This schedule is based upon the zone system, with a penny fare as the standard, with over-lapping zones. These zones range from one mile to two miles, a majority of the zones being less than two miles in length. There are no ha'penny fares. For a tuppence (4 cents American) a passenger may ride the full distance of any route.

Taxation

The amount charged for rates and taxes for the year ending March 31, 1908, was $23,624.

Wages

A week's work for motormen and conductors consists of 54 hours. The men are graded into six classes, depending upon the length of time they have been in the service, ranging from one year to six years. The present scale of pay is: First year, 4½d. per hour (9 cents American); second year 4¾d. per hour (9.5 cents American); third year, 5d. per hour (10 cents American); fourth year 5½d. per hour (11 cents American); fifth year 5½d. per hour (11 cents American); sixth year 5½d. per hour (11 cents American); after six years 6½ d. per hour (13 cents American).

The general manager has recommended a change in the scale of wages, so that the men will be paid on the following basis; First year 4½d. per hour (9 cents); second year 5d. per hour (10 cents); third year 5½d. per hour (11 cents); after three years 6½d. per hour (13 cents).

Political Interference

When Mr. Nance accepted the position of general manager under the municipality, he had an iron-clad contract which gave him autocratic and absolute powers as general manager, so far as pertained to the employment and discharge of men and in certain other respects; theoretically he was absolutely independent of the council in these respects; practically his contract was wholly ignored by the city so far as his employment and discharge of men were concerned; in actual practice he was constantly hampered by demands made by members of the council to employ or reinstate certain men; he has been repeatedly put on trial before the council upon charges preferred by men whom he had discharged, and although he has been vindicated in every instance by the council, the effect has been a noticeable demoralization of the service.

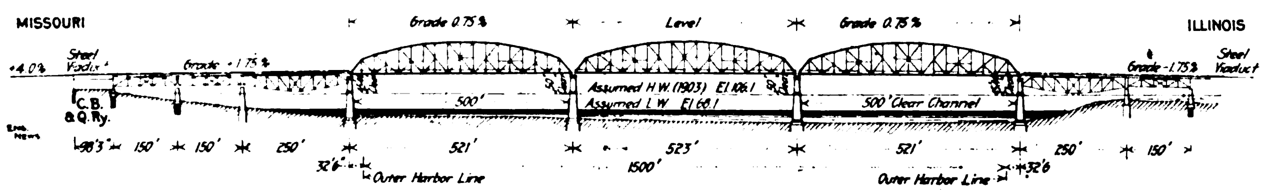
In Belfast, as in Glasgow, the traveling public must keep clear of the tramway cars at their own hazard and this fact has prevented an excessive increase in personal injuries. But the accident and injury account in respect to property has increased enormously; one officer of the company stated it had increased 20-fold. This was perhaps an over-statement, but there was a unanimous agreement on the part of all whom I interviewed that, under the municipal control and because of political interference, there has been a serious let-down in discipline and a large attendant increase in accidents; that the same capable general manager, with the same operating officers, hampered by this interference, could not give the same results that he could give under similar conditions with the lines operated by a private company.

Opening of McKinley Bridge Across Mississippi

In Presence of Distinguished Guests this Structure Was Formally Opened and Dedicated on Thursday, November 10

The new McKinley bridge of the Illinois Traction System, spanning the Mississippi river at St. Louis, was formally opened and dedicated with impressive ceremonies on Thursday afternoon of this week. Two especially decorated cars started from either end of the bridge. On the one advancing from the St. Louis side was Governor Hadley of Missouri, surrounded by members of his staff. On the other from Venice was Governor Deneen of Illinois with the members of his official family. The cars met at the center of the bridge, where Governors Hadley and Deneen clasped hands, each congratulating the other on this newest bond between Missouri and Illinois. The ceremonies were witnessed by a large number of guests of the traction company. In the evening there was a fireworks display. At the Planters' Hotel, St. Louis, the Illinois Traction System gave a banquet to its prominent guests.

The completion of the great structure, upon which construction was begun in 1907, is the crowning triumph in the notable achievements brought about through the initiative of Congressman William B. McKinley, president of the Illinois Traction System. This is the largest bridge across the Mississippi and



Illinois Traction System Bridge Across Mississippi River at St. Louis is the largest bridge ever attempted by an electric railway company, its cost being in the neighborhood of $4,500,000. Credit for the work from an engineering standpoint belongs to Ralph Modjeski, M. Am. Soc. C. E., who was chief engineer in charge of both design and construction, while F. E. Washburn was resident engineer in charge of the work.

The new bridge crosses the river at the northern part of St. Louis, about three-fourths of a mile below limits. The bridge consists of three through truss channel spans and five deck truss shore spans, with viaduct approaches at either end. The middle channel span is 523 ft. in length and the other two channel spans 500 ft. each, while the five shore spans aggregate 950 ft. The east viaduct approach, on the Illinois side, is 3,050 ft. long and the west viaduct approach, on the Missouri side, is 2,600 ft. long. The middle channel span is 85 ft. above low water and

Views of New Mississippi River Bridge, Showing Completed Structure and as It Appeared at Various Times During Construction

the Merchants' bridge, a steam railway structure, and three miles above the Eads bridge, a double-deck railway and highway structure. The total length of the bridge and viaduct approaches is 1.5 miles, beginning at 9th and Salisbury streets in St. Louis, Mo., and extending to street level at Main street in Venice, Ill. The main channel of the river at the point crossed is 1,500 ft. wide between government harbor lines and the shore piers were required to clear these has a clear headway above high water of 50 ft., receding to 45 ft. at the shore piers of each of the side spans. The center span is level, while the two other spans have a grade of .875 per cent. The grade of the deck spans and viaduct approaches is 1.75 per cent. The four large river piers which support the structure are built of red granite and Bedford limestone, backed with concrete. They are 150 ft. from bedrock to capstone, 26 ft. thick and 76 ft. wide at the bottom. The material of the bridge is open hearth steel, having an ultimate tensile strength of 62,000 to 70,000 lbs. per sq. in., an elastic limit of 37,000 lbs. and an elongation of 22 per cent in 8 ins.

The bridge carries two railway tracks, which are laid between the trusses, and two 13 ft. roadways which are carried outside the trusses by cantilever floor beams. In designing this bridge it was thought wise to make provision for its possible use in the future for steam railway service. In the three river spans the trusses are of full strength to carry the heavy concentrated loads on the driving axles of locomotives, but the flange cover plates were omitted from the floor beam construction and various parts of the shore spans were omitted, with the idea that they can be added at a future time if necessary to strengthen the bridge for steam railway service.

The St. Louis approach to the bridge, at 9th and Salisbury streets, begins as a solid embankment, held by concrete retaining walls. This also includes a $60,000 bridge station. The west approach passes over 24 acres of freight yards, owned by the Illinois Traction System. The approach crosses Broadway, St. Louis, by a plate girder bridge and beyond this extends the steel viaduct of 41 spans, broken by two through-girder spans at street and railway crossings. Under the west approach, also, stands one of the most complete and modern power plants in the west. It will have an ultimate capacity of 28,000 h. p. and will cost, when completed, $1,000,000.

The bridge station is not the terminal. The company's tracks extend beyond this 2½ miles to 12th and Lucas streets, where the company owns a block of land and where immense terminal buildings are being constructed. These include a freight and express terminal now being completed and a large passenger station with train sheds, yet to be erected.

The Illinois Traction System was started by William B. McKinley in 1900, being at that time but six miles in length, connecting Danville with one of its suburbs, Westville. It has grown until now the system operates over 500 miles of interurban, connecting Danville, Urbana, Champaign, Decatur, Clinton, Bloomington, Peoria, Lincoln, Springfield and St. Louis. The lines in the north now reach from Princeton, through Ladd, Peru, Marseilles, Spring Valley, La Salle, Ottawa, Streator and Morris. The 20 miles between Morris and Joliet will be completed within a few months, and from there the line will be built into Chicago. Connection will also be made between Streator and some point on the Illinois Traction, making a continuous electric railroad from St. Louis to Chicago. Besides the interurban property the company of which Mr. McKinley is the head, controls electric lighting plants, gas and heating plants and street car lines in 22 cities in Illinois, Iowa and Kansas. This system is not an interurban, as these are commonly known, but is an electrically operated railroad, doing all classes of railroad business and giving a service, if anything, better than the steam roads. It also has the distinction of being the only electric railroad in the world to operate sleeping cars.

H. E. Chubbuck, with headquarters at Peoria, is vice-president executive of all the properties controlled by the McKinley system. He is recognized as one of the foremost electric railway managers in the United States. The bridge at St. Louis was built under his supervision, and it was his idea to make it the largest bridge over the river, so that it will take care of any development which the future may bring.

TAMPING

The indispensability of tamping in producing a good roadbed is brought out in an article in the North-Western Bulletin by J. A. Roland, roadmaster of that road at Sioux City, Iowa. Mr. Roland states that, with a well-built sub-grade, a liberal coat of good ballast, ties of proper size and quality and rail of sufficient weight, it would seem that the responsibility of keeping the track in good condition rests largely with the men whose duty it is to tamp the ballast under the ties.

A few years ago but little tamping was done, it being the custom to raise the track high, shovel ballast under the ties loosely—and let the trains do the tamping. This practice would invariably leave the track rough, as the settling of the track would be very uneven, and does not do at all on a modern railroad to-day.

In order to maintain track in good condition under the heavy traffic and fast speed to which it is subjected at the present time, it is absolutely necessary to place it in perfect surface, and if the raise is not in excess of 1 in., to tamp every tie with a modern and approved type of tamping bar. This refers to gravel ballast.

Tamping bars being important tools on the section, they should be made of steel, properly formed, and the blades of different thicknesses, so as to pass under the ties and disturb the old bed as little as possible.

Track foremen will find it a paying investment to exercise patience and persistency in teaching their men the art of tamping, as poor tamping always results in rough track, which means a reflection upon the ability and experience of the foremen and a discredit to the qualifications of the roadmaster.

Hudson & Manhattan Railroad Extends Service

The fine new underground station of the Hudson & Manhattan Railroad at Broadway, Sixth avenue and Thirty-third street, New York city, had been brought sufficiently near to completion so that operation was extended to that station on November 10. The station has two island platforms, 400 ft. long, for loading and two side platforms for unloading. Above the platforms there is a concourse level of 33,000 sq. ft. 18 ft. below street level.

upper bars have their ends bent round at right angles for a length of 2 ft., the ends being on the inner side of the inner horizontal bars in the wall of the Public Office Block. When the centering under this bridge was struck the sag, Mr. Watson states, was imperceptible, and when tested with 50 per cent overload over the whole area the deflection did not exceed 1/12,000 of the span.

THE FALSEWORK ACCIDENT AT THE McKINLEY BRIDGE.

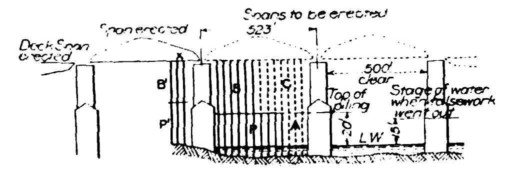
By Richard H. Phillips, Consulting Engineer, St. Louis.

Shortly after 4 o'clock on the afternoon of Dec. 31 one of those accidents occurred at the McKinley Bridge now being erected across the Mississippi River at St. Louis which are dreaded by bridge erectors engaged on such work in the upper Mississippi Valley. Fortunately, no life was lost at this recent accident, but the ice floes which threaten all winter bridge work in this part of the country wrecked the falsework for one of the large spans. The piling on which the framed bents were supported was surrounded by ice, and had the hoisting engine operators not observed the breaking up of this ice and warned the workmen, many of the latter would doubtless have been killed.

The bridge will be 8500 ft. long and will have three main spans, the middle one 523 ft. and the other two 521 ft. long. Their clearance above assumed high water is 50 ft. Steel approaches on each side will lead up to them. A temporary approach on the Illinois side will carry the tracks and wagon way into Venice on a 4 per cent grade. Eventually, however, the approach for the car tracks will be extended at a grade of 1¾ per cent across several railroad tracks and to Madison.

sketch. The channel span on the St. Louis side had been erected and the traveler and the two hoisting engines employed on the work were standing on three pile and frame bents, *B'* and *P'*, near pier 2. The pile bents, *P*, for the mid-channel span had been driven nearly to pier 3, only three of them remaining to be put in place. The frame bents, *B*, had been completed to within the seventh from pier 3. The pile bents were spaced about 28 ft. center to center and their tops were about 20 ft. above low water mark, which is from 5 to 6 ft. deep. The piles were 60 to 70 ft. long and there were 16 in each bent, except three which had 32 each. The frame bents were made of 12 x 12-in. timbers with 3 x 12-in. braces. At the time of the accident the water was about 15 ft. above the low-water level. A small barge with a pile driver and two large material barges were moored at *A*, where the pile driving was being done.

For some days previous to Dec. 31 the weather

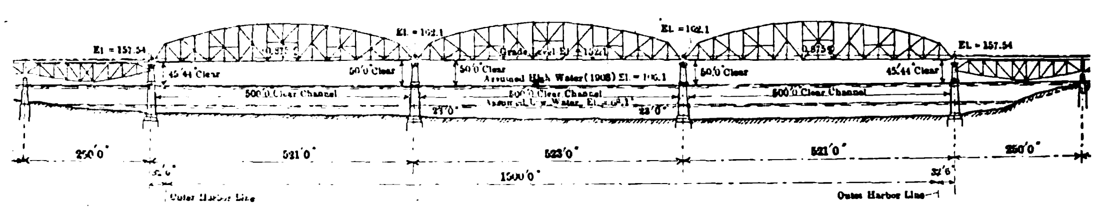


Location of Wrecked Falsework.

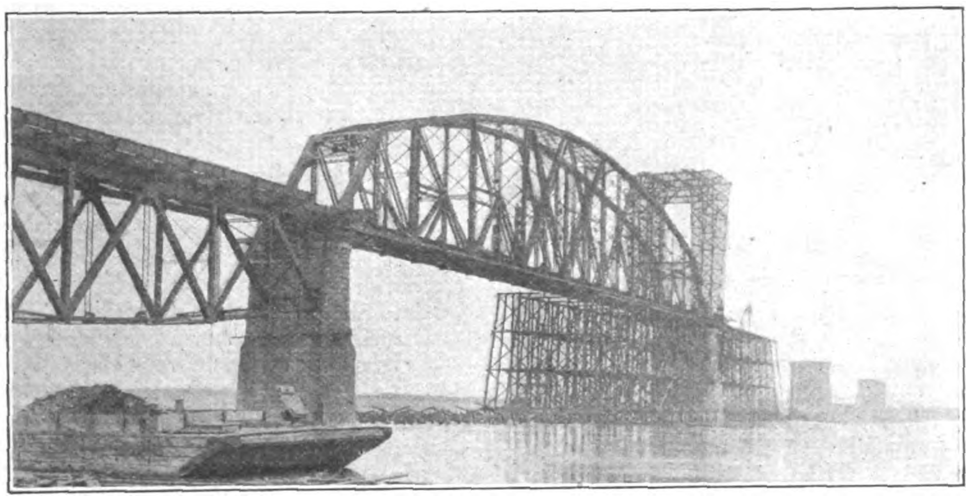
clusive of that due to delay. It is proposed to start work at once on the Illinois approach spans, and to wait until the condition of the river is more favorable before resuming operations on the uncompleted channel span. The warm weather preceding the breaking up of the ice caused a rise of something like 5 ft. in the stage of the water, and under such conditions it is not considered that anything could have been done to save the falsework which went out. For some time prrevious to the rise of water progress on the construction had been rapid.

Inverted Macadam Road Construction.

Inverted macadam road construction has been adopted in a number of cases by Mr. A. N. Johnson, highway engineer of Illinois, as a means of meeting conditions which obtain in many parts of that State. The specifications proposed to cover this method of construction and the reasons for placing the fine material on the bottom and the large pieces of stone at the top were described in a paper Mr. Johnson presented before the Western Society of Engineers. This paper was reprinted in the Engineering Record for Nov. 7, 1908. During a discussion on macadam roads at a recent meeting of that society, several engineers in charge of highway construc-



Elevation of the Central Spans of the McKinley Bridge at St. Louis.



View of the McKinley Bridge from the West Side of the River.

On the St. Louis side the wagon way and car tracks will be carried at a 1¾ per cent grade over the Chicago, Burlington & Quincy Railroad. The wagon way will then be carried down to Salisbury Street at a 4 per cent grade. The car tracks will continue at a grade of 1.75 per cent over other railroad tracks and over Broadway to Ninth Street. All piers are of concrete with stone facing and granite coping. Those supporting the main span and the two adjacent ones under the approaches have been carried down to bed rock, about 150 ft. below the pier coping.

The bridge was designed by Mr. Ralph Modjeski for the Illinois Traction System. It will carry two tracks between the trusses and a 14-ft. roadway supported by cantilever brackets at the ends of the floorbeams. A live load of 10,000 lb. per linear foot of track and 3000 lb. per linear foot of driveway were assumed in designing the structure. The contract for the fabrication and erection of the steelwork is held by the Missouri Valley Bridge & Iron Works.

The conditions at the time of the accident are indicated diagrammatically in an accompanying

had been severe. The river was frozen over, but the work of driving piles and raising the framed falsework on top of the pile bents was progressing rapidly. The space between the completed falsework and the center pier was practically clear of ice, and the floe above the bridge was solid and stationary. On Dec. 30 the weather began to moderate and there was a slight movement both above and below the bridge, and the ice began to jam above the falsework. On Dec. 31 the weather continued to become mild, and the ice jam piled higher and also extended down from 12 to 15 ft. below the surface of the water.

The first bents to give way were those located on the St. Louis side of pier 2, which supported the traveler and hoisting engines. The piles were sheared off, dropping the framework, but, in some inexplicable way, the traveler was overthrown without injuring the completed span. The piles in the mid-span went out later. An attempt had been made to strengthen these bents by trussing them with wire cables, but the precaution was apparently of very little use.

The total loss is estimated at about $40,000, ex-

tion and maintenance in Chicago and vicinity mentioned favorable experience resulting from this method of road building. Mr. A. C. Schrader, engineer of the West Park Commission, of Chicago, spoke of a stretch of macadam built last summer under his direction over a clay soil that was in bad condition, due to continued wet weather. A length of several hundred feet of the pavement was finished by using 8 or 9 in. of 2½ to 3-in. stone at the bottom, but much difficulty was occasioned in rolling this base, due to the clay working up through the stone. On the balance of the work the subgrade was lowered so a 6-in. layer of fine cinders could be placed over the clay. These cinders were readily compacted by the roller into a firm footing for the macadam, which was then laid without difficulty in the usual manner. The Board of Local Improvements in Chicago has followed this same idea for some time, using fine stone or slag screenings when a soft spot in the pavement subgrade is encountered. Mr. John B. Hittle, engineer of that board, is of the impression that the idea of putting fine material at the bottom and large pieces on the surface also will overcome the excessive wear on macadam subjected to heavy automobile traffic, and is satisfied with the results of this method of construction made under his supervision by using 3-in. pieces of granite thoroughly rolled and bonded with gravel. The experience obtained by Mr. Johnson in constructing experimental roads in all parts of Illinois since his paper was presented has strengthened his belief in this type of construction. The soft lime-stone used to surface most roads in that State has very low cementing value and grinds up under traffic. At the same time the soil over almost the entire State is of such character that it rapidly works up through macadam roads of the ordinary type. Furthermore, the soil in many localities is so adhesive when wet that traffic coming on a hard road from one not improved easily picks the fine material out of the surface.

THE SUPERSTRUCTURE OF THE McKINLEY BRIDGE AT ST. LOUIS.

By H. M. MORSE, ASSISTANT ENGINEER WITH RALPH MODJESKI, CONSULTING ENGINEER, CHICAGO.

An important bridge in the middle west, now approaching completion, is that being built across the Mississippi river at St. Louis, for the St. Louis Electric Bridge Company (the Illinois Traction System) and known as the McKinley bridge. The Central Illinois Construction Company has direct charge of its construction. The designer and chief engineer of the bridge is Mr. Ralph Modjeski, M. Am. Soc. C. E., of Chicago.

The consideration which led to the enterprise was, of course, the desire of the traction people to secure, for their extensive system of interurban lines in Illinois, a means of entrance to the city of St. Louis. In determining the type of structure to be built, however, it was concluded that a bridge of general utility would prove a more valuable asset to the promoters of the project than one restricted to their own direct uses. Accordingly the bridge has been designed to carry highway traffic on two roadways in addition to ordinary double-track railway service with electric locomotives. Moreover, the trusses and all the connections are designed of sufficient strength for the heaviest freight service, and the floor and approaches to admit of being strengthened to this capacity with little difficulty, should the demand for it develop. The bridge is therefore a combined railway and highway bridge adequate for all present conditions of traffic and easily made equal to any increased loading which it may, conceivably, be called upon to carry.

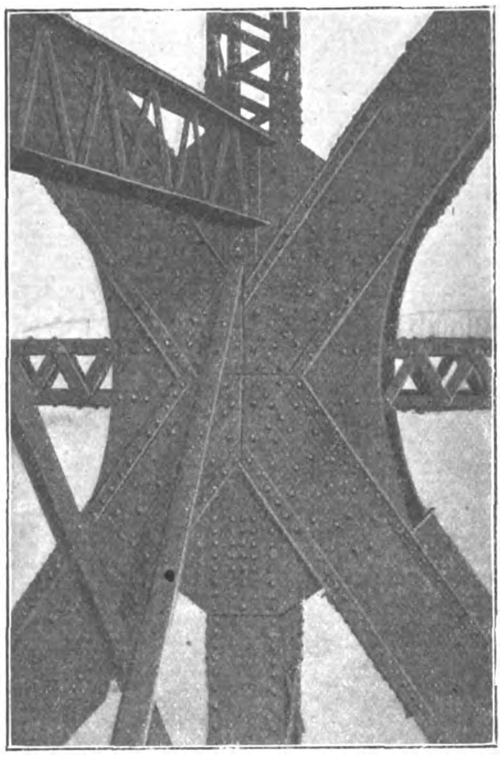
The site is about three-quarters of a mile below the existing Merchants bridge and 3 miles above the Ead's bridge, crossing the river at a point just south of Salisbury street in St. Louis, to the town of Venice on the east bank, where it connects with the present interurban lines to Granite City and other neighboring towns.

A general profile of the entire bridge with its approaches is shown herewith, drawn with the vertical scale 2½ times the horizontal. The total length of the structure covered by existing contracts is about 1¼ miles.

The bridge proper is 2514 ft. 4 in. in length, from center to center of end piers, and is made up of eight truss spans, on nine piers marked A to E and I to IV inclusive, arranged as shown in the accompanying profile. The four numbered piers supporting the channel spans are 10 and 12 ft. under the coping and are battered ½ in. to 1 ft. They are faced with Bedford limestone with concrete backing. The bearing stones in the copings and the nosing stones in the upstream ends are of granite. The piers are on pneumatic caissons, sunk to bed rock. The five piers A to E, inclusive, are of concrete reinforced by steel rods in their shafts and copings. Piers C and D are on caissons sunk to bed rock, and A, B and E are on wooden piles.

The length of the channel spans was governed by the requirement of the War Department for a minimum clear channel, at low water, of 500 ft. The actual channel afforded by the spacing adopted is about 4 ft. more than this. A clear head room of 50 ft. was required and is provided between high water and the lowest point of the steel in the middle span.

The three spans are each 517 ft. 6 in. center to center of end pins, one end of each truss resting on a fixed cast-iron bolster, and the other on a nest of eight 18-in. segmental cast steel rollers, moving on a bed plate of steel rails. The outlines of these trusses are similar to those of the Merchants' bridge, just above, but the members are larger and the spans have a much stronger and heavier appearance. Counters, used in some of the panels of the Merchants' bridge, are



Detail at Middle of Center Panel.

omitted in this, the members in the panels where counter stresses occur being made capable of resisting both tension and compression.

The trusses are of the through pin-connected Pratt type, with curved top chord and subdivided panels. They are placed 29 ft. 8 in. apart on centers, giving, with a 44-in. cover plate on the end post, a clear width between trusses of 26 ft. Between the trusses are the two railroad tracks, placed 12 ft. apart on centers with 8 x 8-in. creosoted pine ties, 7 in. apart, and carried on four lines of stringers, 3 ft. 10 in. deep, framed between floorbeams 5 ft. 7½ in. back to back of flange angles. On the outside of either truss, a 14 ft. roadway is carried on brackets projecting at the panel points, and connected to form cantilever ends to the floorbeams.

Plate girder stringers, 2 ft. 7½ in. deep, under the inner and outer edges of the roadways are framed between the solid plate webs of the brackets, their upper flanges supporting the edges of the paving and the wooden curbing. A 15-in. rolled cross beam is framed between these stringers, at the center of each panel, forming the intermediate support of the wooden floor joists, which are 8 x 16-in. yellow pine, creosoted. The roadway is provided with Shuman sectional paving 3¾ in. thick.

The 250 ft. of levee, between the outer and inner harbor lines, on either side of the river, as established by the War Department, is spanned by a deck truss, 245 ft. 4 in. long between the centers of the end pins, with a pin-connected curved bottom chord. One end rests on fixed bearings in niches in piers I and IV, expansion taking place on 12-in. segmental rollers on piers C and D.

The three shorter deck spans, two on the St. Louis side and one on the Venice, completing the main bridge, are each 146 ft. 9 in. long between the centers of the end pins, and are of similar type and construction as those last mentioned but with parallel chords.

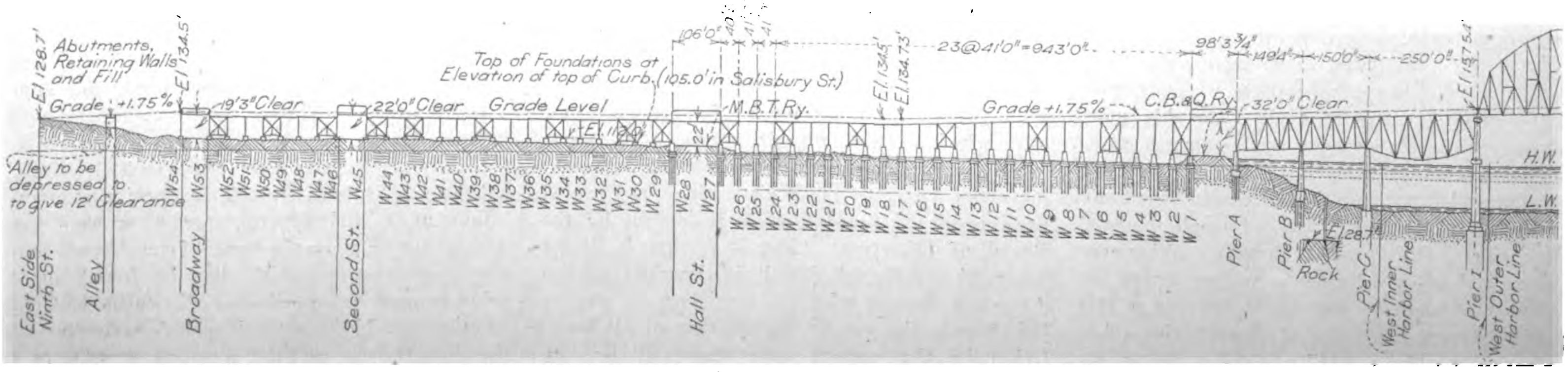
Loading.—The electric railway loading for which the floors and the viaduct approaches are proportioned, consists of continuous lines of 75-ton cars on both tracks, each car occupying 40 ft., with 25 ft. between centers of trucks, and the two axles in each truck 6 ft. center to center. The roadways are proportioned for a live load of 100 lb. per square foot, or a road roller weighing 35,000 lb., where the latter would produce the greater stress.

As previously stated, the floor and viaduct steel is designed with a view to possible strengthening in the future. This may readily be done by the addition of flange plates to the stringers, floorbeams and girders to make them adequate for a load on each track of 5000 lb. per foot and a concentrated load of 50,000 lb. placed where it will produce the greatest stress. All the connections are made of sufficient strength for this increased loading, and the hangers and subdiagonals in the trusses are proportioned for it in combination with the maximum load on the roadways.

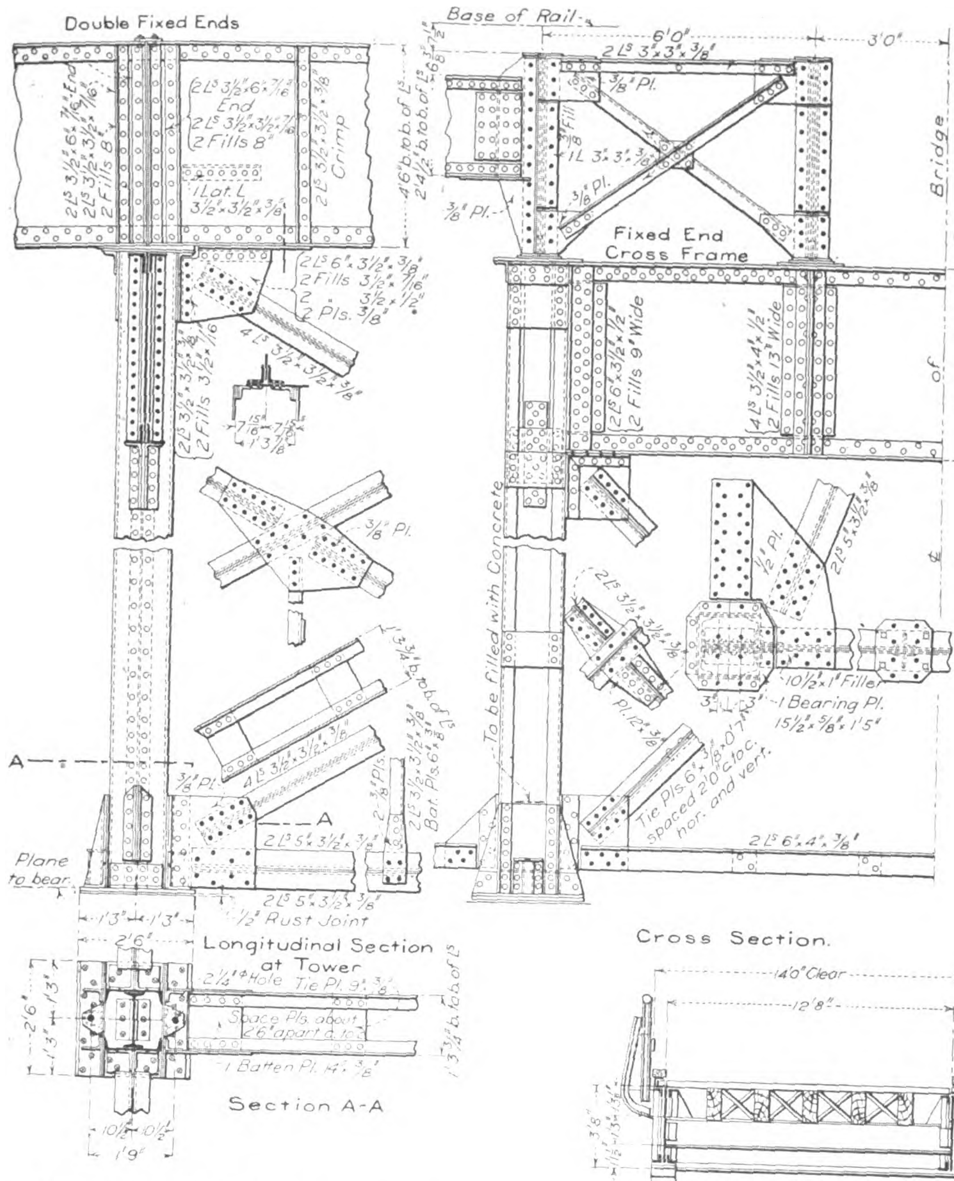
For the main truss members, on account of the double track, the loading was taken at 20 per cent less than the total given above. The dead loads used included the weights of the future reinforcements, in addition to the weight of the present structure.

The wind pressures assumed for computing the lateral stresses were: For the loaded chords of all spans, 600 lb. per foot, one-half as moving load; for the unloaded chords of through spans, 250 lb. per foot, uniform, and for those of deck spans, 200 lb. per foot, uniform; for the viaducts, 250 lb. per foot, moving load. Impact was allowed for by a reduction of from 30 to 50 per cent in the unit stresses from those used for static loads.

All metal in the bridge, excepting the cast-iron in the pedestals, and similar parts, is open-hearth steel, which is classified in the specifications as rivet steel, medium steel, and pin steel. The rolled material was required in the speci-



Profile of the McKinley Bridge over the Mississippi River



Typical Details of Viaduct Approach.

fications to have the following physical properties, shown by specimen tests:

	Rivet Steel	Med. Steel	Pin Steel
Ulti. Strength, lbs./sq. in....	52,000 to 60,000	62,000 to 70,000	62,000 to 70,000
Elastic Limit, lb./sq. in.....	Not less than 30,000	Not less than 37,000	Not less than 35,000
Elon. in 8 in....	26%	22%	20%
Cold bending without rupture.........	180° flat on itself	180° to diam. = ½ thickness of piece	180° to diam. = thickness of piece

Steel castings are specified to show, in specimen tests, an ultimate tensile strength of from 65,000 to 75,000 lb. per square inch, and an elongation of 15 per cent in 2 in., including the fracture. Full-size tests of eye-bars were required to show an ultimate strength of not less than 57,000 lb. per square inch, an elastic limit of at least 30,000 lb., and an elongation in 20 ft. of 12 per cent or more.

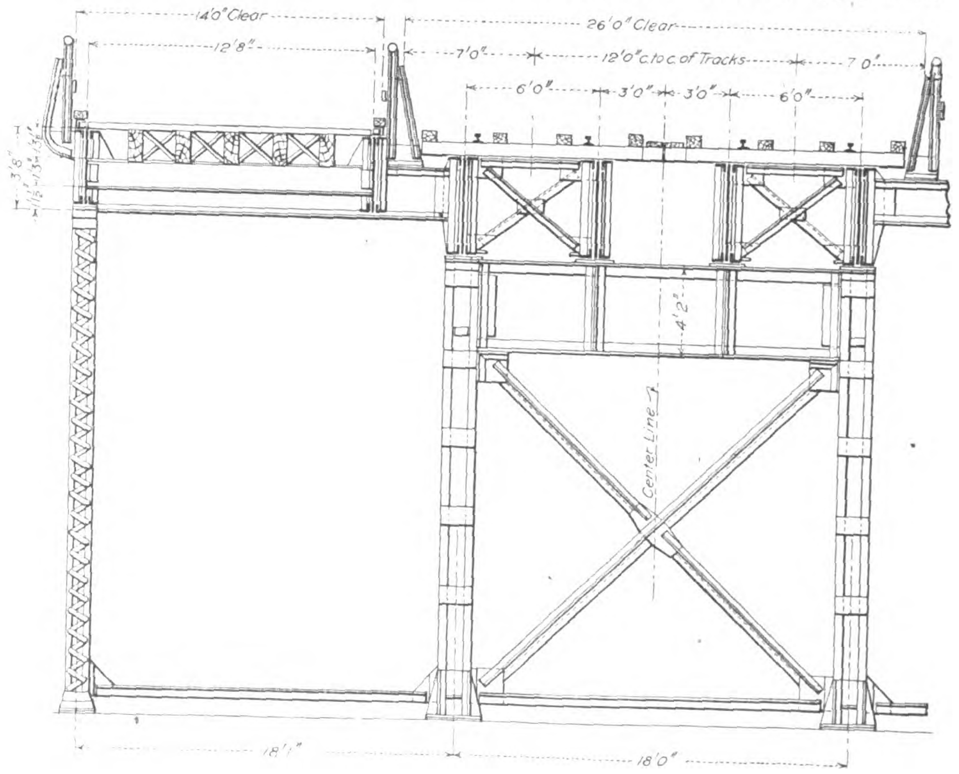
Chemically, the maximum percentages of phosphorous allowed was 0.08 of 1 per cent for acid steel, and 0.04 of 1 per cent for basic, while the maximum sulphur was specified at 0.04 of 1 per cent in both. The material was subjected to rigid inspection both in mill and shop. All rivet holes, except those in lateral bracing, were reamed with a twist drill after being punched with a die 3/16 in. less in diameter than the finished holes. This reaming was done with the pieces assembled as for riveting, and held together by at least one bolt for every third hole. In floorbeam and stringer connections the holes were reamed to an iron template.

The joints in the top chords were faced to the exact bevel and length required for a full bearing, and bored for pin holes while assembled in pairs, with the end surfaces held firmly in contact, especial care and accuracy being called for in this part of the work. Stiff chords were assembled in the shop for a length of 75 ft. or more, and holes for field splices were reamed with the members fitted together.

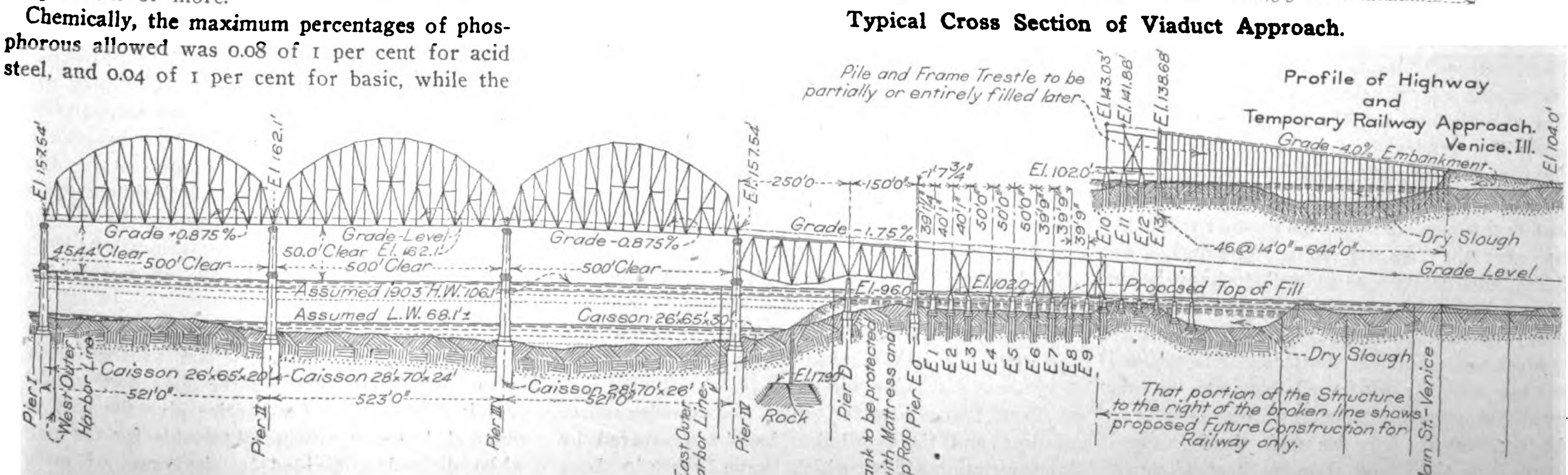
Camber was given the truss spans by increasing or reducing the geometrical length of each member by the amount of axial distortion which would theoretically be caused in it by the dead load and the uniform live load over the entire span, allowance being made for a play in pin holes of 1/32 in. at each pin.

The general details of the truss spans are shown in the large folding plates and little explanation is necessary. The cross sections show the arrangement of the floors and their connections, the roadway brackets and other details.

In the trusses of the channel spans the maximum chord stresses provided for are: Dead load, 2,166,000 lb.; live load, 1,998,000 lb. in



Typical Cross Section of Viaduct Approach.



at St. Louis; Vertical Scale 2 1/2 Times the Horizontal.

both top and bottom chords at the middle panel. The top chord is made up of four built-up channels 33½ in. deep with a top cover plate 44 in. wide.

The bottom flanges are connected, in pairs, by 5-in. bar lacing at 60 deg. The two pairs of channels are connected, clear across, at or near the panel points, by wide tie plates, and, at intermediate points about 5 ft. apart, by smaller tie plates between the inside channels only. Vertical diaphragms are placed between the webs, three in each panel length.

The first two panels of the bottom chord at either end are of similar construction. A somewhat unusual feature in the design of the trusses is the use of a common gusset and a riveted connection between the web members at the middle and bottom chord panel points, at and near the center of the span, in place of the usual pin connections. This allows a more uniform thickness for the web members and its use at the center of the span, in connection with double-length eye-bars in the center panel of the bottom chord, gives a perfectly symmetrical span about its center line, as to both details and packing.

On the afternoon of Dec. 31, 1909, the false work which had been practically completed for the erection of the middle channel span was carried away by the ice in the river. This accident was described in the Engineering Record of January 8. All erection work on the channel spans was suspended at that time until the danger of ice should be past.

Approaches.—The approach to the bridge on the St. Louis side, extending from Niinth street to pier A, where the main bridge begins, is a little more than ½ mile in length. Except for about 150 ft. of embankment at the west end, from Ninth street to the alley adjacent, it is of steel viaduct construcion. Between the alley referred to and Broadway, the space underneath the tracks and roadway is occupied by a new passenger station, the floors, ceiling and roof of which are supported on the viaduct posts, which are here placed 21 ft. 1¼ in. on centers.

On this portion of the structure, and as far as Hall street, there is but one roadway, which is here 24 ft. wide, and is carried along the south side of the main tracks. Along their north side, from Second Street to Hall Street and crossing the latter to an abutment, is a side track, to be used for yardage purposes. From Hall Street eastward there are two 14-ft. roadways, one on either side of the tracks.

On the Venice side about 1700 ft. of approach is under construction. This includes, besides the permanent steel portion of the main viaduct, 644 ft. of temporary wooden trestle, and 300 ft. of embankment, in a turnout which carries the tracks and roadways in common, at a 4 per cent grade down to the street level at Main Street. This will accommodate the local highway traffic and connect with the local traction lines in Venice. The main railway tracks, it is expected, will be continued, later, at an elevation which will carry them over the several railroad crossings in the vicinity for the use of the through service. The grades used on the different parts of the structure are shown on the profile.

The typical cross sections of the permanent viaduct and typical details of its construction are shown in the accompanying drawings. The track columns are two 15-in. rolled channels and one 15-in. beam, in section as shown. The columns under the outer edges of the roadways are two 12-in. channels, latticed. All the columns are set on reinforced concrete circular pedestals, supported on concrete piles.

The contractors for the main bridge superstructure are the Pennsylvania Steel Company of Steelton, Pa., and for its erection the Missouri Valley Bridge & Iron Company, of Leavenworth, Kan., who were also the contractors for the substructure. The steel in the viaducts is furnished by the Strobel Steel Construction Company, of Chicago and erected, under subcontract with them, by the erection contractors of the main bridge. The concrete foundations for the approach steel were furnished and placed by the American Concrete Company, of Chicago. Mr. F. E. Washburn, C. E., is in direct charge as resident engineer for Mr. Modjeski.

The total weight of the steel in the main bridge is about 8575 tons; in the approaches, approximately 3800 tons.

PLACING CONCRETE AQUEDUCT LINING IN FREEZING WEATHER.

Owing to delays in building the foundations and piers of some of the aqueduct bridges on the Illinois and Mississippi Canal it was necessary to place some of the concrete lining in cold weather. It was important, therefore, that precautions be taken to keep the concrete from freezing. The methods employed were described by Mr. H. E. Reeves, U. S. junior engineer, in a paper before the last convention of the Illinois Society of Engineers and Surveyors. A complete description of these bridges will be found in the Engineering Record, June 29 and July 6, 1907.

The last concrete was deposited Dec. 28 and the temperature during the final weeks dropped as low as 12° or 15° above zero, barely rising to the thawing point in the middle of the day. Owing to the thinness of the lining, 6 in. on the bottom of the trough and 9 in. on the sides, and its exposed position considerable care was necessary. To heat the concrete materials, the exhaust steam from the mixer engine was turned into the drum of the mixer. This was accomplished by conducting the exhaust pipe to a point in front of the discharging opening of the drum, so that the drum when tilted for discharging would just clear the end of the pipe. The force of the exhaust then carried the stem into the revolving drum, where complete mixture with the dropping particles of concrete utilized practically all of the heat remaining in the steam. Though the expense was absolutely nothing, the results were really surprising. The temperature of the deposited concrete averaged probably 70°, while if a batch were left in the mixer 3 min. or more its temperature would be 90° to 100°.

To protect the deposited concrete, the inside of each 35-ft. span at the close of the day's work was roofed over with inch boards laid loosely on horses, the ends being closed with pieces of canvas; and into the room thus formed live steam from the boiler was conducted through a hastily laid pipe line. The night watchman kept up the steam, the amount needed being very small. Steam was kept on the concrete for two nights or for about 40 hours after being laid. It was considered that the outside was sufficiently protected by the 2 in. forming. On the third day the forms if needed were removed and the concrete left exposed. The cost of this protection was about 12 to 15 cents per cubic yard of concrete and the results, Mr. Reeves states, were perfect. As an illustration of the need of protection, it may be noted that the feed pipe for the boiler froze one night about midnight and steam was shut off from the concrete for about 7 hours. The concrete froze to some extent, and about ½ in. of the surface afterwards shelled off.

The Extension of the Barge Canal to Seneca and Cayuga Lakes has been assured by appropriation bills which have recently been signed by Governor Hughes of New York.

DEPRECIATION AND RESERVE FUNDS.

In order to show in full the actual cost of performing the services required public service corporations must take into account certain expenses that cannot be appropriately included in the day-by-day operating and office costs or in the current maintenance expenses of the company. These accounts are for the sums that must be set aside to cover depreciation replacements and to provide a reserve fund to care for extraordinary costs. A paper covering these two points was presented this week before the Western Society of Engineers by Mr. William B. Jackson, and while they were discussed with particular reference to electrical properties, the following notes taken from the paper refer to public service corporations in general.

The term "depreciation" as here used is divided by Mr. Jackson into two parts:

1. Decrepitude; which covers the gradual wearing out of the apparatus from the effects of use and of age, which cannot be overcome by current repairs, and which results eventually in ending the operative life of the apparatus.

2. Obsolescence; which takes into account the reduction in the useful life of apparatus, on account of advances in the art whereby otherwise operative apparatus is made uneconomical for further use.

The term "reserve fund" as here used may also be divided into two parts:

1. Required Reconstruction; which takes into account reconstruction costs made necessary by municipal or other legislative requirements.

2. Special Insurance; to cover expenses that cannot be forecast with any degree of certainty, caused by extraordinary occurrences such as unusual storms, explosions, great conflagrations, acts of strikers, etc.

In considering depreciation it is well to separate clearly in one's mind the annual depreciation of the plant as an average whole and that of the component parts making up the plant. To obtain the true amount of the annual depreciation in the value of any property, it is necessary to estimate a sum of money which represents the yearly depreciation of each of the component parts, and the aggregate of these gives the annual depreciation for the plant. Any method of arriving at the amount of annual depreciation that does not take into account the individual depreciations of the component parts of a plant, must be an approximation at best.

This division of a plant into its component parts for purposes of determining its annual depreciation is usually a simple matter. It requires that each of the component parts shall be such that when it has reached the end of its useful life the part in its entirety will be discarded, and that it shall be possible to determine intelligently its probable salvage value as a whole.

If we consider the overhead lines of an electric light plant, the lines may be divided into the following parts: Bare wire, weatherproof wire, rubber covered wire, transformers, lightning arresters, insulators, and poles and cross-arms with their hardware. It will be seen how impossible it would be to determine a fair amount for the depreciation of poles and wires without thus analyzing the aggregate, owing to the widely differing useful lives of the two kinds of plants and the great difference in the proportions of their salvage values.

The total amount of depreciation to be annually charged against any part of the installation should be equal to the first cost of the part installed ready for service plus the cost of removal, less any salvage obtainable for the part when discarded, divided by the years of probable life of the part.

The Construction of the Substructure of the McKinley Bridge Across the Mississippi River at St. Louis, Mo.

By F. E. WASHBURN,* C. E.

A new bridge across the Mississippi River at St. Louis, popularly known as the McKinley Bridge, is being built for the interurban electric railway lines of the Illinois Traction System by a company organized for the purpose under the name of the St. Louis Electric Bridge Co. Mr. Ralph Modjeski, M. Am. Soc. C. E., is Chief Engineer of the company, and the writer is Resident Engineer in charge of the work.

The bridge (with its approaches) extends from the northern part of St. Louis to the town of Venice, Ill., and is located between the existing Eads and Merchants bridges. It has a double track railway between the trusses and two roadways outside of the trusses. The bridge proper has eight spans, and the general arrangement of the spans and piers is shown in Fig. 1. The channel is crossed by three through-truss spans, 523 ft. c. to c. of piers for the center span, and 521 ft. for the two side spans. At each end is a 250-ft. deck truss span, followed by one 150-ft. deck truss span at the east end, and two 150-ft. deck truss spans at the west end. The approaches are steel viaducts.†

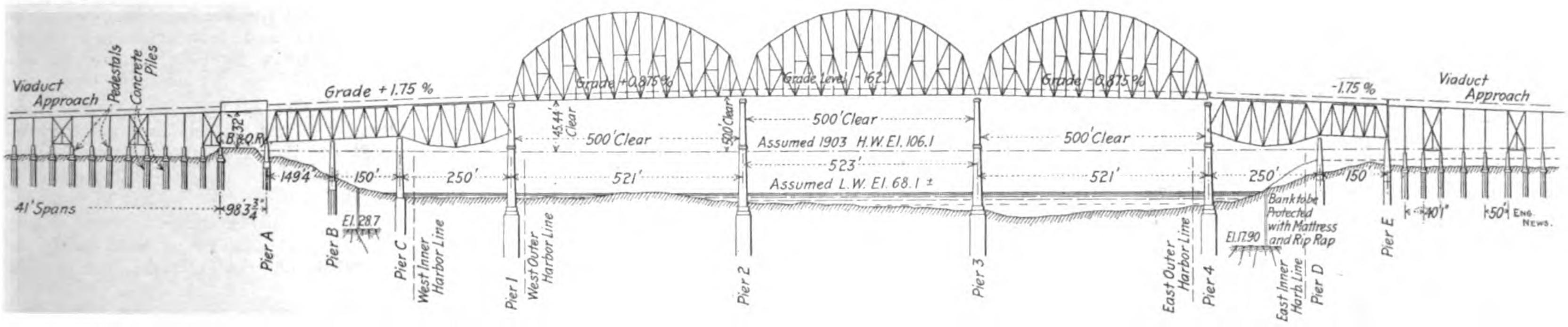


FIG. 1. PROFILE OF RIVER BED AND ARRANGEMENT OF SPANS OF THE McKINLEY BRIDGE OVER THE MISSISSIPPI RIVER AT ST. LOUIS.

River Conditions.

The Mississippi River at the bridge site is about 1,950 ft. wide at low-water stage and nearly double this width at high water. The west bank has the steeper incline, beginning at low-water shore line near the west inner harbor line and reaching above the high water line at the embankment of the C., B. & Q. Ry. in a distance of 300 ft. The east bank rises with a gradual slope to an elevation of about 15 ft. below the high water line near the east inner harbor line. From this point east to Main St., in Venice, the country is low and flat, and is traversed by sloughs across which railway embankments have been thrown. The main flooded area is on the eastern shore, and the level of this area fluctuates yearly according to the action of the current.

The river bed is composed of sand which is continually changing its level, but in general its slope is towards the east. For a distance of 600 ft. east of the west inner harbor line it is comparatively level at an elevation of from 1 ft. to 4 ft. below the low water line. It then slopes gradually to the east, reaching its lowest point about 400 ft. west of the east outer harbor line, where it is from 18 ft. to 25 ft. below low water line. The changes noted in the river bed during the construction of the bridge were such as to transfer the natural channel of the river toward the east.

The location of the piers was governed by the harbor lines adopted by the War Department in 1903. The distance is 1,500 ft. between the outer harbor lines and 2,000 ft. between the inner lines, thus making a levee area 250 ft. wide on each side of the river. The plans approved by the War Department provided for clear spans of not less than 500 ft. at low water between the outer harbor lines. This required the location of the outer piers, outside of these lines, and the lengths of the main spans were made as above stated. The difference in distance between centers of piers is on account of the larger size of the inner piers. The actual distance from the outer harbor line to the center of the adjacent pier was made 32 ft. 6 ins.

The War Department required a clearance of 50 ft. between high water and the lowest point of the superstructure. The assumed high water level is that of June, 1903, when a stage of 38 ft. was reached; this was the highest stage since 1844, when 41.32 ft. was recorded by the Mississippi River Commission. All elevations used on this bridge were referred to a datum 100 ft. below the St. Louis directrix which marks the elevation of high water in 1828. Check levels were run over the Merchants' Bridge between St. Louis city bench marks and the U. S. benchmark No. 8 established at the levee in Venice, Ill., from the Memphis datum. These levels were checked across the new bridge piers as soon as construction permitted. The low water stage, that of 1863, coincides with the zero of the St. Louis gage, which is 33.7 ft. below the city directrix, or at an elevation of 66.3 ft. referred to the bridge datum. The elevation of assumed high water was therefore 106.1, allowing for a slope of the water surface of 0.6 ft. per mile.

Probably on account of the banking up of the water at the Eads and Merchants' bridges the slope of the water surface between these structures varies with the rising or falling stage of the river for stages of 20 ft. and above. During the construction of the McKinley Bridge the slope varied from 0.17 ft. per mile at a 5-ft. stage to 0.83 at a 35-ft. stage. The intermediate slopes were as given in Table I. Stages of the rising river were noted from the middle of February, 1908, to the latter part of June. During this time the fluctuations were quite pronounced, and the average rate of rise was about 8 ins. in 24 hours. Stages of the falling river were noted between the latter part of June, 1908, and the early part of September, when there were no pronounced fluctuations, the general rate of fall being about half the rate of rise.

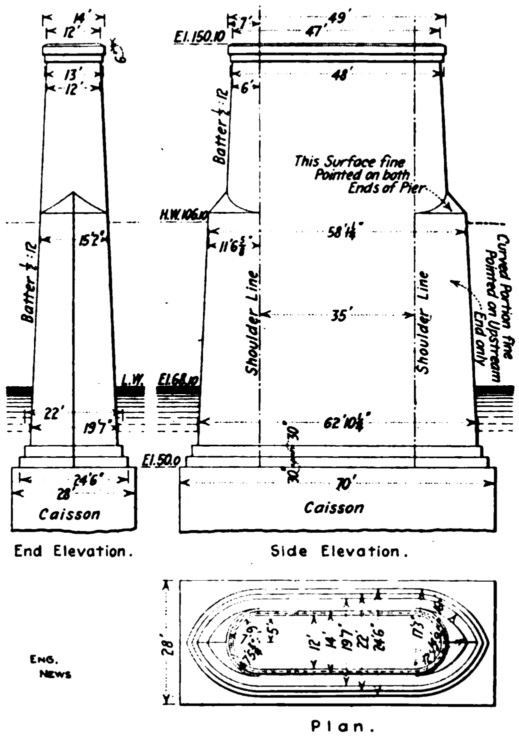


Fig. 2. Piers Nos. 2 and 3 for the Channel Spans of the McKinley Bridge.

TABLE I.—SLOPE OF RIVER SURFACE BETWEEN THE MERCHANTS AND EADS BRIDGES.

Stage	5 ft.	10 ft.	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.
	Slope in ft. per mile						
Rising	0.17 ft.	0.20	0.23	0.45	0.60	0.70	0.83
Falling	0.17 ft.	0.20	0.23	0.37	0.40	0.60	

Piers.

The substructure for the bridge proper consists of nine piers. The four piers of the channel spans (Nos. 1 to 4) are of concrete faced with stone masonry. Piers (A), (B) and (C), on the west side and (D) and (E) on the east side, are of concrete. All have caisson foundations, except that the three piers (A), (B) and (E) were founded in open excavation upon wooden piles.

The caisson foundations were placed on bed rock, which consists of a bluish gray crystalline limestone practically free from fissures, clay pockets or vertical seams. Horizontal clay seams were found in some cases near the surface of the rock. The surface in general was corrugated and worn smooth by erosion. The corrugations invariably lie in the direction of flow, the greatest span and depth of the valleys being about 1 ft. The material overlying the bed rock consisted of clay in small quantities, quicksand, gravel, sand and small boulders. Its average depth was 30 ft. at the main piers and 40 to 70 ft. at the approach piers. The rock was comparatively level at the sites of the piers, but its general slope was to the east. The difference in elevation across the river was 14 ft., the average slope being 0.7% and the steepest 1.25%. The slope east and west of the main piers averages about 0.5%.

From two to four wash borings were taken at the site of each pier for the determination of the elevation of bed rock. The difference between the average results for each pier and the actual elevations varied from 6 ins. to 8 ft., the average difference being about 3 ft. These results show that little dependence can be placed on the accuracy of wash borings, especially where gravel or boulders are encountered.

The facing of the main piers (Nos. 1 to 4) is of Bedford limestone, except that the bridge seats and the upstream nose stones above the river bed are of granite. Concrete was used for backing, except for the three courses below the main coping course, which are backed with limestone. The curved surfaces of the upstream starlings are close pointed to ¼-in. projection. The exposed surfaces of the main copings and the projecting bottom beds of the belting courses are planed. A 4-in. draft line is cut along the lower edges of the belting courses and on each side of the vertical angles of the downstream starlings. All other stones are quarry faced, with projections not exceeding 3 ins.

The design of the channel piers is shown in Fig. 2, and Fig. 3 is a view of one of the completed piers. A distinctive feature in the design of the starling coping consists in the manner of closure of the pointed and circular portions. The usual starling coping is dispensed with, and a heavy batter is made from the point of the nose at the base of the starling course to the top of the next course above. This results in a conical surface which adds considerably to the appearance of the pier.

Piers 1 to 4 are 10 ft. and Piers 2 and 3 are

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†The superstructure of the bridge will be described more fully in a later issue.—Ed.

12 ft. in width beneath the belting course, with shoulder distances 32 and 35 ft. respectively. Piers A to E are 7 ft. wide beneath the coping, which is 30 ins. high with a 12-in. projection. These piers are reinforced with steel bars spaced 18 ins. apart 6 ins. from the surface in shafts and copings.

Pier B consists of two square pillars on a common foundation with an arched connection at the top; the latter was used for appearance and stability, the former for the prevention of unequal settlement in the arch masonry. Piers C and D each consist of one monolith with parallel sides and circular ends. Piers A and E are each composed of two square pillars on separate foundations. The batter for all the piers was made ½-in. per ft.

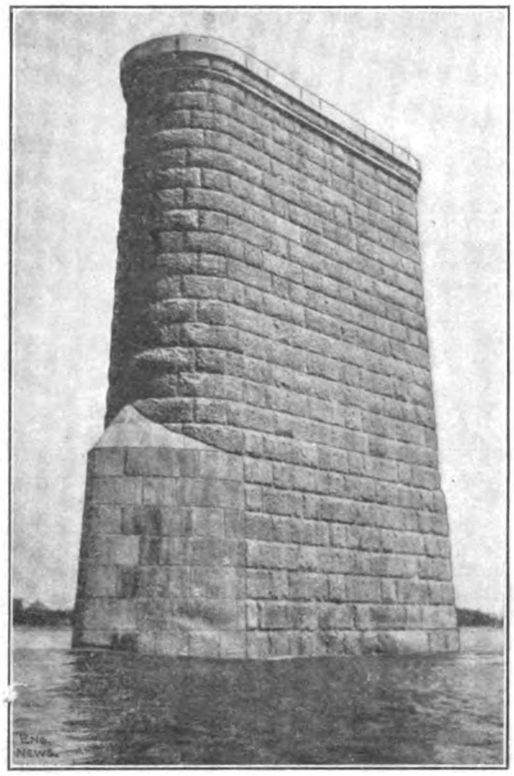


Fig. 3. Completed Pier No. 3; McKinley Bridge. (This shows the upstream end; the starling of the downstream end is of quarry-faced stones.)

Surveys for Locating the Piers.

The piers were located by means of a triangulation system (Fig. 4), the lengths and positions of the base lines of which were determined by local conditions, which were far from ideal. The C., B. & Q. Ry. occupied the only available position for a base line on the Missouri shore, and the only advantage of this location was its elevation above high water. The disadvantages were the impossibility of using triangulation houses, interruptions due to passing trains, and heat vibrations over a cinder bed. The length of this base line was 2,016 ft., about 66% being to the north of the bridge tangent on account of local conditions.

Collapsible targets were substituted for triangulation houses, each target consisting of a hinged tripod with adjustable target and plumb bob attachment. Hubs with grooved metal tops, in which screws were placed for level adjustment, were driven in the ground for the reception of the tripod tips. This arrangement enabled the target to be accurately set without great loss of time, and was particularly valuable when trains were frequent.

The location of the Illinois base line was made such that the end hubs could be readily seen from the Missouri base line hubs, and local conditions limited its length to 1,910 ft. It was placed at as high an elevation as the nature of the shore would permit, and the end hubs were thoroughly referenced on account of the danger of disturbance by flood. Owing to the general unevenness of the shore and intervening gullies this line was more difficult of accurate measurement than the Missouri base.

Triangulation houses were used on this base line for the protection of the transit and elevation of targets, which were similar to those used for the collapsible targets. The adjustment of the target was made from within the house by means of hook bolts which extended through posts braced against the roof, the lower ends being in reach of the operator. The target was set on a round base and the bolts were placed at the circumference to allow adjustment at any angle. Two windows, hinged at the top to act as sunshades, were provided on adjoining sides of the house, and the corner posts were made so that a beveled section could be removed from the inside thus allowing an unobstructed range of vision. The base lines were laid out for measurement at 98-ft. points, the tape being supported at quarter points. A 100-ft. Chesterman tape standard at 38.1° F and 12 lbs. tension (continuously supported) was used for determining lengths. The temperatures were obtained by means of thermometers with exposed bulbs placed on supports at each end and center of the tape.

The observed values were corrected for sag, temperature and difference of elevation. Observations were made during the months of October and November and the range of temperatures was from 32° to 83° F. Of 31 measurements, 10 were rejected on account of poor weather conditions and the personal equation of observers. The following results were obtained:

	East.	West.
Max. variation in observed lengths	0.671 ft.	0.287 ft.
Max. variation from mean absolute length	0.0361	0.0284
Max. variation in absolute length	0.0626	0.0345
Probable error of the mean	1 in 500,000	1 in 590,000
Probable error of a single observation	1 in 150,000	1 in 185,000

These probable errors denote the relative accuracy in the measurement of the two base lines, but as these errors are a function of the variations of the absolute lengths from the mean, the discrepancies in mean absolute lengths are given as being an index of the probable actual maximum error of the work.

The instrument used for angle observations was a Berger & Sons inverting transit reading to 20 secs. of arc. Each set of observations consisted of at least ten settings with the telescope direct and ten reversed, the repetitions being made in opposite directions to eliminate errors of graduation, of clamp and axis movements, and of adjustment for collimation. The target used was a flat board 8 ins. wide and 30 ins. high. The face of the target was divided into triangles, except for a narrow vertical area through the center which was of sufficient width to subtend 4 secs. of arc for a radius equal to the greatest length of sight in the quadrilateral. This angular width was sufficiently great to extend beyond the vertical cross-hair and allow immediate accurate setting of the instrument. This narrow area and alternate triangles were painted white, the remainder of the surface being red. The white triangles merging into the central white area formed an optical line which was easily located.

The angles of the system varied from 35° to 58°. Small angles were avoided on account of the greater error in resulting distances for an equal error in observed values. The observed values of the angles for the entire quadrilateral were corrected according to the angle equation, and these corrected values were again corrected for the side equation according to the tabular differences for one second for the logarithmic sines of the various angles. The angular values resulting from this method of rigid adjustment were used in all computations for pier location after being verified by computation of base line distances. The coordinates of the triangulation stations and piers and the bearings and distances were then computed and tabulated, the bridge tangent being taken as an east and west line for convenience.

Caissons.

The inside width of the caissons was determined by the width of the required bearing area of the superstructure, the height and batter of the pier, and the allowance for offsets in foundation courses. The inside length was determined by the width between trusses and the width and radius of the bottom foundation course.

The height of the caisson proper was dependent upon the required height of the working chamber and the depth of roof necessary for sufficient strength during sinking. The limiting factors for the determination of the height of crib were the elevations of bedrock and river bed, depth of water at the working stage, effective sinking weight, and the relative cost of caisson and masonry construction. For Pier C, the effective sinking weight was the determining factor, and it was found necessary to increase this weight by flooding the cofferdam. In the case of Pier D the height could have been reduced by 15 ft. with good results. The dimensions of the caissons are given in Table II. The depths of water at low water, given in the table, are those during construction. The depths change on account of scour.

A cofferdam was used for each pier, its height varying to accommodate the work for the stage of the river at which the pier was being constructed. This height in most cases was sufficient to allow from 6 to 10 ft. penetration of the cutting edge at the setting of the last offset course. The heights were as follows: Pier No. 1, 12 ft.; No. 2, 36 ft.; No. 3, 10 ft.; No. 4, 6 ft.; C., 18 ft.; D., 4 ft.

The caissons were of timber (long-leaf pine) and reinforced-concrete construction, and the caisson for Pier 4 is shown in Fig. 5. The concrete was of gravel, in proportions of 1:2½:5, and the reinforcement consisted of ⅝-in. and ½-in. round steel rods. In general the walls were made of 6 x 12-in. timbers supported by 6 x 8-in. and 10 x 10-in. cross and longitudinal struts, making 11 ft. to 12 ft. panels and 3 ft. to 4 ft. vertical intervals. The wall timbers were laid horizontally, with intermediate butt joints and halved corner joints, and they were bound

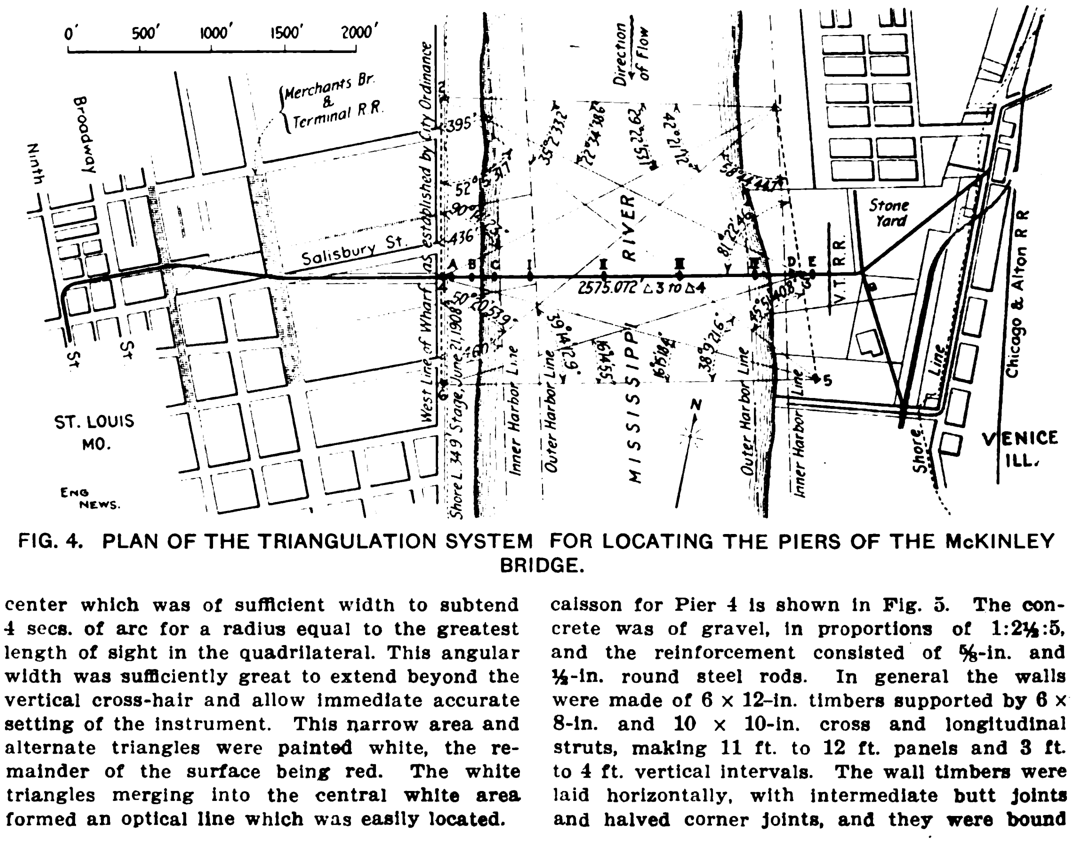


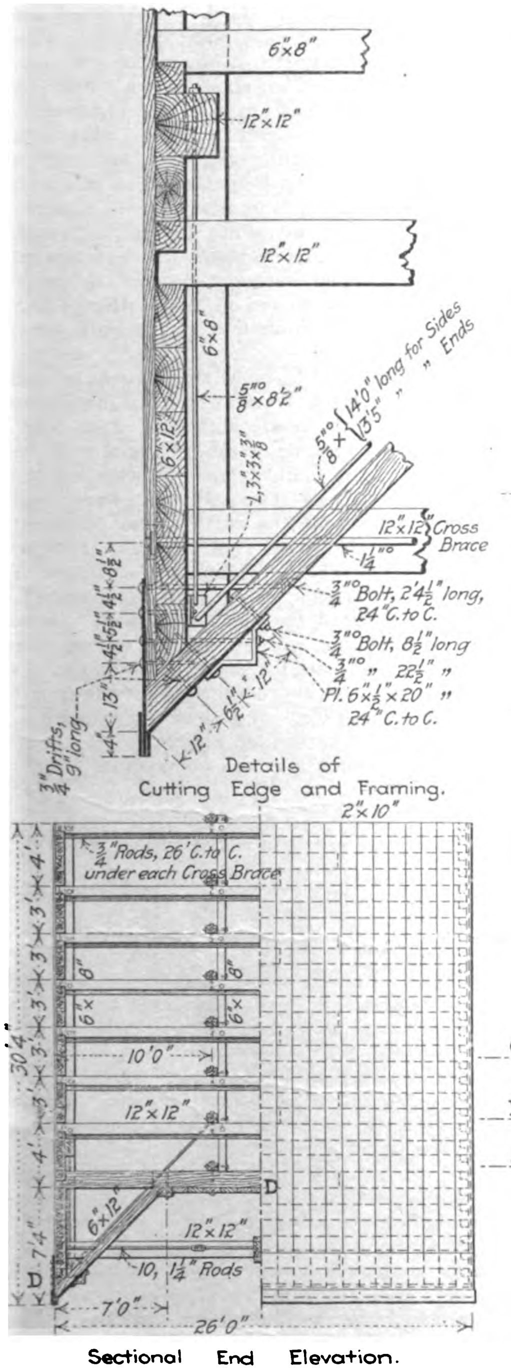
FIG. 4. PLAN OF THE TRIANGULATION SYSTEM FOR LOCATING THE PIERS OF THE McKINLEY BRIDGE.

TABLE II.—CAISSONS AND FOUNDATIONS OF McKINLEY BRIDGE.

Pier.	Depth of water at L. W., ft.	Caisson, outside dimensions, ft.	Height of caisson and crib.		Relation of weight to penetration: Wt. per sq. ft. of caisson surface exposed to friction.		Relation of weight to penetration: Depth of penetration, ft.	Sinkage in 24 hrs.,		Depth from L. W. to bottom of foundation, ft.
			ft.	ins.	lbs.	lbs.		Max., ft.	Ave., ft.	
1......	8	26 × 65	20	4	1,850 to	1,145	10 to 33	3.0	1.8	41.27
2......	18	28 × 70	24	4	3,056 to	1,142	10 to 33	3.0	1.0	47.72
3......	20	28 × 70	26	4	1,977 to	956	10 to 34	4.0	1.6	50.90
4......	21	26 × 65	30	4	1,725 to	896	10 to 36	4.3	2.1	52.87
C......	3	18 × 42	36	4	1,447 to	323	10 to 39	7.3	2.5	39.90
D......Land		18 × 42	66	4	992 to	498	10 to 70	7.7	4.1	54.00

to the adjoining courses by ⅞-in. drift bolts 2 ft. 8 ins. long, spaced 5 ft. in every course. The walls of the cribs in the higher caissons were reinforced by 4 × 8-in. diagonals between the posts.

Posts 6x8 ins. were provided at panel points in the walls and intersection points of the struts.



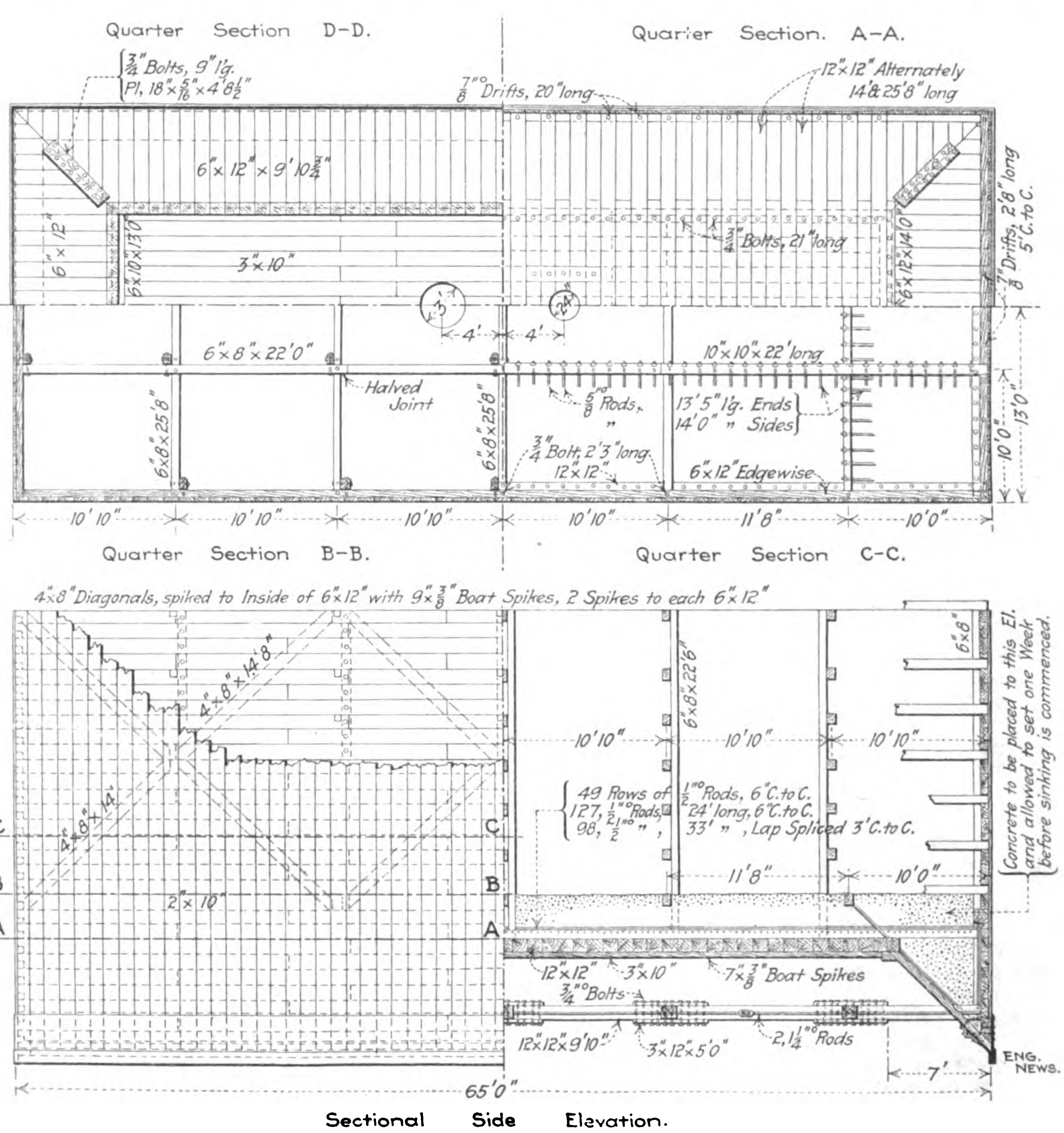


FIG. 5. TIMBER AND CONCRETE CAISSON FOR PIER NO. 4.

The wall posts were beveled at the bottom where they encountered the inclined roof timbers, while the posts at intersections of struts extended to the horizontal roof timbers. These posts were bolted to the longitudinal struts, which in turn were bolted to the cross struts at intersections. A ¾-in. tension rod was supplied under each cross brace to overcome any tendency to distortion during launching and to counteract any excess of pressure due to fresh concrete. The walls were sheeted with 2x12-in. friction plank laid vertically and thoroughly calked.

The working chamber was made 7 ft. high, with side and end roof timbers sloping at 45°. The main part of the roof was composed of a single course of 12x12-in. cross timbers laid horizontally, and covered with concrete. Each alternate timber extended to the side walls, where it was framed in with halved joints. The intermediate timbers extended a sufficient distance from the center to form butting surfaces for the upper ends of the inclined roof timbers, which were composed of 6x12-in. timbers laid flat. The inclined roof timbers in the corners were necessarily of varying lengths and their upper ends were secured against upward pressure by bent plates bolted on the outside of the roof.

The inclined roof timbers extended to the outside of the sheeting, the lower wall timbers being framed to fit the angle (45°) forming the apex or cutting edge. This edge was fitted with a shoe of ⅝-in. plate. It consisted of two outside plates 33 ins. and 8 ins. wide, riveted at the bottom to a bent plate 3 ft. wide extending up the under side of the inclined roof timbers. The riveted portion of these three plates extending below the timber formed the bottom of the cutting edge, which was 4 ins. high and 1⅛ ins. wide. These plates were spliced at the centers of the sides of the caisson and reinforced at the corners with ⅝-in. plates. The shoe was fastened to the caisson timber by drift bolts at the bottom, and secured at the top by ¾-in. bolts 2 ft. apart extending through the wall and inclined roof.

On account of the liability of buckling of the cutting edge due to the small area at the bottom, it was necessary to provide lugs upon which to distribute the weight of the caisson and pier during construction. These are ½-in. steel plates 6 × 20 ins. spaced 2 ft. apart and bent so as to form horizontal bearing areas of 36 sq. ins. about 16 ins. above the cutting edge. They were drift bolted to the inclined roof timbers at the bottom and bolted at the top, the center being fastened by bolts extending through the wall, sheeting and outside plate. These are shown on the enlarged detail in Fig. 5.

As a further precaution against distortion of the cutting edge, the concrete in the V-shaped portion of the caisson was reinforced by two rows of ⅝-in. round steel rods spaced about 1 ft. apart. One row was placed vertically 2 ins. from the wall timbers and the other the same distance from the inclined roof timbers, the object being to take up the tension to which the concrete would be subjected by distorting strains in either direction. Lug angles bolted to the wall in the apex of the V-shaped part of the caisson were used to hold the lower hooked ends of the rods in position while concrete was being deposited. The upper threaded ends of the vertical rods were held in position by being extended through projecting wall timbers in the second course above the roof, while the upper ends of the inclined rods were bolted to stay rod supports in the third and fourth courses.

The walls of the chamber were reinforced by one longitudinal brace and five cross braces, (all 12x12 ins.), which extended through the inclined roof timbers and butted against the walls between the second and third courses above the cutting edge. On either side of each brace a 1¼-in. round steel rod extended through the caisson, the washers at the ends being countersunk in the wall timbers. These rods were provided with turnbuckles by which they were adjusted to give sufficient tension to prevent the distortion of the walls. The ceiling of the chamber was planked with 3 x 12-in. sheeting laid longitudinally and 6 x 10-in. waling timbers were provided in the angle of the roof, these timbers being beveled to receive the upper ends of the inclined roof timbers. The entire inner surface of the chamber was thoroughly calked with oakum and all joints in the iron plates were coated with asphaltic cement to prevent leakage of air through the walls.

The roof or deck consisted of the single course of 12 x 12-in. timbers and a covering of reinforced concrete. The steel reinforcement for the latter consisted of two layers of ½-in. round steel rods placed longitudinally and transversely from wall to wall. The rods were spaced 6 ins. c. to c. and the layers were placed as close to the deck and as close to each other as good bonding would allow.

The above description applies in general to the caissons for Piers 1, 2 and 4. On account of the assumed greater depth of water at Pier 3 the caisson for that pier was made considerably heavier than the others. The walls and posts were made of 12 x 12-in. timbers, and the cross and longitudinal braces were similar timbers framed into the walls with dovetailed joints. The tension rods in the cribs were omitted, while the splicing of the struts and the details in general were made stronger than in the other caissons.

The construction of caissons for Piers C and D was similar to that for Piers 1, 2 and 4, except as to walls and bracing. The solid wall in the caisson for Pier C extended 24 ft. 4 ins. above the cutting edge, the remaining 12 ft. of the wall of crib being composed of 2 x 12-in. sheeting on 6 x 12-in. timbers supported by 6 x 6 in. stay blocks at 4 ft. vertical intervals. Toe braces of 6 x 8-in. timbers were supplied in the end panels. The solid wall in the caisson for Pier D extended 11 ft. 10 ins. above the cutting edge; the remaining 54 ft. 6 ins. of the wall and the bracing, etc., were similar to that for Pier C.

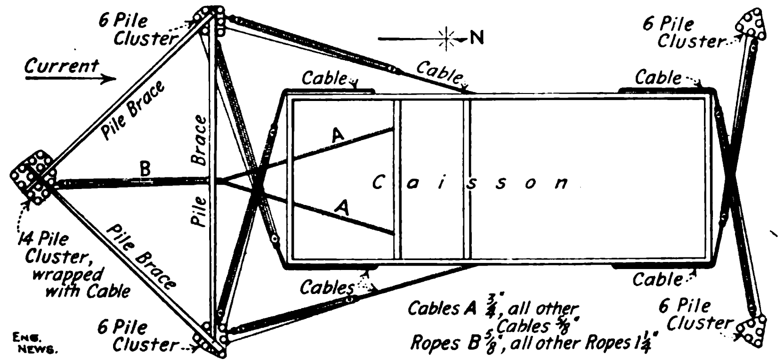


FIG. 6. ARRANGEMENT OF PILE CLUSTERS AND MOORING CABLES FOR SETTING THE CAISSONS IN POSITION.

Timber and Concrete Caissons.

The type of caisson originally intended for this bridge was of timber, similar to that used on the Thebes Bridge, but the type actually used was designed by the Missouri Valley Bridge & Iron Co., the contractor for the substructure. This design was modified by the engineer only in the case of the caisson for Pier 3.

This style of caisson differs from the ordinary timber caisson chiefly in the use of reinforced concrete in the place of timber in the construction of the walls and roof. The timber roof was designed to support only a few feet of fresh concrete and this safe depth was the limit set for concreting until an interval of one week had elapsed. Further increments of weight were then supported by the reinforced-concrete deck, the transverse reinforcement being made sufficient to increase the strength of the roof to an amount necessary to bring the angle of loading to 60° and to develop a constant working stress in the steel rods for all increased loading.

The longitudinal reinforcement was made sufficient to prevent distortion in a horizontal plane, and to distribute the weight. In the actual conduct of the work it was not found necessary to delay construction for setting of the concrete when the safe load had been placed on the timber deck, as the conditions of support of the cutting edge for which the caisson was designed were encountered only at Pier D. There the roof was made comparatively much stronger than in the larger caissons, and, therefore, work was carried on continuously as in the others. This caisson was designed for construction at the site of the pier, and the roof was not designed to resist upward pressure. It became necessary, therefore, to concrete the V-shaped portion of the caisson before launching in order to prevent the displacement of the roof timbers at the waling and the dislodgement of calking by the pressure of the confined air during launching.

The economy in the use of this type of caisson lies in the saving of timber and the time and labor of framing. The ratio of timber volume to total volume of a timber caisson 28 x 76 x 20 ft. was 37.5%, and the same percentage for a caisson of reinforced-concrete construction 28 x 70 x 24 ft. was 13.2%. For caissons of comparatively equal size this represents a saving of 64.8% of the timber volume, and a substantial cost reduction varying with the relative prices of timber and concrete construction. The iron cutting edge of this caisson has an advantage over the wooden one in that it sinks more readily and its form is such that it is more easily reached in excavating. Its chief disadvantage is in its comparatively small bearing area, which necessitates the use of bearing blocks for uniform distribution of the weight to prevent buckling during construction.

Launching and Placing the Caissons.

Each caisson was built on shoes or butterboards bolted to launching ways which were supported on pile foundations with a slope of 1¾ ins. per ft. These shoes consisted of timbers extending the full width of the caisson, resting on caps upon which they slid during launching. They were spaced about 6 ft. apart and were bolted to the caps on the land side of the caisson. The launching was started by sawing the shoes simultaneously below these bolts and thus allowing the caisson to ride to the water. The launching ways were extended into the water a sufficient distance to allow an immersion of about 10 ft. In order to reduce the required depth for immersion the caisson was only partially constructed preliminary to launching. The timber work was completed as required for concrete construction in order to reduce the cost of handling the material.

Before the caisson was launched, the warp of the cutting edge was determined by levels to the four corners and its plane was established through three of these points. Benches with known equations to this plane were placed at the corners above the depth of immersion and perpendiculars to the plane at the centers of the sides and ends of the caisson were extended by striking equal arcs of circles from the established corners. By this means the position of the cutting edge could always be determined, irrespective of the irregularities in timber construction.

Four pile clusters were located by triangulation and driven near the proposed site of the pier. The largest cluster, usually consisting of about 14 piles, was driven at a point on center line of pier about 35 ft. north of the north end of the caisson, and a smaller cluster was driven at a point about 15 ft. northeast of the northeast corner. The other two small clusters were located at corresponding points off the northwest and southwest corners. All clusters were bound with cable, and those to the north were braced together at the top by piling placed horizontally, forming a triangular support between the clusters. After the caisson was towed to position, a fifth cluster was driven off the southeast corner. Fig. 6 shows the arrangement of the pile clusters and mooring lines.

It was necessary to moor the caisson in such a manner as to allow freedom of movement and at the same time to secure stability. This was accomplished by the use of cables rigged with block and tackle. The main cable was attached to the large cluster, and two strands were passed through the end of the caisson and fastened at each side to one of the roof timbers. This main cable, and two cables which passed direct from the small north clusters through the sides of the caisson, were used for south movement. A cable from each of the corner clusters passed across the caisson and was fastened to the opposite side about 10 ft. from the corner. These four cables were used for lateral and skew adjustment.

The caisson was located approximately in position before concreting was commenced, but was not located accurately until after the cutting edge struck the river bed. An excess weight of about 100 tons was then added and air pressure applied sufficient to raise the cutting edge free from the river bed while the caisson was being located. Locations were made usually by simultaneous observations from opposite ends of the same base line. Small platforms were built at the ends of the caisson upon which the observers

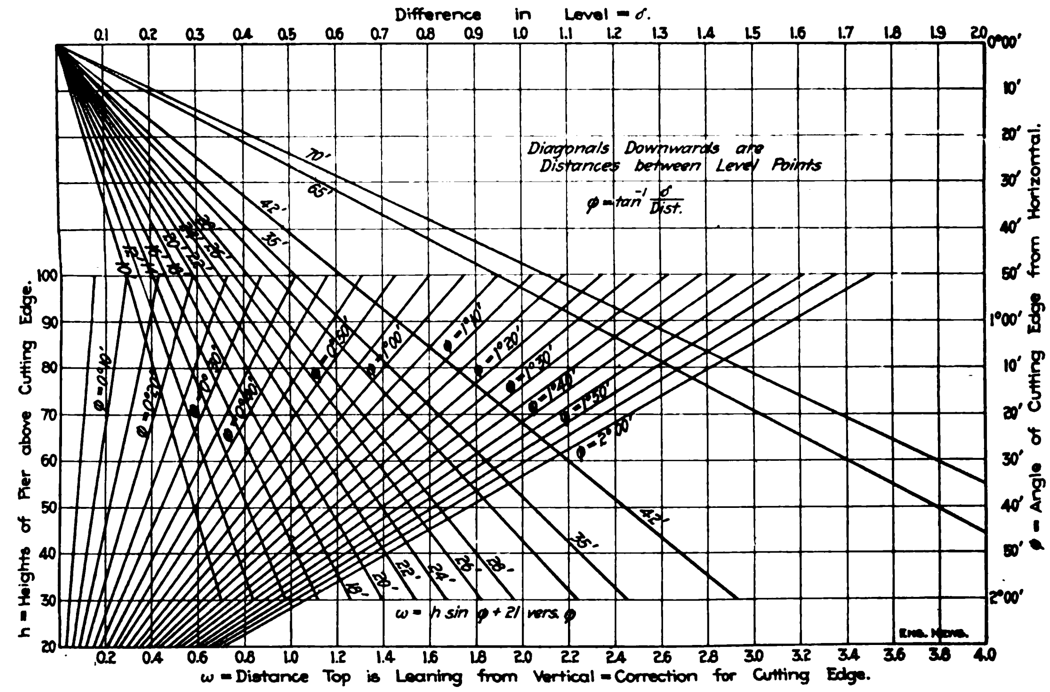


FIG. 7. DIAGRAM FOR SINKING THE CAISSONS.

located the exact points. A comparison of these located points with the corresponding points on the cutting edge referred to the elevation of the observed points readily denoted the movement necessary to bring the caisson to its correct position. The required movement was made by the use of the cables above mentioned and the operations of location, comparison and movement were repeated until the correct position was obtained. Then the air pressure was gradually released and the caisson allowed to settle in the mud.

Excavation was begun as soon as possible after the location was made in order to prevent possible distortion of the chamber struts and to make the position more secure by the penetration of the cutting edge. The mooring cables were removed as soon as this penetration was sufficient to render the caisson safe from disturbance by the direct effects of the current. Difficulty was experienced in preventing the caisson from moving against the current during early sinking on account of the comparatively short length of the cables, and this is probably the only point in which this method of location is inferior to that in which long cables and anchors are used. As sinking proceeded it was necessary to determine the position of the pier each day when atmospheric conditions permitted. This consisted in determining the levels of the cutting edge by means of the established points on the caisson previously described (or to points transferred to the shoulder points of the pier as construction required) and simultaneous readings for position by observations from the base lines.

The point observed was on the bridge tangent at a measured distance from the center of the pier as constructed. This bridge tangent was thrown across the pier for the determination of north and south position and skew. Usually but one transit was used, the observer establishing the bridge tangent and then determining the angle by the repeating method from a base line hub. The hub selected depended upon the distance of the pier from the base line and the resulting value of the observed angle. Any movement of the pier between these transit and level observations was noted by the levelman, who then signaled for the repetition of observations.

In order to facilitate the field computations a diagram (Fig. 7) was made for determining the corrections to observations for level position. The upper part of the diagram consisted of a group of lines constructed on the following formula

$$\phi = \tan^{-1}\frac{S}{D}$$

where S is the difference in level and D is the distance between observed points. The lower part of the diagram was constructed on the formula $M = h \sin \phi + 21 \text{ vers. } \phi$. Here M is the correction, h is the height of the observed point from the plane of the cutting edge, and ϕ is the angle of lean determined from the upper part of the diagram. The second term of the equation depends upon the distance between the observed points, and as this was a variable for each caisson and for each masonry observation the number 21 was introduced as an average quantity so that the diagram could be used for any observation. This assumption involved a maximum error of ⅜-in. for the limiting value of ϕ on the diagram. When ϕ exceeded 2° in value the correction was figured for actual conditions.

Sinking the Caissons.

The forces considered in the sinking of the caisson were the weights of the water, the air, water and sand pressures, skin friction, and current with its counteracting effect of eddies. The magnitude of these forces could be definitely determined, with the exception of sand pressures and skin friction.

Ordinarily the effect of the current as a direct disturbing force is negligible, but as an agent of erosion and deposition it becomes a factor of much importance, nullifying entirely its own direct force by the counteracting effects which it produces. This is especially true in the case of a rising river, for the energy of a rapid current impinging on the end of a caisson is expended in scour and consequent reduction of sand pressure. The sand thus removed by erosion is carried in suspension to the sides and opposite end of the caisson, the greater part being deposited at the downstream end where the eddies are produced. The resultant effect of the current, therefore, is to create a tendency to movement opposite or at right angles to the direction of flow and its magnitude depends upon the rate of flow and is equal to the resultant sand pressure.

Daily soundings were taken during the entire period of sinking in order to guard against undermining of the cutting edge and possible loss of the pier by displacement or overturning. Exposure on the cutting edge was especially guarded against during a high and rising stage of the river, for rapid sinking was then required to prevent the erosion from following the cutting edge down and exposing the caisson to the direct force of the current, when displacement was almost certain to follow if the lateral sand pressures were unequal. During a falling stage of the river this danger was not so imminent, on account of deposition.

The value of skin friction for starting purposes was found to range from about 300 lbs. per sq. ft. for 40 ft. depth to about 600 lbs. per sq. ft. for 70 ft. depth of penetration. As the magnitude of frictional resistance increases with repose it is probable that these values should be reduced about 50% for sinking purposes. The average weights per sq. ft. of surface exposed to friction for penetration exceeding 10 ft. for the different piers are given in Table II. On account of the weights made necessary to facilitate construction it was impossible to determine actual frictional values except in those cases where the ratios of net weights to exposed surfaces were not excessive.

The greatest difficulties in sinking were at Pier 2, as described later. The sinking of the caisson for Pier 3 in the fall of 1907 was delayed by floating ice, and the pier had to be abandoned when the chamber was about half filled with concrete. The shafts were capped and an ice flow broke off a section of the material shaft, allowing the chamber to be filled. This necessitated the removal of the mud and thorough cleaning of the concrete before sealing was resumed.

The caisson for Pier D was located 6 ins. east of its proper position, with the expectation that there would be a westward movement due to the pressure of the bank on the east. But the cutting edge actually moved 7½ ins. further east, in opposition to the lean. The water was about 13 ft. below the surface of the ground when sinking was begun and this condition was taken advantage of by ditching the caisson for that depth. This pier was submerged the day that sealing was completed.

The caisson for Pier C was carried away by drift soon after it was moored in position, but it was captured without damage above the Eads Bridge. It was necessary to sink this caisson to bed-rock before the shaft of the pier was located, and the cofferdam was flooded in order to provide sufficient weight for sinking. When an endeavor was made to unwater the cofferdam it was found impossible to do this on account of an opening between the caisson and cofferdam, which was caused by the friction of the sand on the walls of the cofferdam. Concrete was, therefore, deposited in a narrow space between the inside wall of the cofferdam and the outside of the pier, thus forming a concrete cofferdam which was unwatered without difficulty as soon as the concrete had set.

With the exception of the cases above mentioned there was no particular difficulty encountered in the sinking of the six caissons. Table III. shows the maximum variations of the positions of the various caissons from the true positions, the figures referring to the center of the pier in each case:

TABLE III.—VARIATIONS IN POSITIONS OF CAISSONS.

Pier.	Displacement in ft. N.	S.	E.	W.	Total variations in ft. N. & S.	E. & W.
1......	0.22	0.04	0.21	0.16	0.26	0.37
2......	0.80	0.40	1.25	0.70	1.20	1.95
3......	0.00	0.27	0.02	0.28	0.27	0.30
4......	0.43	0.08	0.58	0.46	0.51	1.04
C......	0.14	0.05	0.32	0.00	0.19	0.32
D......	0.17	0.16	1.10	....	0.33	0.64

Pressure and movement curves prepared from daily records gave the approximate conditions existing during sinking, and Fig. 8 shows these curves for Pier 1. An exact record of the variations in movement and position would, of course, be impracticable (if not impossible) on account of the frequent changes in level. The records show that with favorable conditions of penetration and weight the movement of the caisson can be controlled without difficulty. But the movement, especially in sand, does not always follow the law of lean, frequently working directly opposite to that law. The records also show that the general tendency of movement is opposite to the direction of flow, on account of the invariable excess of sand pressure on the downstream surface of the caisson. Fig. 9 is the record of sinking at Pier 1.

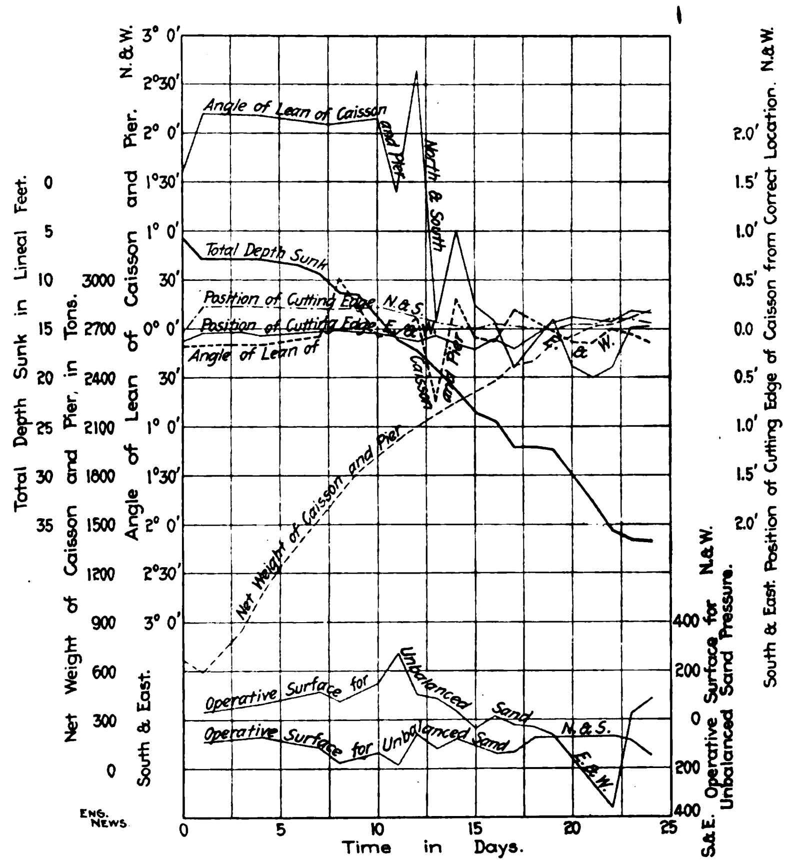


FIG. 8. PRESSURE AND MOVEMENT CURVES OF THE CAISSON AT PIER NO. 1.

Sinking was done in all cases by means of the wet or dry blow, the latter being used only under low air pressures. There were two discharge pipes and one spoil shaft for each caisson, the latter being used only for excavation in boulders and for the handling of the shoring timbers and riprap. The excavated material was practically uniform throughout, consisting mainly of coarse sand, quicksand, gravel and boulders. Loess and wood were also encountered in the shore piers. Two forms of clay hoist were used (Fig. 10). In one, the bucket was hoisted through the top and swung clear of the pier before dumping. In the other the bucket remained in the hoist and its contents were dumped through a side door on to a sloping platform from which they were shoveled into the river. Fig. 10 shows the arrangement of the plant for the pneumatic sinking work.

The rate of sinking varied with the size of caisson, depth of water, temperature of air, character of excavated material, number of pressure men employed, and rate of masonry or caisson construction. The average rate for all the piers approximated 2 ft. in 24 hours, and the maximum rate was 7.7 ft. in 24 hrs. In Table II are given the maximum and average rates of sinking, the average rate being obtained by dividing the total sinkage under air pressure by the actual number of days during which sinking was in progress. The number of hours work per day was regulated

The sand blow was then used in the downstream end to bring the caisson to a level position and sinking was carried on as rapidly as the construction of the masonry work would allow. After sinking about 8 ft. the water rose so rapidly that the masonry work could not be kept in advance of it and the chamber was filled with sand while cofferdam and masonry work was rushed. The increasing pressure on the cofferdam required the addition of toe braces to support the upstream wall, and the lower portions of the cofferdam were flooded as soon as possible after the masonry work was constructed in order to balance the water pressure.

When an apparently safe leeway had been obtained for sinking, the chamber was cleared and shoring was placed to correct the skew, which

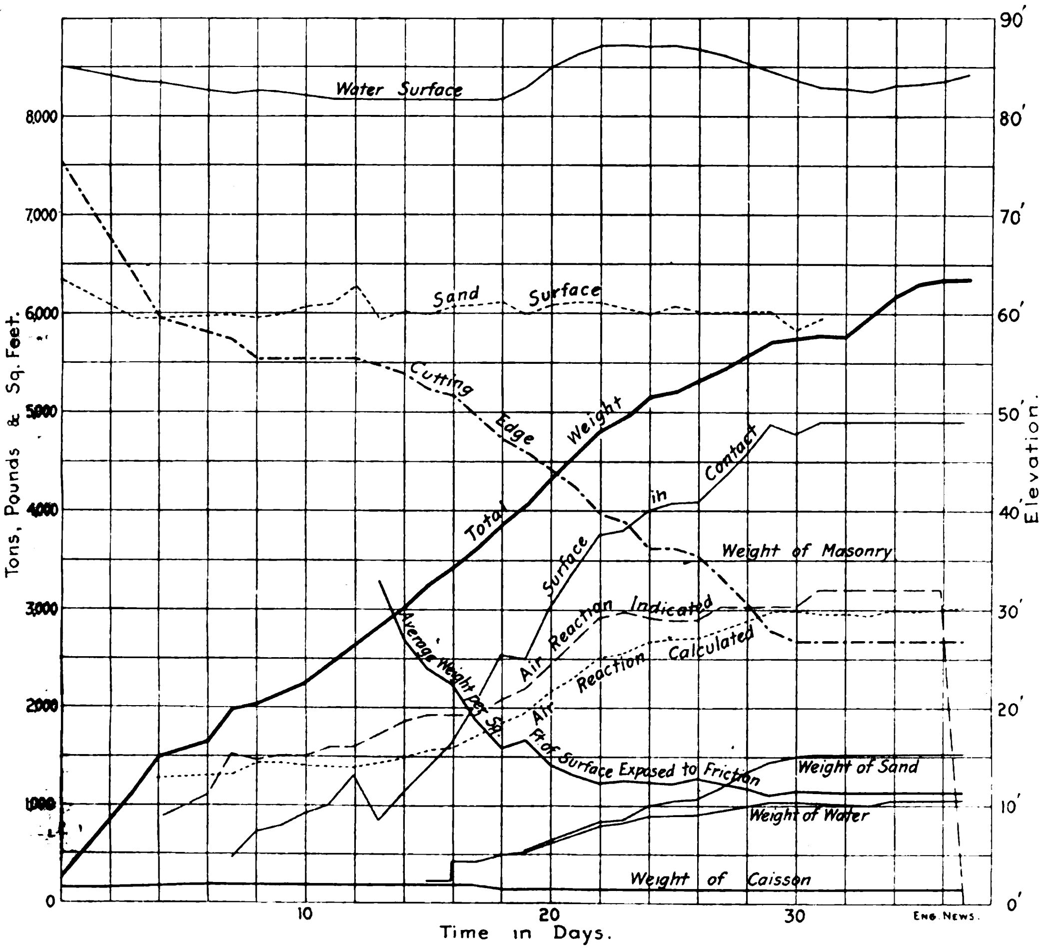


FIG. 9. DIAGRAM OF RECORD OF SINKING THE CAISSON AT PIER NO. 1.

according to the depth of immersion, the following scale being adhered to:

Immersion, ft.	Hours, No.	Shifts, No.	Immersion, ft.	Hours, No.	Shifts, No.
0—50	8	..	60—70	4	2
50—60	6	2	70—80	2	2

Difficulties in Sinking the Caisson for Pier No. 2.

By far the most interesting sinking was that for Pier 2, where the construction was greatly interfered with by the high water of the summer of 1908. During the progress of sinking, the water rose 21 ft. and the surface velocity of the current increased from 4 ft. per sec. (2.7 mi. per hr.) to 8.8 ft. per sec. (6 mi. per hr.), and this velocity was greatly increased in the immediate vicinity of the pier.

Considerable scour was anticipated and sacks of gravel were thrown in above the caisson before it reached the river bed. As soon as the cutting edge neared the bottom the scour increased rapidly and the sand was piled up by the current in the downstream end, causing the caisson to land on that end first. Launching timbers which had not become disengaged also held up the downstream end and served as a pivot for a skew movement of the caisson. As soon as air was applied these timbers were cut up and removed and the sand which had piled up to the beams in the downstream end of the chamber was sacked and carried to the opposite end for protection of the cutting edge against undermining.

had increased to 7½ ins. in 70 ft. This skew was entirely corrected in a drop of 3 ft. against an average penetration of from 3 ft. to 5 ft., the net weight moved being from 1,300 to 1,400 tons.

Considerable scour was then observed to the east and the caisson was given an inclination to overcome the tendency to move in that direction, but the easterly movement was rapid, averaging nearly 3 ins. per day for six days during a total sinkage of 10 ft. The maximum movement was 5 ins. in 24 hrs., which occurred at two different times within the six days eastward and northward movement. The eastward displacement was finally arrested by a lean of 2° 38′.

On account of the continued rise in the water, sinking was discontinued and it was not resumed for 8 days, during which time undermining of the cutting edge was prevented by placing sacks of gravel in the chamber and outside of the upstream wall of the caisson. Watchmen were kept constantly in the chamber with a supply of gravel in sacks to replace that drawn out by the force of the current. Sinking was again resumed after building up the masonry, but the gravel which had been deposited outside of the caisson did not seem to protect it from scour. The rate of sinking was not great enough to prevent the scour from following the cutting edge, and after sinking a few feet the chamber was filled with sand to the beams and all attention was given to proper protection of the pier from greater displacement.

The height of the pier had reached 69 ft., with little or no penetration on the upstream end, on account of the gravel which was intended for protection having been carried away by the current. An attempt was made to lower sacks of gravel by means of a clamshell bucket, but this was attended with little success and with great danger of losing the bucket.

Finally the following method was used: Five sections of supply shaft, 2 ft. diameter, were bolted together to form a chute which was suspended from a derrick boom by cables which passed through bolt holes in the flanges of the shaft. Cables fastened to the lower end of the shaft and passing beneath barges moored beside the pier formed a means for controlling the location of the discharge. By this method riprap was placed exactly in the desired position in depths of water exceeding 60 ft. and in a current exceeding 6 mi. per hr.

Accurate soundings were taken through this shaft and the riprapping was continued until a penetration of from 20 to 23 ft. had been obtained. The pier remained in this condition until the flood had abated, the water rising to within 0.1 ft. of the top of the masonry before starting to fall.

Air pressure was then taken off until sufficient leeway for sinking had been obtained, and the caisson was given a heavy lean to the north to correct the north displacement. Shores with a batter of 1 in 12 were placed in the north end of the chamber to correct the skew of about 16 ins. to the northeast. A dredge was employed to reduce the pressure on the west side of the pier, in addition to the usual method of decreasing the pressure by pulling in from the chamber.

The shores used were timbers 12 x 12, 10 x 10 and 8 x 8 ins., resting on timber grillages, but considerable difficulty was experienced in preparing suitable bases below the cutting edge on account of the interference by water. The entire northern half of the chamber was filled with these struts set on a batter in the direction of the desired movement. The net weight of the pier during this work was 3,750 tons and the penetration was from 25 to 15 ft.

Probably on account of the excessive weight and penetration the results were unsatisfactory in the correction of skew. As a result of a heavy lean of 3° 36′ the north displacement was corrected an amount of 3½ ins. and a lean to the east improved the east displacement by 6 ins. The remainder of the errors of position were corrected in the batter and level of the pier, and the skew of the belting and main coping courses.

Building the Pier Foundation.

Upon the completion of sinking, the bedrock was tested by means of drilling, and the surface was thoroughly cleaned preliminary to sealing. The latter operation was carried on by benching methods, the material being concrete (1:2½:5) and mortar. In order to obtain a compact body of concrete in the chamber the mixture was made dry and tamped in layers about 10 ins. thick. These layers were begun about 6 to 8 ft. wide at the cutting edge and they were worked up in benches gradually narrowing in width toward the top. A space of 4 ins. was left under the ceiling and struts; into these mortar was rammed as each strut was reached and as each bench was carried to the roof. On account of the rapidity with which the concrete set there was no difficulty in keeping the benches in good order.

The concrete was dumped from the bucket through a funnel into the upper section of the material shaft. The funnel was then removed, the upper section equalized and the concrete allowed to fall into the chamber, from which it was shoveled to the various benches. The clay hoist was also used for sealing, in which case the concrete was dumped from the bucket to a platform at the door of the hoist. From there it was shoveled on to the steel door at the roof of the chamber and the entire shaft was equalized for the final drop to the chamber. The former method was found to be the more satisfactory, as it economized air and did not require an extra handling of the concrete.

The final trench between the material and main shafts was filled by sacking in concrete and the main shaft was filled for several feet by the same method, the air being supplied by a reduced extension of the main air pipe from the chamber. Air pressure was then retained for 12 hours, after which the filling of the shafts and pipes was completed under atmospheric pressure.

The rate of sealing depended upon the same conditions as the rate of sinking and the results obtained are given in Table IV. For the greater

TABLE IV.—FILLING THE WORKING CHAMBERS.

Pier.	Depth immersed, ft.	Air pressure indicated, lbs.	Temperature outside, degs. F.	Yardage Total, cu. yds.	Yardage Per hour, cu. yds.
1......	56	26	77	297	3.1
2......	68	31	90	355	2.0
3......	53	25	54 & 88	355	2.4
4......	55	26	63	297	3.2
C......	51	28	79	110	3.4
D......	73	37	43	110	3.0

depths more time was lost in changing shifts than in other cases. An average of about one hour per day of each man's time was consumed in transfers through the lock and shaft. During warm weather, the air from the receiver was allowed to pass through immersed pipes before going to the chamber in order to regulate the caisson temperature. By means of a 1-in. ventilation pipe and an electric fan a good working temperature was maintained in nearly all cases. The temperatures given are the average maximum temperatures for the time during which sealing was in progress.

After sealing was completed, the sections of shaft extending above low water were removed where provision had been made for removal by boxing the shaft sections and the entire space was filled with concrete. Masonry work then continued at a more rapid rate owing to the noninterference of shafts, air and water pipes, etc.

Locations of the pier were determined every second or third course, and computations were simplified by the use of a table giving angles to the center of the pier for varying distances east or west of its correct position. The most advantageous baseline station was selected for observations on each pier, and the angles were usually figured for intervals of ¼-in. from 0 in. to 2 ins. in each direction. Where the variations exceeded this amount locations were determined more frequently and the position figured for each particular case.

After the shoulder points were established, offsets for striking the arcs were laid off by the foreman mason and inspector, who also trammeled the starling for error of position of nose point and error in radius of ends. Levels were transferred from benches established in the bedding joints for every second or third course as the work progressed. Small errors in position of the pier were corrected by varying the batter of each course the desired amount. In this manner each pier was completed in the required position at the desired elevation for the bearing of the superstructure.

Concrete Pile Foundations for the Approaches.

The approach foundations were placed in ground alternately wet and dry on account of the fluctuations in river stages, and concrete piling was used therefore in all cases. The piles are of the Chenoweth type, and a plant was installed at the bridge site in St. Louis for their manufacture.* The piles were 14 to 15 ins. diameter in lengths of 25 ft., 20 ft., 16 ft. and 14 ft., capped and pointed with mortar. Their weight averaged about 170 lbs. per lin. ft. They were made of gravel concrete mixed dry in the proportions of 1:2:4, the pebbles ranging in size from ¼-in. to 1¼ ins. The points consisted of conical tips 12 ins. long and 8 ins. diameter at the small end, which were formed on the piles immediately after the rolling was completed. The caps were composed of mortar placed after rolling in order to true the driving head of the piles. The reinforcement consisted of five ⅝-in. round Johnson bars wired to two widths of wire netting (No. 19 wire, ½-in. mesh), 36 ins. wide. No. 17 binding wire was used during rolling to hold the pile in shape.

After seasoning for 30 days or more the piles were driven to an average penetration of ¼-in. by the use of a No. 2 steam hammer weighing 7,000 lbs. and having a 3,000-lb. drop operating through a drop of 2 ft. at an average rate of 70 blows per minute. A special cushion cap was provided to reduce the shattering effect of the blow, and a rope cushion was placed on the head of the pile for the same reason. The special cap consisted of a cylindrical steel shell with an oak bottom, rubber filling and a cypress driving head. After the pile had reached its full penetration below the surface of the ground the cap was placed on a follower which consisted of a cypress driving block fitted with a steel hood which engaged the head of the pile. By this means driving was continued from 4 ft. to 6 ft. below the surface, thus dispensing with preliminary excavation and greatly facilitating the movement of the pile driver.

More than 1,000 piles were driven in this manner without fracture and with as much ease and dispatch as ordinary wooden piles. The weight of the piles (170 lbs. per lin. ft.) increased the labor of handling in comparison with wooden piles, but on the other hand it reduced the difficulty of driving. The soil penetrated was variable in quality and consisted mostly of muck and filled ground near the surface, and silt, sand and clay at greater depths.

*Engineering News, May 20, 1909.

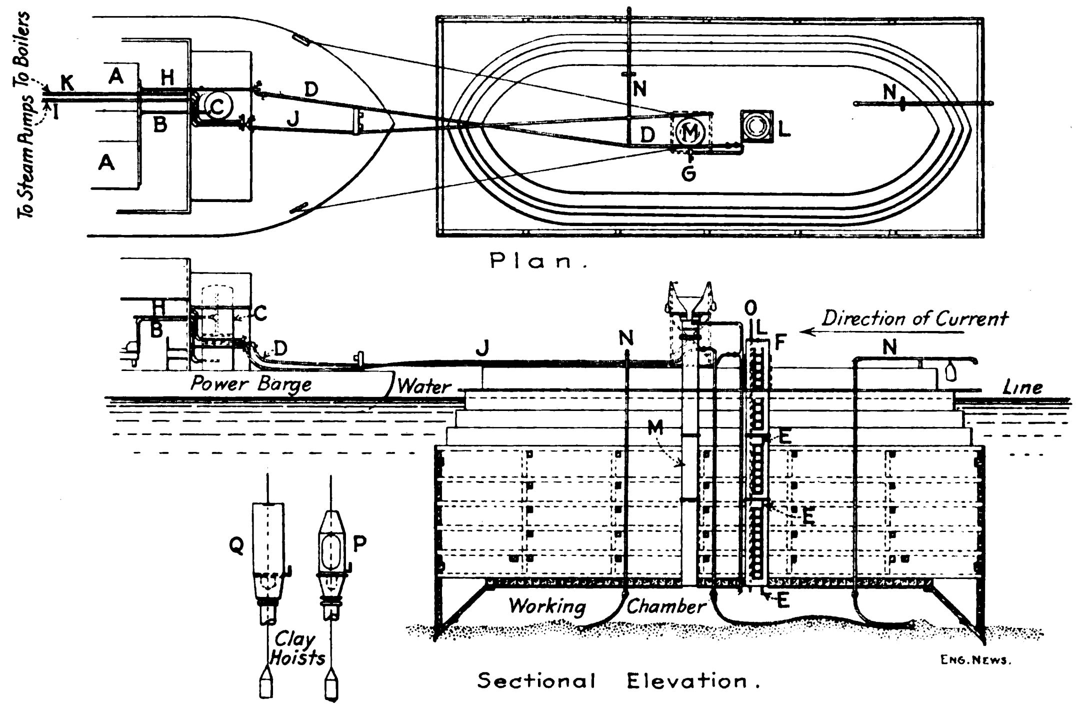


FIG. 10. ARRANGEMENT OF THE CONSTRUCTION PLANT FOR SINKING THE CAISSONS.

A. Air Compressor.
B. Air Delivery Pipe.
C. Air Receiver (48-in.).
D. Air Hose (3-in.).
E. Air Pressure Equalizer Valve (¾-in.).
F. Air Atmospheric Equalizer Valve (2-in.).
G. Air Exhaust.
H. Air Emergency Pipe (4-in.).
I. Water Pipe (3-in.).
J. Water Hose (3-in.).
K. Steam Pipe (2-in.).
L. Main Shaft (36-in.).
M. Material Shaft (24-in.).
N. Sand Blow Pipe (4-in.).
O. Ventilation Pipe (1-in.).
P. and Q. Clay Hoists.

Pedestal Blocks.

The approaches have 41-ft. spans with four columns to each bent; two for the railway and two for the roadway supports. Five concrete piles were used for each railway pedestal and one for each roadway pedestal (12 to each bent). Each pedestal has two foundation blocks 2 ft. thick, the lower one octagonal and the upper one hexagonal. These blocks support a conical frustum shaft, reinforced near the surface with ⅞-in. vertical and ½-in. horizontal square Johnson bars. Anchor bolts, 3 ft. to 4 ft. long were placed simultaneously with the concrete, and adjustment was provided for erection by encasing the bolts in pipes which extended 1 ft. below the surface of the concrete.

The tops of the pedestals are at such an elevation as to keep the steel work above high water.

Construction Plant.

The contractor's yards were located on a strip of ground above ordinary high water, about 600 ft. east of the inner harbor line, near the bridge approach in Venice. An incline trestle was constructed from this point to the river for delivery of material to barges. All of the timber and stone and part of the cement was handled in this manner. The cement was stored in a warehouse near the incline trestle and also in a storehouse at the west end of the Merchants' Bridge. The sand was dredged from the river near the bridge site, and the gravel was shipped by rail from the Meramec River to St. Louis, where it was loaded on barges for delivery at the site. All handling of material in the yards was done with a 10-ton derrick car, and the transfer of material at the river was done with derrick barges. Cement was shot down in a chute from the trestle to barges.

The fleet engaged in the construction consisted of a pressure barge, pile-driver barge, three derrick barges, two concrete barges, four material barges, one cement barge, two coal barges, one signal lighter and one tug. The pressure barge was a model barge 28 × 155 ft., 6½ ft. deep. It was equipped with three marine boilers with a combined capacity of 180 HP.; these were fed by a feed pump, an injector, and an inspirator, the latter being used in case of accident to the feed pump or feed water heater. The boilers supplied steam to two air compressors 10 × 13½ × 14 ins. which delivered compressed air to a receiver from which it was piped to the caissons. Air pipes were also laid for direct delivery in case of an emergency. A steam pump 8 × 5 × 10 ins. supplied water for the wet blow during sinking, and a steam pump 7½ × 5 × 6 ins. furnished water for cooling the air cylinders of the compressors and for mixing the concrete. A 5-HP. high-speed engine and generator operated a 110-volt circuit which furnished lights for the working chamber. A 9-HP. marine engine and a generator operated a circuit for the exterior lights. Quarters for the pressure men were provided in the stern of this barge.

The pile driver barge, 18 × 64 ft., was equipped with a hoisting engine 7¼ × 10 ins. and a 2,400-lb. drop hammer. This barge was used for driving the piles for launching ways, caisson moorings and fleet protection. The derrick barges were from 26 × 63 ft. to 42 × 83 ft., the depths being from 50 to 60 ins. For early construction one barge was equipped with a 66-ft. boom and 27-ft. mast, a second with a 54-ft. boom and 32-ft. mast, and a third with a 64-ft. boom and 40-ft. mast. Booms and masts were 12 × 12 ins., and the stiff-legs 10 × 10 ins. For later construction, the derrick of the second barge was raised on framed bents a distance of 30 ft. above the deck, and the third barge was equipped as a high derrick with a 66-ft. mast and 80-ft. boom, the boom seat being elevated 22 ft. above the deck The mast and boom were 18 ins. diameter and the back stay and stiff legs were 10 × 10 ins., with 3 × 12-in. cross bracing. The boom seat was supported on 12 x 12-in. posts and tied to the deck with 1¼-in. rods. The barge was 6 x 10 ins. high with a 3-in. deck, 6-in. walls and six 4-in. solid bulkheads. Engines with cylinders 7 x 12 ins. were used in operating the derricks. The concrete barge was 26 x 80 ft.

The cement house occupied an area 20 x 42 ft. and the remainder of the space was used for a concrete mixer, engine, and delivery platform. The cement house was 7 ft. high to the rafters, with a working capacity of 300 bbls. Material was taken in wheelbarrows to the mixer from material barges moored alongside. The concrete was dumped into a bucket set in a compartment in the hold of the barge and the bucket was raised by a derrick and dumped with a trip line. The material barges for sand and gravel were 30 x 80 ft., with bins 28 x 62 ft., 20 ins. deep, having a capacity of 135 cu. yds. A cement barge 26 x 64 ft. having a capacity of 1,125 bbls., was used to keep the concrete barges supplied. The material barges used for the transfer of cut stone were 24 x 60 ft. The signal lighter was a barge 12 x 38 ft., which marked submerged construction for the benefit of navigation.

The disposition of the fleet during caisson sinking was as follows: The power barge was moored on the downstream side of the caisson, the concrete derrick and mixer barge to the east, the material barges alongside, and the stone derrick and material barges to the west of the caisson and power barge. The fleet above described was used for the construction of Pier C and Piers 1 to 4. In the case of Pier D, a mixer was installed at the site of the pier and a stiff-leg 10-ton derrick was erected to handle the concrete. This derrick was equipped with a 30-ft. mast and 40-ft. boom. For Piers A, B, and E, the concrete was mixed on the concrete barge and delivered by derricks to tramways from which it was placed in the forms by means of stiff-leg derricks at the sites of the piers. The piling for these piers was driven by means of a drop hammer operated by the hoisting engine in leads suspended from the derrick boom.

The main substructure work comprised the handling of 1,000,000 ft. BM. of timber, 14,000 cu. yds. of excavated material, 7,000 cu. yds. of stone, and 15,000 cu. yds. of concrete. The timber includes that for permanent work, for the fleet and for temporary purposes. The substructure for the approaches required about 20,000 lin. ft. of concrete piling, 16,000 lin. ft. of wooden piling, and 4,000 cu. yds. of concrete. The concrete piling was driven by a hammer, as described above.

The concrete plant for the west approach had a concrete mixer mounted on wheels. The mixing platform was placed on the ground and the concrete was delivered to the forms by wheelbarrows running on inclined staging. A wheelbarrow elevator was used for high abutments. The concrete for the east approach was delivered in dump carts of 6 cu. ft. capacity operated on trestle work. This method was used for crossing a slough about 400 ft. wide.

The wooden piles were used in a pile trestle which crossed a slough about 650 ft. wide. These piles were driven by a drop hammer which operated in leads pivoted at the top and held in position by an A-frame. The lower end of the leads swung on a moon beam to accommodate driving on a batter. The engine platform was made of sufficient length to counterbalance the overhang necessary to span one panel length. Caps were placed in position as the driver was moved forward and the bents were held in place by temporary struts.

Contractors.

The Missouri Valley Bridge & Iron Co., of Leavenworth, Kan., has the contract for the entire work on the bridge proper, including foundations, substructure and superstructure. Mr. E. H. Connor, M. Am. Soc. C. E., is Vice-President and Chief Engineer of the company, and Mr. J. B. McMahon is its Superintendent on the work. The American Concrete Co., of Chicago, had the contract for the approach substructure, and gave the Myers Construction Co., of St. Louis, the subcontract for driving the concrete piles and constructing the timber trestle.

Street Lighting in the Business District of St. Louis.*

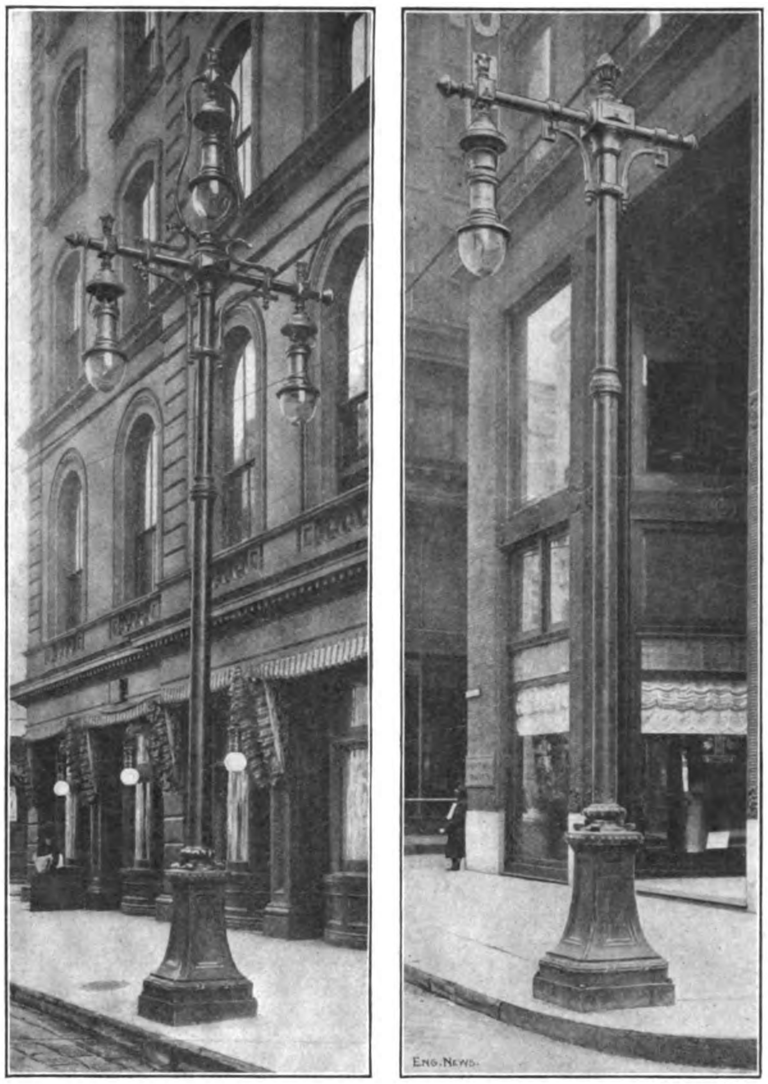
It was long realized by merchants and property owners in St. Louis, that a new street-lighting system was badly needed in the business district and it was finally agreed, among the parties most affected, that definite steps for a change should be taken. The work of arousing sentiment in favor of a new lighting system in the business district and of carrying the project to successful completion was placed in the hands of the officers of a voluntary organization, composed of merchants and property owners within the business district, known as the Down Town Lighting Association. This organization began work early in 1909. Committees were appointed to make a thorough investigation of all existing forms of street illumination, and to ascertain what system was best adapted to the local conditions. After eight months it was decided to install the latest type of magnetite arc lamps. Therefore a committee was appointed to secure the design of suitable lamp standards, which could be made and erected at a moderate cost but which would be more dignified and ornamental than the unsightly old fixtures with their overhead service connections.

These several matters having been settled, the plans were approved and adopted by the municipal Board of Public Improvements and by the Union Electric Light & Power Co. The city assumed liability for the bulk of the maintenance charges and the company undertook the installation of the new system, including the wiring and lamps, at its own expense, the only part paid for by private parties being the new standards.

It was estimated that the cost of the standards would be $30,000. To obtain this sum an assessment of $1 per front foot was made on all property fronting on the streets to be lighted by the new system. The response showed the movement to be popular.

The district thus illuminated is bounded by Fourth St. on the east, Twelfth St. on the west, Washington Av. on the north, and by Market St. on the south, comprising a total of 48 square blocks.

Formerly there were in this district only 138 arc lamps of the old enclosed type, which had been installed ten years previous. Under the plan of the Down Town Lighting Association there will be 437, 6.8-amp. magnetite lamps. These are placed in a uniform manner on all the streets in the district, with the exception of Broadway. This street was not included in the general lighting scheme, but was left to the City Improvement Association, composed of property owners and merchants on Broadway. This association installed on this single street 240 4-amp. magnetite lamps, the maintenance of which is paid for by this association.



LAMP STANDARDS DESIGNED FOR THE BUSINESS STREETS OF ST. LOUIS.

The plan of the Down Town Lighting Association calls for four lamps at each street intersection, one on each corner and so arranged that two will line up with those on the north and south streets and two with those on the east and west streets. In addition, there are placed two lamps in the middle of the block, so arranged that they are approximately 80 ft. between centers. This gives a total of six lamps per block.

On Broadway the lamp standards are designed to carry three 4-amp. lamps; the standards are placed opposite each other on both sides of the street, and are at approximately 60-ft. centers. This gives a total of ten standards, or 30 arc lamps per block. This illumination is very brilliant, and has transformed the old dark Broadway into one of the most brilliantly lighted thoroughfares in America. When this work is completed there will be five miles of streets, brightly lighted by 667 lamps.

To furnish direct-current for the magnetite lamps the power company has installed three 75-lamp, 4-amp., and seven 75-lamp, 6.8-amp. mercury-arc rectifiers. It has also been necessary to increase the central-station capacity slightly.

The cost of the change, to the property owners in the district, exclusive of those on Broadway, was $30,000, and the installation on Broadway cost the City Improvement Association $10,000. The city having agreed to maintain all of the lights, excepting those on Broadway, the additional cost to it will be $30,000 per year, to be paid out of the general funds of the city. On Broadway, where the maintenance is borne by the merchants, the cost is approximately $9,000 per year. The cost of new equipment and of construction work assumed by the power company is estimated at $100,000.

The new system is permanent and will be in charge of Mr. Harry S. Sanderson, Supervisor of City Lighting.

*From information furnished by Mr. J. E. Tiedeman, Secretary of the Down Town Lighting Association, 124 North Fourth St., St. Louis.

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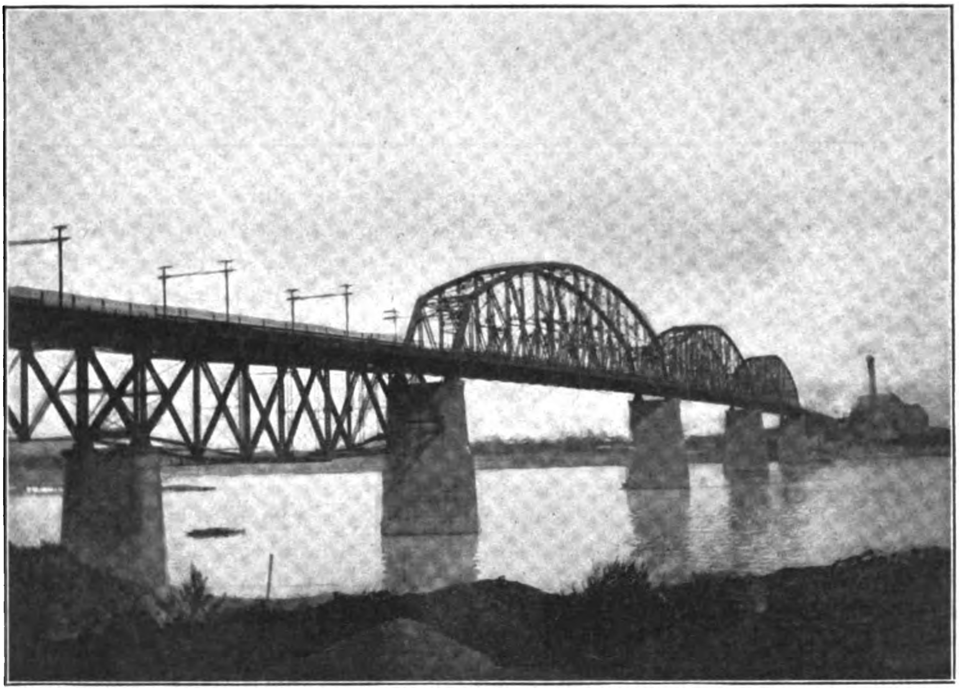


McKinley Bridge, November 3, 1910

The Building of the McKinley Bridge

Frank E. Washburn
Resident Engineer of the St. Louis Bridge Company

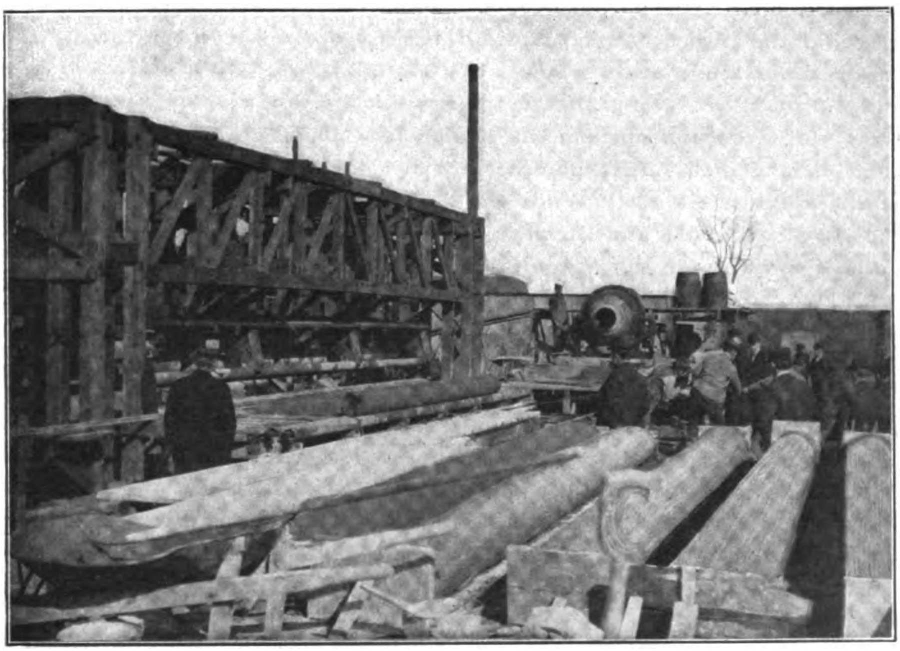
THE McKinley bridge, recently completed at St. Louis, is one of the largest bridges in the United States. It spans the Mississippi river between St. Louis, Mo., and Venice, Ill., deriving its name from Congressman William B. McKinley, president of the Illinois Traction Company, which owns and operates the bridge. It is the third bridge which has been built at St. Louis, the other two being the famous Eads bridge and the Merchants' bridge.

A vast amount of work is required in the building of such a structure; and the steps taken, from the inception to the completion of the McKinley bridge will be briefly described. In order to secure sufficient funds to carry the work to successful completion, financial arrangements were first made by the Illinois Traction Company. This required the presentation of the project before men of capital and the arousing of interest to an extent such that these men were satisfied with the prospects of the undertaking as a business proposition, and were willing to advance the necessary funds. A chief engineer was then appointed to take charge of the bridge work for the Illinois Traction Company and to assume entire responsibility for the successful completion of the structure. The engineer selected for this position was Mr. Ralph Modjeska, C.E., (son of the famous actress, Madame Modjeska). He appointed a resident engineer to take direct charge of the work. Preliminary surveys were then made to determine the first cost of construction, and borings taken to ascertain the best location of the bridge as regarded facility of operation. Borings were taken at the site of the main piers to determine the depth to bedrock and thus to arrive at an approximate estimate of the cost of the foundation work.

The locations of the main piers are determined by the location of the harbor lines, which are established by the U. S. War Department. The main channel is 1500 feet wide between outer harbor lines, and this distance was divided into three approximately equal parts, so that there were only two piers in the main channel. On either side of the main channel is a levee which extends between the inner and outer harbor lines a distance of 250 feet, and the shore piers were so placed as to span this levee. The U. S. Government therefore practically decides what the length of the spans of the main bridge shall be, and this is proper in order that the shipping interests shall be protected. The U. S. Government also fixes the clearance of the bridge from high water to the lowest point of the superstructure. In this case the clearance was fixed at 50 feet, a distance corresponding to that established for the Merchants' bridge. This clearance was considered necessary to allow steamboats to pass under the bridge at the high water stage. The difference between ordinary high and low water at St. Louis is about 38 feet. Low stages ordinarily occur in the winter season and high stages in the summer, so that it is always well to build piers in the fall, as the water recedes.

As soon as the location and height of the piers was decided upon, a set of specifications and plans was made which gave details regarding the extent and character of construction desired for the substructure. This information was given to contractors who desired to bid on the work; and upon the receipt of a satisfactory bid the contract was let and work was begun. In the meantime the design of the superstructure was being made, so that the steel would be on hand when the piers should have been completed. Upon completion of the design of the superstructure, bids for the fabrication of the steel and its shipment to the bridge site were received from steel companies; and the contract was let to the successful bidder. As soon as possible the contractor placed the orders for material with the steel mills, where the various plates and shapes which make up each member are rolled from hot ingots of steel. These plates and shapes were then shipped to the shops, where they were marked according to templates prepared from the detail plans, punched, assembled, reamed, riveted, planed, bored, etc., according to plans, until each member was complete. The chief engineer had inspectors to look after all details of this work as it proceeded at mills and shops, to see that satisfactory material and workmanship were obtained. Chemical and physical tests of the steel were made at the mills to determine its strength and character and thus insure its uniform good quality. This inspected steel was marked with heat numbers to enable the inspectors at the shops to identify it during fabrication. As carload after carload of fabricated material was completed, it was loaded and shipped to the bridge site.

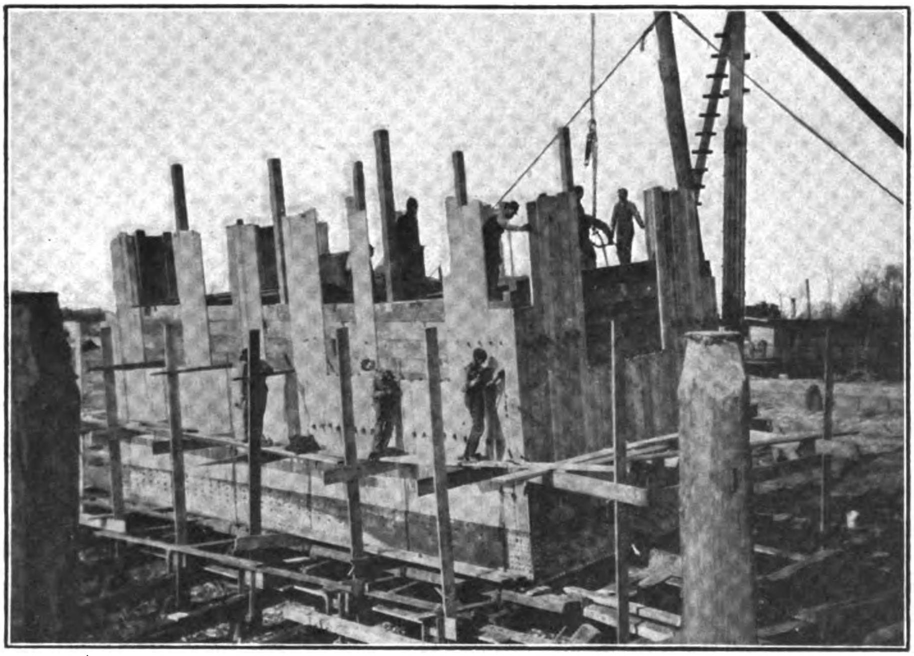
In the meantime the contractors for the pier work shipped their outfit to the bridge site. This outfit consisted of hoisting-machines, boilers, air-compressors, concrete-mixers, pile-drivers, derricks, timber,



Making Concrete Piles, January 27, 1909

piling, tools, etc., with which to commence work. The contractors started work by making a storage yard for the immense amount of cut stone which they had ordered from the quarries, each stone being numbered according to the plan, and fitting into its particular place in the pier. They also drove piling near the shore and constructed launching ways for the caissons. Caissons, (boxes with false bottoms), are used for sinking pier foundations when the latter are too deep or difficult to be constructed without the use of compressed air. The caissons for this bridge were made of timber and concrete reinforced with steel, and the cutting or bottom edge was made of iron. The space between the bottom edge and the false bottom was called the air or working chamber, and was made just high enough to allow men to work comfortably in it. Entrance to this chamber was effected by means of iron shafts equipped with air locks. Pipes providing for air and water supply and for discharge of excavated material were run into the air chamber from the top of the caisson. The false bottom was made strong enough so that the pier could be built on top of it without danger to the workmen below. The walls above the false bottom were made high enough to keep the water away from the men building the pier in the box. The caisson, built on the launching ways and launched like a boat, after it was towed to position, was kept in position by means of cables fastened to piles driven in the river bottom. Its accurate position was determined daily by means of a triangulation system. A base line about half a mile long was laid out on either shore, intersecting the bridge tangent, and the lengths were very accurately measured. These base lines with lines connecting their ends formed a quadrilateral with diagonals. The eight angles from points established at the ends of the base lines were then accurately measured, adjusted, and checked by measured lengths of the base lines. Angles to any pier were then figured, and the pier was located accordingly by transitmen stationed on the base lines. If the caisson was found to be out of position it was moved to correct position as required by the transitman.

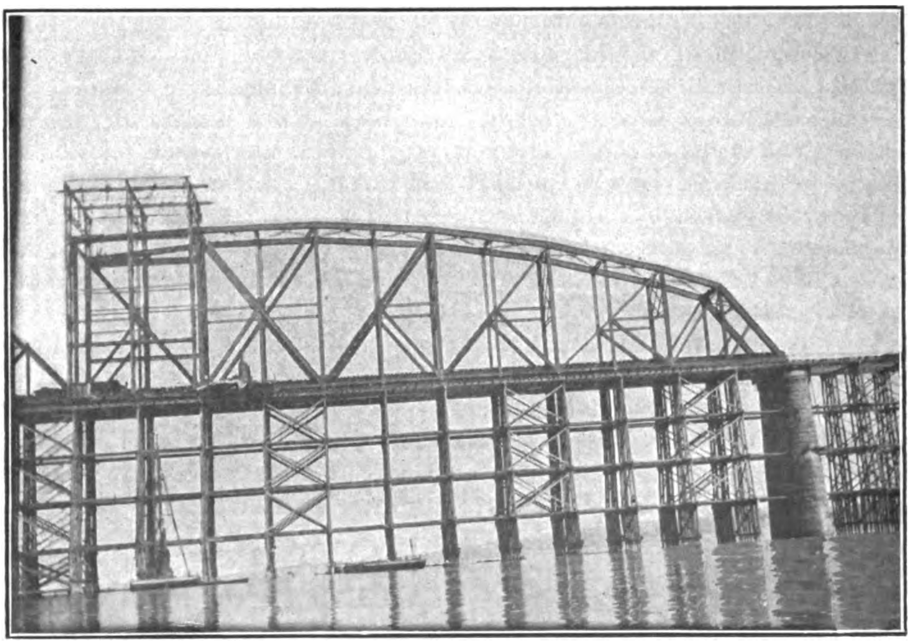
After the caisson was towed to position, barges loaded with stone, cement, gravel, and sand were secured to the caisson, and the workmen mixed concrete and filled the box with it until the cutting edge struck the bottom of the river. A power-barge equipped with air-compressors was moored alongside, and compressed air was forced through the air pipes down into the air chamber, driving all the water out under the cutting edge. The air chamber workmen, or "sand hogs," as they are



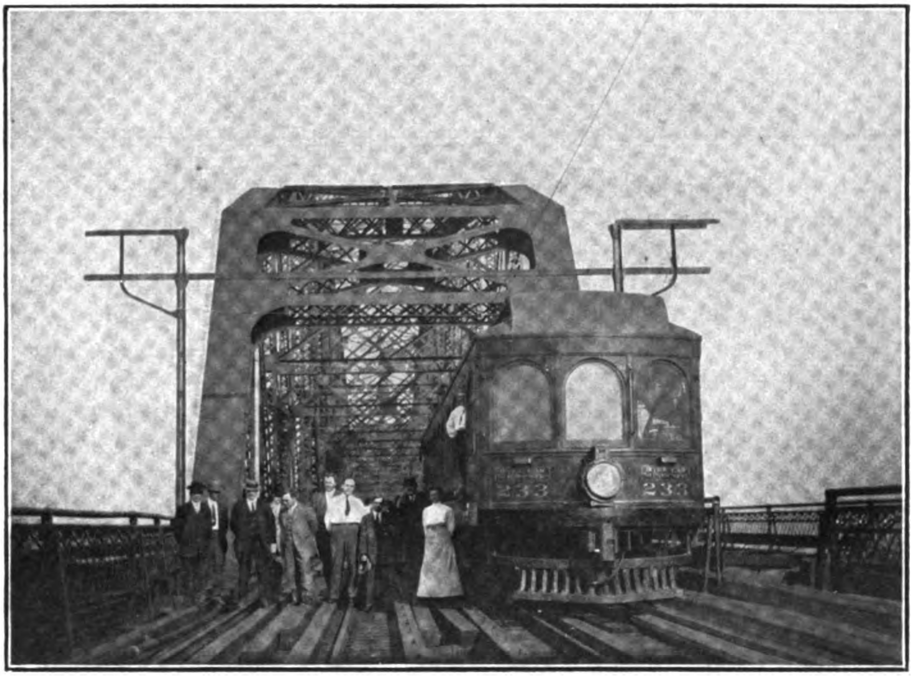
Building Caisson for Pier "C," April 17, 1910

called, then descended into the air chamber through the shafts by means of air locks, and climbing down ladders found themselves on the bottom of the river. The air chamber was lighted with electricity and cooled with electric fans and ventilation pipes, but work under air pressure is exhaustive, so that the "sand hogs" were always perspiring freely, though they wore scanty clothing. "Sand hogs" do not whistle while they work, for it is impossible to do so while under air pressure. It is also rather difficult to hear unless the speaker shouts. One should be in perfect condition before entering a caisson; the effects of compressed air are sometimes serious. Many "sand hogs" get a temporary caisson disease called the "bends" which is very painful and which physicians say is an effect of air saturation of the blood. It is sometimes experienced if the passage from the air chamber through the lock to ordinary atmospheric pressure is made too quickly. To restore the patient, he is put back under air pressure, which is then gradually reduced to atmospheric pressure.

Upon reaching the river bottom, the "sand hogs" shovelled the mud to the mouths of the sand pipes, and opened valves; and the compressed air forced the mud up the pipe and out into the river. As they shovelled the mud, the caisson sank and the masons on top of the caisson built the pier up as fast as it was lowered. In this manner the cutting edge finally struck bed rock. The rock surface was then cleaned and the air chamber filled with concrete. As the space grew smaller and smaller the number of "sand hogs" was reduced until finally there was room for only one. Then he came up the shaft and all the shafts and pipes were filled with concrete, thus sealing the caisson. The masons continued working on top until the pier was completed, course by course, to the proper height. There were six of these pneumatic foundations finished in this manner for the main bridge, and three other foundations were constructed without the use of caissons by what is called the cofferdam method, sheet piling being driven to keep the water out while excavation was proceeding. These nine foundations completed those required for the main bridge. The foundations for the approaches rest on concrete piling, made at the bridge site in the following manner. Wire mesh was spread on a rolling table and long rods tied to it. This mesh was then covered with concrete and the whole mass was rolled up like a jelly roll, pressed tightly, wound with wire, and left to season. After a month's seasoning the piling were driven like wooden piling, with a steam hammer. While the foundations were being completed the fabricated steel was being received and unloaded by the contractor. Large derricks were erected near the approach to the bridge and were used to erect a small section of it. A mule or derrick traveler was then erected on top of this section and used for the erection of the girder spans along the approach. The truss spans required the use of a traveler and falsework. Falsework consists



Falsework, Piers II-III, August 19, 1910



First Trip, Official Car, September 30, 1910

of temporary work which serves the purpose of supporting the traveler and the steel spans until all the members are connected. Timber piling about 65 feet long were first driven and three 20-foot bents of heavy timbers were erected on it and joined with lines of stringers. The traveler which was erected on top of this falsework consisted of a timber structure 104 feet high with three legs or bents which straddled the trusses. It was operated on wheels which ran on a track along the stringers mentioned above. This traveler weighed 126 tons and was rigged with block and tackle and hoisting engines of sufficient power to raise the heaviest piece of steel in the bridge. The steel members were brought to the traveler on flat cars drawn by a locomotive, and as the erection proceeded the traveler was moved along. The truss members were connected mostly by pins which were driven as soon as all the members meeting at any one point were erected. After the last pin in any span was driven, the falsework was removed and the rivetting was begun. This consisted in heating rivets in forges and driving them, while hot, by means of compressed air. Rivetted connections were bolted during erection and these bolts were removed as rivets were driven. Upon completion of rivetting the steel was thoroughly painted. The permanent deck was then laid. This consisted of yellow pine creosoted timber for the railway floor and pitched maple blocks for the roadways. The completion of the deck was followed by the laying of rails and stringing of trolleys, thus finishing the construction.

Three years were required for the construction of the bridge and its approaches. The main bridge consists of two 521-foot, one 523-foot, two 250-foot and three 150-foot spans, the larger spans being through spans and the smaller deck spans. The approaches consist mostly of 41-foot deck spans. The total length of the bridge and its approaches is about one and a quarter miles, and it is of sufficient width to provide two railroad tracks and two wagon roadways. The total height, including masonry and steel, is 223 feet, the height of masonry alone being 136 feet. The formal opening of the bridge occurred on November 10, 1910.

Student Interests and the College Paper

Arthur W. Proetz, '10

IT is a well-known psychological fact that the mind cannot be developed along one line by exercising it in another. In other words, mental gymnastics in Latin, Greek, or History will not develop a knack for Mathematics, and vice versa. Botany will not make a banker. And still the practical business man of to-day is sending his son to college as a foundation for his career, be it commercial or professional, because he knows that nowhere else can be found equally good conditions for general mental broadening.

A college has an atmosphere peculiar to itself. The environments which it affords are denied the young man and the young woman who go forth from the high school to make their way in the world, for the college is a community—a miniature city, a sort of laboratory where the student may work out the big things of life in a test-tube.

The opportunities for personal development through the various student activities are, in my opinion, equal to those offered in the curriculum, and the student who does not utilize them robs himself of one of the finest things a college has to offer. A student community is the one place where one can "try it on the dog" with impunity. It praises successes and pardons failures. It tolerates the struggles of the aspiring far longer than does the great world.