This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

The Michigan Boulevard Improvement

Abstract of an address by Hugh E. Young* before the Society, April 12, 1920, dealing particularly with the engineering features of the Boulevard Link Bridge.

GENERAL.

The Michigan Avenue improvement extends from the north line of Randolph Street to the south line of Chicago Avenue. The part of the improvement on the north side of the river between Ohio Street and Chicago Avenue is a street improvement. The width of the street is 104 feet. The roadway is 80 feet wide. The parkways and the walks on either side of the roadway occupy a space of about thirty feet.

The pavement for this improvement, the asphalt pavement, has a concrete base. One interesting feature of this particular part of the work was the placing of all the public utilities underground in the parkways between the curb lines and the building lines to avoid digging up the street after the pavement is laid. The upper level between the north line of Randolph Street and Ohio Street is a boulevard, being 141 feet wide on the north side of the river, having an 80 foot roadway and 30 foot walks on either side of the roadway.

On the south side of the river the street is 127 feet wide, having a 75 foot roadway and walks 25 and 27½ feet wide. The lower level of the improvement extends from Lake Street to Grand Avenue and is paved with granite block pavement the entire width of the street. Along the building frontages between these limits are constructed loading platforms to facilitate the handling of freight. All of the east and west streets such as Grand Avenue, Illinois Street, Austin, North Water, South Water and Lake Street, pass under the upper level of this improvement and connect with the lower level of Michigan Avenue. It was necessary in some cases to depress the streets as at Grand Avenue, Illinois Street and make a slight depression at Austin Street. At North Water Street it was necessary to raise the street slightly. All utilities between these limits are placed on the lower level. Stairways are provided at street intersections to give ready access from the lower to the upper level. The only ducts or cables that are placed in the upper level are those for street lighting purposes. The foundations for the north approach and the south approach are similar. The fill approaches between Randolph Street and between Ohio Street and Grand Avenue and on the south approach between Randolph Street and Lake Street have the retaining walls along the curb lines. These retaining walls are supported on pile foundations. The space between the building lines and these retaining walls is used for sub-sidewalk purposes, and in these sub-sidewalk areas are placed the utilities, so that a very strenuous effort has been made to place all the underground utilities in this entire area either in sub-sidewalk areas, in the lower level, and in the parkways on the North Side.

The foundations for the superstructure generally consist of pile foundations capped with concrete. In some places where the columns were located near or over tunnels concrete caissons were used, and in other cases the caissons were combined with the pile foundations to give cantilever foundations, which were brought about by having beams projecting or cantilevering over the caissons and tied back on the pile foundations. In other words, where this type of foundation could not be used, two caissons were used straddling the tunnel, on which was placed a concrete beam which in turn supported the columns for the superstructure. The superstructure of the approaches north and south of the river are similar. Over the sub-

*Engineer Chicago City Plan Commission.

Digitized by Google

sidewalk areas are placed I-beams about four to five foot centers, which are encased, the upper parts of them, in a four-inch slab. One end of these beams is supported on the retaining walls along the curbs and the other end is supported on girders parallel with the street, which, in turn, are supported on foundations about eight feet six inches out from the building line. The ends of these beams cantilever this distance of eight feet six inches from the row of girders near the building lines and is a very efficient way of constructing the sidewalks along the improvements for the reason that they readily adapt themselves to the varying locations of buildings. On every improvement, some buildings are out one foot, two feet, three feet, or maybe more, or they may be back that much. It is just a matter of cutting off the ends of these beams and building the sidewalk up to the building line, with a provision for an extension.

The superstructure for a viaduct part is of the usual steel column girder floor beam construction. There are two rows of columns about eight feet six inches out from the building lines; another row along each curb, and a row of columns along the center line of the street. The columns are spaced about 28 feet in the direction of the street and support the framework of floor beams which in turn carry the stringers. Intermediate floor beams are also provided which in turn are connected to the floor beams that run in a longitudinal direction of the street so as to give a span of about 14 feet for the stringers. As on the sub-sidewalk areas over on the fill approach, the sidewalk beams on the elevated structure are arranged with the slabs extending in the transverse direction of the street, supported in a similar manner as those on the filled approach. The roadway slab is about eight inches thick and is re-inforced with half inch bars so arranged that they are six inch centers over supports and at center beams. The sidewalk slab is four inches thick reinforced with mesh.

In constructing the foundations for the plazas the contractor first drove the piles. Then he started the construction of the deadmen, then drove the piles for the docks. The piles and sheeting of the docks are capped with large blocks of concrete. The elevation of the top is about 5 feet plus.

After the piles for the dock were driven and the rods were placed anchoring these docks to the dead line, the areas between the dock and the shore were then filled—in these particular places with clay and cinders. They were figured to withstand a pressure due to clay, but later it was decided to use some cinders in order to relieve this pressure, as it was considered a little more conservative.

FOUNDATIONS.

The foundations for the bridge proper consist of two large concrete re-enforced counter-weight pits, one on each side of the river. The counter-weight pits are much like a large concrete box having four sides and a bottom. These pits are supported on concrete bases which are carried down to rock, or hardpan, depending on the conditions determined in the field. Allowable pressure, as a rule, for caissons on hardpan varies from six to eight tons; and in these cases it was necessary to bell out the caissons in order to get the desired unit pressure. Where the caissons are carried to rock unit pressures of 350 pounds per square inch, which I think amounts to about 25 tons per square foot—varying from that to 30 tons per square foot—were used. The caissons under the outer trusses of the river pier were nine feet in diameter and at the center of the bridge under the river pier I think they are 12 feet in diameter. The caissons under the trunnions on the outer trusses are 10 feet in diameter and those at the center are 12 feet in diameter. The caissons under the anchor pier on the pits on the outside are 7 feet in diameter and those at the center about 7½ feet in diameter. The abutments back of the pits are supported

Digitized by Google

on timber piles. The cross girders that support the trunnions of the bridge are supported on grillage beams imbedded in the side walls of the pit, and at the center of the bridge are supported on steel columns which extend down and bear on caissons. The machinery for operating the bridge, the frame of the machinery gear trains which operate the bridge are supported on grillage beams imbedded in the concrete in the side walls of the pit. The live load reactions of the truss is carried on grillage beams under these trusses on the river pier, both at the outsides and at the centers. The anchorage for taking the uplift due to the live load acting with the river pier is taken by beams of steel columns imbedded in the anchor pier of the pits. The bottoms of these anchorages are placed as a rule at the top of the floor of the counter-weight pit in order to facilitate the adjustment of these columns, it being necessary to pour the floor first and provide grout here, and it is very necessary that they be placed at the correct elevation in order to assure that the stringer work when placed will fit and be at the correct elevation.

The large steel column that supports the cross girders at the center of the bridge are encased and stiffened by means of concrete walls extending back to the river pier. The concrete for this wall, however, was not placed until after most of the loads had been placed on the columns, in order to avoid cracks owing to what settlement might take place. The upper part of the river piers are about six feet thick, the lower part seven feet nine inches. The river piers are about five feet thick at the top and seven feet six at the bottom. The side-walls of the pit are four feet six except the lower portions which have extensions on which are fastened the emergency brake track castings. The floor of the pit is about five feet thick, varying somewhat, due to the fact that the floor is sloped to provide drainage to sumps which are connected with the pumps for pumping out the pits. The vertical loads used in designing the pits are for the floor—two cases—downward pressure consisting of the weight of the masonry taken as 150 pounds per square foot, and that due to water pressure in the pit, it being assumed that the pit has about 12 feet of water in it. In this case it would happen when the pit is enclosed in a coffer-dam.

For upper pressures the factors that should be considered are those due to buoyancy and hydrostatic pressure and the weight of the masonry itself at 150 pounds per cubic foot, and the pit empty. The vertical loads on the river pier, the anchor pier and side walls are the dead loads of the superstructure, three-quarters of the live load of the super-structure, masonry taken as 150 pounds above datum and 50 pounds below datum. For the horizontal loads on the side walls and the anchor pier earth pressure is taken above datum as about 28 pounds per square foot, and below datum 60 pounds per square foot for one case, the other case being half of the water pressure from the inside, which might be the case where the pit is full of water, and it being enclosed in a coffer-dam. The river pier is figured for internal and external loads of water pressure up to datum.

The floor is figured as a slab supported by the four walls of the pit and has been re-inforced laterally and longitudinally; the floor has been figured as a slab supported by the walls of the pit and consequently, over a girder at the center of the pit. The re-inforcing steel was distributed, for the transverse or longitudinal directions, inversely as the fourth power of the span. The span for the short span being about 33 feet and the long span about 49 feet.

The river pier, anchor pier and the side walls have been figured for vertical loads as continuous beams over three-fourths and for the lateral loads or horizontal loads the side walls have been figured as beams supported by the floor of the pit and horizontal girders at the top of the pit which extend from the river pier to the anchor pier. The horizontal girders are re-inforced on the lower side for the ver-

Digitized by Google

tiacl loads of the enclosure walls and superstructure, and the inner sides for the horizontal pressure caused by the pressure on the side walls.

The anchor piers have been re-inforced for horizontal pressures due to earth pressure on the outside, and the water pressure on the inside, and is figured as a retaining wall supported by the side walls of the pit and the buttress formed by the extension at the center of the pit, which is also used as a support for the emergency brake rail casting (or casing). The river pier is figured as a retaining wall with proper allowance made for the resistance given by the side walls, and in the design of the pit floor provision is made for the moment induced by the cantilever action of the river pier about this connection with the pit floor.

Coffer-dams for the pits are so constructed that provision is made for a clearance of about two feet from the inner edge of the dam to the network of the concrete pit, so that there will be some allowance for the caving in, so to speak, of the inner row of the sheeting. The dam is built, or consists, of a row of sheet steel which encloses the entire counter-weight pit and then an outer row of timber piles and sheeting spaced about 10 to 12 feet from the inner row of sheet steel. The space between the sheeting is filled with clay or any other suitable material, in order to give it a proper puddle. The puddle walls are braced by means of 12x12 timbers spaced about 10 feet centers, and in layers, about 5 foot centers, in the depth of the pit. Within the area of the coffer-dam itself are driven at certain places timber piles to support the bracing and take the sag that would naturally come by having such a large area of timber or bracing. When the bracing has been carried down to the necessary depth, the bottom 5 foot spaces cleared of all bracing, and piles, with the exception of those that support the center part to take the sag here and around these piles, on the bottom are built conical shaped forms, and after the concrete floor has been poured, and of course the walls are carried up and the pit finished, these piles are cut off below the bottom of the pit and then these openings are plugged with very rich concrete. This method has been used on a number of city bridges with success.

The concrete for the counter-weight pits, the mix was 1—3—5, to which was added hydrated lime, about 8 or 9 or 10 per cent, or about one quart to each bag of cement. Hydrated lime has been used with success, not alone on the pits for the Michigan Avenue bridge, but also the Franklin-Orleans bridge and others. It certainly does facilitate the pouring of concrete. It makes a much denser concrete, too. You would have no leakage of these pits except that due to minor cracks which quickly fill in. These cracks were perhaps hair cracks.

BRIDGE STRUCTURE.

The Michigan Avenue bridge is known as the double deck double leaf trunnion bascule bridge. Each leaf has four trusses. The center of the outer trusses is about sixty feet center to center. The center to center of the inward trusses is about 6 feet. Each leaf is split longitudinally to center, making the centers of the two trusses for each half 27 feet center to center. The trusses do not project above the upper level but in order to obtain an improvement in the appearance of the bridge the bottom chord was raised at the center above the lower floor approximating the curve of a parabola. This made it necessary, of course, to suspend the portion of the roadway from about the second panel point on. The appearance of the bridge has been greatly improved by having the gusset plates curved, and this was done in the shops by means of the oxy-acetylene torch.

On the upper level or upper deck is placed an ornamental iron hand railing with structural rails and supports and with panels made of cast iron. The lower level railing is of simpler design and it is constructed throughout with wrought iron and malleable casting. The abutments for the bridge are very wide and are con-

Digitized by Google

structed from the level of the dock to the lower level street of granite, backed with brick, and from the lower level to the upper level they are constructed of Bedford stone. The specifications called for buff Bedford. The houses are also faced with Bedford stone. The stone work for the ballustrades and ornamentation around windows and belting and cornices will be very richly carved and give a very pleasing and ornate appearance to the bridge.

The distance between center to center trunnions of the bridge is 256 feet. The distance between masonry is 220 feet. The government requires a clearance of 80 per cent of the distance between masonry, which in this case amounts to 176 feet. The city ordinance requires that when the bridge is raised no part of the structural steel shall extend beyond the river coping for at least 170 feet above datum.

Each length of the bridge is figured as a cantilever with the reaction at the trunnion for dead loads, and for live loads it is figured as a cantilever with the reaction at the river pier, and at the anchor columns, and the extraordinary case of where it is assumed that the live load acting about the river pier lifts the load at the trunnion. The depth of trusses at the center is 11 feet, at the river pier about 27 feet. The panels are spaced about 14 feet center to center. The factors that determine the location of the trunnion are many and they vary in every bridge. It is very hard to lay down any hard and fast rules. Some of the factors that govern the location are the grades. In this particular bridge there is a grade on the upper level, the grade on the lower level under which must be placed the trunnions, the distance that the paneling extends back of the trunnions in order to keep the material down within limits of sheet material, all of which conditions will control the location of the bottom chord from the river pier to the connection with the counterweight box.

Another condition that we considered is the depth of truss at the rear part. Another condition is the bridge and floor on the upper deck, as this floor revolves back it must not foul the floor back of the breaking floor. These factors caused the trunnion to be located about 14 feet back of the center line of the river pier.

The outline of the bottom chord must satisfy the condition of 16½ feet clearance above datum for the government requirements, after which the outline followed that of giving the best appearance to the structure.

As stated, each leaf of the bridge is split longitudinally into two parts. It was therefore necessary to provide for bracing between the inner trusses in order to carry over deflections that would be caused by the live load on one leaf, and in order to do that heavy diaphragms were constructed at each panel point, the head of the trunnion, and at the back of the trunnion members wherever clearances would permit. Without going into a long theoretical analysis of what would be put in there, we simply put the diaphragms in there sufficiently to take the live load from one truss and back of the points provided diaphragms there that would take the entire shear load that might come on one pinion. The upper level of the roadway is 27 feet between curbs. In fact, the sidewalks are 15 feet wide, floor beams spaced about 14 feet and the stringers about 2 feet 10 inches. The flooring will be 6x12 sub-blocking, calked in, on which will be placed a rectangular block supported at intervals of six feet with small angles. Knee bracing was provided at each floor beam in order to improve the looks of the upper level, that is, the under-side of the floor from the lower deck, also to stiffen up the structure transversely.

The lower level of the bridge has two roadways 18 feet curb to curb and two walks about six feet wide. The roadway planking on the lower level will consist of 6x12 sub-planking laid close, on which will be placed rectangular creosoted block. The part of the grade on the upper and lower level roadways are about one-half of one per cent, except that on the lower roadway from a short distance ahead of the

Digitized by Google

river pier there is a break in grade and from that point back on the approach there will be a three per cent grade, and for this part of the lower level pavement sandstone block will be used, which will be better for traffic than creosoted block, as a sandstone block has probably the least factor of slipperyness of any pavement, except something that will give a corduroy effect like having spacers placed between the creosoted block, which has been used more or less successfully on some of our city bridges. The sidewalks on the upper level are tied back to the trusses by means of angles, in order to take the sag when the leaves are raised. Both on the upper and lower levels for the two end panels the lateral bracing has been fastened by means of three-quarter inch bolts temporarily so that adjustment would be possible. I might say that these end panels or bracing are to be drilled and reamed in the field, except that in each connection one or two holes were provided in the shops, in which were placed three-quarter inch bolts so that when the bridge is lowered, should it be out of line the trusses could be pulled over by means of steamboat jacks. This actually happened at Michigan Avenue and the bridge was readily pulled over in this manner.

The trunnions of the bridge are supported by means of cross girders which extend from the side walls of the pit to columns located at the center of the pit. These cross girders are box section and have been provided at points where the trunnion bearings come with shims of varying depths to take the deflections that come on the bridge when the bridge is fully loaded. The deflection must be anticipated and proper shims provided. When the leaves of the bridge were erected the center trusses had a tendency to creep together. That was before the full loads were on the cross girder. This, of course, was due to the fact that the trunnions were not horizontal, which was caused by the levels on the shims. However, after a number of panels had been erected the diaphragms were placed, this corrected the line, and as the full loads came on the trusses they settled down into the horizontal position so when all the loads are on the bridge the bearings for all the trunnions will be on a horizontal line.

The bridge is figured for two cases; one case is the bridge closed and the other bridge open, or fully opened. For case of bridge closed the dead loads are figured on the bridge as a cantilever with the reaction at the trunnion. Live loads are also figured for two cases; one, the reaction being taken at the river pier and the anchor column, and the other case where there is an additional reaction caused by the impact. What we formerly used is $\frac{100}{nl} + 300$ where n is, I believe, one-tenths of the weight of the loaded length, and l is the length. Then the stresses are combined and placed in one column and in the next column, if there be any reversal for a combination of the stresses just mentioned, fifty per cent of that reversal is placed in the second column and then the total governing stress figured for this case and tabulated.

For the case of bridge opened or fully opened the dead loads are figured for bridge closed, or nearly closed. To these stresses twenty per cent is added for vibration, to which are added stresses due to number of pounds exerted on the exposed area of the leaf. These are summed up algebraically. If there be any reversals for this case they are placed in another column for this particular division, and a total combined stress figured for this case. Then the combined stress is figured for the bridge closed, and the combined stress for the case of bridge opened or fully opened. If there be reversals on these two cases, then six per cent of that reversal is taken and placed in a column for the final consideration of combined stresses.

Then in another column are placed the governing stresses. They are picked out and the one giving the largest stress is tabulated,—both the tension and compression.

October, 1921

Digitized by Google

For the determination of the counter-weight for the leaves it is necessary to find the center of gravity of every component part of the trusses and work these back into the final center of gravity of the leaves exclusive of the counter-weight. For this particular bridge the center of gravity of the leaf exclusive of counter-weight is about 25 or 26 feet ahead of the trunnion, and about 9 feet over a horizontal line through the trunnion. The weight of the leaf exclusive of the counter-weight was about 2,500,000 pounds for one-half of each leaf and the corresponding counter-weight required 1,500,000 for each half of each leaf. The center of gravity of the counter-weight box is about thirty feet back of the trunnion, and, I don't just know what the distance is below the horizontal line through the trunnion. The center of gravity of the leaf exclusive of the counter-weight is quite high, and this causes the counter-weight necessary for balancing to be placed in a very low position in the box. The counter-weight for these leaves was made of common concrete at 145 pounds for the upper and front part of the boxes and for the lower left hand corner of the boxes of composition concrete weighing 300 pounds per cubic foot. This composition concrete is made of punchings and grout. The inside trusses tended to come together, which was due to the fact that the trunnions were supported on bevel shims and caused a little concern at first, but when the matter was explained this was ironed out all right, and after a number of panels had been placed diaphragms were inserted between the trusses, which corrected the alignment from that point to the end of the leaves. When the leaves were lowered the trusses were out of line laterally, I believe, about three inches, but steamboat ratchets were immediately placed and by means of cables the ends were very readily drawn over, and within a short time the four trusses fit perfectly.

MECHANICAL AND ELECTRICAL EQUIPMENT.

In the plane of the rear arms of the trusses are built racks which are of about 19 ft. 9 in. radius. These racks are engaged by pinions on frames which are located on the outside of the outer trusses. The frames at these points have three counter shafts. The last counter shaft is connected by means of bevel gearing to a line shaft which is carried back into the machinery room and thence over to the motor stand. The motors are at the ends of the line shafting, keyed in with bevel gears which are a part of the equalizer, vertical bevel gears, which engage bevel gears at right angles to the vertical gears, which in turn are fastened by means of pins into a large spur gear, which is engaged by the pinions on the motor or armature shafts. The armature shafts are continuous right straight through both motors, the motors being raised in pairs.

A provision is made on the motor shafts for fleible couplings to insure proper working of the motors and the pinions that engage the equalizers are extended up and are engaged by clutches. These clutches were provided to permit of an easy changing of the motors, it being considered necessary to alternate the use of the motors from week to week, and the particular reason for putting in clutches there was to avoid the necessity of going to a machine shop or the municipal plant to get the necessary craftsmen to take out the bolts if bolts were provided, which would cause considerable delay. The bridge operators are not supposed to take any bolts out of any couplings or any other apparatus. The pinions on the armature shaft are always in mesh and the ones not engaged run as idlers.

On the second counter-shaft is provided an air operated brake. The machinery for operating the barriers is located on the river pier. Each half of the leaf is operated by one motor, that is, each half of the rear lock machinery of each leaf is operated by one motor. The bridge is made for operating all of the various functions of the bridge by motors. In case one half of the bridge may be damaged due to impact by boat it would be necessary to raise this leaf for repairs, and in order not to delay traffic an arrangement is made to operate the other half.

Digitized by Google

The shoes of the air brake are operated by means of air cylinders which are direct acting. These cylinders are controlled, the admission of air into these cylinders is controlled by magnet switches operated from the operator's house. Near the cylinders are placed auxiliary tanks to insure the proper supply of air. In the houses on both sides of the river are placed two automatic air compressor plants. Each unit has a capacity I believe to displace about fifty feet of cubic air per minute. The motors and the compressors have a herring bolt pinion and gear, and arrangement is made by means of an automatic governor to insure pressure in the main air tank at the plant of about ninety pounds pressure, or any pressure necessary to have about sixty pounds pressure at the brake cylinders themselves.

The shoes of the hand operated brake are operated by means of toggle arrangement as in case of the air brake, which, in turn, is operated by a cable which is deflected around over pulleys and finally led around to the brake stand in the houses. In addition to these brakes the emergency brake, air operated, is provided.

The electric control equipment for the bridge comprises the operator's house, the operator's room and a control room immediately below the operator's room and a gateman's house on each side of the river on the lower level at the center of the street back of the counter-weight pits. In the control room are placed the necessary resistances for controlling the currents in the main operating motors, the center lock motors, etc.; also panel boards on which are mounted the relays, contractors and double throw switches and other electrical apparatus. In the operator's room, which is arranged in convenient manner and somewhat in accordance with the sequence of operations, are placed the controllers for the barriers, which are of the drum type. The controllers for operating the emergency brake and also the service air brake on the gear train are located near the stand of the operator. Also near the stand of the operator are provided the master controllers for operating the center locks and rear locks and also the main operating motors. The controllers for the operating of the main motors, also the center lock and rear motors, are of the magnetic type and have provision for certain points of acceleration which by means of magnetic switches operate the contacts and relays located on the control panel boards in the control room. The barrier controls are of the drum type, the fingers of which operate the current directly, are provided as described.

The brake stand for operating the hand operated brake is on the right hand side of the operator and near the side of the house, near the roadway side of the house. Provision has been made for this bridge, as I believe in the Monroe Street bridges and the Franklin-Orleans bridge, for a bench board. On this are mounted switches which control the cut-outs for the various interlocks, also the signals and bells and the double throw switch which is mounted on the control board in the control room. When a steamer gives the operator the signal to open the bridge—and in this particular bridge the main operator is located on the north side of the river, the north operator signals his gateman and also the operator on the south side of the river, who in turn signals his gateman. After these gatemen return the signal to the operators—the purpose of these signals being to call the operators and gatemen to their stations—after the main operator has received the signal back that these men are at their stations he sends another signal out which is for the purpose of closing the gates. The signal gates are lowered first on the side of the ingoing traffic, that is, both on the upper and lower levels, and when the signal gates on the side of ingoing traffic are lowered they give current for operating the barriers on those particular sides, and after these are lowered and the traffic goes off the other side of the bridge then the signal gates on that side are lowered and they give current for the operation of the barriers and when the barriers are lowered on both levels current is furnished for operating the rear locks. In the meantime the north

Digitized by Google

This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

INDEX

Engineering World

A Journal of Engineering and Construction

Volume 14

January 1—June 15, 1919

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH

BY THE

INTERNATIONAL TRADE PRESS, INC.

MONADNOCK BLOCK, CHICAGO

Digitized by Google

The Michigan Avenue Improvement

Is the Most Important Addition to Chicago's Boulevard System

By HUGH E. YOUNG

Engineer of Bridge Design, City of Chicago.

This municipal improvement, which forms a part of the boulevard system connecting the business and residential districts of Chicago, has been developed entirely by the city's engineering forces without the aid of outside experts. Michael J. Faherty, president, and C. D. Hill, engineer of the Board of Local Improvements, supervised the general development of the engineering, legal and financial features of this improvement. William A. Mulcahy is the chief engineer in charge of the construction. The plans and specifications for the entire improvement were prepared in the Bridge Designing Section, Bureau of Engineering, Department of Public Works. Hugh E. Young, engineer in charge of the design; Thomas G. Pihlfeldt, engineer of bridges; John Ericson, city engineer, and Charles R. Francis, commissioner of public works. The entire construction work is being handled under 12 separate contracts at a total cost of about $7,700,000, exclusive of engineering, inspection and property damages due to street widening and grade changes. The Great Lakes Dredge & Dock Co. was awarded the major contracts for the substructure and superstructure of the improvement. Capt. William Murphy is the general superintendent for the contractors.

For many years the abominable traffic facilities in Michigan avenue and Rush street, between Randolph street and Chicago avenue have made this street the most congested thoroughfare in Chicago. The comprehensive boulevard system connecting the central business and residential districts of the city has been incomplete between these points, where only narrow streets and the old Rush street draw-bridge existed to take care of an immense volume of automobile traffic between the north and south sides of the city. This condition was further aggravated by the addition of the east and west-bound heavy traffic caused by the location of railroad yards and warehouses east of Michigan avenue. This congestion in traffic will be remedied with the completion of the Michigan Avenue Improvement, known as the Boulevard Link, which provides a spacious boulevard from Randolph street to Chicago avenue for automobile traffic, and has a lower level extending from Lake street to Grand avenue for teaming traffic, both levels being made continuous across the river by means of a double-deck, double-leaf bascule bridge.

Location, Extent and Grades.

The south portion of the new thoroughfare extends from Randolph street to the river along Michigan avenue, widened eastward to 127.5 ft. with a 75-ft. roadway. The boulevard level rises with an easy grade from the present elevation of 15 ft. above datum at Randolph street, to the upper deck of the bridge at an elevation of 37 ft. above datum. City datum is the average elevation of the lake level.

The bridge connects the north and south approaches at a slight angle, due to the offset of the two approaches at the river. North of the river the thoroughfare continues to Chicago avenue along what was formerly Pine street, widened westward to 141 ft., with an 80-ft. roadway. The upper level from the bridge descends to the north, with an easy grade to the present surface of the street in the block north of Ohio street. From this point to Chicago avenue the grade is practically level at an elevation of 13.25 ft. above city datum. Near each end of the bridge the approaches are widened out into spacious oval-shaped plazas provided with ornamental balustrades and safety islands.

Fig. 1 gives some idea of the magnitude of the improvement and shows the extent of the work in Michigan avenue south of Ohio street and in Lake street. The boulevard level has a total length of 4400 ft. along the main thoroughfare, with a lateral approach in Lake street from Wabash avenue, and east and west approaches in Ohio street. The lower level over which the boulevard is carried by viaduct construction has a total length of 2300 ft., and connects with all intersecting streets and alleys from South Water street to Grand avenue. Just north of Lake street the lower level is narrowed to 45 ft. and connects with Lake street to the east. The elevation at each end of the lower level is about 8 ft. above datum, which necessitated heavy cuts in Lake street, South Water street and Grand avenue. The lower deck of the bridge is at an elevation 20 ft. above datum and its immediate approaches have grades up to 3.25%; otherwise the grades are easy, ranging from 1 to 2%.

Viaduct and Aproach Construction.

Fig. 2, which is a substructure plan for the portion of the viaduct from Ohio street to south of Illinois street, shows types of foundation and construction which are quite typical for the improvement, except the sub-piers and cantilever supports, which were

Digitized by Google

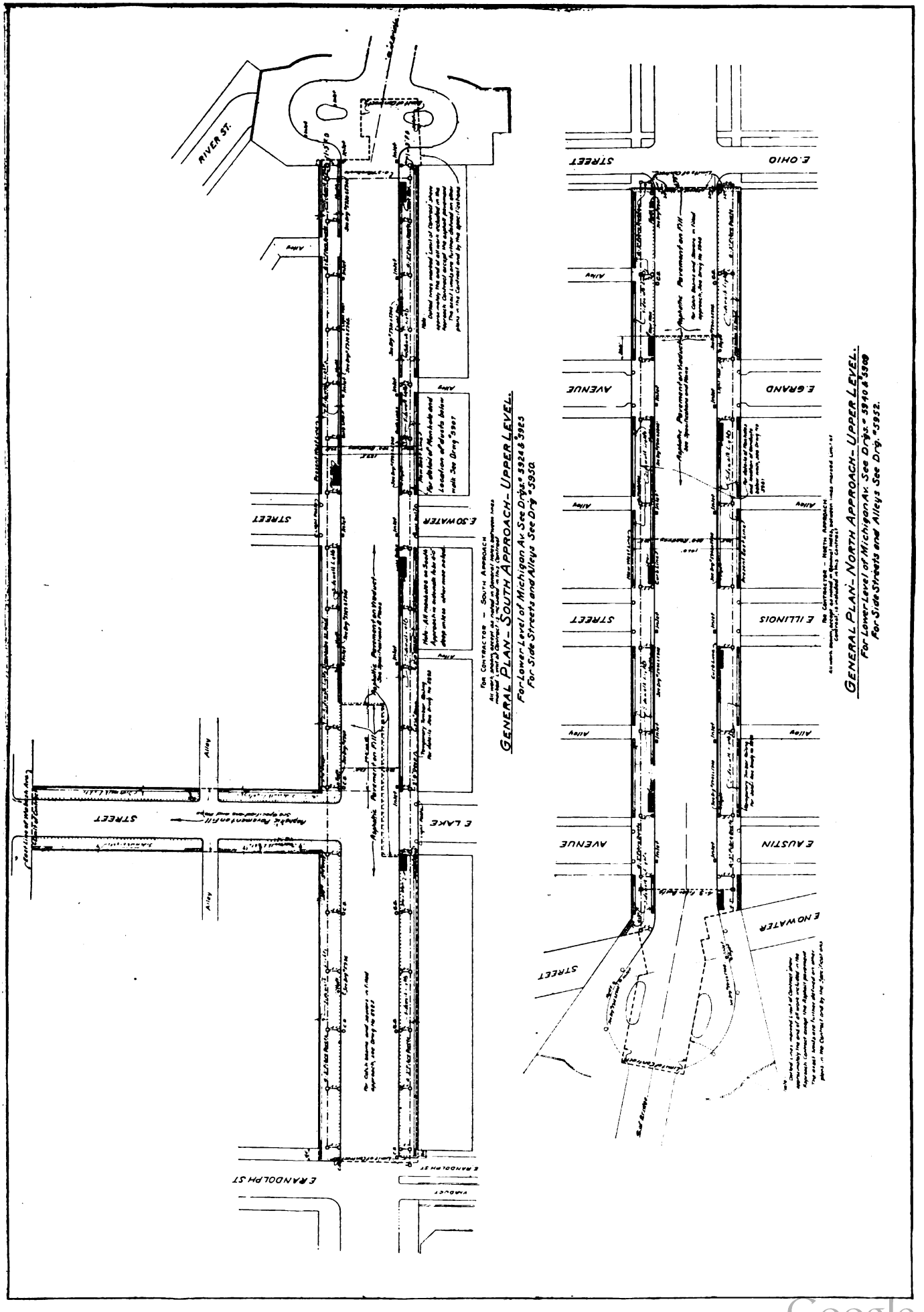


Fig. 1.

Digitized by Google

necessitated to avoid interference with the Illinois Tunnel Co.'s bore. Sub-piers were also used south of the river for one line of viaduct columns located close to a 4-ft. sewer, where piles and footings could not be used.

The cross sections on Fig. 2 show the type of viaduct construction with concrete roadway and sidewalk slabs supported by steel beams and columns incased in concrete, and the concrete curb walls used to retain the filled approaches and support the sidewalks. The latter also have concrete slabs and steel beams and a row of light columns near the building lines at each side of the street. Concrete platforms extend along the building lines on the lower level, the tops of these platforms being about 3.5 ft. above the street level. These platforms are used for loading of trucks, and steps are provided at all street and alley intersections. The upper and lower levels are connected by stairways at the street corners.

In the course of making the excavation for the improvement, some interesting things were found. An old log pipe was dug up in South Water street between Michigan and Wabash avenue. It is 12 in. in diameter with 4-in. bore, and was part of Chicago's first water works system, laid about 1840. Two human skeletons were also found, which, from the manner of burial, are thought to have been those of victims of the Fort Dearborn massacre in 1812.

Bridge Substructure.

The substructure for the bridge proper consists of two immense concrete counterweight or tail pits, one on each side of the river. These pits are constructed as follows: The front wall of the pit called the river pier, which is about 95 ft. long, is supported on three caissons, one at the center line of the bridge and one on the line of each outside truss. This wall carries one-half of the sidewalls and floor of the pit. The rear wall of the pit, called the anchor pier, is approximately 95 ft. long and is supported on three caissons located in line with the river pier caissons. The anchor pier takes the uplift due to live load on the bridge. The sidewalls on the pit are approximately 65 ft. long and are supported by the river and anchor piers. The floor of the pit is 5 ft. thick and is carried by the front, rear and side walls of the pit. The trunnion loads are transmitted directly to three caissons located approximately under the bridge trusses. The floors of these pits are about 29.75 ft. below the surface of the river; these pits receive the counterweight or tail ends of the bridge leaves which swing downward below the water level when the leaves are opened. Ample provision is made in the reinforcement of these pits for the various conditions of water and earth pressure.

The concrete caissons supporting these pits are carried either to rock or hard pan, with spread footings.

The bridge houses and plaza foundations, also the abutments back of the pits, are supported on piles.

Fig. 3 shows the extensive cofferdam work necessary for the construction of these pits and is a view along the north side of the river, looking east. Fig. 4 is a close-up view of the same cofferdam, looking south, and shows the massive timber bracing required to sustain the puddle walls. The dam consists of a double row of sheet piling, 12 to 13 ft. apart, with a clay puddle wall between. At the right is the old Rush street draw-bridge, built in 1884.

The general character of the work in connection with reinforcing the pit floor is shown in Fig. 5.

Bascule Bridge.

The bridge across the river is shown on Figs. 6 and 7 which indicate the location, grades, dimensions, materials and its general appearance. It is a trunnion bascule bridge having two levels or decks corresponding to the two levels of the north and south approaches. The trunnions are supported on cross girders which rest on the side walls of the pit and the steel column, at the center line of bridge. At the back of each rear or anchor pier there is a machinery room in which are placed the motors which move the bridge. On each side of the machinery room there is provided a basement space under the lower plaza, extending to the ends of the abutment walls.

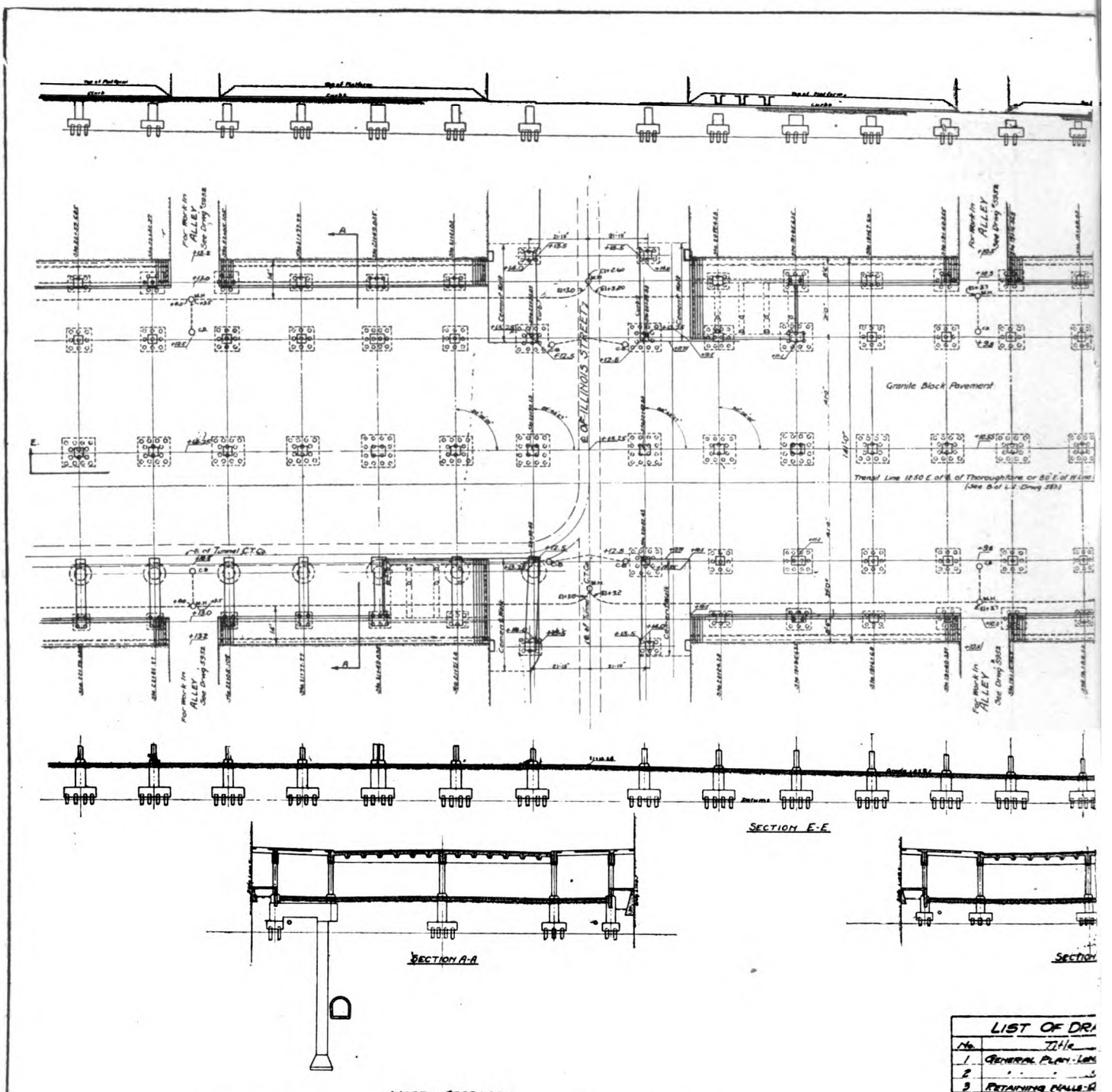
The movable portion of the bridge consists of four equal parts symmetrically arranged with respect to two vertical planes at right angles to each other, one plane being along the center line of the bridge and the other plane midway between the two center lines of the trunnions. Each of these four parts may be considered as a single arm, and two adjoining parts on the same side of the river form a double arm. Each single arm is carried by two main trusses rigidly connected to each other by the floor beams of the two decks, laterals and the counterweight. Each double arm is formed by the two single arms which are connected to each other by a series of diaphragms placed between the vertical members of the inner main trusses.

The clear span between masonry abutments is 220 ft. The clear height under the bridge, when in its lower position, is 16½ ft. above city datum for a distance of 176 ft. The distance between the trunnions of the bridge is 256 ft. The distance between the centers of the main trusses of each single arm is 27 ft. and the distance between the centers of the inner trusses of the two adjoining single arms is 6 ft. The clear headroom between the lower roadway floor and the lowest part of the floor system carrying the upper deck is 13½ ft.

The upper deck of the bridge is entirely above the trusses and consists of two roadways, each 27 ft. and 3 in. between wheel guards, separated from each other by a slightly elevated floor strip or island, 5 ft. 6 in. wide, and two sidewalks, each 15 ft. wide, on the outer sides of the roadways, making the upper deck of the bridge 90 ft. wide over all, which will be the widest movable span in Chicago.

The lower deck or level of each single arm con-

Digitized by Google



The quantities given in table of Estimate of Quantities are approximate only for the purpose of canvassing bids
The City of Chicago assumes no responsibility for the correctness of the same

ESTIMATE OF QUANTITIES

Item	Description	Amount		Item	Description	Amount	
A	Lump Sum			AA	Blocking and filling old catch-basins		
B	Excavation			BB	Cast Iron - furnished and set		
C	Removal of masonry			CC	Sewer - 12" tile pipe		
D	Removal of street pavements			DD	Sewer - 8" tile pipe		
E	Removal of sidewalk & Basmt. floors			EE	Sewer brick		
F	Removal of reinf. conc. in vault, sidewlks.			FF	Resetting beams, frames, etc.		
G	Removal and hauling of metal			GG	Cement sidewalk on ground		
H	Removal of timber			HH	Pavement - Per. granite with base		
I	Test piles			II	" - Asphaltic with base		
J	Piles furnished, & delivered - Oak, Pine etc.			JJ	" - Asphaltic on slab		
K	Piles driven			KK	Curb - concrete - 15"		
L	Concrete 1:2:4 Platforms, Beams, Cols. etc.			LL	" - 30"		
M	Concrete 1:3:6 Walls, footings etc.			MM	Sidewalk Lights		
N	Subpiers			NN	Timber - Pine - erected and removed		
O	Removal of boulders			OO			
P	Concrete in subpiers under air			PP			
Q	Filling - general						
R	Filling - sand						
S	Struct. Steel - Furn. and erected						
T	Reinforcing Steel						
U	Safety Treads						
V	Cement - surface Finish						
W	Catch-basins						
X	Manholes						
Y	Adjustment of old manholes						
Z	Adjustment of old catch-basins						

For amounts see Proposal

For amounts see Proposal

LIST OF DRA

No.	Title
1	General Plan - Lo
2	" " "
3	Retaining Walls - S
4	Column Footings - S
5	" " Arc
6	Elevated Platform - Lo
7	Gen. Plan - Upper Level - Lo
8	" " "
9	Framing Plan "A"
10	" " "B"
11	Tabulation of Girder
12	" "
13	General Cross Sec
14	General Cross Sec
15	Typical Structr. Detail
16	Typical Conc. Slab D
17	" Manhole and
18	" Column Encase
19	" Stairway and
20	General Plan - Steel
21	Sections and Detail
22	Street and Alley P

Fig. 2.

Digitized by Google

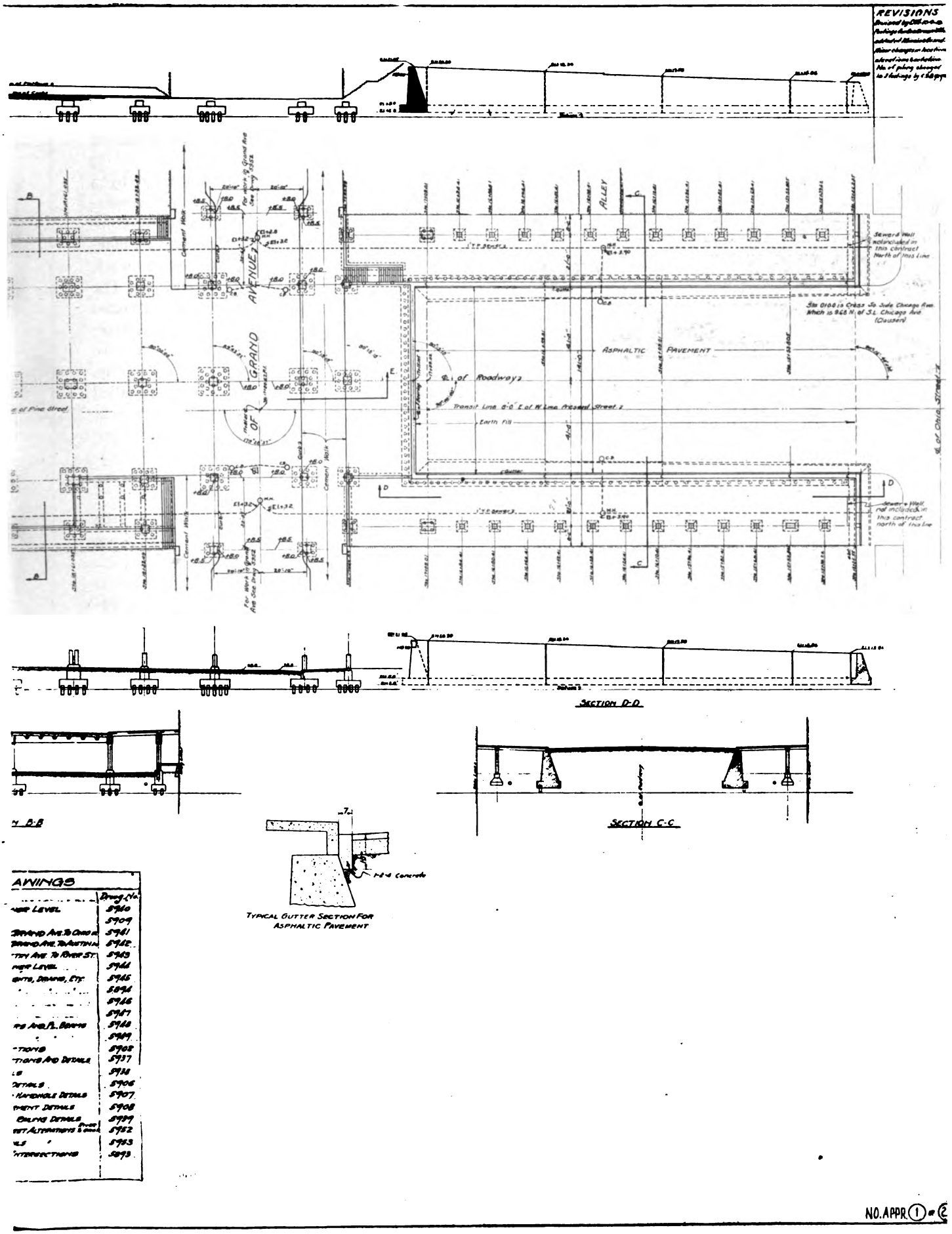


Fig. 2.

Digitized by Google

sists of one roadway 18 ft. wide between wheel guards and one sidewalk 5 ft. wide, both of which are located between the main trusses.

The total weight of the two movable leaves, including their counterweights, is 6770 tons. The weight of

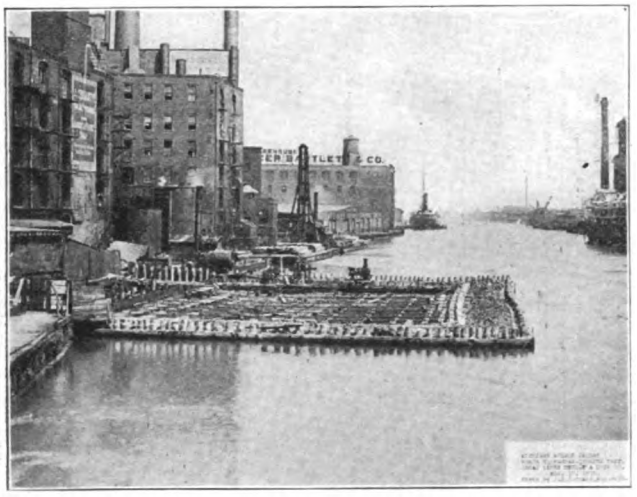


Fig. 3—Michigan Avenue Bridge Coffer Dam—Looking East.

the steel in the movable part is 2500 tons. The fixed part contains about 700 tons of structural steel.

Operation of the Bridge.

The bridge is electrically operated. Each leaf is equipped with four 100-hp. interpole type electric motors of the heavy mill type construction, series wound. The motive power is transmitted from the shafts of the main motors to the movable leaves by means of gear trains ending in main pinions which engage the teeth of large circular racks attached to the movable trusses. The bridge is designed so that the center of gravity of the entire mass of the movable part is at the trunnions. The principal forces to be overcome in operation of the bridge are friction, wind loads and inertia, and the machinery is designed to accomplish this in about 1 min. Under normal operating conditions only one pair of motors connected in parallel is used for raising each leaf, and provision is made by means of a system of mechanical clutches to cut off the auxiliary pair.

The movement of the leaves is controlled by a triple system of brakes. One system of brakes operated by hand power and another operated by compressed air are applied at each gear train, and an independent braking system operated by compressed air is applied at the rear ends of the movable trusses. The compressed air is supplied by two direct-connected motor-driven air compressors, each having a displacement capacity of 20 cu. ft. of free air per minute. In addition to the main operating motors, four 10-hp. motors, two at each side of the river, are installed with proper gearing for opening and closing the rear locks supporting the tail ends of the main trusses when the bridge is closed, and two 5-hp. motors for operating the center locks connecting the trusses at the break in span.

All bridge operating machinery, as well as the gates, barriers and safety signals, are controlled from the operators' towers located at each side of the river, and a system of bells, signal lamps and telephones is provided for communication between the bridge tenders on the opposite sides of the river and also between them and their respective gatemen at the lower level of the bridge approaches.

The operation of the bridge is remote-controlled by means of a master controller of the reversible drum type which opens and closes the magnetic switches of the motor and brake circuits in the proper sequence.

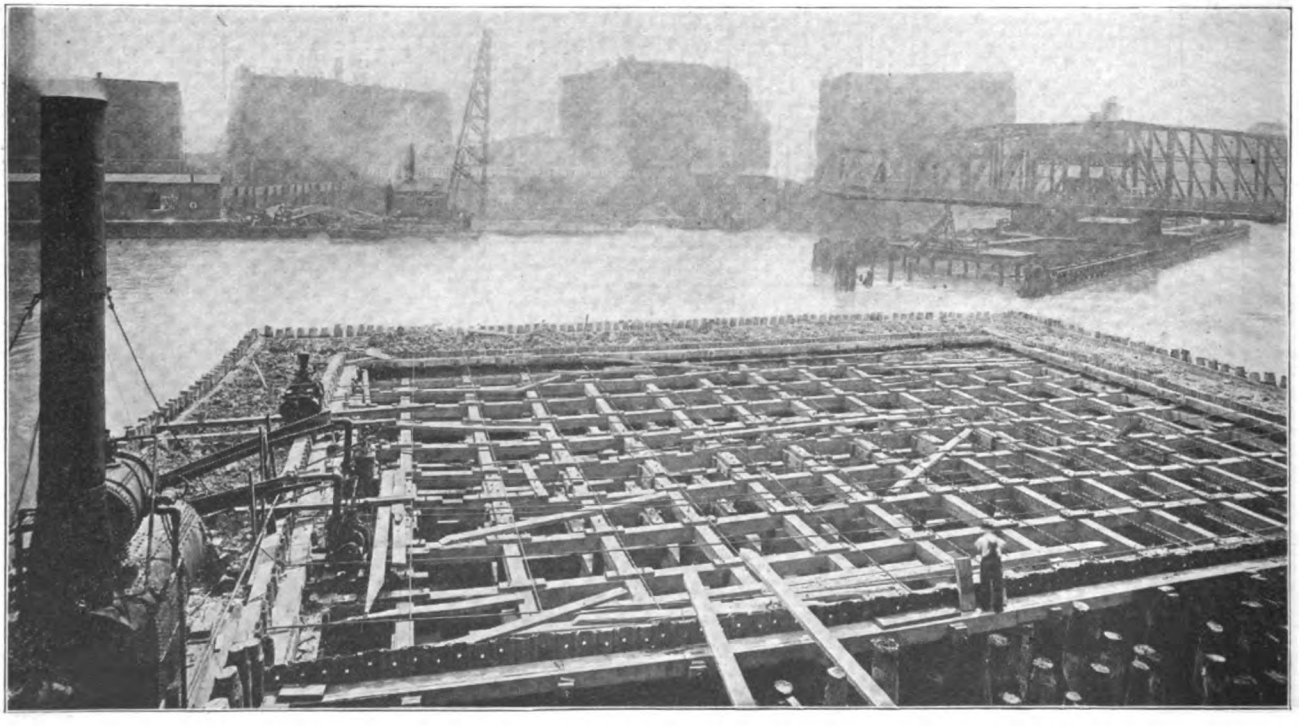


Fig. 4—Michigan Avenue Bridge, North Coffer Dam—Looking South.

Digitized by Google

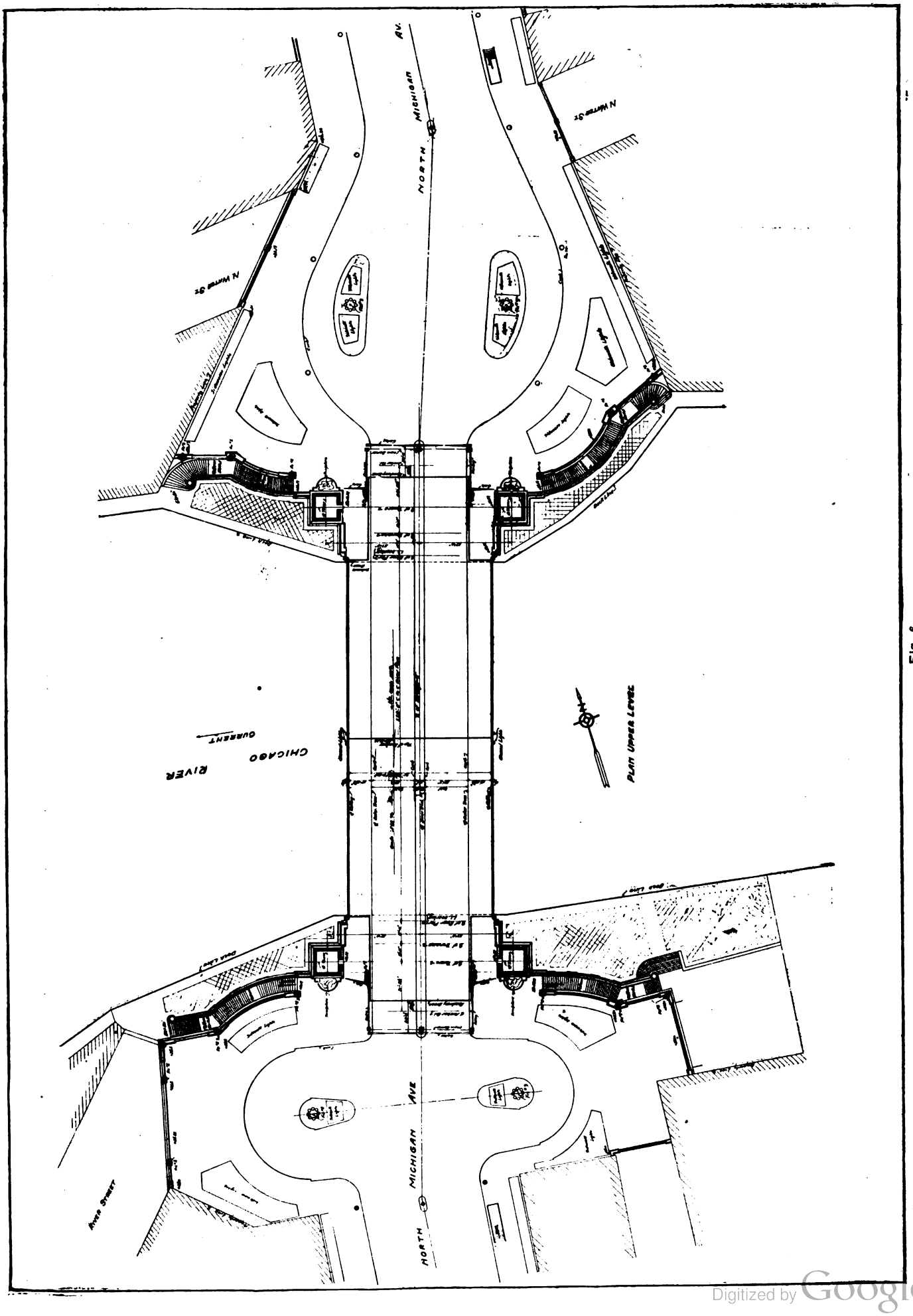


Fig. 6.

Digitized by Google

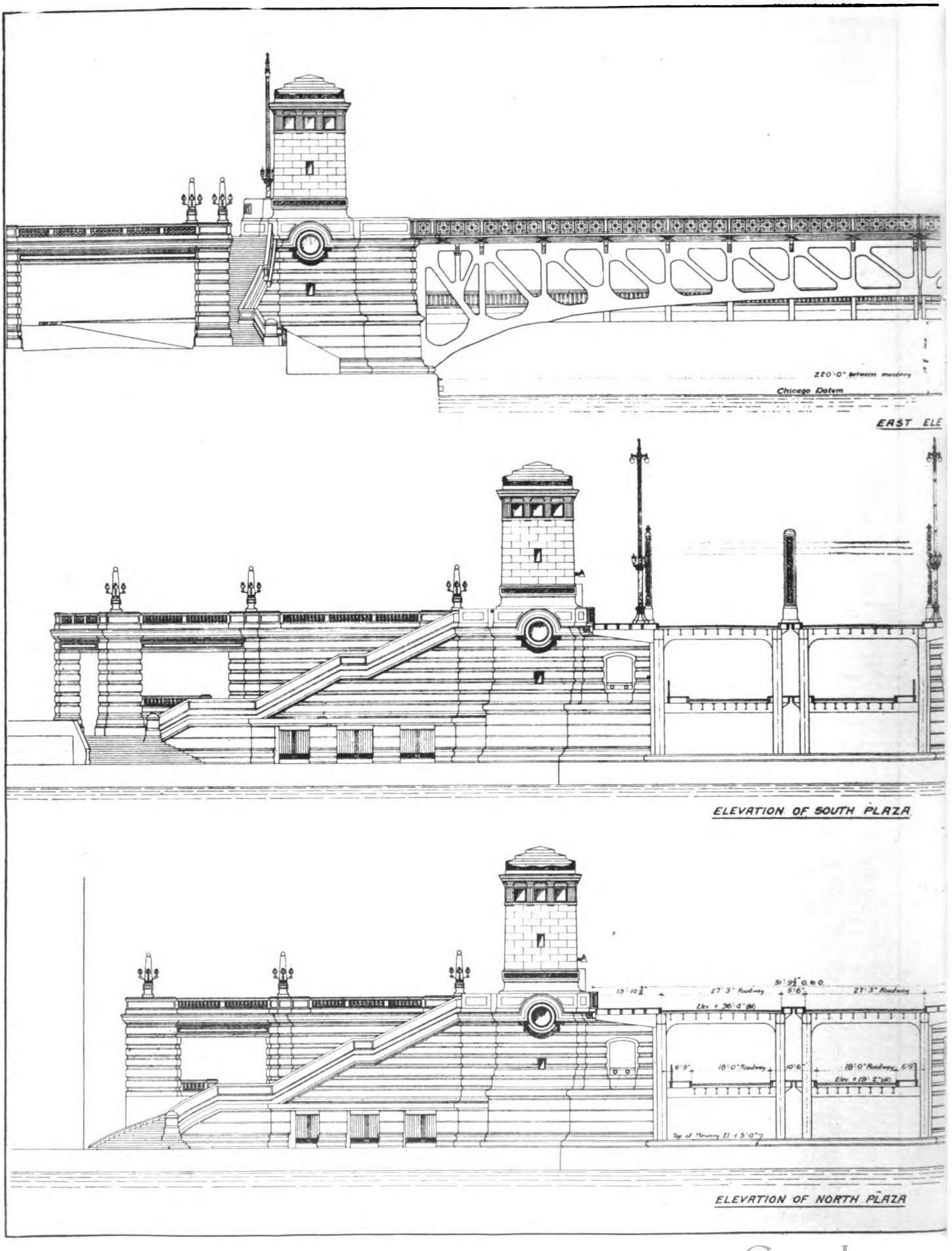
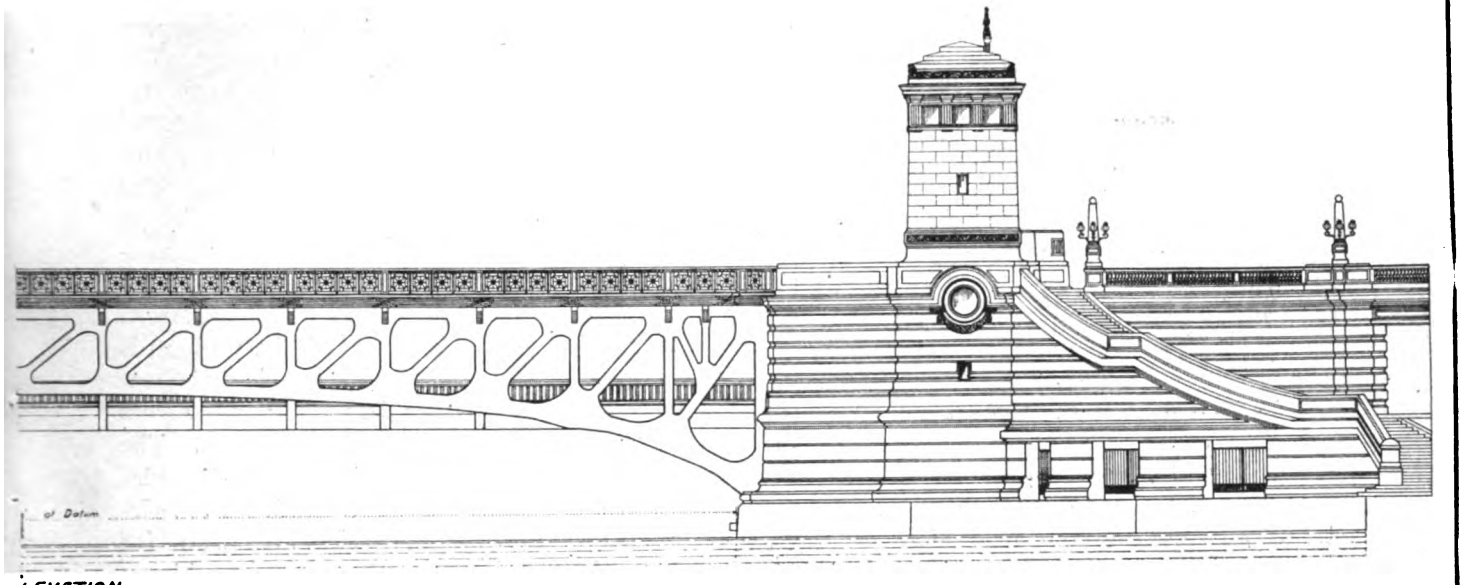
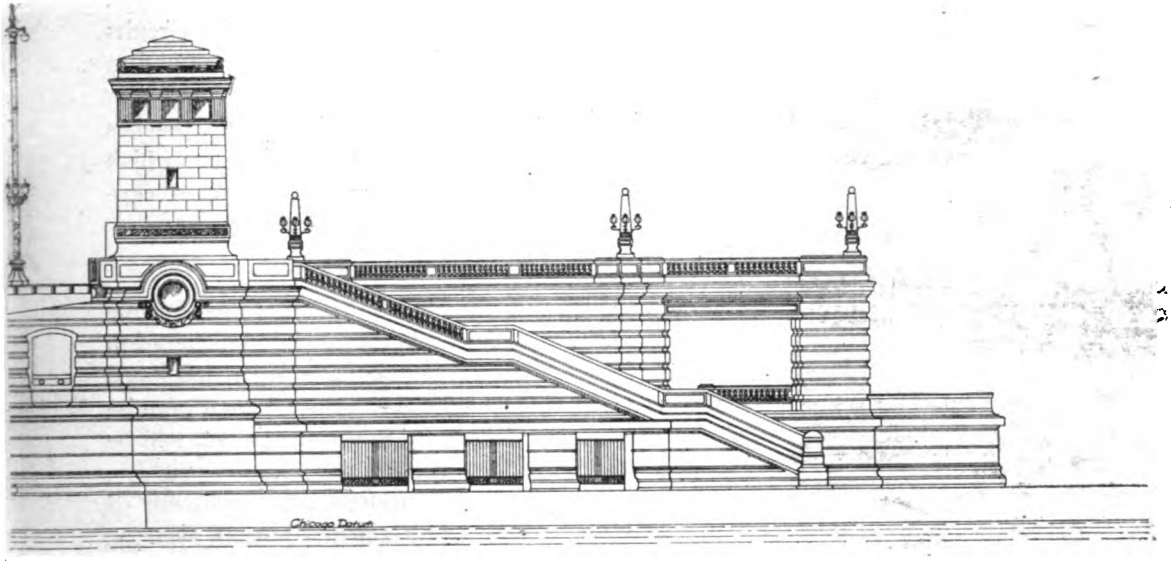


Fig. 7.

Digitized by Google



LEVATION



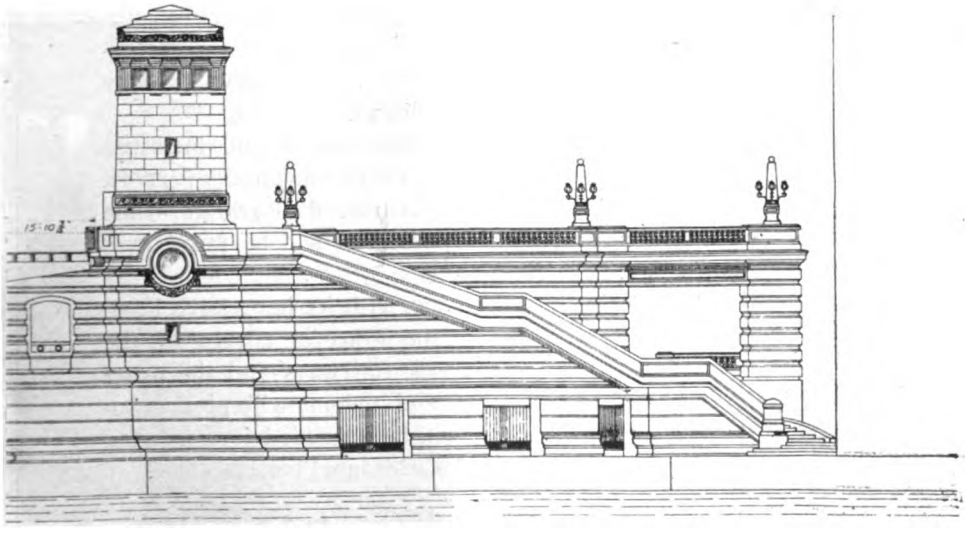


Fig. 7.

Digitized by Google

One of the most important features of the machinery control system is the provision for automatic current-limiting devices to prevent excessive loads in any motor circuit until the leaf has accelerated sufficiently to generate the required counter electromotive force, thus making it impossible to overload a motor by hasty operation; another safety feature is the system of "limit of travel" automatic cut-outs, preventing the bridge leaves, gates or barriers from reaching their extreme points of travel at full speed. The idea of safety has been further embodied in the elaborate system of electrical interlocking devices between the motors operating the leaves, gates, barriers, locks and signals, arranged in such a manner as to insure the sequence of operation both in opening and closing the bridge.

Pavement.

Because of the heavy and diversified traffic anticipated on this improvement, the question of paving was carefully considered, and it was found necessary to use several types of paving to meet the conditions peculiar to different parts of the improvement, the kind of traffic and the grades. On the boulevard level

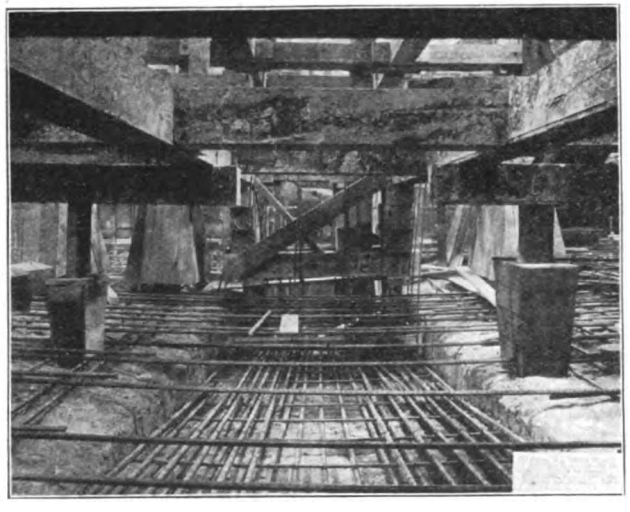


Fig. 5—Michigan Avenue Substructure North Tail Pit, Concreting Beam at Center Line of Bridge Bed.

the roadways of the bridge are paved with creosoted blocks, while the plazas, the viaducts and their filled approaches have an asphaltic pavement.

On the lower level, the bridge floor between the trunnion is also paved with creosoted blocks, but the portions behind the trunnions and the immediate approaches, where the grades are in the neighborhood of 3%, are paved with sandstone blocks to insure good footing for teaming. The rest of the lower level, with its connecting streets and alleys, are paved with granite blocks.

Illumination.

The problem of lighting the entire improvement was complicated on account of the varying local requirements. The lower level under the elevated structure between Lake street and Grand avenue must be lighted during the entire 24-hour period; the upper boulevard level called for ornamental street lighting to harmonize at each end of the improvement with the adjoining lighting fixtures of the park system.

The energy for the street and bridge lighting systems is supplied from four independent sources. The boulevard level north of the river is lighted by fifty-eight 400-candlepower globes, mounted on ornamental concrete poles 14 ft. high and connected with the Lincoln Park lighting system at Chicago avenue. The boulevard level south of the river is lighted by 36 clusters of six 100-watt lamps each, mounted on ornamental cast-iron posts 18 ft. high and connected with the South Park lighting system at Randolph street. Illumination of the lower level beneath the viaducts is provided by a number of subway-type incandescent lamps, with reflectors and guards, which are fed from the circuits of the Commonwealth Edison Co. The ornamental lights of the bridge, plazas and balustrades are also connected to the Commonwealth Edison circuits. The current for the bridge signal lights and for the lighting of the bridge leaves, houses and machinery room is drawn from the 600-volt bridge power supply, which is provided by feeders connected to the circuits of the Chicago Surface Lines at Grand avenue and at South Water street.

The sub-sidewalk spaces along the two approaches to the bridge are lighted by means of vault lights which consist of round glass disks 2 in. in diameter, supported by the steel framing of the sidewalks.

Architectural Treatment.

The aesthetic treatment of the Michigan Avenue Improvement has received very careful consideration and the features of this work have been developed under the supervision of the Chicago Plan Commission. The bridge and plazas, when completed, will be the best looking bridge structure in Chicago.

Figs. 7 and 8 show the architectural treatment of the bridge, plazas and the ornamental portals over the intersecting streets. The bridge trusses have a graceful, arched appearance; at each corner of the bridge are located the operators' towers and machinery inclosures. The entire bridge structure with its balustrades and stairways will form an impressive gateway to Chicago from Lake Michigan.

The portion of the bridge houses and inclosure walls from the dock level to an elevation of 11 ft. above city datum will be constructed of granite, while the structure above this elevation will be faced with buff-colored Bedford stone.

The entire improvement, with its impressive lines, the spacious roadways, the graceful curves of the plazas, towers, curved dock stairways and the ornamental lighting fixtures and pylons will present an artistic appearance and will be a decided forward step in the development of the Chicago Plan.

After many experiments and failures it was learned that engineering could not be taught in a 4-year course, and that an engineer's education should cover many studies besides those of pure technics.

Digitized by Google

operator can operate the center locks of the bridge. When the center locks are operated they give current for the operation of the rear locks, so we have the rear locks interlocked with both the barriers and the center lock. When the center lock has been drawn the interlocking arrangement is divided and each leaf is operated independently. After the rear locks are withdrawn then the current—and of course in each of these pieces of apparatus limit switches are provided which control the travel of the mechanical parts, and of course in the extreme positions operate the switches that control the interlocking. When the rear locks are withdrawn current is released for the main operating motors and these can be operated in the usual manner.

In lowering the bridge the sequence of operation is somewhat similar except that the rear locks must be placed before the center lock bolt is driven.

In the plane of each truss of each leaf are placed rear locks which are operated by trains of gears mounted on the river pier. To these gears are connected a toggle arm which engages a casting on the rear of the counter-weight box. The live load that comes on these locks is about 138,000 pounds. These locks are operated by ten horse power motors, and it is more or less of an arbitrary assumption of what should be provided in the way of power, but experience has shown that ten horse power motors are the proper thing to use, and the loads under which these operate are those loads due to raising the leaf and placing it back in position. At each lower floor at the center of the bridge are provided center-locks. These locks are operated by four or five horse power motors and so arranged that two locks of each span can be operated independently. The machinery for operating the locks is placed below the lower level floor and the gearing is connected to rods which in turn operate connects here which push out the bolts. The principal reason for the provision for center-lock apparatus is to insure that when a live load is on one span that the other span will deflect a corresponding amount so there will be no unevenness in the break of the bridge floor at the center. Emergency brakes are provided, one at each truss at the rear end of the counter-weight end. The casings or brake shoes are supported on projections on the pit walls, the side walls and the center wall of the pit. These tracks are gripped by means of shoes which are operated by a device very similar to a pair of shears. The outer end of these shears is operated by means of levers, at the end of which is provided a toggle arrangement operated by an air cylinder. The air entering the cylinder is controlled by means of a magnetic air valve which is controlled from the operator's house. The cylinders are about 10 in. x 10 in. and operate with 60 pounds pressure. The force on the side of the track, on each side, I believe, is about 95,000 pounds. The actual cantilever force is about 85,000 pounds. This, of course, goes down through these various levers so that at the cylinder six or eight thousand pounds is necesary, it would be less than that,—the diameter of these cylinders is about ten inches and they operate on 60 pounds pressure.

The machinery for operating this device is fastened to casings which are attached to the counter-weight box. It is an additional reason for braking, and on a bridge of this character it was considered justifiable, to go to this expense to provide everything possible that would make for safety. The leaves as erected have been controlled very easily by means of the hand operated brake, but, of course, when the floors are placed and these leaves are raised and exposed to high wind pressure, it will be necessary, or at least it will be a greater assurance of safety, and you will have more to rely upon than merely one hand operated brake, so we have for each leaf of this bridge two hand operated brakes, two service air brakes that are mounted on the gear trains and four emergency air brakes mounted on the rear end of the tail arms that are firmly imbedded in the side walls of the counter-weight pits.

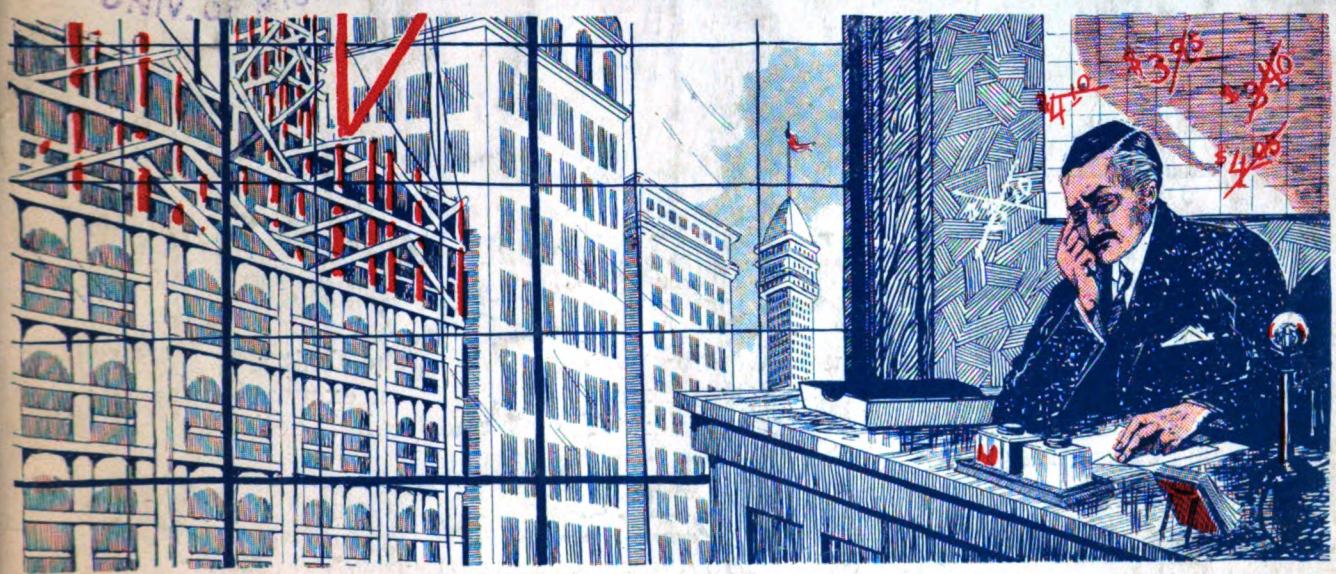
Digitized by Google

Engineering World

A Journal of Engineering and Construction

Published Semi-Monthly by International Trade Press, Inc., Chicago

16. No. 1. CHICAGO, JANUARY 1, 1920. $2 a Year; 15 Cents a Copy.



TRY YOUR MEMORY

PRICE OR SERVICE~WHICH?

WHAT DID THE STEEL COST ON THAT JOB LAST YEAR?
The chances are you cannot remember the price you paid ~

WAS THE JOB HELD UP BY STEEL DELAYS?
You remember that no doubt, ~ delays cost money ~

IN OTHER WORDS
ITS SERVICE ~ NOT PRICE
THAT REALLY COUNTS

HAVEMEYER BAR SERVICE

IT IS NOT INFALLIBLE BUT IT HAS BEHIND IT A NATION WIDE DISTRIBUTION OF WAREHOUSES TO MINIMIZE AS FAR AS POSSIBLE DELAYS DUE TO MILL CONDITIONS AND TRANSPORTATION

NEW YORK PHILADELPHIA DETROIT BOSTON CLEVELAND BIRMINGHAM CONCRETE STEEL CO. CHICAGO KANSAS CITY DALLAS SAINT LOUIS MINNEAPOLIS OMAHA

Digitized by Google

Michigan Boulevard Improvement to Be Opened May 15

By W. T. CHRISTINE

May 15 is the date set by Michael J. Faherty, president of the Board of Local Improvements, for the opening of the Michigan Boulevard Improvement to traffic. The top of this double-decked span will carry the motorist across the river and the approach to the bridge will raise him above the jam of traffic on the streets below. This improvement forms a through north and south connection between the boulevards of Chicago and has been long and anxiously awaited. In many ways this is the greatest improvement Chicago has attempted, and its completion in the face of advancing costs of labor and materials, strikes that have tied up both and made them exceedingly scarce, set a new mark for the real booster of Chicago.

Originally this structure was estimated to cost $7,700,000, but changes in plans and increasing costs of labor and materials have raised the cost of this improvement materially. The improvement is justified on the ground of necessity. Once Chicago motorists have had the satisfaction of riding over the improved roadway, no price would satisfy them to part with the betterment of conditions and return to the old tortuous wending of their ways through the downtown streets of Chicago.

Brief History of the Improvement.

In 1905 congestion of traffic became pronounced at and in the vicinity of Rush street bridge. This bridge, built in 1884, was the easternmost bridge across the river and, in addition to all the traffic to and from the Illinois Central terminal south to the river, it received much of the traffic between the north and south sides.

In 1912 the Board of Local Improvements began work on the present plan, the first work being condemnation proceedings against the buildings on the east side of the streets, part of which were condemned and the land taken for the new street.

The plan adopted called for the widening of Michigan boulevard on the east side from Randolph street north to the river, the purchase of sufficient wharfage at the river to afford two plazas, and the widening of Pine street on the west side north to Chicago avenue, which street has since been renamed Michigan boulevard. This gives a through north and south street for Chicago, but the streets do not exactly meet, hence the bridge is set on a slight skew.

The Double Deck Bridge.

A detailed description of this improvement was given in the April 15 (1919) issue. The bridge is a trunnion bascule bridge with two levels. The movable portion of the bridge consists of four equal parts, arranged with respect to two vertical planes at right angles to each other, one plane being along the center line of the bridge and the other plane midway between the two center lines of the trunnions. Each of these four parts may be considered as a single leaf and the two adjacent parts on the same side of the river form a double arm. Each single arm is carried by two main trusses rigidly connected to each other by floor beams of the two decks, laterals and counterweights. Each double arm is formed by two single arms which are connected to each other by a series of diaphragms placed between the vertical members of the inner main trusses.

The Main Boulevard.

Leading up to the bridge from the south is a roadway 75 ft. wide, between the curbs, with a sidewalk 27.5 ft. on the west side and of 25 ft. wide on the east side. Two roadways lead across the bridge, and these are placed above the trusses. These are 27 ft. 3 ins. wide between wheel guards and are separated by a slightly elevated strip 5 ft. 6 ins. wide. The sidewalks will be built outside of this on specially prepared supports. Each sidewalk will be 15 ft. wide, making the total width of the bridge over-all, 90 ft., which makes the Michigan boulevard bridge the widest in Chicago.

North from the north plaza to Ohio street the roadway is 80 ft. wide, with a sidewalk 30½ ft. wide on either side of the street. From Ohio street to Chicago avenue the roadway continues 80 ft. wide, but the sidewalks are 12 ft. wide, with an 18-ft. grass plot between the walks and the curbs.

From Randolph street north to Chicago avenue will be paved with asphalt with the exception of the bridge which will be paved with creosoted paving blocks. The foundation for the asphalt on the southern end of this improvement to Lake street is concrete cast in place. East Lake street also was raised up to the level of Michigan boulevard and the street was made in the same manner. From East Lake street to the river the street is carried on an elevated structure.

Concrete was use to form a subgrade on the improvement, was cast to a depth of 8½ ins. and was heavily reinforced.

The upper roadway of the bridge was floored with 6 by 12-in. creosoted Douglas fir. These pieces were long enough to form one roadway. On these will be set the creosoted paving blocks.

North of the bridge the treatment is much the same—first a reinforced concrete slab, followed by a sand fill between concrete retaining walls.

The Lower Level Roadway.

This roadway is constructed from East Lake street on the south to Grand avenue on the north. All street and alley grades correspond with those of the new roadway where they intersect.

Lake street opens eastward from Michigan

Digitized by Google

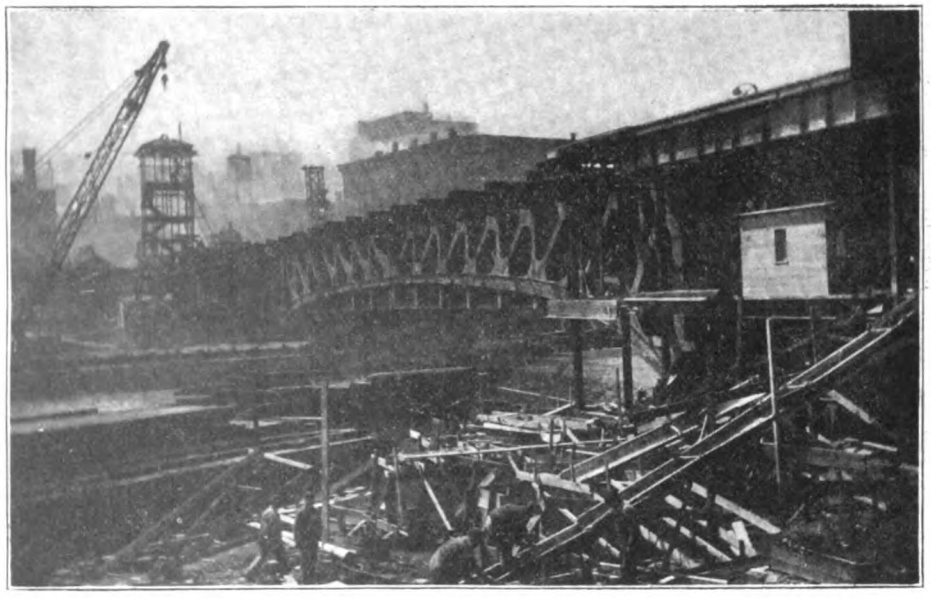


Fig. 1. Michigan Boulevard Bridge as It Appeared from the Northeast April 13.

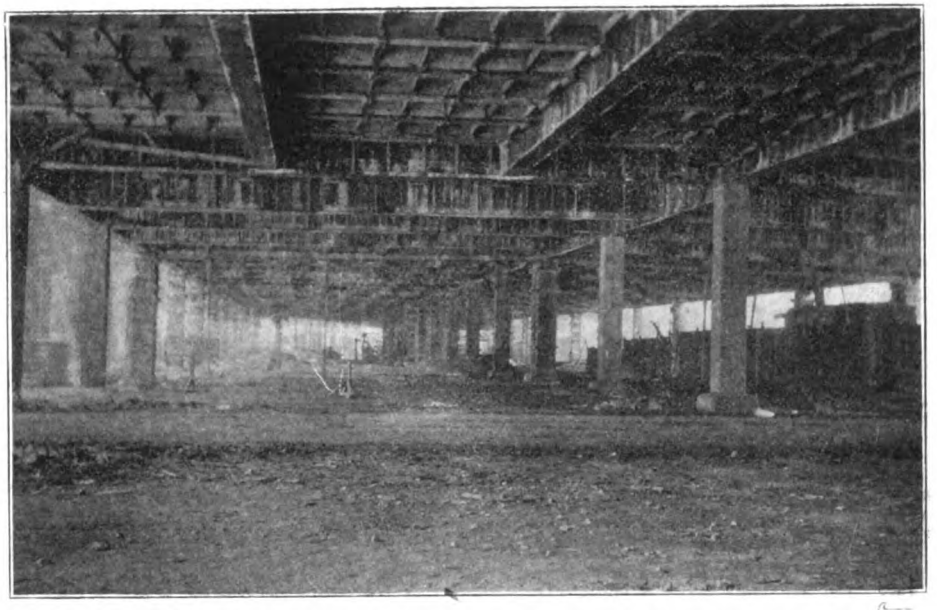


Fig. 2. Looking South from Illinois Street; Forms Are in Place, Except Column Forms.

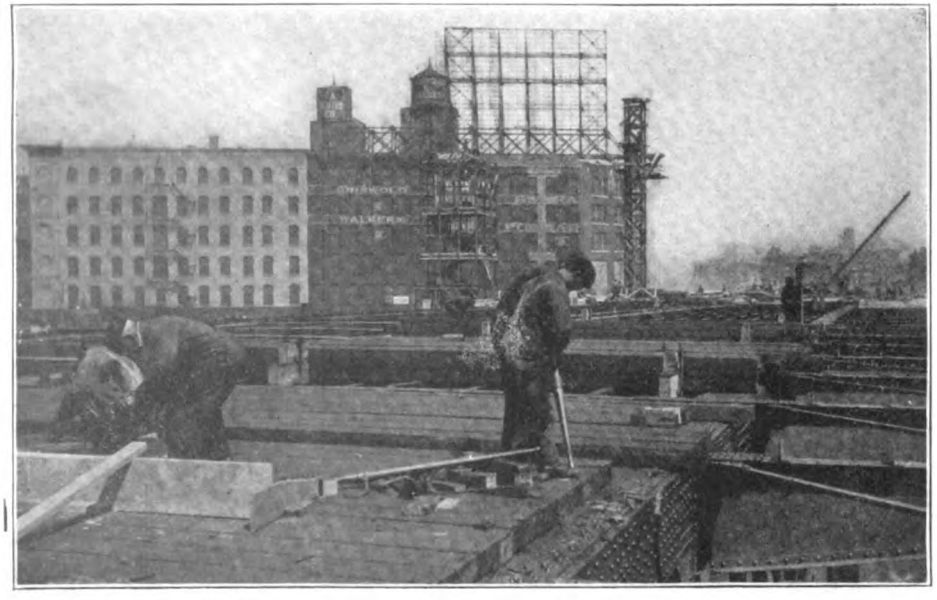


Fig. 3. Placing the 6 by 12 Creosoted Fir on Top of the Bridge.

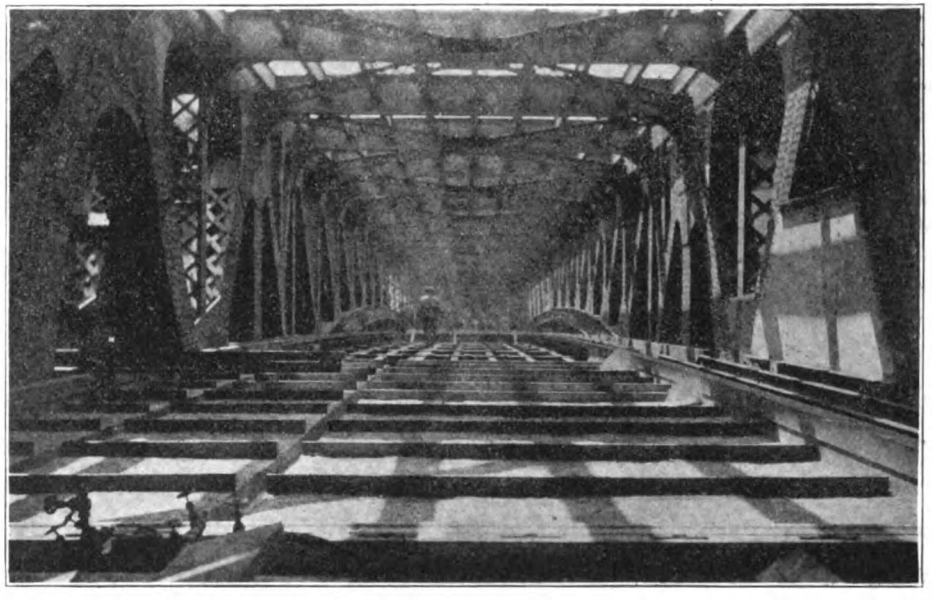


Fig. 4. A View of the Lower Level of the Bridge Showing the Heavy Steel Structure.

Digitized by Google

boulevard, but the west end is closed and it will be necessary to go through South Water street to get into Lake street east of Michigan boulevard. At South Water street there is a slight depression and the same is true at Grand avenue. Approximately, the levels of the old streets—River street, North Water street, Austin avenue and Illinois street—are coincident with the level of the new street. Grand avenue is depressed 5 ft. to permit the passage of street cars along that street.

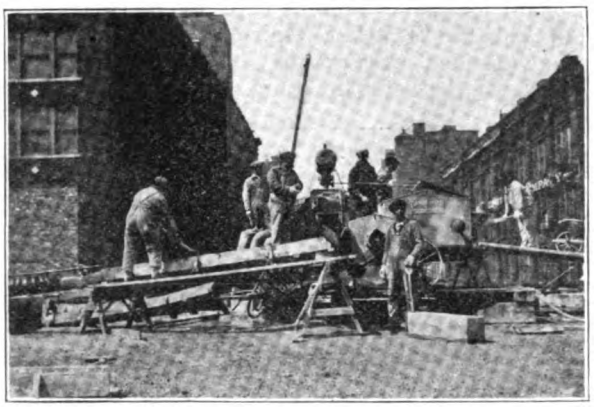


Fig. 5. Dandie Mixers Were Used Almost Entirely on the Concrete Work of the Michigan Boulevard Improvement.

This street will be used principally by the heavy traffic which exists between the Illinois Central and the Loop district. As will be noted, there are two main entrances south of the river, while north of the river there are three, viz., North Water street, Austin avenue and Illinois street. These streets are paved with granite blocks, except the approach to the bridges which are paved with sandstone blocks. The bridge itself will be paved with creosoted blocks.

Through the bridge the street will have two roadways, each 18 ft. wide, and two sidewalks, each 5 ft. wide. There is no sidewalk outside of the main trusses, as is the case overhead. The streets and sidewalks take up all the room, allowing ample space for the trusses.

At each street intersection sidewalks connect the upper and lower levels. The sidewalks on the first level are raised about 3½ ft. above the street, connecting with the latter by steps.

All grades are easy, ranging from 1 to 2%, except the immediate approach, where the grade is 3.25%.

Concrete Incased Steel.

From East Lake street north to Grand avenue the street is carried on an elevated steel structure, set, in the majority of cases, on caissons extending down to hardpan. Steel in this structure, with the exception of the bridge, is all incased in concrete, which is intended to prevent corroding and rusting.

In making the forms on which the street was cast, over 1,000,000 ft. of 1-in. lumber was used, some of it being used two or three times. Making these forms, where the space to be filled was uniform, was a comparatively simple matter, growing more complex and involved as the forms differed in size and shape and the number of openings in them became greater. Forms for the columns were made of 1½-in. lumber, secured in place by 2 by 4's bolted together.

After they were made, the forms were coated with oil and were thoroughly wetted down before the concrete was cast. Columns were cast at the same time as the general concrete used in the main slab of the street. In pouring particular pains were taken to ram and tamp the concrete into the corners of the forms and the result, where the forms have been torn off, is highly satisfactory. The concrete is usually hard and durable.

Concrete Placement.

Concrete placed by the workmen accomplished two things: It formed the slab on which the asphalt was laid and, subsequently, formed the ceiling above the lower street. The lower sides of the beams and girders were not included in the form. After the forms are removed these girders will be coated with concrete with a Cement Gun, first being wrapped in wire mesh to hold the concrete. About 2 ins. of concrete will be cast in this fashion.

This is an elevated structure, ending at the time the concrete was cast with one end up in the air, the bridge not having yet been lowered. In order to prosecute the work it was necessary to haul by wheelbarrow quite a distance the aggregate to the mixer and the mixed concrete to the place it was deposited. This distance averaged about 200 to 250 ft., as the concrete was not considered safe enough to permit the trucks hauling the aggregate to come closer with their loads.

The Dandie mixer was used on this job, of which a great many were used on different parts of this work. On the roadway proper, in addition to the mixer on the structure, another mixer was used, located on the level of the first street. Concrete was delivered to a bucket containing about ½ yd. and hoisted by a converted Erie shovel, which had been equipped with a 60-ft. boom. This system permitted the work to be rushed more than it would have been possible otherwise. The concrete work on the street level was finished about April 17.

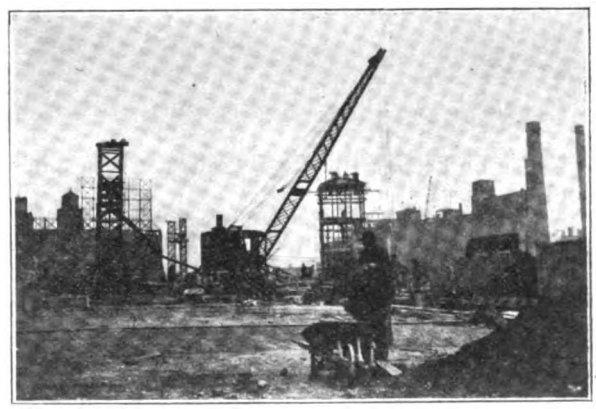


Fig. 6. An Erie Crane with a 60-ft. Boom Hoisted Concrete from the Lower Level.

Interesting Facts.

Viewed as a piece of roadway this street will be one of the most expensive ever built. It is

Digitized by Google

4400 ft. long, from the southernmost limit to the place where the street forms the level of old Pine street. The length of the lower level is 2300 ft.

Th lower level of the bridge is 20 ft. above city datum and the upper level is 37 ft., leaving 17 ft., less the heavy cross girders, for headway. One line of viaduct columns south of the river are used to support the structure, it being im-

Fig. 7. Pouring Concrete for the Substructure of the Plaza

possible on account of a 4-ft. sewer, to use piles and footings.

The bridge will be operated with motors, each leaf being equipped with four 100-hp. interpole electric motors of heavy mill type construction. Under normal conditions one pair of motors will be used for raising and lowering the bridge.

Architecturally Considered.

It is too early yet to get a glimpse of what the bridge will look like when finished. It will be the most complete structure of its kind in Chicago, if not in the world. On either side of the Plaza steps will lead down to the dock level, where a beautiful promenade is to be erected, concrete already being placed for a part of this structure. Up to 11 ft. above city datum this portion will be of granite, while above that the remainder of the structure will be faced with buff-colored Bedford stone.

This part of the bridge will not be finished for some time, but the men are now at work on caissons and digging foundations for walls, on which the structure is to be erected. The bridge, seen from any point of view, will be a symmetrical affair, whose beauty of design will be enhanced by a wonderful system of electric lights. These lights will be in harmony with their surroundings, partaking of the character of the adjoining lighting fixtures of the park system.

The entire improvement is a step upward in the Chicago Plan, a plan by which improvements in Chicago are to be made to correspond to a general scheme, which has been developed far beyond Chicago's present capacity to carry out, but with the "I WILL" spirit back of the movement, decided progress may be looked for in the course of the years to come.

Relation of Elastic Strengths of Steel

"The Relation Between the Elastic Strengths of Steel in Tension, Compression and Shear," by F. B. Seely, Associate Professor of Theoretical and Applied Mechanics, and W. J. Putnam, Associate of Theoretical and Applied Mechanics, has been issued as Bulletin No. 115 of the Engineering Experiment Station of the University of Illinois.

The severe uses to which carbon and alloy steels are put in some phases of engineering, as for example, in automobile and in aeroplane construction, have developed a need for more detailed knowledge of the action of steel, under various types of stress, as well as of the factors which affect the physical properties of the material.

Our knowledge of the breakdown of elastic action of ductile materials, particularly in the case of combined loading, is far from complete. The various theories of combined stress lead to results which differ rather widely when applied to various machine parts or to structural elements, such as thick cylinders, flat plates, crankshafts, webs of girders, etc. The maximum shear theory of combined stress for ductile materials as expressed by Guest's law, which has gained rather wide acceptance in recent years, assumes that the elastic shearing strength is one-half of the elastic tensile strength. Available experimental results, however, have, in general, failed to justify this assumption. The importance of the limitation imposed by the shearing stress upon the elastic strength of ductile material is, of course, generally recognized. It is of special importance to know the relation between the shearing and the tensile (and compressive) elastic strengths for various grades of ductile and semi-ductile steels. The main object of the investigation herein recorded was to determine carefully the elastic shearing strength of ductile and semi-ductile steel and to find the ratio of the elastic shearing strength to the elastic tensile strength with the hope that definite information would thereby be obtained on the breakdown of the elastic action of various grades of steel and on the limits of the theories of combined stress.

Apart from the problem of combined stress there has been also a lack of knowledge of the correct elastic shearing strength of various grades of steel and of the general nature of elastic shearing failure as well as of methods of determining the correct shearing strength from tests.

Digitized by Google