Vol. IV. January to December, 1899.

JOURNAL

OF THE

WESTERN SOCIETY

OF

ENGINEERS

PAPERS, DISCUSSIONS, ABSTRACTS, PROCEEDINGS

CHICAGO
PUBLISHED BI-MONTHLY BY THE SOCIETY
1736-41 Monadnock Block

SUBSCRIPTION PRICE $2.00 PER VOLUME
OF SIX NUMBERS

Journal of the
Western Society of Engineers.

VOL. IV. AUGUST, 1899. No. 4.

LXXV.

THE SALIENT FEATURES OF THE CHIEF ENGINEER'S ANNUAL REPORT OF THE DRAINAGE CANAL OF THE SANITARY DISTRICT OF CHICAGO FOR 1898.

BY ISHAM RANDOLPH, M. W. S. E.

Read June 21, 1899.

Some months ago in response to a request from our Committee on Papers, I was rash enough to obligate myself to prepare and deliver a paper at this meeting of the Society. The day fixed seemed then so far away that I had no doubt I should have ample time to give such a paper careful thought; such thought and preparation as I always wish to give to anything which I offer to this Society, for I feel that the Western Society of Engineers is entitled to my best thought and most earnest effort. I was disappointed, however, in my purpose, for each day has brought its manifold duties and the time, which I could call my own, has never materialized.

My topic, as announced, is a presentation of the salient features of the Chief Engineer's annual report on the Drainage Canal, of the Sanitary District of Chicago for 1898. I quote from the introduction to that report as follows:

"Taking up the record of the Engineering Department of this District for the year 1898, I submit in the following report, the facts necessary to a clear understanding of the condition of the work at the close of the year giving, as has been done in my previous reports, the essential facts in a concise form and citing such references as would enable any one whose duty or interest might prompt such investigation to verify the several statements made.

"My report for the year 1897 appears in the volume of your Proceedings for the year 1898 (pages 4592-4651) under date of March 9th. Where that report ends, the one now submitted takes up the history of this Department and brings it to December 31, 1898.

"The value of the work performed within the year 1898 aggregates $1,210,536.09. The amount vouchered for payment (including payment of reservations on completed work) was $1,286,021.15.

"The approximate value of all contracts to January 1, 1899, is $22,002,081.09. The total amount earned to same date is $20,457,825.09. Percentage of work under contract completed, about 93.

"The volume of excavation accomplished during the year was 1,493,048.1 cubic yards of glacial drift and 371,865 cubic yards of solid rock, a total of 1,864,913.1 cubic yards. The volume of excavation accomplished from the beginning of the work to January 1, 1899, was 28,657,677.6 cubic yards of glacial drift and 12,631,518.1 cubic yards of solid rock, a total of 41,289,195.7 cubic yards, or 96.3 per cent of the total estimate.

"In the last annual report, 100 per cent of the estimate for retaining wall was reported as completed, but since then an estimate of 6,300 cubic yards of this class of work is contained in the contract on Section 18, and is not yet built. This item reduced the percentage completed to 98.3.

"The volume of masonry and concrete work other than retaining wall done during the year amounted to 24,162.13 cubic yards. The volume done from the beginning of the work was 35,193.34 cubic yards, or 56.1 per cent of the total estimate.

"The amount of piles driven for bridge foundations during the year was 47,407.5 lineal feet. The amount driven from the beginning of that class of work was 61,420.5 lineal feet, or 64.6 per cent of the total estimate."

Taking the volume of work done and the value, thereof, it is small as compared with the output for 1895, of 7,434,999 cubic yards of glacial drift and 5,060,666 cubic yards of solid rock, or a total yardage of 12,495,665 cubic yards. The value of that year's work as the contract prices footed up, was $6,277,268.77. This report, which has been reduced to the minimum of verbiage covers 73 printed pages, with eleven tables of statistics.

THE BY-PASS.

I am, however, to speak only of those features of the report which seem to me to have a claim upon your interest. Among these is the By-Pass through the lands of the Pennsylvania Company, on the west side of the Chicago River, commencing just north of Adams street and ending just south of Van Buren Street. The river

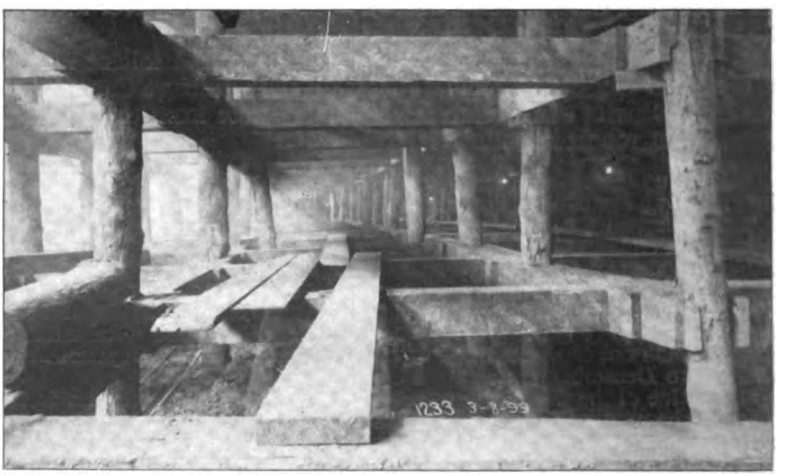
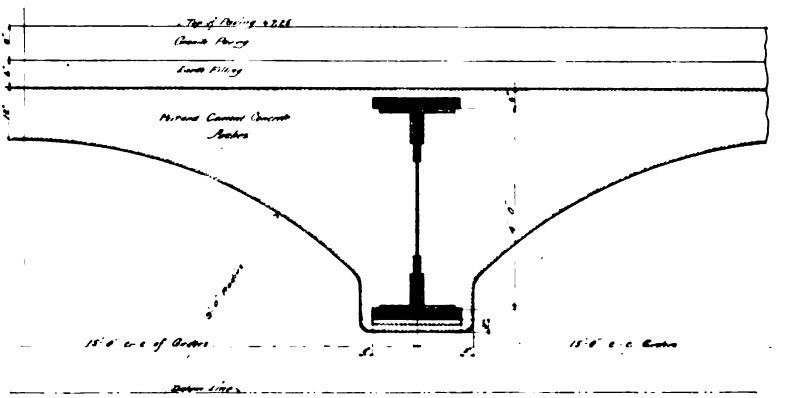
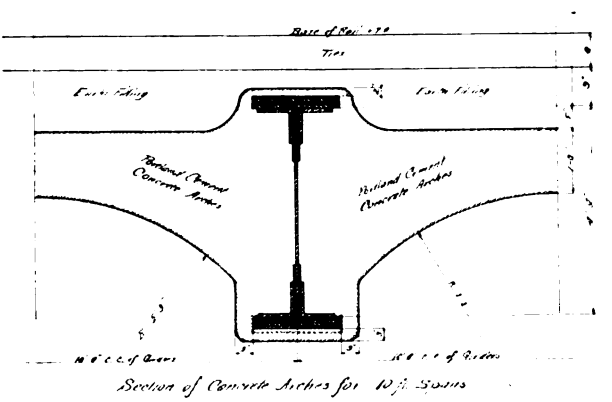


Fig. 1—Timbering in Adams Street By-Pass.

throughout this stretch is not of sufficient width, with the depth attainable over the tunnels of the West Side City Railway to carry the minimum volume of water (300,000 cubic feet per minute) which must form the initial supply of the Sanitary Canal. Owing to the immense value of the abutting property the widening of the river was not to be thought of and the idea of the covered conduit presented itself as the only feasible escape from the dilemma. This was presented to the Pennsylvania Company's officials, and was at first scouted, but certain cogent arguments finally prevailed and they made an adjustment which enabled us to proceed with our plans, their only compensation being the payment of a rental of $3,000 per annum. The side walls of this conduit are of Portland cement concrete, coped with Bedford stone. The distance between the vertical faces of walls is 50 feet. The opening is spanned by steel plate girders spaced 10 feet, center to center, on the portion



Section of Concrete Arches for 15 ft Spans



Section of Concrete Arches for 10 ft Spans

Figs. 2 and 3—Concrete Arches Supported by Plate Girders Covering By-Pass.

upon which railroad tracks will be laid, and 15 feet, center to center, on the other portions of the work. Concrete arches will fill the spaces between the girders and all parts of the metal work will be embedded in concrete. The depth of flow through this By-Pass will be sixteen (16) feet. In the prosecution of this work many difficulties have been encountered and the progress has been slow. The business of the railroad is not interfered with, tracks and driveways are kept open. Bids on this sub-structure work were on alternatives, stone, brick and concrete, this on recognition of the claims of the craftsmen and the dealers. The concrete proved to be the cheapest, $4.75 being the price on which the work was awarded and based on the following specifications:

"Concrete shall be made in the proportion of one (1) part of cement, three (3) parts of sand and six (6) parts of broken stone. It shall be mixed by machinery, if so directed by the engineer, or if mixed by hand it shall be done upon a suitable platform. Care must be taken to first thoroughly mix the dry cement and sand; after which stone shall be added, together with a proper amount of water, all to be thoroughly mixed; water to be applied by a sprinkling pot; on being placed, the concrete shall have a wetness such as to permit quaking or mobility likened to liver. The stone for concrete, of a quality approved by the engineer, broken into angular pieces of a size small enough to pass through a ring one and one-half (1½) inches in diameter, and be entirely free from dust, sand, dirt and any foreign substance. The stone must be thoroughly drenched with clear water before mixing with the mortar.

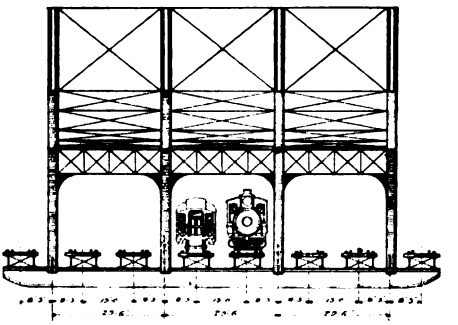
"The concrete is to be deposited in layers not exceeding six (6) inches in thickness, as directed by the engineer, and to be thoroughly tamped or rammed. The walls shall be capped or coped with Bedford stone as shown upon the plans."

A By-Pass at Taylor Street was also under consideration, but it was practicable there to get the requisite flow of water by substituting bascule bridges for those now existing and removing the center and protection piers. The cost of doing this was greater than building the By-Pass, but the benefit to navigation justified the adoption of this plan. Contracts have been awarded for bridges of the Scherzer Rolling Lift design for Taylor Street and for the Chicago Terminal Railroad. This latter structure is now the most daring venture with that type of bridge, the span being 275 feet between points of support; this, too, gives a channel of 120 feet wide at right angles to the trend of the stream. The contract price of this structure is $297,384.96.

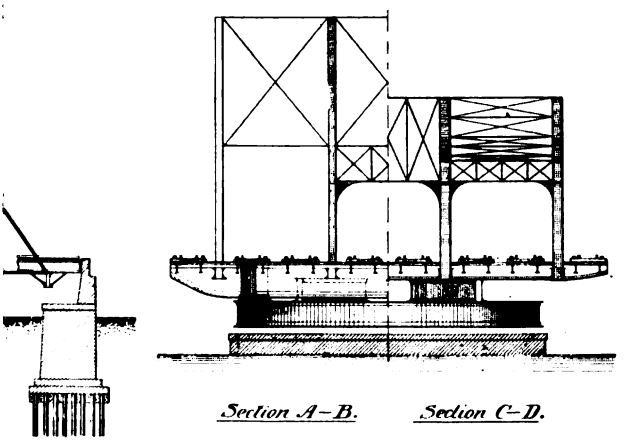
BRIDGES ACROSS THE MAIN CHANNEL.

A brief description of the bridges over our main channel will, I hope, prove interesting. We have first the Southwest Boulevard Bridge, main channel, section "O." Double roadway, each 24 feet wide; two sidewalks, each 6 feet wide; length, 321 feet; weight of steel and iron in structure, 1,458,809 pounds. Benezette Williams, contractor for the sub-structure. J. G. Wagner & Co., contractors for the superstructure. Total cost $152,938.79.

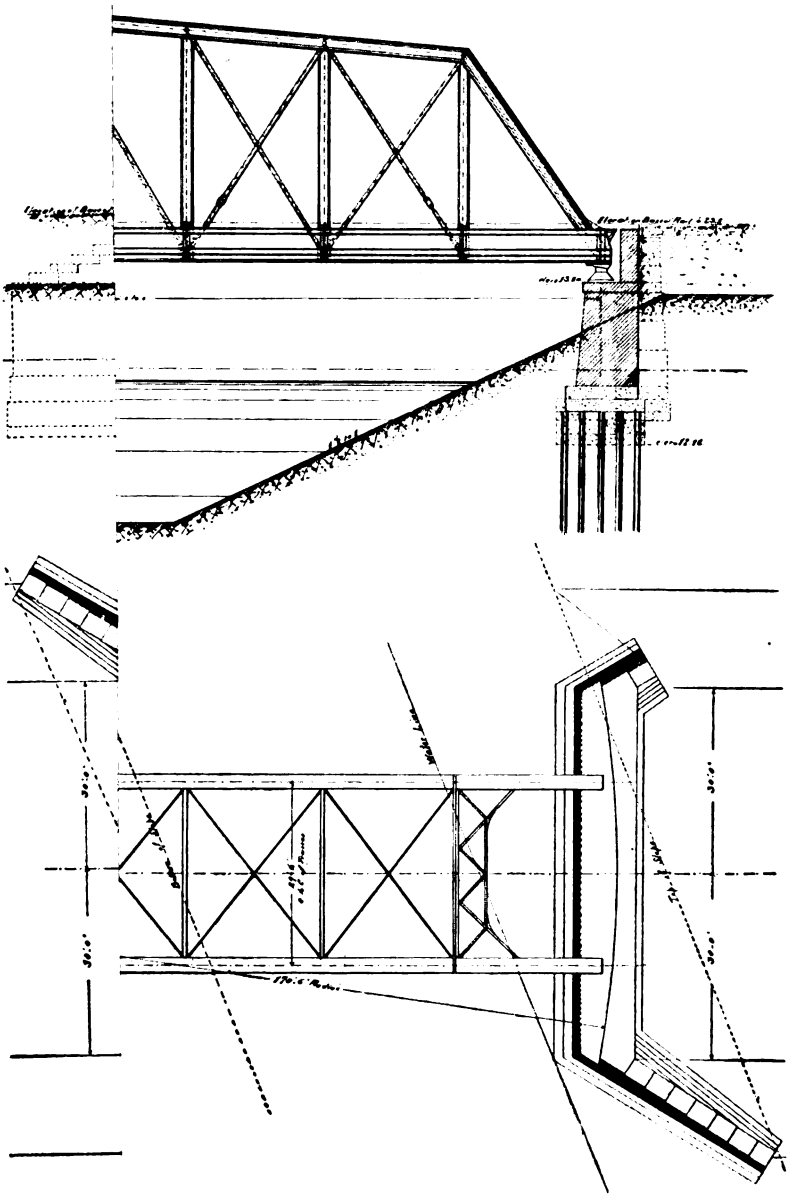
Just west of this bridge is the site of the eight-track bridge, which has proven a vexed problem. For this location our own Bridge



End Elevation.



Section A—B. *Section C—D.*



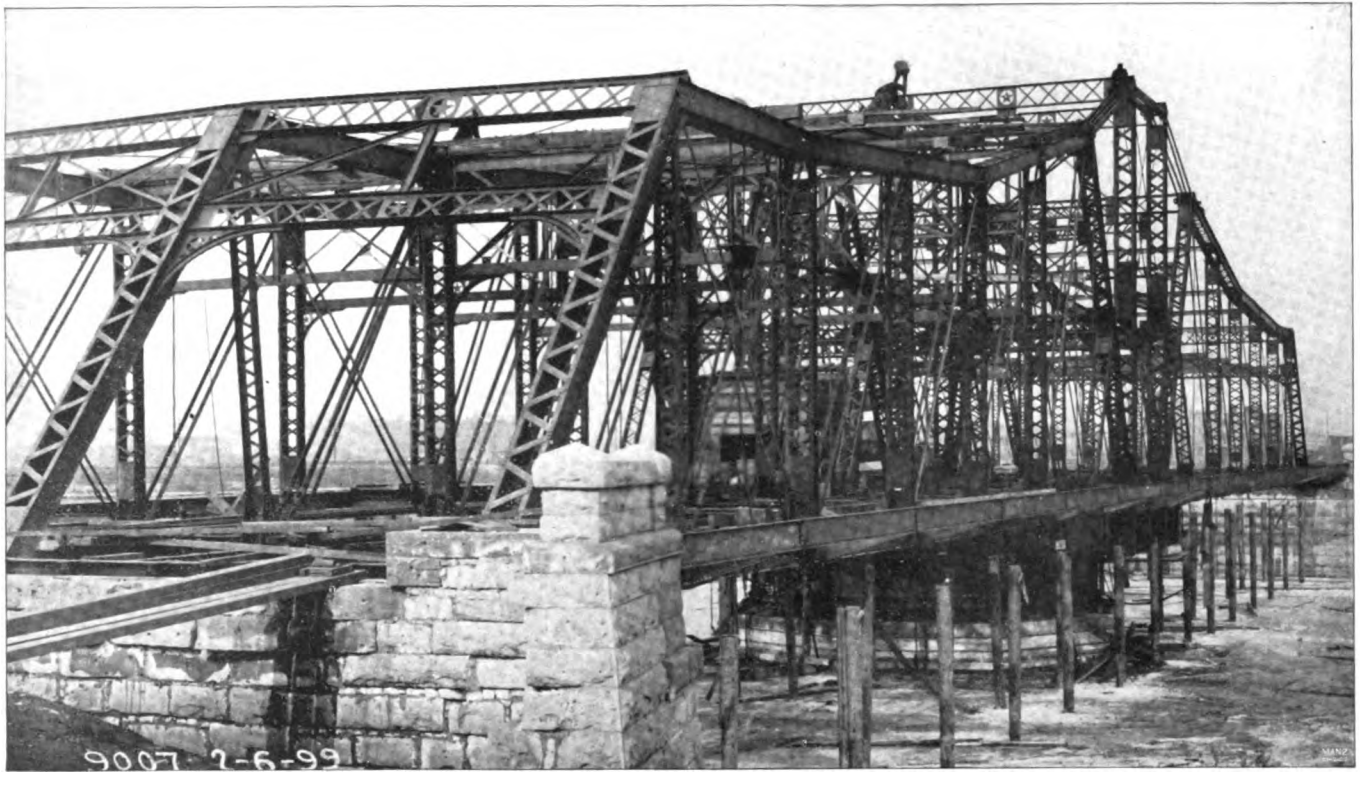


Fig. 6—Southwest Boulevard Bridge.

Department prepared plans for an eight-track swing bridge, the weight of which was figured at 3,800 tons and the cost based on bids received, at $317,454. In an evil hour, on my advice, which I repent having given, competitive designs and bids were asked for, and in response we received designs from C. L. Strobel, Onward Bates (represented by the Edgemoor Bridge Company), M. G. Schenke, Wilman & Franson. The Scherzer Rolling Lift Bridge Company, J. A. L. Waddell, and a design by Mr. Breithaupt. The result was contention, law suits, delays and feelings hard as the heart of Pharaoh after it had taken the many contracting chills mentioned in the Book of Exodus. As a result the Scherzer Rolling Lift Bridge Company now holds the contract for this structure, located on Campbell Avenue, main channel, section "O," for the joint use of the Pittsburg, Cincinnati, Chicago & St. Louis Railway Company, the Chicago & Northern Pacific Railroad Company, and the Union Stock Yard & Transit Company. It is made up of four double-track bascule bridges, each 150 feet in length, and eight double-track approach spans, each 105 feet and 3 inches in length, except that the N. E. and S. W. girders are 113 feet and 3 inches, each bridge consisting of one span and one approach at each end of same. The Scherzer Rolling Lift Bridge Company, contractor

Fig. 7 Chicago, Madison & Northern R. R. Bridge.

for sub-structure and superstructure. The cost of the design, $35,000; of the sub-structure, $184,415; of the superstructure, $175,565. Total $394,980.

The Chicago, Madison & Northern Railroad Company's bridge, main channel, section "N," double track; length, 479 feet 5 inches; weight of iron and steel in structure, 2,511,140 pounds. McArthur Brothers and Winston & Company, contractors for sub-structure.

The Toledo Bridge Company, contractor for superstructure. Cost of sub-structure, $38,113.46; superstructure, $72,531.39; total, $110,644.85.

The Kedzie Avenue bridge, main channel, section "N," single roadway, 21 feet wide; two sidewalks, each 5 feet wide; length, 324 feet 6 inches; weight of metal, 640,525 pounds. Chicago Star Construction and Dredging Company, contractor for the sub-structure. The King Bridge Company, contractor for the superstructure. Cost of sub-structure, $18,411.85; superstructure, $21,315; total, $39,726.85.

The Atchison, Topeka & Santa Fe Railway Company's bridge, main channel, section "N," double track; length, 327 feet 8 inches; weight of iron and steel in structure, 1,519,183 pounds. McArthur Brothers Company and Winston & Company, contractors for sub-structure; The Carnegie Steel Company, Limited, contractor for superstructure. Cost of sub-structure, $21,030.85; cost of superstructure, $43,931.12; total, $64,961.97.

We now come to the Belt Railway, of Chicago, over which the battle waged in the courts for nearly two years, and the result was a complete surrender, out of court, on the part of our district, and the capture, by the railway, of the contract for a four-track bridge, which in my humble opinion they ought never to have had, and do not need, but they have the contract and that ends the contest. The design of this bridge is a concession from our friends the enemy, who when they go into a fight go in to win, but when they have won can be magnanimous and listen to any humble petition, which is presented in the interest of economy, by which they will not suffer. As shown in the view presented, this is a two-truss bridge and two tracks are carried on the floor system between the

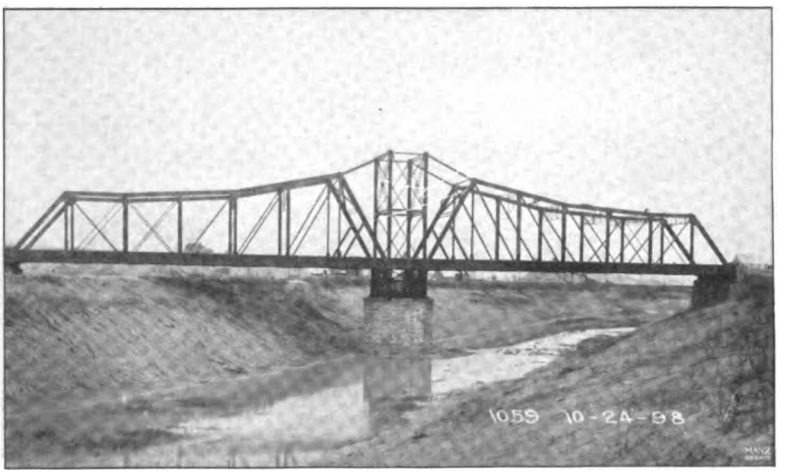


Fig. 8—Atchison, Topeka & Santa Fe Ry. Bridge, Section G.

Fig. 9—Lyons-Summit Road Bridge.

trusses. The floor beams are cantelevered out beyond the trusses so as to carry one track outside of each truss. The weight of this bridge is estimated at 2,676,000 pounds, and the contract price is $36,092.50 for sub-structure, and $131,200 for superstructure. Total $167,292.50.

The Atchison, Topeka & Santa Fe Railway Company's bridge, main channel, section "G." McArthur Brothers' Company and Winston & Co., contractors for the sub-structure. The Carnegie

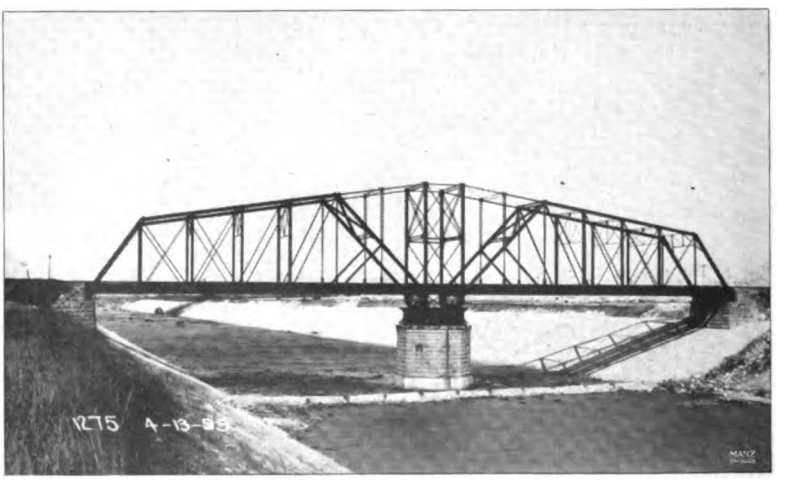


Fig. 10—Chicago Terminal Transfer R. R. Bridge.

Steel Company, Limited, contractors for the superstructure. Double track, length, 372 feet 6½ inches; weight of iron and steel in structure, 1,724,636 pounds. Cost of sub-structure, $25,364.19; cost of superstructure, $51,040; total, $76,404.19.

The Lyons-Summit Road bridge, main channel, section "F." McArthur Brothers' Company and Winston & Co., contractors for the sub-structure. C. L. Strobel, contractor for the superstructure. Single roadway, 18 feet wide; length, 323 feet 10 inches; weight of steel and iron in structure, 370,690 pounds. Cost of sub-structure, $18,420.95; cost of superstructure, $12,620; total, $31,040.95.

The Chicago Terminal Transfer Rail·oad Company's bridge, main channel, section "E." McArthur Brothers' Company and

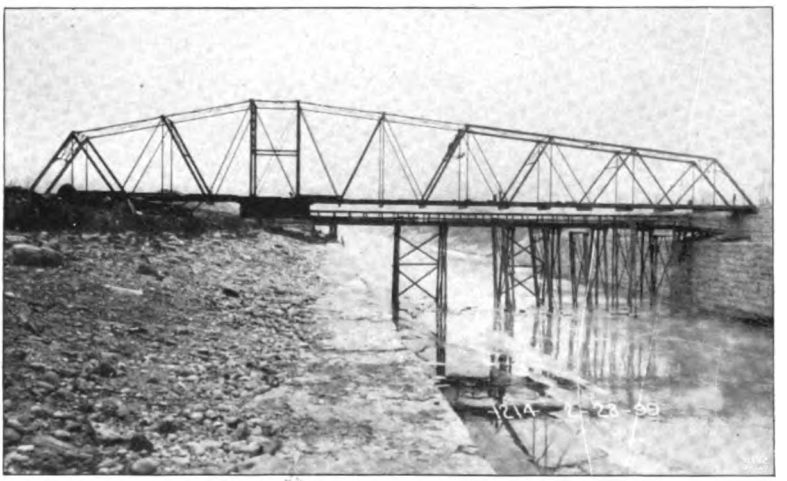


Fig. 11—Willow Springs Highway Bridge.

Winston & Company, contractors for the sub-structure. Wisconsin Bridge and Iron Company, contractors for the superstructure. Double track, length, 316 feet 7 inches; weight of steel and iron in the structure, 1,051,924 pounds. Cost of sub-structure, $18,016.48; cost of superstructure, $28,930.95; total, $46,947.43.

We now come to the rock channel in which there are no center piers, all of the pivot piers are on the north or right side of the channel and the superstructures are all "bob tailed" and counter weighted. The Willow Springs Road bridge, main channel, section 1. Sackley & Peterson, contractors for the sub-structure. C. L. Strobel, contractor for the superstructure. Single roadway, 20 feet wide; length, 306 feet 1¼ inches; weight of steel and iron in the structure, 339,294 pounds; counter weight, 209,040 pounds. Cost of sub-structure, $7,918.52; cost of superstructure, $14,990. Total $22,908.52.

The Atchison, Topeka & Santa Fe Railway Company's bridge, main channel, section 8. McArthur Brothers Company and Winston & Co., contractors for the sub-structure. Carnegie Steel Company, limited, contractor for the superstructure. Double track; length 398 feet, 6 inches. Weight of steel and iron in the structure, 2,315,656 pounds. Counter weight 858,645 pounds. Long arm 259 feet 7 inches; short arm, 138 feet 11 inches. Cost of substructure $7,912.05; cost of superstructure, $76,479.40. Total $84,391.45.

Attention should be called to the disproportion in cost between the sub and the superstructure of the bridge. The former costing a

Fig. 12—Atchison, Topeka & Santa Fe Ry. Bridge, Section 8.

shade over 10 per cent of the latter. The pivot pier is practically a course of Bedford stone resting on a concrete bed, replacing the top stratum of native rock which was scabbled off.

The Lemont Road, (Stevens Street) bridge, main channel, section 8. Sackley & Peterson, contractors for sub-structure. C. L. Strobel, contractor for the superstructure. Single roadway, 20 feet wide; length, 306 feet 1¼ inches; long arm, 205 feet 8½ inches; short arm, 100 feet, 4¾ inches; weight of iron and steel in the structure, 339,705 pounds; counter weight, 207,300 pounds. Cost of sub-structure, $5,983.50; cost of superstructure, $14,990; total cost, $20,973.50.

The Romeo Road bridge, main channel, section 12. Heldmaier & Neu, contractors for sub-structure; C. L. Strobel, contractor for superstructure. Single roadway, 20 feet wide; length, 306 feet 1¼ inches; long arm, 205 feet 8½ inches; short arm, 100 feet 4¾ inches; weight of iron and steel in the structure, 339,505 pounds; counterweight, 208,100 pounds. Cost of sub-structure (subject to revision

on final), $9,659.75; cost of superstructure (subject to revision on final, $14,990; total, $24,649.75.

These are the main channel bridges and all are movable structures. Besides these there are three double-track plate girder bridges across the Desplaines River and five highway bridges.

About six years ago I prepared the approximate estimates for the bridges on the main channel and a providential balancing of conditions kept those estimates quite close to the actual result. I based my weights of the metal on the specifications and practice of that day. Before we were ready to let our bridge work the railroads made radical increases in the loadings and requirements of their specifications, but the cost of metal work declined and instead of paying 4¼ cents per pound as was figured on, we paid from 2¾ to 3 cents per pound. Our masonry, too, went below my approximate figures.

CAPITALIZATION FOR MAINTENANCE OF BRIDGES.

Before leaving the discussion of the bridges a few words as to their maintenance are proper. Although they are all movable structures it is provided by the Sanitary District law that they may be operated as fixed structures during the first seven years after the completion of the channel. The contract with the railroads crossing the channel provides for the payment of a sum of money to the owners of the bridges, the interest on which will maintain the structures. I quote from the Santa Fe contract the conditions relating to this capitalization.

"Section 17. The Sanitary District shall pay to said California Company, within the time hereinafter fixed, as compensation for the *ordinary maintenance and repair* of the bridge structures referred to in section 1, and the portions of the bridges mentioned in sections 3 and 5 to be constructed by the Sanitary District, as shown on Exhibits A and B, a sum in cash to be arrived at as follows:

"(*a*) The annual cost of painting said structures shall be estimated at three-hundredths of a cent per pound of the weight of iron and steel in the structures, exclusive of the guard-rail bolts, and the rails, spikes and fastenings in the tracks over said structures.

"(*b*) The annual cost of the renewal of cross ties and guard rails shall be estimated at five dollars ($5.00) per thousand feet, board measure, of the lumber in said cross ties and guard rails.

"(*c*) The annual cost of inspection and minor repairs, such as tightening rivets, adjusting truss rods and minor repairs to floor systems, including the general inspection and care of the bridges, shall be estimated at twenty cents per lineal foot of track crossing said bridges.

"The total estimated annual cost for *ordinary maintenance and repair* shall be composed of the three items above mentioned, and twenty times the sum so arrived at shall, within the time hereinafter fixed, be paid by the Sanitary District to said California Company as compensation, it being estimated that the sum so paid, at five per cent interest, will yield a revenue equal to the estimated annual expenditure for *ordinary maintenance and repair*."

"Section 18. Said Sanitary District shall also pay, within the time hereinafter fixed, to said California Company, in addition to the sum provided for in the preceding section (17), as compensation for the *general depreciation and wearing out* of the bridges mentioned in sections 1, 3 and 5 of this article,

and for assuming all liability of accident to the same, a sum in cash to be arrived at as follows:

"The annual depreciation of the wrought iron or steel in the four bridge structures shall be estimated at the rate of one and one-half per cent of the total cost of the iron and steel in said structures, erected in place; said cost to be arrived at and verified by the Chief Engineer of the Sanitary District and the Chief Engineer of the California Company, and twenty times the sum so ascertained shall be agreed upon as the amount that said Sanitary District shall pay to the said California Company for assuming all liability for *general depreciation, wearing out and accident,* and on the payments mentioned in this and the preceding section (17) being made, said company shall thereafter keep said bridge structures in safe order and repair."

These provisions cover the maintenance of the bridges as fixed structures, supplemental agreements provide for the payment of additional sums to cover cost of operation as movable bridges.

This capitalization for maintenance did not come as a demand from the railroads, but was a suggestion of my own to the parties interested, as being, in my judgment, the most simple and satis-

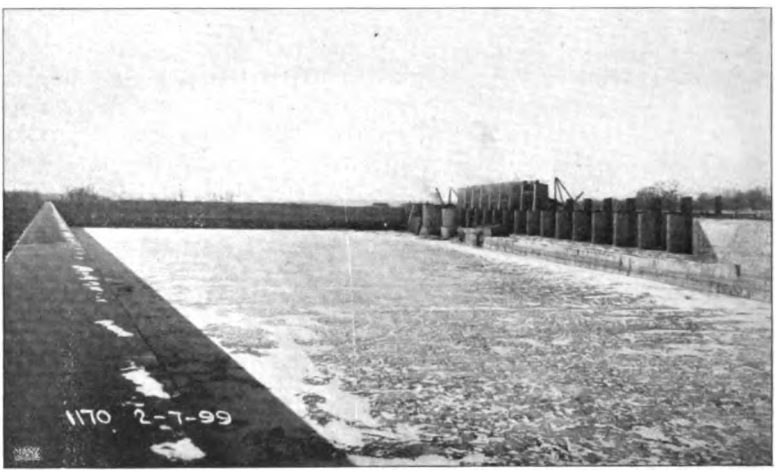


Fig. 13—Windage Basin and Controlling Works.

factory solution of the problem of maintenance and renewals, and it was so recognized by all of the contracting parties. The negotiations leading up to these contracts were very protracted and tedious, but I am pleased to say that we have had to engage in but one legal contest with any road and substantial justice was the result of all of our amicable settlements.

THE CONTROLLING WORKS.

Another portion of the work, in which I believe you are all interested, is the controlling works located at the end of our channel, near Lockport, the discharge of our flow being into the Desplaines River. The seven Stony gates, and the piers and masonry for eight

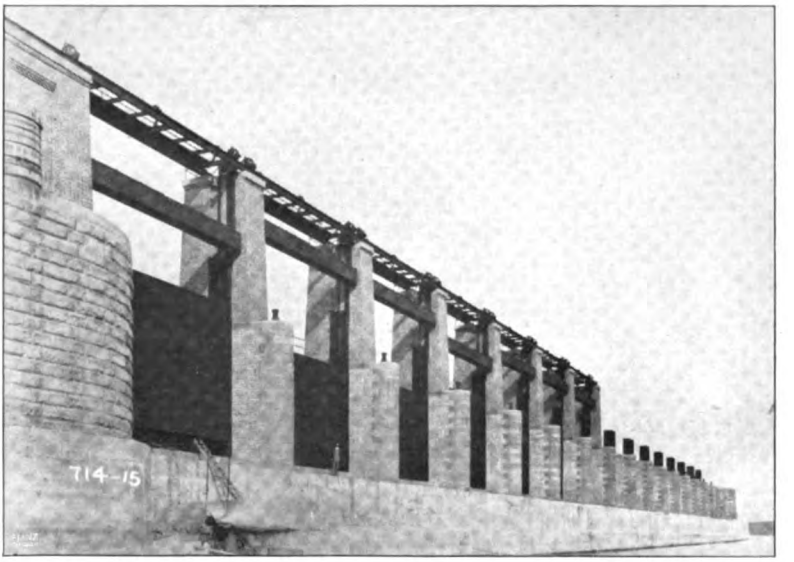


Fig. 14—Stoney Gates Controlling Works.

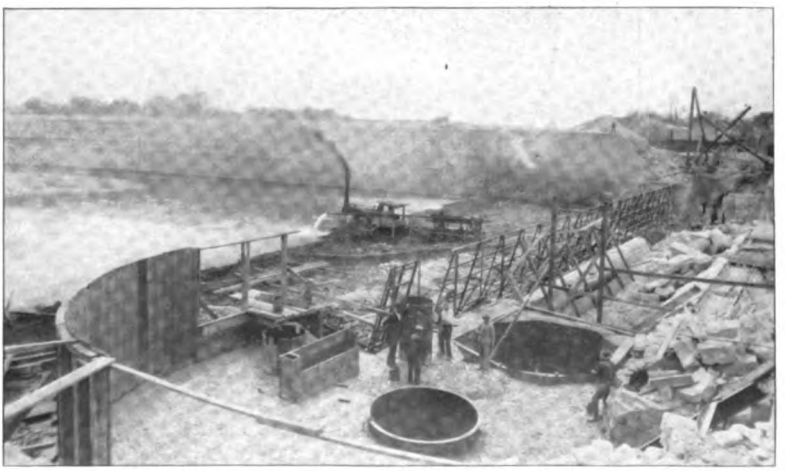


Fig. 15—Construction of Foundations, Bear Trap Dam.

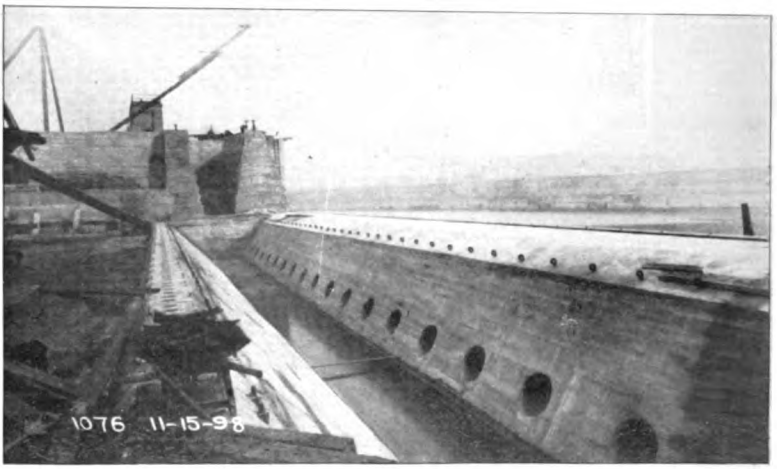


Fig. 16—Foundation, Masonry and Conduit, Bear Trap Dam.

Fig. 17—Counter Weight Cylinder, Bear Trap Dam.

Fig. 18—Construction View, Bear Trap Dam.

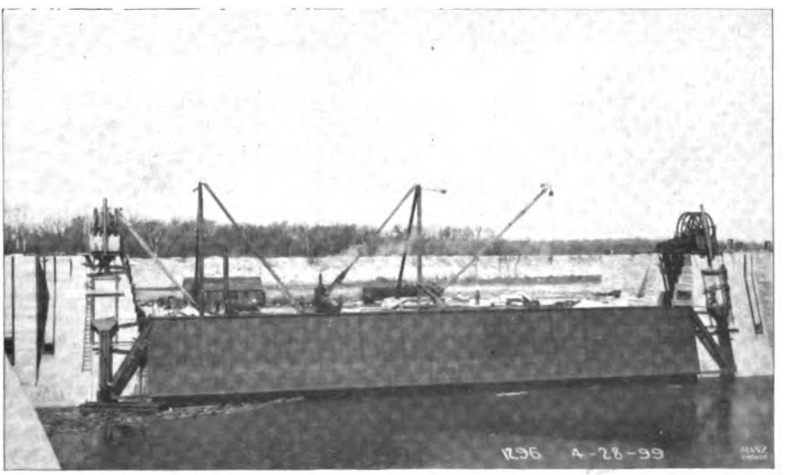


Fig. 19—Front View, Bear Trap Dam.

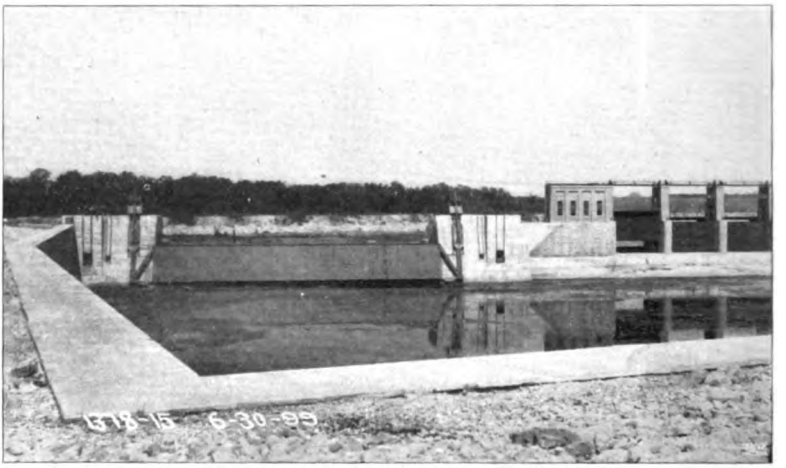


Fig. 20—Controlling Works.

more, should they ever be needed, were completed in 1896. The Bear Trap dam was not completed at the time of making my annual report, which we have under consideration, but last week the finishing touches were given to it barring a little piping, which has not yet been placed. This is a structure that is entitled to an evening all its own, and Messrs. T. T. Johnston, E. L. Cooley and L. K. Sherman should present its many interesting features.

At the Upper Basin, Joliet, a marine warfare, dire and dreadful, waged for months, between the Sanitary District of Chicago and the Commissioners, of the Illinois & Michigan Canal. No blood was shed, although there were captures and reprisals, for the scene of strife was transferred to the halls of justice, of the Will County courthouse, where the blind goddess never seemed to know which way her scale tipped, but we knew that the other fellows were too heavy for us before we got through. The history of this case would occupy several evenings in the telling, and having only a portion of one left me, I will give a fragment only of the tale, that fragment being an item from the annual report.

"The history of the dealings of this District with the Commissioners of the Illinois & Michigan Canal as a part of the annals of 1898 is sufficiently voluminous to make volumes of itself. The contract between this District and the said Commissioners is found in the Proceedings for March 11th (page 4654) and the report on same on March 16th (page 4661). Other references in the Proceedings are found on pages 4943, 4963, 4979, 5010, 5091, 5151, 5160, 5328 and 5345. The fullest history of this case is found in the "Abstract of Record" prepared by Attorneys Haley & O'Donnell and John S. Miller for appeal from the Circuit Court of Will County to the Supreme Court of Illinois, "Sanitary District of Chicago, appellant, vs. Canal Commissioners, appellee.'"

"This abstract of the evidence presented in the trial of the case before Judge Robert W. Hilscher covers 777 printed pages, condensed from over 5,000 pages of type written stenographic reports. The trial lasted from

September 19th to October 28th. The attorneys for the District were Haley & O'Donnell, F. W. C. Hayes and Special Counsel John S. Miller. A very large number of witnesses gave testimony. Besides its own engineers, the following named eminent engineers appeared for the District: John T. Fanning, John W. Rafter, George Y. Wisner, Ambrose V. Powell, W. S. McHarg and William W. Tyler.

"The Chief Engineer's examination consumed five days. The decision of the court sustained the contention of the District that its plans complied with all the terms and conditions of the contract of March 11, 1898, but denied the power of the parties to that contract to enter into it. On December 14th (page 5328) the attorneys of the District were ordered to dismiss the appeal to the Supreme Court, and by mutual consent the decree shown upon pages 5328-39 was entered in the Will County Circuit Court. In many particulars this legal contest is of deep interest to engineers, involving as it did questions in construction and hydraulics, the discussion of which by the experts was very instructive.

"On March 11th (pages 4654-9, the Board authorized its President and Clerk to execute the agreement with these Canal Commissioners for changes in the upper and middle basins at Joliet. The form of agreement appears in the Proceedings of March 11th (pages 4656-9). On March 16th (pages 4661-2) President Boldenweck announced that he had signed the said agreement."

On the side of the Canal Commissioners appeared in the court room Mr. John Bogart, Colonel Ruger, Mr. John W. Alvord, Mr. George H. Benzenberg, Mr. Daniel W. Mead, General Wm. Sooy Smith, and Mr. Albert Porter. They were interested listeners, but never took the stand. We used in this trial a discharge curve or rather several curves applying to dams of varying width of crest under varying volumes of flow, calculated and platted by Mr. E. L. Cooley, which I hope he will on a fitting occasion present to this society for discussion, as his work should find a place in our Journal. We are now building a dam on approximately the old location of dam No. 1 in Joliet of concrete; the down stream face of this dam and the coping is of concrete, formed of granite screenings, sand and Portland cement, the specifications of which reads:

"Granite screenings concrete shall consist of 100 pounds of Portland cement to two cubic feet of clean, sharp sand, to four cubic feet of granite screenings. These ingredients shall be thoroughly incorporated so as to make a homogeneous mass."

The supply of the Chanahon Level is through a conduit in the rear of the dam, the water having first been utilized for power purposes on the east side of the stream. The water at this dam belongs to the State of Illinois, and is leased to the Economy Light & Power Company, whose power development will occupy about 875 feet on the east side of the basin. We had to excavate a tail race to take the discharge from the power plant; this race is about 30 feet deep and 75 feet wide. All of the construction under the settlement with the Canal Commissioners is interesting, but some of it is absolutely useless and a waste of taxpayers' money, which is to be regretted.

To maintain the navigation in the upper and middle basins during the progress of the work it is necessary to segregate from the basins a channel for the canal. This was quite a problem, as driving piles or sheet piles was impossible. I decided to build a crib, sink

it with stone and fill it with earth. In the upper basin it was necessary to dredge a channel in the muck in which to place this crib. The manner of constructing and lowering the crib has points of interest. We build two flat barges about 60 feet long and 16 feet wide; on these we placed at close intervals cast iron rollers with flanges seven inches apart, one line on each side of the boat so as to get the proper spacing for the width of the crib, which was made of 2 x 6-inch scantling superimposed and spiked together and tied across at five foot intervals with scantling of the same dimensions. The rollers, which were the suggestion of Mr. Burke, Superintendent for Heldmaier & Neu, acted as guides.

The crib was built up about two feet high on the boat and the boat forced ahead, letting the crib tail out behind, to be built full height by men on rafts, who followed in the wake of the boats. This proved a very rapid and effective mode of construction and the crib was tailed off at the rate of 150 to 200 feet per day. At intervals of 10 feet there were pockets five feet long with bottoms, in which the rock for sinking was placed; the rest of the spaces had no bottom; as soon as the crib was sunk it was filled with earth.