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THE 186 FOOT BASCULE BRIDGE OF THE C. & N. W. RY., OVER THE NORTH BRANCH OF THE CHICAGO RIVER AT DEERING

By O. F. Dalstrom, *M. W. S. E.**

Presented March 12, 1917

The C. & N. W. Ry. put in service on July 30, 1916, a new Strauss Heel Trunnion Bascule bridge over the North Branch of the Chicago River, at Deering Station, Chicago. This bridge carries three tracks and spans a channel of 145′ 0″ clear width between fenders, crossing it at an angle of 74 degrees. The rest pier and the front end of the movable span are skewed to parallel the channel. Fig. 1 is a General Plan of the bridge.

The new structure replaces an old double track swing bridge of 176′ length, supported on a center pier. The old bridge was worn out, and it had become necessary to replace it with a bridge of greater capacity and strength, to take care of the great volume of traffic and the heavy power on this line, which is the Railway's main line between Chicago and Milwaukee.

The railway traffic during construction consisted of about 200 trains every 24 hours, about 80% of which were passenger trains. The normal river traffic required from 30 to 100 swings per month, the greatest activity being from July to October. This made it necessary to keep at least one of the two channels continuously available for navigation during construction.

The necessity for maintaining river and rail traffic uninterrupted during construction was a governing factor in determining the type and design of the new bridge. The design adopted possessed the following advantages in construction: (a) The new substructure could be constructed complete with but little disturbance of the old substructure; (b) The temporary structure required was of simple and inexpensive construction, being only a few spans of timber trestle at each end of the old draw span; (c) The new superstructure could be erected almost complete without interruption to traffic; (d) The counterweights could be cast solid in forms supported on the floor of the counterweight pit; (e) The old draw span could be kept in operation continuously during the entire period of construction, maintaining traffic uninterrupted on both river and railway.

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*Engineer of Bridges, C. & N. W. Ry. Co.

In addition to the increased facilities for handling the heavy railway traffic, the conditions for river navigation are greatly improved under the new structure. A single channel of 145'-0" clear width replaces the narrow channel on each side of the old center pier, and this channel is deepened to 21.5 ft. below Chicago City Datum. Water level of bridge varies from 1.6 ft. below to 1.2 ft. above Datum. The vertical clearance under the old span was 16.5 ft. above Datum, and this clearance is increased to 18.25 ft. under the new span, which permits a large proportion of the boats navigating this channel to pass without opening bridge.

SUBSTRUCTURE

The substructure under the tower consists of four steel cylinders 12 ft. in diameter, filled with concrete, and connected at the tops by a rectangle of heavy reinforced concrete girders. The cylinders are carried down to rock. The tops are 2'-0" below Datum, the concrete girders being carried up from this level to elev.+17.25, the level of the superstructure bearings, 6'-9" below base of rail.

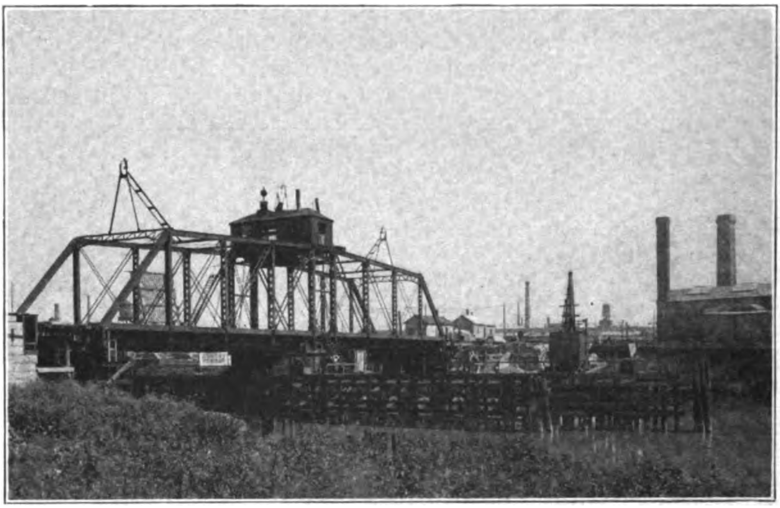

Fig. 2. General View of Old Bridge.

The concrete girders are reinforced with embedded structural steel trusses and with horizontal and vertical reinforcing bars near the surface. The trusses were designed to carry the entire weight of the concrete, together with the superimposed track load where any occurs. The reinforcing bars were provided for local reinforcement and to prevent surface cracks. The longitudinal reinforcing in the bottom of the girders was made heavy to prevent the development of tension cracks.

The girder directly under the heel trunnions is the heaviest of the four, being 8′ 0″ thick and reinforced with two trusses. It carries one end of a 35 foot deck plate girder span, the other end of which rests on an abutment built between the side girders. The other girders in the substructure of the tower are 6′ 0″ thick and contain only one reinforcing truss each.

With the bridge in the fully open position, the counterweights extend about 14 feet below the base of rail, and their inner surfaces are 8′ 3″ from the centers of adjacent tracks. The operating struts are between the counterweights and the tracks, and when the bridge is fully open they extend about 12 feet below the base of rail. This circumstance made it necessary to build retaining walls just beyond the pier, to hold the embankment, placing the walls inside the limits of clearance required by counterweights and operating struts. To provide the necessary clearance for the operating struts, the faces of the retaining walls were placed 5′ 8″ from the center of track, for a distance of 15′ 6″ to the rear of the vertical tower post. This brought this portion of each of the walls so close to the track that hand railing could not be erected on top of them without encroaching on the required clearance. To safeguard these sections, platforms were built level with the top and just clear of the face of the wall. One end of each of the platforms was hinged to the tower post and the other end suspended by rods from the framework of the counterweight truss bracing directly above. Gas pipe hand railing was erected on these platforms, just outside the clearance lines. As the bridge opens, the platforms,

Fig. 3. Temporary Bridge. Excavating for Retaining Walls.

swinging around the hinged ends, drop down out of the way of the operating struts, returning to normal position at the top of the wall as the bridge closes.

The rest pier, at the front end of the span, consists of two cylinders, 12′ 0″ in diameter, connected at the tops by a concrete girder 8′ 0″ thick and reinforced with two embedded steel trusses. The details of this girder and its reinforcement are similar to those of corresponding parts of the substructure under the tower.

All cylinders were carried down by open excavation to rock, those under the tower pier about 50 feet below datum, and those under the rest pier about 40 feet. The lower section of each cylinder was fitted with a horizontal steel diaphragm 8 ft. above the cutting edge, to make this section a working chamber. In the center of this diaphragm was a circular opening 3′ 0″ in diameter, over which

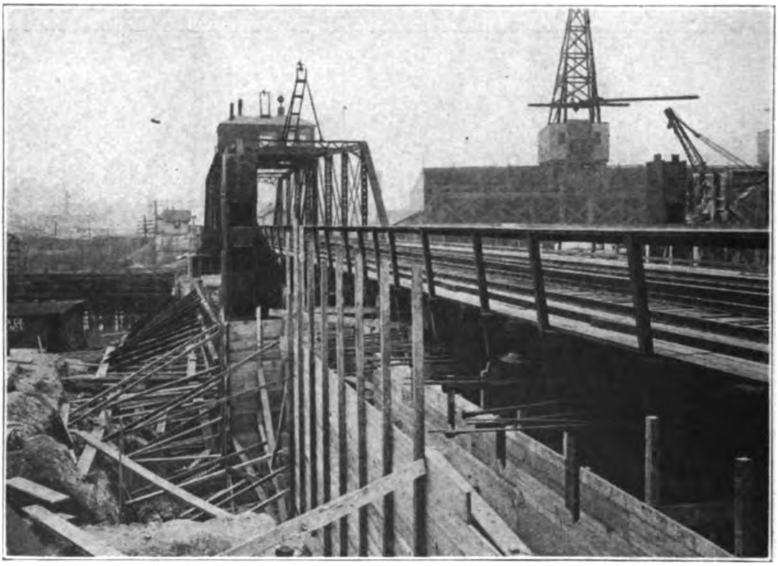

Fig. 4. Forms for Rear Substructure and Retaining Walls.

was built up the working shaft, consisting of a steel cylinder 3 feet in diameter. The horizontal diaphragm was rigidly braced to the section of cylinder below, with eight solid webbed radial braces extending from the diaphragm to the lower edge. This edge was heavily reinforced with thickening plates and an angle, to enable it to cut through stiff clay, gravel and hard pan, and to resist crushing by boulders.

The excavation was carried on by men digging inside this working chamber, and the material was hoisted out in buckets through the working shaft. Water was pumped out with a Nye pump let down into the working chamber and connected by steam hose running up the shaft and out to a steam boiler set on the ground.

The cylinders were delivered at the bridge site riveted up in sections of about 8′ 0″ length. As fast as the cylinder was carried down by the excavation in the working chamber, sections were riveted on above, carrying up the working shaft at the same time as the large cylinder. As soon as a section was riveted on it was filled with concrete. In all but the last stages of the sinking of each cylinder, the concrete gave the weight necessary to overcome the friction of the earth against the sides of the cylinder and carry it down as excavation progressed. As the cylinders approached final depth, it became necessary to add pig-iron on top of the concrete to over-

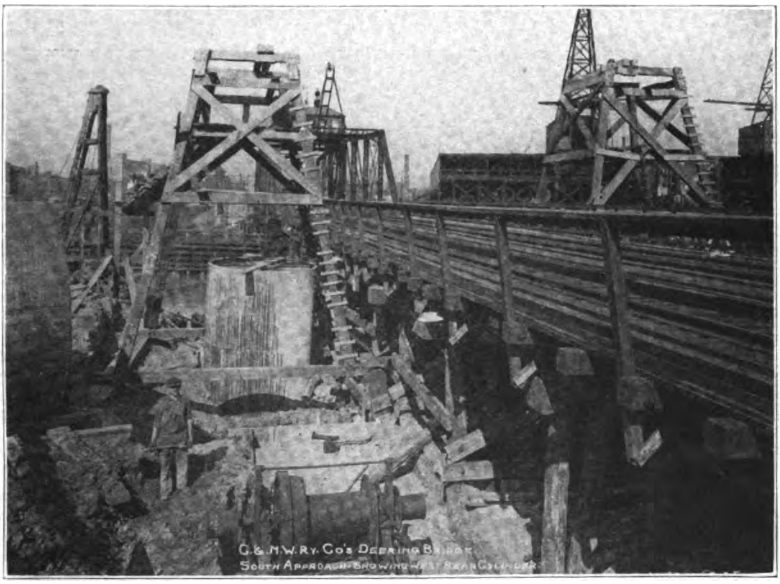

Fig. 5. Rear Substructure. Head House in Place for Sinking Cylinder.

come this friction and make them sink. Following is an extract from the log of the Great Lakes Dredge and Dock Company, covering that portion of the work which developed the greatest skin friction of the cylinders:

No. 1—Caisson South Abut. (East Front Well), 8:00 A. M., Nov. 10, 1915.

Stopped at Elev.—41.22.
56 ft. of shell in place.
40 lin. ft. concrete in place.
Cutting edge undercut 6 ft.

Load—Steel shell .... 43,190 lbs.
Concrete ....593,600 lbs.

636,790 lbs.

Area—37.7'x41'=1,546 sq. ft. for 41 ft. penetration.
Skin Friction=412 lbs. per sq. ft. and shell stopped sinking.
Later, at 8:45 A. M., after 100 tons of pig iron was added to load, shell dropped to bottom of excavation, about 6 ft., to Elev.—48 and continued moving.

Load—Steel shell .... 43,190 lbs.
Concrete ....593,600 lbs.
Pig iron ....200,000 lbs.

836,790 lbs.

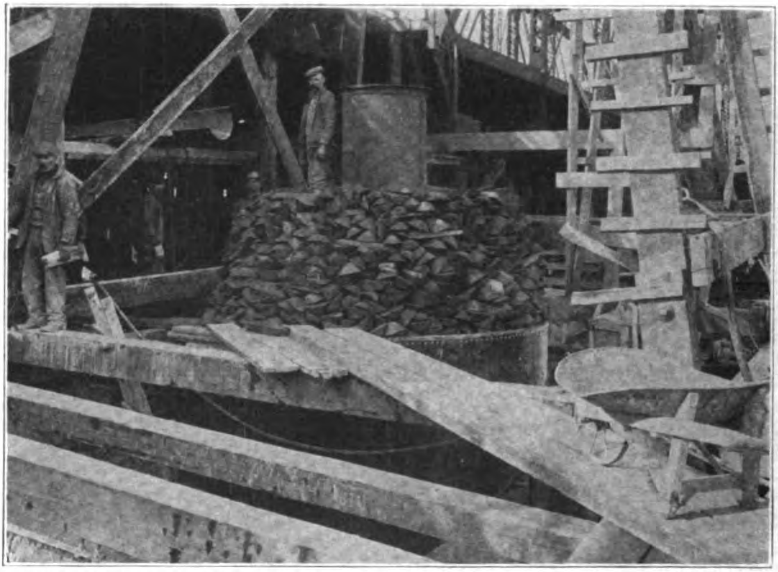

Fig. 6. Cylinder Loaded with Pig Iron to Make It Sink.

Area—37.7'x48'=1,809 sq. ft. for 48 ft. penetration.
Skin Friction—463 lbs. per sq. ft.

No. 3—Caisson South Abut.—West Front—8:00 A. M., Nov. 10, 1915.
Moving at Elev.—43.93'.
56 ft. of shell in place.
40 lin. ft. of concrete in place.

Load—Steel Shell .... 43,190 lbs.
Concrete ....593,600 lbs.

636,790 lbs.

Area—37.7′x44′=1,658 sq. ft. for 44′ penetration.
Skin Friction=384 lbs. per sq. ft.

No. 2—Caisson S. E. Rear stopped at Elev.—26 with friction of 304 lbs. per sq. ft. Started again when loaded to develop a skin friction of 516 lbs. per sq. ft.

When the cylinders reached final position on rock, the surface of the rock was leveled off and cleaned and the work chambers and shafts filled with concrete. In the top of each of four of the cylinders were set vertically 18 track rails 12 feet long, embedded half their length in the cylinder, the other half projecting above the top to be built into the concrete girders to strengthen the bond between cylinders and girders. These rails were omitted from the

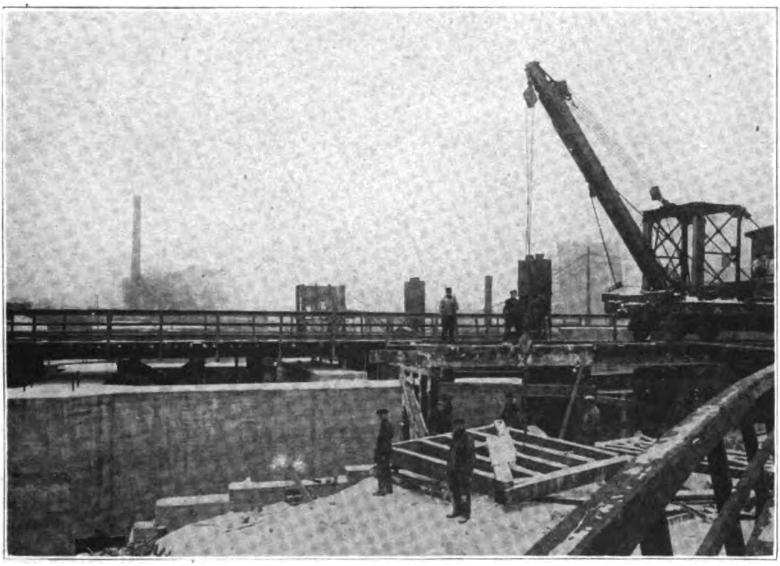

Fig. 7. Rear Substructure Complete.

two rear cylinders, as the vertical posts of the towers were embedded in the tops of these cylinders and, in addition to doing duty as tower posts, served the purpose for which rails were provided in the other cylinders.

As the concrete girders were designed to extend down 2′ 0″ below datum, it was necessary to enclose the piers in coffer dams to construct the lower portions of the girders. A dam of sheeting and puddle was constructed on the river side of each pier and run shoreward well into the river bank. The bank formed the fourth side of the dam. The reinforced concrete girders were built in place inside this dam, on top of the cylinders, first erecting the structural steel trusses, building the forms around them, assembling the reinforcing inside the forms, and proceeding in the usual way with the filling of the forms with concrete.

SUPERSTRUCTURE

The superstructure is here arranged under four heads for convenience in description:

(a) Movable span and counterweight. This includes all moving parts, except machinery.
(b) Tower.
(c) Operator's house.
(d) Machinery, power and operating equipment.

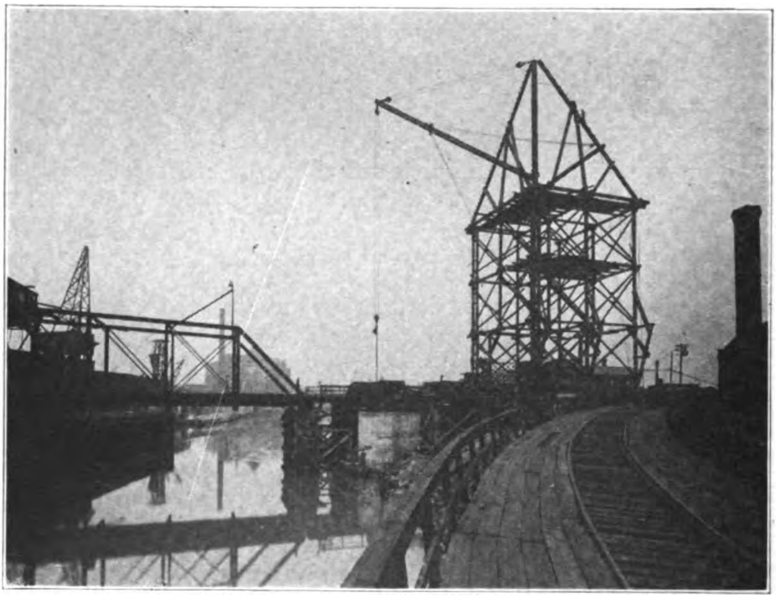

Fig. 8. Erection Tower and Material Track.

MOVABLE SPAN

The movable span, being skewed at one end to fit the angle of the channel, has trusses of unequal length, the long truss being 186′ 0″ from center of main trunnion to center of bearing at front end.

The live load used in designing was Cooper's Class E-55, applied as follows:

Stringers—Track fully loaded.
Floor beams—Full load on middle track and ⅝ of full load on two outside tracks.
Trusses—Three-quarters of full load on all three tracks.
Design, detail and material to be in accordance with C. & N. W.

Ry. Specification for Steel Bridges, supplemented by special specifications prepared by the Strauss Bascule Bridge Company to cover all features not covered by the C. & N. W. Ry. specifications.

The counterweight consists of two reinforced concrete wings, one on each side of the bridge, outside of the clearance lines. They are cast around the framework of the counterweight trusses, which are mounted on trunnions set in heavy bearings at the top of the tower. The aggregate used in the counterweights was Fayalite, a very heavy and hard rock obtained in Northern Illinois. The con-

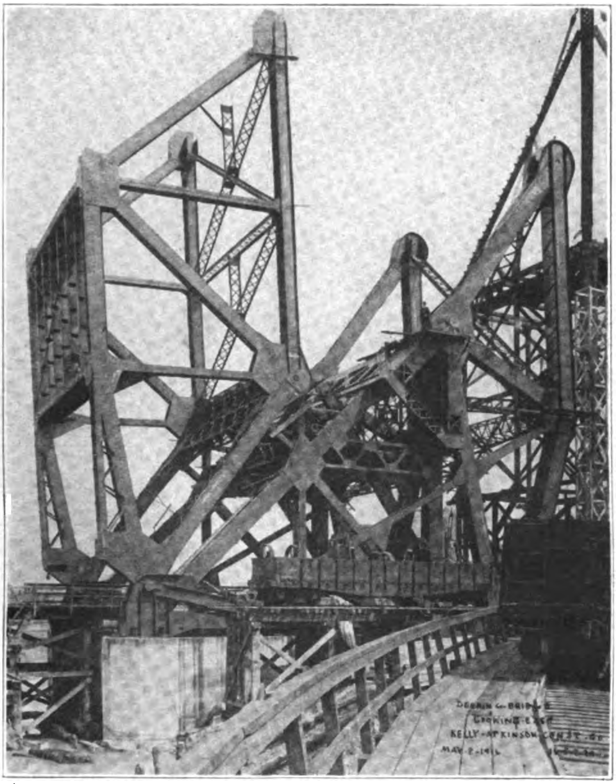

Fig. 9. Tower and Part of Bascule Span Erected.

crete was mixed in different proportions for the two wings, in order to keep the volume and outline the same for both, but to give to each wing the weight necessary to counterbalance the corresponding side of the skewed movable span. The concrete in the counterweight for the short truss weighed about 160 pounds per cubic foot at 20 days; that for the counterweight of the long truss about 168 pounds. The composition giving these weights was almost exactly 1:2:4 for 168 lbs. and 1:3:5 for 160 lbs. per cu. ft.

The detail of the counterweights provided a number of horizontal cylindrical pockets for adjusting blocks. These pockets are 1′ 11″ in diameter and extend all the way through the counterweight, excepting where interrupted by the members of the counterweight trusses, where they extend only 1′ 11″ from the surface. Cylindrical concrete adjusting blocks 1′ 10″ in diameter and 1′ 8″ to 1′ 10″ long were cast for these pockets. The volume of the pockets constitutes about 7% of the total volume of the counterweight, and it was estimated that the counterweights would balance the span when half of the pockets were filled with adjusting blocks, giving a possible adjustment of 3½% of the total amount of coun-

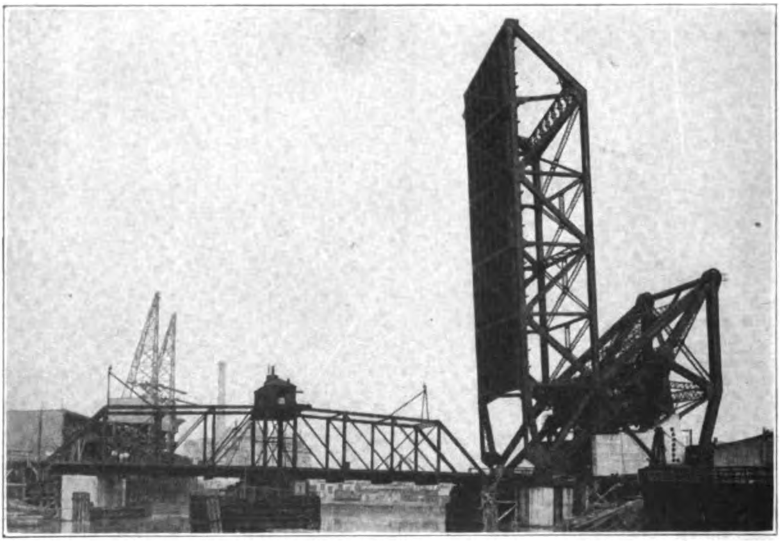

Fig. 10. Erection Nearly Completed, as Bridge Appeared the Day Before It Was Put in Service. Old Bridge Shown Still in Service.

terweight either way from the estimated requirement. After bridge was completed and the counterweights adjusted, these pockets were all sealed with cement mortar spread on wire netting on frames set in the ends of the pockets. This effectually conceals the pockets and gives the counterweights the appearance of being solid throughout.

On account of the great weight of the moving parts, the trunnions are of unusual size. The trunnions at the top of the tower, carrying the counterweight trusses, are 24″ in diameter. The heel trunnions are 17″ in diameter and those at the ends of the connecting links are correspondingly large. The four trunnions on each side of the bridge are so arranged that the four lines connecting their centers form a true parallelogram, a condition essential in applying the principle of counter-balance of this type of bridge. The counterweight, while revolving around a center different from that of the moving span, always moves through the same degree of angle as the span, but in the opposite quadrant of the circle.

TOWER

The tower carries at its highest point the two trunnions on which are mounted the counterweight trusses. The size and general outline of the counterweights determined the height at which

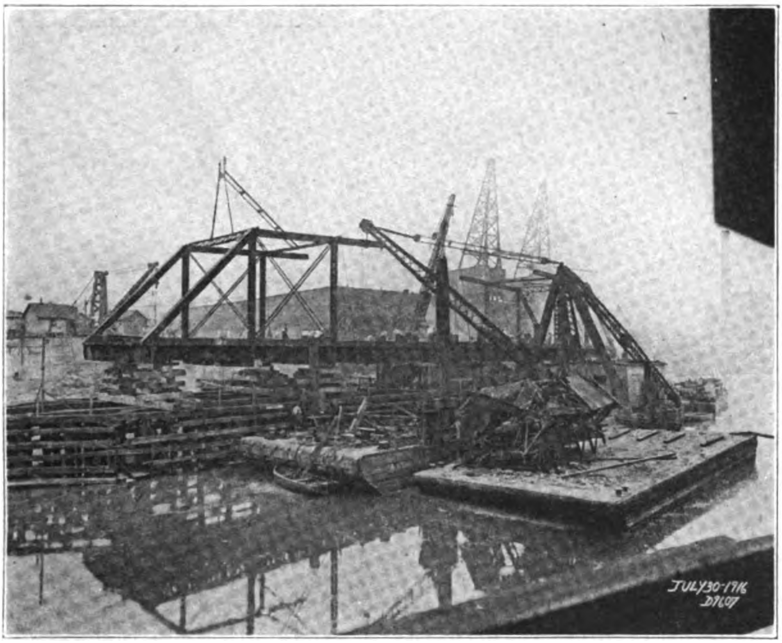

Fig. 11. Cutting Out Middle Portion of Old Span to Make Way for Lowering the New Bascule Span.

the supporting trunnions must be placed to keep the counterweights above the level of the water in river when in their lowest position. This fixed the general dimensions of the tower, which is 50′ 5¼″ from base of rail to center of counterweight trunnion, and its span 55′ 6″ between front and rear bearings on the substructure.

MACHINERY, POWER AND OPERATING EQUIPMENT

The machinery was designed to open the bridge the full angle of 87 degrees in one minute, against an unbalanced load of 2½ lbs. per square foot of floor area of moving span, acting normal to the floor of the bridge. The specifications also provided that machinery should be of the required strength, and the power sufficient, to open the bridge slowly against an unbalanced snow load of 10 lbs. per square foot of floor area, combined with an unbalanced wind pressure of 10 lbs. per square foot of this area; also, to hold the bridge stationary in any position against the snow load of 10 lbs. per square foot combined with a wind pressure of 15 lbs. per square foot.

The power installation consists of two 150 H. P. motors coupled in parallel. The power is alternating current, 3 phase, 60 cycle, 440 volts.

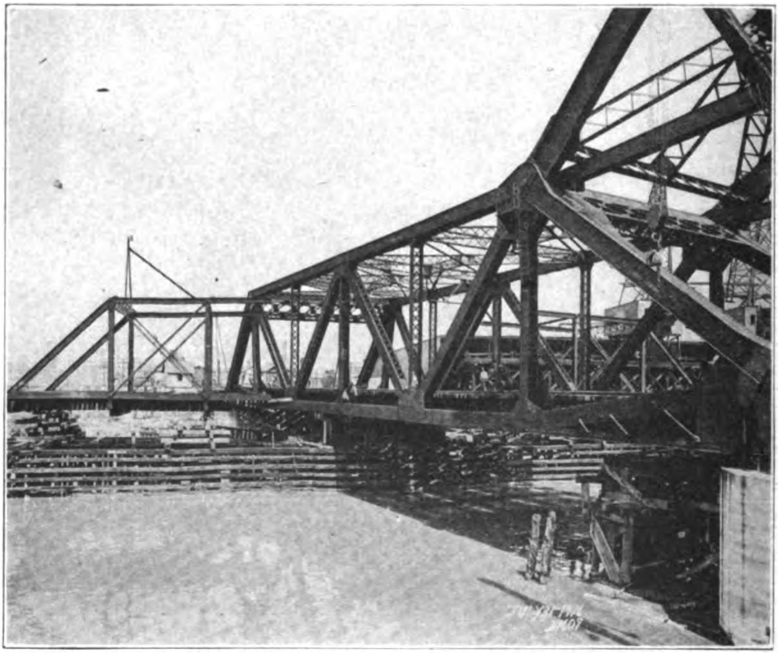

Fig. 12. New Bridge in Position Ready for Trains. Ends of Old Bridge Still Resting on Blocking, as Left When Middle Portion Was Removed to Permit Lowering New Span.

Auxiliary power is provided in the shape of a 45 H. P. high speed gasoline engine connected through reduction gearing and reversible friction clutches with the spur gear driven by the motors. This arrangement makes the motors run idle when operating the bridge with the engine. The solenoid brakes on the motors, which are normally released only when current is driving the motors, are held in release position during operation of engine, by special mechanism provided for this purpose. An auxiliary hand brake is provided for control of bridge when operating with engine. The emergency brakes described below are also available for this purpose.

To protect the operating machinery from the effect of applying brakes at the motor shaft, emergency brakes operated by compressed air are mounted on the operating shafts, enclosing the operating pinions. When set, these brakes seize the operating struts and transmit the action of the moving parts direct to the bearings of the operating shafts, without passing it through a single gear of the machinery. Compressed air for these brakes is furnished by a small electrically driven compressed air unit which is automatically controlled by the pressure of the air in the storage tank.

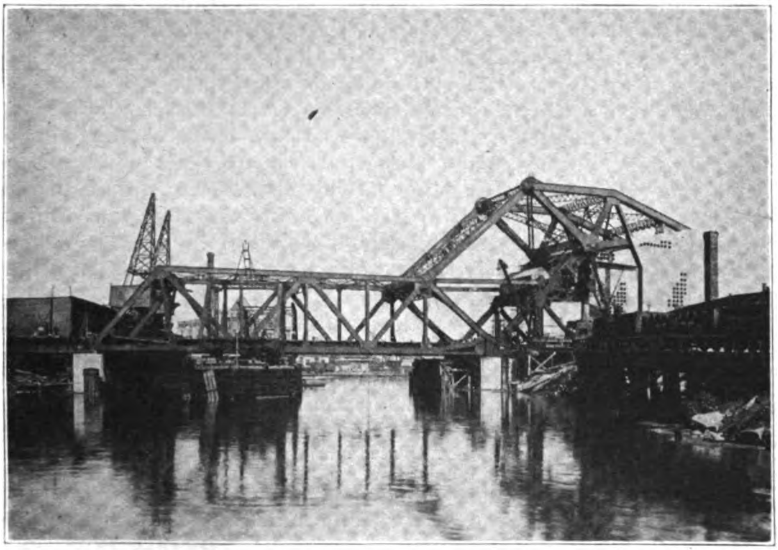

Fig. 13. Another View of New Bridge Just After Bascule Span Was Lowered.

Following is a table of quantities in the superstructure:

Structural steel—	
Moving parts	1,769,000 lbs.
Tower	757,800 lbs.
Machinery and trunnions	255,800 lbs.
Total	2,782,600 lbs.
Concrete in counterweight	2,360,000 lbs.

The upper part of the tower, above the clearance line of 22′ 0″ above top of rail, is occupied by the operator's house, which contains the operating machinery, power installation, interlocking plant, and all the equipment for operation and control.

The design of the operator's house was given considerable study by the Railway Company's engineering department. The outside dimensions of the house were fixed by the clearance required in all directions—below by the clearance required above the tracks; in all other directions by the moving parts of the bridge and by the tower bracing. The operator's floor occupies the rear half of the house, and is placed 3′ 5″ above the machinery floor. This gives the operator a clear view above the machinery from any point on the operating floor. The location of windows, positions of installations in the house, and the arrangements of operating equipment, were all made to conform to the requirements for unobstructed view from the operator's position behind the controllers, and for quick and easy access to all operating levers. The air tanks, water tanks, and most of the piping were suspended from the roof to avoid overcrowding the floor space.

The steel framework under the house is protected from the locomotive blast by concrete covering. The walls and roof are of wood, protected with fireproof asbestos covered metal. The inside is finished with beaded wainscoting up to the level of the window sills, and with beaver board above that level. All windows are double, the removable sash being on the inside to facilitate placing and removal. It is intended to have the inner sash in place during the winter only, to prevent excessive radiation by the large glass surface; and to prevent frost coatings on the glass, which would obstruct the operator's view.

The house is heated by a hot water heating plant. Running water is provided by direct connection with the city water main. Lavatory and sanitary conveniences are provided, with soil pipe discharging into the river below the water level.

ERECTION

The bridge was erected in open position, the usual method of erecting this type of bridge where traffic must be maintained during erection.

The material for the superstructure was delivered at the bridge site, for erection, on a spur track built along the west side of the new substructure and as near to it as practicable. A timber tower spanning the main tracks was built just behind the proposed location of the bridge tower. On top of this timber tower a stiff leg derrick was erected, on the side adjacent to the material track. The timber tower and the derrick were designed to handle material direct from cars on the track, and set it in place in the bridge. From this first position of the derrick, the bridge tower, the operating machinery and the first three panels of the movable span, except the floor member of the lower panel, were erected. These floor members were omitted to avoid obstructing rail traffic.

At this stage of the work the derrick was moved up to a higher level and set in position on the highest point to which erection had been carried. From this second position the erection of the structural material was completed, except the members omitted to avoid obstructing traffic. The deck and track on all except the lower panel were also put on with the bridge in the open position.

The parts which it was not practicable to erect while traffic was still being carried on the old bridge, included the floor members of the first panel, some of the bracing between counterweight trusses, and certain minor parts at the front end of the span. The plan of erection adopted therefore provided for the suspension of traffic on railway and river while the old bridge was taken out and the new bridge put into service. To make this interruption as short as possible, every member that could be erected was put in place and riveted up before traffic was suspended. Power transmission connections were completed and the operation of the machinery was tested under power. The bridge was also moved through a small angle and the counterbalance adjusted. Sunday, July 30th, was selected as the day for putting the new bridge in service. A schedule of operations for the day was prepared and issued to all officials in charge of any part of the work, providing for the suspension of traffic on the river at midnight, Saturday night, and on the railway at 12:23 Sunday morning.

Following is the schedule:

Schedule of Work on July 30th, 1916, for Placing the New 3-Track Bascule Bridge in Operation.

Suspension of Traffic:

Railway traffic over the old bridge will be suspended at 12:23 A. M., Sunday, July 30th, after train No. 301, northbound, has passed.

Railway traffic will be resumed at 4:07 P. M., at which time the new bridge must be in position to let train No. 166, southbound, pass.

Navigation in the river will be suspended from 12:00 o'clock midnight, Saturday night, to 6:00 P. M., Sunday.

Schedule of Operations:

Immediately after traffic has been suspended at 12:23 A. M., the old bridge will be opened and swung over the old pier protection. The order of work outlined below will then be followed:

FIRST PERIOD

(From the suspension of traffic at 12:23 A. M., to the lowering of the bridge at 8:15 A. M.)

By C. & N. W. Ry. Co.'s Forces:

(a) Immediately after the suspension of traffic at 12:23 A. M., division forces will begin removing the track and the timber bridges in the north and south approaches. The iron bridge crew will have a derrick in operation at each approach to handle and load the material removed by the division forces.

The work on both approaches will be started at the same time, one division crew and one iron bridge crew working on each approach.

A work train will be in service at each approach after 12:00 o'clock midnight, until 4:00 P. M., Sunday.

(b) Iron bridge crew will lift the concrete backwall blocks into place. Division forces will place the bed of mortar to set them in, and close up the joints with mortar.

Bridge crew will erect the deck plate girder spans. The spans in north approach will be bolted up for traffic.

The spans on the south approach will be erected complete ready for deck at 5:00 o'clock A. M., and the spans on the north approach at 6:00 o'clock A. M.

(c) The division forces will lay the decks and rails on the approach spans. The rails will be in place on the south approach at 7:00 o'clock A. M., and on the north approach at 8:00 o'clock A. M.,

(d) The iron bridge crew will carry the cast iron bearings for the north end of the bascule span to the north pier, but will not place them in permanent position.

(e) The track elevation forces will begin work at 7:00 o'clock A. M., raising the grade and realigning the tracks on both approaches, beyond the steel spans. Tracks will be laid for double track service.

All work on change of grade and alignment will be completed and the tracks ready for service by 2:00 o'clock P. M.

By the Great Lakes Dredge & Dock Co.:

(f) Immediately after the old bridge has been opened at 12:23 A. M., the Great Lakes Dredge & Dock Co. will block it up on the old pier protection, and cut it apart with the oxy-acetylene flame at such points as necessary to facilitate quick removal of the middle section. This section will be removed down to the level of the treads under the wheels of the turntable.

All material removed from the old bridge will be loaded on a scow furnished by the Great Lakes Dredge & Dock Co. for delivery, at later time, to railway company's cars.

The above work of cutting apart the middle section, removing it and loading it on scow must be completed, and the equipment removed by 7:30 A. M.

By the Kelly-Atkinson Const. Co.:

(g) Immediately after the iron bridge crew has completed its work on the south approach span at 5:00 A. M., contractor will pull in on the east track and erect the bracing between the counterweight trusses, and the bottom laterals in the lower panel of the movable span.

Also, move the bearings for the north end into permanent position on the north pier, but will not anchor them at this time.

All of the above members must be in place and bolted up complete by 8:00 A. M.

At 8:15 A. M. the bascule span will be lowered by electric power.

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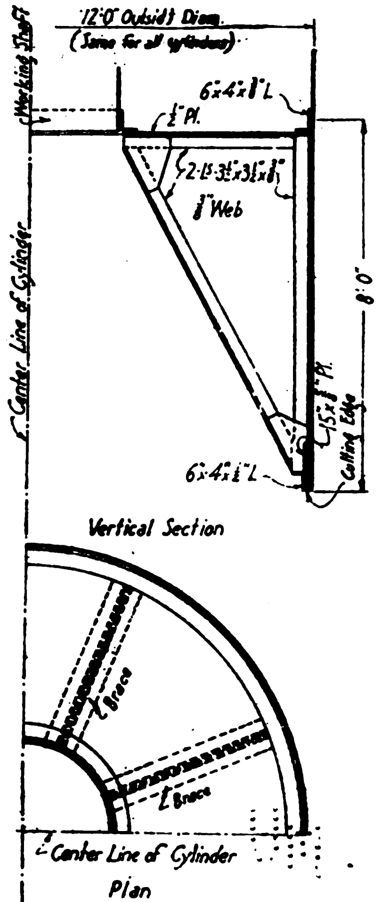
Dalstrom—186 Foot Bascule Bridge.



WORKING CHAMBER OF CYLINDER

SECOND PERIOD

(From the lowering of the bridge at 8:15 A. M. to the resumption of traffic over bridge at 4:07 P. M.)

By the Kelly-Atkinson Const. Co.:

(a) After the lowering of the bridge at 8:15 A. M.:

The bearings on the north pier will be adjusted and anchored.

The floor members in the south panel of the movable span erected and bolted up complete.

Ties and rails in south panel placed.

Holes for end lock casting drilled in the castings on the north pier, and end locks attached and adjusted.

Movable platforms over the counterweight pockets erected and adjusted.

Counterweights adjusted by addition of the necessary number of counterweight adjusting blocks.

All parts at north end of span not in place will be erected and adjusted.

Bridge will be locked by closing end lock with hand operating mechanism.

By C. & N. W. Ry Forces:

(b) The track elevation forces will place the tie plates, align and adjust the rails and spike them to the ties.

Immediately after the last train had passed at 12:23 the old span was swung open and the arms blocked up on the old timber pier protection. Eight oxy-acetylene torches were immediately set to work to cut the old bridge into three parts so that the middle portion could be removed to make way for the lowering of the new span. While the torches were cutting the span apart, a scow derrick was at work on each side of the old span, removing the operator's house, operating machinery and deck. By 7:30 Sunday morning the old span had been cut apart, the middle portion lifted out and placed on scows and the scows and equipment removed from the bridge site. At 8:15 the new span was lowered to horizontal position.

After lowering the bridge, the few remaining members were erected, the deck completed, and the end rails put on and adjusted. At the same time track gangs were realigning the tracks on the approaches and raising them to the established grade. This part of the work could not be completed in time to re-establish rail traffic at 4:07 P. M., the time designated in the schedule, and the time was extended to 6:00 o'clock. By that time the bridge and tracks were in shape for trains and traffic was resumed, after an interruption of less than 18 hours.

SIGNALS

The operating mechanism of the bridge is interlocked with the switch and signal system controlling the traffic on all tracks adjacent to the bridge. The system of tracks controlled by the interlocking plant includes the switches about 200 feet south of the bridge where the three track system merges into a two track system; also the switches to a number of industry tracks on both sides of the river whose turnouts are close to the bridge.

The operating mechanism of the bridge is so interlocked with the signal system that it is impossible to unlock or open the bridge when a signal is given for a train, or while a train is within the limits of the interlocking plant. It is also impossible to clear a signal while the bridge is open or unlocked. The interlocking is effected by means of electrically operated locks applied to the controllers of the bridge lock motor and the bridge operating motors, and to the operating shaft of the engine clutches. All operating levers are electrically interlocked to insure proper sequence of operation in manipulating the levers.

The interlocking machine has a capacity of 44 levers. It contains 18 levers for signals, 16 levers for switches and derails, and 3 levers for the special locks between bridge and interlocking apparatus. This leaves 7 unused spaces, reserved for possible future extension of the interlocking plant.

The power for operating the interlocking plant is 110 volt D. C. from storage batteries housed in a building adjacent to the tracks and about 100 feet from the bridge. The batteries are charged by motor-generator sets receiving power from the same source as the bridge motors.

The signals installed are three-position, upper-quadrant type, conforming to the latest established practice on the Chicago & North Western Railway.

Detector bars are installed only at facing points.

The usual channel lights are provided for navigation. These are electrically lighted lamps set on the fenders on either side of channel; also bridge lights at front end of movable span, consisting of lamps with uncolored lenses, suspended in such manner that they hang vertical whatever the position of bridge. In front of each lamp is an arc of red and green glass, the red glass being in front of the lamp when bridge is closed; as the bridge opens, the lamp, swinging about its point of support, passes behind the green section of the arc.

In addition to the lights required by the government, a special wigwag signal for boats was installed on each side of the span, just outside the lower chord and over the middle of the channel. This is a swinging lamp with a red lens, hooded so that the red light is distinctly visible against the dark background, even in bright daylight. The purpose of this signal is to warn approaching boats, by the swinging of the lamps, that bridge cannot be opened immediately, and that they must come to a stop. The lamps are operated by electric motors in the same manner as the swinging signals now much in use at dangerous highway crossings.

The general plan of contruction, and the designs of substructure, approaches, interlocking system, and temporary structures, were made by the engineering department of the C. & N. W. Ry., under the direction of W. H. Finley, Chief Engineer. The superstructure was designed by the Strauss Bascule Bridge Company, and built by the American Bridge Company. It was erected by the Kelly-Atkinson Construction Company, and the power and operating equipment installed by C. H. Norwood. The substructure and the fenders were constructed by the Great Lakes Dredge & Dock Company. This company also removed the old bridge, both superstructure and substructure, and dredged the new channel. Mr. H. M. Spahr was resident engineer in charge of all field work for the railway company.

DISCUSSION

C. H. Norwood, M. W. S. E.: Due to the comparatively large amount of power required and at infrequent intervals, the Chicago & Northwestern Railway Company decided to purchase the power for their new bridge from the Commonwealth Edison Company. This current is furnished from the Division street substation at 4,000 volts. The service is brought overhead to the railway company's right-of-way and then along same to a point just east and adjacent to the bridge. As an auxiliary source of supply a direct connected gasoline engine is used.

The operating machinery is on the fixed part of the bridge, located in a machinery room above the tracks.

The two operating motors are of 150 H. P. capacity each, 440 V 3 phase, 60 cycle and of the Westinghouse make. Each motor is equipped with a substantial solenoid brake of the General Electric make, adjusted for braking 100% of normal running torque of the motor. These motors are controlled by the Cutler-Hammer magnet type control, consisting of four reversing contactors, and five accelerating contactors for each motor. The master controller for these contactors is mounted on a stand and interlocked with the lock motor in such a way that neither can be operated out of proper sequence. The operations of the lift and lock motors are in turn interlocked with the signal interlocking machine. In opening, all track warning signals must be set to "danger" before motor controllers are released.

All gearing is of cast steel with cut teeth. The clutch for the auxiliary drive is on the first reduction from the engine. The friction plates of the clutch are asbestos composition lined, which has proved most satisfactory where a certain amount of slipping is necessary.

A departure from the usual practice is to be noted in the auxiliary power, a high speed automobile engine being used instead of the slow speed continuous duty engine.

This type of engine has its advantages, in that it is light, well balanced and easily started and regulated. In fact, this outfit is handled as you would handle an automobile. The engine is cranked, the operator moves over to the clutch wheel, where are located the throttle and spark levers, and when the engine is up to speed, the clutch is gradually thrown in, at the same time more gasoline is allowed to pass into carburetor. The engine used is a four cylinder 4¾" x 5½", 45 H. P. Wisconsin Motor Mfg. Co. make operating at 1,100 R. P. M. The governor is adjusted so that a maximum speed of 1,200 R. P. M. can be obtained. On a test of the auxiliary power, the slip gear for the engine was thrown in mesh with main machinery drive, the engine started and the bridge raised to an angle of 45 degrees, all in ten minutes. This type of engine is the first of its kind for this particular service that has come to the writer's attention.

It may be well to note here that the Chicago & Northwestern Railway Company was the first railroad to use the gas engine as motive power on a movable bridge. This was in Milwaukee over the Milwaukee River. The gas was stored in tanks on the bridge. Later this engine was changed over to use gasoline. Since that time stationary gasoline engines became very popular among bridge engineers as a drive for movable bridges.

The service transformers were installed by the Commonwealth Edison Company and consist of three 50 K. V. A. single phase transformers 4000 V to 440 V. From the low tension side of the transformers the current is brought directly to fuses on the switchboard in the operator's house. The max-meters and watt-meters are mounted on the same panel with the main fuses. The distributing panel adjoins the service panel and contains distributing switches, ammeter, voltmeter and indicating wattmeter.

The motor operating the lock on the front end of the bridge consists of a 5 H. P. squirrel cage motor of the high resistance type. Both lock motors and main lifting motors are controlled through limit switches at the ends of their respective travel. The main line contactors for the lifting motors, located on the control panel, are tripped out when the moving span is within 15° of the fully closed position; to close it the remaining distance, a foot switch is provided for releasing the brakes and a push switch for closing the circuit through the contactors, thus short circuiting the limit switch. The motors may then be started by the master controller. In case the line contactors go out, due to overload or short circuits the controller handle must be brought to the neutral position before a new start can be made.

Air at 100 lbs. pressure is supplied to the strut brake and warning whistle. The storage capacity consists of two 25 cu. ft. tanks suspended in the top of operator's house. A General Electric Company's 25 cu. ft. direct connected motor driven air compressor with automatic governor pumps the air to the tanks.

The warning and indicating signals on this bridge are most complete. In addition to the usual channel warning lights required by the government, a wig-wag warning to river traffic has been introduced as a signal to vessels in event of failure of motive power for the bridge. The wig-wags are located in the center of the bridge on the lower cord and can easily be seen from the river. They are controlled by a snap switch in the controller stand. Directly in front of this stand is a signal box with a lamp and semaphore to each wig-wag motor. The lamp burns and the semaphore goes to "clear" when the wig-wag is operating. In event of failure the semaphore goes to "danger" and the lamp is extinguished.

Under normal balanced conditions, the bridge now requires 450 amperes to start and 250 amperes to operate. The time required for a complete opening is one and one-fourth minutes. This, in the writer's estimation, is too speedy for such a large structure. The vibration is decidedly objectionable. On the other hand, when the bridge is being operated with the gas engine there is no vibration whatever.

O. E. Strehlow, M. W. S. E.: I would like to ask a question about the foundation. I was wondering why the bridge was swung and hinged at the south end instead of the north.

Mr. Dalstrom: One reason was that there was a shorter approach. Also there was a through bridge near the north end.

Mr. Strehlow: Was not the bed rock at the south end at a much lower elevation than at the north end, and if so, did the additional cost of substructure of four cylinders at the south end and only two at the north end, instead of the reverse, constitute a cost of some magnitude?

Mr. Dalstrom: Yes. The substructure at the south end was carried deeper, but the disadvantages from blocking the tracks at the north end, where they spread out to three tracks, and the three track through girder span over the C., M. & St. P. tracks only a short distance away, would have involved difficult and expensive temporary work. The Milwaukee crossing was so close that it would have had to be taken out before the temporary structure could have been installed.

Mr. Strehlow: How much longer would the bridge have been out of commission if it had been a two track instead of a three track bridge?

Mr. Dalstrom: I think there would have been very little difference. We would have had just about the same amount of equipment. There would have been a smaller amount of deck timber to put in, there would have been fewer stringers to place in the south panel, and one less track to put in on the south end of the moving span, after the span was lowered. The difference would probably have been 2 or 3 hours.

James E. Cahill, M. W. S. E.: Can you give us some idea of the ground conditions as compared with the original borings?

Mr. Dalstrom: Only that the ground was reported as being considerably harder than we had anticipated from the terms that were used in describing the material. It was hard enough so that it had to be worked out with picks where it wasn't wet, and it added a little bit to the delay in progress in sinking the cylinders.

L. W. Skov, ASSOC. W. S. E.: I would like to ask Mr. Dalstrom if the initial lining of those cylinders was computed for air space at that time?

Mr. Dalstrom: It was not.

J. W. Lowell, Jr., ASSOC. W. S. E.: Several inquiries have come to my attention where concrete weighing as high as 350 pounds per cubic foot was desired for bridge counterweights. Naturally, the way to obtain such weight is to use extremely heavy aggregates, such as iron or some heavy ore. I would be interested in learning more about how Mr. Dalstrom solved this problem.

Mr. Dalstrom: The aggregate that was used was a heavy stone that is obtained here in Illinois, and a number of test specimens of the concrete were made at the railway company's yards by the contractors. The proportions were varied until they got a density which gave a weight between 170 and 180 lbs. per cu. ft. immediately after they were made. By slightly varying the proportions, they succeeded in getting test specimens with a known proportion, amounting to 160 lbs. and 168 lbs., after 20 days of drying.

Mr. Lowell: How big were the counterweight blocks?

Mr. Dalstrom: They were six inch cubes.

Mr. Lowell: Did they gage the consistency of the concrete in arriving at the density?

Mr. Dalstrom: They recorded the amount of sand, cement, stone and water used, and that would fix the consistency.

Mr. Norwood: I can tell you how the bascule blocks were made on the Great Northern. Their test blocks were one foot. The counterweights were too heavy and they had to put about 15 or 20 tons on the front of the bridge. The engineers came to the conclusion that the concrete dried out in a foot cube, where it did not dry out more than six inches in the main mass of concrete poured into the counterweight box.

I think their point is pretty well taken and I have talked to other engineers on that subject and have practically agreed with them that concrete will not dry out over six inches in mass, and that the water does not get out. If the Great Northern had made its blocks of a cube three feet in diameter, the weights of their test blocks would have been a better guide for determining the weight of their counterweight than they were. This counterweight, as shown in the views, is a very difficult weight to figure and the Great Northern should have gotten closer to it.

D. N. Becker: I wish to know whether those cylinder subpiers were figured as to unit pressure, or just made at 12 feet for construction purposes, in order to get the weight to sink them.

Mr. Dalstrom: Largely for construction purposes, but the unit pressures were figured and they were considerably less than would be necessary with rock foundation.

Mr. Becker: What would you consider as proper on a rock foundation?

Mr. Dalstrom: I think it would be safe to go to 25,000 or 30,000 lbs. per sq. foot on this material.

Mr. Becker: Along that line, I wish to say that in our city bridge work, on our sub-piers, we figure 300 lbs. per square inch on rock. In the Chicago building ordinance, I understand they allow 300 to 400 pounds at the top of the sub-pier, which is even greater. They are running practically 30 tons on rock, which is usual on the buildings around the city.

Mr. Norwood: I would like to draw the attention of those present to a point in the machinery on this job. The last few years engineers have come to the conclusion that it is a good investment to use cut gears and they used cut gears on this job. It costs a little more, but they certainly pay for themselves.

I think the first job on which the city ever used them was on the Chicago Avenue Bridge. It didn't operate very easily and it had not been shown at that time that it gave them any advantage, but some of the later jobs certainly did show the advantage of cut gearing.

In some jobs the expense may amount to several thousand dollars, but the amount of friction done away with, which adds up in the cost of current during the year, makes it certainly worth while to cut the gears.

J. C. Blaylock, M. W. S. E.: I would like to know if the operation of the bridge during the winter, in the sleet and snow, was hindered to any extent, and did the accumulation of ice or sleet and snow affect the operation of the bridge to such an extent that it delayed traffic?

Mr. Dalstrom: We haven't had a very bad winter this year, and the bridge was not really put to the test.

Mr. Norwood: We had a job in Portland, Maine, where it failed, due to the ice and snow on the tracks. The sleet and snow blew in from the ocean—it was a very exposed place—and the rocker got packed up and froze to the track, and it was necessary to break the ice before the bridge could be raised.

Mr. Blaylock: Has there been any trouble due to ice or water freezing in the pit of the counterweights? We generally have that trouble with the bridges where the boxes are below the water level.

Mr. Dalstrom: This pit is not below the water level. It is just a little above the water level.

Mr. Blaylock: What method have you provided for taking care of the water that falls into the pits? Anything whatever?

Mr. Dalstrom: Yes, that drains right into the river. The bottom of the pit is above the level of the water of the river and the pit is open to the north. Any water that falls into the pit can run right out of it into the river.

Mr. Blaylock: Is it an open drain?

Mr. Dalstrom: Yes.

Mr. Becker: In your judgment, was it necessary to place the steel rails in the tops of the concrete cylinders, or was it done to get rid of old rails?

Mr. Dalstrom: It was not done to get rid of the steel rails, but I do not know that anything would have happened if we had omitted them. They give a greatly increased strength of bond between girder and cylinders, and at a very small cost.

Mr. Norwood: I would like something to be said on the subject of speed of operation.

D. P. Riordan: Why does the city or the government require that speed for the motive power?

Mr. Norwood: To get the river clear as soon as possible. Some of the largest bridges operate in three-quarters of a minute, but if you take a plant like the big bridge of the B. & O. at South Chicago, and try to operate that in too short a time, the power climbs up, and I consider it a very dangerous thing to try to operate these large bridges in such a short time.

E. N. Layfield, M. W. S. E.: I would like to ask Mr. Dalstrom if there is any particular purpose in sealing up those holes in the counterweights, so that the counterweights cannot be changed readily. My experience has been that it is desirable to have some ready means of changing these counterweights. For instance, in the case of one bridge I was concerned with, when we put on heavier ties and heavier rails, it was necessary to change the counterweights. That bridge was nothing like as heavy as the one described by the author, and the percentage of weight of increase was naturally greater than in this case, but it certainly seems desirable to have some ready means of adjusting the counterweights.

Mr. Dalstrom: By sealing them up I did not mean that we closed them up permanently. That sealing consists of only about three-fourths of an inch of cement on a wire netting and any time it is necessary to readjust the counterweight, all that is necessary is to hit it with a hammer and it will come to pieces. The pockets are sealed up more for appearance than anything else.

T. W. Clayton, M. W. S. E.: I would like to ask Mr. Dalstrom the estimated relation of cost of the double leaf bascule.

Mr. Dalstrom: I haven't any figures on that. The double leaf was not applicable to that particular place, and so no comparative figures were made.

Mr. Layfield: I would like to say in response to Mr. Clayton's question that that question received some inquiry in connection with the so-called eight-track bridge over the Drainage Canal near 31st Street and Campbell Avenue. The Sanitary District built this eight-track bridge about 1890, or a little before, for the Pennsylvania Lines, the Chicago Terminal Transfer Railroad and the Chicago Junction Railway. It was a two-leafed bridge, which, from a railroad standpoint, is objectionable on account of the lock in the middle. It was intended to have the machinery installed on each end. Several years elapsed before it was desired to install the machinery, and about 1908, the Sanitary District removed the old bridge and put in an entirely new one with a single leaf. My understanding was that it was cheaper to do that than it was to install the machinery on both ends of the old bridge, and besides, it was very much better from the standpoint of the railroads.

Mr. Dalstrom stated that the bridge could not be opened after a train had passed the derails. I think it would be interesting if he would explain the operation of the electric track circuits by which this is accomplished.

R. M. Phinney: With a high speed signal cleared for a train, the bridge as well as all derails and switches in the route are locked so that nothing can move until the train has passed over the route and cleared the interlocking plant. If, however, the bridge must be opened or the route changed before the train has accepted the signal, it requires from two to three minutes, two minutes being consumed by a time element release between the setting of the signal in the stop position and the opening of the derail, thus allowing a train which is approaching to stop before reaching the derail. There is no time element release for slow speed signals. With these the derail may be placed on the track immediately after the signal has been put to the stop position. However, when a train is within the signal limits, nothing can be moved except by an emergency switch, which is to be used only when a train is at stop or when a track circuit fails. This switch is in a sealed box.

Mr. Becker: I would like to know whether there was any discussion before the structure was built as to which type of cylinder should be used, whether the steel ring, or wood. It seems to me that the wooden type would have been cheaper than with the steel shell.

Mr. Dalstrom: Steel wasn't as costly as it is now, and there is more certainty of action with a construction like the steel shell. I am not prepared to say that it would have been practical to have carried down the wooden one. We would have had to change our procedure considerably from the manner in which we did work and we weren't sure at first that we would not have to resort to air pressure, and we were prepared for it with what we had made.

Mr. Cahill: Supplementing Mr. Dalstrom's remarks on steel cylinders being designed for use on this work, we believe that this design was due in main to a sort of tradition handed down among the outside or field men that a slough or swamp existed in the early days at the site of this bridge and that this slough had been filled in by the railroad company in placing their embankment. In view of this condition, the men believed that it would be necessary to use compressed air and water tight steel cylinders to get down to rock without any danger of trouble from bad material.

John B. Johnson: How much variation did you allow on the cylinders?

Mr. Dalstrom: Variation from the center of the lines fixed, do you mean?

Mr. Johnson: Yes.

Mr. Dalstrom: I don't believe I can give you the exact figures, but it did not exceed six inches, which in that case was immaterial, because the concrete cross-beams were of such size that they could be displaced that much from the center without affecting the stability in any way.

In the last case of cylinder construction we had, which was on the Illinois River at Peoria, the cylinders were carried down somewhat deeper below the ground line, and considerably deeper below the water level—but greater precautions were taken to keep them in their places, and I think the greatest displacement there was three inches. The height of the cylinders from the top to the bottom was about ninety feet, but only about fifty feet was in the earth. About fifteen feet was in the water and the rest of the cylinder above water.

Mr. Norwood: Did you use any special steel on that bridge?

Mr. Dalstrom: No.

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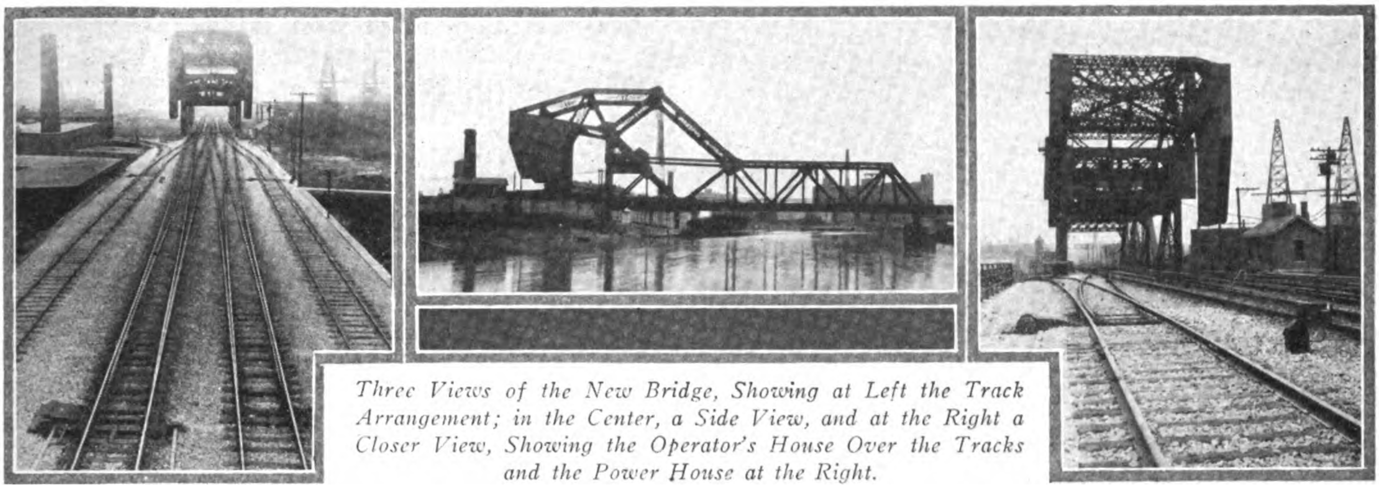
New C. & N. W. Bascule Bridge Interlocking



Three Views of the New Bridge, Showing at Left the Track Arrangement; in the Center, a Side View, and at the Right a Closer View, Showing the Operator's House Over the Tracks and the Power House at the Right.

Electric Plant Protecting Structure Over North Branch of the Chicago River at Deering Station

By R. M. Phinney,
Assistant Engineer, Signal Department

THE three-track bascule bridge carrying the Milwaukee division of the Chicago & Northwestern over the North Branch of the Chicago river at Deering station, Chicago, is protected by a new electric interlocking plant. This bridge, of the Strauss heel trunnion type, replaces a double-track swing bridge built in 1887, which was too light and practically worn out. The old bridge was protected by an electric interlocking plant installed in 1907 by the General Railway Signal Company, and previous to that time an electro-pneumatic plant installed in 1899, was in service on the bridge.

The new bridge was erected almost completely in the open position without interrupting traffic, either on the railway or the river. To this end the counter-weights were placed outside of the tracks, as shown in the illustrations. Traffic was interrupted for 18 hours while the old bridge was dismantled enough to allow the new bridge to be lowered into position for erecting the approach spans and alining and raising the tracks, as the grade of the tracks on the new bridge is two feet higher than on the old. The old bridge was swung at right angles to the railway, supported on false work, and the middle portion cut out with oxyacetylene torches.

The track arrangement over the old bridge provided for the junction of the two-track system on the south and the three-track system on the north, at a point just north of the river. This fixed the north limits of the interlocking plant so far north that while trains were standing at the Deering station, other trains could not pass through the plant to and from the center track. With the new installation, the third track is carried across the bridge and merged into the two-track system just south of the bridge. This brings the north limits of the plant far enough south to allow the use of the center track while trains are standing at the station platforms on the outside tracks. The industry switches in the vicinity of the bridge are connected into the plant. The turnouts used for the junction are 1 in 20, with the center line of the double track coinciding with the center line of the three-track section. This makes the curvature equivalent to a 1-in-40 turnout, or 45 minutes. This is clearly shown in one of the cuts. The speed over these switches is restricted to 45 miles per hour.

Before any work was done toward erecting the new bridge it was necessary to move all wires of the former plant to a place where the shifting of the tracks and erection of the bridge would not disturb them, as they had been installed in lead-covered cables in wooden boxing under the ground, along and between the old tracks. Connections to units were made with trunking running into wooden junction boxes, in which the cables were opened. These cables were hung upon a pole line erected on the east right-of-way line for the permanent cables and temporary extensions were made to branch runs.

It was also necessary to change the location of the power house used for the old plant to house the storage battery and gasolene engine generator equipment. As the old building was of wood and did not suit the new requirements, a building was erected at the location shown on the plan. The new power house is of two stories—the first of concrete and the second of brick, with concrete floors. The retaining wall of the track elevation forms one side of the first story. The first floor is used mainly for storage of materials, while the second houses the storage batteries and generating equipment.

New 120 a.-h. storage batteries of the chloride accumulator type were installed to replace cells of the same type which had become worn out. The interlocking units are operated by 57 cells; 2 cells in duplicate are provided for the auxiliary and automatic control apparatus, and 7 cells in duplicate for track circuits and an automatic signal located on the northward home signal bridge. The generating equipment consists of a motor-generator set in duplicate operating from 220-volt, 3-phase a. c. Service is supplied at 440 volts, 3-phase a. c. for operating the bridge, and transformers are supplied for stepping this voltage down to 220. The switchboard is so arranged that the 57-cell set or either of the 7-cell sets can be charged alone or together, and the 2-cell sets can be charged in series with either of the others.

The tracks were rearranged as much as possible while keeping the old plant in service, which was done up to three days before the bridges were changed. When the old plant was taken out of service everything not required for the new plant was removed. As much of the material in the old plant as possible was used in the new. New wires were installed for the new plant, being made up into cables on the ground and hung on the pole line mentioned above. The wires for 110-volt circuits were separated from those carrying lower voltage and hung on separate messenger wires and terminated in separate junction boxes. The wires were carried under the river in a steel-armored lead-covered cable laid in a trench about five feet below the bottom of the channel. This cable was not installed until after the old center pier had been removed and the channel dredged. The ends of the submarine cable are protected by hexagonal concrete houses manufactured by the C. F. Massey Company. The outlets for the aerial cables consist of three-inch conduit with bushings at each end set at an angle of 45 deg. with the horizontal, the outside end being lowest. There are eyebolts in the concrete just above the outlets on both the inside and outside to which the cables are tied with marline. The submarine cable is brought in through the floor. All wires entering these houses are terminated on R. S. A. terminals on vertical boards, mounted away from the walls to allow access on all sides.

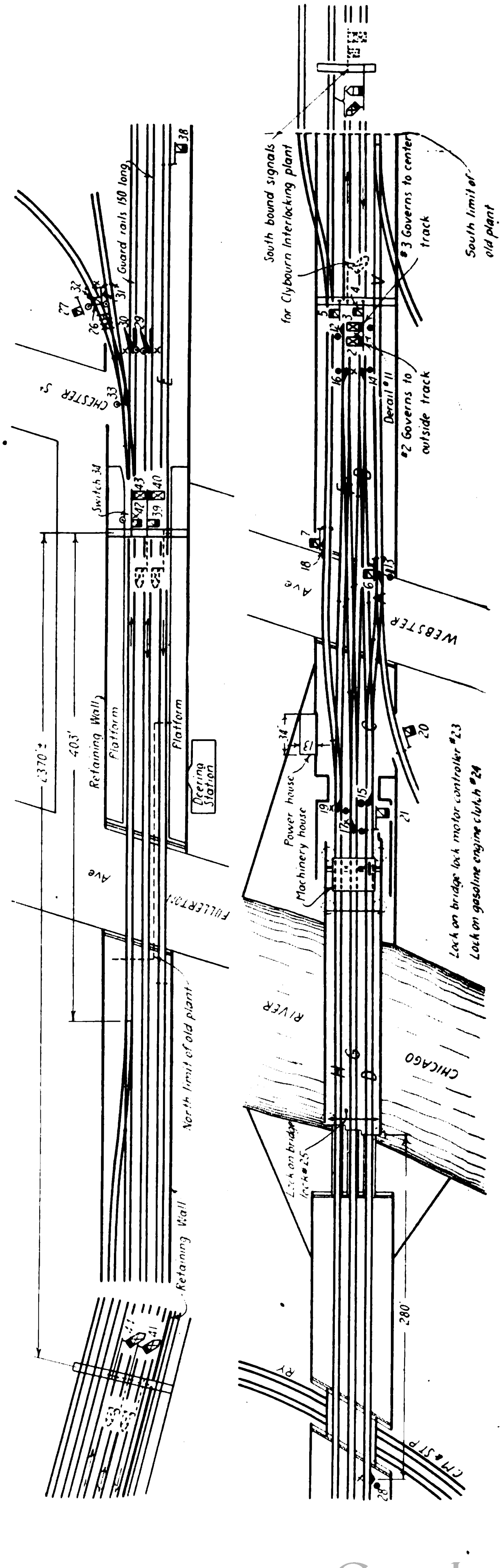
The wires from operated units are carried in trunking to the nearest pole, where they are connected to the wires in the cables through small iron junction boxes in which the wires are brought through holes in a board and spliced. The wires entering the tower, which is located over the tracks in the bridge superstructure, are brought from the concrete terminal house by overhead cables to a terminal box located on the bridge structure just in front of the house. From this box the wires are carried in conduit and a trough built into the house to the back of the interlocking machine. All other wires in the tower are enclosed in metal conduit.

A new interlocking machine of the unit type, manufactured by the General Railway Signal Company, was installed containing 18 levers for 18 signals, 16 levers for 8 switches and 8 derails, 3 levers for special locks between the bridge and interlocking apparatus, and 7 spare spaces, totaling a 44-lever frame. This machine is located near the controllers for the bridge-operating machinery.

The slot indicators showing the condition of the automatic blocks on the tracks leaving the plant, annunciators indicating the condition of the tracks approaching the plant, and the track circuit indicators, are arranged in a group on the wall back of the machine. The relays are located in a case below the indicators. The hand screw releases and emergency switches are located on a separate board to the right of the interlocking machine within easy access of the operator.

Advance, route and section locking are provided. The advance locking is accomplished by permitting the indication of the high speed signals only while a train is within the home signal limits. The route and section locking are accomplished by means of magnetic blowout relays of model 1 type which open the bus bars feeding current to the switches. These relays are so controlled that all routes are locked ahead of and behind a train while the train is within the limits of the plant. No stick relays are used. Hand screw releases of Federal Signal Company design are used for releasing the routes of the high signals in case a train has not arrived. Knife switches enclosed in individual boxes are provided for each track circuit to provide a release in case of track circuit trouble.

The operating machinery for the bridge is located in the operator's room and consists of two 150-hp. motors operating from a 3-phase, 440-volt a. c. circuit. For emergency, a 50-hp. high speed gasolene engine is provided. Electric brakes are applied to the shafts of the motors with emergency air brakes on the operating struts of the bridge. The bridge is locked in the closed position with two plungers located on either side of the

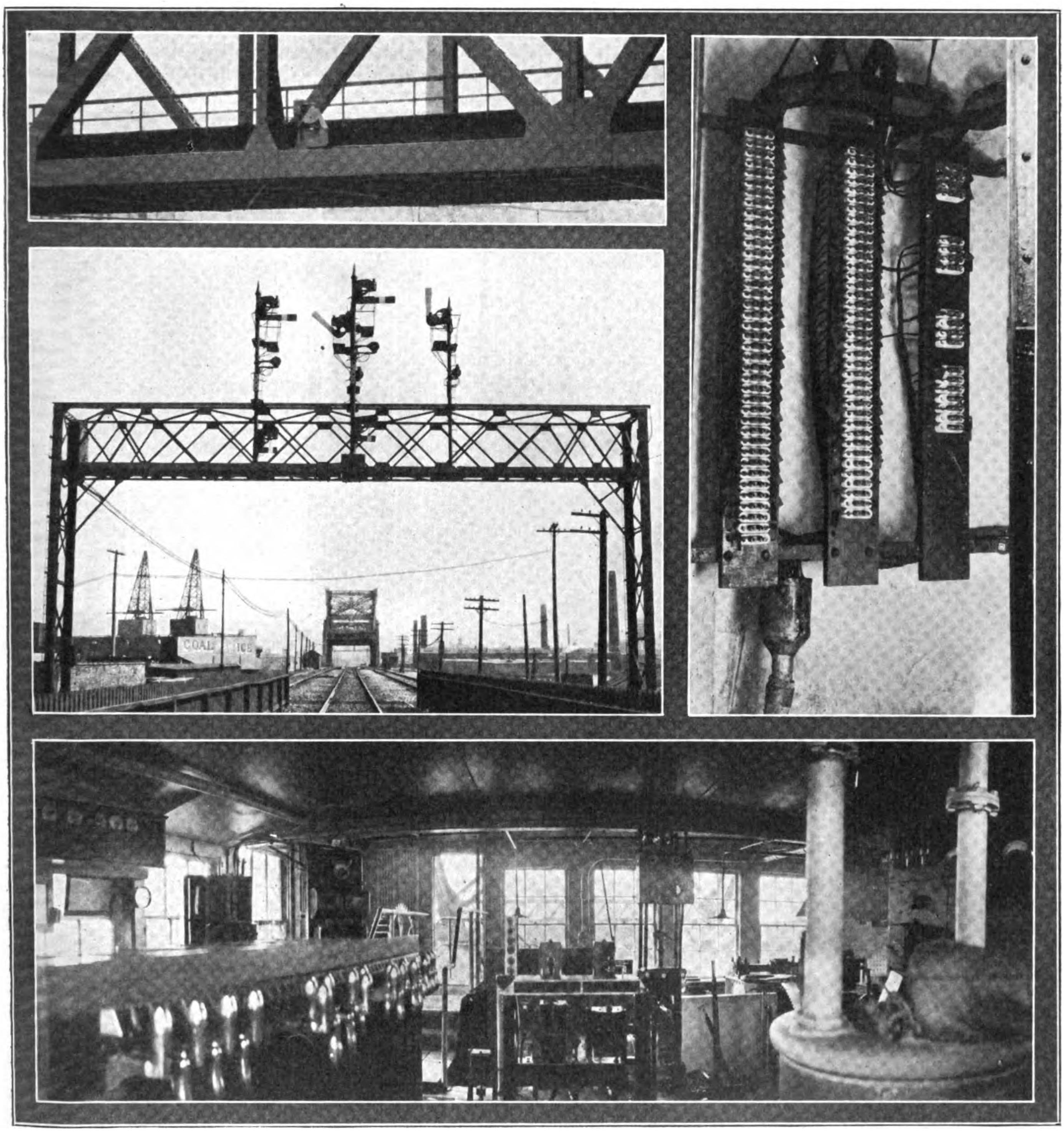


Track and Signal Layout of the New Deering Bridge Plant

bridge which engage slots in members anchored to the abutment. These plungers are operated by an a. c. motor located at the end of the bridge.

The controllers for the operating and lock motors are mounted on a common frame, shown in the interior view of the tower. The controllers are electrically interlocked by means of solenoid locks mounted on each controller and controlled as follows: The lock on the bridge lock motor controller is controlled by a contact on the lift motor controller in the off position, by a circuit breaker located on the end of the bridge which closes when it strikes the abutment and by contacts on the detector locks operated by the interlocking machine, mentioned later. The lock on the lift motor controller is controlled by a circuit breaker on the bridge lock motor which closes only when the bridge is unlocked and by a contact on the bridge lock motor controller in the off position.

The interlocking between the electrical operating machinery and the interlocking machine is effected by another lock on the bridge lock motor controller operating from the interlocking machine. This lock is made by using an electrical pole changer unit from a model 2 switch machine, and works a dwarf signal lever with battery indication. The circuits are so arranged that the



Autoflag Mounted on Lower Chord of Bridge to Warn Boats — Interior of One of the Terminal Houses, Showing Cable Connections

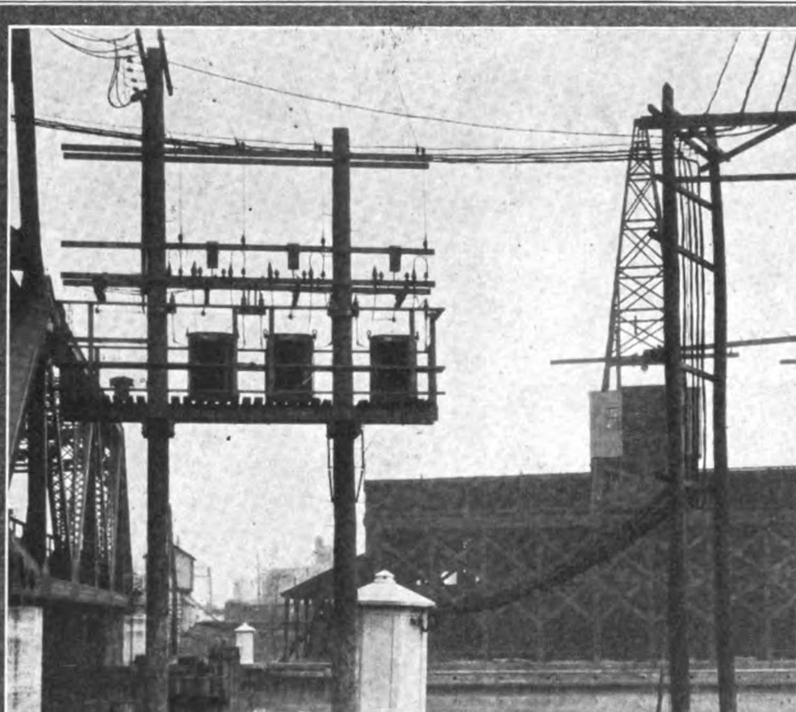
The Southbound Home Signal Bridge

Interior of Operator's House, Showing, from Left to Right, Indicators, Interlocking Machine, Emergency Switches, Bridge Operating Mechanism, Autoflag Indicators and Main Switch Board lock will not reverse and lock the controller handle, unless both of the solenoid lock plungers are seated and locking their respective controller handles. When the lever is reversed there is current in the reverse coils of the lock reduced by a 1,000-ohm resistance. This prevents any vibration from working the plunger out of its locking slot. Should the plunger be forced away from its locking position the resistance is shunted and full current goes through the magnets to force it back to locking position. The lever in the interlocking machine is locked by derail levers so that the bridge and its operating machinery must be normal before a derail can be reversed.

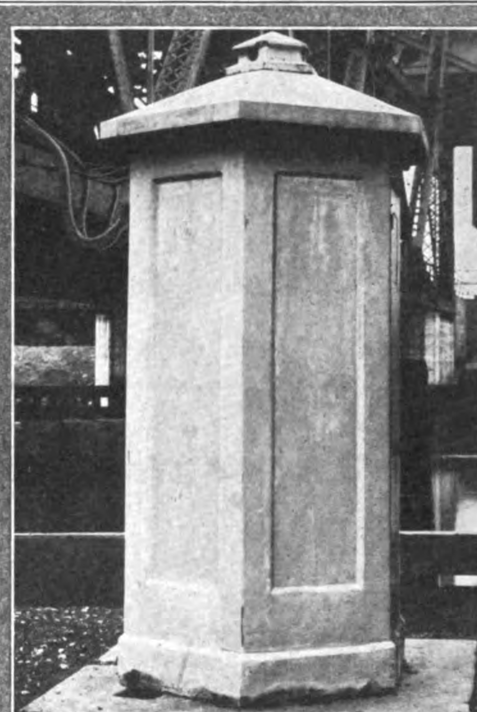
A lock of this same design and controlled in the same way is mounted on the shaft between the gasolene engine clutch and its control wheel. This clutch is locked in the neutral position.

In addition, detector locks were applied to the bridge by the bridge lock motor. This circuit breaker is located on the opposite side of the tracks from the one used for the control of the switch machine operating the plunger locks.

The city of Chicago has an ordinance requiring that a bridge tender shall, upon the approach of a boat, whenever he cannot immediately open the bridge, wave a red flag by day and a red light by night until the boat has stopped, and then continue to display the signal until the bridge is opened. To comply with this requirement and at the same time not tie up the bridge tender so that he cannot use his time in preparing to open the bridge, special "autoflags" were installed on each side of the bridge near the center of the channel, as shown in one of the illustrations. The autoflags were manufactured by the Bryant Zinc Company, being standard apparatus modified to provide a waving red light in front of a black



Cables from Transformers to Bridge and from Terminal House to Bridge and to Line



Near View of One of the Hexagonal Concrete Terminal Houses

locks located at the end of the bridge. These are plunger locks of R. S. A. type with circuit controllers and the plungers enter holes in the bridge lock bars which slide in the grooves provided for lock rods. The adjustment on the plungers which operate the contacts was modified so that the contacts are closed only when the plungers are disengaged. If the plungers are removed the contacts will open also. The contacts control the lock on the bridge lock motor controllers as mentioned above. These plunger locks are operated by a model 2 switch machine located on the ties between the tracks. The control wires from the interlocking machine to the switch machine pass through the submarine cable and a Stiles circuit breaker operated by the bridge lock motor, providing an extra check on proper operation.

The track circuits are carried across the break in the floor of the bridge at the trunnion end by a flexible cable suspended outside of the bridge in such a manner as to produce the least possible bending. All wires are stranded and in duplicate. At the other end of the bridge the wires are carried through a Stiles circuit breaker operated

background. The lights are 25-watt, 55-volt tungsten lamps behind standard signal lenses with the lamp closer to the lens than the focal point, thus increasing the spread of the rays. This light can be seen through a very wide angle in daylight as well as at night, its range being increased by a hood. In order for the operator to know that these autoflags are operating properly, a control board was installed just above the controller stand with a lamp in series with each of the lamps of the autoflag and a disc indicator of the Z armature type in series with each of the motors. A double-pole, snap switch is provided to control the autoflags.

Northward, a two-arm approach signal is used with a two-arm home signal giving advance information for both routes. All signals on bridges are model 2A. Dwarf signals are model 2 solenoid and switch machines are model 2. Detector bars are used only on facing points of high speed routes. The signals were changed to three-position upper-quadrant from two-position lower-quadrant. The slow speed arms on masts of high signals are used for "call-on" purposes. All signals are electrically lighted. Telephones are located on each signal bridge for communication between trainmen and operators in the tower.

As there was no room near the signal bridge south of the river to install a battery well, wires were run out from the seven cells of storage battery in the power house, to operate the low-voltage automatic signal located on this bridge. Seven track circuits also take current from this set of battery. A closed loop for both the positive and negative wires runs from the battery to the junction boxes on the cable poles, where the local connections to the track are made. Resistances are used on both sides of the circuits between the local feed wires and the loop which are adjusted for the particular section. A main adjustable rheostat is used between the battery and the loop, which is adjusted from day to day to take care of weather conditions. A voltmeter connection is made to one of the relays operating from this loop and the rheostat is at all times adjusted to give the required voltage on this relay which acts as a pilot. The relays connected to this system are of approximately 11 ohms resistance.

The material for this plant was furnished by the General Railway Signal Company and installed by railway company forces under the supervision of E. C. Carroll, superintendent of construction, signal department. The bridge was placed in service on July 30, 1916, and the new plant on September 15.

CONFESSIONS OF AN EX-MAINTAINER

BEING ruminant and reminiscent, I shall digress for a moment and analyze a typical character of the old-time signal fraternity. We might as well start this in the regular old-time style by saying ambiguously that he was born a Smith, christened John Henry and afterwards called "Red" by the bunch, due to his vermilion-tinted top-knot. Red grew up in a small town that was short on "kultur" and ultra-violet ideas, but long on yellow dogs, Hirams and Hatties. He was really a pretty kid and his folks never lost an opportunity of letting him know about it. In early youth he was some pet of the community, but when one considered the community this distinction was about as much of an asset as the title of admiral in the Swiss navy.

When Red was 17 he graduated from the grammar school and "accepted a position" in Skinner's toggery shop. It was here that he burst forth into full bloom. Soon the little girlie-girlies could not keep their eyes off of him, and Red became *some* gink.

During this period of youthful bliss and ignorance one little wren with soulful eyes and large bronze freckles fell head over heels in love with Red. This was before the days of moving pictures, so they used to go to the penny arcade and stuff their coppers into the slot in order to hear the latest selections played by the Edison military band.

It takes more than nine bones per week to keep up a reputation as a "good dresser," even though one does get 30 per cent off the list price. In three years Red owed Skinner money, not to say anything about sundry other liabilities that hung around his neck. Everyone lost confidence in him except the little doll with the bronze freckles. About the time Red began to wonder if he should commit suicide or decamp some dark night via the through freight that stopped at the crossing around 11 p. m. something happened that changed his entire career.

The afternoon train spilled out a gang of uncouth-looking individuals and some of them drifted into the toggery shop to purchase red bandanna handkerchiefs and "some of them three for a quarter socks." They told Red they were going to build an interlocking plant at the crossing. They might as well have spoken in Siamese or Sanskrit so far as Red was concerned, but he said "Uh huh," and was nice to them.

The next day Skinner cut Red's hawser and shoved him out into the stream. Jobs were about twice as scarce as hen's teeth in Red's town, but his folks thought he ought to do something that would save the family exchequer from sinking the third time. There being no other alternative, Red decided to go strike these interlocking men for a position.

Red and the foreman connected up all right, but you could not truthfully say that Red secured a position. What he got was just a plain job. He dug holes, mixed concrete, turned the drill press, carried pipe carrier foundations and did other little things that are always wished on the novice who is just being initiated into the fraternity. Under outside pressure Red stuck, and when the plant was put in service and the gang moved westward he packed up his wonderful wardrobe and went along with them.

On the night they left, Red dolled up in his glad rags and slipped over to see his freckled female friend. He tactfully explained to her that he had been threatened with consumption and that the doctor had ordered him to secure outside employment. They swore eternal allegiance to each other on the station platform and Red promised to write to her every day.

Bobby Burns once told about the "best laid plans of mice and men" going to the bow wows. Well, this same thing happened to Red. He became more interested in the articulation of signal material than in trying to find an excuse for bronze freckles and soon forgot all about the little lady with the soulful eyes. In four years Red was a regular guy. He had lost the index finger on his right hand while feeling for a clear hole in a plunger box casting, he had increased in weight and accumulated a new vocabulary and all the finer points of etiquette, as practiced by the "old timers" during that particular period. The original eight or ten good suits of clothes had been worn out under various pairs of striped overalls and his wardrobe had gotten out of synchronism with the seasons.

This pack of pirates finally migrated to a junction point only a few miles from Chicago. She of the silicon-bronze-tinted freckles found out the location of her long lost Red in some mysterious manner while visiting in the Windy City and penned a few burning lines to the effect that he should romp in, stay over Sunday and again get acquainted.

Red perused this letter three times, looked himself over four times, thought of what a sunburst of loveliness he used to be and then answered that he could not make the trip because he was sick in bed. He hinted about a return of his old tubercular trouble and dribbled gobs of gloom on each page. It was a real work of art.

Instead of setting a brake on Girley-Girlie, it accelerated her desire to do some heroic, noble act. Her romantic nature conjured up a mental photograph of poor Red sick and lonesome in some old shack, surrounded with poverty and medicine bottles, so she packed up her little handbag and hot-footed out to the aforementioned junction.

Arrived there, the little lady hoisted her pink parasol and started up the hot, dusty track on her mission of mercy. She finally got to the home signal and was just opening her mouth to ask for Red when an apparition clad in a flannel shirt and excruciatingly dirty overalls came up the bank with a coil of rope, two heavy bars, a pinnacle casting and five days' growth of whiskers. She was so flabbergasted she could not close her month, and when Red saw her he, too, was afflicted with the same kind of lockjaw. He tried to explain, but the more he waded around in this dismal swamp of crude oratory the more he got mired. She refused to talk to him and refused to accept his help in getting back to the station. She returned home soon, told her folks that Red had slid down to the dregs of despair and then married Red's successor at Skinner's Toggery Shop..

Does Red worry about this? Well, I should hope not. Red has a family of his own now; he is quite a way up the ladder and is still going. He was prancing around Mackinac last September in a dress suit and looked almost as fancy as he did in Skinner's Emporium some twenty odd years ago.

Red is now a respected personage in his home town. He tells the fond parents of pretty boys, who sport fancy names, not to pet such offspring, but to push them out of the nest so they can rough it for a few years and winds up his oration by saying, "Look at me." Red can only pull this in just this one town; it's not egotism, however, it's horse sense.

All little stories have a moral, I reckon, so the thing to tack on the tail of this dissertation is the fact that some mighty good signal engineers learned the art of signaling while wearing bib overalls.

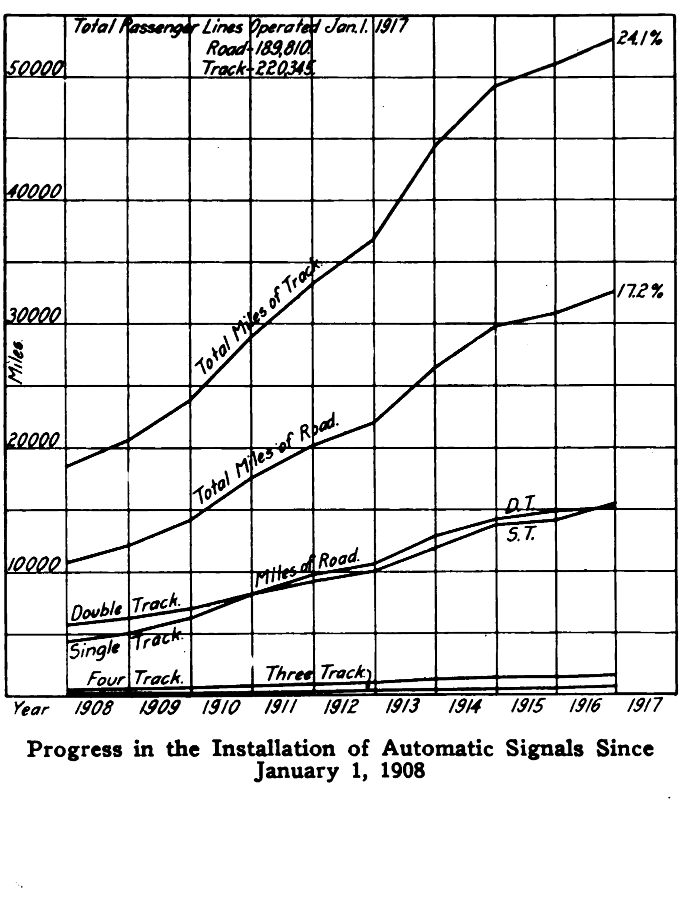
Mileage and Details of Signals in Use

I. C. C. Divisisn of Safety Issues Annual Statistical Tables Pertaining to Block Signals and the Telegraph and Telephone for Transmission of Train Orders

THE annual tabulation of block signal statistics compiled by the Division of Safety of the Interstate Commerce Commission has recently been issued. These tables cover the same details as in previous years with the exception that the two tables referring to interlocking plants which were published for the last three years are omitted in the 1917 tabulation. As shown in table No. 1, which is reproduced here in full, the total length of railroad in the United States operated under the block system on January 1, 1917, was 98,407.9 miles. Of this total 32,954.6 were automatic and 65,453.3 were non-automatic. Comparing these figures with the corresponding figures for January 1, 1916, there was an increase of 2,012.1 miles in the length of road operated by the automatic block system, and a decrease of 179.8 miles of road operated by the non-automatic block system, making a net increase during the year of 1,832.3 miles. The Baltimore & Ohio, the Louisville & Nashville, the Pittsburgh, Cincinnati, Chicago & St. Louis, and the Wabash continue to report automatic block signals in manual block signal or train order territory, these automatics not being included in the table. The total mileage of such signaling is 165.4. The use of automatic stops reported to the commission is the same as last year, with the exception that one of the six companies, the Maryland & Pennsylvania, has discontinued the stop installation during the year.

The total mileage as shown above includes 398 miles of automatic signals and 83.1 miles of non-automatic signals on lines operated jointly by two roads, and reported by both companies. Deducting these duplications, the net mileage of automatic signals is 32,556.6 miles, and of non-automatic signals 65,370.2 miles, a total of 97,926.8 miles. The total mileage of passenger lines operated is shown as 189,810, of which 17.2 per cent is protected by automatic signals, and 34.4 per cent by non-automatic signals, leaving 48.4 per cent still unprotected.

The small table shows the principal changes in the mileage of individual roads since last year, including five roads which had not previously reported block signal



Progress in the Installation of Automatic Signals Since January 1, 1908

Names of railroads.	Increase.		Decrease, nonautomatic.
	Automatic.	Nonautomatic.	
Atlantic Coast Line	74.6		71.5
Baltimore & Ohio	74.6		77.0
Canadian Pacific			136.6
Chesapeake & Ohio and Chesapeake & Ohio of Indiana			39.5
Chicago & North Western	62.5		61.2
Chicago, Burlington & Quincy	182.7		294.5
Chicago Great Western	106.1		
Chicago, Indianapolis & Louisville	44.7		
Chicago, Lake Shore & South Bend [1]	56.0		
Cincinnati, Indianapolis & Western [1]	99.0	282.0	
El Paso & Southwestern System	25.3		
Erie	83.4		41.8
Hudson Valley [1]	23.7		
Illinois Central	244.2		
Long Island		129.2	
Los Angeles & Salt Lake	56.3		
Louisville & Nashville	175.2		
Minneapolis, St. Paul & Sault Ste. Marie		140.5	
New York, New Haven & Hartford		48.2	
Norfolk & Western	80.2		42.2
Oahu Railway & Land Co.[1]	22.2		
Portland [1]	23.4		
St. Louis, Iron Mountain & Southern	38.4		38.8
Southern	67.8		65.9
Southern Pacific (Pacific System)		354.2	
Galveston, Harrisburg & San Antonio		53.5	
Houston & Texas Central			27.0
Texas & Pacific		316.6	
Union Pacific	54.0		
Wabash	33.9		40.1
Western Maryland	102.0		
Total	1,735.2	1,324.2	926.6

[1] Roads which have not heretofore reported block-signal mileage.

Principal Changes in Block Signal Mileage During the Past Year