HMS HEAVY MOVABLE STRUCTURES, INC.

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Holiday Inn Surfside
Clearwater Beach, Florida

SESSION WORKSHOP PRESENTATIONS

"REMEMBER THE PAST TO INSPIRE THE FUTURE"

by JOHN A. SCHULTZ, Jr., S.E.
Hazelet & Erdal, Inc.

REMEMBER THE PAST
TO
INSPIRE THE FUTURE

Historic Development of Movable Bridges

Prepared for
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Definition

A movable bridge includes any bridge that is designed to carry pedestrians, cattle, horse drawn wagons, railroad trains, and/or vehicular traffic over a body of water, that has a portion or span in it that can be changed in position by being moved horizontally, vertically, by rotation, or by any combination of these to open a clear channel or to provide more underclearance for the passage of a boat in a navigational waterway.

Preface

This presentation is the initial collection of historic data obtained, which pertains to the development of Movable Bridges. The author admits that this material only represents a small portion of the historic data that should be recognized and recorded. The accuracy is not guaranteed since a large amount of it is related by a great variety of authors. Any correction of inaccuracies, along with substantiating backup would be appreciated. Equally important is the submission to the author of additional data that has not been covered, along with backup material and any pertinent pictures and/or 2"x 2" slides that are available.

A bibliography of all referenced material and its sources, is being kept up to date and will be printed at a later updating of the History.

Acknowledgements

My presentation has been accomplished for this Symposium only because of the patience and understanding of our secretary, Ms. Mary Ericksen who typed these pages over and over again, making my additions, insertions, rewordings, corrections, etc.

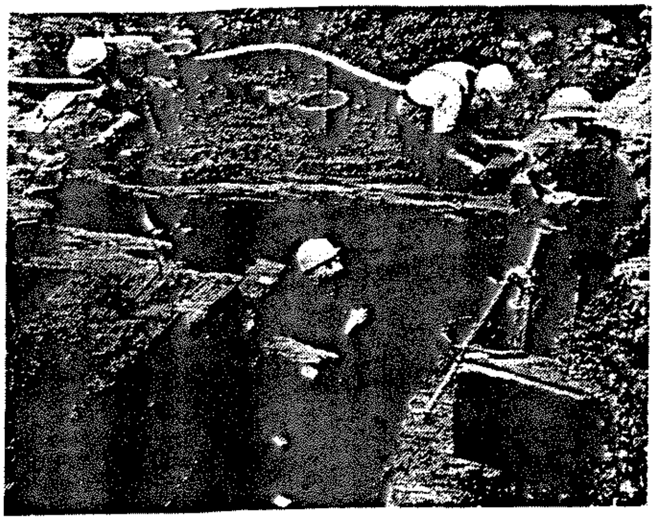
I am also indebted to Mr. Michael Harris, our ingenious electronic medium presenter, who made the sketches of the many types of movable bridges herein.

"REMEMBER THE PAST TO INSPIRE THE FUTURE"

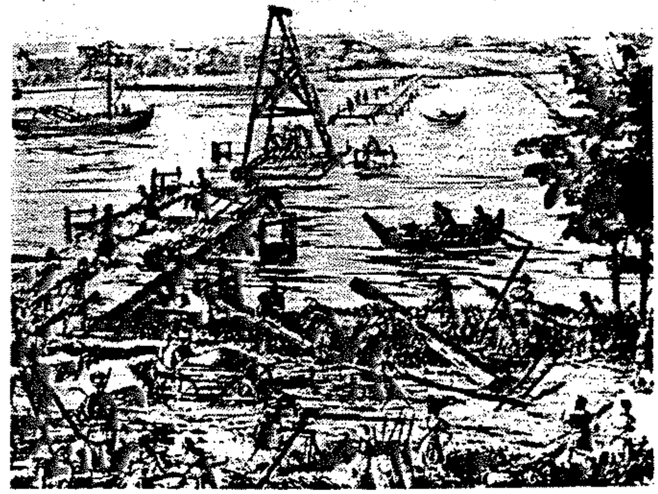
Historic Development of Movable Bridges

By John A. Schultz, Jr. S.E. (Illinois)

1355 B.C. in Egypt	*In an article on draw bridges, in the "American Mechanical Dictionary," Boston,1884, Edward H. Knight states that, "the earliest mention is in the Egyptian monuments, when Rameses II celebrated his victories over fortified cities, 1355 B.C. ...The sepulchral and palatial paintings represent the bridges as crossing the moats around castles and fortified towns." Also, "the Egyptians built no permanent bridges across the Nile River, but were familiar with framing trestle work and pontoon draw bridges."*
621 B.C. in Rome	*The Romans built pontoon bridges to carry their roadway systems across rivers. One portion could be removed to allow one of their boats to pass or to prevent others from using the bridge. It is a matter of debate whether the earliest movable bridges were intended for military protection or to allow the passage of boats. "The earliest Roman bridge of which we have a record is the Pons Sublicius, built in 621 B.C. by Ancus Martius. It connected the Janiculum and Mons Aventinus. As indicated by its name, it was a pile bridge and some writers state that it had a draw span."*
460 B.C. in Babylon	*"About this time, Nitocris, Queen of Babylon, built a bridge across the Euphrates, after temporarily diverting the water. According to Herodotus, the piers were of stone blocks bound together with iron and lead, and the spans were wooden platforms built so that they could be withdrawn at night, to prevent people passing from side to side of the river."*
Circa 60 A.D.	*In 1992, archeologists believed they had discovered one of the foundations of the bridge across the River Thames in London, (circa 60 A.D.), a crossing thought to be 900' long, built by Roman legionnaires to extend their empire throughout the British Isles. They say "the find", a waterlogged crib of oak beams, is probably a pier footing dating back to about 60 A.D. The ancient bridge was adjacent to wharves and a sizeable commercial development that had been built at about the same time.*



Timber crib believed to be footing for . . .

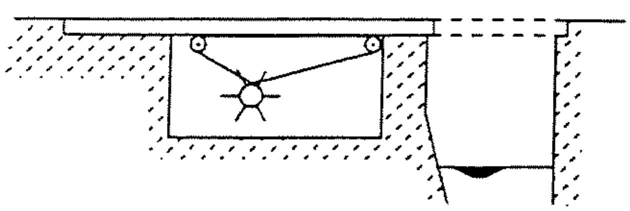


Roman bridge over the Thames in London.

Feudal Period — *Lift bridges were built across castle moats to provide access and then raised to close the opening in the wall to prevent access. These bridges were pivoted at one end and lifted by manual power thru ropes or chains. They were not counterbalanced so that the force required to lift the bridges was large but reduced as the span was opened.*

1189 — *Late in the twelfth (12th) century, bridge building was stimulated by the organization of the "FRATRES PONTIFICES," or "Brethren of the Bridge" by Johannes Benedictus. This brotherhood was formerly recognized by Pope Clement III in 1189. The founder commonly known as St. Benezet, has been termed the "Patron Saint of Bridge Engineers". He built the fixed arch bridge at Avignon, which was finished in 1176, and at his death, in 1222, was interred in a chapel which he had provided on the bridge.*

Circa 1350 — *As part of fortifications, rolling retractable bridges were commonly used, particularly in the southern provinces of France and Italy.*

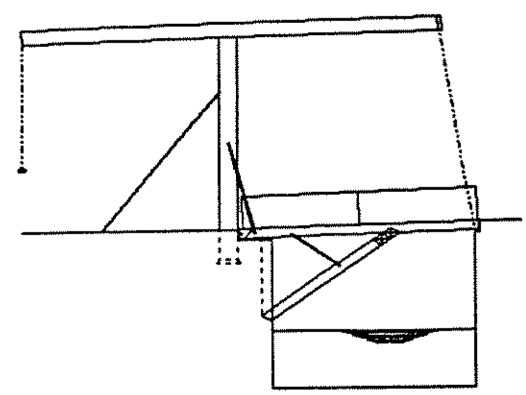


ROLLING RETRACTABLE BRIDGE

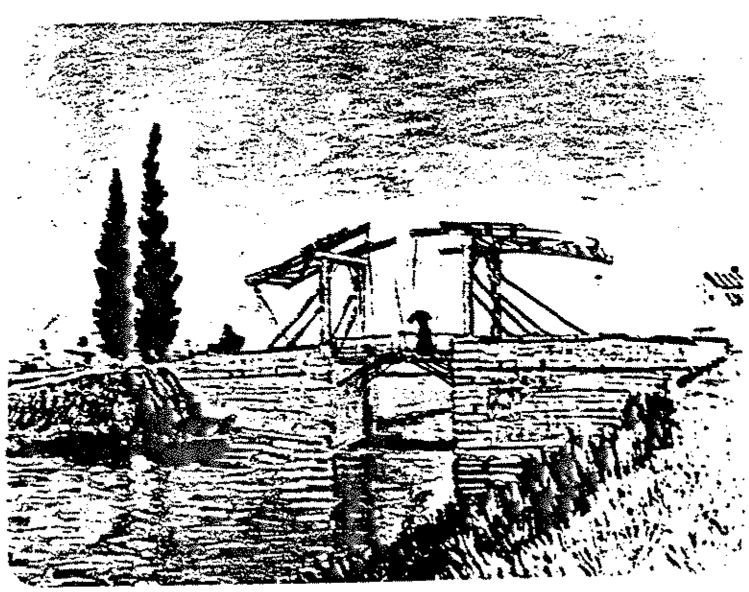
The Renaissance

Circa 1380 through 1550 *Leonardo da Vinci, one of the most remarkable men of that time, was a diversified genius whose writings and sketches included movable bridges. A sketch made about 1500 represented unequal-armed or bob-tailed, center bearing swing bridge, operated by hand winches, by means of ropes passed through snatch blocks. Another sketch represents a very well-conceived pontoon swing span, which enters a niche in the canal wall when opened. Some rough, small sketches show that he had also developed the general ideas of counterweighted draw bridges turning on end trunnions and also counterweighted vertical-lift bridges.*

Holland *Hollanders developed the first movable bridges over navigable streams and canals. They were also the first to balance their bridges, so that constant but small force was required to open the bridge. The force needed was essential to overcome friction. They were usually operated manually.*



EARLY DESIGN WITHOUT COUNTERWEIGHT

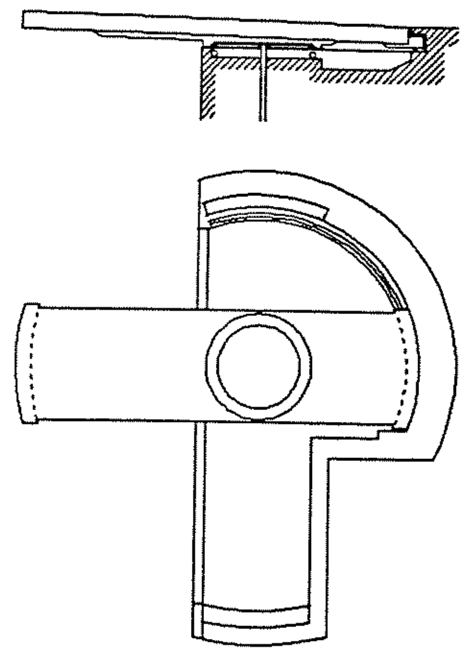


THE BRIDGE OF LANGLOIS, VINCENT VAN GOGH

Prior to 1625	*The earliest swing bridges were center bearing wooden structures. The centers were usually made of cast iron and in some cases were fitted with "steel" discs.*

Circa 1625

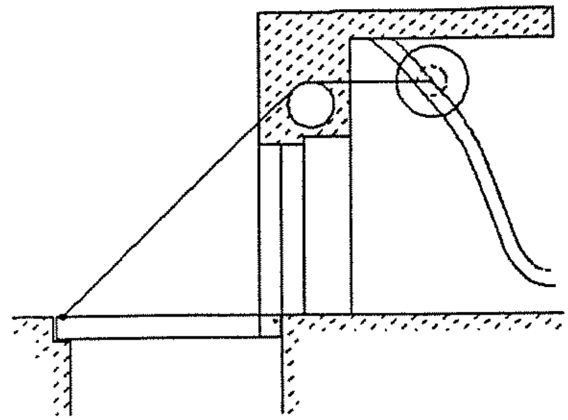
An article found in "La Science des Ingenieurs" described a double-swing bridge at Cherbourg during the early 17th century. It stated that "of all the swing spans which have come to my attention, none is more perfect than that for the large lock at Cherbourg". This bridge was designed by M. Salomon de Caux, the eminent engineer and architect, "Royal Engineer-in-Chief" after his return to France. It was built about 1625. The bridge provided a clear waterway of 42.65 feet, roadway width of 12.5 feet, the length of the long arms was 27.6 feet and that of the short arms was 15.4 feet. The two swing spans were center bearing, with balance wheels on a 10 foot radius.



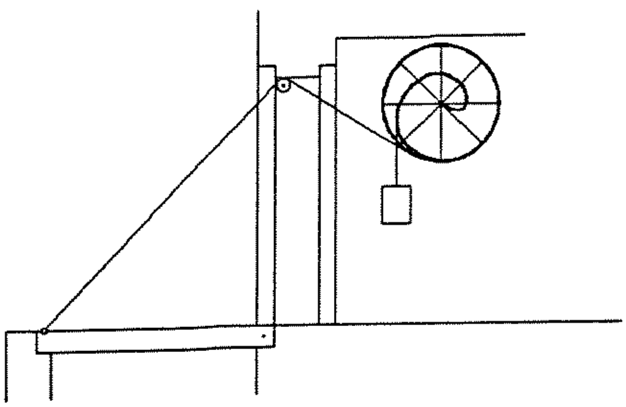
RIM BEARING SWING -- ½ OF DOUBLE-SWING -- AT CHERBOURG

Circa 1800	*Early 1800 English engineers built several rim-bearing bridges. These were mostly double-swing spans, meeting at the middle of the channel. The arms were unequal length, the shorter shore ends being counterweighted.*

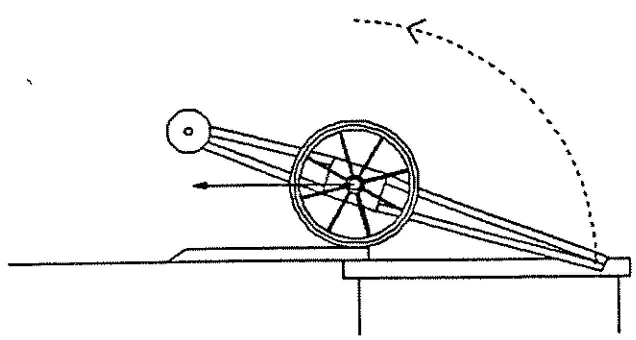
1816 *A Frenchman named M. Belidor was the first to compensate the counterbalances as the lifting bridge opened.*



Early 1800's *Captain Derche provided compensating counterbalance using the radius of the spiral (moment arm of counterweight) which decreased as the span was operated to compensate for the decreasing moment arm of the leaf.*



1825 *A wheel bridge was designed by Colonel Bergére. The lift span is a simple span for dead load and live load. A varying portion of the dead load is carried by the wheel during operation. Manual movement downward of the shaft on the left would cause the wheel to roll to the left and lift the bridge. When fully open, the shaft would rest on the ground because there is no dead load from the lift span in the vertical position.*



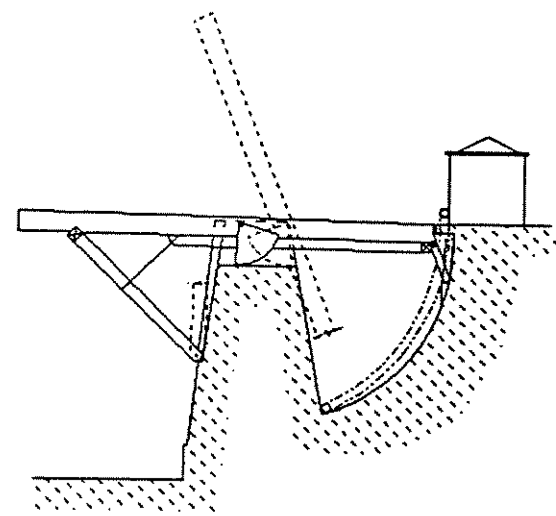
WHEEL BRIDGE 1825

Circa 1825

All of the types of Movable Bridges that had been developed obstructed the needed "tow path" along the sides of the canals. According to M. Gauthey's "Treatise", M. Lamblardie designed a double leaf bascule type bridge that rolled back away from the canal wall to provide space for a "tow path" in front of the open leafs.

The counterweight (not shown) between the girders was a rigid part of the moving leaf. If the center of gravity of the entire moving leaf was at the center of the circular arc on which it rolled, the leaf would be in balance in all positions of roll.

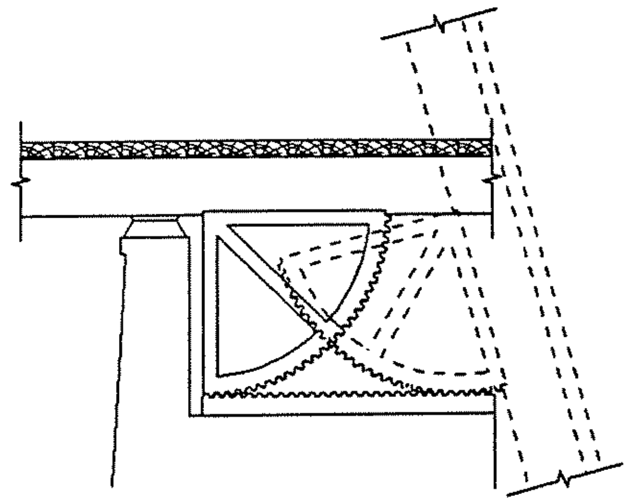
A short strut acted as a rear lock and prevented the leaf from rotating open under live load. A compression strut supported the live load on the cantilever arm over the canal. In the fully closed position, the arc was made thicker to carry the rolling dead load plus the live load. The bridge was operated by turning a winch by the house after pulling the rear lock out of the way.



FIRST ROLLING LIFT TYPE BASCULE BRIDGE

This system of counterbalancing and rolling back away from the channel was the method applied extensively in designs starting in 1893. William Scherzer was the first to apply it (knowingly or not) in the United States in his design submitted to Chicago's Metropolitan West Side Elevated Company in 1893. Hansa applied it in Germany (details and the year are unknown to the Author at this time).

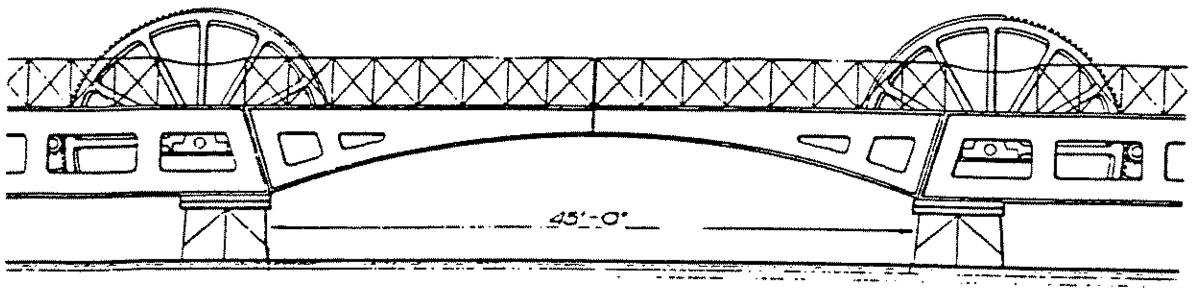
Circa 1825 *Mr. J. B. Strauss's paper presented before the Second Pan American Scientific Congress, Washington, D.C., U.S.A. (12-27-1915 through 1-8-1916), titled "Bascule Bridges" showed a modification on this Rolling Lift built at Harve. It would roll back farther from the channel, but not provide a tow path along the canal. Some portion of the dead load and the live load would be carried by the support bearing on the front wall. The method of operation is unknown, but it must have been similar to the previous bridge.*



"ROLLING LIFT" TYPE – HARVE, CIRCA 1825

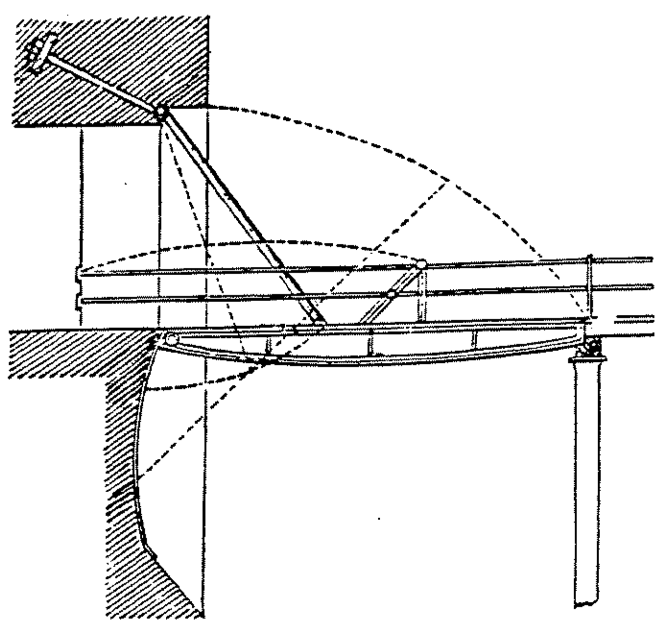
1839 *An early type of bascule bridge found in northern Europe, England and Sweden was known as a "Fixed Trunnion" type. Two "In Line" trunnions (or fulcrums) divided the leaf into a long arm, spanning the channel, and a relatively short arm extending landward, which was counterweighted sufficiently to make the turning moments of the two portions equal and opposite. This means the center of gravity of the moving span is at the fixed trunnion, and the leaf is balanced in all positions. This formed the basis for the Tower Bridge in London and the later "Chicago Type Bascule Bridge."*

1839 Cont'd.	*One of the first "Fixed trunnion" bridges was a double leaf bridge on the North Eastern Railway System at Selby, England. It had a rack wheel, hand powered gearing and when closed, it acted like an arch.*



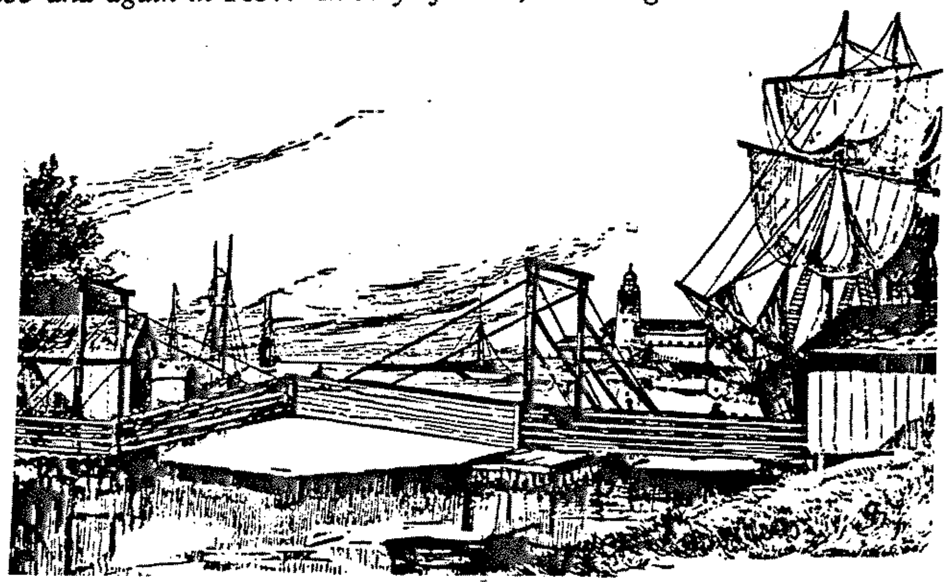
EARLY "FIXED TRUNNION" BRIDGE, BUILT 1839.

Year Unknown	*Another early idea for bridges moving in a vertical plane was introduced by Ardagh. Strictly speaking this bridge is not a bascule , but a "Folding Bridge". It does not have a counterweight. Harman applied this principle on two bridges in Chicago, IL, in 1891 and 1893. Schinke also applied this principle on two bridges in Milwaukee, WI circa 1896.*



FOLDING BRIDGE.

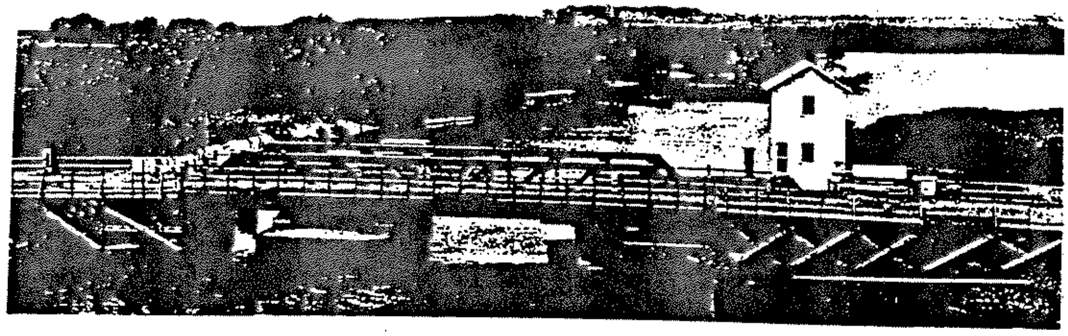
1834 thru 1839 — *The first bridge built in the City of Chicago was the Dearborn Street Bridge. It was a primitive castle drawbridge type constructed of wood. It had two movable leaves, lifted with chains, to provide a sixty-foot opening for passage of marine traffic. At each end of the movable sections was a framework tower of upright timbers connected at the top. The blows of passing ships necessitated repairs in 1835 and again in 1837. In July of 1839, the bridge was ordered dismantled.*



DEARBORN STREET DRAWBRIDGE, BUILT IN 1834. (Chicago Historical Society.)

1840 — *A pontoon swing bridge was constructed at Clark Street. This was the first publicly financed public works project of note, and was built at a cost of $3,000. It was a simple structure anchored to each bank, first by ropes which floated and often obstructed the passage of boats, then by chains fitted to windlasses, one stationed east and the other west of the floating bridge on opposite banks. To accommodate marine traffic, the bridge was swung open by cranking one windlass and slacking off on the other. To close, the procedure was reversed.*

1841 thru 1847 — *A similar type of pontoon bridge was built at Wells Street. Six years later it was replaced by another floating bridge at a cost if $3,200. Its total length was 202 feet, with the draw section floating on boiler-iron drums. Stringers supported the deck which was 100 feet long from the pivot to the opening point, making a marine passageway 81 feet wide. The bridge had two tracks for teams and a side walk on either side for pedestrians.*



TYPICAL PONTOON BRIDGE, BUILT 1840 TO 1847. (Chicago Historical Society.)

1847 — *Two more floating bridges of modified design were installed at Madison and Randolph streets across the South Branch. These may be described as "semi-floating" draw bridges, which indicates that the pivot ends were supported on solid abutments. Both were equipped with self-regulating aprons that rested on the roadway to maintain a desirable alignment despite variations in water height and bridge loading. They also had two lanes for teams and walks on both sides.*

1848 thru 1849 — *The snows of the winter were exceptionally heavy causing a disastrous flood on March 12. The water swept down the Chicago River wrecking the ships at anchor, damaging the wharves and destroying all of the bridges.*

As plans were being drawn up by bridge engineers, three ferries and two jury structures were employed to cross the waterway. One of these was a canal boat at Randolph Street, the other was a schooner at Clark, both moored across the river connecting the opposite banks.

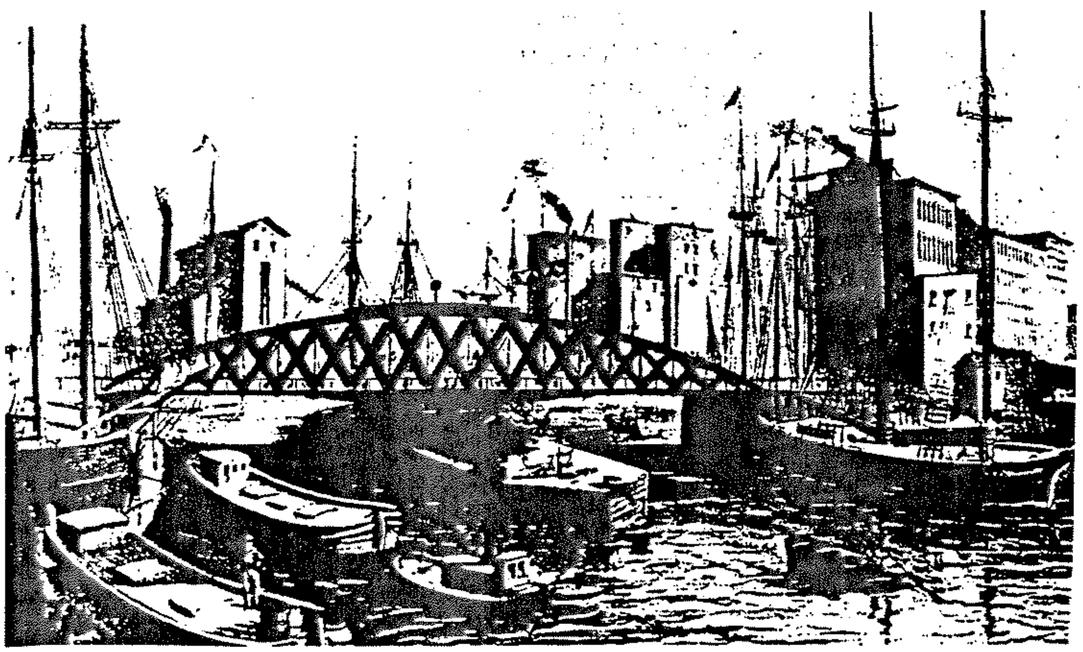
1849 — *The state of the art of bridge engineering was still primitive. Much was learned by repeated trial and error in earlier structures. This experience enabled designers to move swiftly and avoid previous errors.*

Chicago's Swing (Pivot) Bridges

1849 *Shippers and marine interests objected to the impediment to river traffic caused by the pontoon bridge obstructions. Structural engineers were commissioned to study possible development of improved movable bridges. This effort introduced the design of the swing bridge to Chicago, supported on a pier in mid-stream and rotated in a horizontal plane. When open, the structure lay parallel to the center line of the river, providing a passage for vessels on each side of the pier, which had a diameter equal to the width of the bridge.*

1854 *The first of this type was a crude wooden structure which Chicagoans referred to as a "pivot bridge." It was erected at Wells Street at a cost of $12,000.*

The following year both ends of the bridge sagged, because the arched top chords of the timber superstructure gave way, the damage was repaired by bolting on heavy iron plates to reinforce the timber.



TYPICAL SWING BRIDGE - ALL WOOD CONSTRUCTION. (Chicago Historical Society.)

1856 *Madison Street was the first Chicago bridge built with a masonry foundation, and the first publicly financed project. During the same year, the old pontoon bridge at Randolph was removed, and replaced with a new swing bridge at a cost of $48,000. Also, the Wells Street Bridge was built and at the time was the longest draw bridge in the West, 190 feet in length and eighteen feet above the water.*

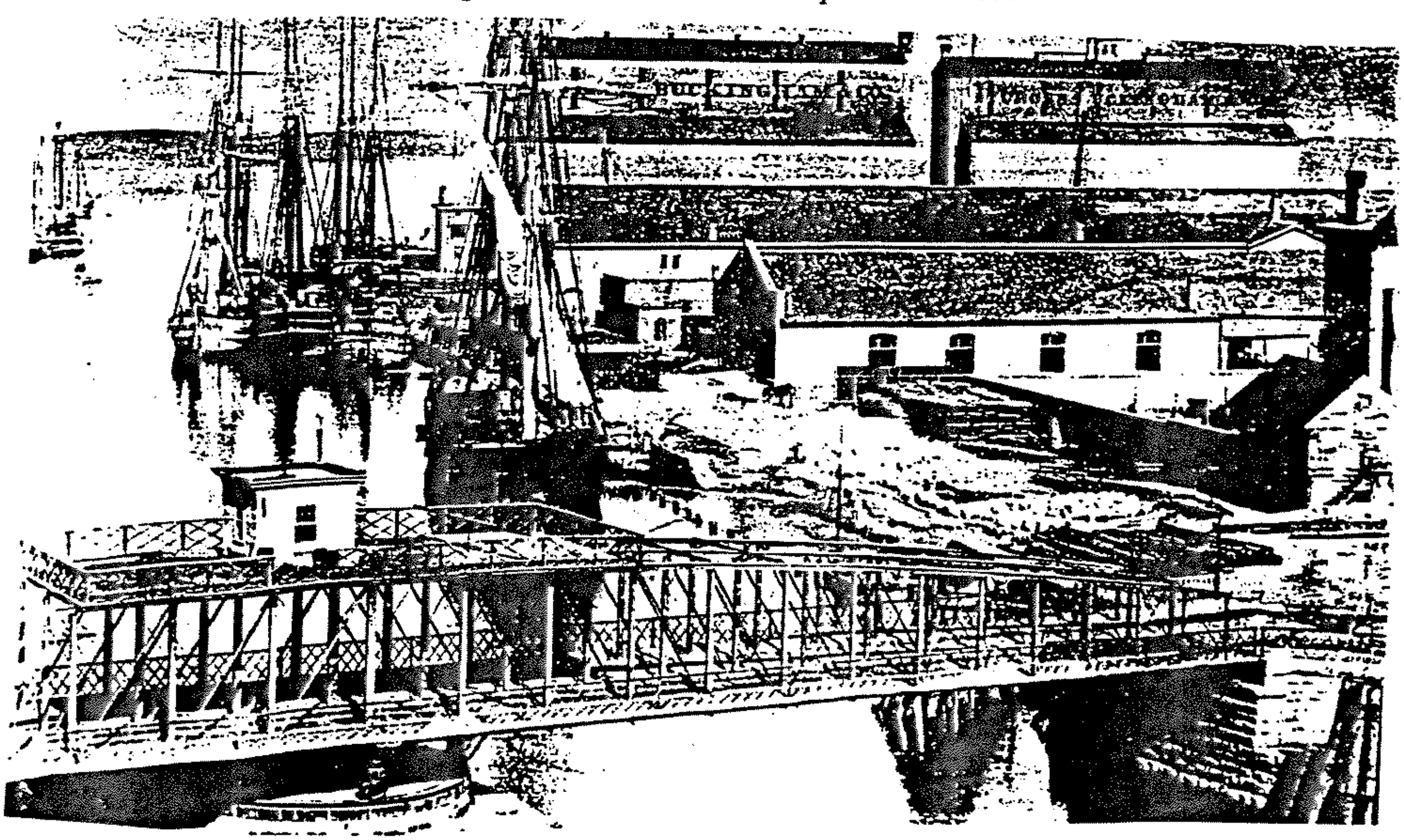
1857 *The advances in bridge design and construction since 1849 were visibly demonstrated on February 9, 1857, when Chicago experienced still another flood. On the North Branch of the river an immense gorge of ice formed at the Chicago Avenue Bridge. This mass broke up, subsequent to heavy rains, and the blocks of ice passed into Lake Michigan causing only relatively minor damage.*

Chicago's Rush Street Bridge

A historical review of movable bridges built at one particular location, Rush Street in Chicago, provides additional flavor concerning the life and times of movable bridges in the mid to late-19th century.

In 1853, the floating bridge at Rush Street was being pulled open with a number of laborers on the roadway deck when the structure careened and was swamped. A number of laborers were drowned and the structure was wrecked.

Following this, in June, 1856, the City contracted to design and build an iron swing bridge across the river at Rush Street between the railroads. It was the First Iron Bridge in the West and was completed in 1859.



"THE FIRST IRON BRIDGE IN THE WEST." (Chicago Historical Society.)

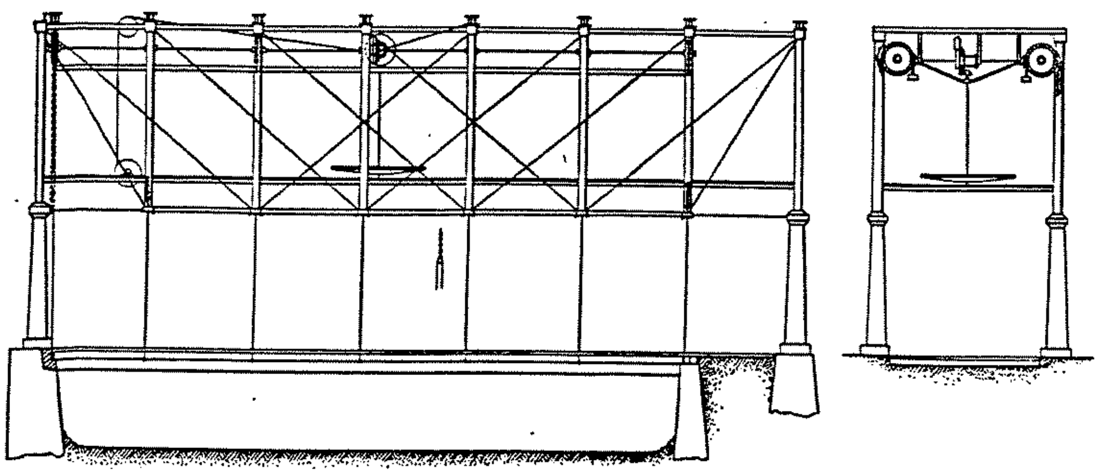
This bridge also met a disastrous end on November 3, 1863. At about five o'clock in the afternoon, with a hundred head of cattle, a horse and buggy and a horse-drawn wagon on the bridge roadway along with several people, a tugboat whistled about two blocks away. The events that followed were described in the Chicago Tribune: "...the cattle crowded to the south end of (the bridge)... the tender recklessly swung the bridge from the abutment. In an instant the north end of the bridge was elevated twenty feet in the air, there was a snapping of iron, a cracking and crashing of timbers, a shriek of horror from the bystanders, and the bridge, breaking in two across the center pier, fell with all its burden of people, cattle and vehicles splashed into the river..." A young girl was killed, two-thirds of the cattle were lost, and the bridge was totally destroyed.

The bridge was replaced by another iron swing bridge in 1864, and this one too was destined to be the scene of another costly accident. On the morning of November 23, a lumber-laden schooner was being towed westward up the river by a steam tug. From the opposite direction, a steam barge was leaving harbor. For some unaccountable reason, all three vessels chose to pass the opened bridge on the same (south) side of the center pier. The resulting collision drove the schooner's jib boom into the bridge at about the middle. Both ends of the structure slowly sagged onto the "protective" piling, which prevented the broken structure from dropping into the river. The damage was repaired in two weeks. In 1871 the bridge was destroyed by the Chicago Fire, but was rebuilt and survived without further incident until 1921. Construction of the adjacent Michigan Ave. Bridge caused settling of the Rush Street abutments at that time, and the venerable structure finally was demolished and not replaced.

Historical chronology, continued:

19th Century in Europe	*There were a number of very short spans with low vertical lifts constructed in Europe. The first vertical lift bridge on record was located in Vienna over the Danube River. A 30 ft. portion of a wooden trestle was lifted 6-1/2 ft.*
1867 in Europe	*The Knipplesbro trunnion bascule bridge at Copenhagen, Denmark was completed. It was a double leaf bascule bridge with hydraulic power operation. At the time of completion the span was 56' - 8" in length and 34' - 5" in width. It was the largest bascule bridge that had ever been constructed.*

1870 in U.S.A. *During the decade between 1870 to 1880, Squire Whipple designed, patented and built several vertical lift bridges along the Erie Canal in New York. There was one built in Syracuse in which only the roadway deck moved. Two parallel Whipple trusses spanned the Canal and towpath. They were braced by lateral systems and rested on cast-iron posts on the abutments. The roadway platform was an independent iron structure 60 feet long and 18 feet wide, which was suspended at each panel joint by rods passing upwards from the ends of the floorbeams and telescoped inside of the hollow vertical posts of the truss overhead. The vertical lift of the roadway was 11.5 feet. Wire ropes, 3/4" in diameter were attached to the tops of the rods and passed over 3 foot sheaves.*



WHIPPLE VERTICAL LIFT BRIDGE.

The other end of each rope carried counterweight about 1600 lbs., balancing the weight of the roadway deck. This type of system was later used by Waddell and Harrington for their bridge in Kansas City.

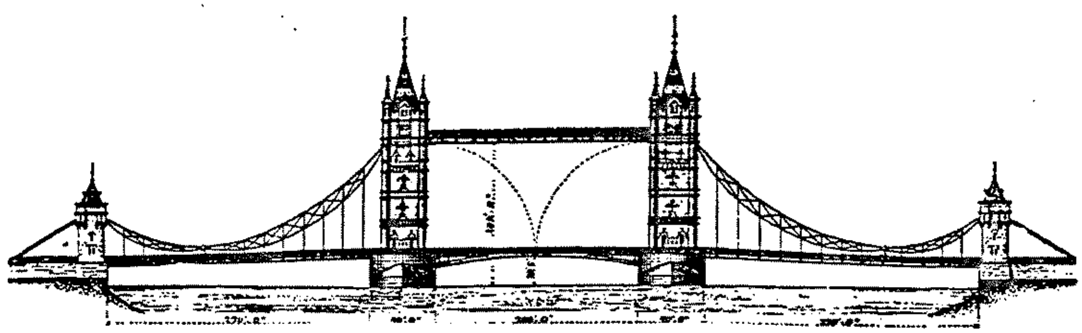
Squire Whipple was the first American Engineer to analyze the stresses in ordinary bridge trusses under passing loads. His work did much to advance the art of iron bridge building in the United States.

During the next two decades, a number of small vertical lifts were built across canals in eastern states and a few were constructed abroad.

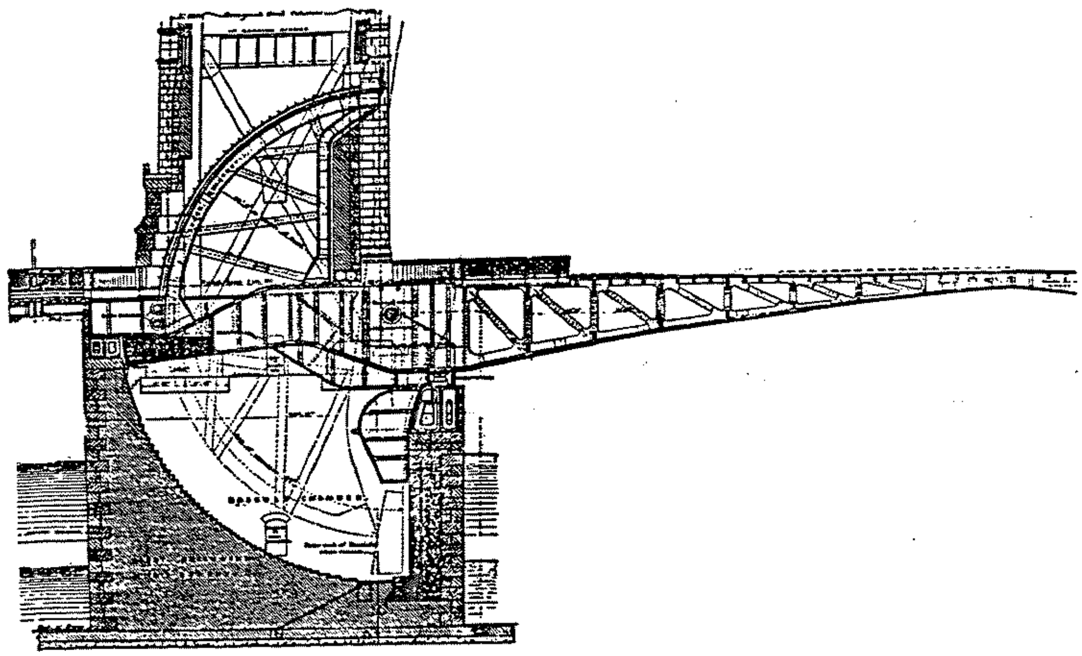
1871 in U.S.A. *Charles Macdonald designed and built the Point Street Swing Bridge over the Providence River in Providence, Rhode Island.*

1878 in Europe — *The Fijenoord trunnion bascule bridge at Rotterdam, Holland was completed. The clear channel provided was 75.5 feet. The bridge was 34.4 feet in width. It surpassed the Knipplesbro span (1867) and was operated by hydraulic power. Also, M. H. Matthyssens made an elaborate design for a vertical lift bridge crossing the Scheldt River in Antwerp, Belgium that involved a span of 131' and about the same height.*

1878 thru 1894 in Europe — *Sir John Wolfe Barry started the design of a simple (single) trunnion bascule which would provide a 200' span across the Thames River. The construction of this, the Tower Bridge, was not completed until 1894. From the beginning it was hydraulically operated, using the London water distribution system which provided a pressure between 500 to 600 psi.*



TOWER BRIDGE OVER THAMES RIVER IN LONDON, ENGLAND.



DOUBLE LEAF BASCULE - HALF LONGITUDINAL SECTION

1880 *The Hornig Trunnion Bridge was built at Koenigsberg, Germany.*

1887 in U.S.A. *Design of swing bridges was much improved by C. C. Schneider, Engineer of the Pencoyd Iron Works during the period from 1887 to 1900. Later while he was Consulting Engineer for the American Bridge Company, his strong advocacy of this type as well as the superior design, influenced many engineers and firmly established the center-bearing design in American Practice.*

Catalyst to the Modern Era - The Needs for Navigation and Flowage in Chicago

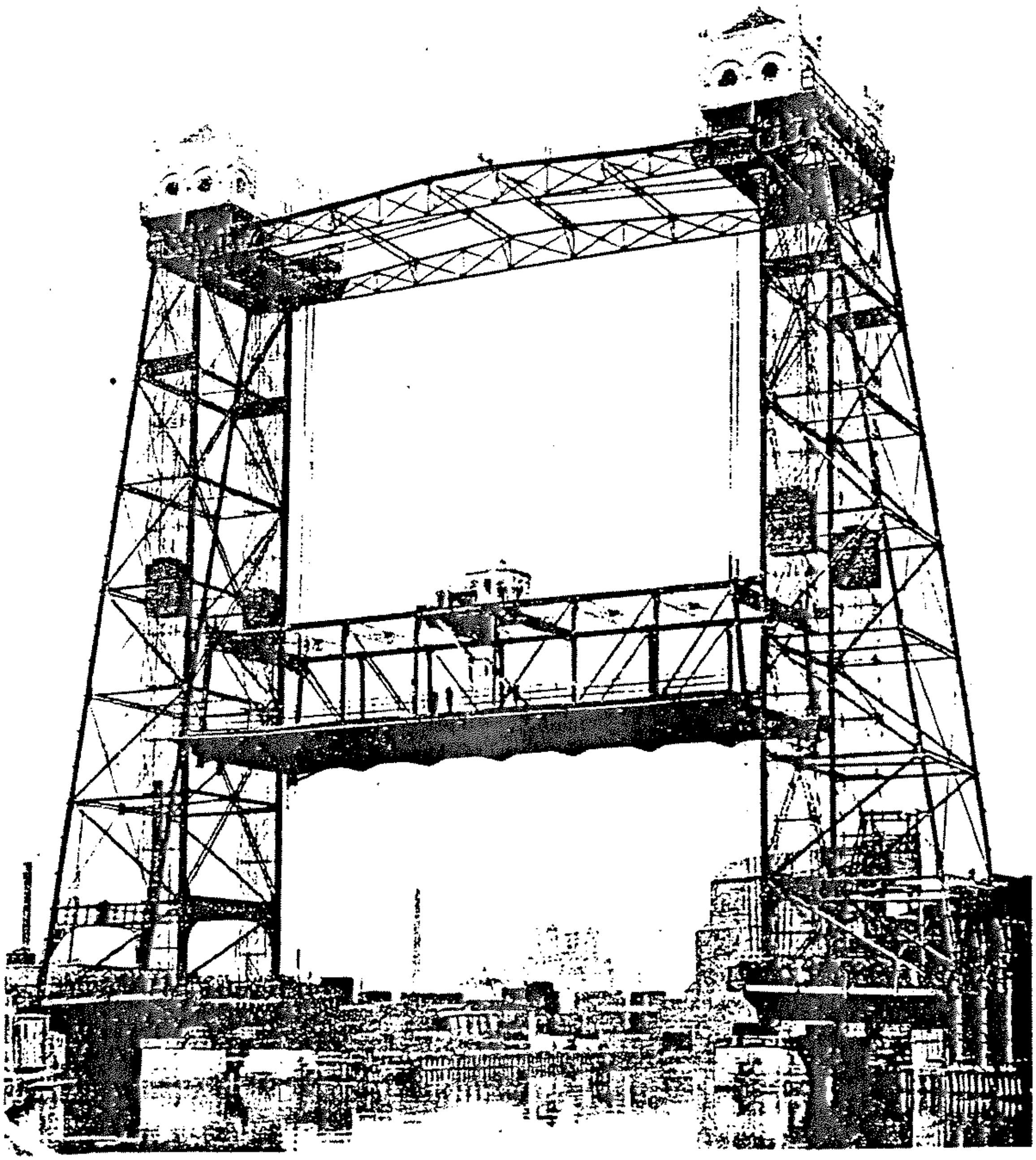
The completion of the Sanitary and Ship Canal, joining Lake Michigan and the south branch of the Chicago River with the Illinois Waterway and the Mississippi River, brought about increased navigation with larger boats passing through the south branch. The sanitary purpose of the Canal also necessitated minimizing all hinderances to flow. The elimination of the multitude of swing bridges with their center piers, while maintaining and increasing capacities for vehicular and rail traffic in the City, became a priority. While Chicago's needs were reflected to a lesser extent in other parts of the country, the magnitude and complexity of the situation in Chicago created the need for the majority of movable bridge innovations over the twenty years between 1890 and 1910. THESE INNOVATORS, PARTICULARLY THE SUCCESSFUL ONES, DREW ON OTHERS' PAST WORK FOR THEIR OWN INSPIRATION.

1890 *The first folding lift or so-called "Jack-Knife" bridge was built under a patent issued to Captain W. Harmon. This was installed at Weed street on the north branch.*

1891 *A swing bridge was built at Canal Street. However, there was so much objection to the swing bridge because of the bend in the river at that location that it was ordered removed almost immediately.*

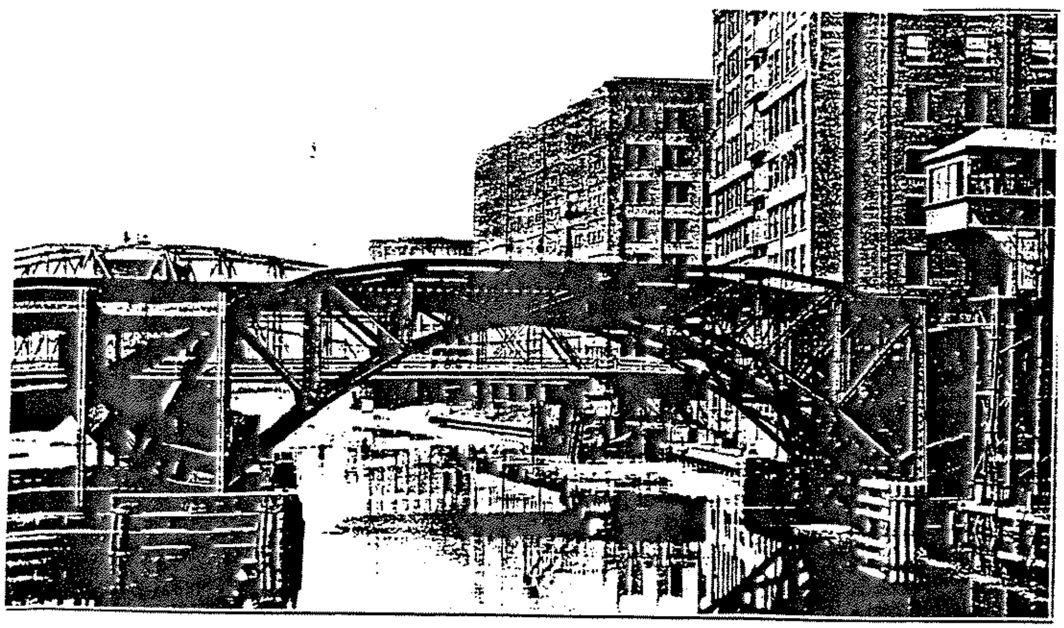
1892 *A second Jack-Knife bridge was built to replace the swing bridge at Canal Street. The double leaf design provided 80 feet of clear channel - the widest for any movable span built until that time - but was of light construction and was poorly executed.* *See picture, Page 23.*

1892 *The first major vertical-lift bridge was designed and patented by J.A.L. Waddell* *HE REMEMBERED THE PAST AND WAS INSPIRED. The steel lift span was 130' long and 58' wide. It was raised vertically between two steel towers on opposite banks from 15' to a height of 155 feet clear above the river at South Halsted Street. The bridge was opened to traffic on March 22, 1894 and it served traffic until 1932, but was not problem free.*



HALSTED STREET VERTICAL LIFT BRIDGE
OVER THE SOUTH BRANCH OF THE CHICAGO RIVER

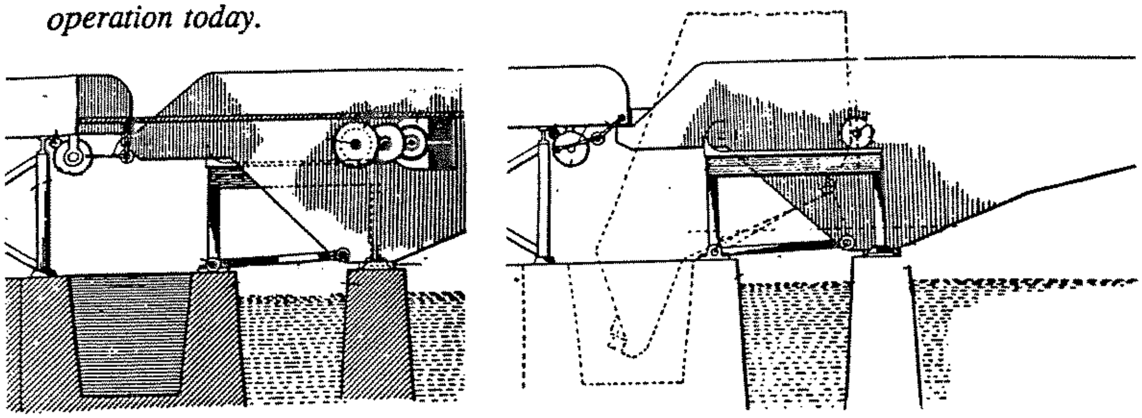
1893 *The Metropolitan West Side Elevated Company faced the problem of building a movable bridge to carry four tracks in a location between two heavily travelled swing bridges a block apart. There was not enough room for a third swing bridge to align end-to-end between two others for passage of navigation. They contracted William Scherzer, who had opened an office in Chicago on January 1, to design a bridge to overcome these obstacles, on the South Branch of the Chicago River between Jackson and Van Buren Streets. HE REMEMBERED THE PAST AND WAS INSPIRED. Concurrently, he designed the first modern rolling lift bascule bridges for the Company, and for the City of Chicago to carry Van Buren Street over the Chicago River. He died July 20, 1893 before the bridges were built and opened to traffic in Spring of 1895.*



FIRST SCHERZER ROLLING LIFT BRIDGE, COMPLETED IN 1895

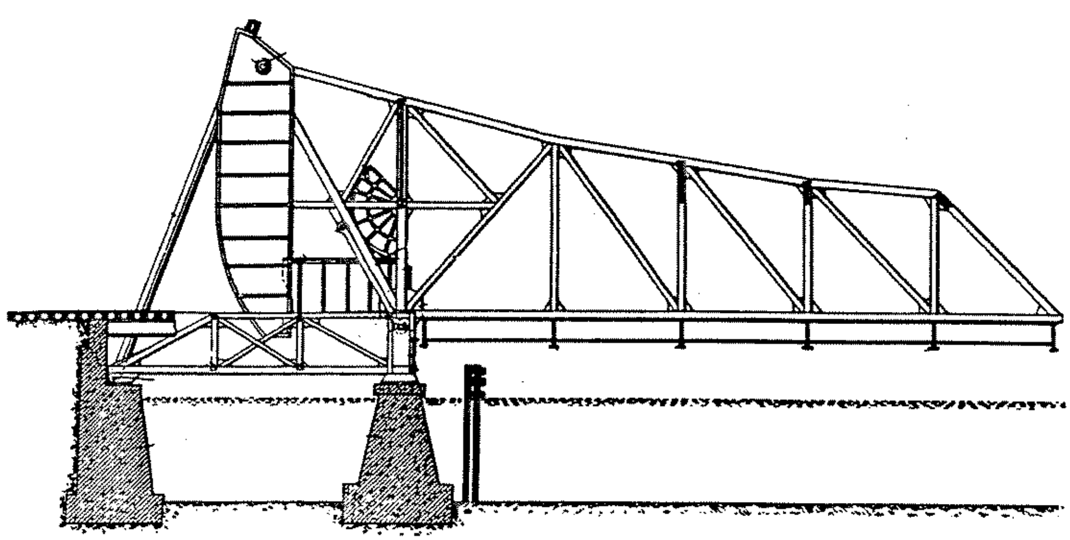
1896 *Schinke applied the folding bridge principle for bridges built at Sixteenth Street and at Huron Street in Milwaukee about 1896. Later, efforts were made by others to design folding bridges, but were not successful and this type of bridge became obsolete.*

1901 *Theodor Rall developed another rolling contact type of bascule bridge. HE REMEMBERED THE PAST AND WAS INSPIRED. The first one was built over the Miami and Erie Canal for the Pittsburgh, Fort Wayne and Chicago Railway. The span was only 26-1/2 feet. "The Broadway Bridge" over the Willamette River in Portland, Oregon was designed and built under the supervision of Ralph Modjeski, Consulting Engineer, of Chicago. It has the cylindrical shaped pivot roller central to the combination horizontal slide and upward swivel opening movement of a Rall-type bascule. It is a double leaf through truss with the main span length of 297 feet. It carries four lanes of traffic with two 11 foot sidewalk/bike paths. It was open to traffic on April 22, 1913, as the 2nd longest double leaf bascule, but it is now the 4th longest in the world. It is still in operation today.*



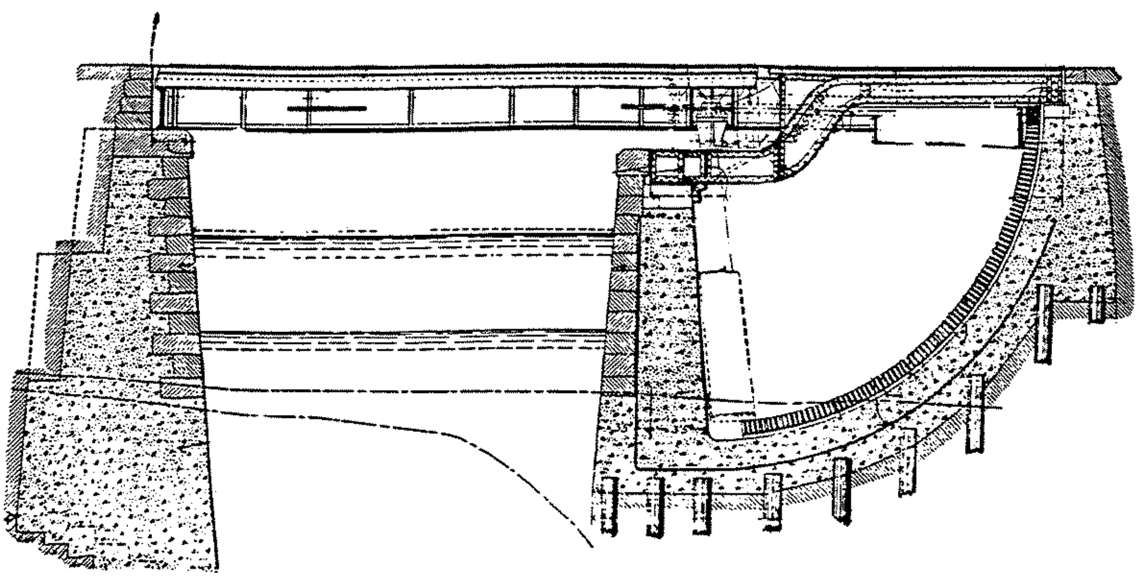
REAR END LOCKED. REAR END READY TO OPEN.

RALL DOUBLE LEAF BASCULE BRIDGE.



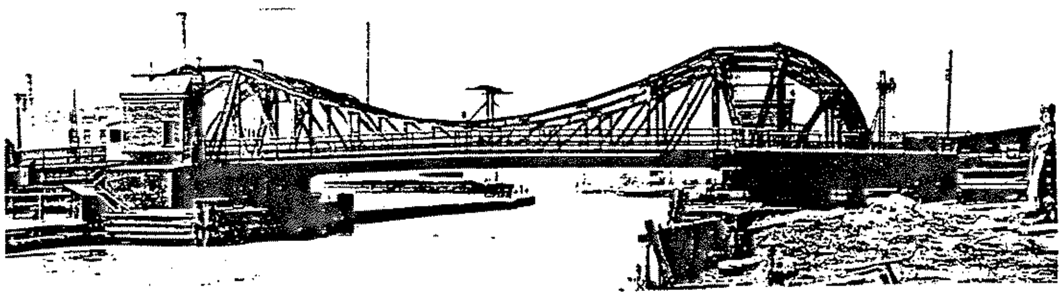
RALL SINGLE LEAF RAILROAD BASCULE TRUSS BRIDGE

1901 *According to J.B. Strauss, preceding the City of Chicago, the City of Milwaukee, and himself were the independent efforts of Augustus Smith to use the characteristic "S" trunnion supporting cross-girders of the early European bridges in the development of a little single leaf deck bascule which had a 30 ft. span. (Note: Hovey credits Mr. George R. Ferguson with the design of the bridge.) It was built over the Mott Haven Canal at 135th Street in New York City in 1901. The designer placed the driving mechanism on the moving leaf with the pinions operating against fixed lift racks on the inner side walls of the counterweight pit. This is unusual because the operating mechanism was usually placed on the fixed part on opposite sides of the moving leaf.*

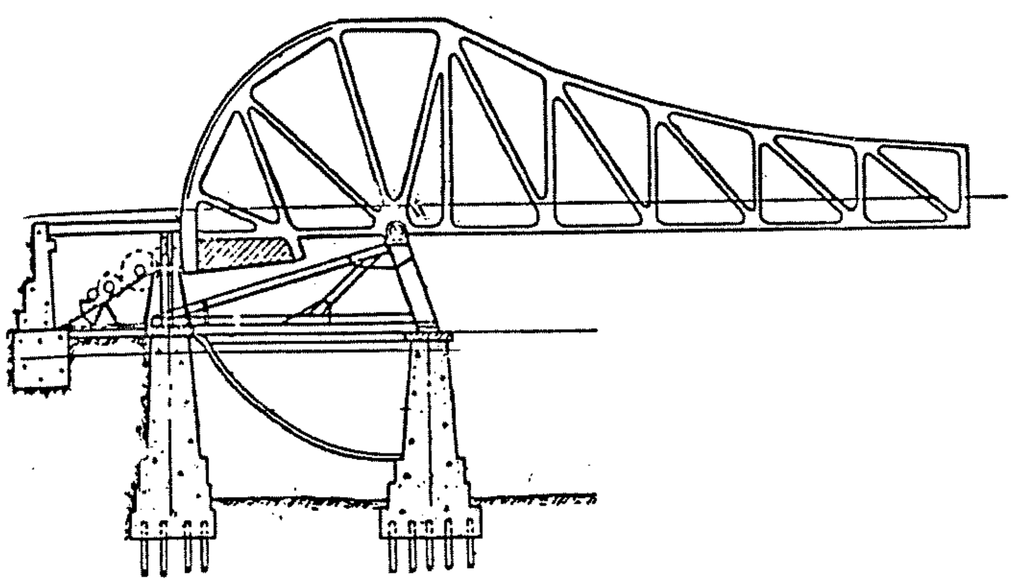


135TH STREET TRUNNION BASCULE BRIDGE, NEW YORK CITY, BUILT 1901

1902 *The City of Chicago's Bureau of Engineering, under the direction of the City Engineer, John Ericson in 1899, made a critical analysis of the literature on movable bridges built in this country and in Europe. In their report, they concluded that the single "fixed trunnion" would provide the best solution for Chicago. The first one was designed by John Ericson and Edward Willman. It was built at Clyborn Place over the North branch of the Chicago River and completed in 1902. The street name was later changed to Cortland Street. The bridge was electrically operated through streetcar motors and cast steel gear trains driving pinions meshing with a pin rack in the circular top chord of the tail end of the truss. This Chicago Type Trunnion Bascule Bridge has passed through various stages of evolution. Further developments of the Chicago Type Trunnion are credited to Thomas G. Philfeldt, Alexander Von Babo and to Hugh E. Young, who were successively in charge of the design of the bridges.*

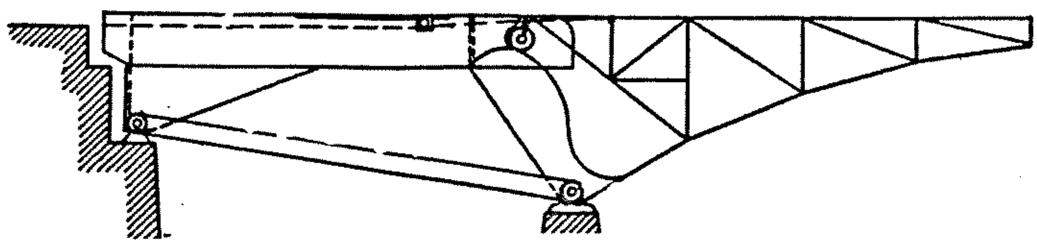


FIRST CHICAGO TYPE TRUNNION BASCULE BRIDGE.



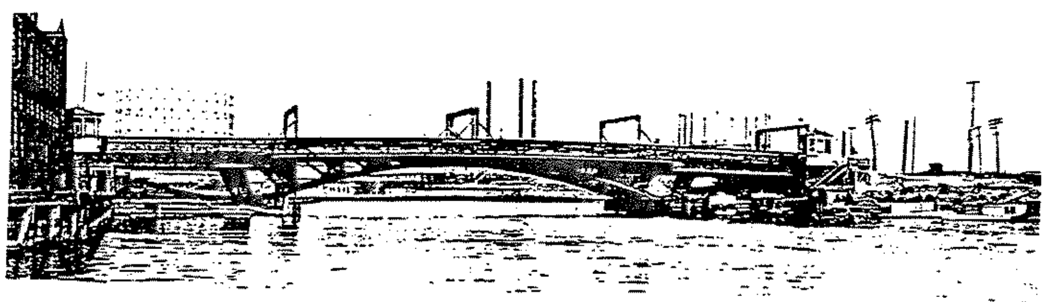
LONGITUDINAL SECTION ON CENTERLINE OF BRIDGE.

1902 *John Page developed a combination rolling contact and trunnion bridge for the Sanitary District of Chicago. The approach span of the bridge is utilized as the counterweight. Trunnions support the approach end, and the bascule end is supported by rollers resting on a specially curved track girder within the moving leaf. Trunnions support the moving leaf which is pulled open by a strut. As the leaf rotates open, the rollers follow the curved track and keep the bridge in balance. The trunnions are connected bv a strut.*

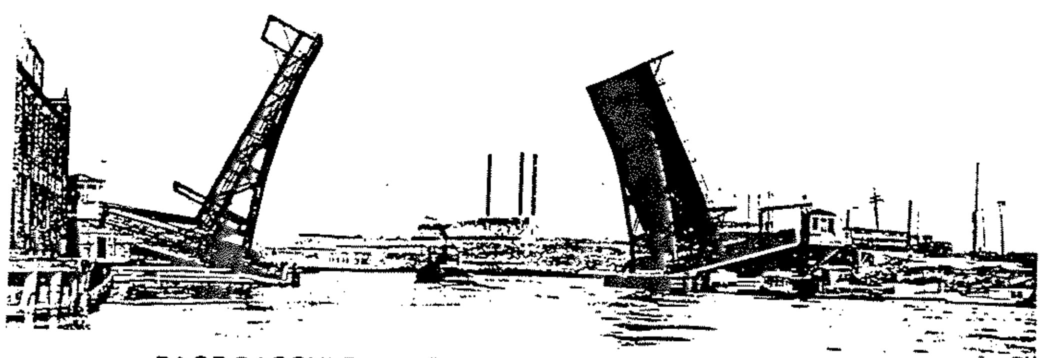


PAGE BASCULE BRIDGE.

The first bridge was built across the West Fork, South Branch of the Chicago River at South Ashland Avenue. Three additional Page bridges have been built. One, a highway bridge at San Francisco; the second was a double track structure for the Chicago and Alton R.R. Company; the final one was a single track railroad span for the Monon Rwy. near Chicago. No known Page bridges have been built since 1907.



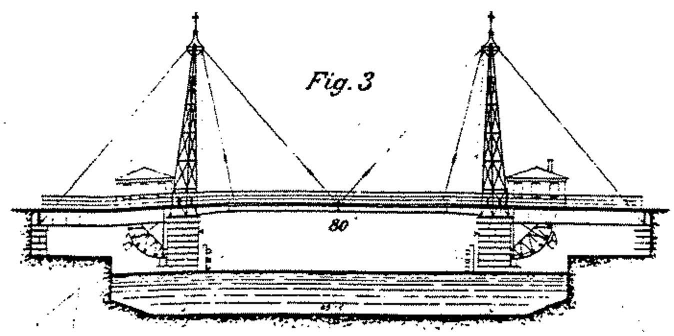
PAGE BASCULE BRIDGE IN CLOSED POSITION.



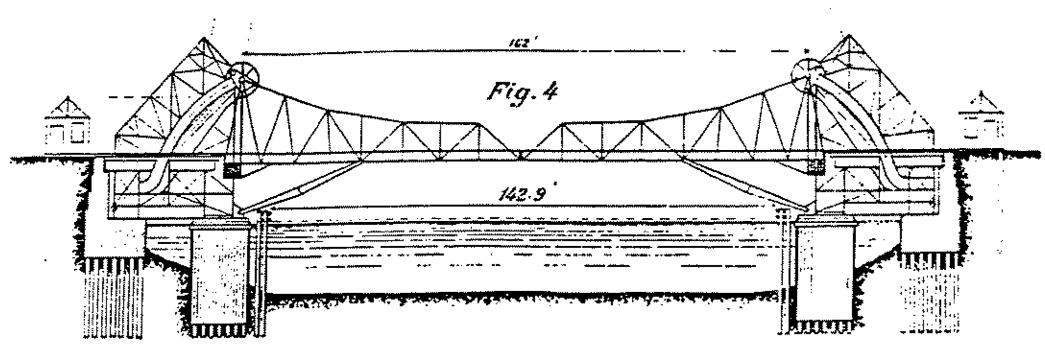
PAGE BASCULE BRIDGE IN OPEN POSITION.

Prior to 1903

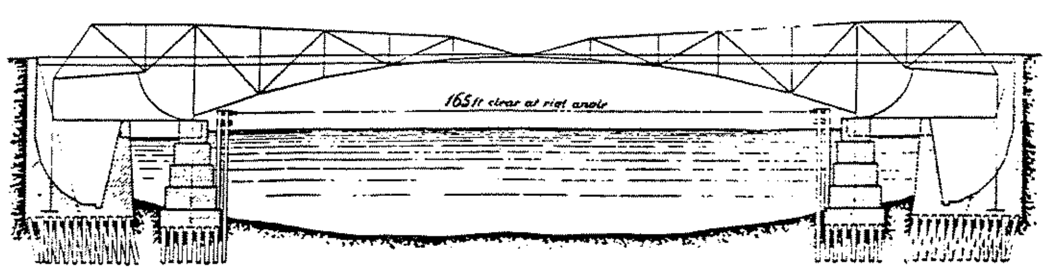
The Metropolitan Sanitary District (MSD) of Chicago invited competitive designs for a new bridge without a center pier to carry traffic across the south branch of the Chicago River at <u>*Canal Street.*</u> *"The Bridge must provide a clear channel of 120 feet for navigation between the pier protection at right angles to the centerline of the Channel". There had been many maintenance problems with the existing Harmon Jack-Knife type bridge because of its light construction and poor execution. The 80 ft. wide channel also was not adequate for navigation nor for sanitary flow. The Scherzer Rolling Lift Bridge was selected and built, increasing channel width to 165 ft.*



HARMON JACK-KNIFE TYPE BRIDGE PROVIDED 80 FT. CHANNEL AT CANAL STREET



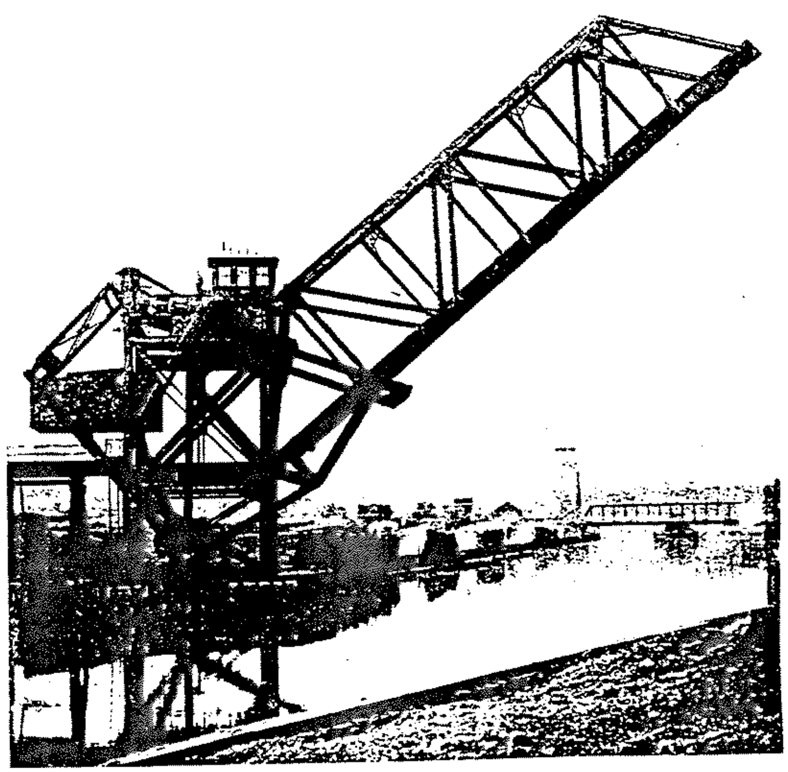
PROPOSED SCHINKE BASCULE BRIDGE FOR CANAL STREET - 142.9 FT. CHANNEL



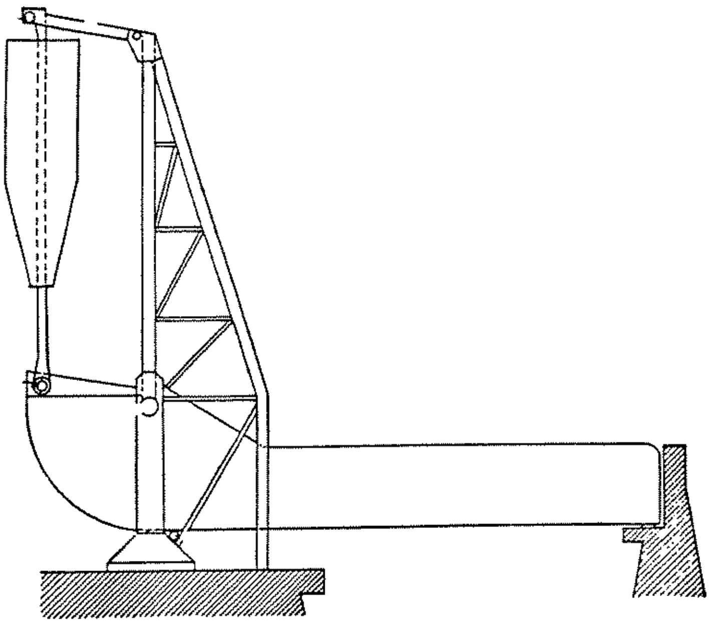
SCHERZER ROLLING LIFT BRIDGE BUILT IN 1903 AT CANAL ST. - 165 FT. CHANNEL

1901-03 *Joseph B. Strauss had been associated with the work on practically all types of bascules in use. HE REMEMBERED THE PAST AND WAS INSPIRED to remove the limitations of existing bridges and their counterweight arrangements, i.e., by selecting from the available types those features that promised the greatest efficiency, and to modify the counterweight mechanism in such a manner that cost was improved and efficiency was not sacrificed. With the opinion that the fixed trunnion type was the most dependable, he substituted concrete for the cast-iron counterweights, effecting at once a savings in cost proportional to the relative cost of the two materials. He then proposed the use of the pin-connected concrete counterweight for the underneath counterweight type of trunnion bascule bridge. His plans for this were in a patent issued in September, 1903. He also made an adaptation of the pin-connected counterweight in a 30 foot Scherzer bridge of the underneath counterweight type built at Marseilles, Illinois.*

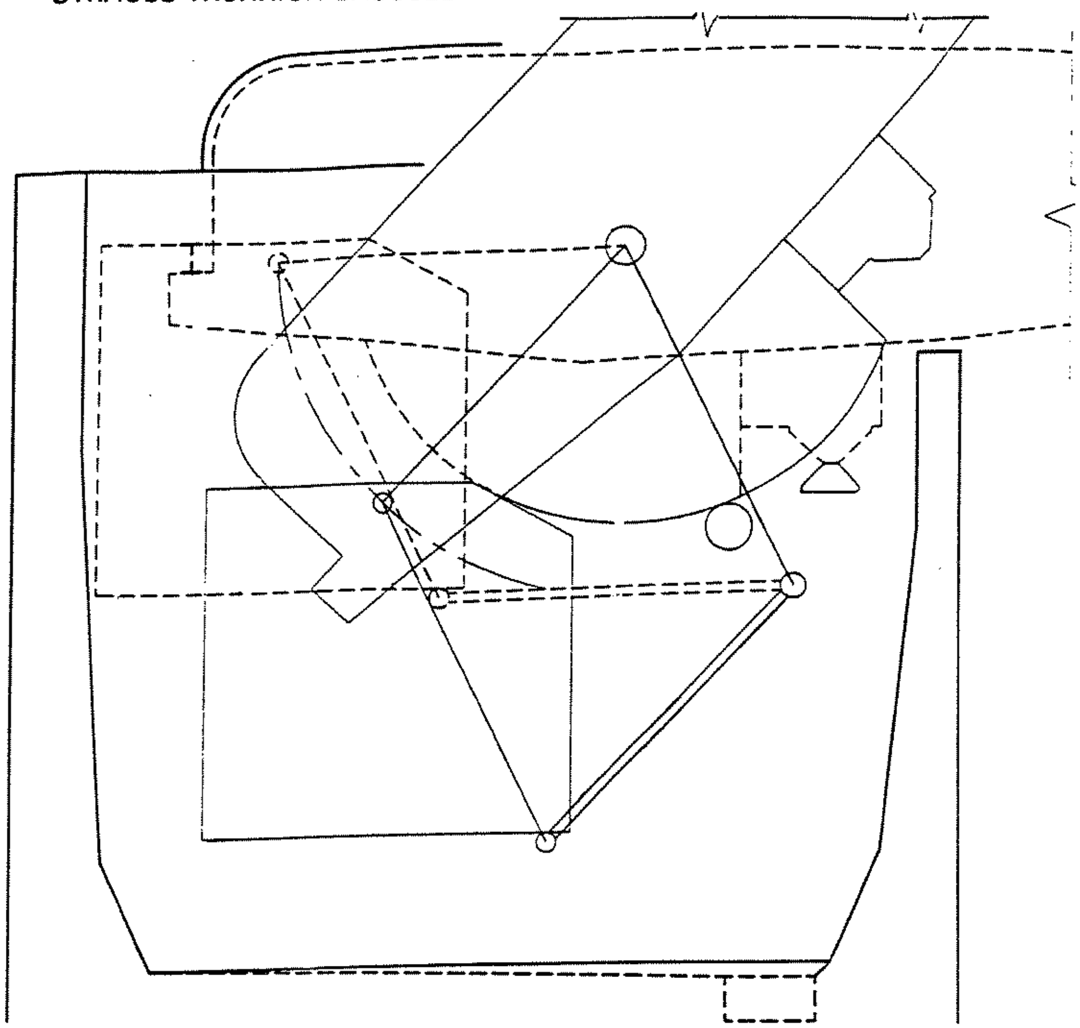
1905 *Strauss's first overhead counterweight type bascule bridge was built for the Wheeling & Lake Erie R.R. over the Cuyahoga River in Cleveland, Ohio.*



FIRST STRAUSS TRUNNION BASCULE BRIDGE.

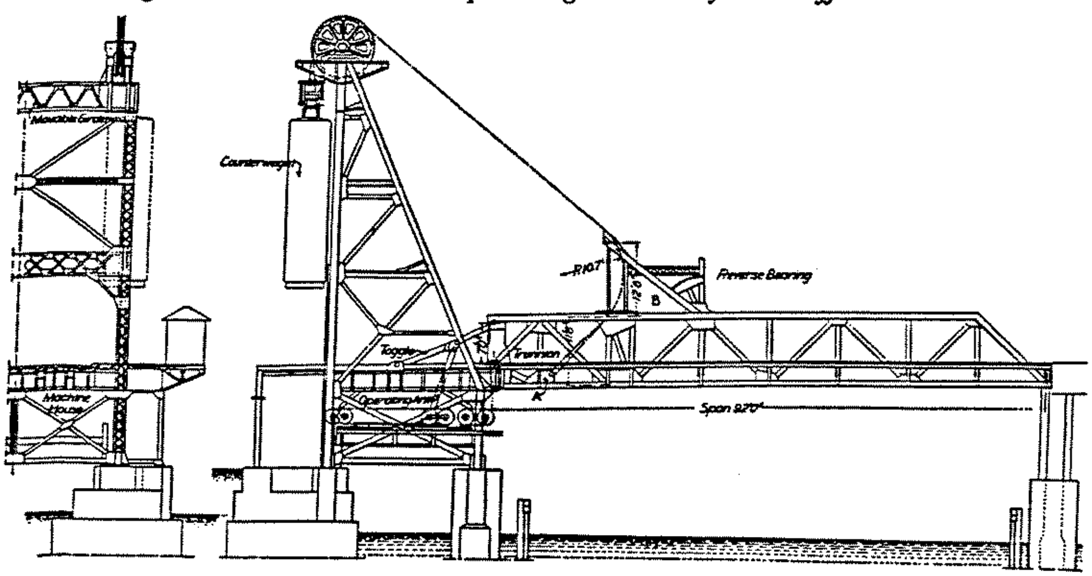


STRAUSS TRUNNION BASCULE BRIDGE - VERTICAL OVERHEAD CWT TYPE

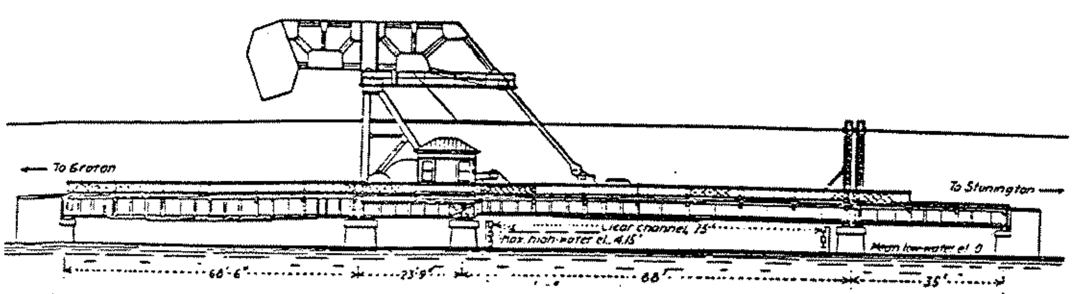


STRAUSS TRUNNION BASCULE BRIDGE - UNDERNEATH CWT TYPE

1906 *Mr. Thomas Ellis Brown developed and patented a method of balancing a bascule leaf by means of a counterweight moving vertically. The first one was built in 1906 in Buffalo, New York., and carried Ohio Street over the Buffalo River. He used 10 ft. diameter sheaves on top of towers similar to a vertical lift except the span supporting cables went diagonally downward toward the middle of the moving leaf. Cam girders were attached to the top of the trusses around which the ropes were wrapped and then anchored to the main trusses at the first lower panel point from the trunnion. As the leaf is opened, the ropes unwrap from the cam girders and their effective lever arms are reduced to keep the moving leaf in balance in all positions. Power was applied by hydraulic accumulators and rams. The bridge was a single leaf and provided a clear channel of 140 ft. between fenders. The span was 166 ft. between trunnions with a 30 ft. roadway and two 7.5 ft. sidewalks. Another bridge was built in Buffalo in 1913. It carried a city street across the Buffalo Ship Canal as shown in the drawing. The method of balancing was the same but the operating machinery was different.*



BROWN BASCULE BRIDGE IN BUFFALO, NY, 1906.

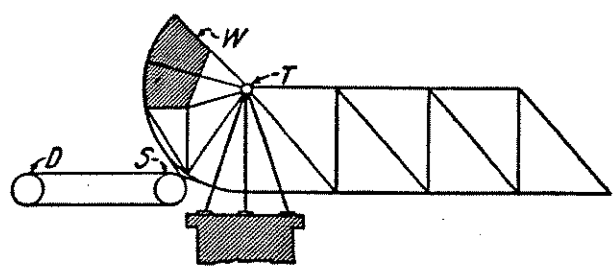


BROWN BASCULE BRIDGE IN MYSTIC, CONNECTICUT, BUILT IN 1922.

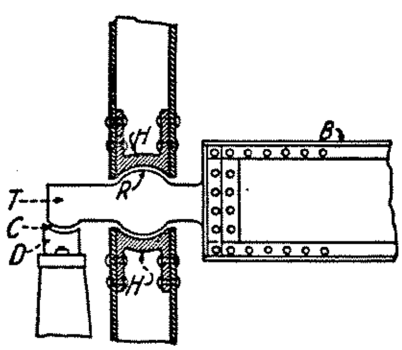
1909 *John Lyle Harrington designed and patented (with his partner, J.A.L. Waddell,) a double deck vertical lift bridge for the O. & W. Railroad and N. Company over the Willamette River at Portland, Oregon. THEY REMEMBERED THE PAST AND WERE INSPIRED. The bridge approach trusses carry highway traffic on the upper chord and two railroad tracks on the lower chord. The movable portion is a through truss "Lifting Span" for the highway traffic. The railroad traffic is carried on a "Lifting Deck" that is suspended at each panel point from the highway "Lifting Span" above.*

It is unique in the fact that when a low clearance is required, the railroad Lifting Deck is raised against the bottom of the Lifting Span without interruption of highway traffic. However, when a greater under clearance is required, the Lifting Span is raised to full height. If more clearance is needed, the Lifting Deck can also be raised to provide the maximum underclearance. The bridge is still in operation today. Pictures are on the next page.

1910 *John A. L. Waddell and John L. Harrington designed and patented a Fixed Trunnion type bascule bridge where both outer bearings for the two trunnions were resting on the pier and both inner bearings were carried by the moving leaf itself between the girders.*

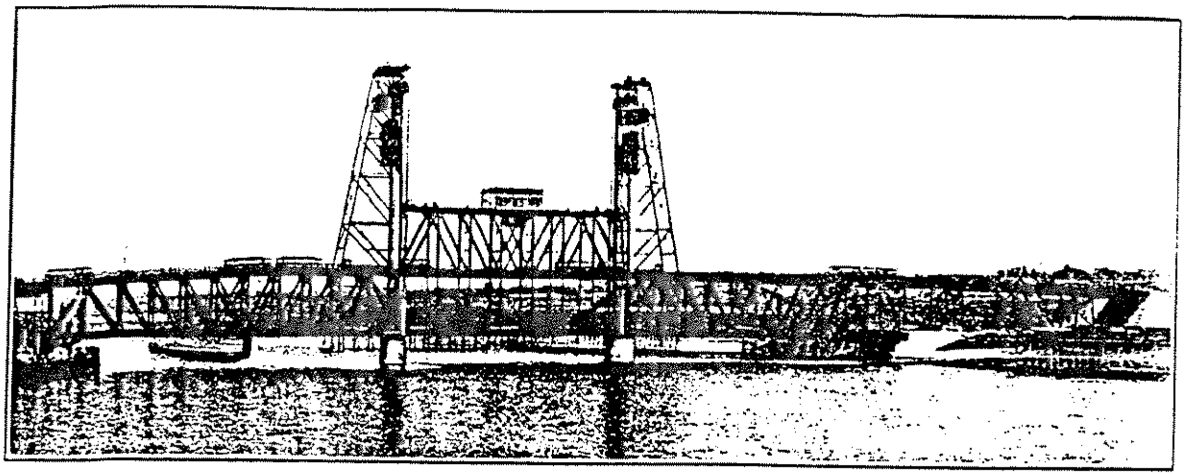


ELEVATION OF BRIDGE

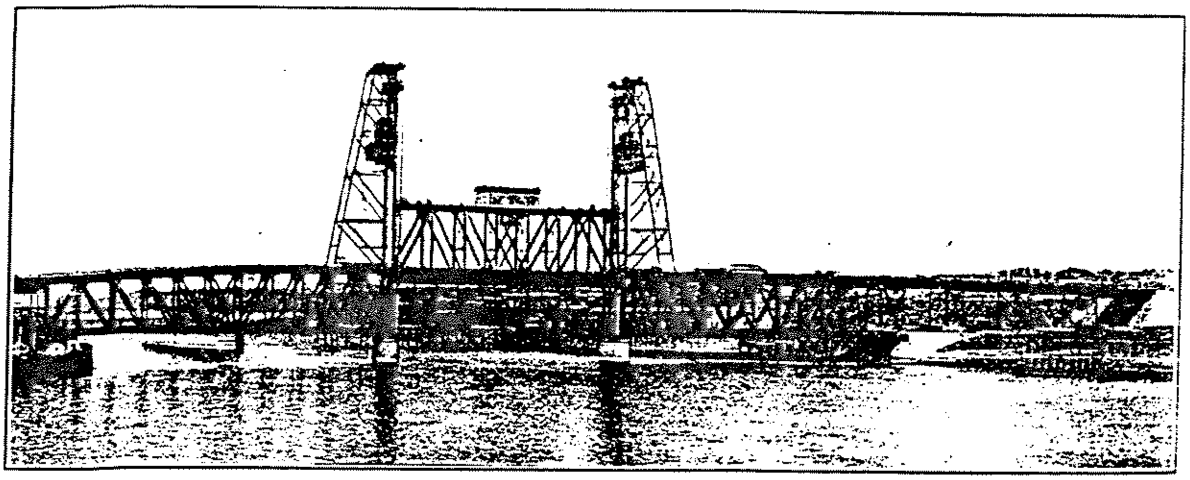


ENLARGED DETAIL OF TRUNNION "T"

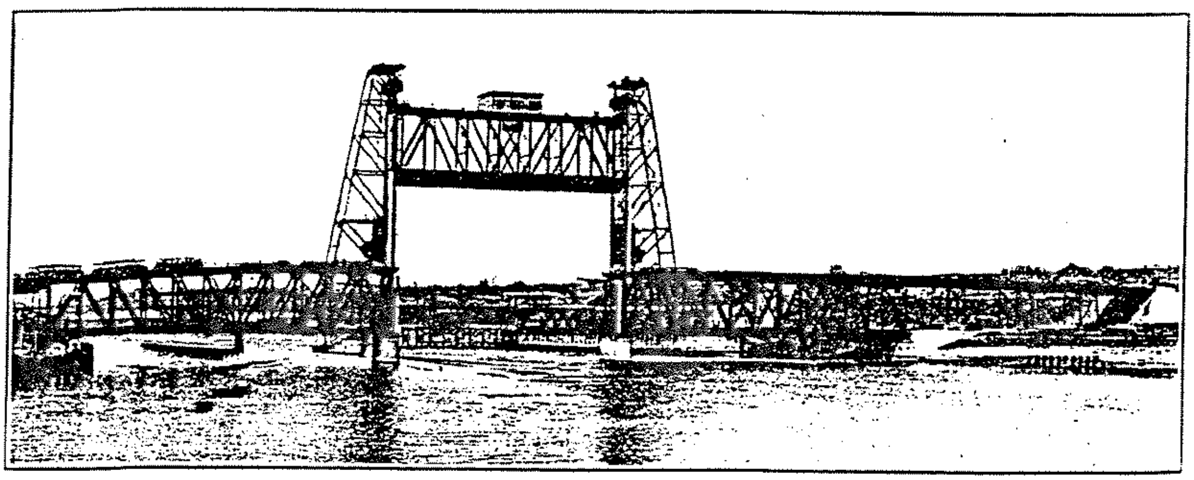
WADDELL & HARRINGTON BASCULE BRIDGE



LIFTING DECK AND LIFTING SPAN DOWN



LIFTING DECK UP, LIFTING SPAN DOWN

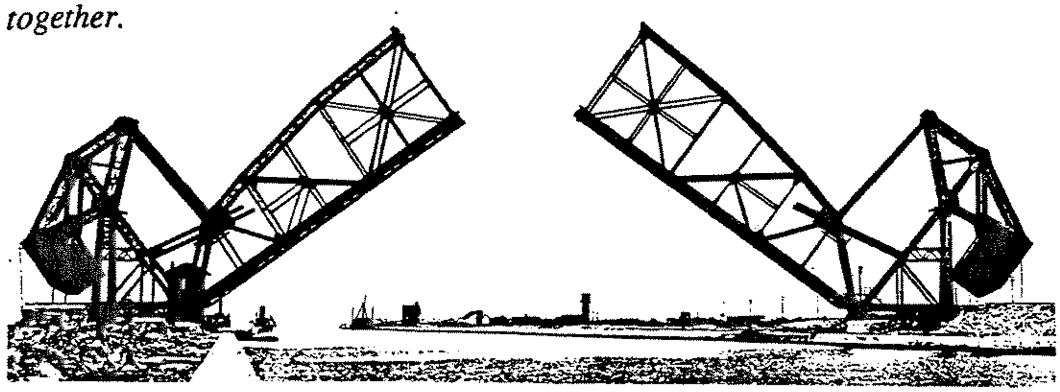


LIFTING DECK AND LIFTING SPAN UP

O & W R.R. AND N CO.'S BRIDGE OVER WILLAMETTE RIVER

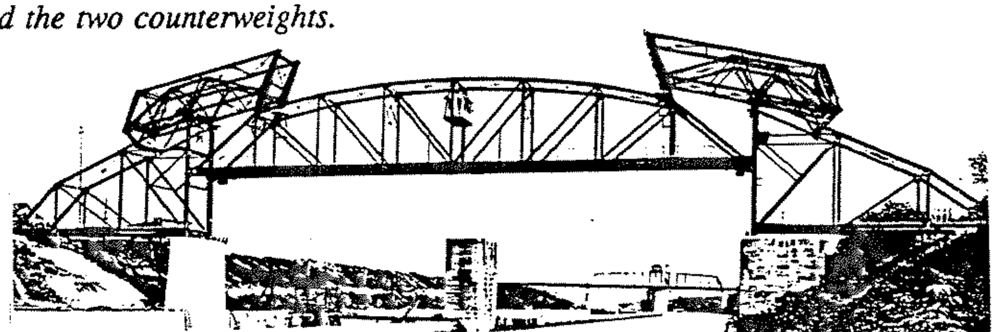
PORTLAND, OREGON

1912 *J. B. Strauss develops the Heel Trunnion Type bascule to design the longest double leaf bascule bridge in the world. The distance between the centerlines of the trunnions is 338 feet, but provides only a 282 foot channel width. The bridge forms a part of the International Railroad Bridge linking Sault Ste. Marie, Michigan to Sault Ste. Marie, Ontario. This bridge is unique in the fact that the through trusses carry moment at the centerline of span in addition to transferring shear. All double leaf bridges must transfer shear in order to keep the deflection of the end of the cantilever arms the same. The moment is transferred by providing compression plates at the ends of the upper chord. There are opposite slopes within the same group of compression plates which provides for the transfer of shear. The bottom chords have vertical tongue castings on the end of the trusses on one leaf and vertical socket castings on the end of the other leaf. The leaf with the sockets almost closes first and then the leaf with tongues almost closes allowing the tongues to slide into the sockets. Both leaves then close together.*



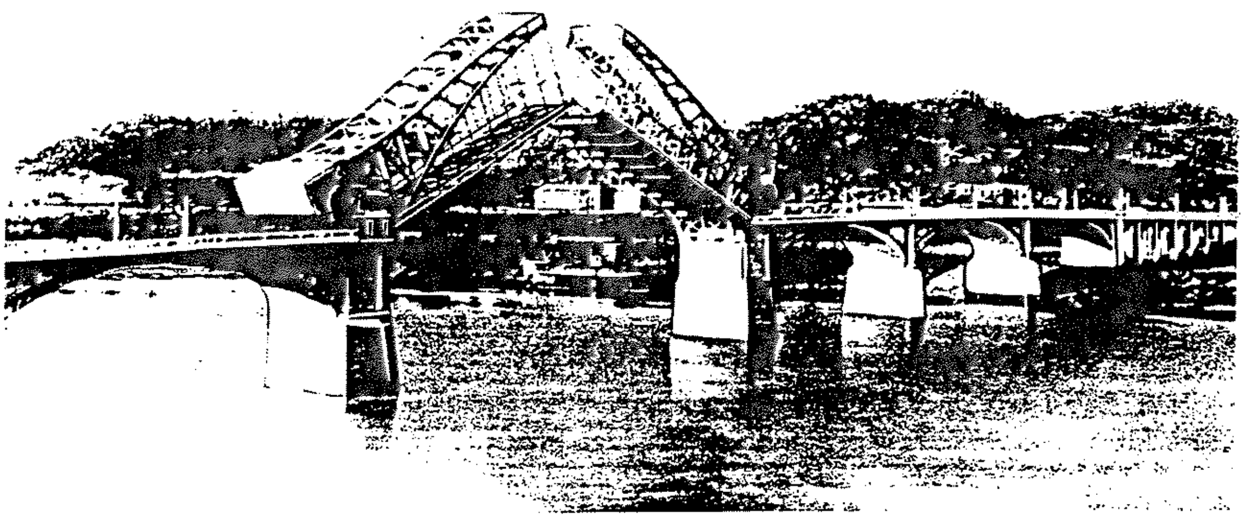
STRAUSS HEEL TRUNNION TYPE BASCULE BRIDGE.

1915 *Strauss designed a Direct Lift type vertical lift bridge which omits the need for wire ropes and sheaves. He used a system of parallelograms between the lift span and the two counterweights.*



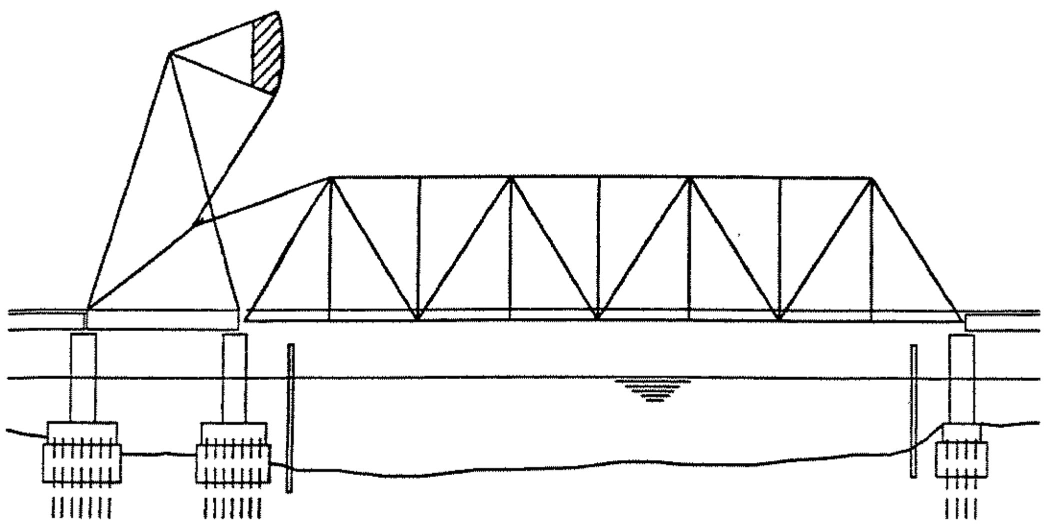
STRAUSS DIRECT LIFT BRIDGE.

1915 *Albert Scherzer, brother of William, and founder of the Scherzer Rolling Lift Bridge Company in Chicago in 1897, designed a through truss rolling lift bascule bridge with overhead concrete counterweight for the Tennessee Highway Department. The bridge was built in 1916 over the Tennessee river at Chattanooga, Tennessee. It provides a 295 foot clear channel width which the writer believes to be the "Widest Channel provided by any type of bascule bridge." This bridge is unique in the fact that when the double leaves are closed, they form a three hinged arch span. The supports on the piers provide hinged action and are 310 feet on centers, which is only 15 feet great than the channel width. The top chord provides a compression joint which also acts as a hinge. The lower chord provides the shear transfer of live loads crossing the span. It was the second longest double leaf bascule when it was built, but it is now the third longest.*

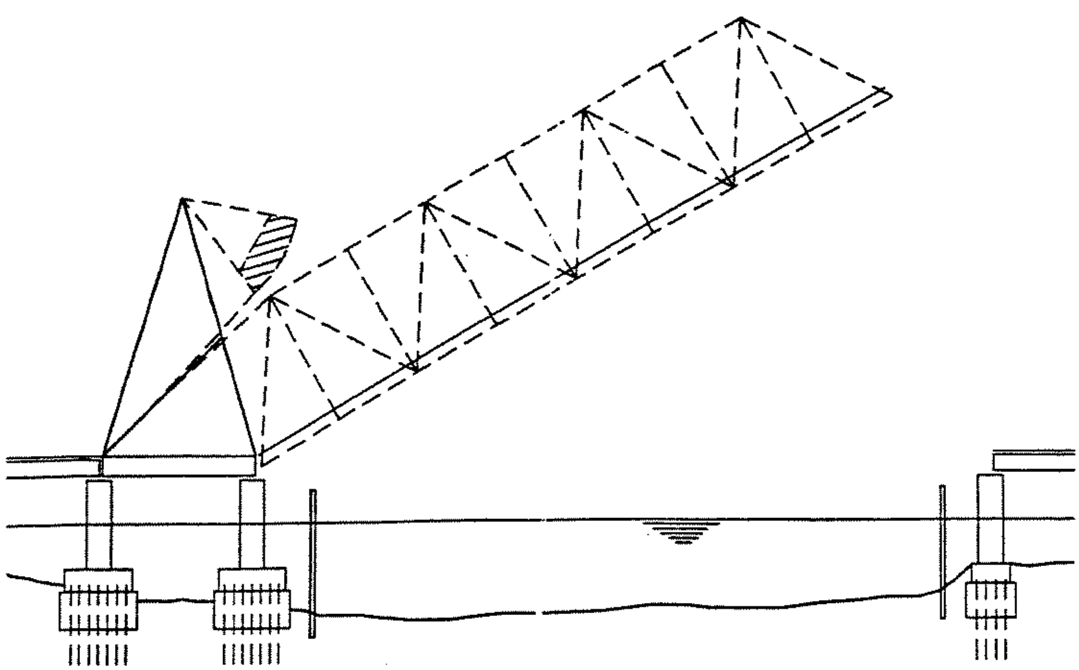


SCHERZER ROLLING LIFT BRIDGE OVER THE TENNESEE RIVER, CHATTANOOGA, TENNESSEE.

1920 *Mr. Hugo A. F. Abt developed and patented a new type of bascule bridge in which the counterweight moves in the opposite direction to the bascule leaf. The first bridge of this type was built for the Wabash Railway across the River Rouge in Detroit, Michigan. There were eight of these bridges built by the American Bridge Company for whom Mr. Abt worked. It is sometimes called the American Bridge Type.*

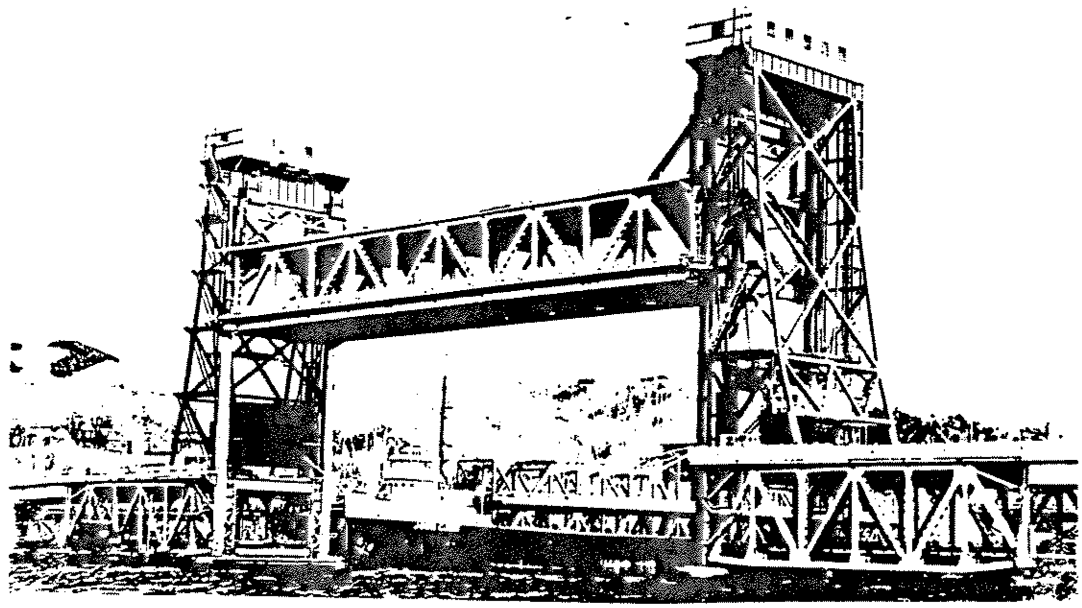


ABT TYPE BASCULE BRIDGE, CLOSED



ABT TYPE BASCULE BRIDGE, PARTIALLY OPEN.

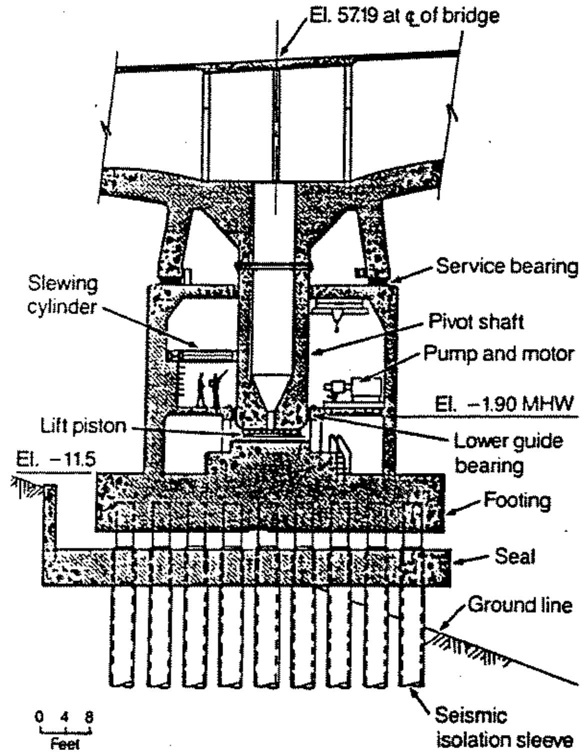
1950's *Hazelet+Erdal, Consulting Engineers, successors to the Scherzer Rolling Lift Bridge Company, designed a double deck vertical lift bridge for the Michigan State Highway Department. The bridge replaced a double deck swing span over the Portage Pass between Houghton and Hancock in Upper Michigan. When the lift span is seated on the piers, it carries a four lane divided highway on the upper level and single track railroad on the lower level.*

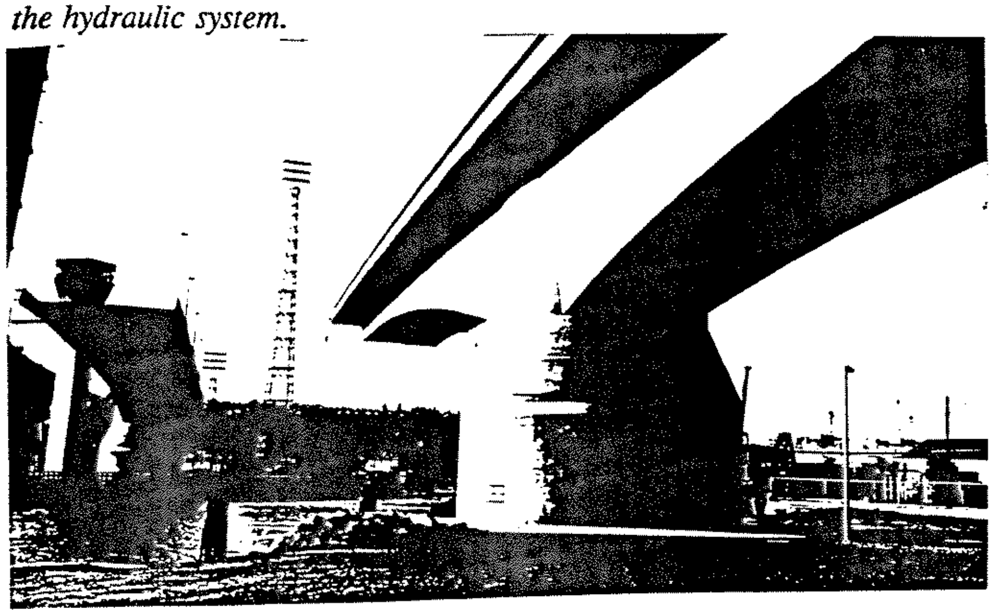


THREE POSITION VERTICAL LIFT BRIDGE
NORMALLY KEPT IN THE INTERMEDIATE POSITION.

This bridge is unique in the fact that the lift span is normally supported in the intermediate position. A four lane divided highway is also provided on the lower level, in addition to the railroad track. An inovative solution was developed to move supports into place to carry the live load of 4 lanes of highway traffic while the bridge is in this intermediate position. This intermediate position provides enough under clearance for pleasure craft to pass under the bridge. When an infrequent train approaches, the lift span is lowered down on the piers to accommodate the train on the lower level while highway traffic uses the upper level. (It is kept on the piers during the winter when the waterway is closed to navigation.) When a large lake liner approaches, the bridge is raised to the full height to provide a maximum underclearance of 90 feet. The original design was directed by H+E's A. L. Ralph Sanders. H+E also provided the design for the recent retrofit of hydraulic shock absorbers to replace the lower air buffers.

1991 *The world's first concrete dual bob-tailed swing bridge set end to end with 418 foot spans over the Duwamish River in Seattle, Washington. Each swing bridge has 240 foot long cantilever arm over the river and a 178 foot "Bob Tail" cantilevered arm. Each swing bridge has 7,500 Tons on its pivot. Hydraulic fluid raises the 9 foot diameter piston one (1) inch and two slewing cylinders with 11 foot strokes rotate the shaft and swing the span 45 degrees. The design team was headed by Andersen-Bjornstad-Kane-Jacobs, Inc. (ABKJ), Seatle. Hamilton Engineering was the consultant for the hydraulic system.*





FIRST CONCRETE DUAL BOB-TAILED SWING BRIDGE

Now that you have some of the historical facts about the Development of Movable Bridges, you, too, should <u>*REMEMBER THE PAST AND BE INSPIRED.*</u>