Bridge's Bascule Machinery to Be Overhauled," *Oregon Journal*, 10/5/1927, 1; as is too often the case this headline and story misstates the technological case. The recommendation was for an examination to determine whether "there has been any considerable wear and tear on it," rather than for an overhaul. I found no report indicating that the examination took place, perhaps because its findings showed little to report. Discussions with John Muenchow and the anchor strut bearing specifications from the 1970 Notice to Contractors provided documentary evidence of repairs as early as 1970 and testimony that physical evidence shows other, in-house repairs for which documents supply no date. The 1978 paint job and the 1990 mechanical repair work both resulted in lawsuits with the usual extensive documentary evidence that lawyers are so good at providing for historians to examine. My characterization of the work performed in each case represents my professional assessment as a historian of technology who has examined the entire body of documentary evidence.

[69] John Muenchow helped clarify details of the work performed in 1983 and described more generally in "Notice to Contractors: Broadway Bridge Mechanical Repairs - Mechanical and Structural," Project No. 952-R, 1982. On the genesis, analysis, and repair of the crack see especially Kenneth H. Wheatley, Structural Engineer, Multnomah County, to File, Re: "Broadway Bridge Maintenance Painting, Proj. 873R, Contract 3099-R-78,"

In 1981, prior to its structural repair, county personnel noted excessive drag at the northwest Rall wheel, causing the bridge to walk itself downstream as it was being operated. By applying braking on the southwest side, maintenance and operating personnel could walk the bridge back into normal position, but the problem temporarily doubled the time needed to operate the bridge and placed its mechanism at risk. Several actions taken immediately and in 1983 helped solve the problem. The damaged safety flange that no longer provided guidance was repaired; the bearings were thoroughly lubricated, a maintenance procedure workers had evidently neglected in the bridge's earlier years because they lacked understanding of the wheel's unusual lubrication provisions; and all four control struts were completely replaced, including their shafts (pins), shaft journals, and all bushings, eliminating bad bearings that had adversely affected roller operation. Rall wheel tracking problems continue, especially at the southeast roller, but since they are no longer major, study of the situation will await repair of other Rall mechanical components that may be contributing, especially the anchor struts.[70]

As noted earlier, the anchor struts have been the system's weakest component and are slated for replacement. In addition to their 1970 bushing replacement, in the early 1980s bars were welded on the fixed span sides of the anchor struts in an attempt to guide strut movement and limit deformation. Continued problems with the anchor struts as well as evidence that the operating struts and span drive machinery needed repairs prompted plans for a major mechanical overhaul in 1990. Stafford Engineering acted as a consultant to the county in designing replacements for some of the system's original components including its anchor strut guide wheels and operating strut pin connection. The county made a less felicitous choice when it came to select its contractor, Lorentz Bruun Company, a local firm with little of the specialized experience to prepare it for work on a unique historic mechanism. A litany of complaints and

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9/1/1978; MEI-Charlton, Inc., "Investigation of Service Fracture in Cast Steel Roller, Broadway Bridge: Increment I, III, and IV - Progress Reports" and "Recommendations for Repair Welds - Broadway Bridge"; File, "Broadway Bridge Cast Steel Roller Repair," 10/19/1978. Archeo-metallurgist Robert B. Gordon of Yale University kindly reviewed data from the study of the Rall wheel and enhanced my understanding of the issues involved in its repair.

[70] The procedure used to walk the leaf is fascinating and deserves to be detailed here: "We moved the west leaf of the Broadway Bridge 3/4" to the south. This placed the structure and its components in line with the east leaf and makes the west leaf run centered on the tracks. First Templex Industries Inc. designed us a heavy duty - extremely high pressure grease to place under the bull wheels of the westerly leaf. We greased the tracks and wheels on the west leaf and began out lifts. We left the downstream brake released and set the upstream brake. This placed drag on the upstream side of the structure and caused the leaf to pivot on its axis. The first few lifts we didn't gain much because we used the one and two positions on the controls. This cause the bank of armature shunt resistors to over heat. After we let them cool down we used position number four which gave us the use of the speed resistors. By alternating between position number two and four we were able to control our heat problem and move the structure 3/16" to the south on each opening." Bart Bonney, Multnomah County Bridge Maintenance, 5/31/1981. For the rest of the story see especially, Ken Wheatley to Tor Lyshaug and Bart Bonney, Re: Broadway Bridge Draw Span, 9/3/1981; Hardesty & Hanover Report, 6/7/2000, 9. Again, my thanks to John Muenchow for clarifying parts of the story.

conflicts punctuates the documentary record of Bruun's interaction with the County. Leaving aside details of a story that goes well beyond what this report permits, it suffices to say that the County terminated the relationship after Bruun completed only one component of the work: rehabilitation of the West span drive machinery, including substitution of bronze bushings for the original babbitt metal bushings which had been poured in place and hand-finished to fit the shafts. Since that time, the County attempted to solve the anchor strut problem by replacing the worn guide wheels with new guide wheel, including new pins and bushings. Less than six months later, County engineering personnel found tilting and deformation had already reappeared in the wheels. A forthcoming mechanical repair will include anchor struts with redesigned guide wheels and tracks and, probably, an additional guide system to limit the strut's lateral movement. Although Hardesty & Hanover and Multnomah County are still at work on the design, it is clear that the hasty design of the original 1913 anchor struts left them too flawed to permit their replication.[71]

Forthcoming work will also complete other unfinished portions of the failed 1990 mechanical repair contract, albeit with designs that have benefitted from subsequent opportunities to review them. New components will replace worn operating strut bearings at the struts' movable span ends as well as the guide wheels on the racks at their pinion ends. The East span drive machinery will undergo bearing work roughly comparable to that performed in the West machinery house in 1990. The hydraulic centerlock, installed in 1979, will be replaced by an electrical/mechanical system more akin to the original centerlocks; the hydraulic system is underpowered, necessitating excessive clearances between the lock components so that heavy traffic now causes vertical displacement between the leaves. The current timetable anticipates that this work will commence in 2001.[72]

Conclusion

More modest than Waddell & Harrington who had proclaimed their first Portland bridge would be "permanent," only a few years earlier, Ralph Modjeski settled for one hundred years when explaining to a newspaper reporter how long the Broadway Bridge was designed to last. But he added, "I can not tell you how long the bridge will stand in good condition, I cannot even estimate what its life will be with certainty. All I can say is that I hope, I might put it, I expect,

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[71] Muenchow to Norman, 6/18/1999; Hardesty & Hanover Report, 7/2/2000; 1990 Broadway Bridge Mechanical Repairs and Lawsuits Files. Discussions with John Muenchow, once again, clarified these issues. Replacement of the babbitt metal bushings was necessary because the technology and skills needed to install molten babbitt bushings no longer exist. Babbitt metal is an alloy of tin, copper, and antimony.

The story of the failed 1990 mechanical repairs is worth recording because it illustrates many of the reasons why owners of historic movable bridges need to make sure that contractors are prepared for work on such structures.

[72] John Muenchow to Stan Ghezzi, Ed Wortman and Ian Cannon, Re: Broadway Bridge Mechanical Renovations Phases 1 &3, 7/20/2000; Muenchow to Norman, 6/18/1999; Hardesty & Hanover Report, 7/7/2000.

that it will still be serviceable, practically as good then as now, at the end of a hundred years." Modjeski was enough of a student of history to foresee many reasons why the bridge might be replaced sooner.[73]

At the same time, like other engineers who helped create a generation of massive steel bridges that were built to last, Modjeski was pleased with his handiwork. "Two ordinary railroad freight trains could cross it at a time without straining it," he noted, "although being a highway bridge, of course, it is not designed for the greater concentrated weight of the heaviest locomotives." The years since 1913 have certainly revealed weaknesses in the bridge: its primitive electrical system, its wooden decks, its inadequate approaches, and the hastily designed components of its mechanism. Nonetheless, I come away from my time with Modjeski's Rall impressed by the capacity of this massive early twentieth century structure to survive and serve despite its flaws. This may be the most important lesson it has to teach us.[74]

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[73] "New Span Designed to Last 100 Years," 1-4.

[74] "New Span Designed to Last 100 Years," 4.

I have acknowledged the assistance of a number of individuals above. Here I take the opportunity to express my gratitude to the many employees of the Multnomah County Department of Environmental Services, Division of Transportation who helped make my work possible. Some of them I can mention by name, notably Ed Wortman, whose patience and clarity of thought continually amaze me; John Muenchow, whose intimate acquaintance with the Broadway Bridge made work on it especially rewarding; Cheryl Strubb, whose enthusiasm for the historic drawings and their preservation and use is a delight; and Mary Hardy, whose genuine commitment to this project and remarkably generous spirit have been an inspiration. But many of those who helped me never told me their names as we chatted while waiting for the xerox machine, smiled when we passed in the halls, or greeting one another when I visited bridges and maintenance facilities. That a bridge such as the Broadway Bridge survives offers mute testimony to work of these and other Multnomah County employees. I feel fortunate to have spent time among them.

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Figure A: **Broadway Bridge Rall Bascule, Open**
(From John Muenchow to James Norman, Oregon Department of Transportation, Re: Broadway Bridge Mechanical Rehabilitation Project No. T5036, 6/18/1999

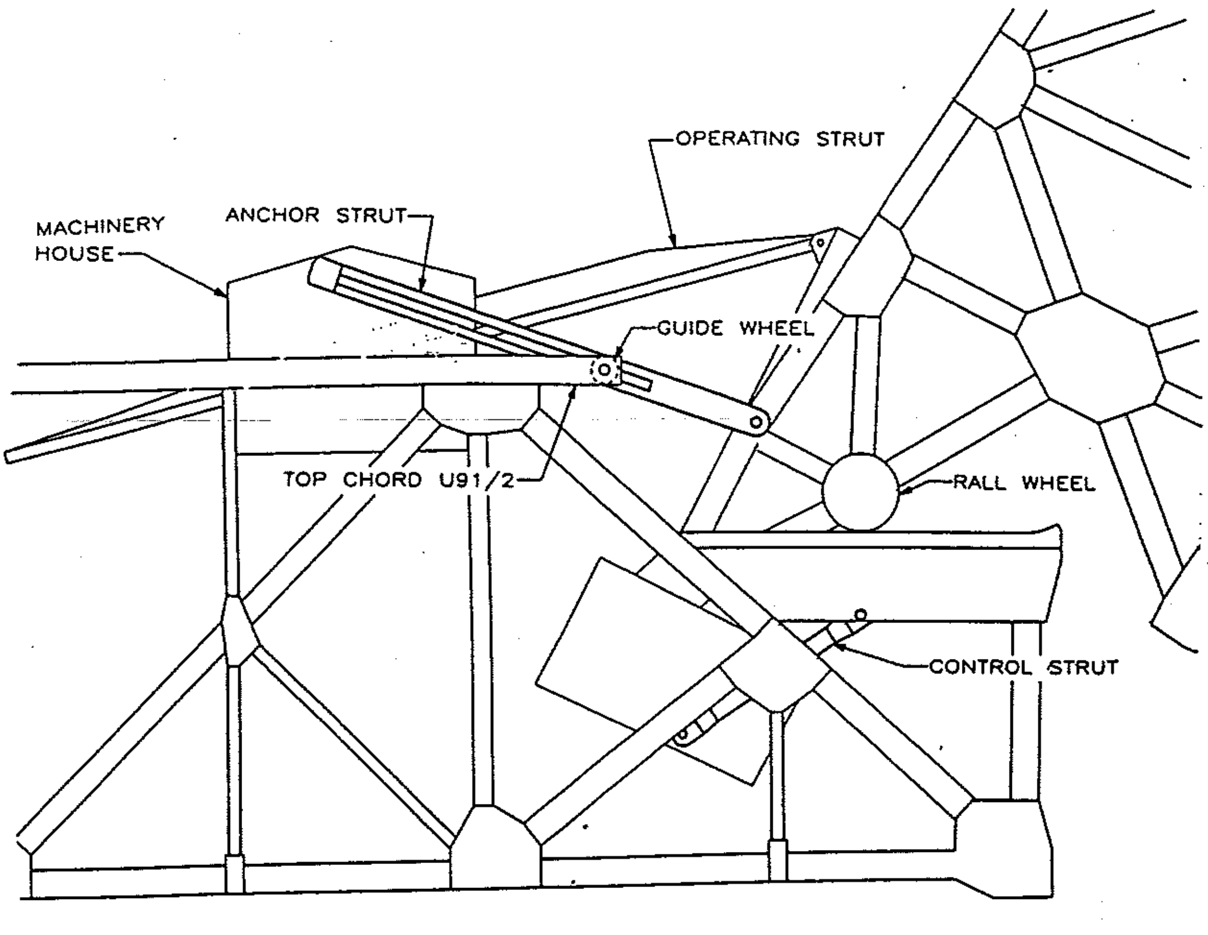

Figure B: **Broadway Bridge Rail Bascule, Closed**
(From Hardesty & Hanover in Conjunction with CH2M Hill for Multnomah County, "Development Study Report: Broadway Bridge, Portland, Oregon." 6/7/2000