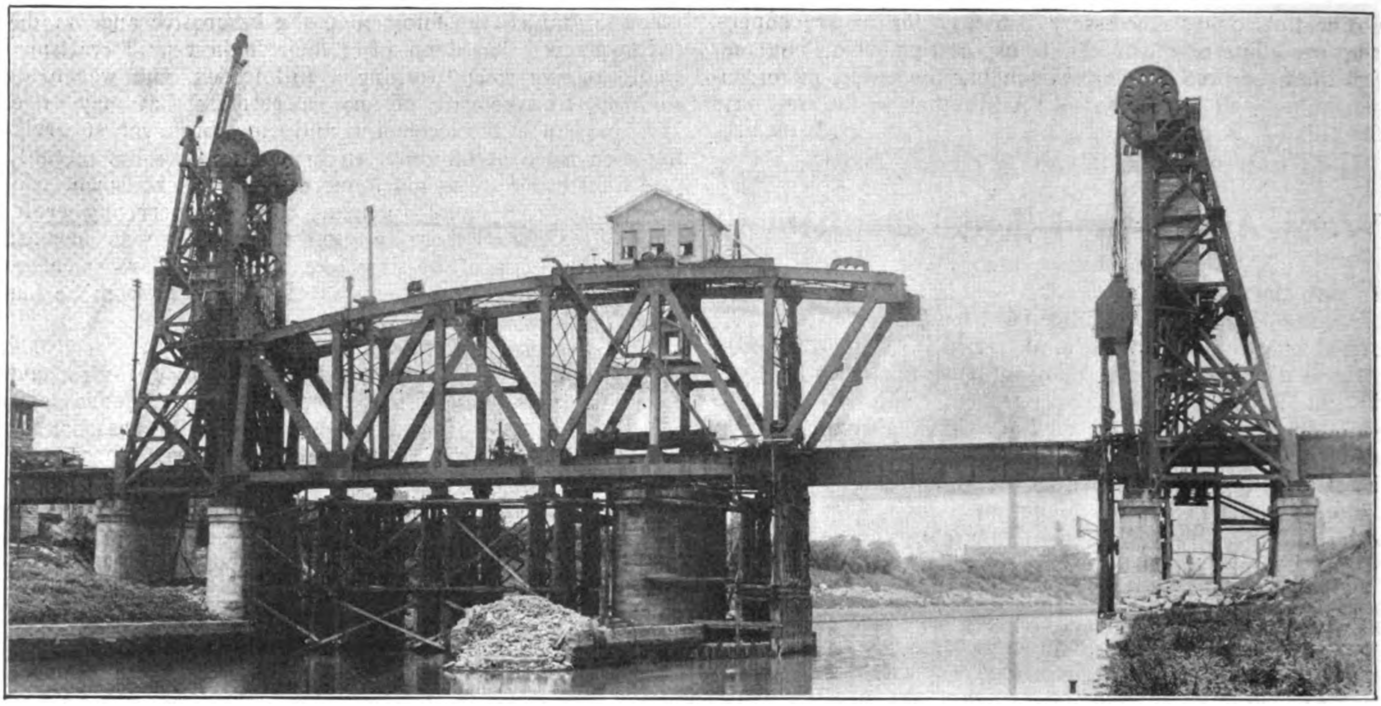


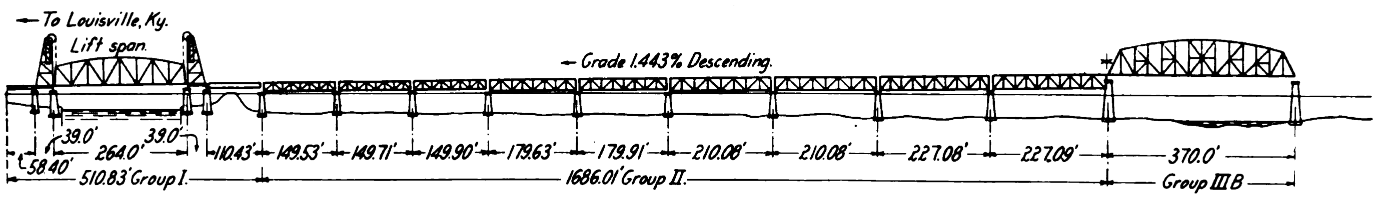
New Lift Span Partially Completed with Temporary Lift Span Still in Place

The Reconstruction of a Notable Railroad Bridge

Ohio River Crossing at Louisville Now Contains Longest Simple Riveted Span in the World

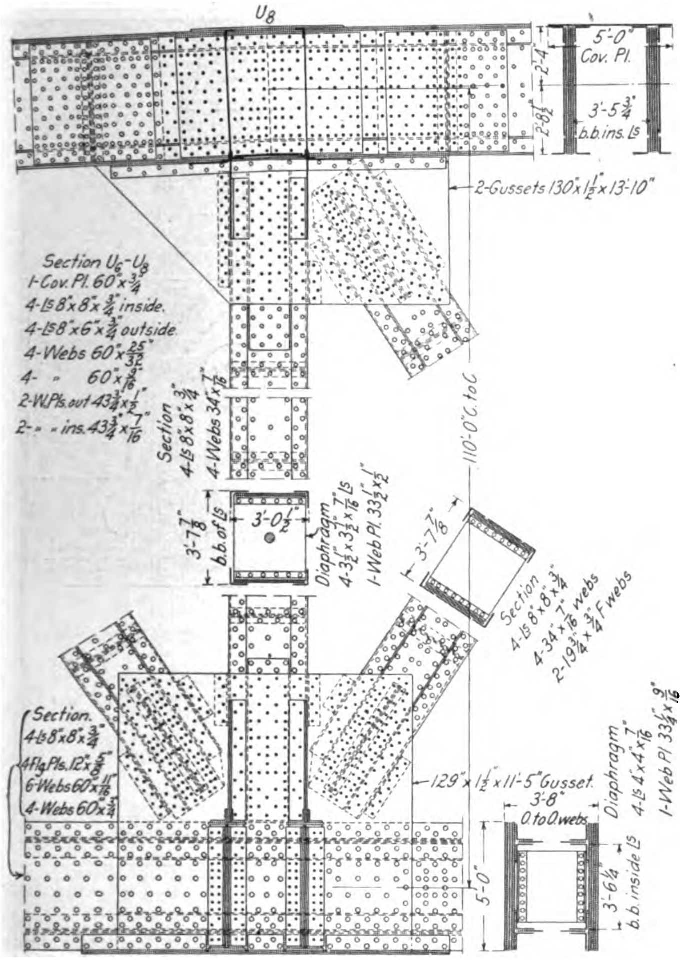
The reconstruction of the Ohio river bridge of the Pennsylvania Lines at Louisville was the foremost railway bridge project under way during the past year. It was the greatest by reason of the length of the structure, which is almost a mile, because of its weight, which aggregates 23,500 tons of structural steel, and because it contains a record-breaking span of 643 ft. 10½ in., the longest simple, riveted truss span in the world. Considerable historic interest also is attached to this project because it marks the passing of a noted structure among American railway bridges, the Louisville bridge built by Albert Fink between 1867 and 1870. Through 47 years this old superstructure carried the increasing loads of railway traffic with but minor strengthening and when removed was in a remarkable state of preservation. But like most other railroad bridges built before the beginning of the new century, it proved inadequate for present loadings and had to be replaced by a new structure of greater carrying capacity and also providing double track. The new bridge, like the old one, is being built by the Louisville Bridge Company, a corporation controlled by the Pennsylvania Company through ownership of 98 per cent of the stock.

The old bridge, as built in 1870, consisted of two through channel spans of 400 and 370 ft., respectively, and a deck swing span of 264 ft. over the Portland canal, with 23 deck spans varying from 50 ft. to 245 ft. 5 in. in length. The two through spans were of the sub-panel Warren type with cast-iron compression members and wrought-iron, eye-bar tension members. The trusses were duplex, there being two complete trusses on each side connected by struts and ties. The deck spans were all of the Fink type with material of the same character as that used in the through spans.



South Half of the Louisville Bridge

Subsequent to first construction certain changes were made. In 1891, the floor beams of the deck spans, which were of a unique cast-iron arch type, were reinforced by placing steel beams on either side of them. About 22 years ago the truss floor beams of the through spans were equipped with equalizers to effect a more uniform distribution of the load to each of the doubled trusses. In 1902, the drawspan was replaced by a through Pratt truss draw. The wooden stringers were also replaced by steel after 25 to 35 years of service. In 1900 instructions were issued limiting the weight of trains crossing the bridge to 3,300 lb. per lin. ft., with engine axle loads of not over 39,000 lb. The speed was also restricted to from 8 to 20 miles per hour, depending on the makeup of the train. The old substructure, of Bedford stone ashlar masonry on rock foundation, was so well preserved that it has been used to support the new steel with only such modifications as were necessary to make it fit the new superstructure. The wrecking of the old structure disclosed the high grade of workmanship which had been applied in its



Typical Truss Details of the Indiana Channel Span

fabrication and erection, as demonstrated by the excellent behavior of the spans through their long service life.

The New Structure

The old superstructure has been replaced largely by spans of equivalent length on the old piers, except for several important modifications. The old 400-ft. Indiana channel span and the deck span adjacent to it on the south have been replaced by a single span 643 ft. 10½ in. long center to center of end bearings. Two of the deck truss spans at the north end of the bridge have been replaced by two deck girder spans of 32 ft. and 99 ft. 6 in. respectively. The old center pier drawspan has been replaced by a span of 264 ft., center to center of piers, operated as a vertical lift, while the necessity for flanking this by 39-ft. tower spans introduced a modification in the makeup of the spans immediately adjacent to the draw.

Except for the presence of the lift span, the new superstructure of the Louisville bridge bears a striking resemblance to that of the Ohio Connecting Railroad bridge of the Pennsylvania Lines across Brunot's island near Pittsburgh, which was rebuilt in 1914-15. Both of these bridges contain two through riveted channel spans of the Petit type, separated by a long series of riveted deck Warren type truss spans, and there is a marked similarity in the structural details. There is also an interesting coincidence in the fact that, until the completion of the record span of 644 ft. in the Louisville bridge, the 525-ft. span of the Brunot's island bridge was the longest riveted simple truss span in the United States. The similarity, however, ends there, since the manner of prosecuting the work in the two structures differed widely.

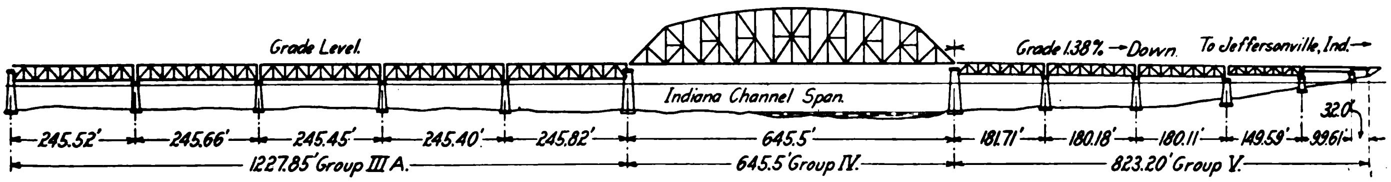
The Indiana Channel Span

As a record structure, a few of the principal dimensions of the 644-ft. span are of interest. It consists of 18 subpanels of 35 ft. 9¼ in. The height of the trusses is 74 ft. at the portals and 110 ft. 6 in. at mid-span, measured center to center of chords. The trusses are 34 ft., center to center, and the total weight of the span is 6,209 tons.

The top chords and end posts are of a double-I section with top cover plates and having 60-in. webs and 60-in. cover plates. The gross sectional areas of the end posts and maximum top chord members are 562.43 sq. in. and 535.09 sq. in. respectively. The bottom chords are of a double-web type with maximum net and gross sections of 487.55 and 587.27 sq. in. respectively. The largest gusset plate, which is at panel point L-4, measures 129 in. by 1½ in. by 13 ft. 10 in. The two webs of the bottom chord are tied together by diaphragms spaced 10 ft. to 12 ft. apart with single lacing of 6-in. by ½-in. bars attached to horizontal plates secured to the webs by means of 8-in. by 8-in. angles. The top chords and end posts are stiffened by diaphragms at intervals of 6 ft. to 9 ft. and the lower edges of the two webs are tied together by lacing bars and tie plates, except that the lacing bars are omitted in the top chords by providing that the spaces between the ends of the tie plates are not greater than three feet.

The floor system, following the design used on the Ohio Connecting Railroad bridge, consists of duplicate floor beams at each panel point, one each to support the stringers in the panel on either side. This makes the floor system at each panel a complete, independent unit, an arrangement that is especially convenient in erection. The end bearing detail of the span is of massive proportions; the bearing pin is 24 in. in diameter and the expansion bearing consists of eight segmental rollers having a diameter of 2 ft. 6 in. and a length of 4 ft. The span rests on a grillage 2 ft. 2 in. deep and 11 ft. long transverse of the piers, which in turn is supported on a grillage covering the entire length of the pier and consisting of eight girders 3 ft. 9 in. deep. The material is high tension steel for main members of the trusses and floor system and medium steel for the gusset plates, bracing and minor details. The rivets are ⅞ in., 1 in. and 1⅛ in. in diameter.

The details of the 370-ft. Kentucky channel span correspond very closely to those of the large span. One difference is noted in the fact that the end post occupies only one sub-panel and therefore has a much steeper slope. Some idea of the relative proportions of the new double-track bridge



North Half of the Louisville Bridge

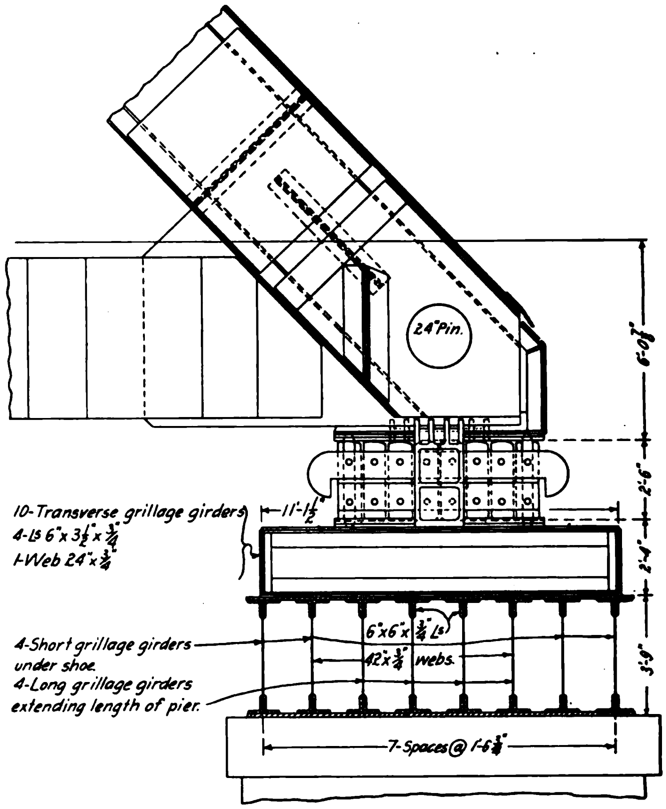
as compared to the single-track structure which it replaces is to be obtained by a comparison of the weights per foot of track of the new and old superstructure for this span, these being 12,272 lb. and 3,050 lb. respectively. The new 644-ft. span weighs 19,650 lb. per ft.

The Lift Span

The lift span is composed of through riveted trusses 260 ft. long, center to center of end bearings, and weighs about 1,320 tons. Towers flanking it on either end afford means for lifting the span a distance of 32.3 ft. to give a clear headroom of 79 ft. above the pool level of the canal. The operating details of this structure conform very closely to those used in the Pennsylvania Lines bridges over the Chicago and Calumet rivers at Chicago. The counterweight towers are 105 ft. high from the top of masonry to the center line of the 15-ft. sheaves from which the span and the counterweights are hung by sixteen 2⅛-in. wire ropes at each corner. The sheaves consist of seven cast-steel rim segments with special steel web members connecting them to cast-steel hubs which are bored for 24-in. diameter shafts. The counterweights are of concrete cast in structural steel frames. Compensation for the weight of the carrying cables is accomplished by means of cast-iron link chains swung between the bottoms of the concrete counterweights and points at mid-height on the towers.

Power is supplied for moving this span up and down by cables attached near the bottoms and tops of the towers and passing over sheaves at the ends of the top chords to drums on hoisting equipment in a house over the center of the span. The hoisting equipment consists of two 150-h.p., 220-volt, 3-phase, 60-cycle induction motors. There are three forms of control, one automatic by means of two solenoid brakes, and two manual through an electric brake and a hand brake. Duplicate control of the structure is provided since it may be operated from a cabin suspended inside of the trusses below the machinery house, and also from an interlocking tower located just south of the bridge which controls not only the movement of the trains that cross the bridge but also the throat of a yard located just south of the canal. Excessive vibration in bringing the structure to bearing on the bridge seat is avoided through the provision for pneumatic buffers consisting essentially of cylindrical plungers passing into cylindrical tubes from which the delayed escape of the contained air through small orifices serves to bring the span to rest gradually.

The grade of the bridge between and including the two channel spans, a distance of 2,242 ft., is level, with approach grades of 1.38 and 1.443 per cent ascending from the north and south respectively. The 1.443 per cent grade extends across the lift span and was taken care of entirely in the attachment of the floor beams to the trusses, so that the bottom chords of the span could be level. There is a possibility that grade separation work in the city of Louisville to the north of this structure will require some future modification of the track grade at the south end of the bridges and as a means of facilitating a change of grade across the lift span, the rivet spacing of the connections of the floor

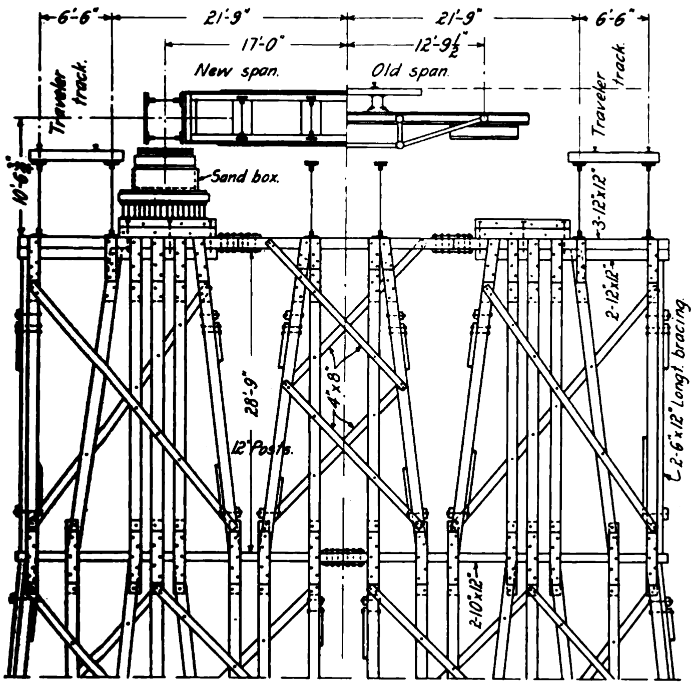


Outlines of the End Bearing for the 644-Foot Span

Falsework for the Erection of the Deck Truss Spans beams to the posts has been made uniform so that the beams may be readily moved up variable distances on the posts.

Erection

The erection of the bridge proceeded slowly because of the masonry changes that had to be carried on simultaneously with the placing of the new steel. The first work to be done was on Group 5, the deck spans between the Indiana channel and the north abutment; this was started June 1, 1916, and finished October 1, of the same year. The next section was Group 3A, the five deck spans between the two channel spans requiring from September 1 to December 15, 1916. The 370-ft. through span was erected between April 25 and July 10, 1917. The remaining deck trusses were erected between May 10, 1917, and January 20, 1918. The erection of the superstructure of the group of spans centered about the lift span started on March 1, 1918, and was completed on September 10 of the same year, while the work on the great Indiana channel span was started on April 20, 1918, and is now practically complete.



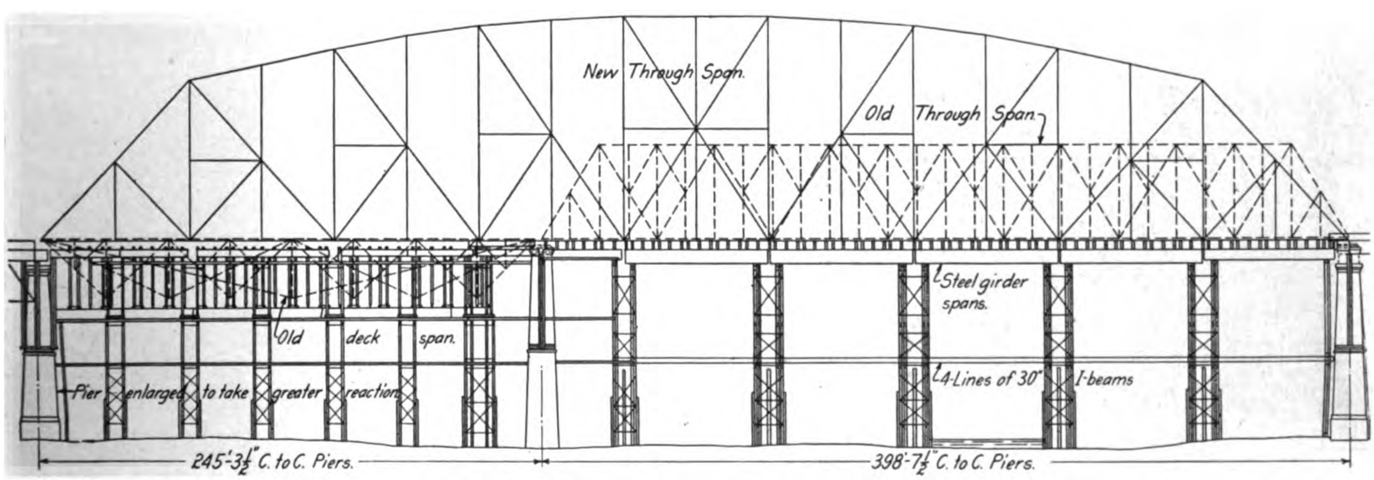
Elevation of the Upper Half of a Bent in the Falsework Used Under the 644-Foot Span

The old masonry was found to be in excellent condition and, although built for single track, the piers were found to be of adequate length to carry the new double-track structure after being provided with longitudinal steel grillages concreted into new copings. In the case of the piers supporting the old Fink trusses, the bridge seat was located just under the top chords so that in order to erect the new deck trusses it was necessary to cut down these piers to afford space for bearing shoes below the level of the new bottom chords, and since the piers had an appreciable end batter, the new pier tops at the lower level were considerably longer than at the old level. However, this change in the masonry proved to be a considerable obstacle to the work since the rate at which the old superstructure could be replaced by the new was controlled very largely by the speed at which the alterations to the masonry could be made.

The falsework for the deck spans consisted of towers of frame posts resting on the rock bottom of the river and carrying plate girder spans below the level of the bottom chords of the new spans. On these, frame bents were erected to support the bridge floor and the old trusses at the level of the top chords. The old trusses were then taken down and the new ones erected, after which the floor system was replaced panel by panel. In the meantime the old piers were removed down to the new level and the grillages installed and concreted in place.

The erection of the Indiana channel span was by far the most formidable problem of the project, not only because of the great weight of 6,209 tons which had to be maintained on the falsework, but because of the very swift current that flows in the channel under this span. Some idea of the velocity of the water may be gained from the fact that there is a fall in the river of 23 ft. in one mile. Erection on falsework under these circumstances would have been an impossibility but for the fact that the depth of water is only from 8 to 10 ft., with a maximum of about 16 ft. The bottom is bare solid rock. The problem was complicated by the necessity for removing the intermediate pier carrying the south end of the old channel span and the need for strengthening the pier to carry the south end of the new span, since this pier now carries a far greater reaction than under the previous arrangement. This was accomplished by inclosing it with a three-foot thickness of new stone masonry on all sides. The pier is 100 ft. high from top of footing to base of rail and the reinforcement entailed the use of 1,392 cu. yd. of masonry in the neatwork and 64 cu. yd. in the coping.

The reconstruction of this pier was accomplished by surrounding it with a rock crib to produce a pool of still water. A cofferdam was then built inside of this and worked down



Elevation of the Falsework Under the 644-Foot Span

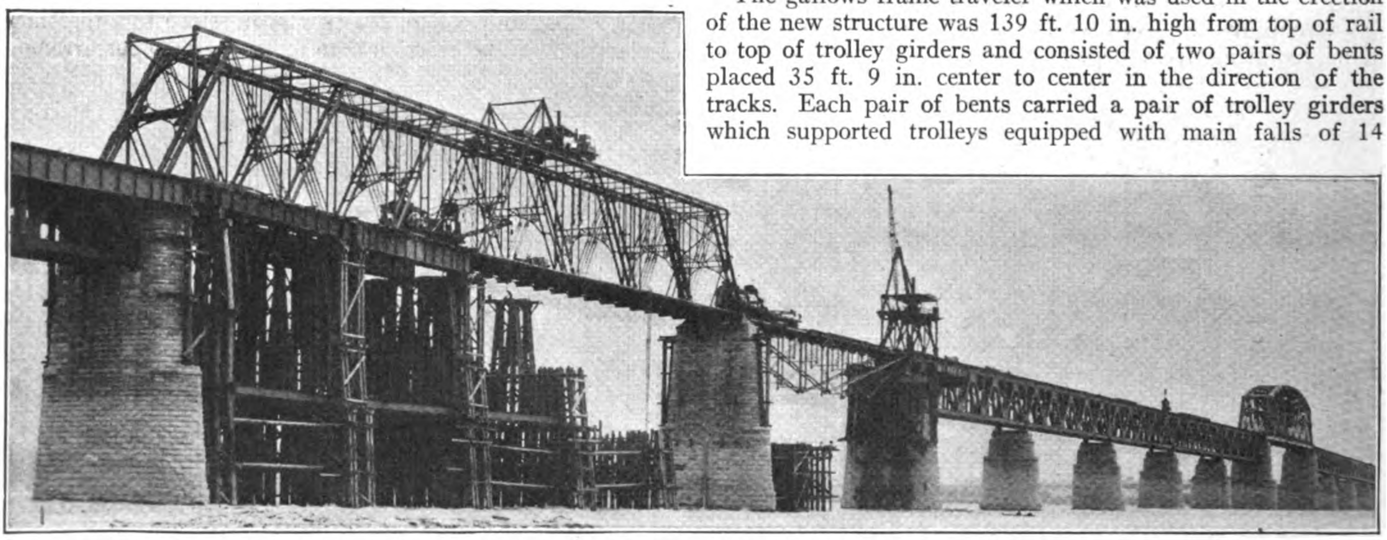
through the loose rock to the bottom of the river, after which it was unwatered and the footing concreted.

Work on the new masonry was facilitated by building a gallows frame supported on the pier and spanning over the track with sufficient clearance to allow the passage of trains. This was equipped with two derrick booms which were used to handle the stones delivered on cars and set them into place in the pier. Material for concrete work was stored in a bin built on the bottom chord of the new deck span to the south, the material being chuted from cars spotted above. As the old deck span to the north was not placed on falsework during this operation it was necessary to support the end of this span over the pier by means of a 50-ft. girder placed crosswise under the end shoes of the old span and supported on frame bents at the two ends of the pier.

Falsework for the Indiana Channel Span

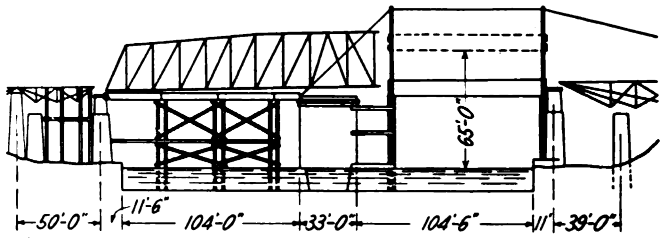
One of the drawings shows an elevation of the falsework used in erecting the 644-ft. span. It consists of a series of frame bent towers supporting deck plate girders. The portion of the falsework under the old span was complicated by the need of placing these girders low enough to clear the bottom of the old span so that the construction was similar to that used in erecting the deck spans. Under old channel span each falsework tower consisted of four bents containing 16 posts each. The most difficult part of the work was to place these posts in the swift current. To accomplish this a timber frame or box truss was designed to surround the entire lower story of the tower. It was built above water, suspending it from lines depending from a creeper traveler riding on the top chords of the old through truss span. This frame was held at a fixed distance out from the pier or the nearest tower previously erected by struts hinged at the ends so as not to interfere with an up-and-down motion of these box trusses. The trusses were fitted with four posts located at approximately the quarter points of each outside bent so that when the box trusses were lowered these four posts could be brought to bearing on the river bottom. With the frames thus supported, the rest of the posts for the tower were let down into place in succession between guides in this frame. Each post was fitted with a cast iron pyramidal shoe and brought to a solid bearing on the rock by subjecting it to several blows with a steam hammer.

No sway bracing was provided between the towers, but four lines of 30-in. I-beams at a level of 31 ft. above the bottom were spanned from tower to tower and made continuous between the piers to serve as sash bracing. The two inside lines of these I-beams were cross-braced to form a horizontal truss.

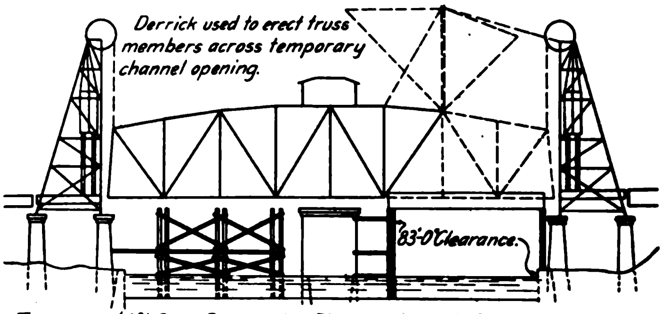


Erecting the Falsework Under the Old Indiana Channel Span

An elevation of the top section of the tower bents shows how the posts were grouped to support the various parts of the superimposed live and dead loads. Two girders in the center carried the track used for revenue traffic and for the delivery of new steel. On either side of these, grillages were provided to carry the sand boxes under panel points of the trusses, while on the outside pairs of girders were placed to support the traveler tracks.



Old Swing Span Partly Removed and Temporary Lift Span in Service.



Temporary Lift Span Remained in Place while while Remaining Members of The New Lift Span Trusses were Erected.

Method of Removing the Old Draw Span and Erecting the New Lift Span

The gallows frame traveler which was used in the erection of the new structure was 139 ft. 10 in. high from top of rail to top of trolley girders and consisted of two pairs of bents placed 35 ft. 9 in. center to center in the direction of the tracks. Each pair of bents carried a pair of trolley girders which supported trolleys equipped with main falls of 14 parts of 7/8-in. wire rope and auxiliary falls carrying a single sheave block. The hoisting engines were carried on trailers standing on the traveler track. The heaviest member erected with this traveler weighed 129 tons.

All parts of the old span were removed by a locomotive crane, the members being cut apart with an oxy-acetylene torch. The work was started at the south end, the old deck span being replaced by the new steel first. The new span was detailed to have a camber of 1 ft. 4½ in. as erected (under no stress), which reduced to a camber of 7.32 in. when under dead load after the span had been swung free of the falsework.

The deck spans were replaced under traffic, using a small tower traveler standing astride the operated track and supported on rails 19 ft. 2¾ in. center to center. This was made of frame posts and floor beams taken from the old structure.

Special Problem in the Lift Span

The replacement of the old swing span by the new lift span was a problem of no mean proportions since the work had to proceed with a minimum of interference with the operation of both rail and canal traffic. The solution was to place the south half of the old span on falsework and replace the north half by a temporary lift span consisting of a pair of 88-ft. girders raised and lowered by lines from gallows frames supported on bents adjacent to each side of the north draw opening. A minimum interference with the canal traffic required that the interval from the time that the swing span was rendered inoperative until the temporary lift span was ready for use should be as short as possible. This was accomplished as follows: The lift span was delivered on the bridge on two flat cars and was picked up by lines from the gallows frames so that the cars could be released. The portion of the old floor system under the temporary span was cut away from the trusses, most of it being lashed to the under side of temporary girders which were then lowered into a position to carry traffic. One hundred feet of the north ends of the old trusses was then cut away and removed so as not to obstruct the channel when the lift span was raised.

The temporary lift span was raised and lowered by means of hand crabs, the span was counterweighed by means of rails suspended from the falsework. The operation of opening and closing the span occupied about 20 min.

After the temporary lift span was installed the towers for the permanent lift were erected and the portion of the old span over the south channel and the pivot pier was replaced by the portion of the new span shown in full lines in the drawing. Navigation was then closed and the remaining members of the trusses were placed by the cantilever method, the temporary span being maintained operative between them. When the trusses were completed the traffic over the bridge was stopped and the temporary span removed and replaced by the permanent floor system, whereupon the bridge was restored to rail traffic after an interval of eight hours. The blockade of the canal traffic from the time that the truss members fouled the channel until the new lift span became operative was seven days, but as the river traffic was inconsequential the delay was of little concern.

The erection of the bridge, with the use of the operating track by work trains supplying material for the new structure and removing the material released from the old one, introduced possibilities of serious interference between the construction operations and the conduct of revenue traffic. This was overcome by adjusting train schedules to avoid the movement of revenue trains on the bridge during the workday hours. Some of the trains were diverted to other bridges crossing the Ohio at Louisville; concentration of movements was also arranged at night and during the noon hour.

This bridge was designed and built under the direction of J. C. Bland, bridge engineer of the Pennsylvania Lines West. The Pennsylvania Steel Company, Pittsburgh, Pa., had the contract for the entire superstructure, the erection being under the direction of J. L. Poffenberger, engineer, and J. J. Kelley, general foreman. The masonry changes were made partly by the railroad and partly by separate contractors. The work on the substructure for the lift span, after being partly completed under an independent contract was taken over and completed by the Pennsylvania Steel Co.

Labor Recruiting Conference at Chicago

A CONFERENCE ON WAGES and means of recruiting labor for railroads was held in the auditorium of the Insurance Exchange Building, Chicago, January 20 and 21. It was called by the Federal Employment Service for the purpose of developing, if possible, some means of co-operation between officers of the railroads and the Employment Service and was attended by some 25 railroad officers and representatives of various departments of the Federal Service. Sanford H. E. Freund, director of the clearance division, United States Employment Service, Washington, D. C., presided.

In their opening addresses Mr. Freund and Charles J. Boyd, general superintendent of the Illinois free employment offices, expressed the opinion that while there is a well defined labor surplus at the present time, there is every reason to believe that there will be a decided labor shortage within a very few months, particularly in common labor. The reasons given for this are the rapidity with which men released from the army and war industries have been placed in positions and the fact that this country is now short 2,000,000 men through the failure of immigration in recent years, since it has always been the immigrant who has afforded the supply of common labor in the past. Mr. Freund urged upon the railroad men the necessity for co-operating with the 750 government agencies. He said that competition between the federal bureaus and those maintained by the railroads would be harmful to both and would increase the labor turnover.

In speaking for the railroads, W. G. Beird, federal manager of the Chicago & Alton, admitted that the railroad situation was grave, particularly with respect to unskilled labor. A particularly unfortunate feature in connection with the unskilled labor is that it is less efficient than formerly, so that one of the most important problems is to restore it to its former efficiency. He said that after listening to considerable of the discussion it was his opinion that there was a missing link between the organizations of the Federal Employment Service and the railroads and as a means of securing this necessary connection he believed it should be the sense of the meeting to call upon the United States Railroad Administration to appoint a committee to confer with representatives of the Employment Service to formulate the necessary means of united action.

Representatives of a great many of the different state branches of the Federal Employment Service spoke of the success of their work, quoting figures as to the large number of men to whom they had given employment. They decried the failure of railroad officers to co-operate with them and assumed a rather critical attitude concerning the employment practices of the railroads. Exception was taken to this by Robert H. Ford valuation engineer, Chicago, Rock Island & Pacific, who reviewed the labor problem of the past few years in detail and called attention to the fact that the problem is not solely one of searching out the man without a job and putting him to work, but also of keeping him at work. This means that the working and living conditions must be favorable. Moreover, the floater must be prevented from traveling all over the country at the expense of the railroads. He gave as one reason why the federal service was unable to supply men properly during the past year, that they were too much concerned with supplying men for other employments at higher rates and cited instances of the intense competition of varied independent agencies of the Employment Service with each other. He also quoted from orders of the regional director of the Western region warning railroad officers that applications for men at the Federal Employment offices did not relieve the railroad man of

Engineering News

VOLUME 77 FEBRUARY 8, 1917 NUMBER 6

Old Ohio River Bridge at Louisville—Nearly Fifty Years in Service

Modernization is about to destroy a landmark of bridge engineering, the Louisville bridge across the Ohio River between Louisville, Ky., and Jeffersonville, Ind., used by the Pennsylvania Lines West of Pittsburgh. Its larger part consists of spans of the long-obsolete Fink type. It is one of the few surviving railway bridges having cast-iron members. It has been continuously in railway service for 47 years and now is not worn out, but is forced into the scrap heap by the increase of railway loads and the need for a second track.

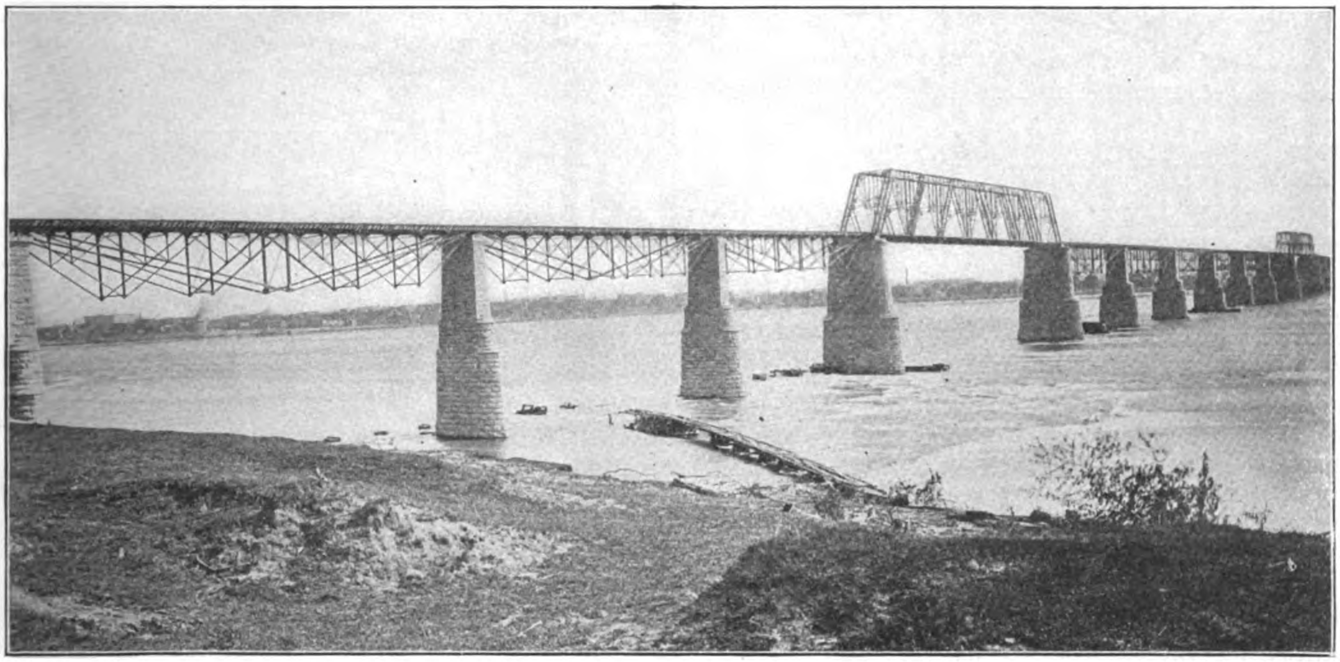


FIG. 1. AN EARLY PHOTOGRAPH OF THE OLD LOUISVILLE BRIDGE, COMPLETED IN 1870
One of the unsymmetrical Fink spans, 12 panels, 180 ft. long, is seen in the foreground; the nearer through span is the 400-ft. Indiana Channel span

In 1872, two years after the completion of the Louisville bridge, Albert Fink, in writing the Chief Engineer's final report, said: "The bridge has . . . stood during that time as severe a test as it can ever be subjected to. Experience so far has not developed any defect either in plan or execution."

The bridge has stood since that early day the test of modern railway traffic, far more severe than any foreseen by Fink. Engineers of the present day will readily grant that it has proved itself remarkably durable and that it bears testimony to the excellent work of the bridge engineers of half a century ago.

In its 47 years of service the bridge has required practically no repairs and no reconstruction or replacement except in the floor system. It has had only three coats of paint since its first field painting.

The bridge is practically a mile long (5250 ft.). It consists of a long succession of deck spans of the truss-rod type, originated by Fink, in spans up to 245 ft. 5 in., and two through channel spans of Warren type with vertical hangers and subtie system. Its top chords are of cast iron—octagonal with a round central hole, the ends squared. Its bottom chords and tension diagonals are of eye-bars, and its posts and compression diagonals of Phœnix columns.

Fig. 1 shows the bridge as it was built, and as the larger part of the structure—it is in process of replacement—still appears today. The Portland Canal draw at the Louisville end (see span diagram, Fig. 2) was replaced 15 years ago by a "modern" Pratt truss draw, which except for the difference in type and make-up looks as old now as the rest of the bridge.

The deck spans are typified in all details by the longest, the 245-ft. 5-in. spans of 16 panels, Fig. 3. However, there are 10-panel and 12-panel spans also, and their webbing necessarily is unsymmetrical (see near span in Fig. 1). The sketches in Fig. 4 give the arrangement of posts and truss rods. The 50-ft. approach spans have four panels, the 210-ft. spans 16 panels like the longer ones.

Cast-iron arch floorbeams with iron tie-rods are a special feature of these Fink spans. Their form is

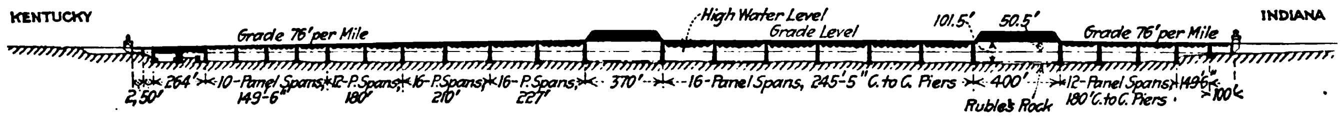


FIG. 2. DIAGRAM ELEVATION OF LOUISVILLE BRIDGE ACROSS THE OHIO RIVER

clearly apparent from the cross-section in Fig. 3. The end of the floorbeam forms the connection block between post and top chord, and the floorbeams themselves constitute also the upper struts of the sway system. Therefore, although the floor loads today are being carried by steel floorbeams (placed 25 years ago), the old cast-iron floorbeams are still in place. The lower struts of the sway bracing are also cast-iron members.

In their 20 years' service the cast-iron floorbeams gave some trouble. Their tie-bars, originally shrunk on, tended to become loose—it was believed because of wear at the pins. Some of them were reshrunk, while others were fitted with turnbuckles. After many years one of the arches broke on account of loose tie-bars; it was not strong enough as a beam to carry the stringer load.

In 1891 the cast-iron floorbeams in all the deck spans were displaced by steel (that is, put out of service, though left in position). A pair of shallow plate-girders was set at each floorbeam, a girder on either side of the arch, with ends resting on the top chords of the trusses.

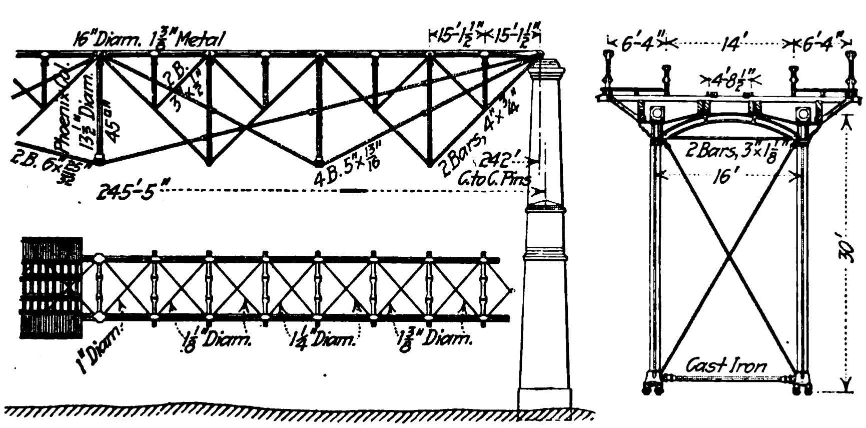


FIG. 3. FINK DECK SPAN OF 16 PANELS, LOUISVILLE BRIDGE

Wooden Stringers in Service 25 to 35 Years

The original stringers throughout the bridge, on the through spans as well as the deck spans, were pairs of 8x16-in. white-pine timbers. As they rotted out, they were replaced by yellow-pine timbers of the same size. Some time after the floorbeam replacement on the deck spans, however, a start was made in putting in steel I-beam stringers. The stringers of the two through spans and the six deck spans between were replaced by steel in 1895 and 1896. Ten years later the remaining spans were equipped similarly.

In general, the durability of the timber was very satisfactory. The early failure of the wooden stringers was due largely to rotting and crushing at the ends, where they rested on the floorbeams. This rotting and the liability to fire were the reasons for the substitution.

Double-Truss Construction of the Through Spans

The two through-truss spans are most remarkable for their duplex construction. Each side or truss is made up of two identically equal trusses set close, side by side. Why this was necessary may be gathered from the fact that in 1870 the 400-ft. span was "the longest truss girder yet completed in America" and from the heavy sections required in the individual members. The posts, Phœnix columns, range from 5½ to 17 in. in diameter and have sectional areas from 5.7 to 60 sq.in. Members of double the latter size might have been beyond the manufacturing resources of the day, and in any case the details of their connection to the eye-bars would have been very difficult. Probably the same is true of the cast-iron top chords, octagonal sections of 14 in. in diameter, with central circular hole giving 1- to 1½-in. thickness of iron.

The duplex truss construction (see the cross-section in Fig. 7, which shows the complete independence of the component trusses) presented an interesting difficulty. It was necessary to connect the component trusses together and at the same time make each carry its own weight and take a true half-share of the floor load. The former requirement was met by erecting the two trusses separately:

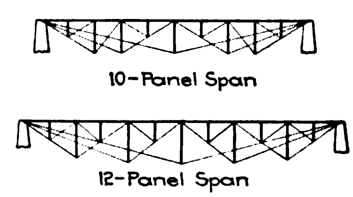


FIG. 4. DIAGRAMS OF FINK TRUSS SPANS

> The trusses on either side of the roadway are now securely connected by bolts and struts; but before being thus connected each was allowed to support its own weight, and assume its natural camber, uninfluenced by any connection with its neighbor. By this precaution the possibility of undue strains from inaccuracy of workmanship was avoided.
>
> It is of interest to note that when thus swung independently no perceptible difference could be observed in the camber of the four trusses, which, while supporting each its own weight, were bolted together without reaming or chipping.

The connection by cast-iron separator "struts" is indicated in Figs. 7 and 8. In the bottom chord it occurs at the ends only, but the floorbeam connections also serve as spacers.

The second problem, equal division of the floor loads, was solved by help of the truss-rod construction of the double 12-in. I-floorbeams. The pair of I's was extended under both trusses and connected to both by similar sets of hangers; and the trussing eye-bars were connected to the I-beams in the center line between the two trusses.

This method of connection appears to have sufficed for equal live-load distribution so far as the major members of the trusses are concerned; the truss separators would help to prevent unequal deflection. But at the subhangers the equal distribution of the single panel load to the hanger bars was not secured, apparently. At any rate a system of equalizer levers was put in at these points 20 years ago, which divides the load equally among the individual hanger bars of the two trusses.

A few details of the truss construction are reproduced in Fig. 8. The general drawing, Fig. 7, shows the form of the portal and sway systems—all cast iron.

A prominent feature of the through spans is found in the eye-bars. The thinnest, which occur in the second panel, are only $\frac{21}{32}$ in. thick in the body (all the bars are 6 in. wide. The heads of the bars are thickened, however, so that they possess lower bearing pressure and better resistance to dishing in the head than might be expected from the dimensions of the bars. The heads were forged separately and welded to the body of the bar.

The stiff diagonals in the middle panel are supplemented by eye-bars extending alongside. This provides for counter stresses. Fig. 7 does not show these counter ties, which indicates the possibility that they were added after the original plans had been drawn.

The only alterations made in these two spans since construction were installing hanger equalizers and providing steel I-beam stringers. Some adjustment of the expansion rollers was required, when these were found to have grooved into their bed plates and rusted fast.

Loads and Stresses; Material

The bridge was designed to carry a rolling load of 2600 lb. per lin.ft. The present-day loads are probably somewhat more than 50% higher. However, the original unit stresses were low, and this accounts for the fact that the bridge has not been fatally overloaded before this. Concerning the unit stresses, Mr. Fink said:

> The factor of safety in the cast-iron chords is from 6 to 7, and in the wrought-iron braces from 5 to 6, by Hodgkinson's formula.
>
> The strain in the wrought-iron tension members is varied according to their position and duty; for example, the suspension and small truss-bars of the channel spans, which are subjected to a maximum load at the passage of each train, have with this load [2600 lb. per lin.ft.] a strain of from 7000 to 8000 lb. per sq.in.; while the bottom chords of these spans, and the main system of the suspension trusses, which rarely, if ever, are subjected to the calculated maximum strain, are proportioned for a strain of 12,000 lb. per sq.in. The other tension members of the bridge are proportioned for intermediate strains, 7000 lb. being the least and 12,000 lb. the greatest strain with a full load.

The iron in the bridge (other than cast) was wrought iron of "not less than 60,000 lb. per sq.in. breaking strength."

On this point of strength, however, interesting figures were obtained by J. C. Bland, Engineer of Bridges, Pennsylvania Lines West of Pittsburgh, in connection with an analysis of the entire bridge in 1901, made to fix the maximum loading that could be used. Of the 6-in. eye-bars forming the lower chord of the trussed floorbeams of the through spans, four were selected at random, taken out, and subjected to full-size test. The results were:

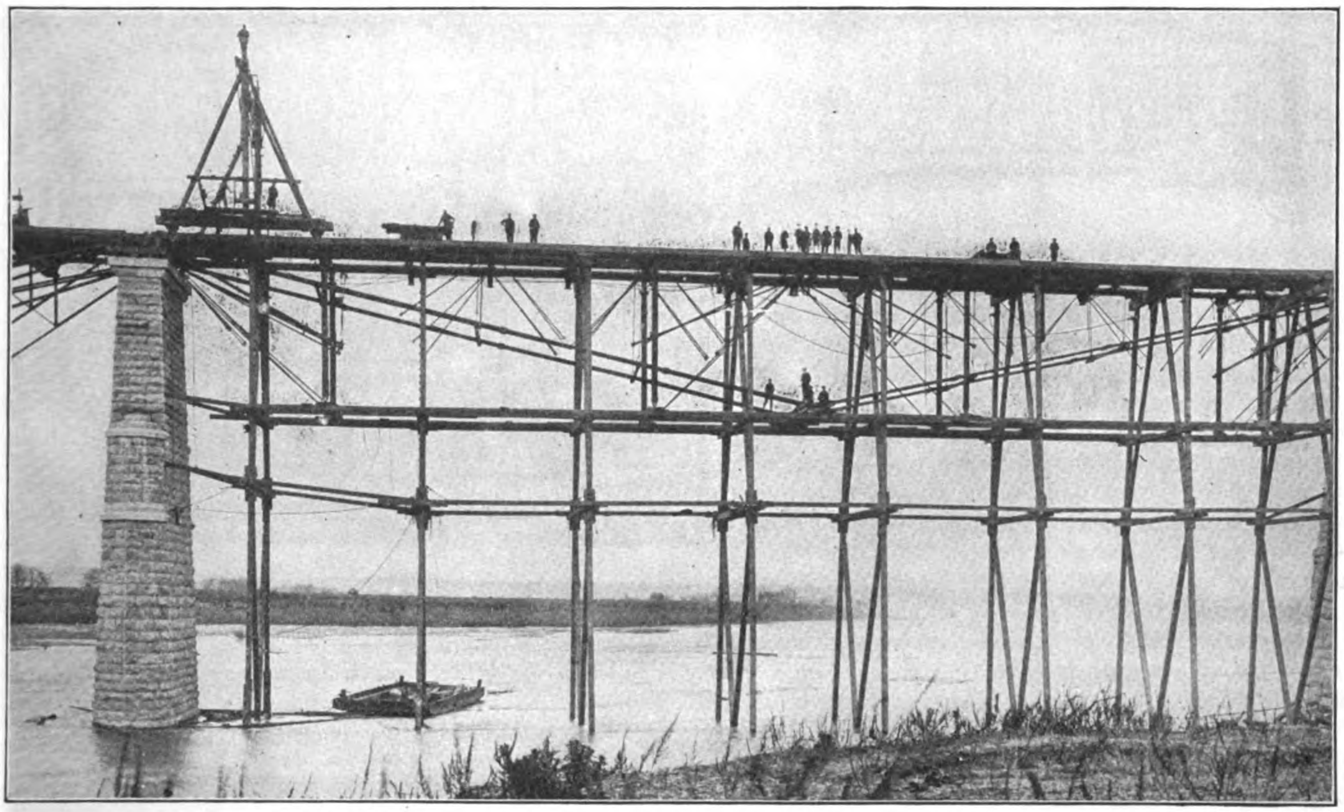


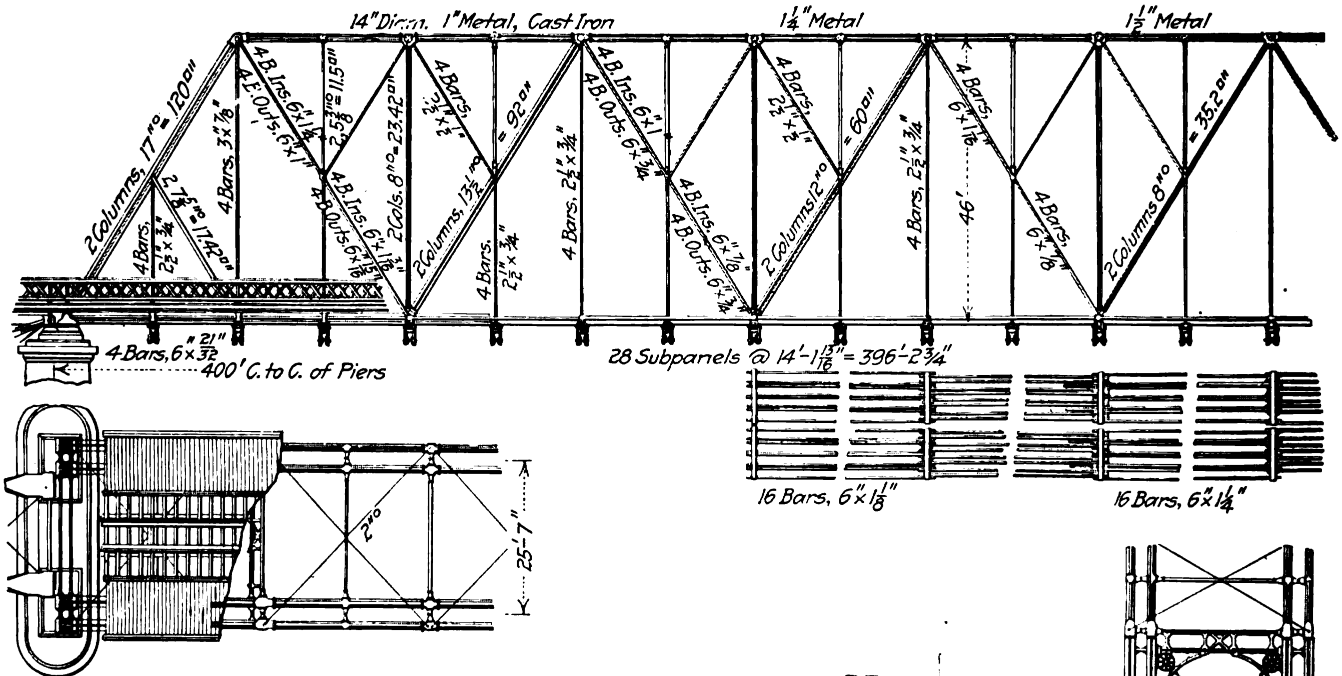
FIG. 5. ERECTION OF ONE OF THE FINK DECK SPANS OF THE LOUISVILLE BRIDGE
Reproduction of an 1869 photograph

Test	Span	Elastic Limit Lb. per sq.In.	Maximum Strength, Lb. per Sq.In.
1	370 ft.	29,580	46,340
2	370 ft.	30,590	45,880
3	400 ft.	33,320	34,835
4	400 ft.	34,157	42,824

Note. Tests 1, 2 and 4 broke in the head. Test 3 broke in the body of the bar, $12\frac{1}{4}$ in. from pin center.

Deflection and Camber

All trusses of the bridge were cambered, the amount of erection camber being such as to bring each span into straight condition under full live-load. The flexibility of the Fink trusses appears to have been rather high, as might be judged from their shallow proportions and the slight inclination of the longest truss eye-bars. The longest Fink spans, 245 ft. 5 in. in length, were tested under a train of four locomotives weighing 200 tons; the center deflection was $1\frac{3}{4}$ in. and the quarter-point deflection $1\frac{1}{4}$ in.



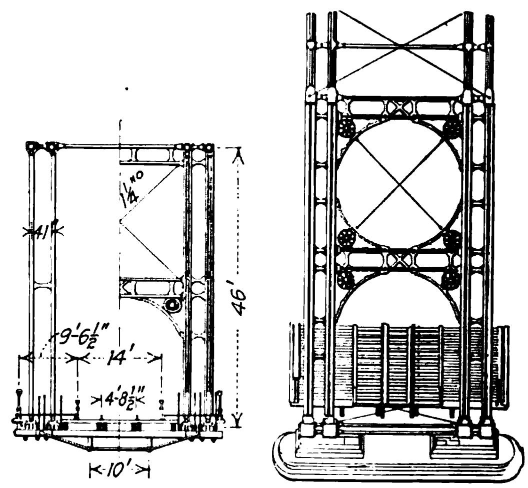


FIG. 7. INDIANA CHANNEL SPAN OF LOUISVILLE BRIDGE

As to the deflections of the through spans, no statement is found, but these may be judged from the amount of camber built in. This camber was provided by making each member shorter or longer by the amount it would extend or compress under maximum load. "In fixing the amount of camber for each span, the design has been to make it such that under a maximum load the span would be straight." But for the Fink trusses the camber was put in "by calculating the length of the chains for a length of post less than the true length by the ordinate at that point."

The camber of the two channel spans is given as 2½ in. for the 400-ft. span and 3¼ in. for the 370-ft. span. The difference presumably is due to settlement of the falsework.

Construction of the bridge began in 1867. Erection of the superstructure was started May, 1868, and finished Feb. 1, 1870. The first train ran over the bridge on Feb. 24, 1870. This was considerably behind time, due to two reasons—delay on the part of the masonry con-

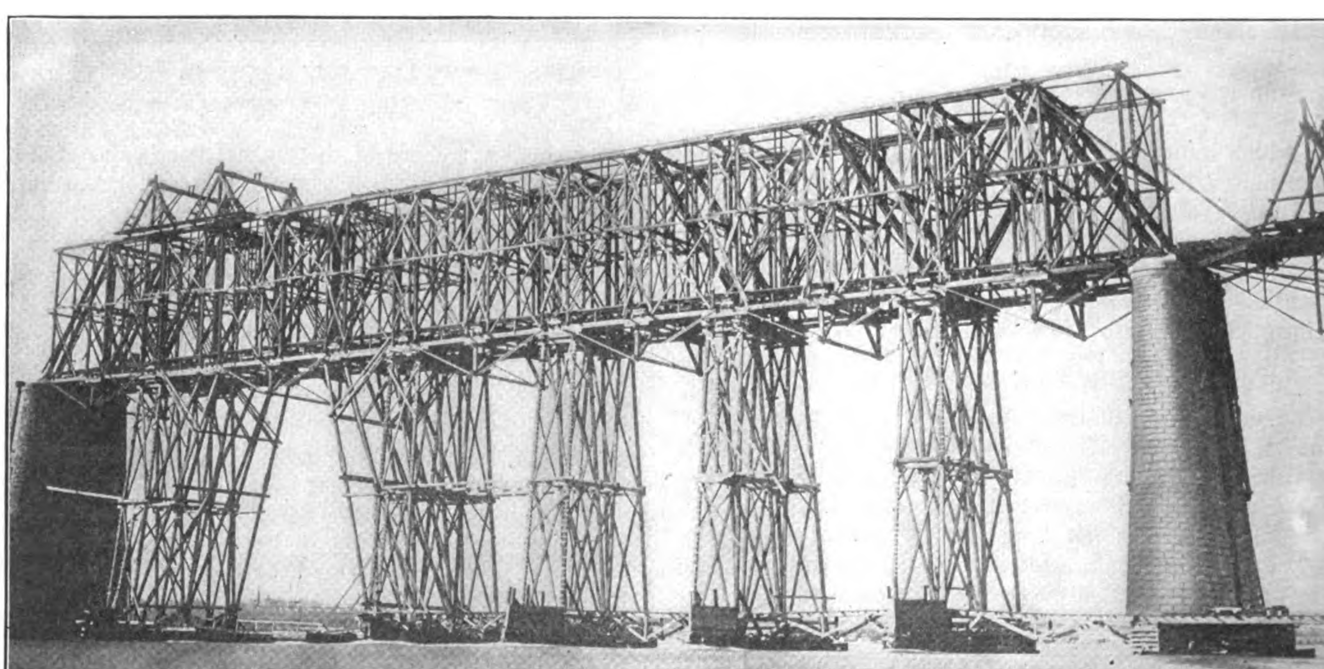


FIG. 6. FALSEWORK AND TRAVELING CRANES USED IN ERECTING THE 400-FT. THROUGH SPAN

tractor (which led to the engineers completing the work by force account) and the loss of the last steel span to be erected. The construction work is well portrayed by the original views, Figs. 5 and 6.

Construction of the Bridge

The piers all rest directly on the river bedrock. A working track supported on 6-ft. square cribs 36 to 40 ft. apart, set diagonally to the current, was bolted down into wedge fastenings in the rock by 4-in. bolts. All masonry and material were handled on this track.

Erection of the Fink spans was managed with the very simple falsework shown in Fig. 5. An elaborate enveloping falsework and scaffolding, however, was required for the through spans. Upper-chord traveling cranes, as can be seen in the photograph, handled the material for these spans.

A few figures of weight and cost may be of interest. For the entire bridge, 5261½ ft. long, the total iron weight is 8,869,000 lb., comprising the following items: Cast iron, 4,317,000 lb.; wrought iron, 3,245,000 lb.; column iron, 914,000 lb.; beam iron, 393,000 lb. In addition, the amount of timber in rail joists and crossties comprises 291,000 and 260,000 ft. b.m. The weights of four lengths of spans are as given in Table 1. The costs of the same span lengths are expressed in Table 2 and the construction cost of the whole bridge, $1,653,586.86, is itemized in Table 3. The original estimate was about 10% lower.

During the life of the bridge it was painted with one coat in 1877, one coat in 1889 and one coat in 1901, or only three coats during the 47 years from its completion up to date. All these coats (subsequent to the erection coat) consisted of straight red lead and oil, without coloring. The oil was bought raw and boiled on the job.

The last coat of paint was in splendid condition when 11 or 12 years old, which agreed with the previous experience that repainting at 10- or 12-year intervals kept the bridge in perfect shape without pitting, flaking or other defects. However, the repainting due about 1913 was omitted because plans for reconstruction were under way. The result is that, although the paint in general looks good (though rather thin), there are occasional

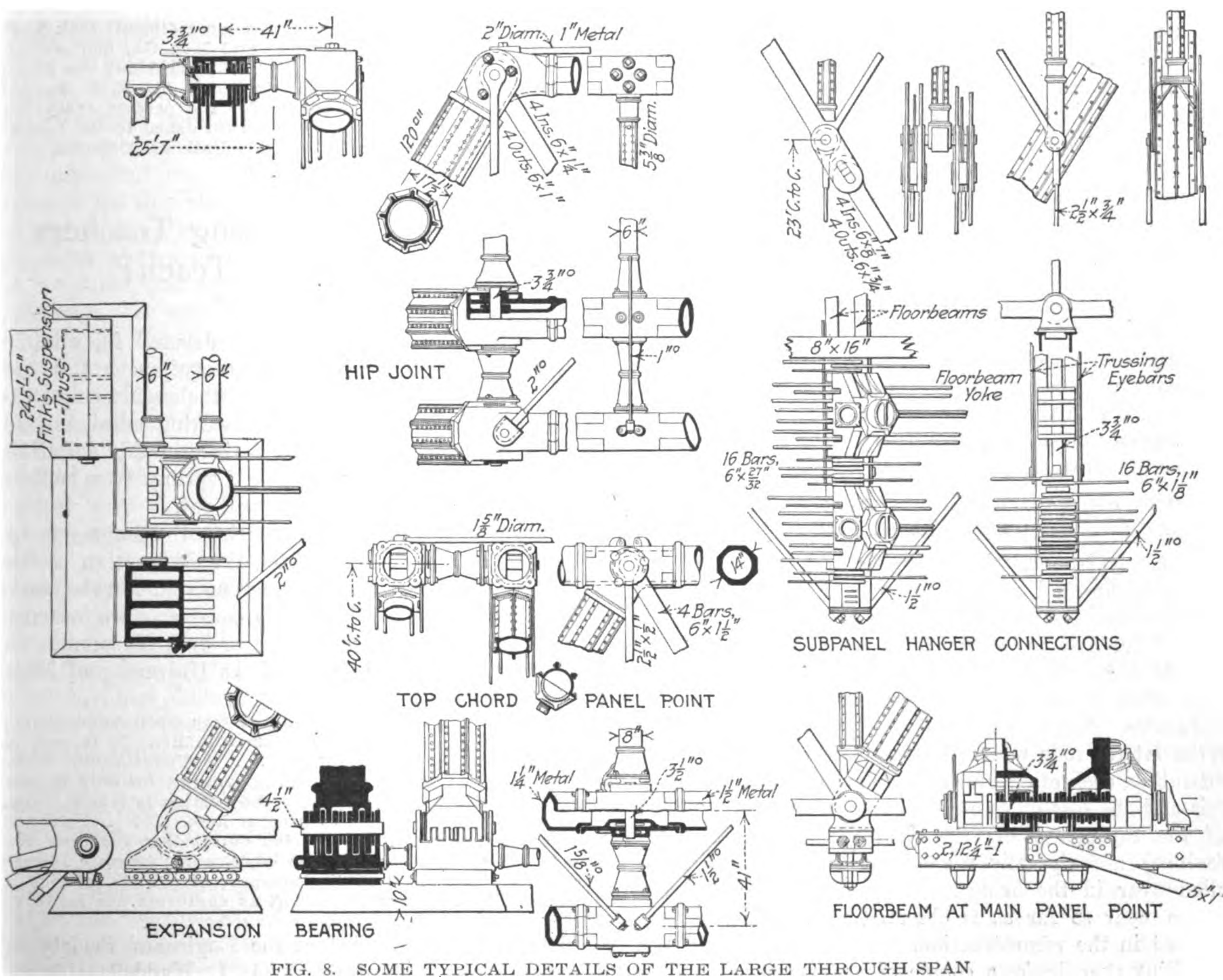


FIG. 8. SOME TYPICAL DETAILS OF THE LARGE THROUGH SPAN

TABLE 1

Span Ft.	Span In.	Cast Iron	Wrought Iron	Column Iron	Beam Iron	Total
146	10½	101,453	63,904	6,320	......	171,677
242	...	213,000	180,000	37,200	......	430,000
368	...	480,953	350,928	228,473	60,694	1,121,048
396	2¾	570,585	478,022	280,920	75,938	1,405,465

TABLE 2

Span Ft.	Span In.	Ironwork	Framing and Raising Falsework	Raising Span
146	10½	$11,758	$450	$700
242	...	30,056	2,500	2,000
368	...	87,764	5,500	4,880
396	2¾	107,995	8,500	10,070

TABLE 3

Foundation	$615,702.52
Superstructure materials	703,067.40
Raising	114,041.75
Scaffolding	76,292.79
Tools and rigging	11,135.13
Painting	12,566.72
Engineering ($45,560.97) and other expenses	120,780.55

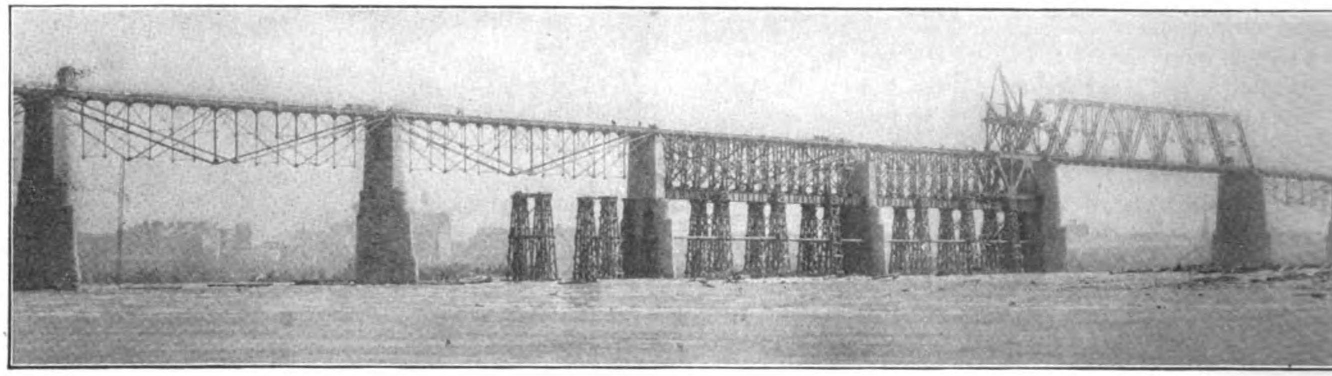


FIG. 9. PART OF THE LOUISVILLE BRIDGE AS IT APPEARS TODAY
View toward Louisville, showing Kentucky Channel span

places where flaking patches indicate that the protection is about at an end.

A most unusual proceeding was the painting of the inside of all Phœnix column members in the bridge, which was done a number of years ago. Some interior rusting of these columns had been noticed or was suspected, and the painting was decided on.

A force pump was used as the painting tool. A hose from the pump led to a perforated nozzle, which was inserted into the column through a hole at the top, lowered and raised up as the spraying proceeded. The paint was practically in brush condition. It sprayed perfectly. The pressure being high, it tended to wash the metal and took off a certain amount of rust, which was caught with the excess paint in a tub at the bottom. This was an iron oxide paint. It is still in good condition and has not lost color materially.

Bridge Shows Great Durability; Few Repairs

This bridge has existed for its entire period of life without any trouble with rivets or any replacement of rivets—an unusual experience with riveted work.

A peculiar feature of the rivets is that they were "beveled for half their length" to enable the rivet to fill the hole when upset.

All other elements of the structure have been almost as durable. There has been a slight amount of wear of the lateral rods where the two rods of a panel cross and rub on each other under the movement of the bridge. This and the loss of free movement at expansion rollers (of the through span; the deck spans slide on plate bearings) are virtually the only things that might be called wear in the bridge. There has been practically no pin wear so far as is observed in the pins already removed in the reconstruction. However, one main pin in a Fink span broke a couple of years ago and had to be replaced.

The pier masonry was repainted 18 years ago. The masonry is today in perfectly good condition and is used for the new bridge, the piers being cut down to suit.

The bridge was erected by the forces of the Louisville Bridge Co. (the owner). The ironwork was fabricated by the Louisville Bridge and Iron Co. The masonry contract was taken over by the company and carried through to completion by force account. Concerning the men in responsible charge of the work, Mr. Fink after commending F. W. Vaughan, Principal Assistant Engineer, says:

> Mr. Vaughan was ably seconded by Mr. Edwin Thacher, assistant engineer in charge of the instrumental work, and Messrs. Patrick Flannery and M. J. O'Connor, in charge of the masonry construction, and Mr. Henry Bolla, in charge of the erection of the superstructure—a most difficult task well performed. The Louisville Bridge and Iron Co., contractors for the superstructure, have faithfully carried out the plans furnished them, and great credit is due to Mr. E. Benjamin, superintendent for that company, for the perfect execution of this work. The wrought iron was furnished to the Louisville Bridge and Iron Co. by the Ohio Falls Iron Works, and satisfactorily stood the test applied.

Should Not Engineering Teachers Know How To Teach?

By A. M. Shaw*

There is a general and insistent demand for an improvement in both the intellectual equipment and the ethical standards of the members of the engineering profession and particularly of those seeking admission to its ranks. A most encouraging feature of this agitation is that the demand for improvement springs from within the profession rather than from without.

The means advocated for securing the improvement desired cover a wide range, from the elimination of the inefficient and those lacking in enthusiasm for the work to the extension of the university courses in engineering from the usual four years to five or even six years. In addressing the freshman class of the University of Minnesota, Dean Shenehon said[1]:

> Primarily, I want to congratulate you upon your choice of a profession and upon your chance in life. It is only a chance, an opportunity thus far . . . Undertaking work in the College of Engineering shows courage, for only strong men knowingly enter here where the portion is man's work. No mollycoddles may hope to prosper here. . . . I do not hesitate to tell you frankly at the outset that the task before you is not child's play nor boy's work; because if any of you does not thrill at the prospect of a stiff fight or a swift race, he is not of such stuff as engineers are made of—he is not in the right group.

In a recent address before the Engineers' Society of Western Pennsylvania,[2] Dr. J. A. L. Waddell said:

> For 30 years the speaker has been preaching the necessity of five-year courses in civil engineering. As long ago as that there was a real need for more time in order to learn the fundamentals of the general science or art of engineering as then known and understood; but since then the amount of knowledge concerning all the numerous branches thereof has increased many fold, and, consequently, the truly necessary things that an engineering student must learn today in order to obtain a proper technical training cannot be taught him in a four-year course, even if there be 11 working months in the year—as there should be when fieldwork is properly covered.
>
> In order that technical education may keep pace with engineering progress, one of two things must be done—either the engineering curricula in the universities and technical schools must be lengthened, or else they must be modi-

*Consulting Engineer, Hibernia Building, New Orleans, La.

[1]"Addresses to Engineering Students," published by Waddell & Harrington, Kansas City, Mo.

[2]"Proceedings" of the Society, Vol. 32, p. 467.

10

FOURTH ANNUAL REPORT

OF THE

LOUISVILLE BRIDGE COMPANY

FOR THE

YEAR ENDING DECEMBER 31, 1871.

FOURTH ANNUAL REPORT

OF THE

PRESIDENT AND DIRECTORS

OF THE

LOUISVILLE BRIDGE COMPANY

FOR THE

YEAR ENDING DECEMBER 31, 1871.

LOUISVILLE, KY:

PRINTED BY JOHN P. MORTON AND COMPANY, 156 WEST MAIN STREET.

1872.

OFFICERS

OF THE

LOUISVILLE BRIDGE COMPANY.

PRESIDENT:

W. B. HAMILTON.

DIRECTORS:

H. D. NEWCOMB, D. RICKETTS,
S. H. PATTERSON, W. C. DePAUW,
W. B. HAMILTON.

SECRETARY AND TREASURER:

A. A. QUARRIER.

CHIEF ENGINEER:

ALBERT FINK.

PRINCIPAL ASSISTANT ENGINEER:

F. W. VAUGHAN.

REPORT

OF THE

PRESIDENT AND DIRECTORS.

OFFICE OF PRESIDENT OF LOUISVILLE BRIDGE CO.
LOUISVILLE, KY., JANUARY 1, 1872.

TO THE STOCKHOLDERS OF THE LOUISVILLE BRIDGE CO.:

The annual report of the Company for the fiscal year ending December 31, 1871, is herewith respectfully submitted.

Table I. shows the cost of the Company's property, resources and liabilities on the 31st of December, 1871.

Table II. shows the earnings and operating expenses during the last twelve months.

Table III. is a statement of profit and loss account.

Table IV. is a statement of the revenue from freight traffic.

Table V. is a statement of the revenue from the passenger traffic.

From Table I. it appears that the net earnings during the last twelve months were		$130,378 85
The net earnings during the ten months previous were, as per last annual report		91,023 77
Total net earnings up to January 1, 1872		$221,402 62
Of this amount there has been applied to the payment of interest up to January 1, 1870, as per last annual report	$54,371 32	
For the year 1871	70,796 20 —	125,167 52
Surplus earnings up to December 31, 1871		$96,235 10

By resolution of the Board of August 14, 1871, the surplus earnings have been applied to the payment of part of the floating debt, and instead of a cash dividend a stock dividend of seven per cent. was declared out of the earnings up to September 1, 1871.

The net earnings amount to	$96,235 10
Deduct stock dividend	78,246 54
Leaves to credit of profit and loss account	$17,988 56

In order to pay off the balance of the floating debt, a call was made on the stockholders for additional subscriptions, which was responded to, and $106,227.40 were paid on this account.

On the first day of January, 1872, the amount due the Company, together with the cash on hand, would have discharged the floating debt of the Company, and have left a surplus of $7,258.79.

The Company will hereafter be able to distribute the net earnings among the stockholders in cash.

Negotiations have been in progress during the past year with the Ohio & Mississippi Railroad Company for the use of the bridge for that company.

Propositions supposed to be satisfactory have been made to that company, and, although not yet finally accepted, it is to be hoped that an agreement will be had at an early date.

During the year Messrs. H. D. Newcomb, W. C. De Pauw, S. H. Patterson, and D. Ricketts have tendered their resignations as directors of the Company, and Messrs. Thomas J. Martin, William Thaw, Thomas A. Scott, and J. N. McCullough have been elected to fill the vacancies.

I herewith submit the final report of the Chief Engineer.

Respectfully submitted.

W. B. HAMILTON, *President.*

TABLE I.

COST, RESOURCES, AND LIABILITIES.

STATEMENT SHOWING COST, RESOURCES, AND LIABILITIES OF LOUISVILLE BRIDGE COMPANY, DECEMBER 31, 1871.

COST OF BRIDGE.

Construction Account	1,653,586 86	
Right of Way	93,720 96	
Special Expense	15,000 00	
Tax Account on Real Estate during construction	2,459 83	
Interest, Discount, and Exchange during construction,	11,786 89	
Interest and Dis. on Mort. Bonds during construction	114,697 96	
Gold Premium Account during construction	10,030 58	
Interest on Capital Stock to March 1, 1870	115,536 55	
		$2,016,819 63

RESOURCES.

Depot Ground for J., M. & I. R. R.	64,409 80	
Depots, Side Tracks, and Ground	31,231 74	
J., M. & I. R. R. Co.	43,997 62	
Gold Account: Gold on hand	1,444 50	
Gold Premium Account	144 45	
Due by Individuals	776 73	
Due by L., N. A. & C. R. R. Co.	814 38	
Cash in Bank	54,563 22	
		197,328 44
		$2,214,202 07

LIABILITIES.

Capital Stock, Stock issued	1,168,800 00	
Stock Dividend, No. 2, Stock not issued	26,604 00	
Stock Subscription, No. 2, Stock not issued	106,227 40	
		1,301,631 40
Mortgage Bonds		800,000 00
Bills Payable	89,157 30	
Due Individuals	5,061 31	
December Pay-roll	363 50	
		94,582 11
Profit and Loss		17,988 56
		$2,214,202 07

A. A. QUARRIER, SECRETARY.

TABLE II.

OPERATING EXPENSES AND INCOME ACCOUNT.

DECEMBER 31, 1871.

INCOME.

Tolls from Freight, as per Table IV	130,970 83	
Tolls from Passengers, as per Table V	30,859 82	
Tolls from Foot-walks, as per Table V	4,828 90	
Gross Earnings		166,659 55

OPERATING EXPENSES.

Track on Bridge	35 50	
Repairs of Track between L. & N. Depot and Main Street	459 39	
Repairs of Cross-ties	40 00	
Salaries	6,344 92	
Watching and Inspecting Bridge	3,395 13	
Collecting Tolls	958 02	
Office Expenses	800 58	
Transferring Passengers bet. Louisville and Jeffersonville	18 25	
Repairs of Foot-walk and Hand-railings	504 75	
General Expenses	831 15	
Transferring by L. & N. R. R.	11,804 16	
Tax Account	11,027 45	
Advertising	61 40	
		36,280 70
Net Earnings		$130,378 85
Interest on Mortgage Bonds	56,835 52	
Interest, Discount, and Exchange	10,569 76	
Gold Premium Account	3,390 92	
		70,796 20
Net Earnings, after deducting Interest, etc		$59,582 65

A. A. QUARRIER, SECRETARY.

TABLE III.

PROFIT AND LOSS ACCOUNT.

Amount of Account, per Table I., for Fiscal Year ending Dec. 31, 1870	36,652 45	
Gross Earnings, per Table II., Dec. 31, 1871	166,659 55	
		$203,331 00
Operating Expenses, as per Table II., Dec. 1871	36,280 70	
Interest, etc., Account, as per Table II., Dec., 1871	70,796 20	
Seven Per-cent. Stock Dividend	78,246 54	
		185,323 44
Balance to Credit of Profit and Loss, Dec. 31, 1871, as per Table I.		$17,988 56

A. A. QUARRIER, SECRETARY.

TABLE IV.

REVENUE FROM FREIGHT TRAFFIC.

STATEMENT SHOWING REVENUE FROM FREIGHT TRAFFIC FOR THE YEAR ENDING DECEMBER 31, 1871.

NORTH BOUND FREIGHT.

1871.	Pounds at 4 cents.	Pounds at 3 cents.	Pounds at 2½ cts.	Pounds at 2 cents.	Pounds at 1½ cents.	No. Cars at $6.	No. Cars at $5.	No. Cars at $4.	No. Cars at $3.
January	....	13,650,097	....	13,468	....	.....	.....	.....	.....
February	....	13,695,174	40,967	....	....	.....	43	23	22
March	....	13,003,960	22,387	....	....	.....	29	13	32
April	....	11,864,785	120,303	....	....	1	16	10	52
May	....	8,535,894	529,825	60,550	....	.....	26	28	7
June	13,597	9,358,794	787,156	....	....	.....	29	8	14
July	....	9,463,666	682,572	....	....	.....	49	32	14
August	....	6,254,889	45,357	....	....	3	25	16	31
September	....	6,169,580	104,736	....	....	1	47	45	31
October	....	12,251,485	310,725	....	3,500	3	51	29	21
November	....	13,465,063	284,274	251,520	1 Loco., $17.50	8	* 117	93	15
December	....	11,665,064	485,523	....	1 Loco., $17.50	7	86	115	14
Total	13,597	129,378,451	3,413,825	325,538	3,500	23	518	412	252

* 14 at $5.25.

SOUTH BOUND FREIGHT.

1871.	Pounds at 4 cents.	Pounds at 3 cents.	Pounds at 2½ cts.	Pounds at 2 cents.	Pounds at 1½ cts.	Loco. and Tenders at $17.50.	Pass. Cars at $12.50.	No. Cars at $6.	No. Cars at $5.	No. Cars at $4.	No. Cars at $3.
January	....	8,443,816	....	4,996,070	....	.....	....	....	....	....	....
February	....	9,132,040	....	1,330,007	....	9	....	57	387	....	40
March	....	10,129,185	....	1,793,104	....	6	2	102	237	....	70
April	766,925	6,763,270	....	1,282,095	....	6	2	50	199	....	44
May	553,261	7,063,472	....	934,168	....	5	2	70	235	....	47
June	....	5,855,099	1,519,619	1,709,652	....	......	4	33	255	....	51
July	....	7,389,132	3,358,535	3,098,223	....	......	2	26	284	1	17
August	....	13,247,836	1,596,585	2,875,385	....	19	....	7	368	4	137
September	....	17,402,164	641,085	4,844,732	....	6	4	47	363	2	68
October	....	14,056,161	....	3,597,765	104,545	11	....	8	369	....	44
November	....	15,772,862	648,364	950,142	....	4	7	51	266	22	326
December	....	14,940,757	875,122	* 420,496	....	2	2	61	130	2	468
Total	1,320,186	130,195,794	8,639,310	27,834,839	104,545	68	25	512	3093	31	1312

* At 2¼ cents.

1871.	SPECIALS.		Total.	Collected from L., N. A. & C. R. R.	GRAND TOTAL.
	North.	South.			
January	394 00	1,710 60	9,758 92	252 96	10,011 88
February	....	....	10,052 50	448 10	10,500 60
March	....	41 00	9,775 17	728 87	10,504 04
April	....	126 55	7,997 24	981 11	8,978 35
May	9 98	14 00	7,393 99	832 11	8,226 10
June	22 50	143 90	7,541 63	889 28	8,430 91
July	2 60	121 59	8,880 94	976 39	9,857 33
August	48 11	186 45	9,837 35	1,334 94	11,172 29
September	....	....	11,409 72	1,190 15	12,599 87
October	....	....	11,893 30	1,072 90	12,966 20
November	78 00	403 90	13,657 27	950 90	14,608 17
December	....	407 70	12,300 71	814 38	13,115 09
Total	$555 19	$3,155 69	$120,582 74	$10,472 09	$130,970 83

A. A. QUARRIER, SECRETARY.

TABLE V.

REVENUE FROM PASSENGER TRAFFIC.

STATEMENT SHOWING REVENUE FROM PASSENGER TRAFFIC FOR THE YEAR ENDING DECEMBER 31, 1871.

1871.	No. of Passeng'rs at 50 cts.	Amount.	No. of Passeng'rs at 25 cts.	Amount.	Conductors' Collect's.		Local Business. Amount.	Commis-sions deducted	Total No. Passen-gers.	Total Amount.	Foot-Walks. Tolls.	GRAND TOTAL.
					No. Pas-sengers.	Amount.						
January	2,806½	1,403 25	1,366	341 50	150	37 50	307 48	5 14	....	2,084 59	483 25	2,567 84
February	2,752	1,376 00	1,018½	254 63	107	26 75	225 26	5 03	....	1,877 61	430 60	2,318 21
March	3,566	1,783 00	1,178	294 50	123	30 75	299 71	6 16	....	2,401 80	763 20	3,165 00
April	2,802½	1,401 25	1,467	366 96	83½	20 87	281 23	6 26	....	2,064 05	746 25	2,810 30
May	3,438	1,719 00	1,023½	255 87	70½	17 62	321 94	7 02	....	2,307 41	358 50	2,665 91
June	3,385½	1,692 75	1,244	311 00	123½	30 87	445 23	7 95	....	2,471 90	258 35	2,730 25
July	3,295½	1,647 75	1,368½	342 12	122½	30 62	508 74	6 23	....	2,523 00	326 85	2,849 85
August	3,937	1,968 50	1,812½	453 12	114½	28 62	359 97	7 88	....	2,802 33	287 35	3,089 68
September	4,974	2,487 00	1,317	329 25	134½	33 62	470 00	9 66	....	3,310 21	347 85	3,658 06
October	5,276½	2,638 25	1,312½	328 12	142	35 50	489 73	10 53	....	3,481 07	400 60	3,881 67
November	3,666½	1,833 25	1,224½	306 11	85	21 37	458 33	7 82	....	2,611 24	276 50	2,887 74
December	3,062	1,531 00	1,247½	311 87	111½	27 87	382 49	4 52	....	2,248 71	149 60	2,398 31
Supplementary Account	11	5 50	61	15 25	....	....	108 40	....	....	129 15	....	129 15
Louisville & Nashville R. R.	....	....	2,187	546 75	....	....	....	....	....	546 75	....	546 75
Total	43,153	$21,486 50	17,827½	4,457 05	1,368½	$341 96	$4,658 51	$84 20	62,348	$30,859 82	$4,828 90	$35,688 72

A. A. QUARRIER, SECRETARY.

REPORT

OF THE

CHIEF ENGINEER.

OFFICE OF CHIEF ENGINEER OF LOUISVILLE BRIDGE CO.
LOUISVILLE, JANUARY 1, 1872.

W. B. HAMILTON, *President Louisville Bridge Company:*

SIR,—I herewith submit a final report of the cost of the bridge.

According to the Secretary's statement, the total cash cost of the bridge up to January 1, 1872, has been $1,653,586.86, which includes the cost of the connecting track between the bridge and the Louisville & Nashville Railroad depot.

Table I. shows a detailed statement of the cost of the bridge.

Table II. shows a detailed statement of the cost of the masonry.

Table III. shows the cost of that part of the masonry that was laid under the superintendence of the Bridge Company after the work had been taken out of the hands of the contractors. Of the 29,779 cubic yards of masonry in the bridge $11,945\frac{8}{10}$ yards were laid under the contract, the remainder by the Bridge Company.

Table IV. shows the dimensions and quantity of masonry in piers.

Table V. contains a general statement of the cost of the bridge superstructure, and Tables VI. and VII. detailed statements of the cost.

Table VIII. is a detailed statement of the quantities of material in superstructure.

These statements give a full exhibit of the cost of the work, and show in all particulars for what purpose, and how the Company's money had been expended.

The estimated cost of the bridge, as per my first report, dated January 1, 1868, was $1,500,000. The estimate had been based upon the actual contract price for masonry ($14.90 per yard); but in September, 1868, it was found that the contractors did not use sufficient energy and did not apply adequate means to insure the completion of their contract in the time specified, and hence I was obliged to recommend to the Board that the work be taken out of the hands of the contractors, and be carried on by the Company's forces. This was done. A series of extraordinary freshets occurred in September and October, 1868, which swept away all the preparations made by the contractors (derricks, temporary tracks, etc.), and the necessity of the renewal of the same, and carrying on the work under great disadvantage at the late season of the year, greatly added to the cost; but as the alternative was presented either to delay the completion of the bridge a year beyond the time contemplated, or to carry on the work regardless of economy, singly with the view of completing the bridge in the working season of 1869, it was thought better to incur the additional expense.

The increased cost is further accounted for in part by a change in the plan. A 400-feet span over the Indiana chute was substituted in place of one of 370 feet, as contemplated in the original plan.

An increase in cost was also occasioned by the accidental destruction of the false work that had been erected in the early part of December, 1869, for the last span of the bridge that remained to be put up at that time next to the Indiana chute. It would have required only one week to have completed the bridge when a freshet came, and made it unsafe to continue the erection of the iron work.

The freshet, however, had commenced to subside, leaving the false work uninjured, when a flat-boat ran against it and knocked it out. This was on the 7th of December, 1869.

The current in the river at the place where this span was to be erected is very swift; the river was high, and extraordinary expenses had to be incurred to put the superstructure in place, or otherwise to submit to a delay of six months in the completion of the bridge.

Had it not been for this unfortunate accident the bridge would have been completed in December, 1869, as originally contemplated. As it was, the connection of the superstructure between the two shores was made on the 1st of February, 1870, and the bridge thrown open to the public February 24, 1870.

Although my official connection with the Bridge Company ceased soon after the completion of the bridge (on the first of March, 1870), I promised to render this, the final report on the cost of the bridge.

I desire to avail myself of this opportunity to put on record an official acknowledgment of the valuable services rendered by Mr. F. W. VAUGHAN, principal assistant engineer, under whose immediate supervision the work has been carried out. After the masonry contract had been taken out of the hands of the contractors, it devolved upon Mr. VAUGHAN to superintend this work, in addition to attending to his other engineering duties. I take great pleasure in testifying to the untiring energy, industry, and watchfulness with which Mr. VAUGHAN devoted himself to the interests of the Company, as well as to his great skill and good judgment as an engineer.

Mr. VAUGHAN was ably seconded by Mr. EDWIN THACHER, assistant engineer, in charge of the instrumental work, and Messrs. PATRICK FLANNERY and M. J. O'CONNOR, in charge of the masonry construction, and Mr. HENRY BOLLA, in charge of the erection of the superstructure—a most difficult task well performed.

The Louisville Bridge and Iron Company, contractors for the iron superstructure, have faithfully carried out the plans furnished them, and great credit is due to Mr. E. BENJAMIN, superintendent for that company, for the perfect execution of this work.

The wrought iron was furnished to the Louisville Bridge and Iron Company by the Ohio Falls Iron Works, and satisfactorily stood the test applied.

The bridge has now been completed and in use for nearly two years, and has stood during that time as severe a test as it can ever be subjected to.

Experience so far has not developed any defect either in plan or execution.

All of which is respectfully submitted.

ALBERT FINK, *Chief Engineer.*

TABLE I.

GENERAL STATEMENT OF THE COST OF CONSTRUCTION OHIO RIVER BRIDGE.

HEADINGS OF ACCOUNTS.	Net amounts chargeable.	General summary.	Total.
Foundations	30,018.49		
Bridge masonry	569,844.18		
Cement	15,839.85		
		615,702.52	
Superstructure material	703,067.40		
Raising superstructure	114,041.75		
Scaffolding	76,292.79		
Tools and rigging	11,135.13		
Painting	12,566.72		
		917,103.79	
Advertising	1,454.48		
Gratuity to workmen	2,625.00		
Engineering	45,560.97		
Graduation	6,066.74		
General expense	28,987.70		
Law Expenses	5,306.52		
Office fixtures	896.64		
Railway track, Kentucky side	22,497.93		
Street paving	4,000.00		
Stationery	1,180.92		
Toll-houses	365.15		
Watching canal draw	1,838.50		
		120,780.55	
			1,653,586.86

TABLE II.

GENERAL STATEMENT OF THE COST OF MASONRY OHIO RIVER BRIDGE.

HEADINGS OF ACCOUNTS	Purchased from contractor at transfer of work..........	Purchas'd since transfer of work.........	Total amount expended...........	Credits from all sources..........	Net amount chargeable up to Dec. 31, 1871............
Auxiliary arrangements......	973.24	13,789.76	14,763.00	6,474.00	8,289.00
Bardstown quarry expenses..	....	....	18,406.69	4,167.03	14,239.66
Utica quarry expenses.......	....	....	19,852.96	402.78	19,450.18
Cutting Bardstown stone.....	....	....	55,539.39	....	55,539.39
Cutting Utica stone	....	....	24,050.33	....	24,050.33
Freight on stone from Bardstown quarry......	....	....	22,581.48	4,717.10	17,864.38
Freight on stone from Utica quarry	....	....	7,579.91	99.00	7,480.91
Tools for cutting stone.......	503.18	435.28	938.46	110.75	827.71
Hauling stone to piers........	....	....	20,061.01	506.50	19,554.51
Hauling stone from Jeff. Landing to Bridge......	....	....	3,066.02	....	3,066.02
Team account, Louisville ...	203.96	7,171.80	7,375.76	894.30	6,481.46
Team account, Jeffersonville	....	....	2,289.43	13.11	2,276.32
Horses, wagons, carts, cars, and harness.......	11,578.27	2,118.08	13,696.35	7,542.83	6,153.52
Laying stone, Ky. side.......	....	....	33,567.83	....	33,567.83
Laying stone, Indiana side..	....	....	13,673.83	....	13,673.83
Tools for laying stone........	213.67	411.53	625.20	....	625.20
Derrick materials.............	18,435.65	14,492.61	32,928.26	8,690.04	24,238.22
Derrick boats	149.22	12,700.06	12,849.28	2.00	12,847.28
Raising and moving derricks	....	....	7,993.21	....	7,993.21
Tracks and trestles............	904.70	11,923.11	12,832,81	81.57	12,751.24
General tools..................	2,245.28	2,246.93	4,492.21	286.58	4,205.63
Pointing piers.................	....	....	1,382.68	....	1,382.68
Rip-rap.........................	....	....	548.68	....	548.68
Salvage	....	....	1,948,92	9.75	1,939.17
Sand............................	....	....	1,232.40	....	1,232,40
Masonry—general expense..	....	....	17,300.27	1,398.59	15,901.68
Contractor's final estimate...	....	....	253,663.74	....	253,663.74
Total.......................	35,207.17	65,289.16	605,240.11	35,395.93	569,844.18

TABLE III.

DETAILED STATEMENT OF THE COST OF MASONRY OHIO RIVER BRIDGE.

	Bardstown Masonry.		Utica Masonry.		Total cost of Masonry from Bardstown Quarry.	Total cost of Masonry from Utica Quarry.	Total Expenditures for Masonry.	Bardstown stone, 10195.1 cu. yds. laid. Cost per cubic yard.	Utica stone, 7,638.1 c. yds. laid. Cost per cubic yard.
	Net expenditures since Sept. 17, 1868.	Bought of Contractors.	Net expenditures since Sept. 17, 1868.	Bought of Contractors.					
Auxiliary Arrangements	4,738 00		3,551 00		4,738 00	3,551 00	8,289 00	46.4	46.4
Bardstown Quarry Expenses	14,239 66	9,698 00			23,937 66		23,937 66	2 34.8	
Utica Quarry Expenses			19,450 18	35,965 00		55,415 18	55,415 18		7 25.5
Cutting Bardstown Stone	55,539 39	4,621 00			60,160 39		60,160 39	5 90.0	
Cutting Utica Stone			24,050 33	22,364 00		46,414 33	46,414 33		6 07.7
Laying Bardstown Stone	26,114 83				26,114 83		26,114 83	2 56.1	
Laying Utica Stone			21,126 83			21,126 83	21,126 83		2 76.6
Fr't on Stone from Bardst'n Quar.	17,864 38	5,323 00			23,187 38		23,187 38	2 27.4	
Fr't on Stone from Utica Quarry			7,480 91	1,453 40		8,934 31	8,934 31		1 17.0
Team Account Bardstown Stone	5,218 46				5,218 46		5,218 46	51.2	
Team Account Utica Stone			3,539 32			3,539 32	3,539 32		46.3
Hauling Bardstown Stone to Piers	14,944 30				14,944 30		14,944 30	1 47.2	
Hauling Utica Stone to Piers			7,676 23			7,676 23	7,676 23		1 00.4
Derrick Materials	13,869 21		10,369 01		13,869 21	10,369 01	24,238 22	1 36.0	1 35.8
Raising and moving Derricks	4,573 87		3,419 34		4,573 87	3,419 34	7,993 21	44.8	44.8
Derrick Boats	7,351 49		5,495 79				12,847 28	72.1	72.1
General Tools	2,406 54		1,799 09		2,406 54	1,799 09	4,205 63	23.5	23.5
Tools for cutting Stone	473 61		354 10		473 61	354 10	827 71	4.6	4.6
Tools for laying Stone	357 74		267 46		357 74	267 46	625 20	3.5	3.5
Horses, Wagons, Carts, Cars, etc.	3,521 00		2,632 53		3,521 00	2,632 52	6,153 52	34.5	34.5
Masonry, General Expense	9,099 26		6,802 42		9,099 26	6,802 42	15,901 68	89.2	89.0
Pointing Piers	790 48		592 20		790 48	592 20	1,382 68	7.8	7.8
Salvage	1,109 62		829 55		1,109 62	829 55	1,939 17	10.8	10.8
Sand	705 19		527 21		705 19	527 21	1,232 40	6.9	6.9
Tracks and Trestles	7,296 53		5,454 71		7,296 53	5,454 71	12,751 24	71.5	71.5
Rip-rap							548 69		
Total for Company's Work	$190,213 56	$19,642 00	$125,418 20	$59,782 40	$209,855 56	$185,200 60	$395,604 84	$20 58.3	$24 24.7
Contractors' Final Estimate for 11,945.8 cubic yards Finished Masonry							174,239 34		
Total Cost of Masonry, 29,779 cubic yards							$569,844 18		
Average Cost per cubic yard of entire Work							19 14		

TABLE IV.

STATEMENT SHOWING DIMENSIONS AND QUANTITY OF MASONRY IN PIERS OHIO RIVER BRIDGE.

Number of Pier.	Hight from Foundation to top of Block	Size under Coping.	Total Masonry laid by Contractors.	Total Masonry laid by Bridge Co.	Total Number of Cubic Yards in Masonry. Rubble. Bardst'n.	Rubble. Utica.	Shore. Bardst'n.	Shore. Utica.	River. Bardstown.	River. Utica.	River. Bedford.	Total.
Kentucky Abutment	31.0	37.5x69.0	1,146.9		802.1		344.8					1,146.9
0	42.1	5.0x21.0	230.4		96.2		134.2					230.4
1	56.0	6.5x21.0	393.0				393.0					393.0
2	37.7	29.0 diam.	923.0				923.0					923.0
3	59.4	6.5x21.0	574.7						574.7			574.7
4	63.4	6.0x21.0	566.3						566.3			566.3
5	66.1	6.0x21.0	634.4						634.4			634.4
6	66.6	6.0x21.0	639.7						639.7			639.7
7	70.5	6.0x21.0	691.4						691.4			691.4
8	74.8	6.0x21.0	753.4						753.4			753.4
9	77.8	6.0x21.0	507.4	283.0					790.4			790.4
10	80.5	6.0x21.0	335.0	495.4					637.0	193.4		830.4
11	80.9	6.0x21.0	324.0	488.0					538.0	274.0		812.0
12	87.3	6.0x21.0	251.4	678.1					678.1	251.4		929.5
13	90.5	10.4x33.4	833.6	1,367.1					1,211.9	932.3	56.5	2,200.7
14	93.3	10.4x33.4	456.6	1,844.8					1,036.4	1,208.0	57.0	2,301.4
15	93.1	7.0x21.0		1,150.7					849.4	301.3		1,150.7
16	92.4	7.0x21.0		1,127.5					721.9	405.6		1,127.5
17	94.2	7.0x21.0		1,182.5					205.4	977.1		1,182.5
18	97.7	7.0x21.0	240.3	1.039.3					958.6	321.0		1,279.6
19	97.9	7.0x21.0	180.0	1,087.5					1,096.4	171.1		1,267.5
20	100.0	10.4x33.4	223.0	2,408.5					1,976.0	598.5	57.0	2,631.5
21	96.7	10.4x33.4	126.0	2,321.2						2,390.2	57.0	2,447.2
22	89.8	6.0x21.0	286.8	686.0						972.8		972.8
23	86.0	6.0x21.0	605.8	303.1						908.9		908.9
24	74.5	6.0x21.0	725.2							725.2		725.2
25	45.4	6.0x21.0	297.5			91.4		206.1				297.5
Indiana Abutment	38.4	37.5x69.0		1,370.5	96.7	728.6	100.0	445.2				1,370.5
			11,945.8	17,833.2	995.0	820.0	1,895.0	651.3	14,559.4	10,630.8	227.5	29,779.0

TABLE V.

GENERAL STATEMENT OF THE COST OF SUPERSTRUCTURE OHIO RIVER BRIDGE.

DETAIL CLASSIFICATION.	Material.	Labor.	Framing	Raising.	Framing and Raising.	Con-struction	Re-moval.	Painting.		Total Cost.	General Classification.	Total Cost.
								Material	Labor.			
Iron for Superstructure	$648,967.89							$5,040.82	$4,162.36	$658,171.07		
Rail-joist	10,423.15		$3,180.60					367.85	190.37	14,161.97		
Cross-ties	7,178.26		1,392.46					551.77	285.55	9,408 04		
Guard-rail	1,936.17	$1,563.35						92.03	47.61	3,639.16		
Track on Bridge	9,325.15	1,914.81								11,239.96		
Foot-walks	12,338.36	7,242.00								19,580.36		
Outside Hand-rail	10,194.76	2,037.73						870.02	562.02	13,664.53		
Inside Hand-rail	2,503.66	1,480.04						231.23	165.09	4,380.02		
Raising Superstructure										47,159.33		
False Work			4,473.52	34,214.19	$2,257.95					40,945.66	Material for super-	
Second False Work, Span No. 17			1,022.02	5,753.75						6,775.77	[structure.	$703,067.40
Horses, Wagons, Carts, Cars, and Harness										150.00	Labor raising "	114,041.75
Team Account, Louisville										400.00	Painting.	12,566.72
Second Cribbing for F. Work, Span No. 17						$2,970.70	$87.01			3,057.71		
Cribs for False Work, 400-feet Span						6,322.20	1,218.26			7,540.46		
False Work Material, and Cribs										55,044.20		
Tracks and Trestles										9,699.07		
Horses, Wagons, Carts, Cars, and Harness										250.00		
Team Account, Louisville										530.75		
Salvage										170.60	Scaffolding.	76,292.79
Tools and Rigging										11,135.13	Tools and rigging.	11,135.13
Total										917,103.79		917,103.79

TABLE VI.

DETAILED STATEMENT OF THE COST OF SUPERSTRUCTURE OHIO RIVER BRIDGE.

NUMBER OF SPAN.	Span from centre to centre of Piers.	Iron Work.	False Work.			Super-struct're	Rail-joist.		Cross-ties.		Guard-rail.		Foot-walks.	
			Framing	Raising.	Framing and Raising.	Raising.	Material	Framing	Material	Framing	Material	Labor.	Material	Labor.
	feet. in.													
Kentucky Abutment	16—3						$31.27	$9.54	$18.13	$4.18	$5.80	$4.69	$37.01	$21.73
Kentucky Abutment	16—3						31.27	9.54	18.13	4.18	5.80	4.69	37.01	21.73
Shore Spans	50—0	$1,920.48			$71.50	$196.15			149.92	13.50	18.78	15.17	111.04	65.18
Shore Spans	50—0	1,920.48			71.85	196.24			149.92	13.50	18.78	15.17	111.04	65.18
Canal Draw	264—0	39,267.30			1,727.19	5,756.77			835.18	69.35	96.42	77.92	616.92	362.10
No. 1	149—7¼	11,757.60	$122.75	$398.35		759.10	312.69	95.42	181.30	39.26	54.60	44.08	345.47	202.78
No. 2	149—7¼	11,757.60	40.62	410.06		752.40	312.69	95.42	181.30	39.26	54.60	44.08	345.47	202.78
No. 3	149—7¼	11,757.60	65.68	382.19		549.57	312.69	95.42	181.30	39.26	54.60	44.08	345.47	202.78
No. 4	149—7¼	11,279.22	43.67	259.74		700.65	312.69	95.42	181.30	39.26	54.60	44.08	345.47	202.78
No. 5	180—0	15,306.25	129.27	691.52		880.81	385.66	117.68	223.60	47.34	65.83	53.15	419.50	246.23
No. 6	180—0	14,638.81	92.07	584.35		802.80	385.66	117.68	223.60	47.34	65.83	53.15	419.50	246.23
No. 7	210—0	21,088,76	128.19	923.71		1,143.20	437.77	133.58	253.82	55.14	76.67	61.90	493.53	289.68
No. 8	210—0	21,088.77	66.67	809.36		1,166.48	437.77	133.58	253.82	55.14	76.67	61.90	493.53	289.68
No. 9	227—0	24,550.15		992.42		1,305.82	479.46	146.31	277.99	59.73	83.06	67.06	530.55	311.40
No. 10	227—0	24,550.15	198.18	1,426.88		1,459.86	479.46	146.31	277.99	59.73	83.06	67.06	530.55	311.40
No. 11	370—0	87,763.56	1,086.42	4,467.99		4,880.64	781.73	238.54	453.24	97.25	135.15	109.22	863.68	506.94
No. 12	245—6	30,056.08	416.37	2,077.43		2,272.80	521.16	159.03	302.16	64.61	89.84	72.54	567.56	333.13
No. 13	245—6	30,056.08		1,448.19		1,650.72	521.16	159.03	302.16	64.61	89.84	72.54	567.56	333.13
No. 14	245—6	30,056.08	114.70	2,359.47		2,085.09	521.16	159.03	302.16	64.61	89.84	72.54	567.56	333.13
No. 15	245—6	30,056.08	119.03	1,621.58		2,593.71	521.16	159.03	302.16	64.61	89.84	72.54	567.56	333.13
No. 16	245—6	30,056.09	462.06	2,992.35		2,021.32	521.16	159.03	302.16	64.61	89.84	72.54	567.56	333.13
No. 17	245—6	30,056.09		2,576.20		1,879.04	521.16	159.03	302.16	64.61	89.84	72.54	567.56	333.13
No. 18	400—0	107,995.13	843.03	7,602.19		10,070.48	854.70	260.81	495.54	105.19	146.24	118.15	974.85	572.12
No. 19	180—0	14,638.81	343.30	472.81		832.04	385.66	117.68	223.60	47.34	65.83	53.15	419.50	246.23
No. 20	180—0	14,638.82	27.76	757.09		1,031.39	385.66	117.68	223.60	47.34	65.83	53.15	419.50	246.23
No. 21	180—0	14,638.83	135.57	623.67		771.78	385.66	117.68	223.60	47.34	65.83	53.15	419.50	246.23
No. 22	149—7¼	11,279.23	38.18	336.64		784.78	312.69	95.42	181.30	39.26	54.60	44.08	345.47	202.78
No. 23	100—0	5,881.78			387.41	509.87	208.46	63.61	120.86	26.28	36.55	29.51	234.42	137.59
Indiana Abutment	32—6	912.06				105.82	62.55	19.10	36.26	8.63	12.00	9.52	74.02	43.44
Total	5,294—0¼	648,967.89	4,473.52	34,214.19	2,257.95	47,159.33	10,423.15	3,180.60	7,178.26	1,392.46	1,936.17	1,563.35	12,338.36	7,242.00

TABLE VI. DETAILED STATEMENT OF THE COST OF SUPERSTRUCTURE OHIO RIVER BRIDGE—Continued.

NUMBER OF SPAN.	HAND-RAIL.				PAINTING.												TOTAL COST.
	Outside.		Inside.		IRON WORK.		RAIL-JOISTS.		CROSS-TIES.		GUARD-RAIL.		HAND-RAIL. Outside.		HAND-RAIL. Inside.		
	Material	Labor.	Material	Labor.	Material	Labor.	Material.	Labor	Material.	Labor	Material.	Labor	Material.	Labor	Material.	Labor	
Kentucky Abutment	$30.58	$6.11	$7.51	$4.44	....	....	$1.10	$0.57	$1.41	$0.72	$0.27	$0.14	$2.61	$1.68	$0.69	$0.49	$190.67
Kentucky Abutment	30.58	6.11	7.51	4.44	....	....	1.10	0.57	1.41	0.72	0.27	0.14	2.61	1.68	0.69	0.49	190 67
Shore Spans	91.75	18.34	22.53	13.32	$8.77	$7.25	....	....	11.00	6.00	0.89	0.46	7.83	5.06	2.08	1.49	2,758.49
Shore Spans	91.75	18.34	22.53	13.32	8.77	7.00	....	....	11.00	6.00	0.89	0.46	7.83	5.06	2.08	1.49	2,758.68
Canal Draw	509.74	101.89	125.18	74.00	258.95	210.23	....	....	60.00	33.55	4.51	2.37	43.50	28.10	11.56	8.25	50,280.98
No. 1	285.45	57.06	70.10	41.44	88.00	97.06	11.04	5.71	14.09	7.20	2.60	1.34	24.36	15.74	6.47	4.62	15,045.68
No. 2	285.45	57.06	70.10	41.44	88.00	66.77	11 04	5.71	14.09	7.20	2.60	1.34	24.36	15.74	6.47	4.62	14,938 27
No. 3	285.45	57.06	70.10	41.44	88.00	66.89	11.04	5 71	14.09	7.20	2.60	1.34	24.36	15.74	6.47	4.62	14,732.75
No. 4	285.45	57.06	70.10	41.44	88.00	80.41	11.04	5.71	14.09	7.20	2.60	1.34	24.36	15.74	6.47	4.62	14,274.51
No. 5	346.62	69.28	85.12	50.32	99.92	104.80	13.61	7.04	17 38	8.88	3.13	1.62	29.58	19.11	7.86	5.61	19,436.72
No. 6	346.62	69.28	85.12	50.32	99.92	64.80	13.61	7.04	17.38	8.88	3.13	1.62	29.58	19.11	7.86	5.61	18,506.90
No. 7	407.79	81.51	100.15	59.20	168.86	146.49	15.45	7.99	19.73	10.08	3.64	1.88	34.80	22.48	9.25	6.60	26,181.85
No. 8	407.79	81.51	100.15	59.20	168.86	132.75	15.45	7.99	19.73	10.08	3.64	1.88	34.80	22.48	9 25	6.60	26,015.53
No. 9	438.37	87.62	107.66	63.64	173.15	139.43	16.92	8.76	21.61	11.04	3.94	2.05	37.41	24.17	9.94	7.10	29,956.76
No. 10	438.37	87.62	107.66	63.64	173.15	146.99	16.92	8.76	21.61	11.04	3.94	2.05	37.41	24.17	9.94	7.10	30,751.00
No. 11	713.63	142.64	175.26	103.60	924.34	763.77	27.59	14.28	35.23	18 00	6.45	3.32	60.90	39.34	16.19	11.56	104,440.46
No. 12	468.96	93.73	115.17	68.08	218.17	185.70	18.39	9.52	23.49	12.00	4.27	2.20	40.02	25.85	10.64	7.59	38,236.49
No. 13	468.96	93.73	115.17	68.08	218.43	185 70	18.39	9 52	23.49	12.00	4.27	2.20	40.02	25.85	10.64	7.59	36,569.06
No. 14	468.96	93.73	115.17	68 08	218.43	177.05	18.39	9.52	23.49	12.00	4.27	2.20	40.02	25.85	10.64	7.59	38,020.76
No. 15	468.96	93.73	115.17	68.08	218.43	177.05	18.39	9.52	23.49	12.00	4.27	2.21	40.02	25.85	10.64	7.59	37,795.83
No. 16	468.96	93.73	115.17	68.08	218.43	180.55	18.39	9.52	23.49	12.00	4.27	2.21	40.02	25.85	10.64	7.59	38,940.75
No. 17	468.96	93.73	115.17	68.08	218.43	177.05	18.39	9.52	23.49	12.00	4.27	2.21	40.02	25.85	10.64	7.59	37,916.76
No. 18	805.39	160.98	197.79	116.92	877.03	724.67	30.16	15.61	38.52	19.68	7.00	3.63	68.73	44.40	18.27	13.04	133,180.25
No. 19	346.62	69.28	85.12	50.32	99.92	81.10	13.61	7 04	17.38	8.88	3.13	1.62	29.58	19.11	7.86	5.61	18,692.13
No. 20	346.62	69.28	85.12	50.32	99.92	81.10	13.61	7.04	17 38	8.88	3.13	1.62	29.58	19.11	7.86	5.61	18,860.23
No. 21	346.62	69.28	85.12	50.32	99.91	81.15	13.61	7.04	17.38	8.88	3.13	1.62	29.58	19.11	7.86	5.61	18,575.06
No. 22	285.45	57.06	70.10	41.44	87.99	52.60	11.04	5.71	14.09	7.20	2.60	1.34	24.36	15.74	6.47	4.62	14 402.24
No. 23	193.70	38.72	47.57	28.12	23.59	19.50	7.36	3.81	9.39	4.80	1.75	0.90	16 53	10.68	4.39	3.13	8,050.28
Indiana Abutment	61.21	12.26	15.04	8.92	5.45	4.50	2.21	1.16	2.84	1.44	0.57	0.30	5.24	3.37	1.41	1.06	1,410.38
Total	10,194.76	2,037.73	2,503.66	1,480.04	5,040.82	4,162.36	367.85	190.37	551.77	285.55	92.03	47.61	870.02	562.02	231.23	165.09	811,110.14

TABLE VII.

DETAILED STATEMENT OF THE COST OF SUPERSTRUCTURE OHIO RIVER BRIDGE—Continued.

NUMBER OF SPAN.	Span from centre to centre of Masonry..	TOTALS from Table VI....	Scaffolding......	Tools and Rigging........	Tracks and Trestles.........	Horses, Wag's, Carts, Cars, & Harness	Team Account, Louisville.....	Salvage	Cribs for 400-feet Span. Construction	Cribs for 400-feet Span. Removal.	Second Cribbing Span No. 17. Construction	Second Cribbing Span No. 17. Removal.	Second F. Work Span No. 17. Framing	Second F. Work Span No. 17. Raising.	Track on Bridge. Material	Track on Bridge. Labor.	TOTAL.
	feet. in.																
Ky. Abutment.	16—3	$190.67	$12.90	$2.62	$2.27	$0.09	$0.22	$0.04							$28.69	$5.87	$243.37
Ky. Abutment.	16—3	190.67	12.90	2.62	2.27	.09	.22	.04							28.69	5.87	243.37
Shore Spans ...	50—0	2,758.49	187.00	37.89	32.98	1.36	3.16	.58							88.07	18.09	3,127.62
Shore Spans ...	50—0	2,758.68	187.00	37.89	32.98	1.36	3.16	.58							88.07	18.09	3.127.81
Canal Draw....	264—0	50,280.98	3,410.60	690.25	603.30	25.01	57.65	10.53							464.90	95.57	55,638.79
No. 1	149—7¼	15,045.68	1,017.00	206.52	180.00	7.39	17.25	3.14							263.50	54.16	16,794.64
No. 2	149—7¼	14,938.27	1,013.00	205.92	180.00	7.39	17.25	3.14							263.50	54.16	16,682.63
No. 3	149—7¼	14,732.75	1,000.00	203.17	176.76	7.27	17.00	3.09							263.50	54.16	16,457.70
No. 4	149—7¼	14,274.51	968.00	195.90	171.28	7.05	16.40	3.00							263.50	54.16	15.953.80
No. 5	180—0	19,436.72	1,318.00	266.82	233.24	9.59	22.28	4.07							316.98	65.16	21,672.86
No. 6	180—0	18,506.90	1,254.80	253.90	222.00	8.12	21.23	3.88							316 98	65.16	20,652.97
No. 7	210—0	26,181.85	1,775.30	358.41	314.18	12.91	30.00	5.48							369.81	76.02	29,123.96
No. 8	210—0	26,015.53	1,764.00	357.04	314.00	12.84	29.82	5.45							369.81	76.02	28,944.51
No. 9	227—0	29,956.76	2,031.26	411.16	360.00	14.77	34.33	6.28							399.75	82.17	33,296.48
No. 10	227—0	30,751.00	2,085.10	422.14	369.00	15.16	35.26	6.57							399.75	82.17	34.166.15
No. 11	370—0	104,440.46	7,079.40	1,433.75	1,253.28	53.50	119.77	22.04							651.57	133.94	115,187.71
No. 12	245—6	38,236.49	2,592.72	524.82	458.80	18.97	44.00	8.02							432.35	88.87	42,405.04
No. 13	245—6	36,569.06	2,479.70	502.02	438.80	18.14	41.93	7.66							432.35	88.87	40,578.53
No. 14	245—6	38,020.76	2,578.00	521.93	456.00	18.85	43.60	8.00							432.35	88.87	42,168.36
No 15	245—6	37,795.83	2,562.80	518.92	453.94	18.75	43.35	7.92							432.35	88.87	41,922.73
No. 16	245—6	38,940.75	2,640.40	534.28	467.28	19.31	44.56	8.16							432.35	88.87	43,175.96
No. 17	245—6	37,916.76	2,571.00	520.29	460.00	18.75	43.55	8.00			$2,970.70	$87.01	$1,022,02	$5,753.75	432.35	88.87	51,893.05
No. 18	400—0	133,180.25	9,068.15	1,847.05	1,556.89	67.02	152.88	28.06	$6,322.20	$1,218.26					706.02	143.27	154,290.05
No. 19	180—0	18,692.13	1,267.50	256.71	224.28	8.16	21.50	3.92							316.98	65.16	20,856 34
No. 20	180—0	18,860.23	1,277.80	258.90	226.32	8.20	21.60	4.00							316.98	65.16	21,039.19
No. 21	180—0	18,575.06	1,259.50	254.78	222.90	8.13	21.40	3.92							316.98	65.16	20,727.83
No. 22	149—7¼	14,402.24	988.91	197.68	172.80	7.10	16.50	3.05							263.50	54.16	16,105.94
No. 23	100—0	8,050.28	545.85	110.50	96.60	4.00	9.23	1.68							176.14	36.17	9,030.45
Ind. Abutment.	32—6	1,410.38	95.61	1.25	16.92	.72	1.65	.30							57.38	11.74	1,595.95
Total........	5,294—0¼	811,110.14	55,144.20	11,135.13	9,699.07	400.00	930.75	170.60	6,322.20	1,218.26	2,970.70	87.01	1,022.02	5,753.75	9,325.15	1,914.81	917,103.79

TABLE VIII.

DETAILED STATEMENT OF QUANTITIES OF MATERIAL IN SUPERSTRUCTURE OHIO RIVER BRIDGE.

NUMBER OF SPAN.	Depth of Truss.	Span from centre to centre of Piers.	Span from centre to centre of Pins.	Pounds of Iron.					Weight per Lin. Foot of Iron.	Timber. feet, B. M.	
				Cast Iron.	Wrought Iron.	Column Iron.	Beam Iron	Total.		Rail-joist.	Cross-ties.
	feet. in.	*feet. inch.*	*feet. inch.*						*lbs.*		
Kentucky Abutment	1—5	16—3	16—3	....	....	....	....	....	....	965	1,155
Kentucky Abutment	1—5	16—3	16—3	....	....	....	....	....	....	965	1,155
Shore Spans	7—0	50—0	47—6	7,557	6,701	....	9,100	23,358	492	....	5,432
Shore Spans	7—0	50—0	47—6	7,557	6,702	....	9,100	23,359	492	....	5,432
Canal Draw	15—0	264—0	260—1	95,265	49,568	1,069	233,278	379,180	1,458	....	30,260
No. 1	15—0	149—7¼	146—10½	101,453	63,904	6,320	....	171,677	1,169	8,886	6,896
No. 2	15—0	149—7¼	146—10½	101,453	63,904	6,320	....	171,677	1,169	8,886	6,896
No. 3	15—0	149—7¼	146—10½	101,453	63,905	6,320	....	171,678	1,169	8,886	6,896
No. 4	17—0	149—7¼	146—10½	98,920	59,937	7,045	....	165,902	1,129	8,886	6,896
No. 5	20—0	180—0	177—3	125,990	86,754	10,112	....	222,856	1,257	10,692	8,298
No. 6	22—0	180—0	177—3	117,810	79,808	11,529	....	209,147	1,180	10,692	8,298
No. 7	24—0	210—0	207—0	162,274	121,278	20,661	....	304,213	1,470	12,474	9,681
No. 8	24—0	210—0	207—0	163 050	120,755	20,661	....	304,466	1,471	12,474	9,681
No. 9	26—0	227—0	224—0	187,679	141,568	24,548	....	353,795	1,580	13,484	10,464
No. 10	26—0	227—0	224—0	187,680	140.861	24,382	....	352,923	1,575	13,484	10,464
No. 11	46—0	370—0	368—0	480,953	350,928	228,473	60,694	1,121,048	3,046	21,978	11,214
No. 12	30—0	245—6	242—0	216,119	178,611	37,192	....	431,922	1,784	14,582	11,317
No. 13	30—0	245—6	242—0	215,978	179,733	37,180	....	432,891	1,788	14,582	11,317
No. 14	30—0	245—6	242—0	212,231	179,632	37,175	....	429,038	1,772	14,582	11,317
No. 15	30—0	245—6	242—0	213,501	180,070	37,190	....	430,761	1,780	14,582	11,317
No. 16	30—0	245—6	242—0	213,484	180,263	37,200	....	430,947	1,780	14,582	11,317
No. 17	30—0	245—6	242—0	207,053	180,229	37,192	....	424,474	1,754	14,582	11,317
No. 18	46—0	400—0	396—2¾	570,585	478,022	280,920	75,938	1,405,465	3,547	23,760	12,978
No. 19	22—0	180—0	177—3	123,308	79,687	11,672	....	214,667	1,211	10,692	8,298
No. 20	22—0	180—0	177—3	123,479	80,094	11,878	....	215,451	1,216	10,692	8,298
No. 21	22—0	180—0	177—3	122,578	80,117	11,789	....	214,484	1,211	10,692	8,298
No. 22	17—0	149—7¼	146—10½	98,725	59,249	7,237	....	165,211	1,125	8,886	6,896
No. 23	12—0	100—0	97—6	58,323	29,585	....	....	87,908	901	5,940	4,610
Indiana Abutment	4—0	32—6	30—0	1,972	3,400	....	5,373	10,745	358	....	3,990
Total	....	5,294—0¼	....	4,316,430	3,245,265	914,065	393,483	8,869,243		290,906	260,388

PROCEEDINGS

OF THE

STOCKHOLDERS' MEETING.

OFFICE OF LOUISVILLE BRIDGE COMPANY,
LOUISVILLE, KY., March 4, 1872.

The annual meeting of the Stockholders of the Louisville Bridge Company was held at their office in Louisville on the 4th of March, 1872.

On motion of W. B. HAMILTON, H. D. NEWCOMB was called to the chair and A. A. QUARRIER appointed Secretary.

On motion of W. B. HAMILTON, the reading of the annual report of the President and the accompanying tables was postponed to a future meeting of the new Board.

The Chairman appointed Messrs. GEO. S. MCKIERNAN and S. H. PATTERSON judges of the election; and thereupon the meeting proceeded with the election of Directors as provided by the charter.

The following persons, representing stock in the Company, appeared, to wit:

H. D. Newcomb, President L. & N. R. R.	3,988
H. D. Newcomb	10
Geo. S. McKiernan, by proxies	6,910
Thos. J. Martin	6
Geo. S. McKiernan	1
W. B. Hamilton	1
S. H. Patterson	122
	11,038

The vote being taken by ballot, resulted as follows:

W. B. Hamilton received		11,038
Thos. A. Scott	"	11,038
Thos. J. Martin	"	11,038
William Thaw	"	11,038
J. N. McCullough	"	11,038

who were declared duly elected Directors for the ensuing year.

On motion, the meeting adjourned.

H. D. NEWCOMB, *Chairman.*

A. A. QUARRIER, *Secretary.*

APPENDIX.

DESCRIPTION OF BRIDGE.

The annual report for 1867 contains a description of the location and general plan of the bridge. Although the plan there explained has in general been adhered to, several changes have been made; the most important of which are the abandonment of a roadway for carriages, the lengthening of the span over the Indiana channel from 370 to 400 feet, and the reduction of grade on bridge from 82 to 76 feet per mile. Fig. 1, Plate I., is a general view of bridge as completed. It is 5,294 feet long, divided into the following spans from centre to centre of piers:

Kentucky abutment,	32.5
2 spans of 50 feet,	100.0
1 pivot-draw over canal,	264.0
4 spans of 149.6,	598.4
2 spans of 180.0,	360.0
2 spans of 210.0,	420.0
2 spans of 227.0,	454.0
1 span of 370.0,	370.0
6 spans of 245.5,	1,473.0
1 span of 400,	400.0
3 spans of 180,	540.0
1 span of 149.6.	149.6
1 span of 100,	100.0
Indiana abutment,	32.5
	5,294.0

Grade.

The grade of track approaching the bridge on the Kentucky side coincides with that of High Street at its crossing; from this point it ascends at the rate of 76 feet per mile to pier No. 13, a distance of 2,500 feet from the street, and 2,229 feet from back of abutment; from this pier, where the elevation of track is 95 feet above low water, the grade is level to pier No. 21, a distance of 2,243 feet; here the elevation of track above low water is $101\frac{1}{2}$ feet (low-water mark of the Indiana channel being $6\frac{1}{2}$ feet below that of the middle channel.) From pier No. 21 the grade descends at the rate of 76 feet per mile, for a distance of 700 feet, to the Indiana abutment, where it has an elevation above the river-bank of 35 feet; from this point it descends at the same rate till the natural surface is reached, at a distance of 2,500 feet from the abutment.

Foundations.

All of the foundations are on solid rock, with the exception of the abutments and shore piers 0 and 25, which are on hard clay. The foundations from 1 to 11 and from 22 to 24 were put in during the season when there was no water in that part of the river.

The foundations for piers 12, 13, 14, and 15 are in smooth water, and those for piers 17, 18, 19, 20, and 21 in the rapids; the velocity of the water in this part of the river being, during the best working season, from 14 to 20 miles per hour. The difficulty of securing the foundations of these piers, as well as of carrying on the masonry and erection of scaffolding, arose mainly from the want of permanent accessibility to the work, the sudden changes of the river rendering it impossible to supply material for any great length of time by one fixed plan. To meet this difficulty it was necessary to be always prepared to transport men and materials to the work, by either water (with steamboat and barges) or land (by means of trestles and tracks). Only in extreme low water could temporary trestles be maintained; these were frequently swept out by rises in the river, which for three or four days would render it possible to use barges. Upon the subsidence of the boating-stage a trestle would have to be resorted to. These temporary tracks were constructed from pier No. 11, on Corn Island, a low ledge of rock which served as a secondary base of supplies, being secure from the smaller rises. The line of track was parallel to centre line of bridge, and about 40 feet above it. The plan which best withstood the effects of small rises was that in which the stringers were supported on cribs 6 feet square, placed from 36 to 40 feet apart between centres, with their corners against the current; these were secured in place first by being filled with stone, and then by four-inch bolts, which passed one through each stringer to the rock-bed of the river, to which they were secured by split ends with wedges; the stringers were in pieces the length of the span. Some of the cribs were 14 feet high, the clear elevation of stringer above low water being about 4 feet. This plan of track has stood in sections 200 or 300 feet long, with 6 feet of water over it, having been covered before any drift had an opportunity to lodge.

At certain stages of the river it was impossible to approach some of the piers either by trestle or boat. These circumstances largely increased the cost of the work.

The foundation for pier No. 17 was the last put in, and was obtained with particular difficulty, on account of the existence of fissures in the rock, which rendered the necessary pumping out of the coffer-dam difficult.

Masonry.

Table IV. of the foregoing report gives the dimensions of each pier, with the respective quantity of masonry. From this the aggregate masonry is 29,779 cubic yards.

Fig. 7, Plate I., is a side view of pier No. 18, supporting 245.5 feet span Fink truss. In fig. 7 the form of section at different heights is shown. Figs. 5 and 6 are different views of pier No. 20, supporting 400 feet span. The cut-water caps and copings are bush-hammered. The masonry is built of compact limestone, in courses varying in thickness from 12 inches to 2 feet 6 inches. The masonry has been constructed throughout in accordance with the specifications in contract for same herewith published.

Superstructure.

With the exception of the channel span, all of the superstructure is placed below grade, fig. 1, Plate I. The below grade or deck portion (excepting the canal draw, which is entirely of wrought iron, on the triangular plan) is on the plan of Fink's suspension truss; in these spans the chords, post-shoes, cross-struts, and floor-beams (arched with tie-rods) are of cast iron, the posts wrought-iron Phœnix columns, and the tension members of the best wrought iron. The weight is supported by two trusses, placed 16 feet apart, between centres; these trusses rest at the piers on planed surfaces, on which they are free to move when affected by changes of temperature.

The over grade or through portion, consisting of the channel spans, respectively 370 and 400 feet long, is a modification of the triangular plan. This modification consists in the introduction of secondary or auxiliary trusses, fig. 1, Plate II., thereby rendering it possible to use an economical length of panel in the primary triangular truss, and by fixing the braces at their middle effect a great saving of material. In these spans the weight is supported by four trusses (Plate II., figs. 1, 2, 3, and 4), two on each side of roadway.

The entire bridge is, in addition to its own weight, proportioned for a rolling load of 2,600 pounds per lineal foot. With this maximum load the factor of safety in the cast-iron chords is from 6 to 7, and in the wrought-iron braces from 5 to 6, by Hodgkinson's formula.

The strain in the wrought-iron tension members is varied according to their position and duty; for example, the suspension and small truss-bars of the channel spans, which are subjected to a maximum load at the passage of each train, have with this load a strain of from 7,000 to 8,000 pounds per square inch; while the bottom chords of these spans, and the main systems of the suspension trusses, which rarely, if ever, are subjected to the calculated maximum strain, are proportioned for a strain of 12,000 pounds per square inch. The other tension members of the bridge are proportioned for intermediate strains, 7,000 pounds being the least and 12,000 pounds the greatest strain with a full load.

To illustrate more fully the character of the trusses composing the superstructure, the longest spans of each kind of truss have been selected; viz., the 245.5 feet Fink suspension and 400 feet modified triangular spans; the latter being the longest truss girder yet completed in America, is of general interest, and will be considered more in detail than the suspension truss with which the engineers of this country are more familiar.

245.5 Feet Span Fink Suspension Truss.

Fig. 2, Plate I., is a side view, fig. 3 a plan, and fig. 4 a section of the 245.5 feet span. In this span arched floor-beams with tie-rods carry the load to the trusses, which are placed 16 feet apart and have a depth of 30 feet; these floor-beams, extending under the chord, form part of the post, and at the same time act as struts in the system of lateral bracing; they are securely bolted both to chord and post-cap. The tie-rods, being put in while hot, have a slight strain when the beam is unloaded. The chords are formed of 16-inch cast-iron tubes, octagonal on the outside and circular on the inside; they are cast in sections the length of two panels, and connected at joints by sockets and tenons, which are bored and turned to fit. The posts are wrought-iron columns, varying in diameter from 13½ to 8 inches, and in area from 45 to 9 square inches. The number and size of wrought-iron bars are shown by the drawing. The roadway and foot-walks are supported on six strings of 8 by 16-inch white-pine stringers. Only the foot-walks are floored over, the roadway used by trains, 14 feet wide, along the centre line of bridge, being unplanked, as a precaution against fire.

The quantities of iron in this length of span, from Table VIII. of the foregoing report (average for the six spans), are as follows:

	Pounds.
Cast iron, ...	213,061
Wrought iron (bars, rods, pins, etc.), ...	179,756
Column iron, ...	37,188
Total weight of Iron, ...	430,005
Weight of Iron per foot of span, ...	1,776
Weight of flooring (stringers, cross-ties, rails, foot-walks, railings, etc.) per foot of bridge, ...	630
Total weight per foot of complete bridge, . . .	2,396

The deflection of this span under a train of four locomotives, weighing 200 tons at rest, was at the centre $1\frac{3}{4}$ inch, and at the quarter posts $1\frac{1}{4}$ inch.

400 Feet Span.

Fig 1, Plate II., is a half side view of the 400 feet span. In this the primary triangular truss A B C D E F G H, etc., is divided into seven panels of 56 feet $7\frac{1}{4}$ inches each; to subdivide these panels the posts C C′, E E′, and G G′ are introduced, with the auxiliary trusses B J C′, C′ K D, etc. By these intermediate supports the divisions of the top chord are made 14 feet $1\frac{5}{16}$ inch, and by suspension bars from the points I, J, K, L, etc., the floor-beams are supported at the same intervals. The floor-beam next the pier is supported directly by the pier and point B′, the strut I B′ carrying the weight to B′.

Fig. 2 is a partial view of bottom frame, with and without foot-walks. Fig. 3 a partial view of top frame.

Fig. 4 is an end view in a direction perpendicular to plane of braces, showing arrangement of foot-walks and roadway.

Fig. 5 is a half section in front of long posts C′ C and half end view of brace C D.

Fig. 6 is a plan of bottom chord for one pair of trusses.

The distance between centres of trusses forming the pair is 41 inches, and that from centre to centre of pairs 25 feet 7 inches. The depth of truss from centre to centre of chords is 46 feet.

The trusses on either side of roadway are now securely connected by bolts and struts; but before being thus connected each was allowed to support its own weight, and assume its natural cambre, uninfluenced by any connection with its neighbor. By this precaution the possibility of undue strains from inaccuracy of workmanship was avoided.

It is of interest to know that when thus swung independently no perceptible difference could be observed in the cambre of the four trusses, which, while supporting each its own weight, were bolted together without reaming or chipping.

The manner in which the weight of the flooring and moving load is carried equally to the trusses is shown by figs. 7 and 8, Plate III., the concentrated weight at the pin being supported equally by the suspension rods on each side.

The top chords are cast-iron tubes, with an exterior diameter of 14 inches, having an octagonal outside and circular inside form; they are reduced in section from middle to end of span in proportion to diminution of strain; the maximum thickness of metal being $1\frac{1}{2}$ inch and the minimum 1 inch. The braces and posts are close-riveted wrought-iron Phœnix columns, varying in diameter from $5\frac{1}{2}$ to 17 inches, and in section from 5.7 to 60 square inches. The wrought iron (bars, rods, etc.) has an ultimate strength of 60,000 pounds per square inch.

The track stringers, consisting of 4 pieces of white-pine 8 by 16 inches each, are supported by trussed 12-inch I beams, as shown in fig. 5, Plate II.

The cross-ties extend to the edge of the foot-walks, and are supported at their ends by longitudinal pieces, as shown in fig. 5. The principal details of construction are shown by Plate III.

Figs. 1, 2, and 3 show the foot of end brace A B, with its pier bearing the weight being carried to the masonry through the cast-iron pier-box, which also serves as a seat for the adjoining 245.5 feet span Fink truss. Five-inch cast-iron rollers at each end allow the span to readily adjust itself to varying loads and temperatures. The steel pin *c*, $4\frac{1}{2}$ inches diameter, the brace-shoe *b*, and the roller plate *a* form a hinged joint; double struts *d d* connect the opposite sides.

Figs. 4, 5, and 6 are respectively the side, end, and top views of bottom chord connections at C (foot of second brace); *e* is the foot of long post C C′.

Figs. 7, 8, and 9 show bottom chord connections at E (foot of third brace). Here *f* is a side hill washer at end of trussed floor-beam for bottom diagonal bracing.

Figs. 10, 11, and 12 show bottom chord connection G (foot of centre braces C H); the strap *g* supplies all the counter-bracing requisite, the weight of bridge in comparison to moving load being sufficient to neutralize all counter-strains from partial loads beyond the centre braces.

Figs. 13 and 14 show the connection of strut B′ I with bottom chord, *h h* being the floor-beam, and *i* the connecting casting.

Figs. 15 and 16 show connection D′ bottom chord, the lug of casting *j* causing the floor-beam to act as strut for the bottom system of diagonal bracing.

Figs 17 and 18 show connection at F′ bottom chord, and figs. 19 and 20 a similar connection at H′.

Figs. 21, 22, and 23 show the end of top chord B; *k* is the top lateral rod, and *l* the suspension rod.

Fig. 24 shows form of end brace-seat.

Fig. 25 is a side view and fig. 26 a plan of upper chord connections at D (top of brace C D).

Fig. 27 shows section of brace and form of seat.

Fig. 28 shows section of top chord.

Figs. 29, 30, and 31 show connections at F (top of brace E F).

Fig. 32 is a half section of brace, with form of seat.

Fig. 33 shows a section of chord.

Figs. 34, 35, and 36 are different views of centre joint H of top chord; the straps *g g* here shown constitute the only provision required for the counter-strains.

Fig. 37 is a half of brace section, with half plan of seat.

Figs. 38 and 39 show chord connections at top of post for auxiliary truss B J C′. (Fig. 1, Plate II.) The rod *m*, with strut *n*, connect this point with top system of lateral bracing. (See fig. 3, Plate II.)

Fig. 40 is a side view, and Fig. 41 a plan of upper chord joint at top of long post C C′, at this point; the tension bars of auxiliary truss pass through the chord joint-box, and are adjusted with screw ends.

Figs. 42 and 43 show the connection of strut I B′ with centre of end brace.

Figs. 44 and 45 show connection of small post with middle of tie B C. Anticipating that unavoidable inaccuracies of workmanship would cause the trusses to hang with different cambre, this point was provided with an adjustment by which the cambre of the four trusses could be made the same, and their permanent connection thereby rendered simple; the practical results, however, proved these precautions unnecessary, no change in the computed length of the ties being necessary to secure uniformity in the cambre of the several trusses; this adjustment for both the 400 and 370 feet spans was introduced as a precautionary improvement in the original design (single pin connection), and in both spans it proved unnecessary.

Figs. 46 and 47 show the connection of small post with centre of brace C D.

Figs. 48 and 49 show connection at centre of tie D E, and figs. 52 and 53 at centre of tie F G. Both of these ties were provided with an adjustment which proved to be unnecessary.

Figs. 50 and 51, with 54 and 55, show the connection of small post with middle of third and centre braces, E F and G H.

The bottom system of lateral bracing may be understood by reference to fig. 2, Plate II. In this system the floor-beams and bottom chords are made to act as members by the lugs on bottom of brace shoes, and connecting castings at joints between shoes, these lugs being carefully fitted into the flanges of floor-beams. The diagonal rods pass through the centre of the intermediate floor-beams, which they keep in line by a simple connection ; these intermediate floor-beams form no part of the bracing system.

The top system of lateral bracing is sufficiently explained by fig. 3, Plate II.

The weight per lineal foot of 400 feet span, including floor-beams and pier-bearings, and exclusive of track stringers, cross-ties, track, foot-walks, and railings, is 3,502 pounds; without pier-boxes and rollers, 3,378 pounds. The weight of this span complete, with stringers, cross-ties, track, foot-walks, railings, and pier-bearings, is 4,162 pounds per lineal foot ; the total weight of iron of all, 1,395,447 pounds. (The weight of pier-boxes belonging to adjoining spans being deducted from the total given in Table VIII. for this span.)

370 Feet Span.

The 370 feet span is built on the same plan as the 400 feet, with one panel less ; the primary triangular truss being divided into 6 panels of 61 feet 4 inches each ; the length of subdivided panel is 15 feet 4 inches. The depth of truss is the same as for 400 feet span, viz., 46 feet. The trusses forming the pair on each side of roadway are 34 inches apart between centres. The pairs are 25 feet apart between centres. The clear width is the same in both channel spans, viz., 20 feet 6 inches. The weight per lineal foot of the 370 feet span, including floor-beams and pier-bearings, and exclusive of stringers, etc., is 3,008 pounds ; of span proper, without pier-bearings, 2,877 pounds ; and of the entire span, pier-bearings, stringers, etc., 3,668 pounds. Total weight of iron of all kinds, 1,113,338 pounds.

It will be observed that the weight per foot of the 400 feet span is considerably more than for the 370 feet span. This difference in weight is partly due to the longer panel of the 370 feet span, a condition favorable to economy of weight, and partly to the increased length of span. The deflection of the 400 feet span with a train of four locomotives at rest in the centre, weighing in the aggregate 200 tons, is 1 1/8 inch; and the deflection of the 370 feet span, under the same load, 1 inch.

Cambre.

The cambre was put in these two spans by making each part longer or shorter than the calculated length by the amount which it would compass or extend under the influence of the maximum load; on this supposition, when the span is fully loaded the cambre should disappear. This result has been very nearly reached; the cambre of the 400 feet span, when light, being 2 1/2 inches, and of the 370 feet span 3 1/4 inches; a small margin having been allowed in both to insure a cambre in case of irregularities. The elongation of the bottom chord of the 400 feet span under a train of loaded cars is, by actual measurement, $\frac{9}{16}$ of an inch.

The cambre of the suspension trusses was put in by calculating the length of the chains for a length of post less than the true length by the ordinate at that point. In fixing the amount of cambre for each span, the design has been to make it such that under a maximum load the span would be straight.

The erection of superstructure was commenced in May, 1868, and completed ready for trains February 12, 1870. From pier 0 to 12 the false-work rested directly on the rock-bed of the river; from pier No. 12 to Indiana shore it rested on cribs, varying in height from 5 to 12 feet. In the false-work of all spans, except the 400 feet, cribs 6 feet square were used, 3 to each trestle; they were filled with stone and bolted down to the river-bed. These cribs served as an excellent platform on which to put together the trestles, which were raised in one full-length section (some 90 feet high) by a locomotive on the finished portion of the bridge, as well as reliable protection against small rises.

The 400 feet span scaffolding was erected on 5 large cribs, each 14 feet wide, 50 feet long, and 10 feet high, filled with stone, and bolted to the rock; they were sunk, with difficulty, in the following positions: the first 57 feet from centre of pier

No. 20, fig. 1, Plate I., next 114 feet from first crib (making a span of 114 feet for flat-boats and small craft); the third, fourth, and fifth cribs divided the remaining space into about 57 feet spans. On these 5 cribs trusses were erected and connected at the top, except the long span, by single post trusses; for the long span leaning trestles were erected from the cribs on each side at such an angle as to be connected at the top by the same length of truss as spanned the short openings; on the trestle thus erected to grade of track the top trestle was raised 50 feet high, and the iron work put together. The iron work for the 400 feet span was put together in 21 days, and for the 370 feet in 15 days.

The 245.5 feet span between piers 19 and 20 was the last span erected. At this span the raising forces from each side of the river met, and had it not been for an unforeseen accident to the false-work of this span, by which the completion of the bridge was delayed for two months, the force raising from the Kentucky end would have completed this span at the same time that the force from the Indiana end finished the 400 feet span, early in December, 1869. On the 1st of December all of the spans were in place except this; the false-work for it had been raised, the track connected on top, and everything was in readiness to put on the iron of the superstructure, when the river commenced to rise rapidly. As it was impossible to secure the iron work before the water would reach its highest point, it was thought advisible to suspend the putting on of iron, weight the false-work with stone, and wait the action of the water and drift for a few days. On the morning of the 5th a light salt boat was blown from the channel, and lodged against the trestle, knocking out two cribs. The water was now beginning to recede, the cribs had done their work nobly, and everything promised an early resumption of work. These anticipations were soon turned to disappointment, for on the morning of December 7th a steamboat with a tow of barges started over the falls in the fog, missed the channel, struck the false-work, and knocked it down. The trestles carried with them the cribs on which they were supported, leaving a gap of 245.5 feet, at the bottom of which was an almost irresistible body of water, having a velocity of 16 miles per hour and a depth of 16 feet. The 400 feet span was swung on its bearings November 27, barely escaping this flood. The top false-work of this span was taken down and sent in shore, while the bottom, consisting of the five towers, was pulled over into the river, it being of great importance to open the channel to navigation with the least possible delay. A plan for replacing the lost false-work of the 245.5 feet span was immediately fixed upon, and the work carried out as fast as possible under the disadvantages of continual high water and the unfavorable weather of December and January. The plan of the new false-work was such as to do away with the difficult work of sinking cribs in the swift water as far as practicable. One crib, 14 feet wide and 50 feet long, was sunk in the middle of this span, and filled with rock; on this crib three trestles were erected, one vertical and one leaning toward either pier; supported on offset courses near the bottom of each a trestle was erected, leaning toward one on the centre crib, sufficiently inclined to be connected by a fifty feet truss on top, forming a huge straining beam of 122 feet 9 inches span. On this trestle the iron work was put together, and the span swung on the 4th of February. As this false-work was about being completed there came a great rise, the water reaching a depth of 45 feet where the false-work stood; the cutwater of the crib was carried up on the centre tower, so as to prevent a lodgment of drift, large quantities of which were guided through the two spans of 122 feet on either side of the crib. So much confidence was felt in the stability of the trestle that the putting on of the iron was commenced as soon as the trestle was ready, and the span completed before the flood had scarcely commenced to subside.

All of the work of sinking the crib and putting together of trestles was done from barges, which were anchored in place (with difficulty, on account of the smooth rock bottom). The crib was built in and fastened to a barge 15 feet wide and 90 feet long; the barge was then loaded with as much rock as she could float, in addition to the crib, then towed to the site, held in position by lines, and scuttled. The cost of putting in this crib and span of false-work is detailed in Table VII. of the foregoing report as second cribbing and false-work for span No. 17.

Upon its completion the iron work of the bridge was thoroughly painted with red lead and the timber with oxide of iron, excepting hand railings, which were painted with white lead.

The character of workmanship and quality of material for the iron work are in strict accordance with the specifications for the same herewith published. These specifications are given separately for canal draw and fixed spans, as separate contracts were made for them, and the specifications differ in many particulars.

MASONRY CONTRACT.

Article of agreement made and concluded this 20th day of April, 1867, between Nash, Flannery & Co., of the first part, and the Louisville Bridge Company, of the second part: witnesseth that, in consideration of the payments hereinafter mentioned, the party of the first part agrees to construct the masonry of the bridge over the Ohio River at Louisville, Ky., according to the following conditions and specifications.

SPECIFICATIONS FOR MASONRY.

1. River Piers.

These piers will be of the dimensions shown by the drawings. The face of the stone will be left rough, with a pitched line around the edge of the face, the rock projecting beyond the pitched lines not to exceed three inches.

The rounded face-stone forming the circular head on the up-stream end of the piers shall be pointed to within one inch of the pitched line. The beds of the face-stone shall be dressed the entire width.

The top surface of each stone must be parallel with its bed. The vertical joints must be full and square to the face for at least twelve inches back, and must not open over two inches at the inner edge of the stone.

The masonry is to be carried up in regular courses, and to consist of stretchers, headers, and backing, the depth of the courses ranging from fifteen to thirty inches, the thickest courses to be used at the bottom of the piers; in no case is a thick course to be laid on the top of a thinner one.

The breadth of the stretchers is to be at least one and a half times their thickness, and the length from three to four times the depth.

The headers are to be at least two and one half feet wide, and from four to six feet long; the six feet headers are to be used in the lower part of the pier; the headers shall occupy at least one quarter of the whole face of the wall evenly distributed. No bonds less than fifteen inches will be allowed in the face of the piers.

The backing and interior wall shall be composed of large and well-shaped stone, and in no case shall more than two courses of backing be used for one course of face-stone; the lower beds shall be dressed level and even, and all high projecting points shall be dressed from the top, so as to give the succeeding stone a firm bearing.

The backing must be made level with each course of face-stone. No leveler shall be put under a stone to bring it to its proper height by raising it from its bed.

The bed-joints in the backing shall not exceed three quarters of an inch in thickness in any place, and the vertical joints shall not exceed an average of two inches; the backing-stone must all be in contact at some points along the vertical joints, and especially at the rear of the face-stone.

The backing-stone shall have an area of at least four square feet, and must be well bonded together, breaking-joints not less than six inches. No stone less than six inches thick shall be used.

The stone throughout shall be laid in mortar, and each course fully grouted before another is commenced; no spalls or small stone shall be filled in any place before the grout has been put in.

The mortar shall be made of the best hydraulic cement and clean sharp sand, to be mixed in such proportion as the Engineer may direct.

The following modification of these specifications applies to the masonry of the up-stream pier-heads—ice-breakers of the river piers.

The backing in the piers up to high-water mark, and back for a distance of fifteen feet from the front of the ice-breaker, must be made in courses of the same thickness as the face-stone. The vertical joints of the same must be cut square to the beds, and shall not exceed one half an inch in thickness. The face-stone of the pier-heads mentioned must be made of stretchers having not less than three feet bed, with alternate headers. The rear end of the stretchers and headers must be cut square to fit the backing.

The whole pier-head must form a solid block of masonry, made of dimension-stone of such sizes and shape as may be directed by the Engineer.

The stones of the rounded part of the pier-head (up-stream) are to be clamped together (both the backing and face-stone) with iron clamps, at least two clamps being used to each stone, which clamps will be furnished by the Louisville Bridge Company. The clamps are to be made of one-inch round iron, twelve inches long and four inches deep from the top of the stone. The rounded pier-heads are to be coped off as shown by the drawings.

The coping of all the piers and abutments is to be bush-hammered, not less than sixteen inches thick, and laid with alternate stretchers and headers; the headers to reach entirely across the pier.

2. River-pier Foundation.

The foundation-work for the river piers shall be done by the contractor, under the direction of the Engineer. When no other work than leveling off the stone of the river-bed is required, such work shall be included in the price per yard of masonry.

The foundations must be made level, and no spalling used in leveling up the river-bed for the first course of stone.

When blasting is resorted to, to level off the foundation, and where coffer-dams are necessary and pumping required, the same shall be done by the contractor at the expense of the Company; a correct account to be kept by the Engineer of all expenses incurred by the contractor strictly chargeable to foundation-work.

The tools and fixtures of the contractor which may be required to carry on the work shall be used in putting in the foundations. Any damages which may occur to such tools while employed in putting in the foundations, not caused by carelessness on the part of the contractor, shall be paid for by the Bridge Company; but the use of said tools, including the usual wear and tear, and the services of the contractor in carrying on the work, shall be included in the price per yard of the masonry. Tools which may have to be used exclusively for putting in the foundations shall be furnished at the expense of the Bridge Company, and be the property of said Company.

3. Shore Piers, including Draw Pier.

The shore piers will be of the same character of work as the down stream part of the river-piers.

4. Abutments.

The abutments may either be made in the shape of an H, with the stem solid, or arched, or may consist only of two piers with an iron superstructure between.

If the first-named plan is used, the masonry is to be of the same character as the land piers. If the second plan is used, the masonry will also be of this character, with the exception of the ring course, which shall consist of cut stone of the proper dimensions and shape. If the third plan is adopted, the pier next to the embankment is to be of ranged rubble masonry, laid in mortar as far as the same is covered by the embankment and as far as it is exposed to the view. The character of the masonry shall be the same as in the land piers.

5. Culvert Masonry.

The culverts will be either arched or box, and will consist of ranged rubble-work laid in mortar. In box culverts not exceeding four and a half feet in width, the covering stone will be one foot thick and rest twelve inches on the masonry.

6. Cement or Lime.

The cement or lime, which shall be used in such proportions as the Engineer may direct, shall be furnished and delivered by the party of the second part; the cooperage or bags in which the same is transported being furnished by the party of the first part.

After the delivery of the cement to the party of the first part, said party shall be responsible for damage or improper wastage of the cement or lime.

7. Foundation Excavation of Land Piers.

The earth excavated for the land piers and abutments shall be deposited in the nearest embankment, and the price for hauling shall be included in the price for excavating.

General Conditions.

The party of the second part reserves the right to make changes in the plan, and in the quantity of masonry to be built, during the progress of the work.

Should such changes affect the cost of the work, either increasing or decreasing the same, a special contract in writing must be entered into between the parties of this contract, agreeing upon the price to be paid for work resulting from a change in the plan or addition to the work; in the absence of such a special agreement no extra allowance of any kind is to be made to the contractor.

The contractor shall not let or transfer this contract, or any part of it, without the consent of the Engineer and the approval of the Board of Directors of the Louisville Bridge Company.

At least one of the contractors must give his constant personal attention to the work.

The contractors shall commence, prosecute, and complete the work in all its parts, under the direction of the Engineer, who shall have power to direct the application of the force to any portion or portions thereof, and to order the increase of the force to be employed.

The price per yard to be paid to the contractor will include the cost of furnishing materials (except cement or lime and iron clamps and material and labor for foundations of river piers, as heretofore specified) and scaffolding, centering, and all other expenses necessary for the completion of the masonry according to the plans and specifications.

The contractors assume all risk which may be incurred in the construction of the masonry from the stoppage of navigation by the rigging, tools, or other appliances necessary to carry on the work.

No material, stone, or sand, etc., is to be used except with the approval of the Engineer, who shall have the right to reject all material considered by him not suitable, and to have the same removed from the vicinity of the work at the expense of the contractor.

The masonry is to be completed and delivered to the Louisville Bridge Company by the 1st day of September, 1869, *provided* the quantity of masonry in the piers and abutments does not exceed 25,000 yards. Should it exceed that quantity, a proportional increase in the time of completing the work will be made; should the quantity be less, the time of completing the work will be proportionally reduced.

In case the contractors fail to finish the work by the time specified they shall pay a fine of one thousand dollars per month for the first two months, and three thousand dollars per month for every month thereafter that the work remains unfinished, the same to be deducted from their estimates.

Should the party of the first part complete the work before the time specified, a bonus of one thousand dollars per month shall be paid to him by the Louisville Bridge Company for two months of the time saved, and three thousand dollars per month for every additional month which the time of completion has been shortened.

The Louisville Bridge Company shall at any time, and for any reason whatever, have the right to suspend or annul this contract, after giving three weeks' notice to the contractors.

In case of such suspension or annulment, the contractors shall be entitled to receive pay to the full amount of the value of the work done up to the time of the suspension, according to the prices and conditions of this contract, and also compensation for any tools and machinery or materials used or to be used in the construction of the work which may be left on his hands, and which he does not desire to remove. In case of disagreement between the parties to this contract as to the value of such tools and materials, the value is to be determined by a third party, to be chosen by the said parties.

A suspension or annulment of this contract shall not give to the party of the first part any claim for damage against the party of the second part.

The estimates, monthly and final, made by the Engineer of the Louisville Bridge Company, as to the quality, character, and value of the work done, shall be conclusive between the parties to this contract, except for error founded in fraud or mistake.

In case the contractors shall not well and truly, from time to time, comply with and perform all the terms herein before stated and stipulated, or in case it should appear to the Engineer of the Louisville Bridge Company that the work does not progress with sufficient speed or in proper manner, the Louisville Bridge Company shall have the power to annul this contract if they see fit to do so; whereupon the foregoing agreement on the part of said Company shall become null and void, and the unpaid part of the value of the work done shall be forfeited by the contractor to the Bridge Company. The latter Company shall be at liberty to employ any other person or persons in place and stead of the party of the first part to do or complete the work herein mentioned.

Now this agreement witnesseth that the party of the first part do hereby agree and promise with the party of the second part that they will construct and complete the masonry of the Ohio River Bridge at Louisville in the manner and time herein stipulated. In consideration whereof the Louisville Bridge Company hereby agree to pay, or cause to be paid, to the party of the first part, their executors, or administrators, the following prices:

For masonry of river piers, including coping, fourteen dollars and ninety cents for each cubic yard.

For the masonry of the shore piers or solid abutments fourteen dollars and fifty cents per cubic yard.

For rubble masonry in the abutment piers or arched culvert masonry twelve dollars per cubic yard.

For the arched abutments eighteen dollars for each cubic yard.

For box culvert masonry ten dollars for each cubic yard.

For foundation excavation fifty cents for each cubic yard.

The above payments shall be made in the following manner: During the progress of the work, and until it is completed, there shall be a monthly estimate made by the Engineer of the Louisville Bridge Company of the quantity, character, and value of the work done during the month or since the last monthly estimate; eighty-five per cent. of which value shall be paid in current funds to the contractor. When the said work is completed and accepted there shall be a final estimate made by the Engineer of the quantity, character, and value of the work, agreeably to the terms of this agreement, and the balance appearing to be due paid to the contractor.

The contractor when receiving final payment shall give a release to said Company from all claims and demands whatsoever growing in any manner out of this agreement.

It is also understood that the contractor shall give all facilities to the Engineer to keep the cost of the work and to examine his books.

In witness whereof the said party of the first part and W. B. Hamilton, for and in behalf of the Louisville Bridge Company, have hereunto set their hands on the day and year first above written.

Signed and delivered in presence of

W. B. HAMILTON,
Pres't Louisville Bridge Co.
NASH, FLANNERY & CO.

SPECIFICATIONS FOR IRON WORK

OF CANAL DRAW, OHIO RIVER BRIDGE, TO BE DELIVERED READY FOR ERECTION AT A PRICE PER POUND.

1. The draw will consist of one undergrade pivot-span, 264 feet long over all. It is to be constructed entirely of wrought and cast iron, in accordance with plans for the same; the chords, braces, ties, diagonals, pins, bolts, etc., being of wrought iron; the struts, separating pieces, turn-table rims, arms, centres, wheels, tracks, etc., of cast iron.

2. The wrought-iron work will be divided into four classes, on each of which separate respective prices are to be fixed; said prices applying to the finished work delivered; the Bridge Company furnishing the iron (in the rough) at the shops of the contractor, at specified prices, also mentioned hereafter, and deducting the cost of same from the estimate of the *finished* work at the contract prices.

Classes of Wrought Iron.

A. Heavy rolled iron, as beams and plates, used in construction of chords and braces.

B. Bar iron, used in construction of the inclined ties.

C. Cold rolled pins for joint connections.

D. Light rolled iron for diagonal and cross-section rods, bolts, shafting, levers, zig-zag trusses, etc.

A. Heavy Rolled Iron.

The upper and lower chords will consist each respectively of two heavy 15-inch and two heavy $12\frac{1}{4}$-inch beams, made continuous by heavy rolled plates riveted to the beam web at the joints.

Full sized sheet-iron templates shall be made from working drawings, furnished by the Engineer, showing the exact position of all the holes to be drilled in splice-plates and webs. Each rivet-hole in the beam-web must be carefully drilled to a diameter not exceeding that of the smallest part of the rivet by more than one sixteenth of an inch; in drilling the rivet-holes in the web of the beam to *which the plates* are to be *riveted* during erection the templates shall be slipped *from* the joint, forming a *draw-bore* of one sixteenth of an inch; thus facilitating the requirments of close joints. The rivet-holes of the splice-plates, after being drilled, must be reamed coning, the diameter on the face being one eighth of an inch greater than that next to the web.

The plates are also to be drilled for the reception of the pin at each joint; each hole to be of the size shown by the drawings; the diameter of said holes shall in no case exceed the diameter of the pin by more than one sixty-fourth of an inch. The ends of each plate must be cut with a sloping bevel, as shown by drawings.

The rivets for this work are to be made by the contractor of the size and form shown by drawings, the bevel for one half the length being to enable the rivet to entirely fill the hole when upset. All rivets shall be well heated and driven firmly home before upsetting, so that the bevel on rivet shall bear on the sides of the coned holes in the plates; they shall then be carefully upset, and a smooth regular head formed, either with a hammer or cup tool.

The distance from centre to centre of pin-holes in the chords must be *exactly* of the standard length shown on drawings.

The beams to which the plates are riveted must be paired off in such a manner that when placed at the proper distance apart the joint-pins may be passed easily through both beams at right angles to their webs.

The braces are to be formed by riveting plates (bent as per plans) to the webs of channel and I beams, and connecting said beams two and two by separating pieces and wrought iron trusses, as per drawings.

Full size templates shall be made from working drawings furnished by the Engineer, for the drilling necessary at the ends, and the same requirements respecting exactness of workmanship observed as in case of chord-splices.

The beams shall be cut to the proper bevel at the ends, and drilled for the separating pieces and truss-bolts. All the braces shall be connected permanently on delivery, care being taken that the pin shall pass easily through the jaws of each beam at both ends perpendicular to the direction of the webs. The same conditions relative to reaming plates and riveting to the webs will be observed as in chord-splices.

B. Bar Iron.

The bar iron is to be used for the construction of the inclined ties, either as separate bars or connected by lateral wrought-iron trusses, as per plans. When used as single bars sheet-iron templates shall be made from *full-size* drawings furnished by the Engineer, for such different size of head. The heads shall be cut hot, from slabs or plates furnished by the Bridge Company, with the fibre in direction of their length, to within one eighth of an inch of the size of templates, care being taken to have the outline of the head smooth and regular.

The heads are to be welded carefully to the body of the bar, and each head drilled and reamed for the proper size of pin; the diameter of these holes shall not exceed that of the pin by more than one sixty-fourth of an inch, and the distance from centre to centre of hole must be exactly as shown on drawings.

The test of unformity in length shall be that six bars of equal temperature, taken indiscriminately from a lot of equal length (so called), and laid in parallel planes, one above the other, with separating blocks two inches high between, shall admit the the proper size pin to pass readily through each end of the pile.

When the ties are connected by *zig-zag* trusses the same conditions apply to the finishing of the bars as when used single. They shall be carefully drilled for the bolts of the trussing, as per drawings. Said braces shall in all cases be bolted permanently to the bars before delivery, care being taken that when the bolting is completed the pins shall pass easily through both ends at right angles to the planes of the bars.

In the cases shown on plans wrought-iron swivels shall be made for the adjustment of the bars.

C. Cold Rolled Pins.

These shall be furnished by the Bridge Company, cut to the proper length. The contractor shall turn off a chamfer of at least one eighth of an inch, and drill holes for the keeper-pins at each end, as per drawings. Said pins must in every case be fitted to their places before the work is delivered.

D. Light Rolled Iron,

OF WHICH THE DIAGONAL RODS, SHAFTS, BOLTS, ETC., ARE MADE.

The diagonal rods proper are to be upset at each end to such a diameter that the thread shall not cut into the body of the rod, and a sharp regular thread cut on each end at least four inches long. Well-fitting hexagonal nuts, furnished uncut by the Bridge Company, must be put on each end. The cross-section rods are to have on one end a flat-drilled eye, and the other end is to be upset the same as diagonal rods. In the cases shown closed swivels will be made for the cross-section rods.

The bolts are to be of the sizes and lengths shown by drawings, with the thread cut directly into the body of bolts, and fitted with hexagonal nuts.

The radial rods of the turn-table will be made with double nuts at centre end, and single nuts with shoulders at rim end, with threads cut as per drawings; that portion of the rod acting as axle must be turned to fit the box in the wheel. The two circular rings used for spacing the wheels must be made continuous by riveted plates, the joints breaking half-way, and the two forming circles, with their circumferences parallel at the required distance apart.

CAST IRON.

5. This will be divided into two classes, on which separate prices are fixed, viz., finished and unfinished.

A. UNFINISHED.

This comprises separating pieces, all castings for turning and raising-gear, separating pieces for wrought-iron spacing-rim of turn-table, etc.

B. FINISHED.

This comprises the struts, turn-table rim, arms, upper and lower centres, spider, caps for wrought-iron columns, etc., all to be fitted in the following manner:

The struts must be faced off to exact lengths, as shown by drawings.

The turn-table rim must be regularly fitted and bolted together, the holes through the flanges drilled to fit the bolts, the seats for the chord laid out from the centre line and dressed to the proper level, the centre set in position, the arms fitted and bolted to their places, and the spider turned and finished as per plans.

The wheels are to be faced coning, as shown by drawings, and the upper and lower tracks faced to suit the coning of the wheels. The wheels must also be drilled for the reception of the radial rods.

The caps and shoes of the wrought-iron braces must be faced and turned as per drawings.

The contractor shall furnish all patterns, etc., required to make the castings herein specified to the satisfaction of the Engineer.

The quality of all the iron in the castings shall be *first class*, free from cold shuts and air-bubbles, tough, and of uniform texture, with a smooth and continuous skin.

All castings shall be carefully cleaned, and irregularities arising from displacement of cores or other causes chipped off.

Putting together Work.

6. After having finished the work in accordance with the foregoing conditions, the contractors shall, at their expense, fit each truss together, or such portions of them as the engineer may direct; while together the size of the keys at the end of the braces shall be determined, and the keys made.

During the erection of the work should it be found that a portion of the fitting had been overlooked by the contractor, he shall have such work done without extra charge.

Testing, Marking, and Painting.

All bar iron subjected to a tensile strain shall be tested, under the direction of the Engineer, by the contractor; the latter shall at all times furnish such facilities as the engineer may require for examining the accuracy of the work.

The wrought iron shall be marked with white paint, or by a chisel, in such a manner as will best facilitate the erection of the work. The cast iron shall be branded with index letters according to drawings, and when the Engineer deems it necessary certain points or joints shall be marked with a chisel.

Both wrought and cast-iron, as fast as finished, shall receive by the contractor a good coat of mineral paint.

7. The work shall be prosecuted strictly under the direction of the Engineer, who shall have the right to make changes in plans, when such changes do not increase the cost of work to the contractor. Should a change be required that would increase the cost of the work, the Engineer shall, in consultation with the contractor, fix upon a definite price before the change is commenced. He shall also have the right to direct the application of labor to any particular portion of the work, and to increase the force employed when, in his judgment, the work is not being prosecuted with proper energy.

The work shall be commenced immediately after signing the contract, and delivered ready for erection by the 1st day of May, 1868.

Should the contractor fail to have the work delivered by the time specified, he shall pay a fine of fifty dollars for each day required for delivery after that time.

A suspension or annulment of this contract shall not give to the contractor any claim for damages against the Bridge Company.

8. The engineer shall make monthly estimates of the work done, and on this estimate the contractor shall be paid on the 15th of the following month eighty-five per cent. of the entire estimate, a reservation of fifteen per cent. being made to secure the Bridge Company against loss by non-fulfillment of the contract. On the completion of the work a final estimate shall be made, and the contractor paid in full for the work done.

SPECIFICATIONS FOR IRON WORK

OF PERMANENT SPANS, OHIO RIVER BRIDGE, TO BE DELIVERED READY FOR ERECTION AT A PRICE PER POUND.

Classes and Arrangement.

The iron is divided into three general classes, viz.: *Cast iron, wrought iron,* and *column iron,* arranged in the trusses as follows; the chords, floor-beams (except those for channel spans, which are trussed beams), struts, shoes, keys, end-plates, etc., being of cast iron, the posts and braces of Phœnix columns, and the chains, diagonals, cross-section rods, pins, bolts, etc., of wrought iron proper.

SPECIFICATIONS FOR QUALITY AND WORKMANSHIP.

Cast Iron.

The quality of iron in all the castings shall be first-class, free from cold shuts and air-bubbles, tough, and of uniform texture, with a smooth and continuous skin. The test for the quality of iron shall be that a bar 5 feet long and 1 inch square, placed upon supports 4 feet 6 inches apart, shall not break with less than 525 pounds placed at the centre.

The Engineer shall have the right to have made a number of test-bars from each heat, and have the same tested for the quality of iron used at that heat.

All castings shall be carefully cleaned, and irregularities arising from displacement of cores or other causes clipped off. Each chord-piece shall be tested for uniformity in thickness of metal by drilling in each piece two holes in the vertical plane of the core, one on each side of the centre and half-way from the centre to the end. Should it be found by direct measurement in these holes that the metal is $\frac{1}{4}$ of an inch thicker on one side than the other, and on the thin side $\frac{1}{8}$ of an inch less than the drawings call for, the casting shall be rejected.

In chord-pieces of the usual lengths—say twenty-nine feet—a greater deviation than $\frac{1}{4}$ inch from a straight line shall not be allowed. The thickness of metal in the castings must in all cases be as per plans. No allowance will be made for weights accruing from increased thickness.

Cast-Iron Fitting.

This for the several members is as follows:

1. *Chord-pieces.*—These are to be faced off for a close bearing at each end to the exact lengths shown by plans, tenons turned and sockets bored, holes drilled for the pins, seats faced, and sockets bored for the floor-beams. Care must be taken to have the bearings for floor-beams at the centre and ends of the chord-pieces in the same straight line. The holes must be drilled and reamed exactly at the distance apart shown on drawings, and of a diameter not exceeding that of the pin by more than $\frac{1}{64}$ of an inch.

2. *Floor-beams.*—These shall be faced at chord-seat and post-seat, a socket bored for the reception of post-tenon, and a tenon turned for connection with chord; the holes for connecting-pin of tie shall be carefully drilled at right angles to the plane of beam, and the tie-rod made $\frac{1}{32}$ of an inch short, gently heated, and shrunk on the pins; particular care is required in this operation, especially in selecting and fitting the bars to the same length before heating them.

3. *Struts, etc.*—The struts are to be turned and faced as per plans. The post-shoes are to have a turned socket for the reception of the strut-tenon and the post-seat, and beveled seats for the keys faced off; the tenon for connections with column must be fitted with chipping strips, as per plans. The keys must be planed on the top and bottom; also the bearing on the key-seat. The pier-plates are to be faced and the end chord bearing made to fit the bevel surface of the plate, when the chord has assumed the line of grade.

All fitting not mentioned here is to be done to the satisfaction of the engineer and by his direction.

Wrought Iron,

COMPRISING CHAINS, DIAGONALS, BOLTS, PINS, ETC.

If the chains are formed by welding heads to the bars, sheet-iron templates shall be made from drawings furnished by the Engineer for each different size of head. The heads must be welded carefully to the body of the bar, and each head drilled and reamed for the proper size of pin. The diameter of these holes shall in no case exceed that of the pin by more than $\frac{1}{64}$ of an inch, and the distance from centre to centre of holes shall be exactly as shown on drawing. If upset heads are used, they shall be of the form and size specified, and of smooth and regular outline; for these the same requirements for accuracy of workmanship is to be observed as in case of welded bars. The test for uniformity in length shall be that six bars of equal temperature, taken indiscriminately from a lot of (so called) equal lengths, and laid in parallel planes, one over the other, with separating blocks 2 inches high between, shall admit the proper size of pin to pass readily through each end of the pile.

The lateral or diagonal rods shall be upset at each end, to such a diameter that the thread shall not cut into the body of the rod, and on these ends a sharp regular thread shall be cut at least 4 inches long. Each of these ends must be supplied with a well-fitting hexagonal nut.

The cross-section rods are to have on one end a flat-drilled eye, and the other end is to be upset and fitted with a hexagonal nut, as in case of diagonal rods.

The bolts are to be of the sizes shown on drawings, with the thread cut directly into the body of the bolt; all to be fitted with hexagonal nuts.

The pins may either be of the same quality of iron as the chains or of cold rolled iron. In the first case they must be turned to the exact diameter, and in both cases they are to be drilled at the ends for $\frac{3}{8}$-inch keeper pins.

Quality.

The quality of iron used for chains, rods, etc., shall be of the best, having a breaking strength of not less than 60,000 pounds per square inch.

The contractor shall have rolled eight bars, as representatives of the quality of which he proposes to make the chains, rods, etc.; these when fitted with heads shall be put into the testing machine, and each one separately elongated under a strain of 20,000 pounds per square inch, and the elongation of each carefully measured; the strain shall then be increased until the breaking point is reached; if this is at or above 60,000 pounds, a mean of the several elongations under the 20,000 pounds strain will give the standard elongation for the quality of iron required. This standard shall be used in all tests.

For the purpose of further testing the quality each bar shall be ordered from the rolling-mill 3 inches longer than necessary, to admit of being nicked at the end and bent around cold. If the fracture is not as good as shown in the test-bars or samples of the quality proposed, the bar shall be rejected. The contractor shall at all times, at the Engineer's request, make tests for the breaking strength of the iron being used.

Column Iron.

The posts and braces will consist of various sized Phœnix columns. These columns must be faced at each end to the exact lengths, and when made with separating or filling pieces turned out for the reception of tenons at top and bottom. When no filling pieces are used in the manufactnre of the column the tenons are to be fitted by chipping strips.

Any connections required for the suspension of the passing systems shall be made without extra charge by the contractor.

The rivets at the ends for a space of 2 feet shall be placed 3½ inches from centre to centre, and all the columns coated on the inside with coal-tar or mineral paint.

Fitting, Marking, and Painting.

All bar iron, and when necessary round iron, shall be tested by the contractor, under the direction of the Engineer, to a strain of 20,000 pounds per square inch tension. Should the elongation of any bar under this strain differ from the standard elongation by an amount which the Engineer may consider as showing the iron to be of an inferior quality, such a bar shall be rejected. Any bar which does not return to its original length on the removal of the strain shall be rejected.

The contractor shall at all times furnish such facilities for the examination of the accuracy of the work as the Engineer may require.

The wrought iron shall be marked with white paint according to notations shown on bills, thus facilitating the erection of the work, and offering a convenience in weighing and estimating.

The cast iron shall be branded with index letters, according to drawings, and when the Engineer shall deem it necessary certain points shall be marked with a chisel.

Both wrought and cast iron, as fast as finished, shall receive a coat of mineral paint.

Putting together Work.

Any fitting belonging to the contract for completing the work according to plans and specifications required during erection shall be done at the cost of the contractor.

The work shall be prosecuted strictly under the direction of the Engineer, who will furnish all working-drawings, plans, bills of material, etc.

He shall have the right to make changes in plans when such changes do not increase the cost of work to the contractor. Should a change be required which will increase the cost of the work, the Engineer, in consultation with the contractor, shall agree upon the price to be paid before such changes are commenced. The Engineer shall also have the right to direct the application of labor to any particular portion of the work, and to increase the force employed when in his judgment the work is not being prosecuted with proper energy.

The work shall be commenced immediately, and prosecuted with energy. The material for the first span shall be delivered by the 1st of June, 1868, and for the others as fast as required to keep up with completion of masonry.

Should it appear during the progress of the work that a fair proportion was not being executed, and that the delivery at the times specified was doubtful, the Engineer, upon ten days' notice to the contractor, shall be at liberty to transfer any or all the work remaining to be done to other establishments, where it will be prosecuted at the cost of the contractor, which cost shall be deducted in the final settlement.

A suspension or annulment of this contract from any cause whatsoever shall not give to the contractor any claim for damages against the Bridge Company. The latter shall pay the contractor the full amount due him for all work which he at the time may have finished.

If by such suspension any work is left on his hands unfinished, the same shall be taken by the Louisville Bridge Company at a fair valuation, taking as a basis of valuation the contract prices; or if any raw material intended to be used in this work shall be left on his hands, the same shall be taken by the Louisville Bridge Company at the cost to the contractor.

Estimates.

The Engineer shall make monthly estimates of the quantity, character, and value of the work done during the month, and on these estimates the party of the first part shall be paid, on or before the 15th day of the following month, eighty-five per cent. of the entire estimate, a reservation of fifteen per cent. being to secure the Bridge Company against loss by non-fulfillment.

On the completion of the work a final estimate shall be made of the total work according to contract, and the contractor paid in full.

The estimates, monthly and final, made by the Engineer of the Louisville Bridge Company as to quantity, character, and value of the work done shall be conclusive to the parties to this contract, except for errors founded on *fraud* or *mistake.*

REPORT TO CHIEF OF ENGINEERS, U. S. A.,

ON LOUISVILLE BRIDGE, 1871.

This bridge, sometimes known as the Ohio Falls Bridge, is a railroad and foot bridge, and it crosses the Ohio River at the head of the falls, extending from a point just below the city of Jeffersonville, in Indiana, to the foot of Fourteenth Street, in the city of Louisville. It belongs to a special bridge corporation, and serves to connect the Indiana railway system with the roads on the south of the Ohio that centre at Louisville.

The bridge company was chartered by the State of Kentucky, with authority to construct a bridge that should not obstruct the navigation of the Ohio, "further than the laws of the United States and the decisions of the Supreme Court shall hold to be legal." Their authority from the United States is derived from the act of Congress approved February 17, 1865, which is supplementary to the act of July 14, 1862, under which the Steubenville, Bellaire, and Parkersburg bridges are built. Under these acts the company were authorized to build any one of the three following styles of bridges, viz.:

1. Continuous 90 feet above low water.
2. With a draw 70 feet above low water.
3. With three draws 56 feet above low water.

The location of this bridge is peculiar, and the provisions of the act of 1862 do not apply very well. The authority to build under that act might have caused a great deal of injury to navigation had its provisions been interpreted to the letter. At the Falls of the Ohio there are really three navigable channels to be crossed—the Indiana Chute, the Middle Chute, and the Canal. As the act in question only contemplated one channel, an illiberal interpretation might have resulted in seriously affecting navigation through the others. Fortunately the company met the difficulties of the case in a most commendable public spirit, and they not only adopted the highest of the three bridges, but they largely increased the channel-ways that they were required to give.

The bridge, as built, belongs to the class of "high" bridges, as distinguished from bridges with draws, and an elevation of but 70 feet.

It has a single railroad track, and two sidewalks, each 6.2 feet wide, and its total length between abutments is $5{,}218\frac{2}{3}$ feet. The spans commencing at the abutment on the Indiana or north shore are as follows: 99, 149.6, 180, 180, 180, $398\frac{3}{4}$ (Indiana Chute), $245\frac{1}{2}$, $245\frac{1}{2}$, $245\frac{1}{2}$, $245\frac{1}{2}$, $245\frac{1}{2}$, $245\frac{1}{2}$, 370 (Middle Chute), 227, 227, 210, 210, 180, 180, 149.58, 149.58, 149.58, 149.58, 132, 132 (draw over Canal), 50, 50. These dimensions are from centre to centre of piers, and they are greater by the half widths of two piers than the clear waterway. The trusses themselves are of the two styles patented by Mr. Albert Fink, the Chief Engineer of the bridge. The two channel-spaces are spanned by Fink triangular trusses, and all the others except the draw by Fink trussed girders. The draw-bridge is what is generally known as a Warren girder, differing only from the triangular in that the latter has certain additional members that are necessary to adapt it to long spans. The former are "through" or "over-grade" bridges, and the latter "deck" or "under-grade." The clear waterway at the Indiana Chute, measured on the low-water line, is 380 feet, and at the Middle Chute $352\frac{1}{4}$ feet. The roadway bearers of the channel-spans are suspended below the bottom chords, and consequently the height under the bridge available for steamboats must be measured to these members. The line of the roadway bearers of the Indiana channel-span is $96\frac{1}{2}$ feet above low water, and $45\frac{1}{2}$ feet above highest water, the maximum oscillation being 51 feet. At the middle channel-space the river is dry at low water, and the available space above the river-bed is 90 feet. These two channel-spans are on the same level, but at the Indiana channel the break in the rocky ledge is 1,000 feet above, while in the middle channel it is 6,000 feet below. The line of the crest of the falls is exceedingly irregular, crossing the line of the bridge between the two channel-spans nearly at right angles.

The tops of the channel-piers and of all piers between them are $97\frac{1}{4}$ feet above low water of the Indiana Chute. The others are lower, conforming to the grades of the bridge.

The foundations of all the piers of this bridge were laid on the solid rock, and therefore there is no need of any rip-rap protection around them.

Current observations were made by the surveying party, but they were of little practical value. The water was too low to permit boats to cross the falls, and therefore it was of no importance to ascertain the angles between the current at this stage and the piers. As the river rises the effect of the falls becomes gradually less perceptible, and the currents become more and more regular, until in high water the falls entirely disappear. We have good reasons for believing that the bridge is as nearly as possible at right angles to the current at navigable stages, and therefore did not think it worth while to incur the expense of a special survey at high water.

The right pier of the Indiana channel-space is 64 feet 6 inches by 17 feet $10\frac{1}{2}$ inches at bottom; thence it is carried up vertically, with $10\frac{1}{2}$ inches of offsets, to 10 feet above low water. Above this the sides have the uniform batter up to the coping of $\frac{7}{16}$ of an inch per foot. The left pier is 65 feet 6 inches by 18 feet 8 inches at bottom, and is carried up vertically with 1 foot $6\frac{1}{4}$ inches of offsets to 18 feet above low water. Above this the sides have the usual batter. The up and the down-stream ends of the piers are built alike, with starlings formed by the intersections of arcs of circles with radii of $12\frac{1}{2}$ feet. They are capped by hoods at high-water mark, and above this are finished with semicircular sections. These piers, on top (without coping), measure 33 by 10. The piers of the middle channel are 64 by $17\frac{3}{4}$ feet at bottom, and 33 by 10 feet on top, with starlings and hoods like the other channel piers.

The other piers are similarly constructed, excepting that above the lower starlings and hoods they have another starling and hood, which makes a shorter length of pier on top. The top dimensions of pier No. 7 (without coping) are 21 by 7, the dimensions at bottom being $45\frac{5}{6}$ by $14\frac{1}{2}$.

The grades and curvatures on this bridge and its approaches are as follows, commencing at the face of the abutment on the Indiana or northern shore:

Distance.	Grade.	Curvature.	Remarks.
785.1	78.6	Tangent....	Indiana side.
2,241.75	0	Tangent....	Channel-spans and spans between.
2,192.82	79.14	Tangent....	Kentucky side.
5,219.67			

The approach to this bridge on the Indiana shore consists of a long and high embankment. This, however, does not properly belong to the bridge, and, in accordance with the rule adopted for other bridges, we consider that we have reached the end of a bridge when we come to earth-work. Under this rule this bridge has no approaches, the entire space from abutment to abutment being waterway.

This bridge crosses the Louisville and Portland Canal 1,700 feet below the guard-lock at the head. An unobstructed passageway for steamboats is secured by means of a draw, giving a clear opening of 114 feet over the canal. The other end of the draw projects over a portion of the river, and by modifying the canal-bank on this side so that it shall just have the width of the pivot of the draw, it will be practicable for steamboats in high water to ascend the river without lowering their chimneys. This is a very valuable provision for boats that habitually run where there are no bridges, which yet may occasionally wish to go above Louisville. In low water such boats can pass through the canal, and in high water, by using the other end of the same draw, they can pass up the river even should they be too wide to get through the new locks. The changes in the canal-bank necessary to permit this use of the northern end of the draw are being made by the United States as a necessary adjunct to the enlargement of the canal.

The total high-water section of the river on the line of the bridge is 216,249 square feet, of which 13,573 square feet, or 6 per cent., is occupied by the piers. This contraction would probably cause no perceptible increase of velocity. The low-water section is 1,377 square feet, of which 60 square feet, or $4\frac{1}{2}$ per cent., is obstructed. All the water at this stage is running through the Indiana Chute; but there being no navigation possible, the effect of the piers need not be considered.

The losses by collision with the piers of this bridge up to date amount to $26,704.

The board have no changes to recommend in this bridge, which they consider a first-class structure throughout, and very much less an obstruction than it might have been had its builders limited themselves to giving only what they were compelled by law to give. On the contrary, they have chosen to build according to the highest of the three authorized plans, and have exceeded the heights and widths that even this plan required, spending $150,000 more than was necessary to comply with the letter of the law. Instead of a 300-foot opening at low water, one of their channel-spans gives 380 feet, and the other $352\frac{1}{4}$ feet. The total cost of the bridge, from abutment to abutment, was $1,615,120.

If it should be found by experience that owing to the peculiar location of this bridge the channel space on the Indiana side can not be safely run by coal-tows, then a still wider opening will be necessary. Present difficulties, however, may possibly be due to a lack of experience. Should it be found, however, that there are inevitable dangers due to this exceptional location which no amount of experience can avoid, it will be manifestly necessary to widen this span to 500 feet, or in some manner to modify existing conditions so as to facilitate the passage of the present opening.

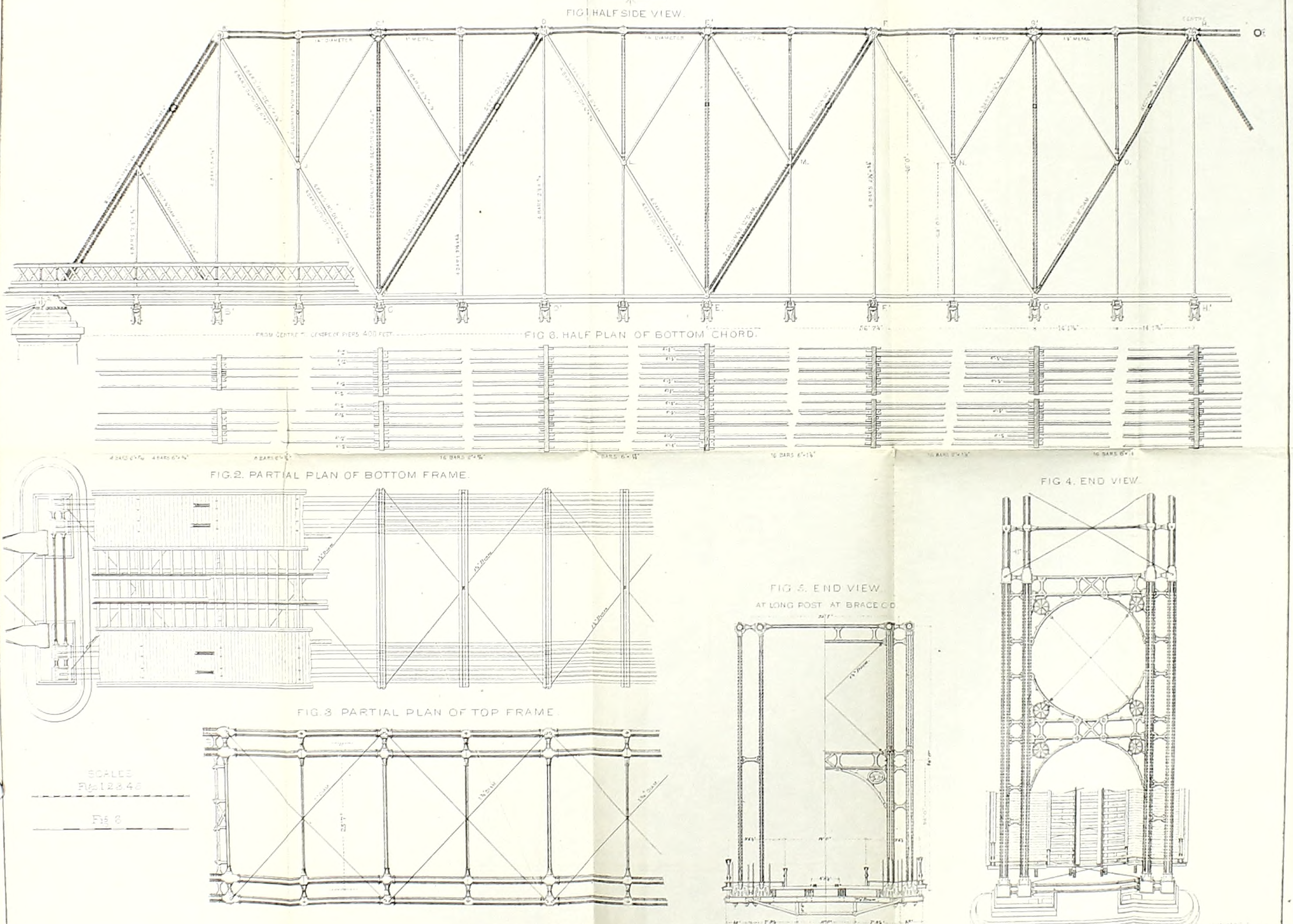
* * * * * * * * *

G. K. WARREN,
Major Engineers, and Bvt. Maj. Gen., U. S. A.
G. WEITZEL,
Major Engineers, and Bvt. Maj. Gen., U. S. A
WM. E. MERRILL,
Major Engineers, and Bvt. Colonel, U. S A.

BRIG. GEN. A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D C


OHIO RIVER BRIDGE
LOUISVILLE, KY.
ALBERT FINK, CHIEF ENGINEER.— WM. B. HAMILTON, PRES'T.— F. W. VAUGHAN, PRIN. ASS'T. ENGINEER.
KENTUCKY
INDIANA.
MIDDLE CHANNEL
INDIANA CHANNEL
Fig. 1.
Span 370'0
Span 400'0
SIDE VIEW OF 245'5 SPAN.
Fig. 2.
PIER No 18
PIER No 19.
TOP VIEW.
Fig. 3.
Fig. 7.
SIDE VIEW
SECTION C-D
SECTION
Fig. 4.
SYSTEM
II.
Fig. 5.
SIDE VIEW.
PIER No 20.
Fig. 6.
END VIEW
SECTION G-H.
SECTION I-J.
SCALES
Fig 1.
Figs. 2.3.5.6.7.
Fig 4.
BUILT BY THE LOUISVILLE BRIDGE & IRON CO.

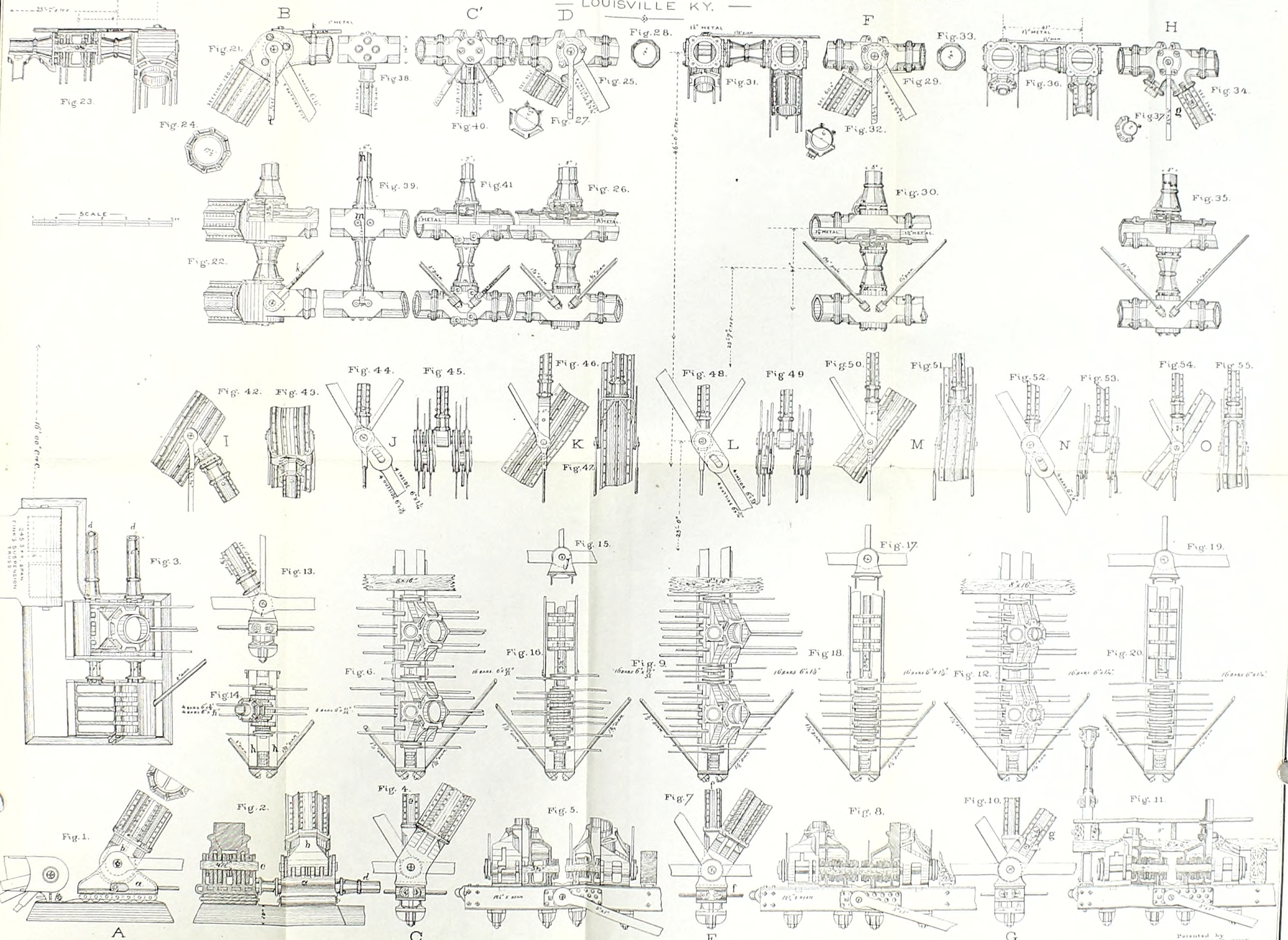
400 FEET SPAN OF THE OHIO RIVER BRIDGE
AT LOUISVILLE, KY.



BUILT BY THE LOUISVILLE BRIDGE & IRON CO.

DETAILS OF THE 400 FEET SPAN. — OHIO RIVER BRIDGE.

— LOUISVILLE KY. —



J. H. Pearson Del.

Patented by ALBERT FINK.

AM. PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS)

11

MESSAGE

OF

GOVERNOR JOHN W. STEVENSON,

TO THE

GENERAL ASSEMBLY OF KENTUCKY,

DECEMBER 2, 1867.

REGULAR SESSION OF THE LE

FRANKFORT, K
PRINTED AT THE KENTUCKY Y
JOHN H. HARNEY, PUBLIC
1867.