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The Selection and Evolution of the Chicago Type Trunnion Bascule Bridge, Historical Development of Movable Bridges, Part III

by

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THE SELECTION AND EVOLUTION OF THE CHICAGO TYPE TRUNNION BASCULE BRIDGES

HISTORICAL DEVELOPMENT OF MOVABLE BRIDGES, PART III

Prepared for:

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DEFINITION

All "Bascule Bridges" by definition, pivot about a horizontal axis to rotate one or more bridge leafs in a vertical plane, for the purpose of providing specified channel clearances, both horizontally and vertically for navigation. The trunnion type bascule bridges pivot about a fixed axis as the leafs rotates "open".

PREFACE

"Remember the Past to Inspire the Future; Historical Development of Movable Bridges" which was presented in 1994 will be referred to as Part I.

"A Century of Progress, Scherzer Rolling Lift Bascule Bridges; Historical Development of Movable Bridges, Part II pertains to another presentation being introduced this year. It relates the culimination of events that precipitated the explosion of new developments that began in Chicago circa 1890. It will focus on the development of the Scherzer Rolling Lift Bascule Bridge including the special features that are being used on current projects.

"The Selection and Evolution of the Chicago Type Trunnion Bascule Bridge"; Historical Development of Movable Bridges, Part III. This presentation will expand on the new developments that started circa 1890. It will then focus on the Chicago Type Trunnion Bascule Bridge.

DEDICATION

I dedicate Part III to my father, John A. Schultz, (Sr.)

John A. Schultz, (Sr.) was born in Kellogg, Iowa on November 17, 1882, which at that point in time was the Rock Island Railroad's western terminal. His parents lived and were married on the island of Fehmarn located in the Baltic Sea in Germany and immigrated to the United States on their honeymoon. Shortly after his birth, my grandparents moved to Davenport, Iowa staying a few years, and then moving on to the north side of Chicago where they settled in the 1300 block of Byron Street (3900 North). The City Limit at that time was Irving Park Road, only a block away at 4000 North. John Sr. was the oldest of six children. He was unable to complete grammar school because he had to work to help support the family. As he grew older, he worked in a foundry on the banks of the North Branch of the Chicago River. The first Chicago Type Trunnion was just a short distance from that foundry. He married a girl who lived a few doors away from him on the same street. Her family had lived in that house since she was five years old. She too was connected to the bridges and the river by the fact that she worked at Adams Street on the banks of the South Branch of the Chicago River within two blocks of the first and second Scherzer Rolling Lift bridges. My parents were part of a generation that witnessed the explosion and growth of new bridges that changed Chicago from a frontier town to a metropolis that attracted national and international recognition.

As for myself, I believe the stability of our family, the proximity of the bridges and river to our home and neighborhood, contributed to my desire to design these fascinating movable bridges. As it has turned out, I am now in my 50th year of designing all types of movable bridges for Hazelet & Erdal.

INTRODUCTION

This presentation will concentrate on the events that affected "The Selection and Evolution of the Chicago Type Trunnion Bascule Bridges". This evolution has been summarized from the notes made by Mr. Thomas G. Philfeldt, Engineer of Bridges, City of Chicago. The diagrams of the Chicago Type Trunnion Bascule Bridge were obtained from the 1944 ASCE Transactions, Paper No. 2226, "Development of the Chicago Type Bascule Bridge" by Donald N. Becker, Engineer of Bridge Design, Department of Public Works, City of Chicago, Illinois., pages 995 thru 1046.

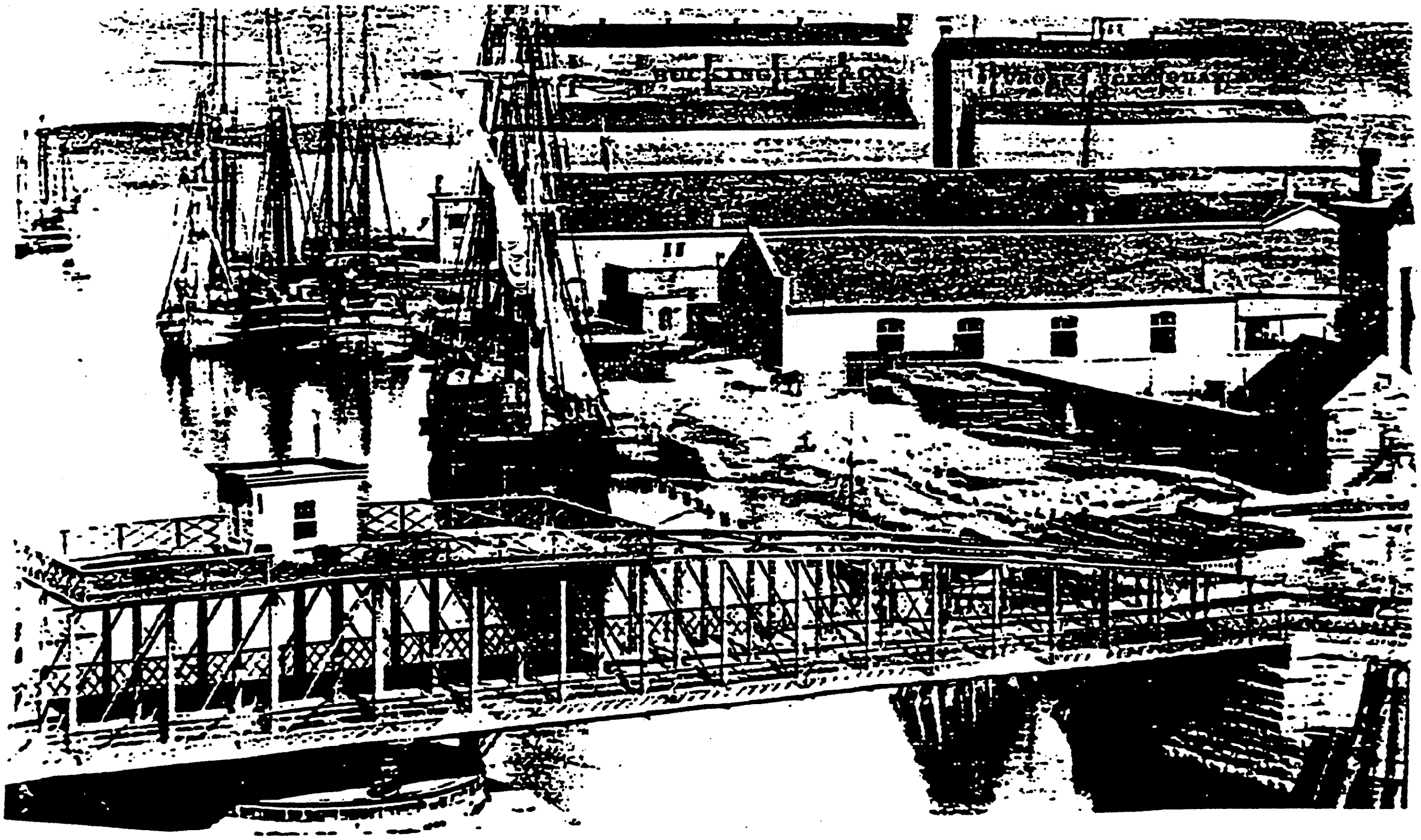
1899 - CHICAGO

The Bridge Division of the Chicago Department of Public Works under the direction of John Ericson, made a survey and critical analysis of the literature on movable bridges built in the United States and Europe. The Department had the responsibility of selecting the type of bridge that best suited the requirements needed for the Chicago and Calument Rivers. The survey showed that there were four types of movable bridges at the time. These results are summarized as follows:

Class 1 - Swing Bridge. Rotates about a vertical axis in a horizontal plane. This is the most economical class because the entire structure is utilized to carry traffic. Symetrical arm lengths about the center pivot pier essentially balance themself without the need for a counterweight. A "counterweight" is required for a "Bob-Tail Swing" when one arm is shorter than the other.

This was not the class of bridge to be used for the narrow Chicago River where a bridge was required at every street downtown. There were two major factors against its use, namely:

1. The pivot pier and the fender system required to protect the swing span in the open position were obstacles that interferred with the great number of schooners in the river trying to move up and downstream. There was very little space remaining along the shore for other schooners to dock, or unload and take on cargo.
2. The direction of flow of the south branch of the Chicago River had been reversed to prevent water in the contaminated river from flowing into Lake Michigan. The "divide" between the water flowing to the Atlantic Ocean and water flowing to the Gulf of Mexico was only a few miles west of Chicago and at almost the same elevation. The Metropolitan Sanitary District took advantage of this fact to change the directional flow of the south branch of the river by digging



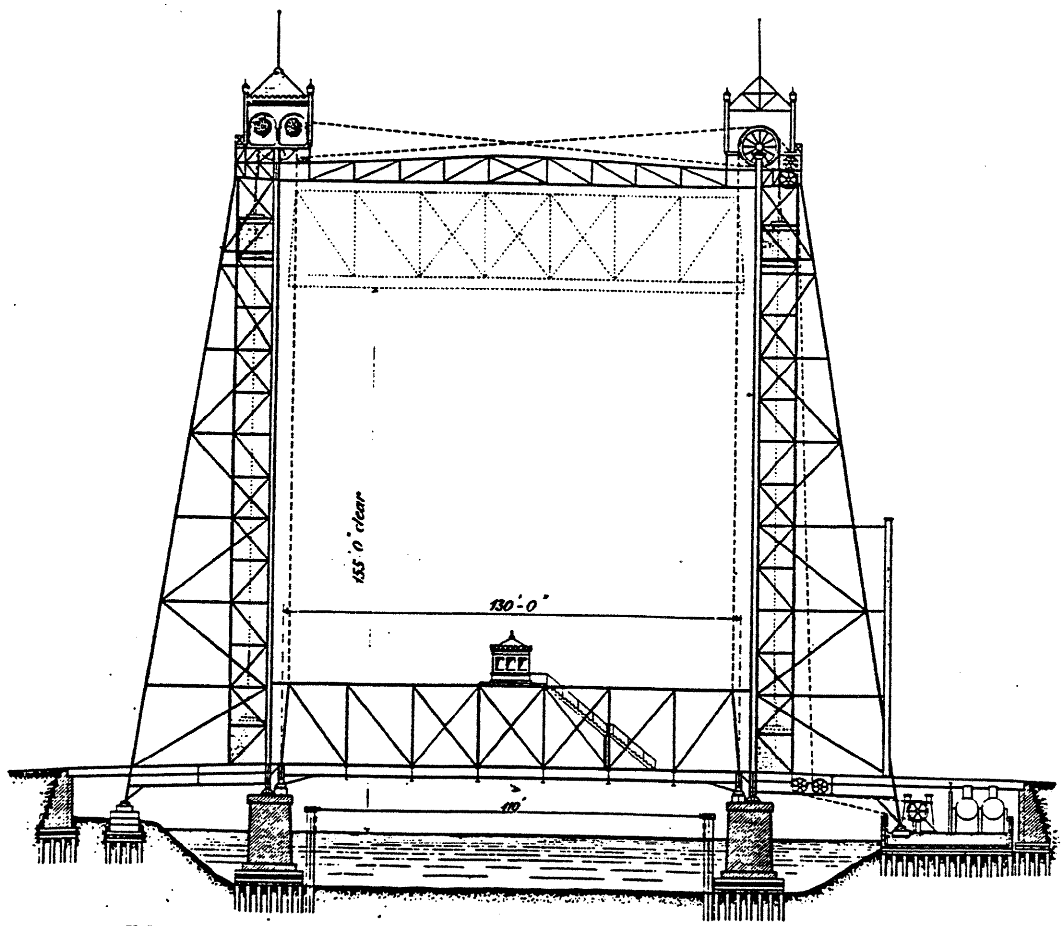
"THE FIRST IRON BRIDGE IN THE WEST." (Chicago Historical Society.)

1857 - Chicago's Rush Street Swing Bridge

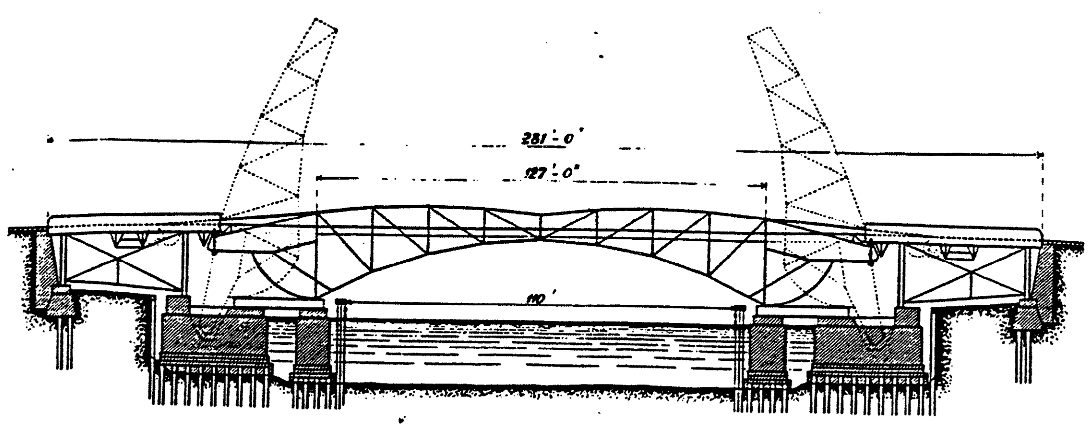
A canal parallel to the southwest direction of the river. The minimum cross sectional area was determined by the quantity of flow needed to carry the treated water from the sanitary plant.

The larger cross sectional area of the river was needed from the mouth up to the junction of the north branch and then south to the junction with the new canal.
The river did not provide the required flow area because of the clogging effect of the pivot piers and the fender systems needed for the swing bridges. The city could not afford to change over the bridges fast enough. Therefore, it was decided by the Metropolitan Sanitary District to build 14 bridges and turn them over to the City. All of the bridges that were built by the Metropolitan Sanitary District were Scherzer Rolling Lift Bridges with the exception of the Jackson Blvd. bridge which was a Strauss bridge.

Class II - Vertical Lift Bridges. The center span was lifted vertically between two towers high enough to clear schooners passing underneath. See Part I, page 17 for the first and only vertical lift bridge built across the Chicago River at South Halsted Street. Very few long span vertical lift bridges had been constructed at that point in time. The initial cost and the cost of maintenance were both very high. There was also the possibility of danger to both street and river traffic.



SOUTH HALSTED ST. CHICAGO. DIRECT LIFTING BRIDGE.



NORTH HALSTED ST. CHICAGO, SCHERZER ROLLING LIFT BRIDGE.

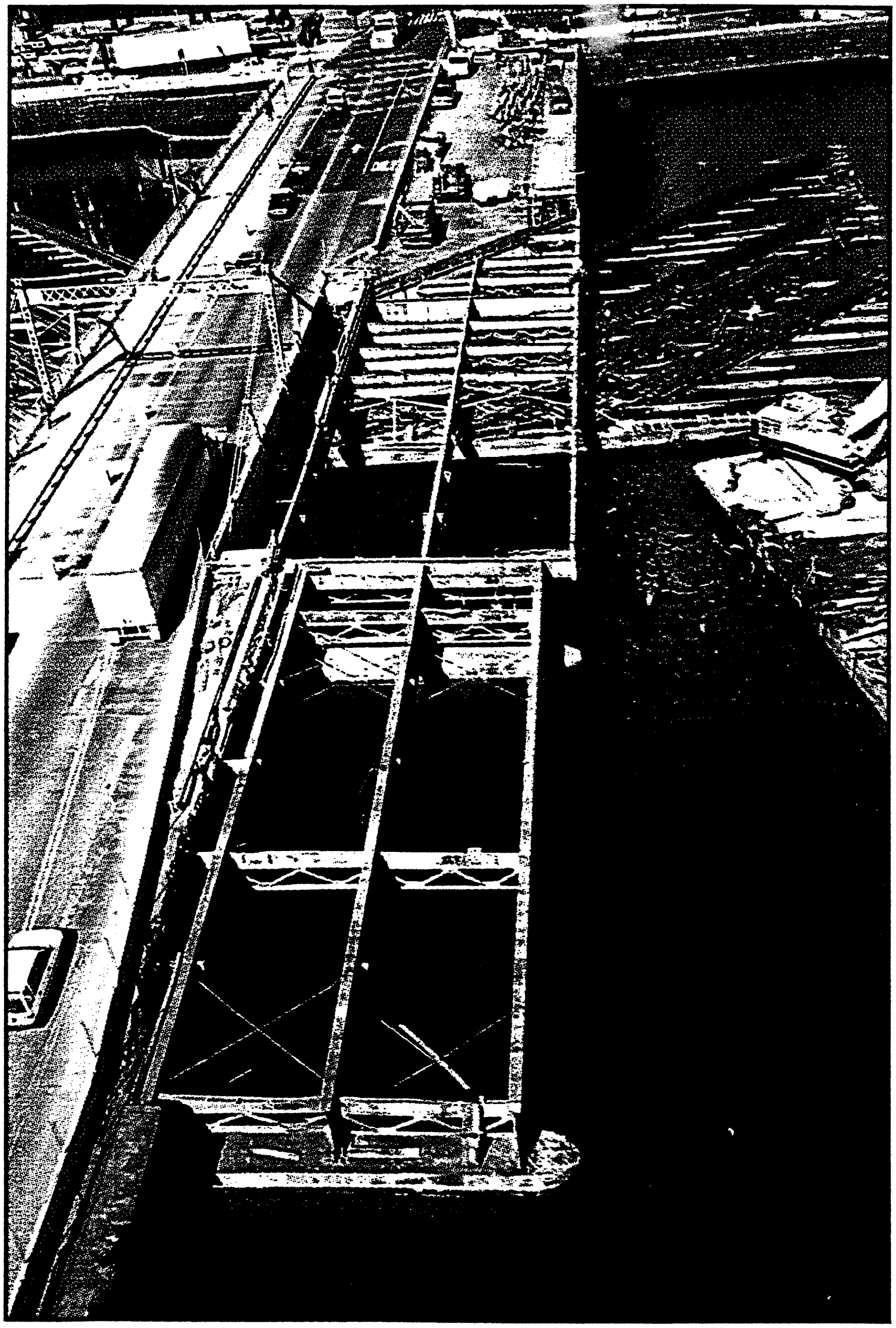
Class III - Horizontal Rolling or Retractable Bridges. These bridges rolled back away from the channel as they translated open. See Part I, page 2 for the introduction to this type of retractable bridge that rolled straight back as part of a fortification in Europe, circa 1350. The "Oblique Retractile Drawbridge" retracts at a 45° angle. It was introduced in Boston, MA circa 1855 where it was developed and primarily used. The Summer Street oblique retractive bridge was built in 1899 and represents the culmination in the evolution of this little known bridge type. An article on the replacement of the superstructure and renovation of the substructure was featured in the February, 1996 issue of Modern Steel Construction. The article stated that "the bridge is the only known surviving example of an electrically operated, paired leaf, oblique retractile drawbridge". As seen in the photo from the article, one of the twin bridges was kept in operation while the other was being rehabilitated. The structure needed for the movable span to retract onto is shown along the outside of the bridges behind the fender system. This class was even less in use than Class II. This class of bridge required considerable space along side of the abutment to provide for the bridge roll at approximately 45° angle back away from the channel. (See Picture with one half being rehabilitated.)

Class IV Bridge Rotating in a Vertical Plane. This class was comprised of two groups those that revolved on moving horizontal axis and those that revolved on a stationary horizontal axis.

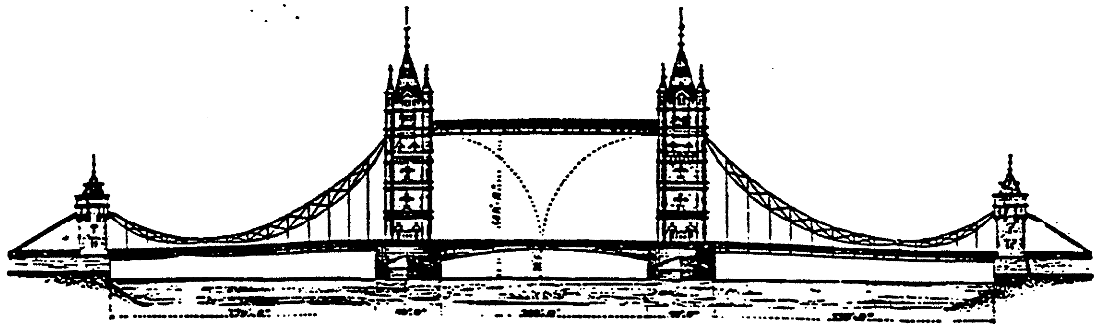
The first group was comprised of the Scherzer Rolling Lift bridge (see Part I, Page 18 and all of Part II) which had the center of gravity rotating and moving back away from the channel in a horizontal plane and the Schinke bridge. The bascule bridges that were in operation at the time of the survey were the following:

Built	Location	Type	Designed By:
1891	Weed Street	Folding Lift	Harmon
1893	Canal Street	Folding Lift	Harmon
1895	Van Buren Street	Rolling Lift	Scherzer
1895	Metropolitan R.R.	Rolling Lift	Scherzer
1897	North Halsted (River)	Rolling Lift	City Bridge Dept.

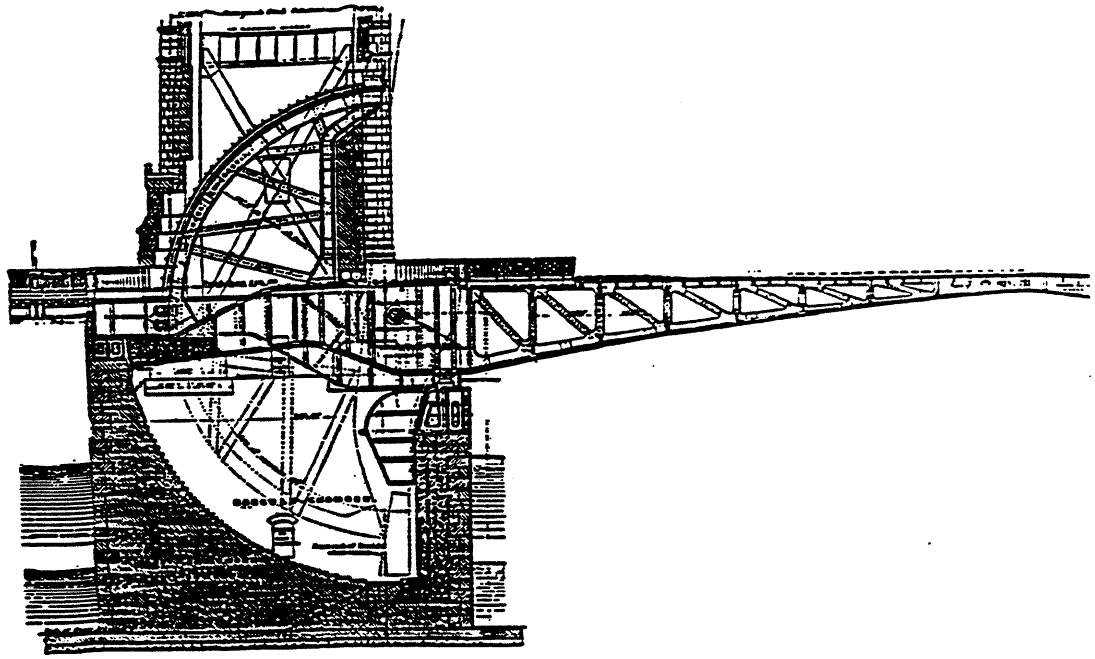
The second group belonged to the various old fortress bridges of which there were many in Europe. The Tower Bridge in London, completed in 1894, was the largest example of this type of bridge in existence. The survey study showed a further subdivision in regard to the counterweight location and application.



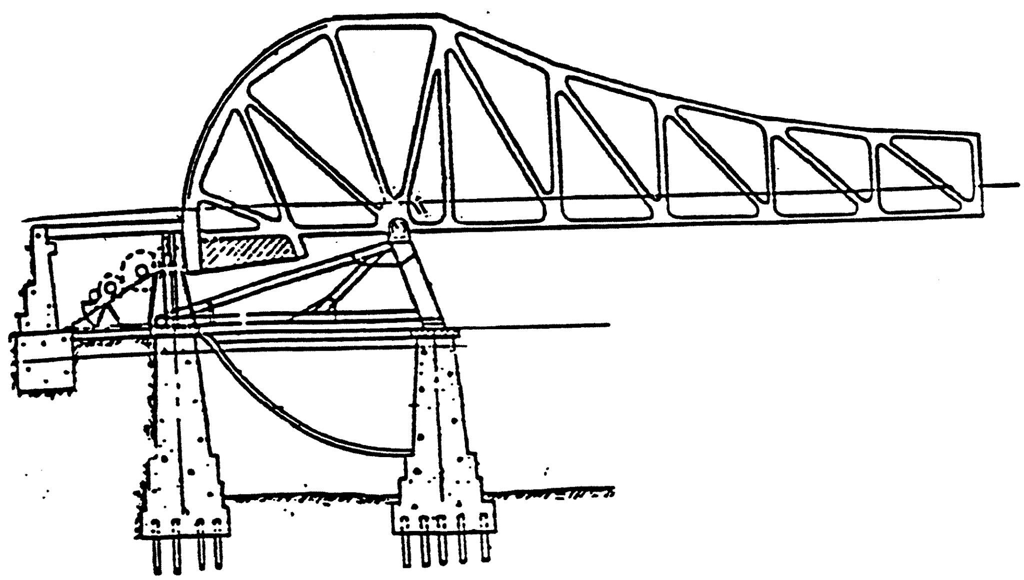
The Summer Street Bridge was kept open to both pedestrian and vehicular traffic during renovation, all of which was staged from barges.



TOWER BRIDGE OVER THAMES RIVER IN LONDON, ENGLAND.



DOUBLE LEAF BASCULE - HALF LONGITUDINAL SECTION



LONGITUDINAL SECTION ON CENTERLINE OF BRIDGE.
FIRST CHICAGO TYPE TRUNNION BASCULE BRIDGE.

Survey Conclusions - A Comparison Between these Two Groups of Bascule Bridges:

Stability against Wind.

All bascule bridges required only a small force to overcome friction compared to the size of the motor required to move the leaf against the horizontal wind load as it approaches the fully open position. The Schinke Bridge was the only one that required less power since the exposed roadway is 15 to 50% smaller. The Tower Bridge in London was designed for a 56 pound per square foot wind force because of the accident to the "Tay Bridge". That force was equivalent to a wind velocity of 105 miles per hour. This resulted in a 370 HP motor due to the heavy structure and machinery. Normally, the machinery for bascule bridges can be made lighter than for other types of bridges.

Foundation.

The 1899 investigation determined that the trunnion bridge with fixed points of load application required less expensive foundations. With the Scherzer type, the "points of application" of the entire load of the moving leaf" changes continuously and in combination with the wind pressure, has a very severe action on the foundation. "If the foundation has not been built of extraordinary large dimensions, at increased expenses, it develops a wagging motion as the Halsted Street bridge over the North Branch of the Chicago River clearly demonstrates."

Author's Note - This bridge was designed by the City engineers. The survey did not comment on William Scherzer's design of the first two Rolling Lift Bascule Bridges, namely, Van Buren Street (1895) and the Metropolitan West Side Elevated Railroad Bridge adjacent to Van Buren Street (1895).

Opening in Roadway.

"The bascule bridge with a stationary axle has an added advantage, that the break in floor can be easily located so that during the opening or closing operations, dangerous openings in the road are avoided and no part of the moving span moves or slips over the stationary end of the approach. "Neither the Schinke nor the Scherzer type has this advantage. During the operation of those bridges, either a dangerous gap exists temporarily or a part of the moving roadway surface has to move over a part of the approach roadway which ordinarily is crowded with traffic".

Author's Note - This was before the use of traffic gates across the roadway and sidewalks.

Three designs were prepared by the City, differing in appearance, method of mounting etc., but all involved the principle of revolving on a fixed trunnion. The three designs were then submitted to a Board of Consulting Engineers consisting of E. L. Cooley, Ralph Modjeski and Byron B. Carter.

Quoting from the Report of the Board of Consultants:

> "The principle of the trunnion bearing meets with our approval as a very simple solution of the problem, the chief advantages being the constant point and direction of application of the load on the foundation, whether the bridge is in motion or stationary, and the reduction of the number of moving parts to the minimum. The first advantage is of no great consequence if the piers are placed on an unyielding foundation, but with such foundations as can be obtained in Chicago at the majority of bridge sites, it is of great importance. The trunnion type of bridge used in these designs is and old and tried device, and is not covered by patents."

The Board selected the Clyborn Place design and made several recommendations one of which stated "that adjustable resting blocks be placed in front of, and near, the trunnions so that when the draw was being closed, the load could be transferred from the trunnions to the resting blocks. This facilitated the lubrication and practically eliminated the starting friction of the trunnions. To meet all possible conditions of wind and incidental changes in the position of the center of gravity, pawls or heel locks were used with the resting blocks. They were capable of lifting the tail ends and holding them firmly against the anchorage. This arrangement was also claimed to facilitate the overhauling and adjustment to the trunnion bearings"

Clyborn Place was the first of a long series of Chicago Type Trunnion Bascule Bridges. It was completed and opened to traffic on May 29, 1902. See Part I, Page 21.

Thomas G. Philfeldt was the Bridge Engineer during most of the development of the Chicago Type and had the able assistance of Alexander Von Babo and Hugh E. Young. The progressive stages of the development (as explained in Mr. Philfeldt's notes for a presentation) have been grouped into five types as follows:

Chicago Type I

The trunnion bearings, two for each bascule truss, were supported on box girders, one on each side of the truss extending from the front, or the river pier to the back wall of the pit. The counterweight consisted of cast iron and was confined within the truss. The top chord of the rear arm was shaped as a quarter circle and formed, in effect the operating rack. The machinery was placed in a space in back of the pit in order to have the operating pinions engage the rack. (See Figure).

The following bridges are of this type:

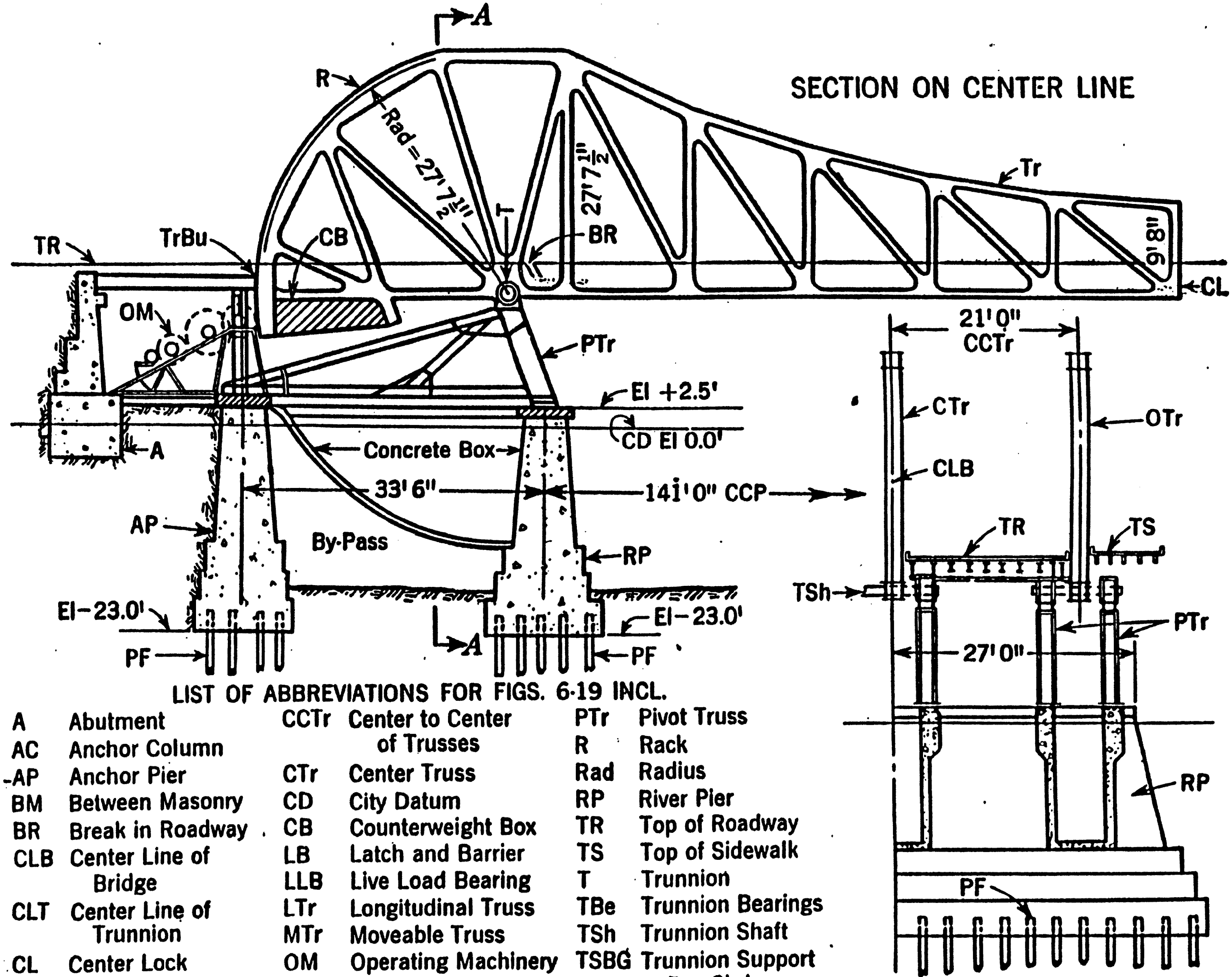
Clyborn Place, (later named Cortland Street Bridge), D.L.	1902
95th Street Bridge, D.L.	1903
West Division Bridge (Canal Crossing), D.L.	1903

Chicago Type 2

The trunnion bearings are supported on two triangular or inverted A frames or girders extending from the front or river pier to the back wall of the pit. Less expensive concrete was introduced for the counterweight material in place of the cast iron blocks used with Type I. This required the rear ends of the trunnion trusses being carried up high enough so that the counterweight may extend from one bascule truss to the other, passing under the two inside trunnion trusses. The shape of the bascule trusses and the location of the machinery is the same as in Type I.

The following bridges are of this type:

West Division Bridge (River Crossing),D.L.	1904
North Western Avenue Bridge (River Crossing), D.L.	1904
Archer Avenue Bridge, S.L.	1906
North Avenue Bridge, D.L.	1907
North Halsted Street Bridge (Canal Crossing), D.L.	1908
Kinzie Street Bridge, S.L.	1908
35th Street Bridge, S.L.	1914

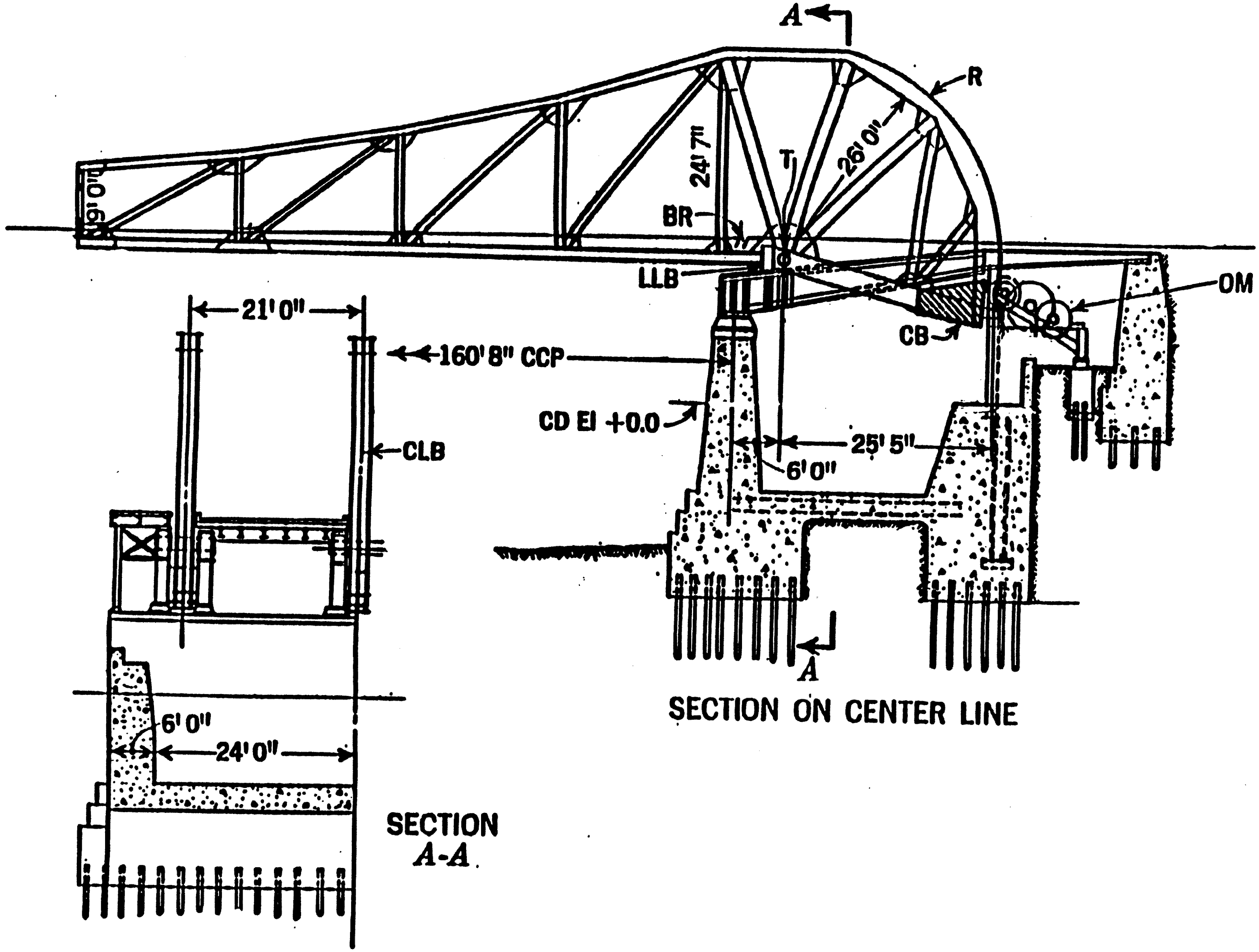


SECTION A-A

LIST OF ABBREVIATIONS FOR FIGS. 6-19 INCL.

A	Abutment	CCTr	Center to Center of Trusses	PTr	Pivot Truss
AC	Anchor Column			R	Rack
AP	Anchor Pier	CTr	Center Truss	Rad	Radius
BM	Between Masonry	CD	City Datum	RP	River Pier
BR	Break in Roadway	CB	Counterweight Box	TR	Top of Roadway
CLB	Center Line of Bridge	LB	Latch and Barrier	TS	Top of Sidewalk
		LLB	Live Load Bearing	T	Trunnion
CLT	Center Line of Trunnion	LTr	Longitudinal Truss	TBe	Trunnion Bearings
		MTr	Moveable Truss	TSh	Trunnion Shaft
CL	Center Lock	OM	Operating Machinery	TSBG	Trunnion Support Box Girder
CCP	Center to Center of Piers	OS	Operating Strut		
		OTr	Outside Truss	Tr	Truss
		PF	Pile Foundation	TrBu	Truss Bumper

—West Division Street Canal Crossing (1903)



—West Division Street River Crossing (1904)

Chicago Type 3

The bottom chord is curved giving the general effect of an arched truss, while the top chord does not extend much above the top of the railing.

The bridge leaves are opened by means of operating struts, pin connected to the trusses and engaged by a gear train located back of the pit as in types 1 & 2. There was only one of this type built.

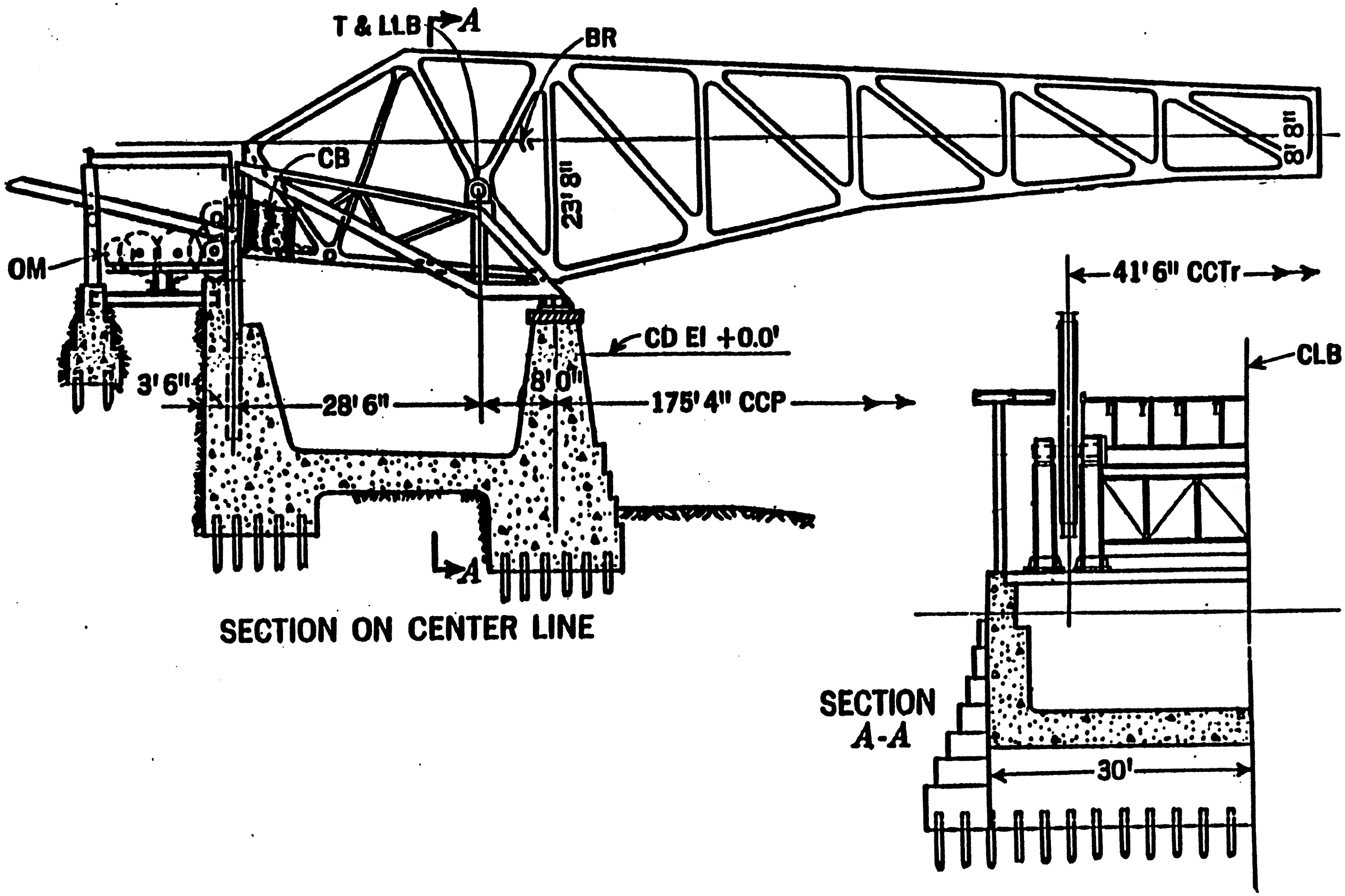
Erie Street Bridge, D.L.	1910

Chicago Type 4

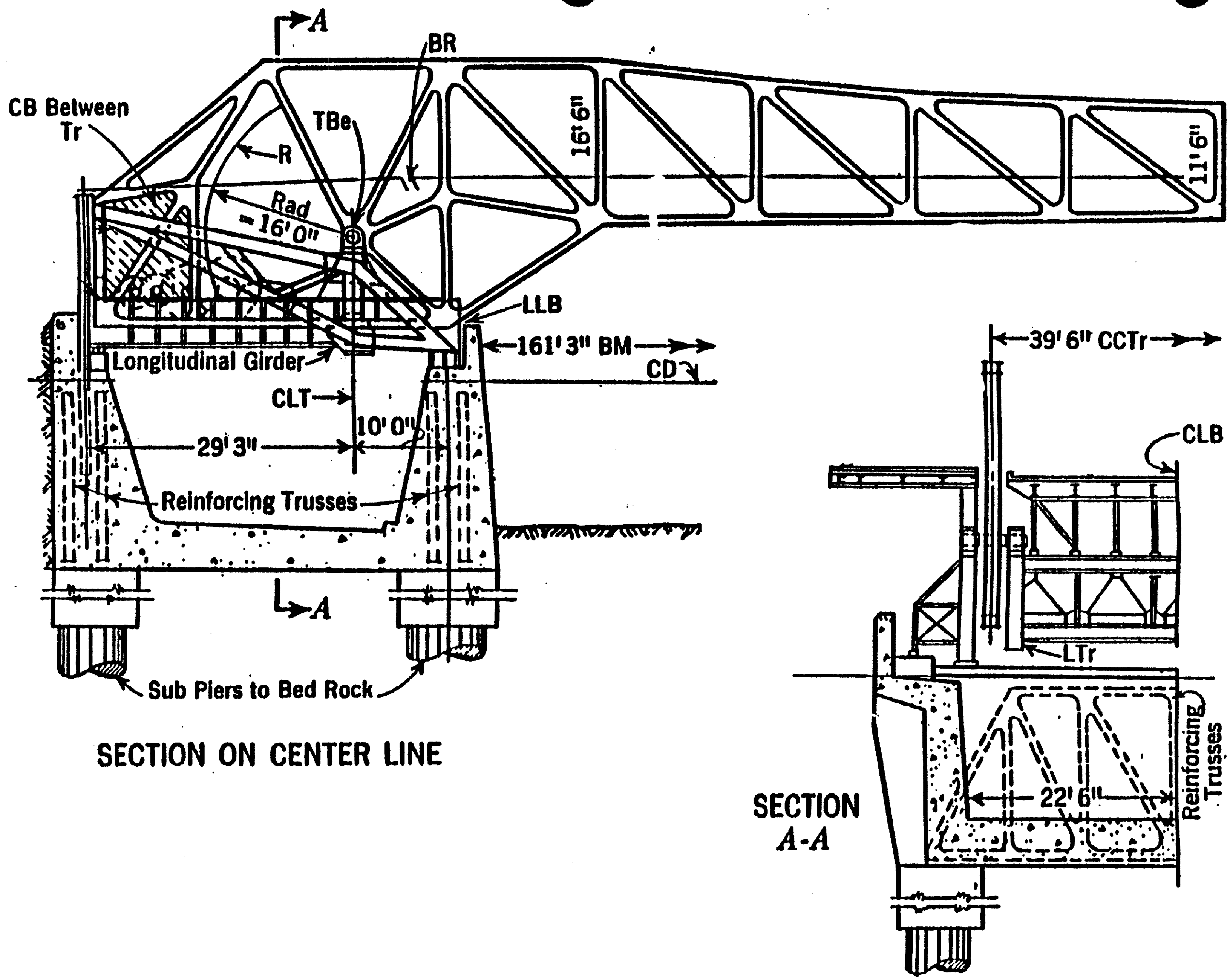
The arrangement of the counterweight and general outline of the inside trunnion trusses is the same as in 2 & 3, but the outside trunnion bearing is supported on a horizontal box girder extending from the front or river pier to the back wall of the pit. The rack is confined within an opening in the truss and is concave while the machinery is in two compact units located on the outside of the trusses. It is supported directly on top of the outside trunnion girder referred to above and a machinery girder parallel to, flush on top with and securely braced against the trunnion girder.

The following bridges are of this type:

Chicago Avenue Bridge, D.L.	1914
Webster Avenue Bridge, D.L.	1916
Belmont Avenue Bridge, D.L.	1917



—West Erie Street (1910)



—West Chicago Avenue Bridge (1914)

Chicago Type 5

Type 5 differs from Type 4 in one respect, that the inside trunnion bearing is supported on a cross girder extending through the opening in the bascule truss referred to above and therefore no inside trunnion girder or truss are needed. There are two modifications of this type:

A. The outside trunnion girders span freely from the front or river pier to the back wall of the pit and support not only the outside trunnion bearing but the end of the cross trunnion girder as well. The following bridges are of this type:

Washington Street Bridge, D.L.	1913
92nd Street Bridge, D.L.	1914
Jackson Boulevard Bridge, D.L. (which was built for the Sanitary District of Chicago. Similar to 5A except that the rack is bolted to the outside face of the truss).	1916
Lake Street Bridge, D.L. (Double Deck-Roadway & "L" Tracks)	1916
Monroe Street Bridge, D.L.	1919
Franklin - Orleans Street Bridge, D.L.	1920
Wells Street Bridge, D.L. (Double Deck - Roadway & "L" Tracks)	1922

B. The outside trunnion girder is eliminated or is replaced with a smaller girder serving as a machinery support and the load on the outside trunnion bearing as well as the reaction from the cross trunnion girder is carried down into the sub-pier located directly under the sidewall of the pit at this point. The following bridges are of this type:

Michigan Avenue Bridge (Twin Double Leaf with Double Roadway Decks)	1920
Madison Street Bridge, D.L.	1922

Chicago Type 5A

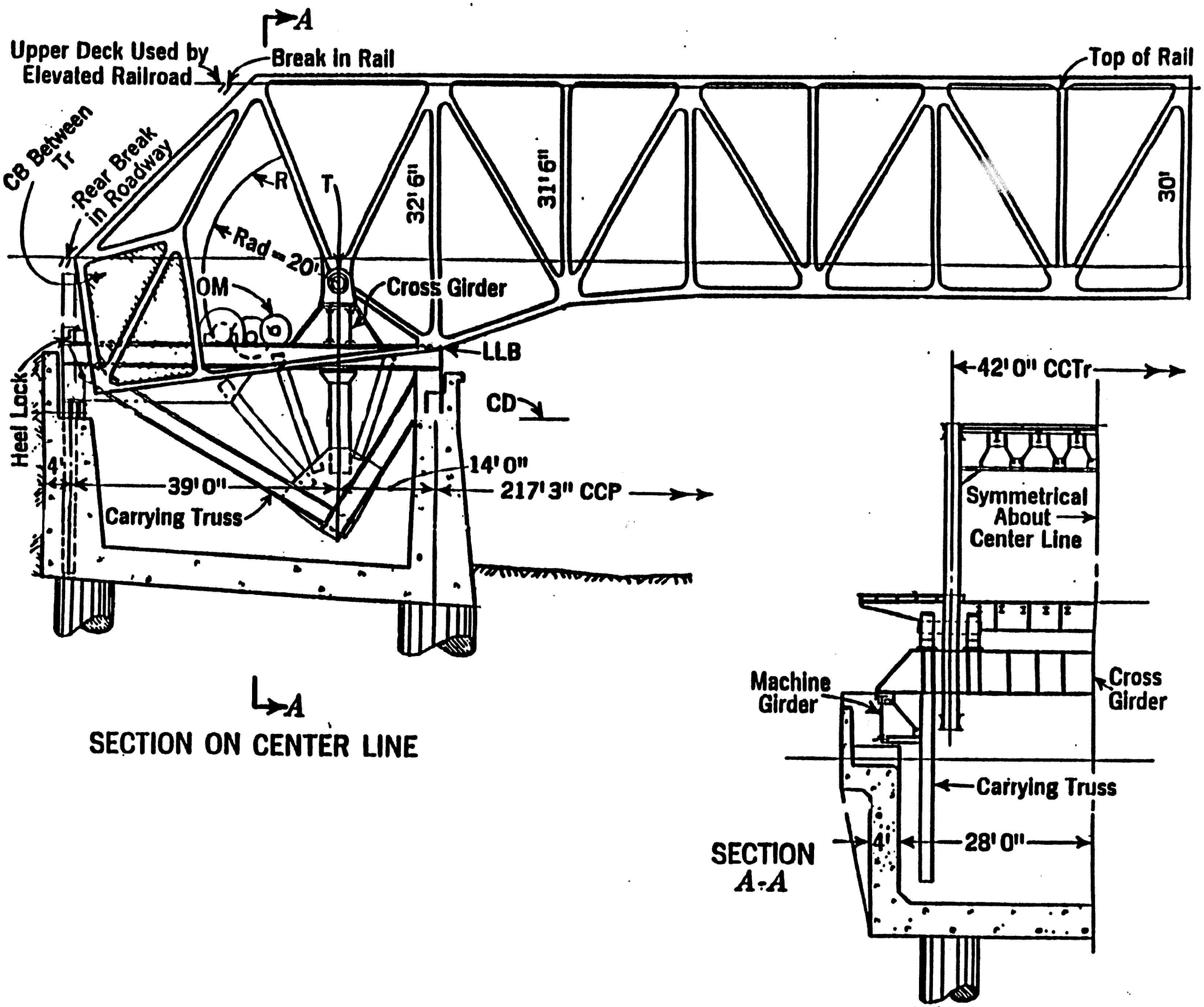
Washington Street Bridge marked a further advance in the development of the Chicago Type. The feature of the internal rack was originated and patented by Mr. A. Von Babo, former Engineer of Bridge Design, City of Chicago. The method of supporting the trunnions on a cross girder was also introduced. However, the Strauss Bascule Bridge Company claimed that the City was infringing on their patent for the cross girder that was filed in 1901 in connection with their Cuyahoga River Bridge. The judicial decision to uphold Strauss's claim was a surprise to the engineering profession, in view of this rather old method of support as shown in the Tiber River Bridge built in 1899.

The inside and outside trunnions are carried on a cross girder which spans the pit transversely (extending through the trapezoid opening of the counterweight arm trusses) and rest on longitudinal girders which span the pit longitudinally, outside of the moving leaf.

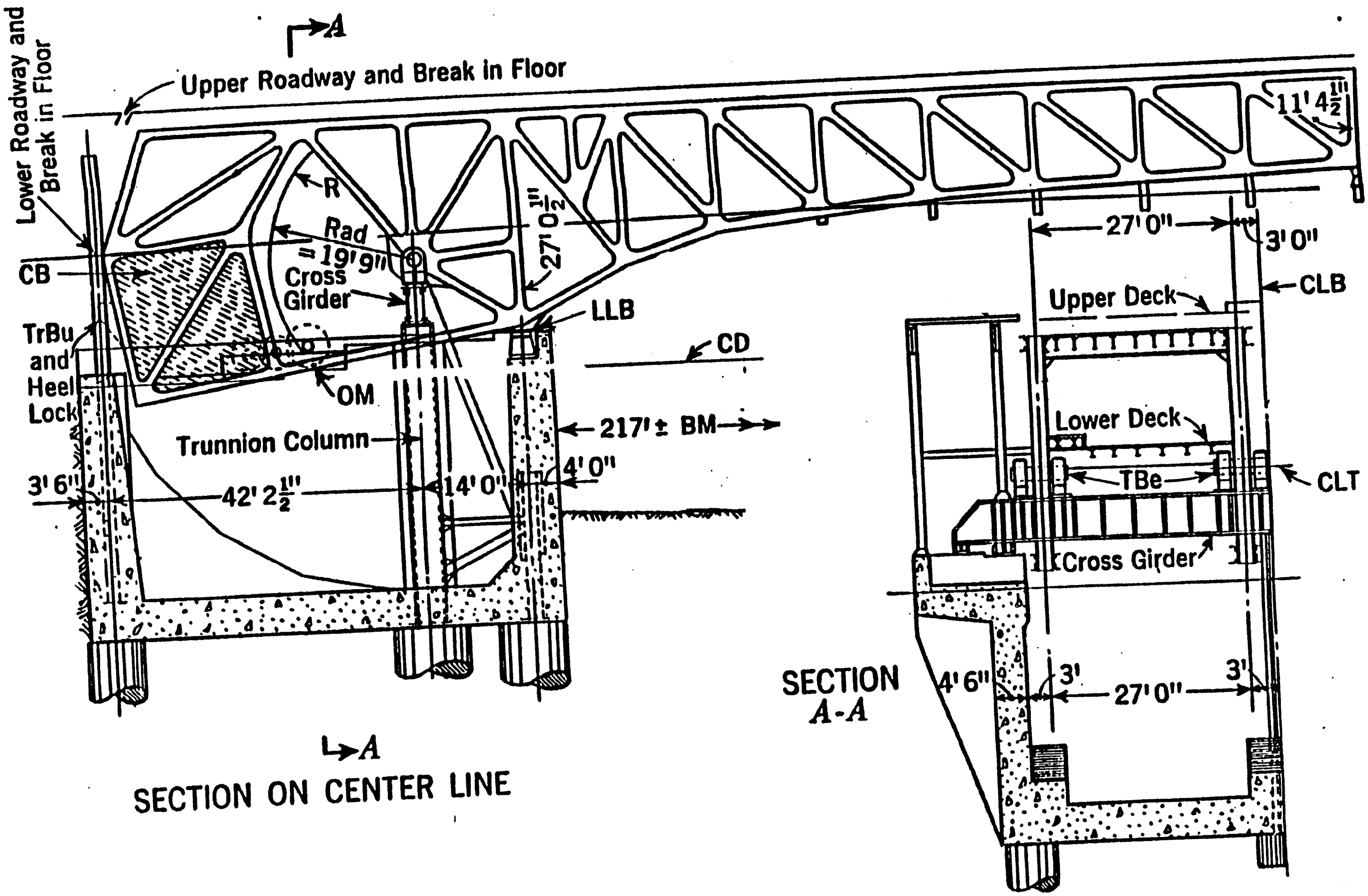
The Lake Street and Wells Street Bridges represent further development of the Chicago Type 5A. Both of these bridges are double-deck, double leaf, trunnion bascule bridges. The upper deck carries two elevated railroad tracks and the lower level carries the street traffic. The structural, mechanical and electrical are generally the same as described herein for the Washington Street Bridge. However, the second deck required that the break in the floor of both decks be located back of the trunnion. This made it necessary to provide rear locks to take the live load reactions back of the trunnions. The rear locks were designed to force the movable leaf against their bearings, so that no vibration can be detected during the passage of either elevated trains on the upper deck or trucks and streetcars on the lower deck or both.

Chicago Type 5B

The Michigan Avenue Bridge is a modified form of the Washington Street Bridge with respect to the trunnion supports. The trunnions are carried by cross girders directly to the sidewalls of the pit of the main pier instead of to a longitudinal girder. There are two levels of roadway, the top deck carries the "Avenue" traffic while the lower level carries commercial traffic. The lower level runs from Grand Avenue (an underpass) on the north side of the river to lower Wacker Drive on the south side. The two directions of traffic on the lower level are separated by two trusses, one on each side of a longitudinal split down the center of the bridge. The bridge has a median with a railing on each side of the center split to make it a twin double leaf, double deck trunnion bascule bridge. A transverse shear lock is provided to require the twin leaves to operate together when it is engaged but they can be easily separated. These features make the Michigan Avenue Bridge the largest of its kind in the world.



—West Lake Street Bridge (1914)



—North Michigan Avenue Bridge (1920)