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Chicago's New Outer Drive Improvement

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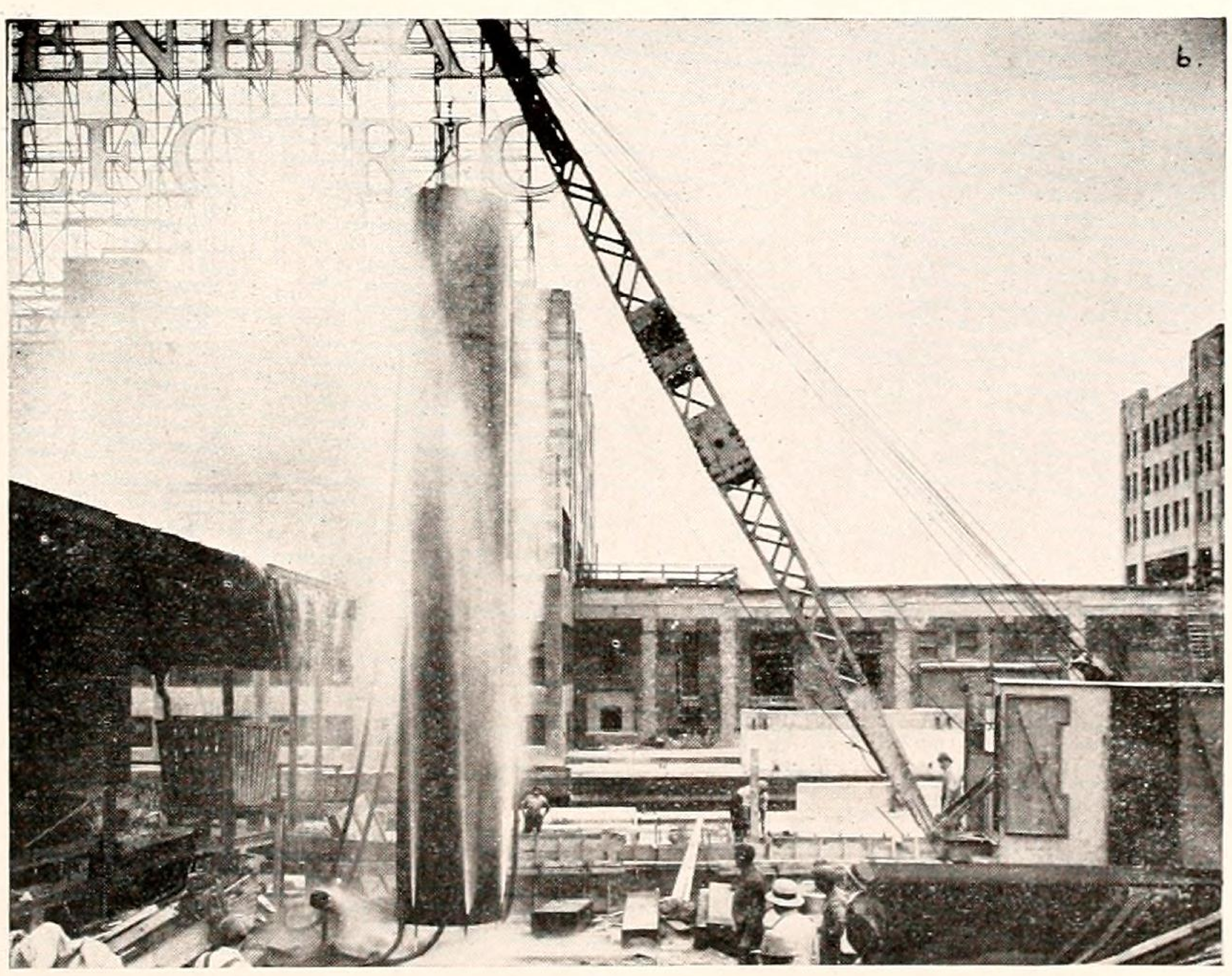
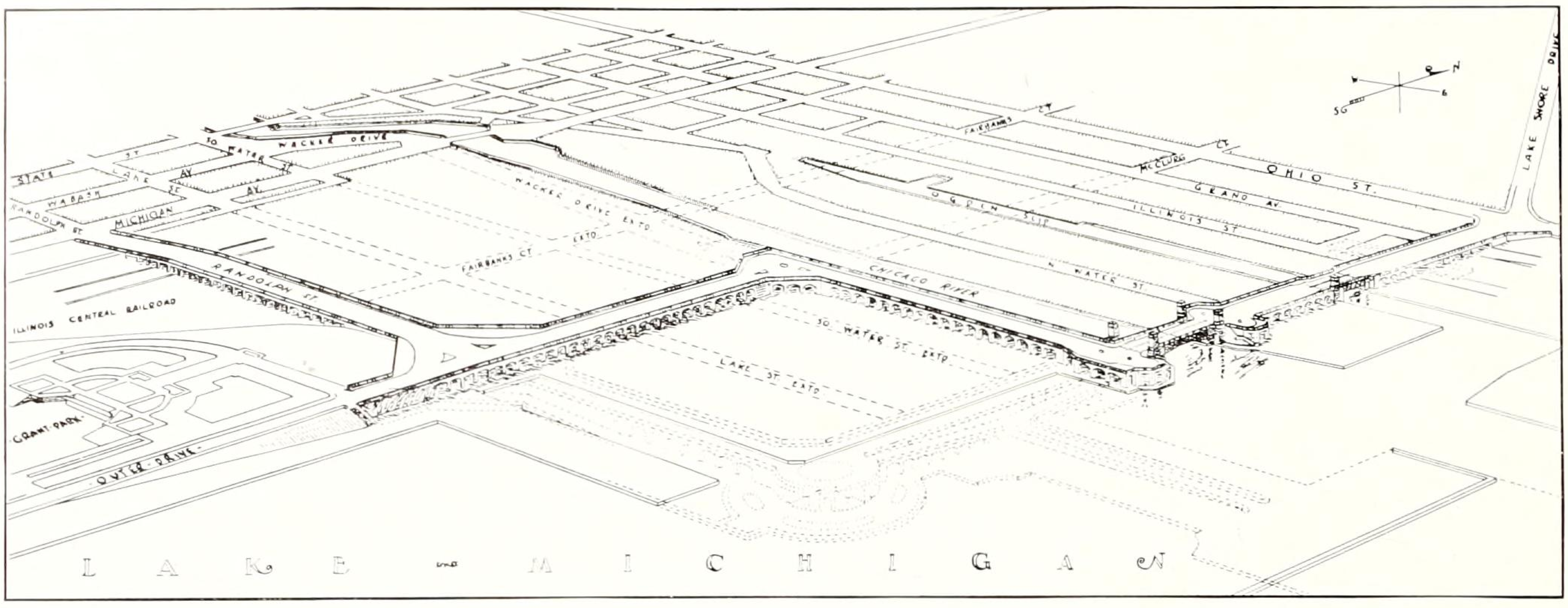
THE outer drive improvement had its inception on October 22, 1926, when Mr. Charles H. Wacker, then chairman of the Chicago Plan Commission, appointed a special sub-committe to make a study of the possible plans for such an improvement. The need for a new river crossing to the east of Michigan Avenue had been felt for some time. The South Park Commission had spent a considerable amount of money in the development of Grant Park and the Outer Drive, which now gives the south side motorist a through, high speed route to the loop. In a similar manner, the Commissioners of Lincoln Park had constructed and improved the Michigan Boulevard—Outer Drive—Sheridan Road system from the loop to the North Side. The Chicago River forms the dividing line between the two systems, the only easy crossing being the Link bridge, already overcrowded with both automobile and truck traffic. In order to derive the full benefit from the large expenditures of both the Park Boards, it is clearly necessary that there be a connection between the South Park Boulevard system in Grant Park and the Lincoln Park System, which now ends at the Navy Pier on the North Side. The advantages of such a completion of the great lake front development, would be immediately felt both by through traffic, avoiding the crowded loop district, and by vehicles leaving and entering the loop, which would find congestion very much reduced.

The committee appointed by Mr. Wacker made a thorough investigation of a large number of alternative plans for making this connection, the results of which narrowed the selection down to seven possibilities. The complete report on the seven studies was made by the committee in May, 1927, and included the discussion of the advantages and disadvantages of each plan and the estimated cost of each. At the very outset, the possibility of a vehicular tunnel or a high fixed bridge was suggested. A careful comparison of the relative advantages of these schemes with the bascule bridge crossing was made. The chief advantage of the tunnel or high bridge is the elimination of traffic blocks due to river traffic. When the relative cost is considered, however, the bascule bridge is well ahead, the total cost being less than half of a tunnel or fixed bridge. The excessive grades required as well as the long approaches and the impossibility of future connections to Wacker Drive when extended led to the final rejection of both tunnel and high fixed bridge schemes.

The final solution was plan number two of the



Above is shown a steel cylinder ready for sinking.



Here is reproduced a plan of the Outer Drive as it will appear on completion.

seven alternatives and utilized a bascule bridge for the river crossing. Lake Shore Drive is to be extended southward from Ohio Street on a filled approach 139 ft. wide to Grand Avenue. Crossing Grand Avenue, which is depressed at this point in order to reduce the viaduct height, the boulevard extends over the tracks of the Chicago Dock and Canal Company on a steel viaduct. The North Pier Terminal Building, extending along the Michigan Canal (Odgen Slip) at this point is cut through and refaced permitting the extension of the improvement to the edge of the slip. The Michigan Canal is crossed by a single leaf bascule bridge 108 ft. wide and providing a clear channel for navigation of 70 ft. The roadway continues over a viaduct structure to the Chicago River, which is crossed by a double leaf bascule bridge. This will be the longest bridge of this type in Chicago being 264 ft. between trunnion bearings, 108 ft. wide, and providing a clear channel of 220 ft. Large plazas at each approach are incorporated in the design, arrangements being made, also, for a future lower level crossing. At the South plaza, the drive will make a right angle turn to the west, along the north bank of the river and the line of Wacker Drive. The Outer drive will then be extended Northward from Monroe Street on a fill and viaduct to make connection at the river. This extension is, up to Randolph Street, already under construction as part of the Randolph viaduct improvement over the Illinois Central tracks. The total cost is estimated at $10,000,000, which is to be divided between Lincoln and South Park Commissions.

At the present time, the improvement has been entirely completed from Ohio Street to the Michigan Canal. On the rest of the work, the pits for the bascule bridges and about 75% of the viaduct substructure between them are finished.

In the following description of the work on the improvement no attempt will be made to do more than "hit the high spots" of construction now in progress. The methods being used are, with a few exceptions common practice in Chicago. The viaducts are steel structures covered with concrete and supported on subpiers resting on solid rock. The bridges are of the usual Strauss type with the trunnion bearings supported on a cross girder, the trusses being left free of bracing to clear. This differs somewhat from the S girder support developed by the City Bridge division. The Strauss Engineering corporation, Chicago, was designer for both bridges and the viaducts now under construction or completed. The entire construction is under the general supervision of Mr. Hugh E. Young, M.A.S.C.E., who is Chief Engineer of the Chicago Plan Commission and Consulting Engineer for the Lincoln Park and South Park Commissioners. Harry Bernstein, C.E., Armour '24 is Engineer of Bridge Construction and in direct charge of the work.

Construction of Cofferdams

The cofferdams for the river and slip bridges differed somewhat in detail and method of construction. In both cases the Carnegie M-110 steel sheet interlocking pile was used. This section is of deep U form, 16″ between centers of interlocked joints and 6″ deep. In building the cofferdams for the Michigan Canal bridge pit, a set of round wood piles was driven around the outside of the proposed dam. To these a pair of 12x12 walers were spiked, outlining the outside of the cofferdams. The sheet piling was driven tightly up against this form. Clay inside the dam was then excavated with a clam shell bucket to an elevation of approximately 35.0 ft. below datum to clear the bottom set of bracing when placed. Bracing consisted of seven tiers of struts and walers. The lowest set was constructed inside the sheeting and floated. As the upper sets were built on top the weight caused the whole structure to sink. When all the timber bracing had been completed, additional weight in the form of reinforcing bars and steel punchings were placed on top until the bottom set had settled to the required elevation.

Very little diagonal cross bracing was used so that the whole dam was not very stiff in spite of the large amount of structure and considerable movement was experienced.

In comparison, the cofferdam built for the Chicago River Bridge substructure, was a simpler and lighter structure. The depth of the pit for the river bridge is about six feet less than for the Ogden Slip crossing so that the water pressure on the dam is considerably less. The method of construction was also somewhat simpler. The lowest tier of bracing was built and floated into position. This was then used as a form for the sheet piling which was driven around it to form the dam. The next tier was then built on top and the whole sunk in the same manner as for the slip bridge coffer dam. A 3″ clearance was allowed between the sheeting and the bracing so that when the water was pumped out the joints tightened. Leaks were sealed by dumping fine cinders around the outside. The inflowing water draws them inside the openings and gives a fairly water tight structure. The pit must be kept dry, however, by more or less continuous pumping, a set of drainage ditches, and a sump being provided for this purpose.

Because of the large amount of cross bracing used on this dam (3x12 planking) the structure was exceptionally stiff and in spite of the fact that on both sides of the river the cofferdams were well out in the water, very little weaving resulted. The advantage of this type of bracing was clearly shown when the large 120′ derrick boom on the North side of the river buckled and broke the top two sets of bracing struts right through the center of the dam. Though the side walers bent slightly, serious damage was averted because of the rigidity of the whole structure.

Construction of Subpiers

The so called "Chicago Open Well" method was used. After the cofferdams had been pumped dry, the engineering force laid out the well centers by tracks and marks on the bracing timbers. Dropping a plumb bob from the intersection of two chalk lines between these marks, the center of the well was located and excavation begun. From four to six diggers are used in a well depending on the size. (8 to 12 ft. in diameter). When the excavation reaches a depth of four or five feet a set of tongue and groove maple lagging is assembled in the hole, the inside diameter being that of the finished well. The lagging consists of a set of finished planks two or three inches thick with beveled edges and five feet four inches long. These are set vertically in the well and interlocked, being held in place by a set of steel rings of the proper diameter. For the small wells these rings consist of two semi-circular arcs with the ends bent and bolted together. Formerly, bent steel bars were used but the more recent type is made of bent structural channels with lugs welded on the ends. For the larger wells the arcs are less than a semi-circle, three or four being used in the circumference depending on the diameter of the subpier. Both lagging and rings are left in place when the wells are concreted.

Clay is removed from the well by means of large metal buckets operated at the end of a rope from a hoist set on a tripod at the top. For the larger wells two buckets are used. The material was dumped through short wooden chutes either directly into the river or into large roughly made wooden boxes in the coffer dam from which it was removed from time to time with an orange peel bucket. Because of the great depth of the excavation, the temperature is very low at the bottom and in mid-August when the thermometer read well over 90° at the top it was necessary to wear heavy coats in the well. Besides this, the cold air condensed the moisture near the top so the men digging at the bottom are subjected to a light, but continuous rain at all times.

When rock is reached the caisson is belled out slightly and the bottom cleaned up and leveled off. Two or more small test holes about five feet deep are drilled to make sure the rock is sound and without seams. Vertical seams filled with clay or soft rock appeared in a few of the wells but since the ledges were considered safe and since there were no horizontal seams they were called satisfactory. When poor rock was found it was excavated until the drilling indicated that satisfactory conditions existed. The rock elevation varied from 85 to 93 feet below datum, the surface being in fair condition. The general slope at the site appeared to be downward toward the North East with a fault line parallel to the South bank of the river. So little of the rock is uncovered, however, it is hard to make general conclusions.

All wells were concreted up to the bottom of the pit floor at ele-

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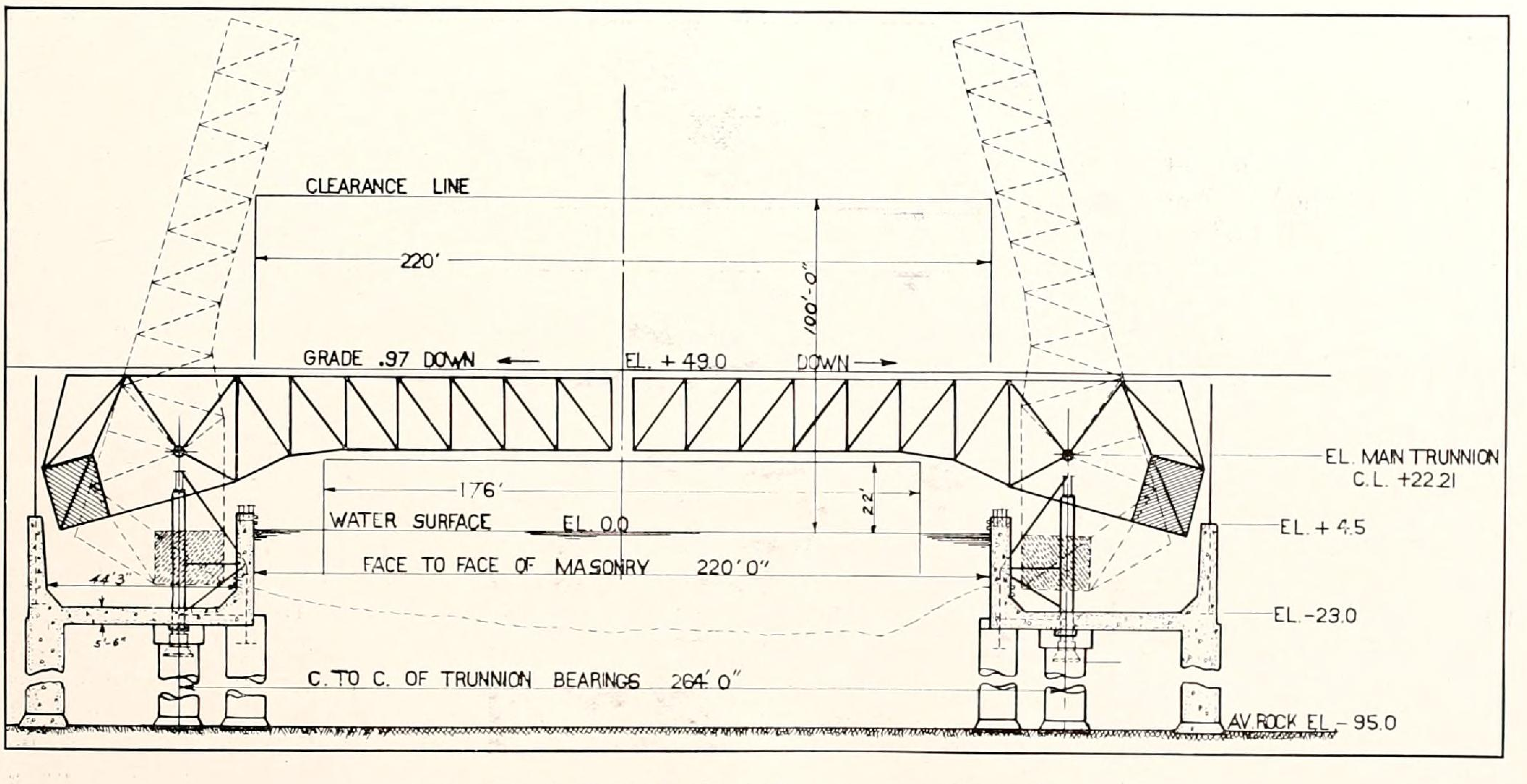

Above is the double-leaf bascule bridge to cross the Chicago River.

Chicago's New Outer Drive

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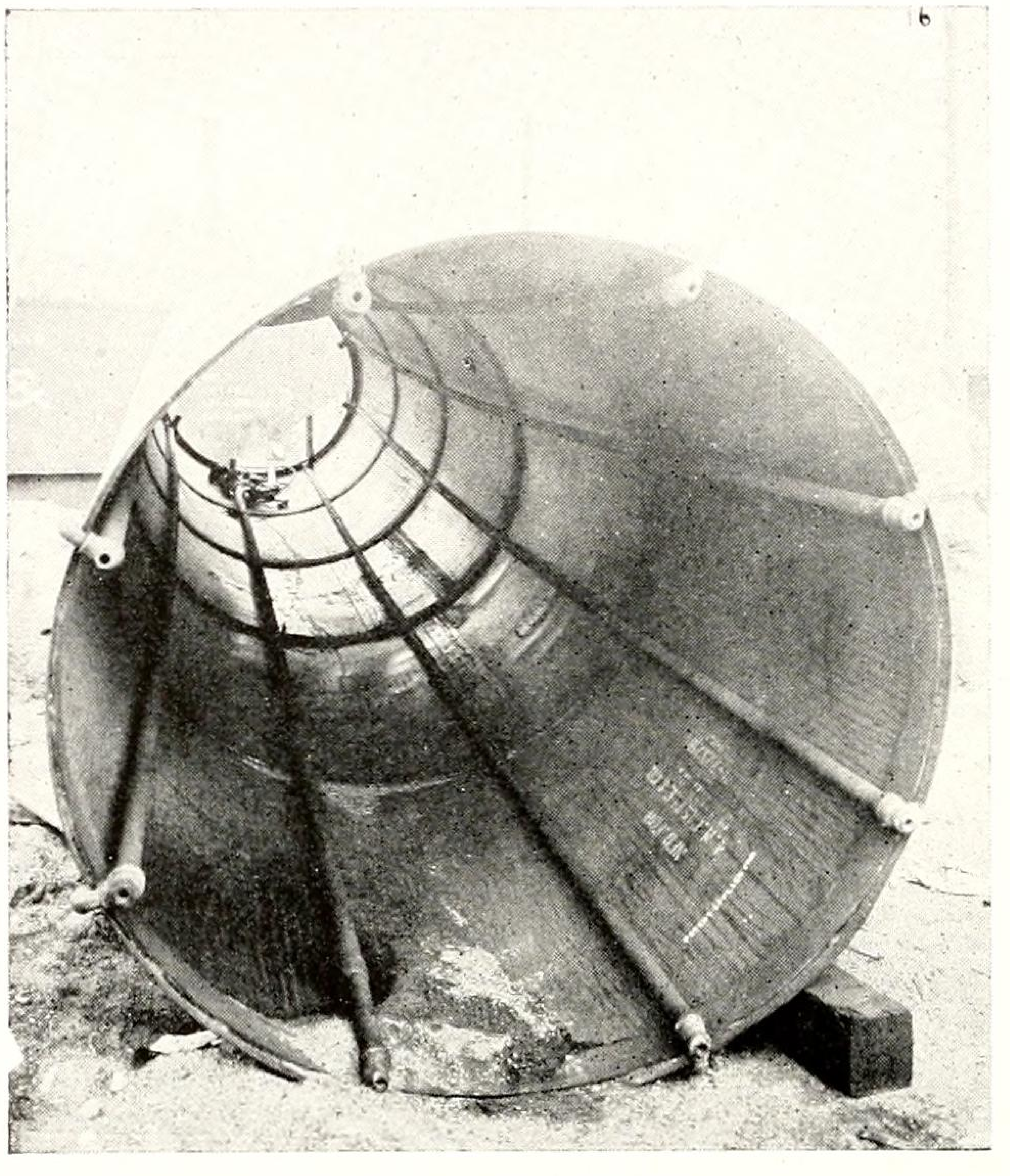
vation, 28.5 feet, except the main trunnion wells and those supporting the wind bracing columns. Long chutes made up of four foot sections of pipe were used to place the concrete in the well. Reinforcing consists of vertical bars and horizontal loops. As each section of the reinforcing was placed, the well was poured, a section twenty to twenty-five feet in height being concreted in each lift. The surface was carefully cleaned off and roughened before each pour. Payment for wells was on a basis of total volume of completed well including reinforcing at $1.29 per cubic foot with $.70 per cubic foot additional for rock excavation.

When starting work on the wells for the North Viaduct, difficulties were experienced due to the water bearing strata of this section. Extremely wet sand is found just below the surface and extends to about 22 feet below datum, a total thickness of about 30 feet. Below this is a layer of soft blue clay about 40 feet thick. The rock surface varies from 88 feet at the river to 100 feet at the slip. The first attempt was to sink a well lined with the usual wood lagging and steel tunnel liners. However, water entered faster than it could be pumped out and necessitated the abandonment of this method. A few other schemes were tried but were unsuccessful.

The final, and successful method provided a rather novel solution to the problem. Large steel cylinders were constructed of 10 gauge steel sheet about three inches larger than the well diameters. (Wells for the North Viaduct vary from four to six feet in diameter). The cylinders were thirty feet long and electrically welded both longitudinally and circumferentially, the circumferential seams being reinforced by a steel band of 2½x⅜" bar welded in place. At the top a 2x2x⅜" L is welded in to stiffen the edge. The well was excavated to a depth of approximately six feet and a square wooden box inserted and carefully centered. Wood guides were nailed to the middle of each side of the box to keep the steel cylinder vertical and centered when it was lowered. The tube was sunk by means of jets until it reached the soft clay layer and then was driven four or five feet into the clay with a steam hammer. When firmly embedded this effectually sealed off the water and made it possible to dig the well down to rock in the usual manner.



The interior of a steel caisson.

For the first few cylinders driven in this manner a four way jet was used. At present, however, an upward and downward ½ inch opening is working very well. Water issues from the jets in two streams and rises both inside and outside the caisson, lubricating it so that it sinks of its own weight into the sandy strata. Six to eight jets are spaced uniformly around the circumference of the cutting edge and are screwed to a two inch pipe on the inside of the tube. Connection between the upper end of these pipes and a four inch main is made with two inch rubber hose. The main carries water pumped from the lake at the rate of 1000 gallons per minute at 130 lbs. per square inch pressure. The joints of the pipe in the cylinder are all welded except the connection to the jet at the bottom, so that after the cylinder tube has been sunk the pipes may be unscrewed and removed before excavation begins. The jets are recovered when the well is dug. For driving, a steel I beam grillage is placed on top and the hammer applied with the water flowing.

In a few of the wells some difficulty was encountered in using this method. In one or two cases the tube was not sufficient length and water rose under the edge of the cylinder. To seal off the water a set of wood lagging was driven around the circumference flush with the cylinder wall and overlapping the end about a foot. A platform was built across the well somewhat below the bottom of the tube and two feet of concrete poured. When set, the center was cut out and the well continued at a slightly reduced diameter, belling out again to full size when below the seal. Additional reinforcing is placed in the throat.

In some cases boulders prevented sinking the cylinder. In one of the wells where this happened a ring of steel sheeting was driven to the clay entirely around the well and the excavation begun using wood lagging until the boulders had been removed. The caisson was then sunk in the usual way. When the cutting edge approached the bottom of the sheeting the cylinder could no longer be driven. Investigation showed that the sheet piling had all bent in toward the center of the well and stopped further sinking of the cylinder. It was necessary to pull the sheeting before any more work could be done. When a large boulder stopped work on a caisson in one of the other wells before it was more than ½ down a hoist was erected and excavation started from the top (about fifteen feet above the ground) until the boulder was reached and removed so that driving could be continued. In a third case a boulder at the edge of the cylinder pushed the side in until the cutting edges of opposite sides approached within eight inches of each other. When diggers reached the narrow portion it was burned out and wood lagging driven.

In spite of the occasional difficulties, however, this method has shown itself to be very successful, so much so in fact, that the construction company has applied for a patent on the scheme.

Counterweight Pits

After the subpiers had been poured to grade the clay was excavated for the counterweight pit. About three feet of clay had to be removed. A clamshell bucket was dropped through the bracing and as much of the material taken out as could be reached this way. The pit was then cleaned up and levelled off by the labor gang. A deep drainage ditch leading to a sump at one end of the cofferdam was dug completely around the inside of the sheeting in order to keep the central portion dry. The clay is very wet and sticky, however, and in order to dry up the floor more completely a two inch layer of concrete was poured. This did not count as part of the floor slab but acted merely as a temporary platform on which to work.

The counterweight pits for the river bridge are 92 feet 6 inches by 56 feet by 30 feet deep, inside. Elevation of the top of the floor is 23.5 feet. The floor of the pit is a 5 foot 6 inch concrete slab with two way reinforcing top and bottom. To make sure that it would be water tight the entire floor was poured in one piece, a total volume of over 1800 cubic yards for each pit. At the rate of about two to two and one half minutes per batch from a one yard mixer, this required about seventy hours of continuous pouring. The supports for the cofferdam bracing were all cut out before the pour started and replaced with plank blocking. When the concrete reached a block it was removed until the surface had been finished and set slightly. The bracing was then blocked directly on the floor surface. A slight settling of the cofferdam was noticed due to this temporary lack of support. Large hoppers and chutes were used, placed at intervals across the entire width of the pit, and not over four batches were placed in each chute before the adjacent one was poured. The chutes were filled in order across the width of the pit then moved forward with the derrick and the process repeated so that at no point would the concrete have time to set before a fresh batch was placed. A three-quarter inch mortar finish was used. The concrete was carefully tamped and spaded around the reinforcing, mechanical vibrators being used to insure a dense structure.

When the floor had been poured, forms for the walls were begun, the lower brace struts being cut out temporarily. The walls were then poured up to the bottom of the second tier, the first set, which had been removed, braced firmly against the wall section, and the second set cut out. The wall was then poured up to the bottom of the third set and the operation repeated. There were, therefore, four horizontal construction joints in the wall. Each joint was sealed with a double key and a set of corrugated copper strips set on edge and overlapping at the ends. The surface was carefully roughened and cleaned up before each pour.

THE MEN OF OLD

I know not that the men of old
Were better than men now,
Of heart more kind, of hand more bold,
Of more ingenuous brow:
I heed not those who pine for force
Aghost of time to raise,
As if they thus could check the course
Of these appointed days.
Still it is true, and over true,
That I delight to close
This book of life self-wise and new,
And let my thoughts repose
On all that humble happiness,
The world has since foregone,—
The daylight of contentedness
That on those faces shone.
With rights, tho' not too closely scanned,
Enjoyed, as far as known,—
With will by no reverse unmanned,—
With pulse of even tone,—
They from today and from tonight
Expect nothing more,
Than yesterday and yesternight
Had proffered them before.

—*Lord Houghton.*

Concrete Control and Inspection

The specifications for the Chicago River Bridge required a constant water cement ratio of 0.9 for class I concrete, to be used for subpiers, and a ratio of 0.8 for class II concrete to be used where additional strength qualities were desired. Slump should not exceed four inches, a stiffer mix than customary being possible because of the massive character of the work and the large size and spacing of the reinforcing bars. The composition of the mix was then determined by the field engineer to meet these conditions, the actual proportions varying of course with the quality and grading of the aggregates available. The inspection of the concrete used was rigid and continuous, both material and final product being subject to careful supervision. A group of test cylinders were made and tested for every portion of the work to make sure the required strength was attained.

The sand being used is lake sand from the Indiana region. The specifications call for the fine aggregate to be "clean, sharp, durable and free from dust, soft particles, organic and other deleterious matter." It was noted that the sand, while somewhat finer than permitted, was very well graded and exceptionally clean. Its use was allowed on this basis, the results of the test cylinders showing that this departure was well warranted. The moisture content of the sand as delivered was quite high but after remaining in the storage pile the percent water dropped to about four percent by weight and varied little from that figure thereafter. In spite of this fact a continuous check of moisture content was made throughout a pour and in case any variation did appear the proportions were changed to compensate. The dry rodded weight of the sand was 110.5 pounds per cubic foot.

The coarse aggregate being used is gravel from the Lockport region. The requirement for coarse aggregates states that it shall be "gravel or crushed limestone of the hardest and best quality, free from dust, organic and other deleterious matter; ranging in size from fine to coarse." "Gravel if used shall be washed and screened to remove sand." The water content of the gravel averaged about one percent though the material was very wet when delivered. The weight per cubic foot is 100 pounds with forty-one percent voids. It was found that while the surface of a

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pile of sand or gravel is rather dry the material tends to increase in moisture content as it is used. It was necessary to keep a careful check of moisture in the aggregate throughout a pour in order to avoid variation of the water cement ratio.

A water cement ratio of 0.9, as used for Class I concrete, means 6¾ gallons of water per sack of cement. A typical mix on this basis would be, for one batch,

6 bags of cement.
1610 lbs. of sand, weighed dry.
2030 lbs. of stone, weighed dry.
40½ gals. of water.

A number of test cylinders were cast at every stage of the work and at a number of intervals throughout a pour. Strength values indicated the correctness of the proportioning by being well above the minimum required in every case. For the mix outlined above, water cement ratio 0.9, the strength values for a 6 x 12 cylinder were:—

At 7 days—2653 lbs. per sq.in.
" 14 days—3148 lbs. per sq.in.
" 28 days—3661 lbs. per sq.in.

Special precautions are to be taken in cold weather, both as to heating of materials and placed concrete and in strengthening the mix. The initial temperature of the concrete after being placed must be 80 degrees Farenheit and the surrounding air must be kept at least 60 degrees Fahrenheit for seven days. This is done by the use of salmanders and tarpaulins, though no concrete has been poured this year in weather cold enough to warrant these precautions.