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Wells Street Bridge, Just Opened (See Page On

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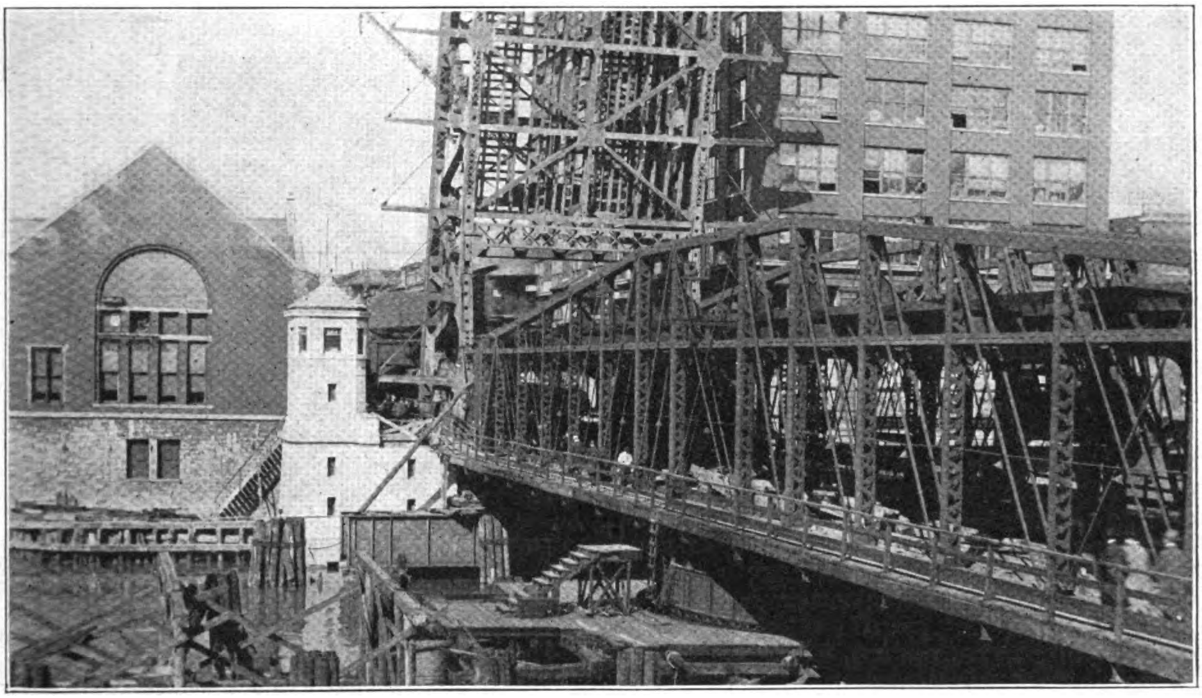

Fig. 1.—View of Old Steam Operated Swing Bridge at Wells Street, Chicago, Showing North Leaf of New Bascule Bridge Being Erected Without Interruption of Elevated Railway Traffic Over Old Structure.

Wells Street Bridge Construction

Building of Chicago's New Double-Leaf, Double-Deck, Trunnion Bascule Bridge Presented Many Unusual Problems — Traffic Maintained Over Old Swing Bridge During New Construction

By R. F. IMLER

Of the many notable achievements of the Department of Public Works of the City of Chicago the most recent is the completion of the Wells street bridge. This newest of Chicago's bridges was lowered and put in operation on Dec. 4, 1921. Its completion is the latest chapter in a long history of bridge construction at the Wells street crossing which is one of the most important thoroughfares connecting the north and south sides of the city. The first bridge constructed on this site was a pontoon bridge built in 1841. In 1849 the floating bridge was swept away by flood and ice.

For the following 7 years there was no bridge over the river at this crossing, but in 1856 a hand-operated wooden swing span 190 ft. in length was erected.

This bridge served the growing city until 1871 when it was destroyed in the great Chicago fire. Following its destruction, another hand-operated iron swing bridge was constructed and was in service at Wells street until 1888 when it was moved to the Dearborn street crossing. In 1888 a steam-operated, steel-swing bridge 220 ft. in length and 59 ft. in width was built. In 1896 this steam operated bridge was reinforced to permit the passage of the Northwestern Elevated railroad trains over its upper deck.

In 1916 the old bridge, which was originally designed for light vehicular traffic, was proving totally inadequate for its additional burden of elevated railroad traffic, giant motor trucks and street cars of greatly increased size and weight. The old swing bridge is shown in Fig. 1 which is a view of the Wells street crossing at the time the new bascule bridge was under construction. At the extreme left of the illustration can be seen the north leaf of the new bridge in course of erection.

After it had become evident that replacement of the old bridge was necessary there was some time consumed effecting a conciliation of the various interests involved before the first steps could be taken in the design and erection of a new bridge. The elevated railway company by the terms of its franchise over the bridge was required to bear one-third of the cost of construction, the city of Chicago bearing the other two-thirds. It was necessary to meet the requirements of the Government as the Chicago river is a navigable stream and as such is under Federal control. After all interested parties had agreed on the type and expenditure involved, a Federal permit for the construction of a new bridge was granted on July 13, 1916.

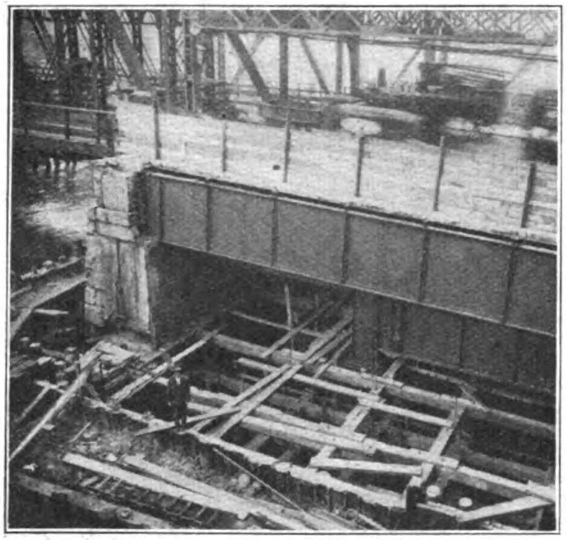

Fig. 2.—View of Excavation for Tail Pit, Showing Cofferdam and Cofferdam Bracing.

GENERAL DESCRIPTION OF BRIDGE.

The bridge constructed was designed by Hugh E. Young, engineer of bridge design of the City of Chicago. It was designed under the supervision of Thomas G. Philfeldt, engineer of bridges, John Ericson, city engineer, and Frank I. Bennett, Commissioner of Public Works. The new bridge is a double-leaf, double-deck, trunnion bascule, built and operated under license from the Strauss Bascule Bridge Co. It is the heaviest and longest two-truss bridge in Chicago. It is designed to carry street railway, vehicular and pedestrian traffic on its lower deck and elevated railway traffic on its upper deck. The overall length of the steel structure from abutment to abutment is 385 ft. The distance from center to center of trunnions is 268 ft. The width of the bridge overall is 72 ft. From face to face of piers is 231 ft., allowing a clear channel of 220 ft. The total weight of each leaf, including counterweight, is 2500 tons.

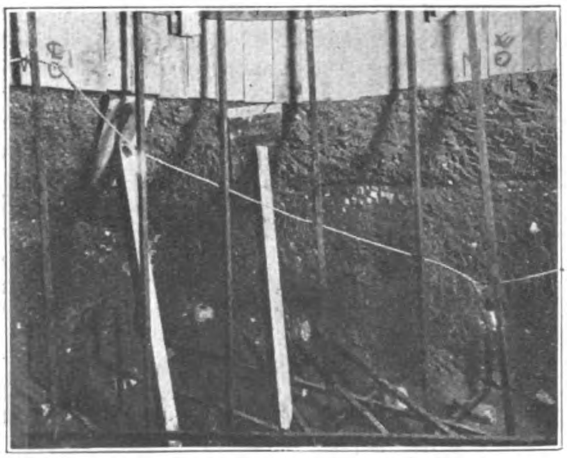

Fig. 3.—Excavation for Base of South Trunnion Sub-Pier.

KEEPING OLD BRIDGE IN SERVICE COMPLICATES NEW CONSTRUCTION.

Replacing of center pier bridges by those of the bascule type is a part of a fixed plan established in Chicago by the Government in 1909. In accordance with that policy a similar bascule bridge had been constructed at Lake street, and experience gained through the design and construction of the latter bridge is largely responsible for the complete success of the Wells street undertaking.

The most serious difficulties which were encountered in the erection of Wells street bridge, as well as the Lake street structure, were occasioned by the necessity of constructing the new bridge without blocking or obstructing traffic on the old structure. Wells street is one of the principal business arteries of the city and all of the elevated railway traffic crossing from north to south sides of the city does so over this bridge. Traffic over bridges in the downtown district of Chicago assumes enormous proportions and even temporary cessation of bridge service at any point results in congestion at other crossings. The enormous volume of traffic over one of these bridges is indicated by a traffic count covering a 12-hour period from 7 a. m. to 7 p. m. Such counts are made semi-annually at all bridges and recently averaged 850 teams, 1130 automobiles, 1000 motor trucks, 1050 street railway cars, 7000 pedestrians and 1000 elevated trains in the 12-hour period. In addition to caring for this traffic the bridge is open for river traffic about 30 times in the same period.

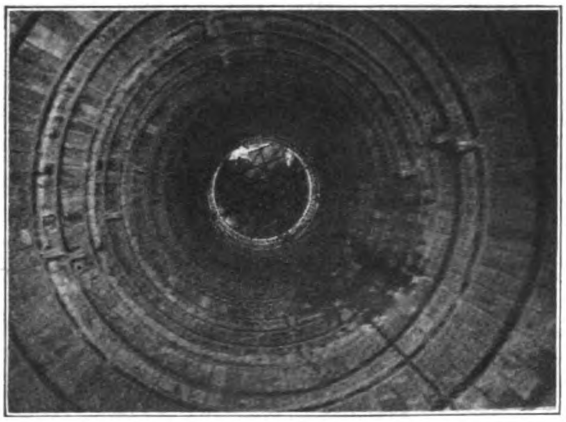

Fig. 4.—View Looking Down Sub-Pier Well Before Concrete Was Poured.

CONTRACTORS AND ENGINEERS.

Construction of the bridge at Wells street was performed under four major contracts. The substructure was built by Fitz Simons & Connell Dredge & Dock Co., Chicago. Kettler-Elliot Co., Chicago, one of the most competent and completely equipped steel erecting firms in the middle

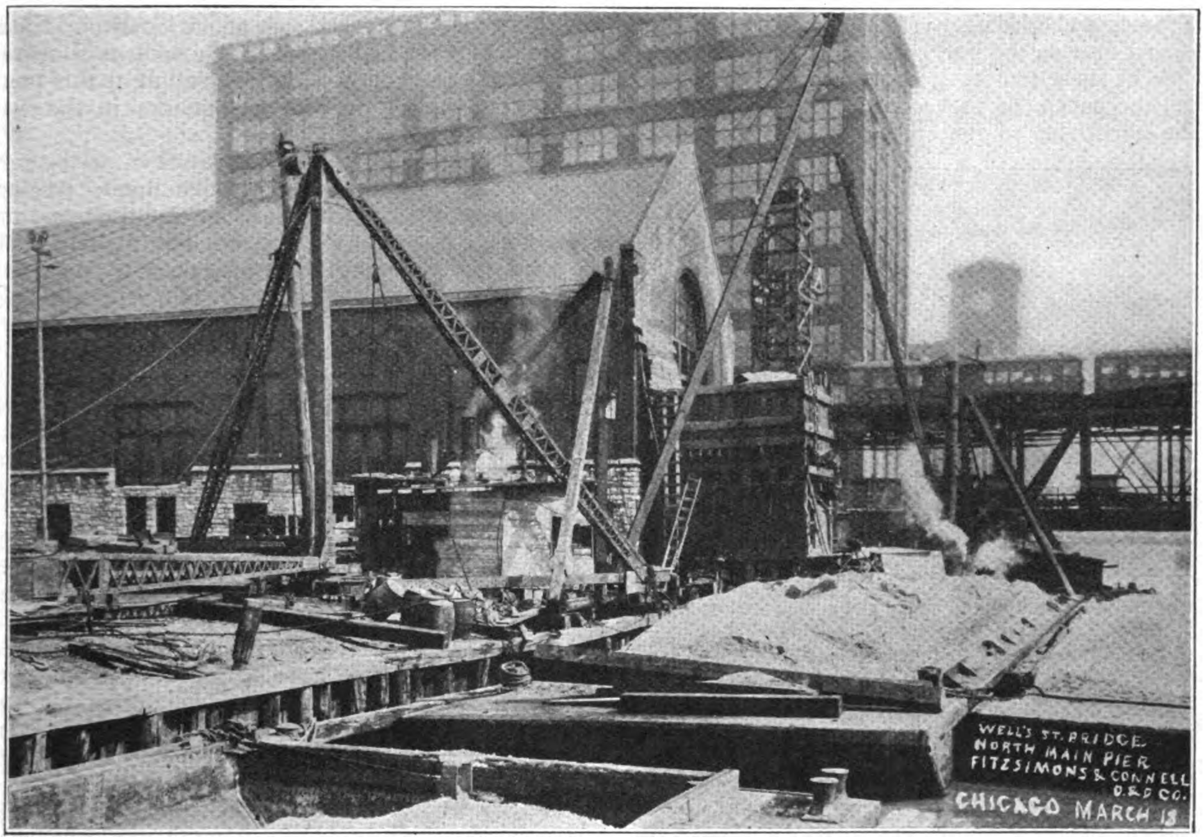

Fig. 5.—Aggregate Handling and Concrete Mixing Plant Used at Wells Street for Constructing Main Piers and Tail Pit.

west, was awarded the contract for building the superstructure, including the furnishing and installation of all operating machinery. This firm also erected the two bridge tenders' houses. Norwood-Noonan Co. installed all of the electrical equipment, including the lighting system, signal system, the electric warning and safety devices.

All work was performed under the supervision of the bridge division of the Bureau of Engineering, Department of Public Works, City of Chicago. Although during the course of construction there have been slight changes in the personnel responsible for the success of the undertaking, credit for its completion is due to Commissioner of Public Works Charles R. Francis, City Engineer Alex Murdock, Engineer of Bridges Thomas G. Philfeldt, Engineer of Bridge Construction Clarence S. Rowe, and assistant engineer in local charge, F. A. Berry. Wells street bridge is one of the numerous important public improvements made during the administration of Mayor Wm. Hale Thompson.

General Description of Substructure.

Substructure for each leaf consists of two principal piers joined by two side walls and a floor forming a monolithic concrete box-like structure. Piers and side walls form a pit into which the rear ends of the movable bridge trusses, bearing the counterweights, descend when the bridge is opened. The center line of the new bridge is identical with the center line of the old. The new substructure was planned to occupy the space just to the rear or land side of the old river pier.

Substructure is supported by cylindrical concrete sub-piers which rest upon a 12-ft. stratum of hardpan at —75 ft. Chicago datum. There are 10 sub-piers for each leaf of the bridge.

There are two sub-piers 5 ft. in diameter under each operator's house; two, 8 ft. 6 ins. in diameter, supporting each anchor pier; two, 10 ft. in diameter, under the trunnion columns for each leaf; two, 7 ft. in diameter under each abutment, and two, 11 ft. in diameter, supporting each river pier. Sub-piers are belled at their bases. The diameters of the bells are such that the combined live and dead load of the bridge, in service, will not exert a pressure on the supporting hardpan in excess of 8 tons per sq. ft. of bearing surface. Sub-piers are located to pass the tunnels of the Chicago Postal Pneumatic Tube Co. and the Chicago Tunnel Co., and are spaced to permit the future construction of a street railway tunnel at this crossing.

Preliminary Work.

Work on the substructure was begun on May 16, 1917. Before starting actual construction the contractor was required to provide for a support for the street approach while the work was in progress. Entering the approach at a level slightly above the water level of the river, tunnels were driven through the filled earth forming the base of the approach. A line of industrial track was established under the sidewalk and excavated material from the tunnels was loaded in buckets and placed on flat cars which were pushed to the river bank. There the buckets were hoisted by a stiff-leg derrick temporarily mounted on pile clumps in the river. This derrick swung the excavated material over to a scow anchored near it and returned the empty bucket to the car. As excavation was through filled earth, timbering the tunnels throughout their length was necessary. When these tunnels were completed either a steel truss or plate girder especially designed to meet local conditions was placed in each of them.

Trusses and girders were supported on cribbing placed outside the limits of the new substructure. One of these trusses is shown in Fig. 7 supporting the pavement above one of the tail pits. On the north side of the river two trusses were re-

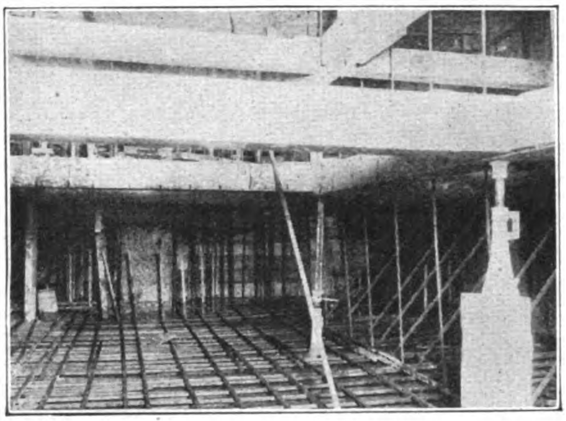

Fig. 6.—View of Bottom of Tail Pit Taken at the Time Concrete Was Being Poured, Showing Method of Supporting Cofferdam Bracing.

quired and on the south side one truss and one plate girder were used. As soon as these trusses and girders were in place a new approach deck was constructed upon them, the street being closed to vehicular traffic, one roadway at a time, during the operation.

A cofferdam was then driven around the outside of the proposed new substructure. This cofferdam is a 4-ft. puddle wall type, both walls consisting of interlocking steel sheeting 45 ft. long. The outer lines of sheeting were reinforced by driving piles about 40 ft. long. Provision for driving those portions of the cofferdam directly under the swinging bridge was made by stopping traffic between the hours of 1 a. m. and 4:45 a. m. for a period of about 2 weeks for each dam and swinging the old bridge to the open position during that time. A portion of the cofferdam is shown in Fig. 2. After the completion of the cofferdam the space beneath the approach was excavated to about +3 city datum, and the work of sinking wells for the sub-piers was begun.

Construction of Sub-piers.

Wells for the sub-piers were sunk before excavation for the tail pit was made as it was believed that it was more economical to thus increase the amount of well sinking necessary than it would be to maintain an open cofferdam during the sinking and concreting of wells. The method of sinking sub-pier wells was to excavate them by spading and in the stiffer strata by grubbing and picking. Excavated material was loaded into buckets which were raised to the surface by hand and power operated windlasses, loaded onto industrial flat cars and the material disposed of in the same manner as that excavated from the tunnels.

A typical example of the strata pierced in sinking these wells follows:

From datum to 27, soft blue clay—spading.
From 27 to 36, medium stiff blue clay—spading.
From 36 to 53, stiff blue clay—some grubbing.
From 53 to 67, stiff dark blue clay—some grubbing.
From 67 to 75, hard dry clay mixed with pebbles—grubbing and picking.

In many of the wells a stratum of soft dark sand was encountered just above hardpan. Excavation for the bell of one of the wells is shown in Fig. 3. The solidity of the stratum at this point mav be judged by the pick marks in the wall surface.

Keeping pace with the excavation, wells were lined with tongue and groove maple lagging. Edges of the lagging were beveled to make the complete caisson accurately circular in shape. This construction offers great resistance to the earth pressure surrounding the well. To retain the lagging, iron bands 3/4 in. thick and 3 ins. wide were used in 5-ft. wells; 1 by 3-in. bands were used in 7 and 9-ft. wells, and bands 1 by 4 ins. were placed in 10 and 11-ft. wells. Fig. 4 is a view looking down a completed caisson. It shows the method of lagging the well. At the bottom of the well can be seen two workmen placing reinforcement preparatory to pouring the sub-pier.

Upon completion of a caisson or well, reinforcement was placed in the bell and lower portions of the shaft and concrete poured. Concrete for sub-piers was 1:3:5 mix. It was mixed in a concrete mixer placed on the sidewalk and passed through chutes to the wells and dropped to place. When the bell was filled with concrete, the lower rings holding the lagging were removed and concrete poured to within a few inches of the lowest remaining ring. Vertical reinforcement rods and hoops were placed in advance of the concrete. This cycle of operation was continued until the sub-piers were complete. Lagging was allowed to remain as placed.

After the completion of the sub-piers, trunnion and anchor columns were placed in wells resting on top of sub-piers at —31 ft., which is also the elevation of the bottom of the pit floor. Longitudinal girders between anchor and trunnion columns were then placed. Loads of the temporary steel girders and trusses which supported the approach were then transferred to the longitudinal girders and the temporary cribbing removed.

Constrution of Piers and Tail Pit.

Preliminary work was then begun for the construction of the river pier, abutment pier and the side walls connecting them forming the pit. Before excavation for the pit could be started it was necessary to arrange for the support of the old bridge and elevated structure. The old river pier of masonry was removed with the exception of

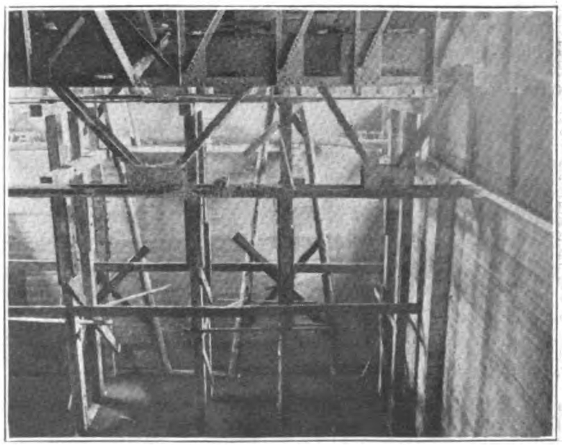

Fig. 7.—Completed Tail Pit. Temporary Steel Truss Resting on Longitudinal Girders Supports Approach Pavement.

three columns, one in the center and two at the ends. These carried the weight of the end of the approach and also the end of the old center pier bridge span until temporary supports were placed. Pile supports were driven outside the cofferdam at the ends of the old abutment and on one Sunday the bridge was closed to all traffic. The remaining columns of the old river pier were dynamited, temporary wooden shoring sustaining the load, and a box girder weighing 25 tons was placed on the pile clumps. Blocking was placed on the steel girder and the load shifted upon it. Temporary wooden bents were then removed. Placing girders and blocking took about 15 hours. Supporting girders are shown under the old bridge in Fig. 1.

Elevated railroad columns were supported on timber bents which were changed at various times as the work progressed until their loads could be transferred to the steel work.

Excavation for piers and counterweight pit was begun after the work of supporting the existing structures was concluded. As much material as possible was removed by pumping. The stiffer material was excavated with spades, loaded into buckets and hoisted to the surface. Timber bracing was placed in the excavated space. Bracing consisted of 12 by 12-in. pine timbers placed from 6 to 12 ft. apart horizontally and from 4 to 6 ft. apart vertically. Horizontal timbers were bolted to the piles of the cofferdam. Timbering in tail pit is shown in Figs. 2 and 6. When the pit was completely excavated concrete was poured.

Aggregates were brought to the site in scows as shown in Fig. 5. Crushed stone and sand were unloaded by a clamshell operated by the stiff-leg derrick shown in Fig. 5, which is a general view of the aggregate handling and concrete mixing plant. The clamshell deposited aggregate in a hopper bottomed bin. From this bin aggregate was fed to the concrete mixer by gravity. The concrete mix used for substructure was 1:3:5. For every sack of cement used, 10 lbs. of hydrated lime were added to the mixture. After mixing, concrete was elevated and passed in chutes to place. In the main piers and tail pit concrete was placed in horizontal layers over the entire area.

Reinforcement bars were first placed and a part of the lower set of vertical timbering was removed. Concrete was then placed over the unobstructed portion of the floor and after it had attained its final set blocks were placed upon it. Surmounting these blocks were bottle jacks which sustained the weight of the remaining timbers, while other vertical braces were removed and concrete poured. This method avoided holes in the concrete which would have occurred if concrete had been poured while vertical braces were in place. Fig. 6 is a view taken at the time of concreting the pit floor. It shows the bottom set of cofferdam braces and the reinforcement bars in place. This view illustrates the use of the temporary supports for the timbering.

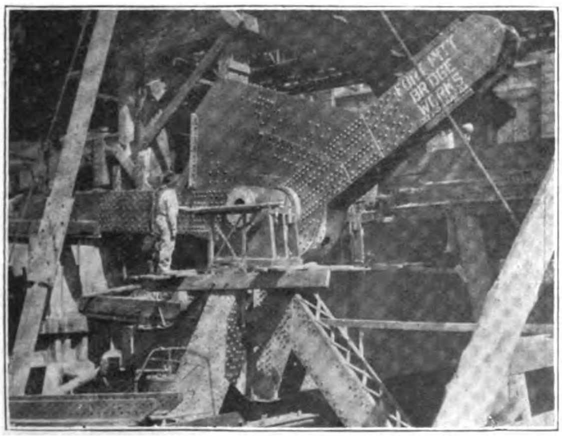

Fig. 8.—A Trunnion Bearing at the Time of Setting Trunnion to Line and Grade.

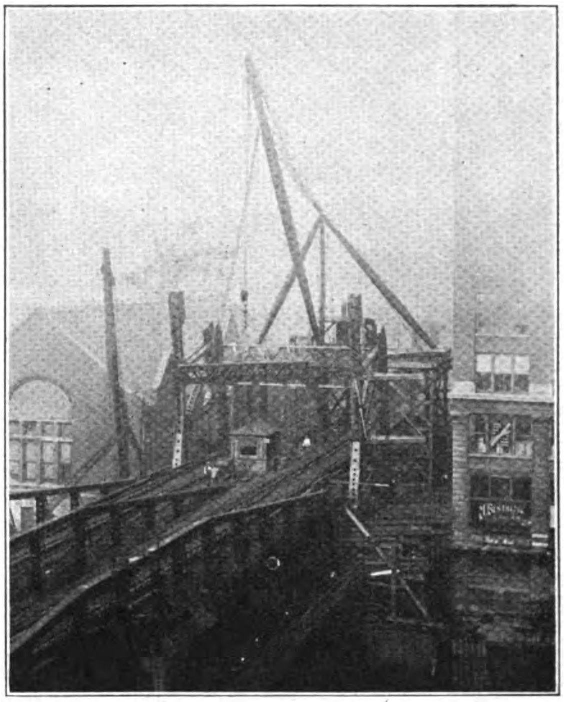

Fig. 9.—Derrick Mounted on Platform Above Elevated Railway Used to Handle Structural Steel Entering Into Bridge Construction.

When placing of concrete in the piers and side walls progressed to within a few inches of the lowest remaining set of horizontal braces, pouring of concrete was stopped and concrete was allowed to set for from 12 to 24 hours. Cofferdam walls were then rebraced to the concrete in place and another set of horizontal braces removed.

Before resuming the placing of concrete all laitance, dust and foreign material were removed from the concrete in place and the surface slushed with neat cement grout.

A layer of cement mortar 6 ins. thick was placed simultaneously with the concrete on the outside of the piers and pit walls. Near the top of the structure this waterproofing course was reduced to thickness of 4 ins. This mortar facing consisted of 1 part cement and 2 parts of fine aggregate. It was placed by putting the cleats or spacers of specially designed mortar boards against the pier forms and filling the space between the board and the form with mortar.

The entire substructure required 8073 cu. yds. of concrete and 530,751 lbs. of reinforcing steel. Structural steel columns and girders forming a part of the substructure had a total weight of 1,344,406 lbs.

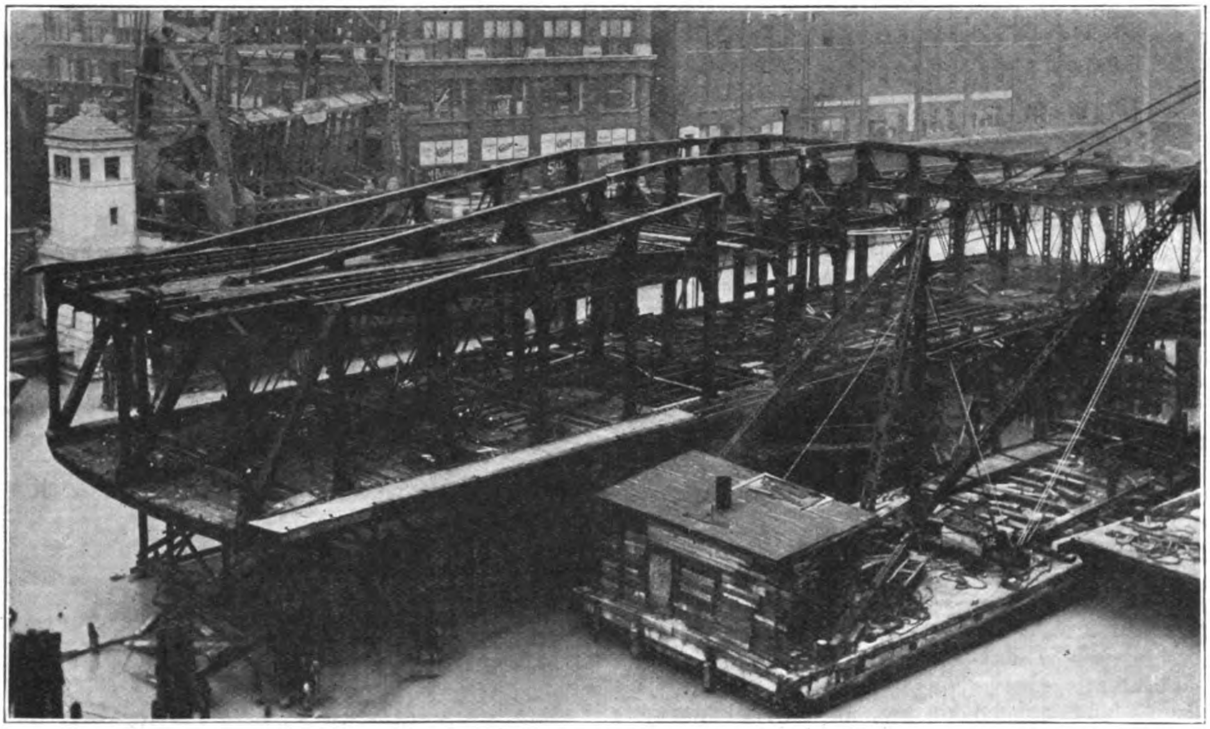

Fig. 10.—Cutting Away the Old Bridge. Derrick Mounted on Concrete Barge Removing Steel Members Cut from Bridge by Oxy-Acetyline Torches.

Complete tail pit is shown in Fig. 7. In this illustration can be seen one of the temporary steel trusses provided as a support for the approach pavement. Design of this truss permitted placing of longitudinal girders of the permanent structure between its diagonal struts.

Upon completion the tail pit was tested by filling the space between the cofferdam walls and the tail pit with water approximately at river level.

No leaks into the pit were found, but if leaks had appeared water would have been pumped out of the space between the cofferdam walls and the pit, the tail pit partly filled with water and the leak traced to the outside of the pit and repaired.

After the tail pit had been tested the cofferdam piles and sheeting were removed and the puddle wall dredged. The north substructure was first completed. Substructure for both leaves was finished on Jan. 13, 1921.

Erection of Superstructure.

Preliminary work for the erection of the north leaf was begun on May 3, 1920. The erection contractor built a timber platform at each side of the river above the elevated structure. The platform had sufficient clearance to permit the passage of elevated trains beneath it. It was supported at the sides by wooden bents resting upon the surface of the ground. Handling of the steel entering into the superstructure was accomplished by a derrick mounted on this platform. Platform and derrick are shown in Fig. 7.

Derrick used for this work was an all-steel, stiff-leg derrick which was designed and fabricated by the Kettler-Elliott Co. Mast is 38 ft. high, boom is 80 to 120 ft. long. Derrick is equipped with a one-piece, cast steel, goose neck—a new feature in derrick design. Cables are operated by an 8¾ by 12-in. three-drum Mundie steam hoist. The lifting capacity of this equipment is 50 tons.

All steel was furnished by the Fort Pitt Bridge Co. A total of 2800 tons of structural steel was used in the superstructure. It was received at the contractor's yard, at 31st street and California avenue, and was brought to the bridge site in scows as required.

Erection of Superstructure.

After building the erecting platform and installing the derrick, the first operation in the erection of the superstructure was to set the trunnion bearings accurately to line and grade and place the trunnion shaft in position. Fig. 8 is a photograph taken at the time of placing the trunnion. This illustration shows the trunnion shaft resting in the lower half of its bearings. The trunnion shaft is a carbon steel forging thoroughly and uniformly annealed. It is 27½ ins. in diameter. A concentric hole is bored through the entire length of the shaft in order to detect flaws. Proper allowances are made in the trunnion shaft for a light driving pit in the bridge truss members and a running fit in the journal bearings with proper allowance for lubrication. Trunnion bearing blocks are cast steel, lined with phosphor bronze.

Upon the degree of accuracy with which the trunnion supports and trunnions are set to line and grade depends the accurate meeting of the two leaves of the bridge when lowered. Setting the trunnions is an engineering feat of extreme nicety. An accurate base line was established at right angles to the center line of the bridge and this base line was transferred to a fine piano wire stretched in close proximity to the trunnion. The trunnion was then set parallel to the piano wire by means of an ordinary rule. For taking up any inequality in the supports for the trunnion, shims are used under the bearing blocks. Trunnions are entered into the truss members before being placed in the bearings.

After this adjustment was complete the tail end of the truss and counterweight box were erected. Counterweight, consisting of shaped castings, punchings, slag concrete and limestone concrete, was assembled and the counterweight box bolted

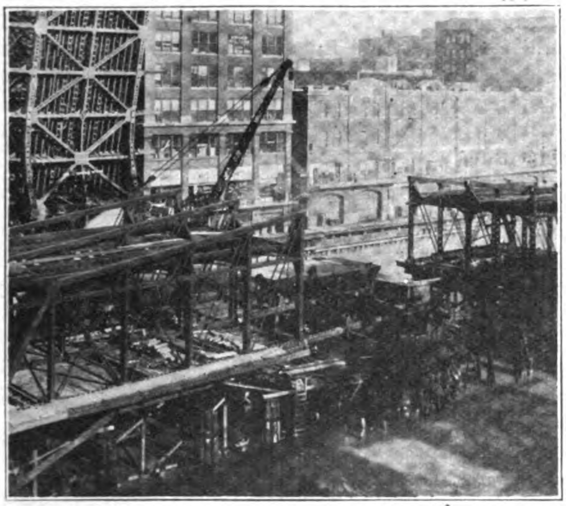

Fig. 11.—Central Portion of Old Bridge Entirely Removed to Permit Lowering the Leaves of the New Structure.

on to the truss members. The tail end of the leaf was then securely shored to the piers.

Leaf was then erected in a plane inclined toward the river about 13 deg. from the vertical. This is the extreme open position of the leaf which rotates through an arc of 77 deg.

In the erection of each leaf, stringers, floor beams, lateral members and decking in two of the lower panels were omitted to allow street and elevated traffic to pass through the structure. In Fig. 1 an elevated train can be seen passing under the erecting platform and through the new leaf.

Truss members and floor systems were kept in adjustment continually during erection. After the leaf was lowered to a horizontal position final adjustment for line was made by means of a lateral bracing left loose for this purpose. The south leaf was erected in the same manner as that used in the erection of the north leaf.

Operators' Houses, Machinery and Electrical Equipment.

During the erection of the leaves the operators' houses were built. There are two of these, one on each side of the river. Each has four floors. The operator's room occupies the top floor and contains controller, brake levers, indicators and other instruments. On the floor below at the sidewalk level is the main entrance and hall, lavatory and steel lockers. On the next floor below are the electric switches mounted on a control board. On the ground floor is located the heating plant and coal bin. Operators' houses and enclosure walls have steel skeleton work, with concrete floors. The walls are constructed of granite blocks backed up with brick masonry. Roofs are of terra cotta tile. The north operator's house is shown in Fig. 1. In exterior design and interior appointment these bridge towers are the most beautiful and complete of any in Chicago.

Opening or closing the bridge is effected by rotating each leaf about its trunnions by means of a system of gearing transmitting power from electric motors. Each leaf is equipped with two 100-hp. electric motors. The total weight of operating machinery for both leaves of the bridge is 300 tons.

The bridge is equipped with safety devices of the latest types consisting of warning bells, sidewalk and roadway gates, roadway gongs, stop signs, and the roadway gates with flashing red lights and Strauss yielding barriers. These devices are electrically interlocked with the operating mechanism of the bridge and the signal system of the elevated railroad, making it impossible to open the bridge unless all safety devices are in operation and the elevated railroad signals set at danger.

Lowering New Bridge.

When construction of the new bridge was as nearly complete as was possible in its upright position, plans were made for removing the old bridge and lowering the new. In the accomplishment of these plans time was the important element. It was desired to place the new bridge in service with the least possible interference with elevated railway traffic. Omitted members of the bridge trusses were brought to the site, material for decking the upper level and laying railway track was in readiness, the erection crew, track-laying gangs and the crew responsible for the wrecking of the old bridge were carefully organized and instructed in their duties so that each man knew exactly his portion of the work.

On Friday, Dec. 2, at 8 p. m., all traffic over the old bridge was stopped. The old bridge was swung to the midstream position over the center pier. Timber bents, supported by piling driven in the river bed, had been previously placed to support the ends of the old bridge when the center section should be removed. At midnight on Dec. 2, cutting out the center section of the old bridge was begun.

Upper members were cut nearly through and allowed to remain in place. With the coming of daylight removal of the old steel members was begun. A concrete barge upon which was mounted a derrick similar to the one used in handling the new structural steel was anchored near the old bridge. A scow was brought alongside for the reception of the steel members as they were removed. The method of removing the old bridge is illustrated by Fig. 10.

Attachment was made to a nearly severed member and the derrick cables tightened. Then the cuts at each end were completed and the free

Fig. 12.—Lowering the South Leaf of the New Bridge. Ends of Old Bridge Supported in Mid-Stream.

member lowered into the scow. In this way a section 80 ft. wide was removed from the old bridge by 4 p. m., Sunday, Dec. 4. Fig. 11 is a photograph taken at the time of the completion of the cut before the new bridge was lowered.

During the cutting away of the old bridge, the omitted portions of the new structure were rapidly erected. The operating machinery was tested by partially lowering the leaves and returning them to the open position. At 5 p. m., Sunday, Dec. 4, both leaves of the new bridge were lowered in place. The two leaves met in the center with less than ¼ in. total error.

Fig. 12 shows the south leaf of the new bridge descending for the first time into the horizontal position. At either side of it can be seen the ends of the old bridge resting upon temporary supports. As soon as the leaves were lowered in place construction gangs of the elevated railroad company started to lay track over the bridge. This was completed and elevated service was resumed at 7 a. m., Dec. 5, after an interruption of only 59 hours.

Completing the lower deck, installation of electrical signals and warnings and building new approaches are now in progress. It is expected that all work in connection with the bridge will be completed early in February, 1922.

Construction of Wells street bridge is a credit to the contractors and is a monument to the ability of the engineering staff of the City of Chicago.

Uncle Sam Helps to Build Good Roads in Every State

Roads built, under construction or under agreement for construction, throughout the United States in conjunction with Federal Aid funds distributed among the states by the Bureau of Public Roads since July 1, 1916, total 28,135 miles, according to a summary of the work just completed. The summary by types shows the following mileages:

Material	Miles.
Graded and drained	6,864.0
Sand-clay	2,695.5
Gravel	10,043.5
Macadam (water-bound)	1,290.7
Macadam (bituminous)	1,323.2
Bituminous concrete	772.5
Concrete	4,653.6
Brick	444.6

In addition to the foregoing, bridges with their approaches to the total length of 47.4 miles were constructed or are now under agreement for construction with Federal aid and state funds combined.

The table shows a large mileage of graded and drained, sand-clay, gravel and macadam roads, while there is less mileage of concrete, bituminous concrete and brick roads. This situation is due to the increased cost of construction for the higher types of roads. The average cost figures per mile of the different grades built during the 4-year period, or now provided for, are as follows:

Material	Cost.
Graded and drained	$ 8,115
Sand clay	8,250
Gravel	10,400
Macadam (water-bound)	17,320
Macadam (bituminous)	31,300
Bituminous concrete	30,350
Concrete	39,540
Brick	49,570

The total cost of the 28,135 miles of roadway is $496,151,683.43; the average cost per mile, $17,630. Of the total cost the sum of $211,135,376.31 was made available through Federal aid, the remainder through the states. This is at the average rate of $7500 per mile of Federal aid funds, for the total mileage built.

The estimated cost of their construction, the amount contributed to their cost through Federal aid, and the mileage in each state, are shown in the following tabulation:

State.	Estimated cost.	Federal aid.	Mileage.
Alabama	$ 8,365,607.83	$ 4,103,084.18	723.4
Arizona	6,529,017.19	3,028,981.25	335.9
Arkansas	10,811,240.09	3,822,922.79	961.3
California	11,826,175.04	5,795,928.96	550.3
Colorado	6,725,763.62	3,272,066.23	435.8
Connecticut	2,901,600.89	1,142,105.93	64.6
Delaware	1,840,122.04	447,654.88	34.1
Florida	4,683,025.65	2,231,810.11	154.3
Georgia	15,498,450.74	6,953,633.12	1,053.8
Idaho	6,673,832.19	3,157,543.70	411.4
Illinois	25,277,757.05	11,500,485.58	739.8
Indiana	9,881,864.78	4,824,692.37	283.3
Iowa	19,728,159.76	7,645,808.51	1,509.2
Kansas	23,076,667.97	6,560,216.55	601.1
Kentucky	7,258,678.58	3,497,723.75	298.2
Louisiana	7,346,281.30	3,443,983.15	636.9
Maine	4,823,712.02	2,843,879.30	146.6
Maryland	4,964,417.88	2,343,121.11	171.0
Massachusetts	6,545,910.09	2,816,492.78	170.2
Michigan	11,685,189.51	5,524,937.65	427.6
Minnesota	17,509,911.01	6,947,373.63	1,713.4
Mississippi	7,270,263.56	3,510,662.81	567.8
Missouri	13,919,138.56	6,301,070.80	824.7
Montana	7,508,665.18	3,672,561.01	680.3
Nebraska	8,479,456.27	4,142,468.38	1,512.4
Nevada	4,730,895.04	2,323,450.32	380.5
New Hampshire	2,273,434.70	1,099,733.75	138.0
New Jersey	10,281,756.21	3,265,298.47	102.3
New Mexico	5,690,688.73	2,843,519.58	805.8
New York	23,432,089.07	10,031,757.49	561.6
North Carolina	12,952,403.46	6,073,217.92	909.6
North Dakota	5,928,891.39	2,932,042.93	999.5
Ohio	24,107,543.39	7,835,671.16	658.9
Oklahoma	11,479,713.98	4,669,720.40	332.1
Oregon	8,569,840.39	4,114,557.39	459.8
Pennsylvania	30,422,799.66	11,351,618.61	580.9
Rhode Island	1,553,979.36	637,411.74	36.6
South Carolina	6,941,948.79	3,213,182.42	614.5
South Dakota	6,521,090.35	3,211,285.50	676.7
Tennessee	9,588,822.05	4,789,884.01	875.2
Texas	32,234,536.64	12,237,022.72	2,485.7
Utah	4,016,966.40	2,005,149.28	292.6
Vermont	1,814,922.42	903,508.99	65.5
Virginia	7,713,322.21	3,798,648.62	400.3
Washington	8,609,476.95	3,910,886.95	362.7
West Virginia	6,083,856.44	2,757,782.94	295.5
Wisconsin	14,312,052.27	5,336,771.42	986.1
Wyoming	5,759,749.73	2,762,045.22	607.2
Totals	$496,151,683.43	$211,135,376.31	28,135.0

Additional Port Terminal Docks for Portland

The Commission of Public Docks, Portland, has purchased the former plant and grounds of the Willamette Iron & Steel Works, having a front of 293 ft. on Willamette river, adjoining Municipal Terminal No. 1, for $180,000. The property purchased is to be utilized as an extension of Terminal No. 1, where the increase of freight has been such as require greater facilities. The buildings on the acquired property are to be remodeled to adapt them to terminal uses, and some additional buildings will be erected. New trackage will be laid. The improvements outlined will cost $80,000. The Willamette Iron & Steel Works recently acquired a new tract farther down stream and moved its equipment thereto.

Two great districts of Chicago, now separated by the canal, are to be connected by the new $1,000,000 bridge to cross at Cicero avenue. It is named the General Pershing bridge. The proposed $1,000,000 Crawford avenue bridge will be christened the General Dawes bridge.

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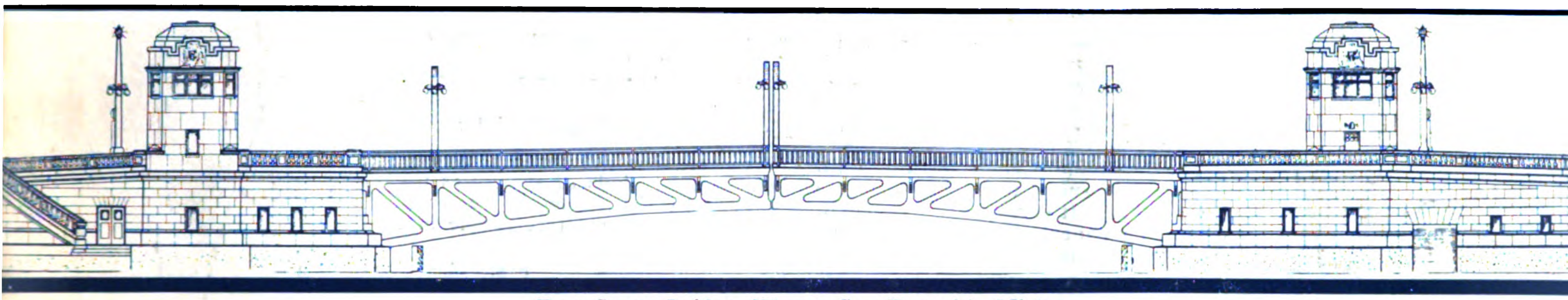
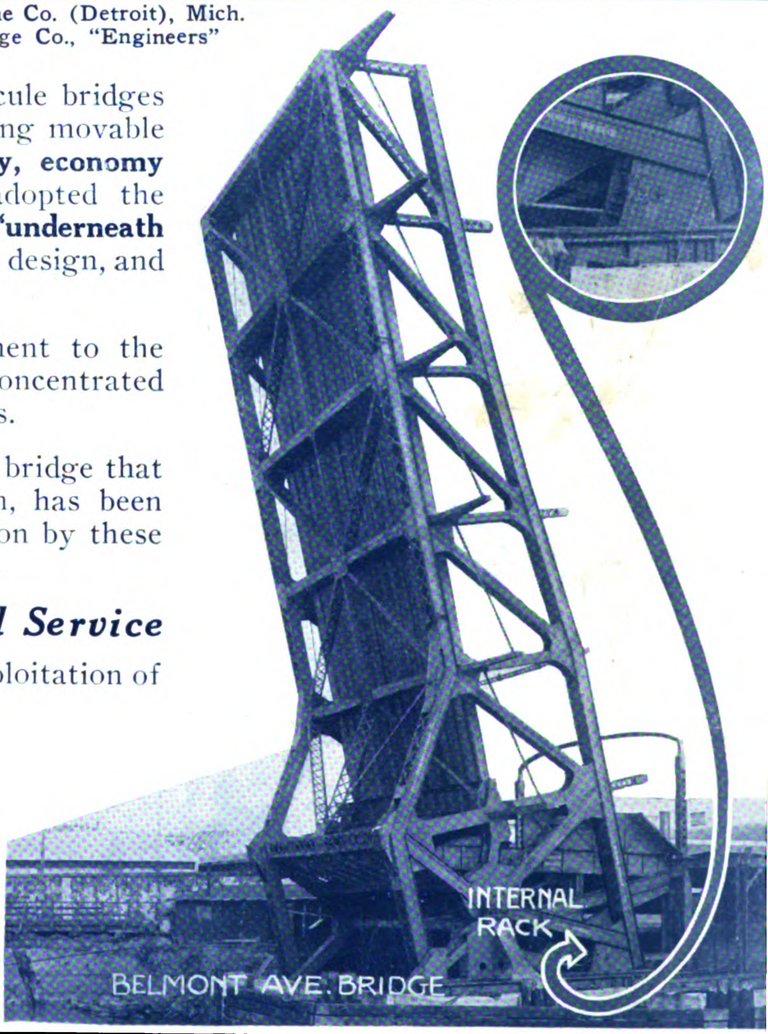


Fort Street Bridge, Wayne Co. (Detroit), Mich.
Chicago Bascule Bridge Co., "Engineers"



BELMONT AVE. BRIDGE

CHICAGO, the home of more modern bascule bridges than any other city in the world, desiring movable bridges which would be **first in beauty, economy of cost, operation and maintenance,** adopted the patented **"internal rack"** and fixed **"underneath counterweight"** as necessary basic elements of their design, and has **contracted for no other type since 1912.**

The great "Boulevard Link" Bridge is a monument to the efforts of engineers who spent ten years in the concentrated study and development of Chicago's bascule bridges.

Such experience and knowledge, insuring a bascule bridge that will embody the most modern features of design, has been available to you since 1920 through the organization by these engineers, of the Chicago Bascule Bridge Company.

Our Engineering Service Means Real Service

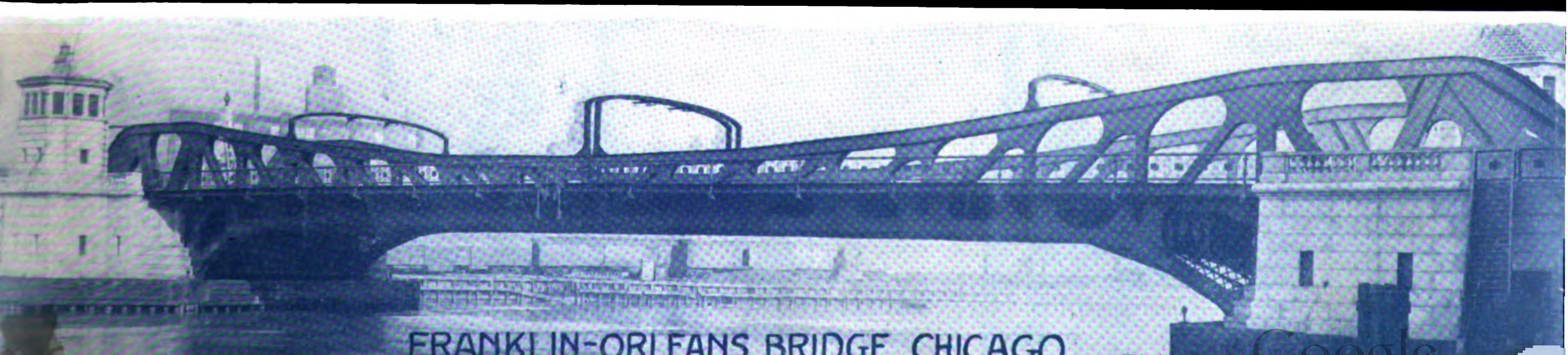
Although we use the "internal rack," it is not an exploitation of this or any other patent which we may use.

It will be to your advantage, whether you are considering a railroad or highway bascule bridge, to consult with us before adopting any other design.

CHICAGO BASCULE BRIDGE COMPANY

Engineers

118 North La Salle Street - Chicago, Illinois



FRANKLIN-ORLEANS BRIDGE, CHICAGO