THE CHICAGO GREAT WESTERN AND THE FORT DODGE BRIDGE.

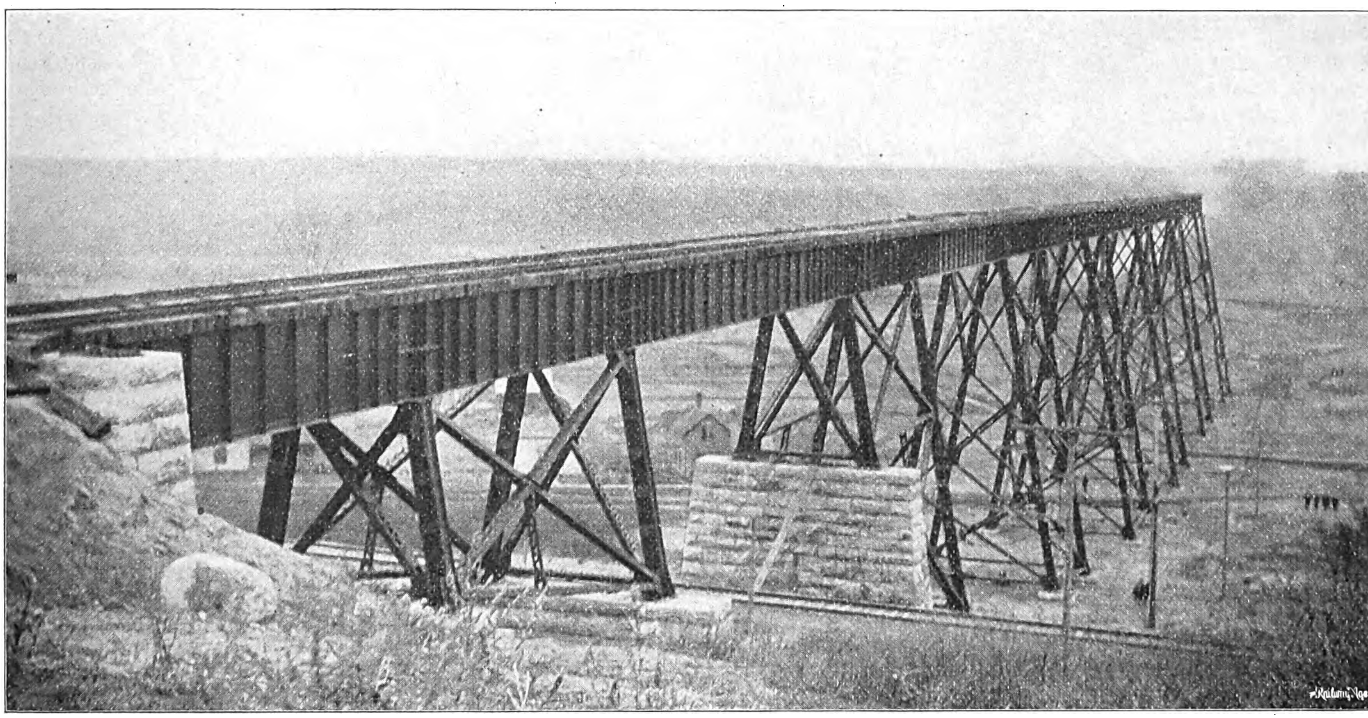
The main lines of the Chicago Great Western Railway, or "Maple Leaf Route," consist of three arms converging at Oelwein, Ia., and having their other extremities at Chicago, Kansas City and Minneapolis and Saint Paul. As the general directions of these lines meet at angles of about 120 degrees, they form fairly direct connection between the various termini, and with a minimum length of road to accomplish this result. In addition to these three arms there are several branches, one of which runs southerly from Hayfield, Minn., on the St. Paul-Minneapolis line, to Manly, Ia.; and another runs westerly from Sumner, Ia. (near the junction of the three arms), to Hampton, Ia.

Prior to 1901 the Mason City & Ft. Dodge Railroad was an independent road between these two Iowa cities, but the management of the Chicago Great Western Railway, desiring to gain an entrance for their road into Omaha and Sioux City, purchased the road and prepared to build connections between it and the above-mentioned branches of their own road. The line from Mason City to Manly is now built and in operation, completing the connection of Fort Dodge with Saint Paul and Minneapolis; and the line from Clarion to Hampton is almost finished, giving a nearly direct line from Fort Dodge to Chicago.

Lines are also projected from Fort Dodge to Omaha and to Sioux City, and the former is now being constructed. At present it is completed to a point a few miles southwest of Manning, Ia. All of the new lines are so planned as to give maximum grades of 0.5 per cent against east and north bound traffic, and 0.7 per cent grades against west and south bound traffic, these grades being compensated for curves at 0.04 per cent per degree. The old line of the Mason City & Ft. Dodge is also being rebuilt to give the same maximum grades, and the line is in other respects being put into a corresponding degree of excellence and fitness for economically handling heavy traffic. When completed these lines will be the shortest routes between Omaha and Sioux City and Chicago and Saint Paul.

Where the Omaha and Sioux City extensions cross the Des Moines River at Fort Dodge the surface of the prairie is about 160 feet above the river, the river valley in this vicinity having a width of about 7,000 feet between the edges of the prairie. As grades and distance are elements of great importance on these lines it became necessary to cross the valley by a viaduct. In addition to the problems attendant upon the crossing of the river and valley, two railroads and five highways are crossed. The Minneapolis & St. Louis Railroad has a freight yard at this point, to avoid which would have increased the length of the line and of viaduct. These conditions led to the adoption of a design with 14 rectangular towers of 38 feet and 15 suspended spans of 75 feet and one of 38 feet, with four truss spans of 219 feet 4 inches across the Des Moines River and the lands of the Minneapolis & St. Louis Railroad. The total length of viaduct is 2,582 feet.

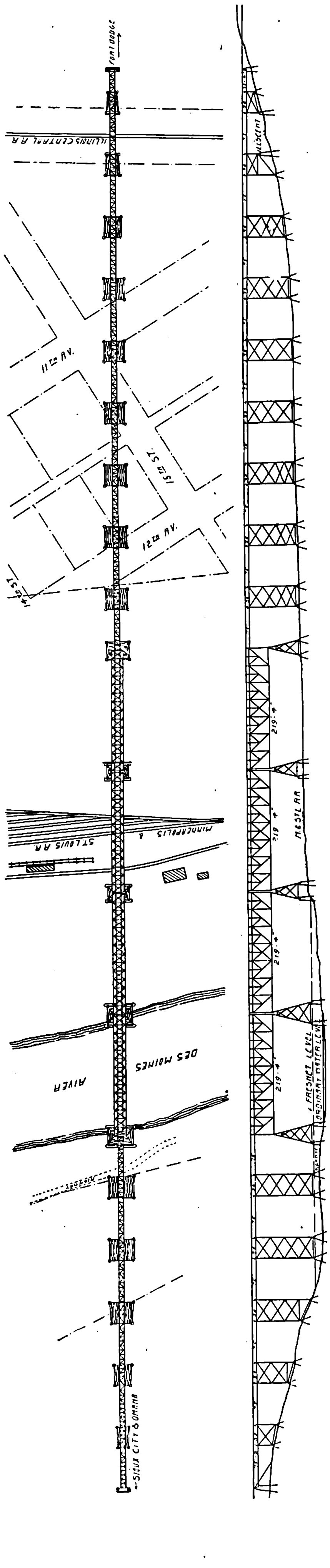
A great variety of soils was encountered, the excavation for a single pedestal disclosing, under the thick layer of rich loam which puts Iowa in the front rank as a corn-producing State, fine sand, gypsum, coal and peat, marl, soapstone, vermillion, iron pyrites, "sandrock" (a flake of which was 2 feet thick at one corner and extended half-way across the pit, running out to a thin edge), several varieties of clay, and finally giving a foundation upon slate at a depth of 15 feet below the surface. These different materials were not found in regular strata, but were mixed up as if they had been stirred together, and showed a variety of coloring that might compete with the rainbow.



CHICAGO GREAT WESTERN—DES MOINES RIVER BRIDGE AT FORT DODGE, IA. FROM A PHOTOGRAPH TAKEN IN NOVEMBER, 1902.

Numerous tests were made to determine the supporting power of the different soils. The surface of the soil to be tested was carefully leveled to receive an iron plate 12 inches square, on which was placed a 10-inch ring, 4 inches high, carefully centered. On this was laid a flat casting 27 inches square by 2½ inches thick, having a circular knob at the center of the under side just fitting inside the ring. Upon this large casting was placed the load of pig iron, care being taken to keep the center of gravity, as nearly as could be judged by observation, over the center of the base plate. The better to keep the load properly centered, plumb lines were marked on the walls of the pit, so that the planes they represented should intersect nearly at right angles over the center of the base plate. All this material was found on hand in a foundry near the bridge site, but could hardly have been improved upon had it been made to order. Before applying the load two stakes were set on opposite sides of the proposed test pile, with their tops at exactly the same level. These stakes were set far enough away so as not to be covered by the pile, but close enough so that an ordinary carpenter's level would readily reach the adjacent corners of the base plate. The elevation of the tops of the stakes was carefully determined, so that they might be replaced in case of accident. Favors done by the "small boy" of the neighborhood proved the wisdom of this precaution. As soon as the base plate was set the height of each corner was compared, by a carpenter's level with sensitive bubble, with the tops of the stakes and note taken. A part of the load was then applied and levels again taken. After a day's or a night's rest new levels were taken, and, if it seemed best, more load was added. Tests were made on soils both dry and wet, and were continued for such length of time and with such weights as to give a pretty good idea of the supporting value of the soils. The above-mentioned "small boy" also assisted in showing the effect of churning the load on a saturated clay.

The abutments at the ends of the viaduct are piers without wing walls, with the slope of the bank running around in front. Next to the tracks of the railroads crossed are piers carried 10 feet above the rails, and at the river banks are piers carried 18 inches above the highest known freshet level (or 20 feet 6 inches above the ordinary water level). At all other towers individual pedestals are built for each leg of the bents. The piers have at the top



CHICAGO GREAT WESTERN—ELEVATION AND PLAN OF BRIDGE AT FORT DODGE.

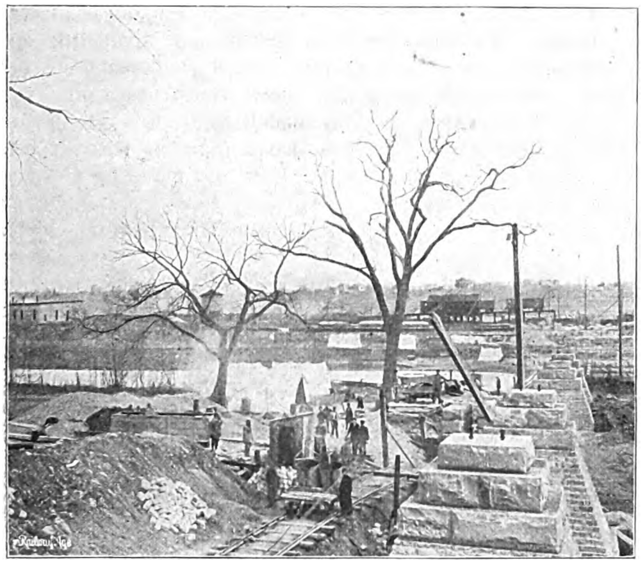
three courses of dimension stone masonry laid to ¾-inch joints. Below this the masonry is of cyclopean rubble (10 to 150 cubic feet in single stones), resting on a concrete foundation. Pedestals have cap stones 5 feet square by 1 foot 6 inches thick, of a single stone, laid on two courses 7 feet and 9 feet square, respectively, by 2 feet thick. Below this is concrete which, above the grounr surface and within about 4 feet below it, is faced with paving stone in 6-inch courses, laid with alternate headers and stretchers. As the high-water mark is 19 feet above normal water level, and as such a freshet widens the flow from about 200 to 700 feet, there are eight pedestals, rising 12 to 15 feet above the ground, faced in this way. All the concrete above the ground level was laid with a general line of face battered 4 inches per foot. Where concrete was built in frames without paving-block facing, a skin coat was made by running a spade down next the frame as each course was laid and working it back and forth, so as to crowd the large stone away from the face and leave the richer mortar next to the frame. The lower portion of the excavation was always filled with concrete, rammed well against the walls of the pit, the area of base being made ample to sustain the weight of the masonry and the loads above it, as best the supporting power of the soil could be judged.

All the stone masonry (including the paving-block facing concrete) is of Kettle River stone, which is a quartzite. In

CHICAGO GREAT WESTERN—RIVER PIERS OF FT. DODGE BRIDGE.

this stone the later deposit of quartz which cements the original sand together does not entirely fill the voids, but in the judgment of the engineer is far superior for bridge work to the magnesian limestones and the soft sandstones found in Iowa. There is some harder limestone found, but generally in such thin layers as to be unsatisfactory for stone masonry, though excellent for concrete. On the other hand, Kettle River stone is much less expensive at this place than granite or the so-called "jasper" found in the northwest corner of the State.

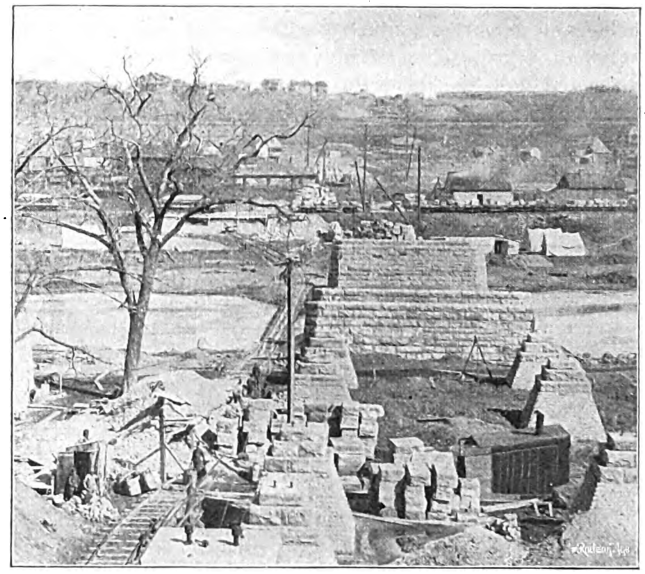
The concrete used was mixed in the proportion of 1:2:6, except that a little extra sand was used if necessary, in order to completely fill the voids when the broken stone was running coarse and uniform. The broken stone used is a hard limestone from Mason City, "crusher-run," but specified to have not less than 75 per cent of such size as to pass a 2-inch ring. The Omega brand of Portland cement was used, and was found to be a very slow-setting cement, requiring 4½ to 7 hours before a pat would support the first Gilmore needle. As most of this work was done in cold and very changeable weather (several times fluctuating over 60 degrees in a day), the engineer would have preferred to have it set a little more rapidly. When the temperature was below freezing, or expected to be before the concrete would be protected from the weather, salt was used in the concrete or mortar in the proportion of one pound for 18 gallons of water at the freezing point, and an additional ounce of salt for each degree, Fahr., below this point of present or prospective temperature. Spawls were sometimes thrown into the concrete of foundations, and the amount of broken stone reduced to assure sufficient mortar to completely cover all surfaces of the stone. The use of these spawls was limited in quantity and position, so that there should be no tendency to cleavage if the mortar should not perfectly adhere to the spawls. Whenever the concrete was left until it had wholly or partially set, the surface was scabbled and dampened and a layer of mortar put on before the next course of concrete was laid. If above or near the level of bottom of anchors, or where the mass did not wholly fill the excavation, stones were set partly in the old and partly in the new concrete, to serve as dowels to tie two parts together. In cold weather both the sand and water used in making mortar and concrete were warmed sufficiently to prevent freezing when the mortar came in contact with the cold stone. Care was taken not to get either sand or water so hot as to cause too rapid setting.



CHICAGO GREAT WESTERN—CONCRETE PLANT.

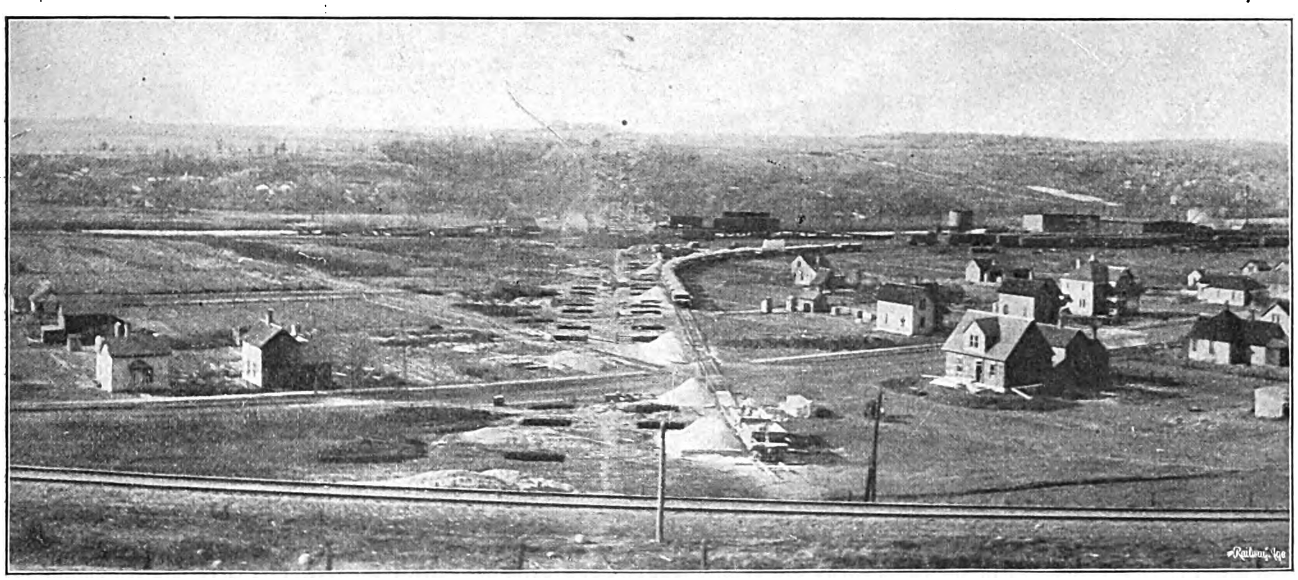
Concrete was allowed to set five days or more (according to the weather) before stone was allowed on it; then the surfaces scabbled and dampened (and if any concrete had been "killed" by freezing it was removed) and the stone set in a bed of mortar.

In all pedestals and piers supporting steel towers anchors were set in the masonry, although in some cases the maximum wind pressure and longitudinal thrust, according to the formulas generally used, could give no uplift. These anchors consist of two 2-inch rods, upset at the screw ends 2½ inches, passing down between two 12-inch channels 6 feet long, laid at 90 degrees with the center line of viaduct and set close to the rods. The bottoms of the rods have 4½-inch square heads and are supplied with washers made of short pieces of channels laid parallel with the viaduct and with flanges turned down. On top of the 6-foot channels are four 8-inch I-beams, laid parallel to the viaduct, giving ample spread and strength, and are thoroughly imbedded in the masonry to such a depth as to give ample weight to resist the maximum uplift.



CHICAGO GREAT WESTERN—CONCRETE PLANT.

In order more conveniently and economically to handle the work, spur tracks were put in, connecting with the Minneapolis & St. Louis Railroad, one curving to the east and paralleling the viaduct, and the other on the west running nearly parallel to the Minneapolis & St. Louis Railroad. Other independent tracks ran from the latter at the trestle where broken stone was dumped from ballast cars, and from the point where large stones were unloaded by derrick to a switch at the river bank and thence across the river to a dumping trestle, near which a concrete mixing plant was installed. All the concrete for use between this point and the top of the hill was mixed by this plant, loaded into buckets, placed on a car and hauled up the hill by a stationary engine near the upper end of the delivery track. Another engine and



CHICAGO GREAT WESTERN—SITE OF FORT DODGE BRIDGE.

derrick unloaded the car and delivered the concrete into the pit. This method of working required three engines (besides the mixer engine) and two derricks, but experience proved its economy, for the capacity of the mixer proved to be the limiting factor, even when the concrete was deposited at the top of the hill, and yet every man and machine was required to do the utmost to prevent blocking the work. In one day of 10½ hours about 140 cubic yards were placed at the top of the hill. This result could not have been accomplished until after considerable experience, during which every man had learned just what was expected of him and how to do it quickly.

On the flats the concrete was delivered from the mixers by wheelbarrows, which was a slower method, but saved the use of engine and derrick. As these foundations were not deep, and so required a comparatively small quantity of material, this method proved more economical here.

On the east side hill the first two piers were so situated that the concrete could be delivered by a trough directly from the mixer into the pits. Had there been sufficient quantity of this work to warrant the organization of the force as well as was done for the work on the west hill, undoubtedly an equal record could have been made for quantity deposited and at a smaller cost.

The study of the field to prepare for this work was begun about the middle of July, 1901, and the construction was begun in October, 1901, the Bates & Rogers Construction Company of Chicago being the contractors. The substructure was completed in May, 1902. This work was done under the charter of the Mason City & Ft. Dodge Railroad, as is also all the other construction of new lines above mentioned.

The following description of the erection of the superstructure is from a paper presented on January 22, 1903, before the Iowa Engineering Society, by Mr. H. C. Keith, bridge engineer in charge of construction, to whom we are indebted also for most of the data contained in the foregoing:

The contract for the superstructure was given to the American Bridge Company in December, 1901, and the work was placed in their shops as follows: The 38-foot girders and towers were made at the Milwaukee shops, the 75-foot girders at the American shops in Chicago, the truss spans and truss towers at the Detroit shops, except the eyebars, which were made at the Pencoyd plant. The erection of the superstructure was sublet to the Kelly-Atkinson Construction Company.

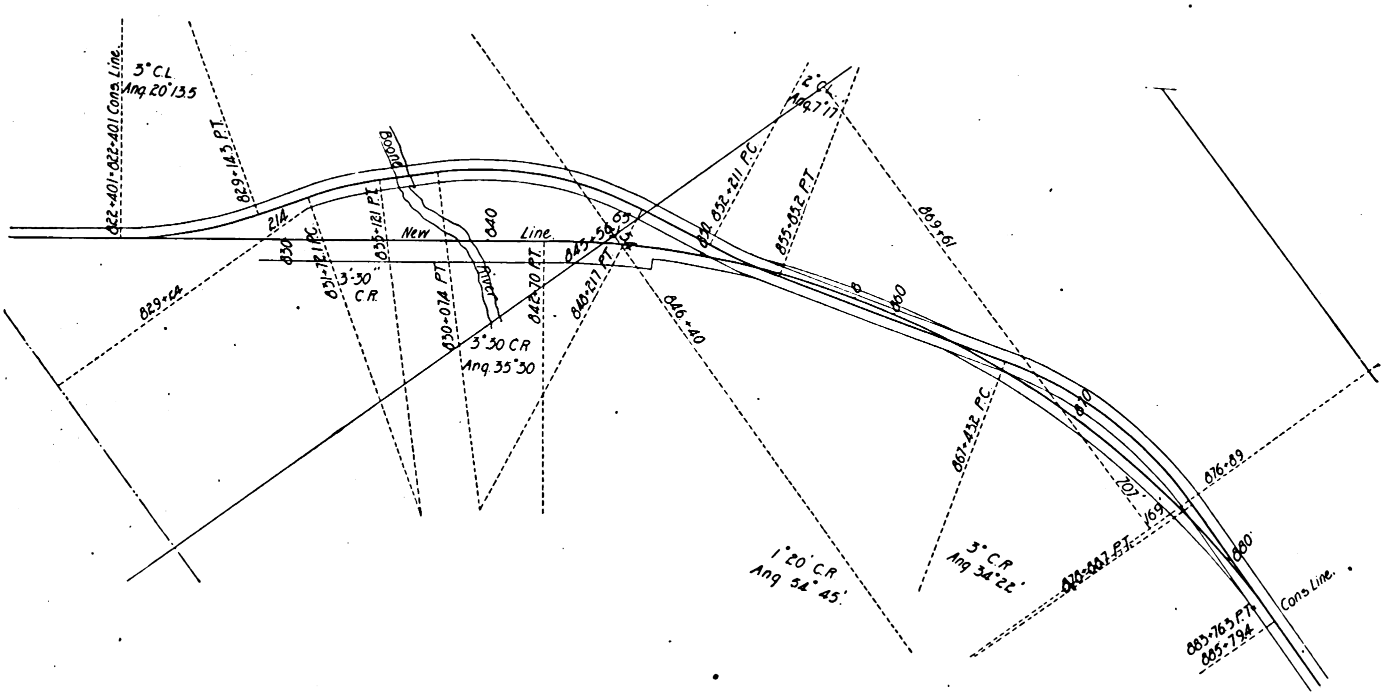
The material was delivered at the east end of the viaduct and unloaded beside and between the tracks for a quarter of a mile east of the end of the viaduct. From this point material was taken as required, the erection beginning at the east end, using for a traveler a large derrick car running on a track with rails 10 feet, center to center. Another derrick car on standard-gauge track serves as a tender for the traveler, bringing it material from the storage yards.

The first bent was bolted together on shore, carried forward and lowered into place by the traveler and guyed. The girders of the first span were then placed upon it and the deck added. The traveler then moved out upon this span and erected the second bent and placed the second span of girders; and so on, proceeding until the truss spans were reached. Wherever a bent was not so high as to require splicing the posts, the bent was bolted together with its bracing upon the ground, and then raised into place by the traveler, a guy being carried forward to hold it, another guy being run back to the portion of the structure which was already up.

Where the towers were so high that the posts were spliced (if the second bent of a tower), the bottom section of one post was raised and secured to the anchor bolts; the first section of the other posts similarly placed, and the bracing put in between them; then the top section of the bent was bolted together on the ground, lying transversely of the bridge, and all but one short section of bracing coupled up. Then the top section of the bent was raised from above, turned and put into place, the omitted section of bracing allowing the post section to spring in enough to make connection.

The reach of the boom of the traveler being only 64 feet, and the long girder spans being 75 feet, the first bent of each tower had to be erected in a slightly different way. The lower section was put together with its bracing and raised and placed upon the masonry, being left at a slight incline so that the axis of this section of the bent pointed toward the head of the boom of the traveler. Next, the top section of the bent was put together in the way previously described for the bents erected with the 38-foot reach, and raised and put into place (still being left on a slant, so that the line of direction pointed toward the head of the boom of the traveler, until connection was made with the first section of the bent). Then guys drew the bent plumb, holding it so while the traveler returned to get a girder to place upon it.

The detail at the top of the post is so planned that the

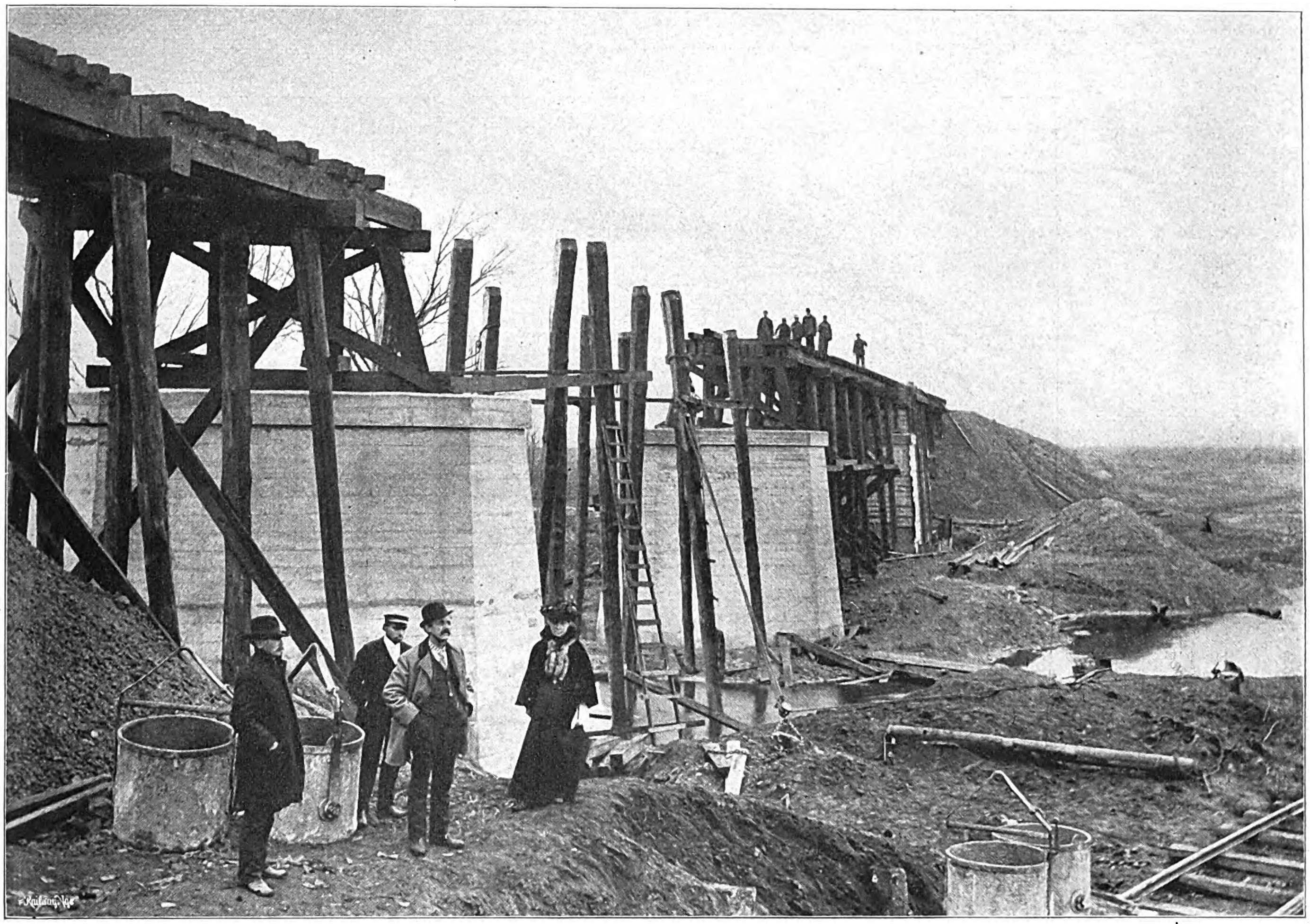


CHICAGO GREAT WESTERN—BOONE REVISION.

center of the bearing for both spans, resting upon the bent, comes directly over the axis of the bent, there being a lower lip on the 38-foot girders which form the top part of the tower, and an upper lip of the suspended span rests upon the lower lip of the tower girders. Ample support for the suspended girder spans during the erection was obtained by extending the cap plates of the posts on transverse angles stiffened by knee angles outside the body of the posts.

When the last tower for the girder spans was reached, false work bents were put up to support the last girder span and allow the traveler to move forward far enough conveniently to erect the "A" tower supporting the end of the truss span. These "A" towers were made with a transverse batter of two inches to the foot, and so placed as to make been previously put up and braced, and so on, completing to the third panel. In this way each truss was erected until the last full panel point was reached, when the next tower was raised and braced before the last panel of the truss was put in place. The same false work was used for all the truss spans, each bent as wanted being taken from its position under the completed span, raised at the side of the truss (guys being carried out on the opposite side from the masthead to prevent overturning), and carried forward above the deck and launched into its new place.

The "A" towers prove a very satisfactory arrangement for supporting the truss spans because of the reduction in the uplift, for which provision would have to be made. If towers were used like those upon the trestle part of the work



CHICAGO GREAT WESTERN—BOONE REVISION.

the posts lie in the same longitudinal plane with those supporting the girder spans. Longitudinally, the posts of the "A" towers have a batter of three inches per foot, the apex being at the bottom pin. Where two truss spans rest upon the same "A" tower, the pins are 3-feet centers and the posts are spread that amount more. For erecting the truss spans, two bents of false work were erected from above by the traveler and braced, and the end posts and first panel bottom chord put in place; then the first section of the top chord and the first panel vertical for both trusses were bolted together on the false work and raised and sway bracing put in subposts and truss diagonals added.

In order to erect the second sections of the top chord readily (the splice being just a little toward the end from the second full panel point), a temporary bent was added upon the false work to support the top chord and allow the floor beams and stringers to be put in up to the middle of the second panel, when a third bent of false work was put out and the second section of the chord and the third vertical were bolted together and raised, coupled to that which had there might be a very considerable longitudinal thrust, due to trains upon the 220-foot span with only the dead load upon the tower to resist the uplift caused thereby. With the "A" towers as proportioned, whenever the maximum longitudinal thrust occurs, there is also a live load to help resist it, so that in no case, according to the usual formulas for longitudinal thrust and wind pressure, can there be any uplift exerted upon the masonry for these towers.

The erection of the steel work began on October 8, 1902, and on January 22, 1903, the structure was in place as far as the center of the third truss span. The last girder was put in place on March 10, and it was planned to run a train across on March 14.

In connection with the work between Oelwein and Fort Dodge there are several interesting pieces of engineering. One of these is a revision of the line and the construction of a bridge over Boone River two miles west of Eagle Grove. The line as originally built by the Mason City & Ft. Dodge Railway was located with a view to economy in first cost, and did not fulfill all the conditions which will be required on that line as a part of the Chicago Great Western when the extension is completed to Omaha. The revision improves the line, as shown in the accompanying engraving, and reduces the grade to a .5 per cent eastbound and .7 per westbound, which are the maximum grades for the western division of the road.

The length of the revision is 6,136 feet, and the line is shortened by 203 feet. Curvature is reduced from 109 degrees 46 minutes to 54 degrees 45 minutes, and the maximum curvature from 3 degrees 30 minutes to 1 degree 20 minutes. The grading involved in the revision amounted to 45,800 cubic yards. The change in line made it necessary to construct a new bridge 400 feet down stream from the old structure. The old bridge consisted of a deck girder span 88 feet 7 inches long, set on sandstone piers and with trestle approaches. The new bridge will consist of three girder spans 60 feet, 80 feet 7 inches and 90 feet in length, respectively. For the middle span the old girders will be used, but will be reinforced by a three-girder under the center line of the track. The old girders were designed for light engines, and the addition of a third girder is made necessary in order to strengthen the bridge for uses of heavier power. The photographs from which the accompanying engravings were made were taken prior to the placing of the old girders and the reenforcing girder, which have since been put in position. The other girders will not be placed until it is necessary to renew the pile trestles which fill the space between the piers and the abutments.

The substructure is of concrete, carried down to hardpan about 12 feet below the bed of the river. This revision is only one of ten similar pieces of work which the road has in progress between Oelwein and Fort Dodge in order to obtain a light grade and curvature to conform to the conditions of the new extension.

We are indebted to Mr. A. E. Harvey, resident engineer Chicago Great Western at Fort Dodge, Ia., for the data concerning this work and for the photographs and blue prints from which the engravings were made.

CHICAGO GREAT WESTERN—BOONE REVISION.

January Trade Movements.

Trade movements for the month of January, 1903, as given by the Treasury Bureau of Statistics, indicate continued prosperity when compared with corresponding movements for the same month of 1901 and 1902. The live stock movement at the five most prominent markets of the West may be taken as an index of the conditions in that section of the country. For January, 1903, a total of 2,724,409 head of cattle, calves, hogs and sheep was reported, in contrast with 2,947,631 head for January, 1902, and 2,789,209 head for January, 1901. A continuous increase has occurred in these three years in the case of the receipts of cattle, calves and sheep, but a very marked falling off in the case of hogs. At Chicago, Kansas City, Omaha, Saint Louis and Saint Joseph, the combined receipts of cattle in the first month of this year were 632,122 head, compared with 586,611 head in January, 1902, and 552,616 head in January, 1901. A comparison of the wheat receipts at eight winter wheat and spring wheat markets for three seasons to the end of January shows that this year the receipts were considerably in excess of either of the two preceding seasons, the total being 189,661,368 bushels, compared with 174,483,763 bushels to the end of January, 1902, and 153,014,293 bushels to the end of January, 1901. Trunk-line shipments of grain of all kinds from Chicago for the first five weeks of 1903 amounted to 13,387,000 bushels, compared with 11,673,000 bushels in 1902, and 12,194,000 bushels in 1901. The provision shipments from Chicago are this year notably in excess of the two preceding years. For the first five weeks of 1903 there were shipped 133,935 tons, compared with 127,948 tons for the corresponding period of 1902, and 104,848 tons for the same weeks of 1901. Receipts of grain and flour at Boston, New York, Philadelphia and Baltimore for January, 1903, were 22,217,827 bushels, including flour reduced to bushels, compare dwith 18,432,409 bushels in January, 1902, making an gain of 3,785,418 bushels.

THE DES MOINES RIVER VIADUCT OF THE MASON CITY & FORT DODGE R. R., AT FORT DODGE, IA.*

By H. C. Keith.†

The main lines of the Chicago Great Western Railway (or Maple Leaf Route, as it is called from a fancied resemblance of these lines to the main lines of a maple leaf) consisted, prior to 1901, of three lines running from Chicago, the Twin Cities of Minneapolis and St. Paul, and Kansas City, respectively, to a central point at Oelwein. In addition, there were several branches, two of which become important in connection with the new work.

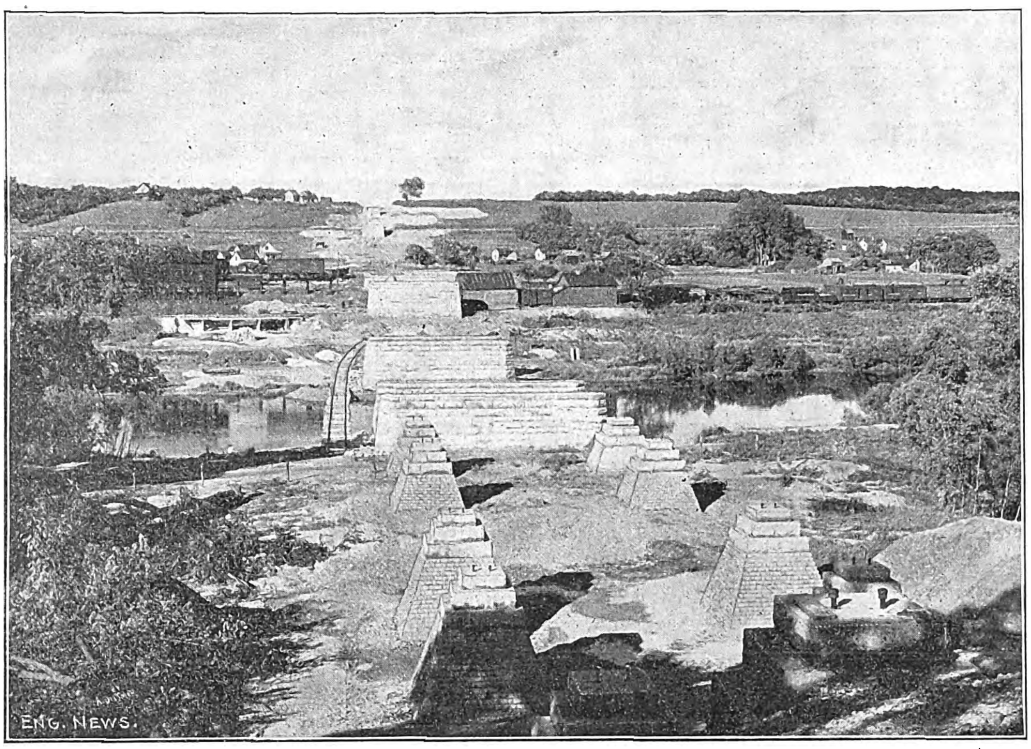


FIG. 1. VIEW OF SITE OF DES MOINES RIVER VIADUCT, SHOWING SUBSTRUCTURE COMPLETED.
H. C. Keith, Chief Engineer, Mason City & Fort Dodge R. R.
Bates & Rogers Construction Co., Chicago, Ill., Contractors.

In the spring of 1901, the management of the road purchased the Mason City & Fort Dodge R. R., and began the construction of lines running northward from Mason City to a connection with its Hayfield & Manly branch, thereby giving a direct route to Minneapolis and St. Paul. Another line, from Clarion to Hampton, connecting with the Waverly branch, gives a fairly direct connection with the line to Chicago. New lines were projected from Fort Dodge to Omaha and Sioux City, and a cut-off from Waverly to Oelwein, giving a more direct connection with the Chicago line. The new lines are built with easy curves and with maximum grades of 0.5% against the eastbound traffic and 0.7% against westbound traffic, and the old lines are being revised to give similar grades.

The line from Fort Dodge to Omaha crosses the Des Moines River valley in the city of Fort Dodge at a point where the valley is 1½ miles wide, and the river is about 160 ft. below the level of the prairie. At the site of the viaduct the line crosses the Illinois Central and the Minneapolis & St. Louis railways, the crossing of the latter being near the southerly end of its freight yard. It also crosses five highways. To avoid the freight yard of the M. & St. L. R. R. would have necessitated an increased length of line, and also an increased length of viaduct. The viaduct at this point has a total length of 2,582 ft. and a height of 138 ft.

The soil here is very uneven in make up, one excavation 15 ft. in depth having, in addition to the rich loam which makes Iowa rank first as a corn-producing state, sand, peat, coal, marl, soapstone, iron pyrites, gypsum, vermillion, sandrock, and several varieties of clay, and finally a bed of slate, all within a depth of 15 ft. The material was not in regular layers, but in layers lying irregularly, resembling marble cake, and with a variety of coloring which discounts the most brilliant rainbow the writer has ever seen.

The viaduct consists of 38-ft. towers with 75-ft. suspended spans, and four truss spans of 220 ft. each. The girders are spaced 10 ft. centers, and the posts of the towers have a transverse batter of 2 ins. per foot. The truss spans are supported on triangular or A-towers having the same spacing transversely as those for the girder spans, and a longitudinal batter of 3 ins. per ft.

SUBSTRUCTURE.—The study of the site began in July, 1901. The substructure work was done by the Bates & Rogers Construction Co., of Chicago, Ill., in the period from October, 1901, to June, 1902. The material for this work was delivered upon spur tracks connecting with the M. & St. L. R. R., one curving around toward the east and running parallel with the viaduct, the other running upon the west side of the M. & St. L. parallel with its main line, and from this the material was unloaded and reloaded on tram cars running across the river and up to the west slope to deliver at any desired point.

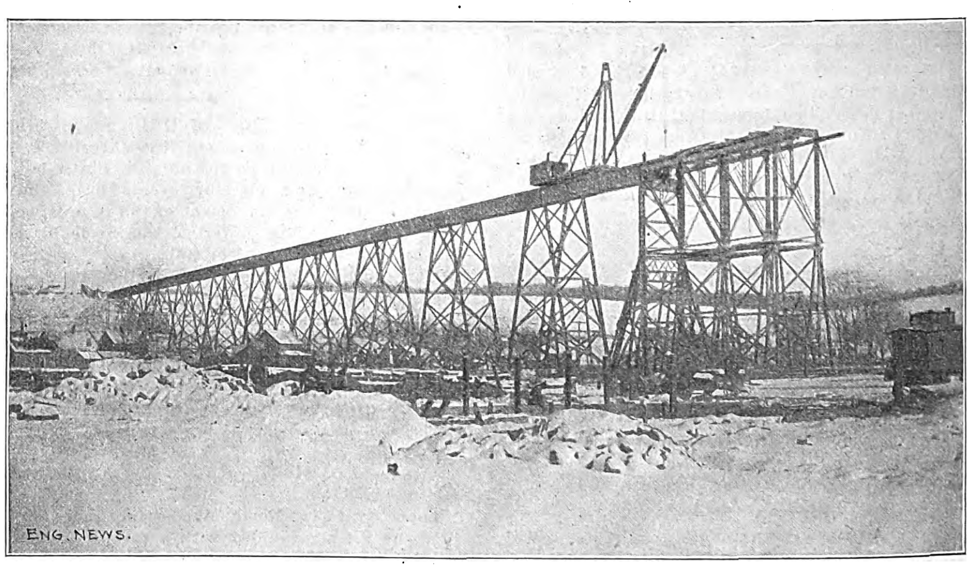


FIG. 2. VIEW SHOWING DES MOINES RIVER VIADUCT IN PROCESS OF ERECTION.

The abutments were made without wings, the slopes being allowed to run in front of the abutments under the end spans of the viaduct. At the river and at each railroad crossing are piers of Kettle River sandstone; the piers at the river running 20½ ft. above the ordinary water level, this bringing the freshet water level at the bottom of the top course of stone of the piers (the river rising 19 ft. and spreading from 200 to 700 ft. in width at the highest freshet of which information could be had). The railroad-crossing piers were carried up 10 ft. above the tracks of the roads crossed in order that a derailed train might spend its energy upon the masonry rather than bring the steel work down on top of it. In all other places individual pedestals were put in for each post of the towers, the top of the masonry being kept as low as practicable, for the sake of stability.

The foundation in all cases was made of concrete; and, wherever the concrete came above a plane about 4 ft. below the natural surface of the ground, the concrete was faced with paving blocks of Kettle River sandstone. Below this level the surface of the concrete was given a facing by spading in such a way as to crowd the coarser material in and force the richer mortar to the surface. Wherever the concrete was built in forms with sloping sides, the batter was made 4 ins. to the foot. The bottom of all concrete foundations was made the full size of the excavation, and the concrete was rammed hard against the walls of the excavations.

The top three courses of the piers beside the river and the railroads, and also of the pedestals, were made of Kettle River stone dressed to lay with ¾-in. joints. Below these three courses the piers were built of cyclopean rubble with stone varying from 10 to 150 cu. ft. The broken stone for concrete west of the M. & St. L. was dumped through a trestle under the west spur track and there reloaded on tram cars: the Kettle River rubble stone was dressed beside the spur track and reloaded upon cars. From these points the materials were carried across the river by a temporary track and trestle to a new delivery yard at the foot of the west hill. The concrete for all of the work on the west slope was mixed at this place and dumped into buckets which were hauled up the track on the slope by a stationary engine at the top of the hill, and delivered by derrick and engine into the excavations prepared for it. After the workmen became thoroughly accustomed to this work so that each man knew just what was expected of him, 140 yds. of concrete were placed in an excavation at the top of the hill in a day of 10½ hours. The concrete on the flats was delivered by barrows, and that near the top of the east slope was delivered by spouts: it had in no case a drop of more than 10 or 12 ft. from the barrow or spout to the bottom of the excavation.

In extreme cold or changeable weather no concrete was laid, but when the temperature was not excessively changeable and was above about 20° F., concrete or stone masonry was laid, using salt in the water in the proportion of 1 lb. salt

*A paper prepared for the Iowa Engineering Society, giving the substance of an address by the author at the annual meeting of Jan. 22, 1903.

†Chief Engineer, Mason City & Fort Dodge R. R., Fort Dodge, Iowa.

to 18 gallons water at 32° F., and 1 oz. additional for each degree below 32° (the temperature used in determining the amount of salt required being taken as the lowest expected in about six hours). In freezing weather both the sand the water were warmed, but not sufficiently heated to make the mortar set too quickly.

In joining new to old work, the old surface was scabbled to give a rough surface, well moistened, and a thin layer of neat cement mortar laid, before continuing with the concrete. Generally, stones were set in the old work projecting about 6 ins. so as to serve as dowels to tie the new to the old work. No stone work was laid on the concrete until the concrete was hard (usually about a week, but varying somewhat with the weather).

In each pedestal and pier at every post, anchors were set, composed of four 8-in. I-beams running parallel with the line of the viaduct; under which were two 12-in. channels back to back, close to, and one each side of, two anchor rods 2 ins. in diameter, passing up through the masonry, with thread and nuts to secure the base of the post. At many of the pedestals there can be no uplift by

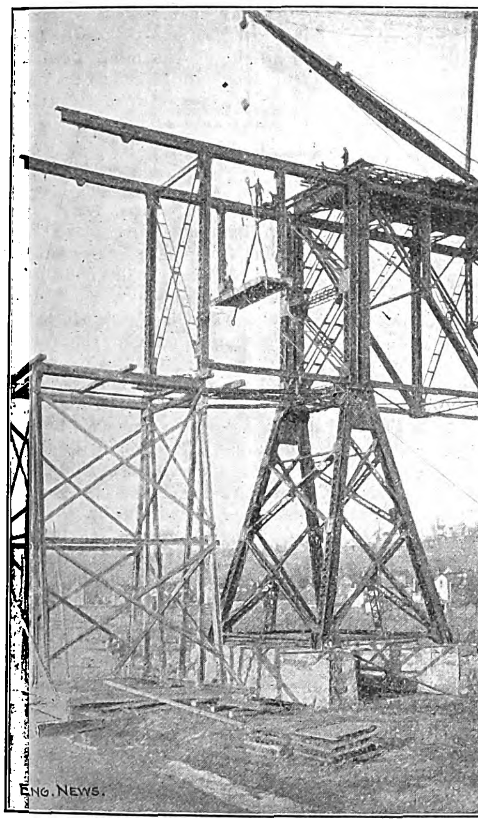


Fig. 3. View Showing A-Tower Carrying Truss Spans for Des Moines River Viaduct.

the usual rules for determining the amount of uplift, but anchors were set in each case.

SUPERSTRUCTURE.—The contract for the superstructure was given to the American Bridge Co. in December, 1901, and the work was placed in their shops as follows: the 38-ft. girders and towers were made at the Milwaukee shops; the 75-ft. girders at the American shops in Chicago; the truss spans and truss towers at the Detroit shops, except the eye-bars, which were made at the Pencoyd plant. The erection of the superstructure was sublet to the Kelly-Atkinson Construction Co.

The material was delivered at the east end of the viaduct and unloaded beside and between the tracks for a quarter of a mile east of the end of the viaduct. From this point material was taken as required; the erection beginning at the east end, using for a traveler a large derrick car running on a track with rails 10 ft. c. to c. Another derrick car on standard gage track serves as a tender for the traveler, bringing its material from the storage yards.

The first bent was bolted together "on shore" and carried forward and lowered into place by the traveler, and guyed. The girders of the first span were then placed upon it and the deck added. The traveler then moved out upon this span and erected the second bent and placed the second span of girders; and so on, proceeding until the truss spans were reached. Wherever a bent was not so high as to require splicing the posts, the bent was bolted together with its bracing upon the ground, and then raised into place by the traveler, a guy being carried forward to hold it, another guy being run back to the portion of the structure which was already up.

Where the towers were so high that the posts were spliced (if the second bent of a tower), the bottom section of one post was raised and secured to the anchor bolts; the first section of the other post similarly placed, and the bracing put in between them; then the top section of the bent was bolted together on the ground, lying transversely of the bridge, and all but one short section of bracing coupled up. Then the top section of the bent was raised from above, turned, and put into place, the omitted section of bracing belowing the post section to spring in enough to make connection.

The reach of the boom of the traveler being only 64 ft., and the long girder spans being 75 ft., the first bent of each tower had to be erected in a slightly different way. The lower section was put together with its bracing and raised and placed upon the masonry, being left at a slight incline so that the axis of this section of the bent pointed toward the head of the boom of the traveler. Next, the top section of the bent was put together in the way previously described for the bents erected with the 38-ft. reach, and raised and put into place (still being left on a slant so that the line of direction pointed toward the head of the boom of the traveler, until connection was made with the first section of the bent). Then guys drew the vent plumb, holding it so while the traveler returned to get a girder to place upon it.

The detail at the top of the post is so planned that the center of bearing for both spans resting upon the bent comes directly over the axis of the bent, there being a lower lip on the 38-ft. girders which form the top part of the tower, and an upper lip of the suspended span rests upon the lower lip of the tower girders. Ample support for the suspended girder spans during the erection was obtained by extending the cap plates of the posts on transverse angles stiffened by knee angles outside the body of the posts.

When the last tower for the girder spans was reached, false work bents were put up to support the last girder span and allow the traveler to move forward far enough to conveniently erect the A-tower supporting the end of the truss span. These A-towers were made with a transverse batter of 2 ins. to the foot, and so placed as to make the posts lie in the same longitudinal plane with those supporting the girder spans. Longitudinally, the posts of the A-towers have a batter of 3 ins. per ft., the apex being at the bottom pin. Where two truss spans rest upon the same A-tower, the pins are 3 ft. centers and the posts are spread that amount more. For erecting the truss spans, two bents of false work were erected from above by the traveler and braced, and the end posts and first panel bottom chord put in place, then the first section of the top chord and the first panel vertical for both trusses were bolted together on the false work and raised, and sway bracing put in and subposts and truss diagonals added.

In order to erect the second sections of the top chord readily (the splice being just a little toward the end from the second full panel point), a temporary bent was added upon the false work to support the top chord and allow the floor beams and stringers to be put in up to the middle of the second panel, when a third bent of false work was put out and the second section of the cohrd and the third vertical were bolted together and raised, coupled to that which had been previously put up, and braced; and so on, completing to the third panel. In this way each truss was erected until the last full panel was reached, when the next tower was raised and braced before the last panel of the truss was put in place. The same false work was used for all the truss spans, each bent as wanted being taken from its position under the completed span, raised at the side of the truss (guys being carried out on the opposite side from the mast head to prevent overturning), and carried forward above the deck and launched into its new place.

The A-towers prove a very satisfactory arrangement for supporting the truss spans because of the reduction in the uplift, for which provision would have to be made. If towers were used like those upon the trestle part of the work, there might be a very considerable longitudinal thrust due to trains upon the 220-ft. span with only the dead load upon the tower to resist the uplift caused thereby. With the A-towers as proportioned, whenever the maximum longitudinal thrust occurs, there is also a live load to help resist it, so that in no case, according to the usual formulas for longitudinal thrust and wind pressure, can there be any uplift exerted upon the masonry for these towers.

The erection of the steel work began Oct. 8, 1902, and the structure was completed on March 10 and put in operation on March 14, 1903.

METHODS AND COST OF WATER-HOISTING IN THE PENNSYLVANIA ANTHRACITE REGION.*

By R. V. Norris,† M. Am. Inst. M. E.

The removal of mine water by hoisting in tanks instead of pumping, while somewhat a reversion to the methods of the ancients, has come very rapidly into favor in the anthracite region of Pennsylvania during the past few years. In fact, so much so, that at the present time there are at least eight large collieries at which all the water is hoisted, and six more plants in preparation.

Besides these, the Delaware, Lackawanna & Western R. R. Co. is constructing a large capacity hoist for a depth approximately 500 ft., to be located in the Keyser Valley, near Scranton. The hoists will be driven by electric motors, geared directly to the sheaves. The Lehigh Valley Coal Co. is planning a large hoist for the Packer collieries in the Shenandoah district, but no work has been done on this as yet.

The earliest regular hoisting, I believe, was done by means of semi-cylindrical tanks (Fig. 1) at the Nanticoke collieries of the Susquehanna Coal Co. These tanks were attached under the regular shaft carriages, taking in water through six large clack-valves in the bottom, and discharging through an endgate opened by a lever which was operated by a guide piece, on the shaft head frame. These tanks were designed July, 1880, by the late J. H. Bowden, one of the very early members of the Institute. Similar tanks are still used in emergencies at the Nos. 1, 2, 3 and 6 shafts of the company. The objections to their use were: that water could only be hoisted during the night shift, or when the shafts were not in use for hoisting coal, requiring a very large pump, and greatly limiting the water capacity of the plants; that the alternate wetting and drying of the shafts did considerable damage to the timber; and that the collection of ice in the main shafts, which are invariably down takes for the ventilation, endangered the men in going up and down in their work. These reasons, with the gradual increase of water beyond the capacity of the plants, led to the abandonment of this method of hoisting, so that now these tanks are only used in emergencies. The method was, however, probably one of the cheapest ever devised for handling a moderate amount of water from deep shafts, as practically the only cost was for the steam used, the extra wear and tear of engines, ropes, shaft guides and timbering, and the extra oil required for lubrication. The hoisting engineers being required by the Pennsylvania Mine Law to be in the engine houses at all times, and night firemen being necessary at all colliery plants, there is really no additional labor cost to this method of hoisting. These tanks have a capacity of 1,800 gallons each, and 50 per hour was an ordinary dump, so the total capacity from a shaft 1,000 ft. deep, was about 750,000 gallons per day of 12 hours.

The present method of hoisting from a special water shaft or water compartment was, I believe, first used in 1896, at the Luke Fidler colliery, Shamokin, by Mr. Morris Williams, then superintendent of the Mineral R. R. & Mining Co., of which Mr. Irving A. Stearns was the manager. The plan was the outcome of the successful use of tanks in unwatering the colliery, which had been flooded to subdue a mine fire.

The tanks were made to dump as shown in Fig. 2, and, to get the maximum size, were made square with angle-iron corners; it was found almost impossible to keep them tight, and round tanks have been substituted.

The original method of dumping was the use of small wheels bearing against the guides to retain the tanks in a vertical position while hoisting; these passed through slots in the guides when the main dumping wheels reached the dumping rails (Fig. 2). These small wheels, if made of iron, rapidly destroyed the guides, and if of softer material only lasted for a few hoists. The present method of handling these dumping tanks is the use of a third guide (Figs. 2 and 3) at right angles to the main guides,

*A paper read at the Albany meeting of the American Institute of Mining Engineers.

†Asst. Engr., Penn. R. R. Coal Co., Wilkesbarre, Pa.

The Craig Goch Dam for the Water Works of Birmingham, England.

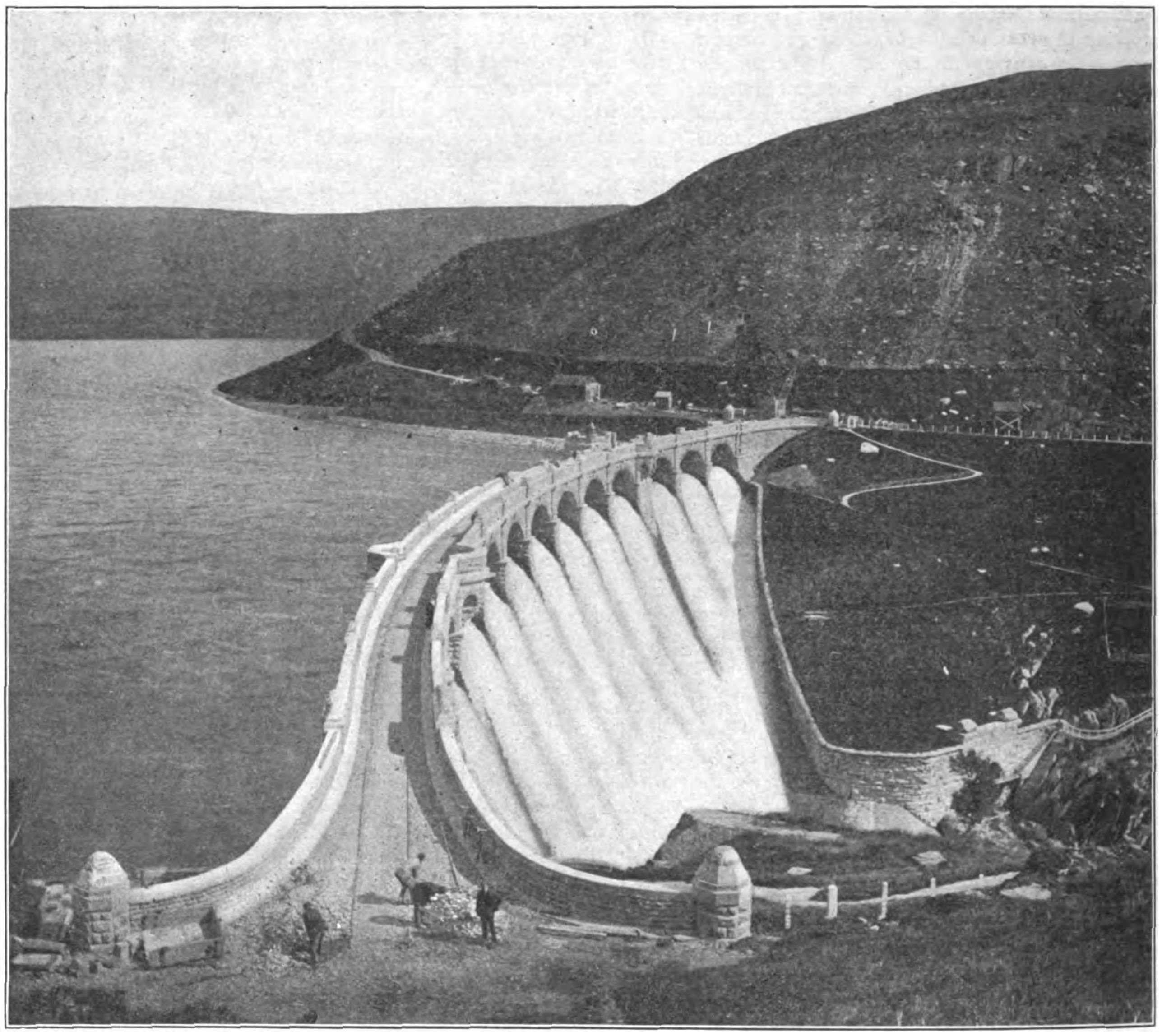
March 7 and December 12, 1903, this journal reproduced a number of views of well known European dams, calling particular attention to their architectural treatment. Herewith are presented two views of a large masonry dam recently completed for the water works of Birmingham, England, which make an interesting addition to the collection. The photographs were kindly sent by Mr. James Mansergh, M. Inst. C. E., the engineer of the works. The Craig Goch dam is the highest of several now under construction to form a system of reservoirs and the first to be completed sufficiently to permit its reservoir to be filled. When the views were taken water was flowing over the crest, and shortly before, the level of the reservoir was 18 inches above the crest of the dam.

The reservoir is located in Elan Valley, Radnorshire, Wales, is 2½ miles long and has a depth of water of 135 feet below the crest of the dam.

The treatment of the superstructure of the dam carrying the road recalls the arches on the top of the Vyrnwy dam. Unlike the five other masonry dams on these works, this dam is of the arched form, as shown by the views. Like them, however, it is built of large blocks of stone only roughly shaped and embedded in Portland cement concrete, for the hearting, and is faced with heavy broken coursed rock-faced grit or conglomerate closely jointed, on both upstream and downstream faces. The dam is nearly 80 miles from Birmingham. Further details of the dam are withheld from publication at present, as the works are to be the subject of a paper to be presented to the Institution of Civil Engineers.

The water works, of which the Craig Goch dam is a part, form one of the most extensive English water-supply undertakings attempted in recent years. Operations were commenced nearly twelve years ago, and there is still considerable work remaining to be done. The total storage capacity of all the impounding reservoirs when completed will be about 18,000,000,000 Imperial gallons. The principal basin, known as Caban Coch reservoir, and its dam were described in the issue of this journal of June 21, 1902. The construction of a portion of the large aqueduct, some 74 miles in length, for conveying the water from the Caban Coch reservoir to the 200,000,000-gallon Frankley distributing reservoir, just outside Birmingham, was described in the issue of September 29, 1900. A part of the system known as the first instalment of Elan water includes those works necessary for storing and conveying the waters of the Caban Coch, Craig Goch and Pen-y-Gareg reservoirs, and has been estimated to cost nearly $29,000,000.

The care bestowed upon architectural details, as shown by the pictures, is worthy of attention.



Craig Goch Dam for the Birmingham, England, Water Works.

The Des Moines River Viaduct of the Chicago Great Western Railway.

PART I.—SUBSTRUCTURE, TOWERS AND TRUSS SPANS.

The Mason City and Fort Dodge branch of the Chicago Great Western Railway, or Maple Leaf route, crosses the Des Moines River and valley at the city of Fort Dodge, where the valley is about 1½ miles wide and the river is about 160 feet below the level of the prairie. In the valley there is a single track steel viaduct 2,582 feet long and 134 feet high from low water to base of rail. It crosses five highways, the river channel, about 200 feet wide at low water and 700 feet wide at highest flood, the freight yard of the Minneapolis & St. Louis Railroad and the single track of the Illinois Central Railroad. There are four deck pin-connected Pratt-truss spans of 219 feet 4 inches each, supported on steel towers and spanning the low water channel, part of the high water channel and the freight yard. The remainder of the structure consists of alternate 38-foot and 75-foot plate girder spans supported on steel towers. The track on the viaduct is without grade or curvature and nine of the towers are from 113 to 80 feet in height, to the base of rail. All tower masonry is carried up above the highest freshet level, and the viaduct and bridge tower piers adjacent to the intersected railroad tracks are carried up 10 feet above them in order to oppose masonry rather than steel work to the possible impact of a derailed train. In all other places each post is seated on a separate masonry pier with the top kept as low above the surface of the ground as practicable.

The piers are located in soil of a heterogeneous character, consisting of rich loam, sand, peat, coal, marl, soapstone, iron pyrites, gypsum, vermilion, sand-rock, several varieties of clay and slate, all, in one case, within a depth of 15 feet. The material was not in regular layers and displayed a great variety of brilliant colors. In some cases the excavation was carried to a depth of 15 feet. The lower parts of the pits were filled with 1:2:6 Portland cement concrete made with Omega cement supplied by the Chicago Crushed Stone Company. The concrete in the bottom was rammed hard against the walls of the excavation and where it extended within 4 feet of the natural surface of the ground, it was faced with paving blocks of Kettle River sandstone. In all pedestals the upper part of the concrete was built to a batter; the slope was made 1:3. Above the foundations the piers, varying from 10 to 150 cubic feet each, were built of rubble stone. The top three courses of piers and pedestals were made of Kettle River sandstone dressed to lay with ¾-inch joints. The river is subject to a rise of about 20 feet above low water, which brings the flood height to the bottoms of the top courses of the river piers.

The concrete was mixed by two Ransome machines and one Smith machine driven by Fairbanks-Morse gasoline engines. It was delivered to the work in cars, buckets, derricks, wheelbarrows and through chutes, according to the relative location of the piers and mixers and as much as 140 yards were placed in an excavation at the top of the hill in one day of 10½ hours. In extremely cold or changeable weather no concrete was laid, but when the temperature was between 20 and 32 degrees Fahrenheit, concrete and stone masonry was laid, using water in every 18 gallons of which 1 pound of salt was dissolved for a temperature of 32 degrees and one additional ounce for each degree below 32. The temperature was assumed at the lowest point which it was expected the mercury would reach in six hours. In freezing weather both sand and water were warmed, but not enough to make the mortar set too quickly.

Where the new concrete was joined to the old, the surface of the latter was scabbled to make it rough; was well moistened and was covered with a thin layer of neat cement before laying the new concrete. Generally stones were set in a face to which other concrete was to be joined so as to project about 6 inches beyond its surface and serve as dowels for the new concrete. No stone masonry was laid on the concrete until the latter was set hard, usually about a week old. Every tower post was anchored by two upset 2-inch screw rods which had bottom heads bearing on a pair of 12-inch transverse channels back to back engaging the lower sides of four 8-inch reaction beams parallel to the axis of the viaduct. These anchorages were provided at every pedestal, although in many cases no uplift could be calculated by the ordinary formula.

The viaduct superstructure has medium steel riveted members manufactured without reaming and is proportioned for the dead load and for a live load consisting of two 154-ton engines coupled together and followed by a train load weighing 4,000 pounds per linear foot. Each engine has a wheel base of 48 feet and has four pairs of drivers 5 feet apart with loads of 42,000 pounds on each axle. The other axles have 30,000 pounds each, excepting those under the pilot, which have 20,000 pounds. The truss spans have two ordinary Pratt trusses with vertical end posts supported at lower chord level and with sub-divided panels carrying the center points of the top chord on sub-vertical posts connected to the middles of the diagonals and braced there with counter-sub-diagonals.

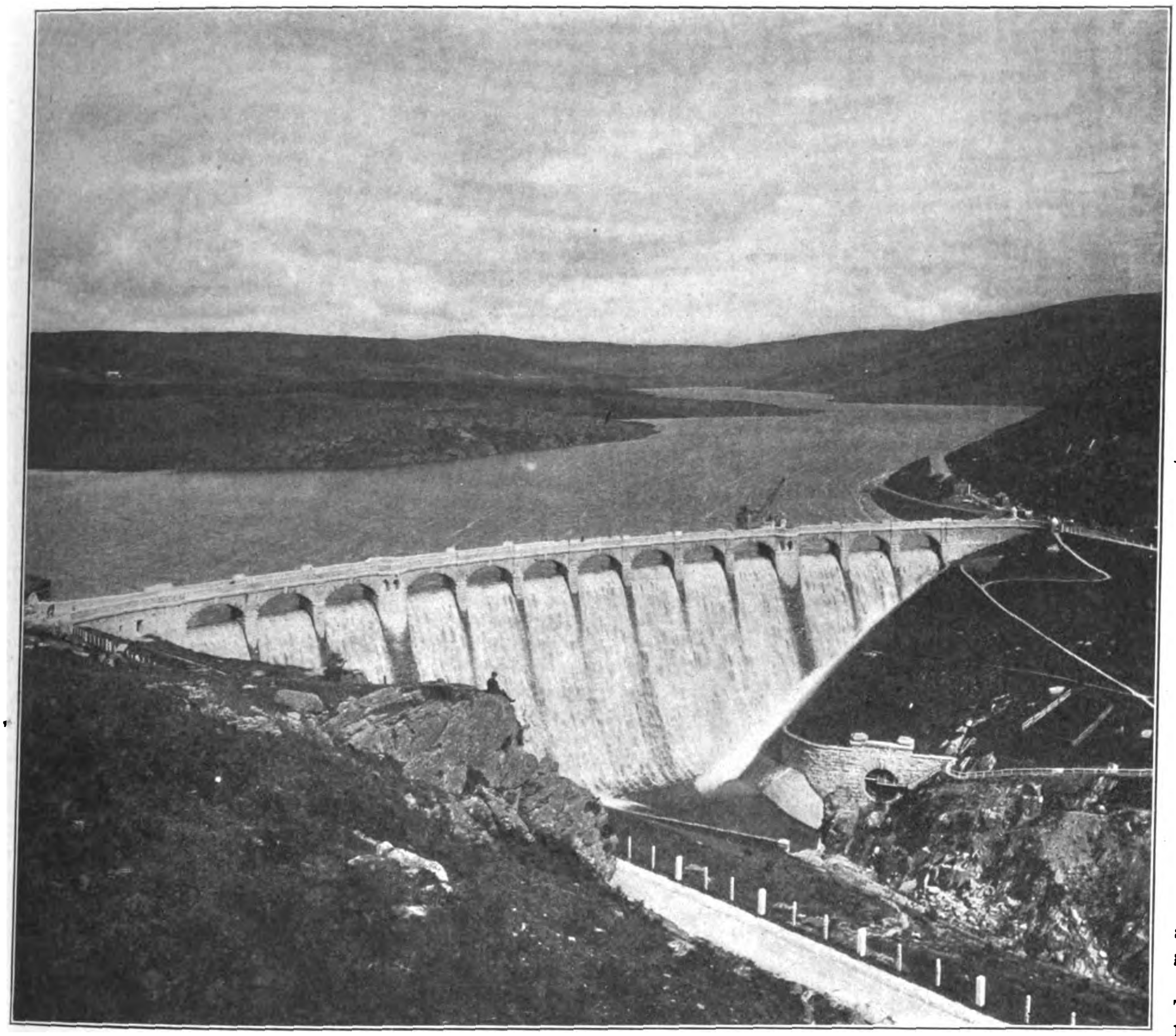
The trusses are 22 feet 2 inches apart and 38½ feet deep on centers. They are divided into seven equal panels and carry plate girder floor-beams resting across the top chords and riveted to them at panel points and sub-panel points. They are of ordinary construction with standard top chords made with a 24-inch cover plate, two 4x4-inch top flange angles, two 4x6-inch bottom flange angles and two 20-inch and two 10-inch web plates. The top chord section has a maximum area of about 68 square inches and is made in two panel lengths about 60½ feet long spliced on the sides of the panel points away from the center. The bottom chord is made of 8-inch eye-bars and has a maximum cross-section of 66 square inches. The main diagonals are made with 6-inch eye-bars, and the sub-diagonals are each one pair of 5x1-inch eye-bars.

The main vertical posts are made with built channels latticed on both flanges and the sub-vertical posts are made with 12-inch channels latticed. The end panels of the bottom chord are made with pairs of 15-inch channels latticed. The top chord pins are 5½ inches in diameter, except those at the ends, which are 7 inches. The bottom chord pins are 7½ inches in diameter at the ends and 6 inches elsewhere. The diagonal main ties are made in two lengths for each panel and connected by 5½-inch pins. The main vertical posts are connected by transverse struts at the top and bottom; the former are each made with a pair of 4x6-inch angles and the latter with two pairs of 4x3-inch angles. Between them the transverse panel is sway-braced by single 4x4-inch angles.

The sub-vertical posts are similarly braced, except that the lower strut consists of a pair of 6x4-inch angles and the sway brace diagonals are single 3x3-inch angles. From the middle of the lower strut a single 3x3-inch vertical angle serves as a suspender to support the two bottom lateral diagonals at their intersection. The bottom laterals consist of single 4x4-inch angles throughout, riveted to horizontal plates which are connected to the lower ends of the vertical posts by pairs of flange angles riveted to the webs of the latter. The end posts of the trusses are braced with an intermediate horizontal strut and two panels of sway bracing, having two angles in each diagonal.

All main truss members are pin-connected except that the upper ends of the vertical and sub-vertical posts are field-riveted to jaw plates which are shop-riveted to the webs of the top chords and project below their lower flanges. The floor-beams are plate girders 41 inches deep made with single web plates and with pairs of 6x6-inch angles and single 13-inch cover plates for each flange. The floor-beams rest across the top chords of the trusses and have wide horizontal plates riveted across the ends of their lower flanges, which serve as additional connections to the top chords and to receive the field rivets through the top laterals consisting of single 4x4-inch X-brace angles in each panel. The floor-beams have standard web connections to the 27-inch stringers and the latter have their bottom flanges field-riveted to the diagonal angles. The four spans are alike.

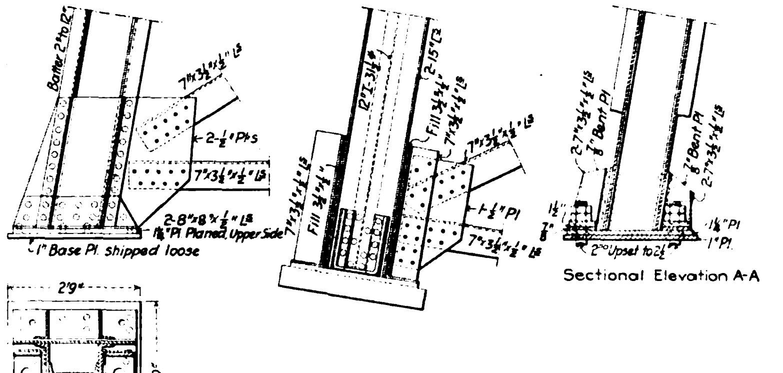
These spans are supported, as shown in the general diagram, on wedge-shape towers each having four steel posts. The tower posts are battered 1:4 in the longitudinal planes of the viaduct posts, which are battered 1:6 transversely. The towers which support only one span have the center lines of their posts intersecting on the end lower chord pin. Those which support two spans are truncated pyramids with the center lines intersecting the lower chord level 3 feet apart. It was considered that the use of these A towers was very satisfactory in reducing the uplift, for which special provision would otherwise have been required. If towers had been used similar to those for the plate girder spans, there would have been considerable longitudinal thrust due to trains on the 220-foot span with only the dead load of the tower to resist the uplift. With the arrangement designed, whenever the maximum longitudinal thrust occurs there is also a live load to help resist it so that in no case will the ordinary formulas for longitudinal



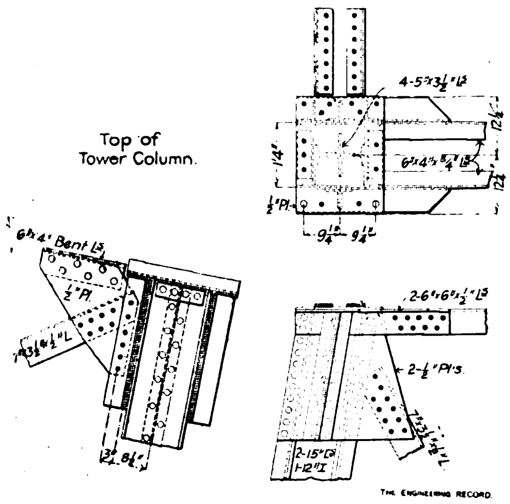
Craig Goch Dam, and Reservoir, Radnorshire, Wales.

thrust and wind pressure show any uplift on the masonry.

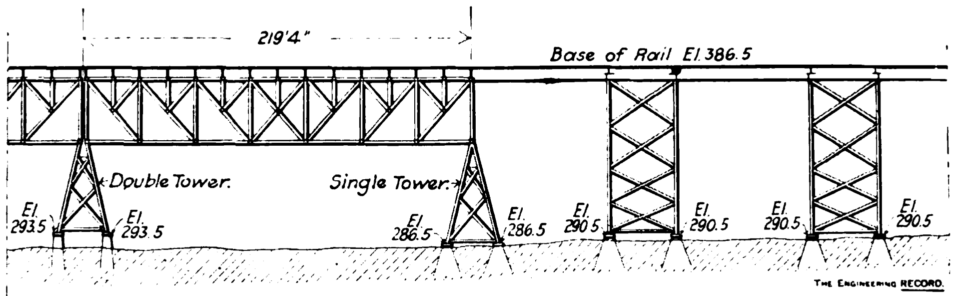
The top of each of the three intermediate towers supporting the truss-spans received the fixed and expansion ends of the 219-foot trusses, all of which were arranged to expand toward the center tower. The vertical end posts of these trusses had their bottom pins fixed in the tops of the towers so that the posts acted as rocker-bents, allowing the top pin to move back and forth longitudinally on the arc of a 38-foot



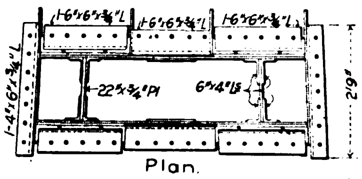
Base of Columns in Approach Towers



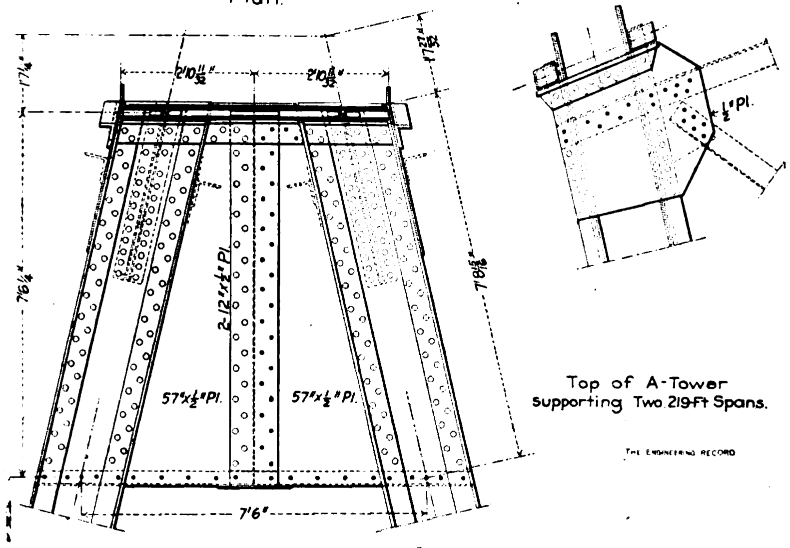
Top of Tower Column.



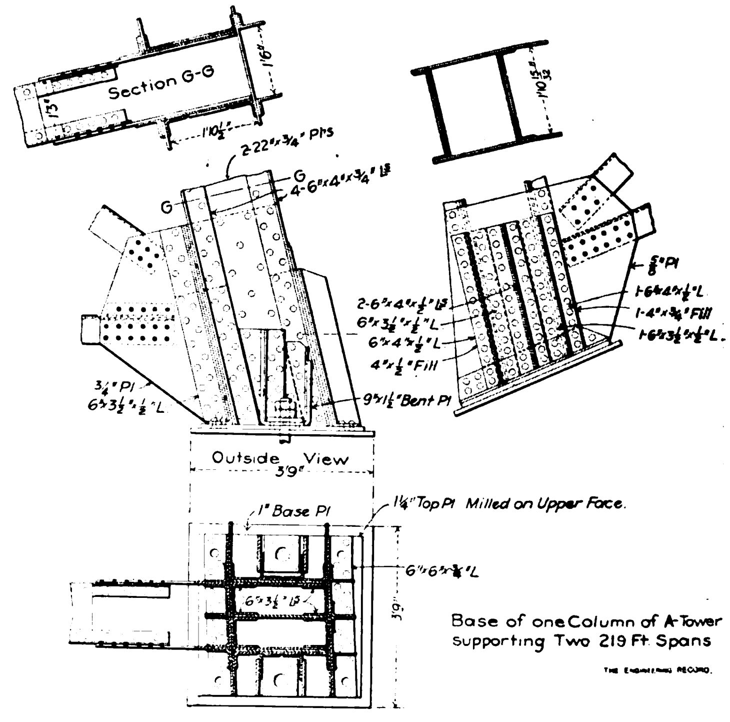
Elevation of One Main Span and Adjacent Approach Spans.



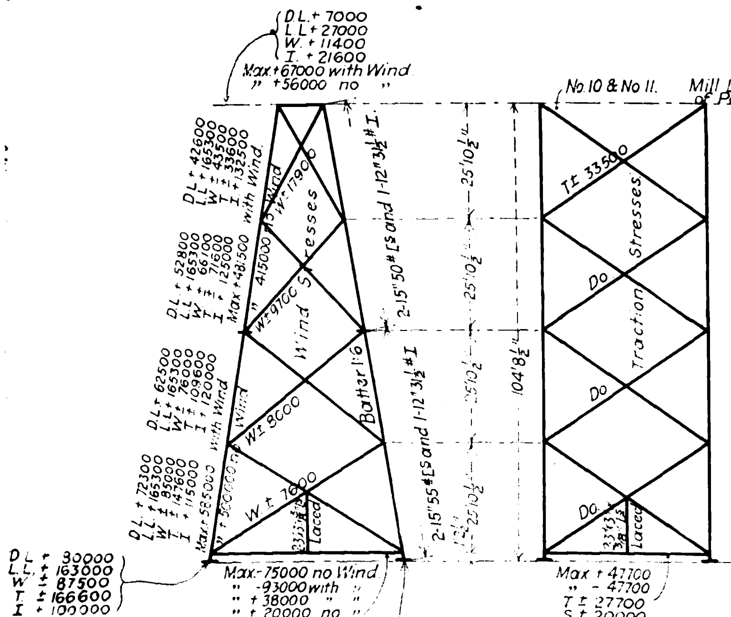
Plan.



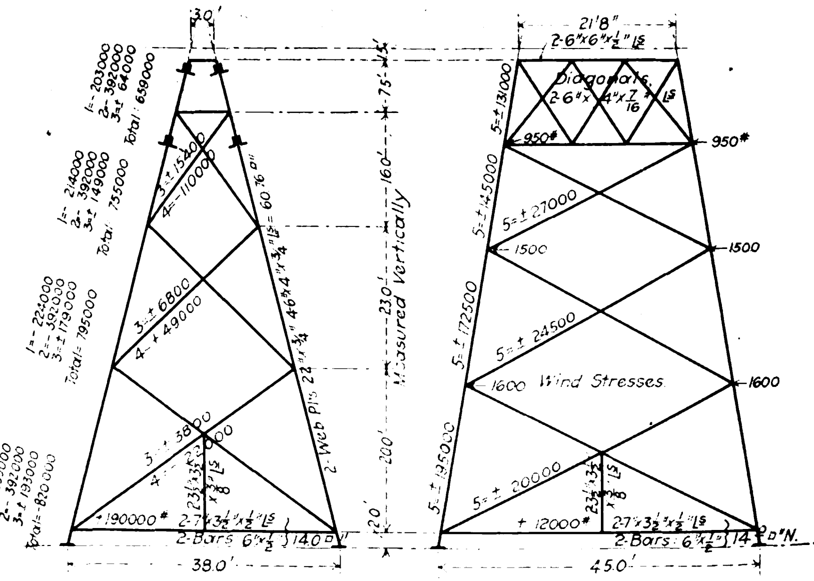
Top of A-Tower Supporting Two 219-Ft. Spans.



Base of one Column of A-Tower Supporting Two 219 Ft. Spans



Approach Tower.



Longitudinal Elevation. Transverse Elevation

Tower 28-29.

All Longitudinal and Transverse Braces, 2-7"×3½"×½" Ls Latticed

Double Tower carrying Main Spans.

THE DES MOINES RIVER VIADUCT: SOME STRESS DIAGRAMS AND STRUCTURAL DETAILS.

circle. The expansion in the lower chord was provided for by slotting the end strut to receive the end lower chord pin. The bottom laterals were attached directly to these struts and thus the stresses were transmitted continuously to the piers.

The three intermediate towers were essentially alike except in height and the two end towers differ from them chiefly in the weights of the cross-sections and in the connections at the top to support one truss instead of two. The principal materials and stresses for one of the intermediate towers is shown in the diagram marked "28-29," in which stresses marked "1" are dead load, "2" live load and impact, "3" traction force, "4" live load and impact when only one span is loaded, "5" wind. The tower stresses given do not include the wind stresses. The pressure on the pier under a light train and wind load is 34,000 pounds downward and under a full train and wind load is 73,000 pounds downward.

All longitudinal and transverse bracing not otherwise marked consists of pairs of 7x3½x ½-inch angles latticed. The tops of the column webs are united by longitudinal plates 7 feet deep, as shown in the detail, and these webs are stiffened by two transverse diaphragms on the center lines of the columns. Each plate is made in two pieces spliced by a pair of cover plates on the center line of the tower shop-riveted to one part so as to make jaws engaging the other plate and field-riveted to it. These plates and the sides of the columns have horizontal angles riveted through them at the top to form seats for the pedestals carrying the end lower chord pins of the trusses. The caps of the end towers differ from the intermediate ones, as shown in the detail, having their adjacent column flanges mitered and field-riveted through the bent angles and having only one stiffening diaphragm, which is vertical and in the center of the combined section.

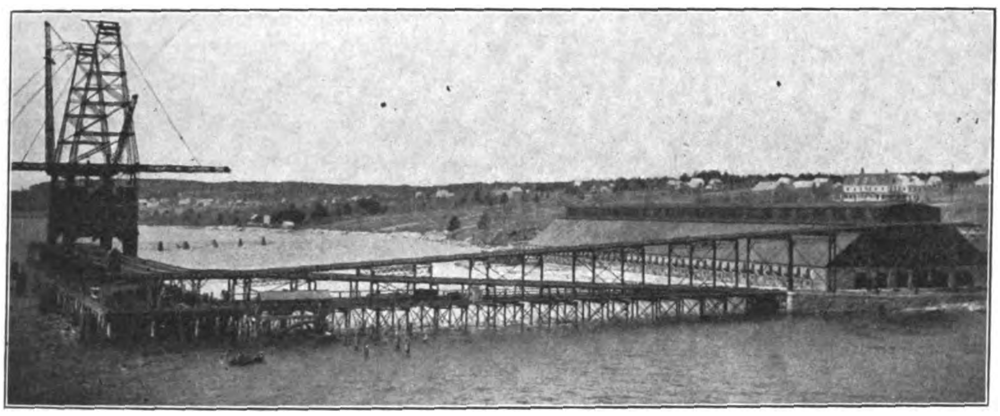
The bases of the columns in all the towers were substantially alike and were made, as shown, with vertical reinforcement angles and projecting gusset plates for the longitudinal and transverse struts and braces. The lower part of each column is made with ten pairs of flange angles and two single angles arranged so as to practically splice the connection plates to the column and make them continuous with the cover and web plates. The viaduct towers are each made with two vertical transverse bents 38 feet apart on centers with their columns battered in the transverse plane and parallel in the inclined longitudinal plane. The columns are X-braced in from one to four panels, according to height, in the longitudinal plane. In the transverse planes they are X-braced in corresponding panels and have no horizontal struts, except at the top and bottom of the transverse bent and at the bottom of the longitudinal bent. The stresses and dimensions of one of the tallest towers is shown in the diagram, where DL indicates dead load stress, LL live load stress, W wind stress, T traction stress and I impact stress.

The towers are substantially alike except for the varying dimensions, and all bracing is field-riveted, as indicated in the accompanying details of the caps and bases of one of the column posts. Each post is made of an I-beam and two channels without cover plates or latticing and the anchor bolts take bearing on U-bars riveted between vertical angles on the webs of the post channels. The base plates are extended to nearly 3 feet square and stiffened by vertical reinforcement angles with bearing on the horizontal flange connection angles. The cap plates extend longitudinally over the flange connection angles, which are reinforced by bearing on the ends of vertical angles. The main viaduct girders are seated on the column caps, to which they are field-riveted, as indicated by the open holes in the plan of the cap.

(To be continued.)

Frenchman's Bay Coaling Plant.

The United States naval coal depot at Frenchman's Bay, Maine, is favorably located on a flat sandy beach with a regular slope to water of 32 feet depth at a distance of about 300 feet from the shore line, where it rapidly deepens and affords excellent opportunity for the approach and sheltered mooring of the largest battleships. The plant consists of a steel pier and a steel and masonry storage shed, with tracks and conveying and handling apparatus, having a capacity for the storage and rapid delivery of 10,000 tons of bituminous coal. The design and conditions are such that this capacity can be greatly increased by extensions to the coal shed without enlarging or changing the pier or the loading and conveying apparatus. Two duplicate traveling unloading towers are provided, and there are four main lines of tracks extending through from the end of the pier to the rear of the coal shed, besides several loops and branches increasing the capacity at both ends. The plant has an independent installation of steam power to operate the machinery and is also designed to receive auxiliary power from the battleships in case of emergency.



General View of the Frenchman's Bay Naval Coaling Station.

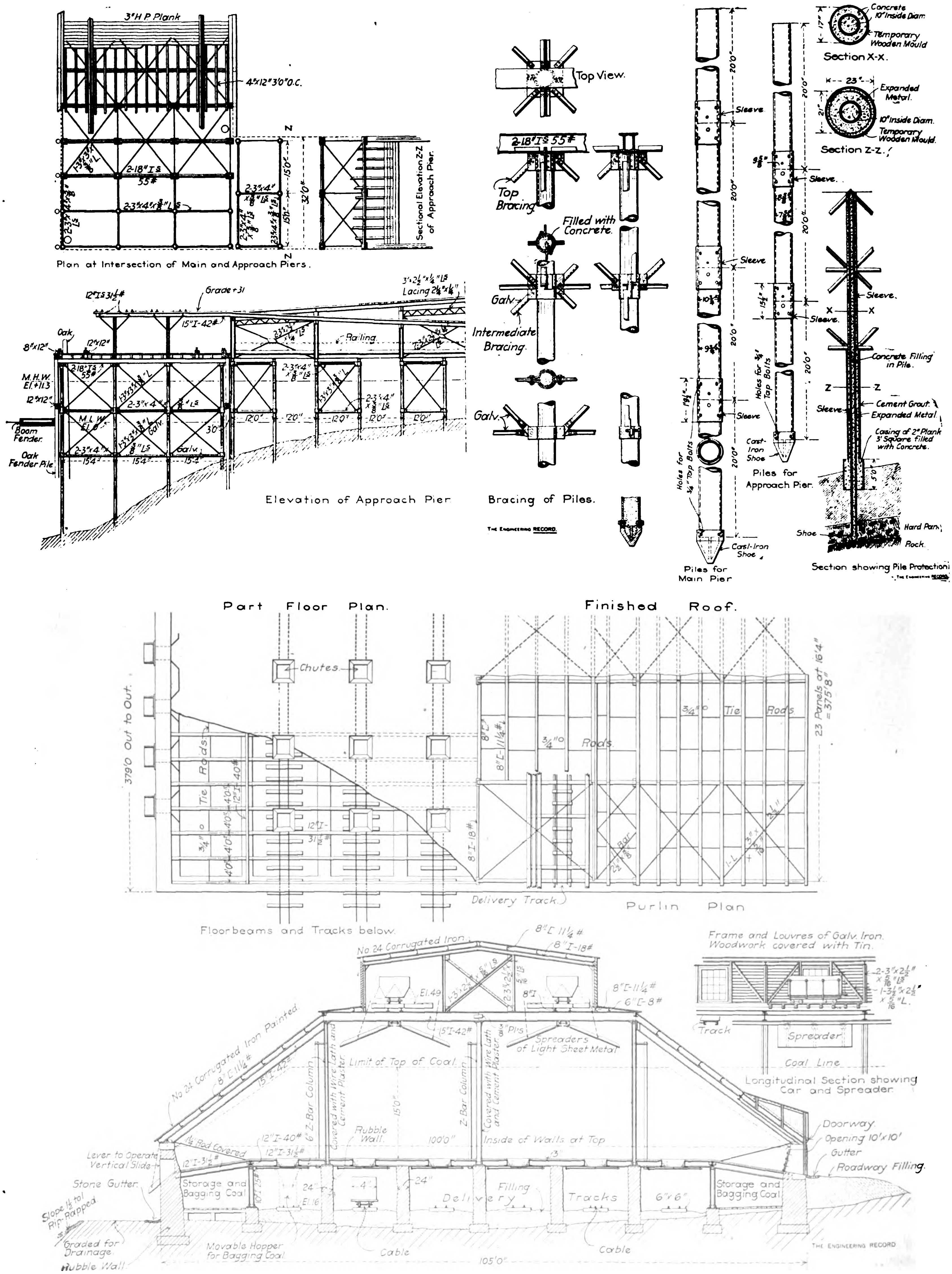
The 380x105-foot steel storage shed, about 90 feet in extreme height, is situated at the water's edge approximately parallel with the shore line. From one end of it an approach pier 32 feet wide and about 300 feet long extends at right angles to it and to the main pier, 48 feet wide and 400 feet long, connecting them and forming the third side of a rectangular construction which encloses a 300x400-foot open slip giving sheltered access for vessels on the shore side of the main pier, where the water is about 30 feet deep at low tide. On the opposite side of the main pier the water is much deeper and vessels can be moored there to receive and discharge coal. The deck of the main pier is 19 feet above mean low tide, and on it there extends from end to end a track of 32 foot gauge with two steel unloading towers 130 feet high and 34 feet long. Each tower has horizontal booms, 54 feet above the deck, which extend 75 and 35 feet beyond the outer and inner faces of the pier respectively and carry the coal buckets traveling from end to end.

The tower has between its columns a clearance 30 feet wide and 21 feet high, in which four narrow-gauge coal tracks are carried on bents elevated about 10 feet above the level of the deck. These tracks connect with those on the approach pier at right angles to the main pier. Two of the latter are incoming tracks graded up to the top of the storage sheds for delivery of coal from the ships to the bins, and the other two are outgoing tracks graded down to the surface of the ground at the shore, for delivering coal from the bins to the ships. The tracks run from the extremity of the main pier through the storage shed, at both ends of which they are connected, by loops and switches, with four other lines of tracks, which make eight in all, and serve the whole area of the shed. The cars are operated by cables driven from the power plant on the pier, and the tracks are arranged on grades so that the loaded cars are pulled up and the empty ones returned by gravity, both for delivering coal from the ships to the shed or vice versa.

The tracks are level, except on the approach pier between the main pier and the storage shed, and the four main tracks are arranged in pairs connected at both ends by loops, so that the cars have a continuous movement around the circuit, always in the same direction, on the same track. At the entrance to the main pier, and at the entrance to the storage shed, switches are provided connecting the incoming and outgoing tracks in the former case, and loops and spur lines in the latter case, so that cars may be diverted from one service to the other, or may be returned to their tracks without passing over the several loops in the continuous line of the lower grade tracks, in the latter case. The spur tracks in the lower part of the storage shed are graded to return the unloaded cars by gravity. There are, of course, separate cable systems for the incoming and outgoing cars. The ropes are driven at a speed of about 200 feet per minute.

The capacity of the conveying system is limited by that of the unloading buckets in the towers. Each tower can operate a one-ton bucket simultaneously on each arm and can unload about 150 tons of coal an hour, thus giving the whole plant a capacity of 3,000 tons in ten hours, which is as great as can be secured without materially increasing the length of the main pier and adding more towers, so as to allow more than one boat to be unloaded on each side at the same time. The capacity for coaling ships from the stock in the shed is considerably greater, and is estimated at a maximum of 50 tons an hour for each hatch in operation. The coal is discharged by automatic dump-cars through chutes inclined downwards from the outside elevated tracks on the main pier to the hatches on the decks of the vessels alongside, so that the speed is only limited by the number of cars in service and the rapidity with which they can be filled through the chutes in the storage shed and dumped in the vessel.

The deck of the main pier is continued at the same level through the approach pier and below both of the inclined service tracks. It is accessible by an inclined approach from the



FRENCHMAN'S BAY COALING STATION: DETAILS OF THE FRAMING AND THE CONCRETE-STEEL PILES.

court No. 1 and later transferred to court No. 2. In its first position it delivered concrete for filters Nos. 1 to 11 and Nos. 12 to 33, and in the second position it supplied the remaining filters.

On both gravity and cable roads the cars run beneath the mixers, and after receiving their loads of concrete carry them to the towers of the proper cableway. At first one cableway was set up to span the filters between Pennypack Street and court No. 1, while the second spanned the filters between courts Nos. 1 and 2. Later both were set to serve this second bank of filters, as shown on the general plan, their span being 750 feet. Afterwards they were set to span the filters between courts Nos. 2 and 3, and in this position will complete the filters now under construction during the coming summer. The third cableway, of 800 feet span, serves the filtered-water basin. The method of operation has been the same in all cases. The buckets of concrete are lifted from the cars by the cableway hoist, transferred to the place where the concrete is being deposited on the bottom or in the forms and dumped. The cableways handle on the average about 200 bucketfuls each per day, and it requires about two minutes to lift a bucket from the car, carry it to place, dump it and return. The maximum record for one cableway was 330 batches, equivalent to 495 cubic yards, deposited in roof and floor in one working day. The floors have been laid in blocks, each block being one-half of the square whose corners are at the centers of four columns. Such a block contains 3 cubic yards, or 2 bucketfuls, of concrete, and is deposited and rammed in layers. About thirty men have placed and finished 300 cubic yards of floor in a day at a cost of about 45 cents per cubic yard after the delivery of the concrete by the cableway. For rapidly spreading the large batches of concrete immediately after they were dumped from the cableway buckets on to the roof forms, long-handled four-tined hooks or rakes were found useful. The method of using these tools is shown in one of the illustrations. The spreading with them was supplemented by the use of shovel and by ramming.

Each day a 6-inch test cube has been made from concrete taken from one of the batches, these samples being taken from different places on succeeding days so as to represent the concrete in all parts of the works. Proper records are made of the date and location of the concrete represented by each cube. These cubes are broken at the end of 30, 90 and 180 days and 1 year. The 180-day cubes have shown an average crushing strength of about 1,500 pounds per square inch, frequently running as high as 2,500 pounds and seldom or never below 1,200. As is not surprising on such extensive works, at a few places the concrete has been found unsatisfactory on the removal of the forms and has required correction. The great bulk of the concrete in the completed filters and the portion of the filtered-water basin which has been built is of excellent quality and presents very smooth surfaces free from voids or protruding stones. Time and trouble were saved and smoothness gained in the roof groins by tacking strips, a few inches wide, of heavy sheathing paper over the groin joints of the forms after the various sections of forms for a given portion of a roof had been set. This remedy was used, however, only on joints which failed to match within ¼ inch; these cases, which were not numerous considering the total number, occurred generally with forms which had been used more than once; large cracks in forms were closed by strips of wood.

Some cracks have occurred in the concrete walls, usually at intervals of about 50 feet. Many of these are only fine cracks requiring but little more than a brushing of grout to close them; the comparatively few larger cracks have been cut out and calked. A number of the completed filter basins have been tested for leakage and have given remarkably good results, as is shown by the following examples:

No. of filter.	Date started.	Date last report.	No. of days.	Final 24-hour leakage. Gallons.	Date accepted.
1	5-21-03	6-8-03	18	244	6-9-03
2	8-10-03	8-26-03	16	244	8-26-03
3	9-4-03	9-23-03	19	0	9-24-03
4	9-29-03	10-24-03	25	0	11-13-03
5	11-1-03	11-24-03	23	488	11-27-03
8	10-31-03	1-12-04	57*	732	1-14-04
9	10-3-03	10-24-03	21	0	11-13-03
11	10-29-03	11-24-03	26	244	11-27-03
29	12-19-03	1-12-04	24	732	1-14-04

*Water drawn off to repair filter 16 days.

Filter Sand and Gravel.—The filter sand and the gravel for covering the underdrains will be of the same kinds and sizes as those used in the other works and previously described. The main collectors will be like those at Belmont, for which drawings were given in a preceding article. The appearance of the gravel, as placed over the underdrains ready to receive the sand, is very clearly shown in an accompanying interior view of a finished filter at Upper Roxborough. For the fifty-five filters now under construction, 99,000 linear feet of 8-inch perforated terra cotta collectors, 62,600 cubic yards of gravel of all sizes and 198,900 cubic yards of sand will be required, and will be introduced through the sand runs and the ventilator openings. The traveling cableways will probably be used to some extent to assist in distributing these materials. The total cost of the sand, gravel and collectors in place will be, in round numbers, $1,027,000. The delivering and placing is expected to begin about May 1, and will be finished about January 1, 1905.

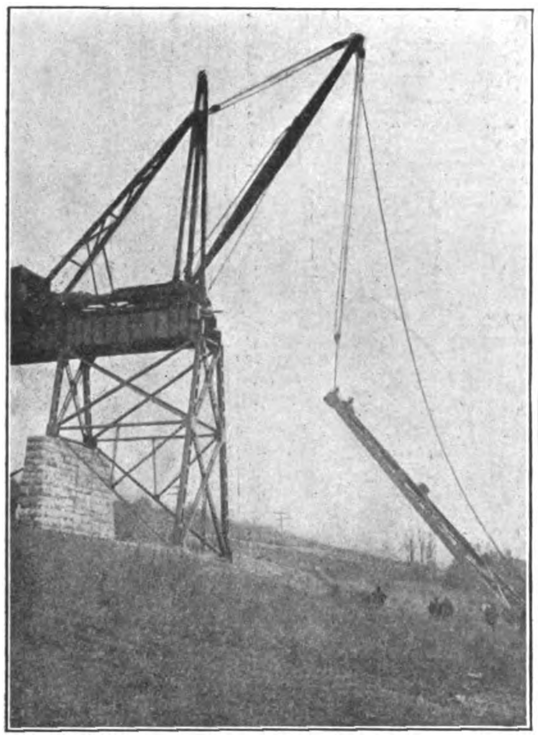
Mr. John W. Hill is chief engineer of the Bureau of Filtration, and the plant at Torresdale, like the others, is being constructed under his general supervision; Mr. Frederick C. Dunlap is resident engineer.

(To be continued.)

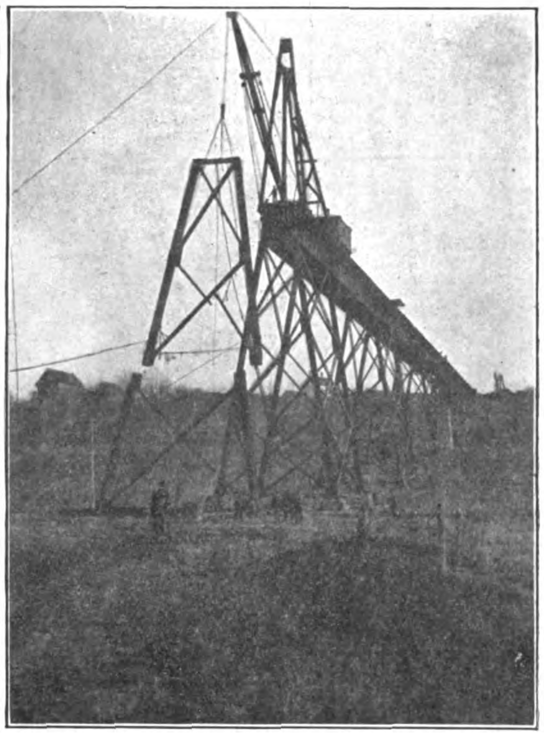
The Des Moines River Viaduct of the Chicago Great Western Railway.

PART II.—PLATE-GIRDER SPANS AND ERECTION.

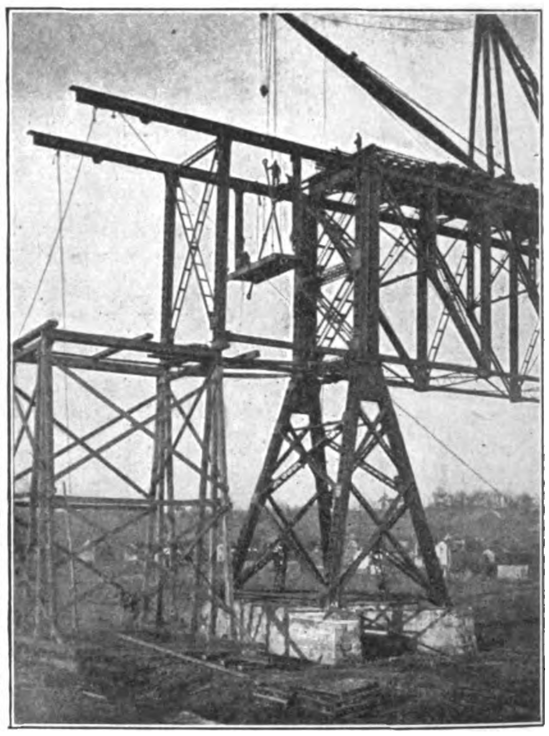
There are two lines of main girders 10 feet apart on centers which are braced together by ordinary sway-brace frames and top and bottom zigzag angles riveted to connection plates on the girder flanges. They have a uniform depth of 7 feet from back to back of flange angles. The regular girders on top of the towers are 39 feet 3 inches long from out to out and 38 feet long on centers of bearings. They are made with two ⅜-inch web plates spliced with two cover plates and four vertical rows of rivets. Each flange has two 6x6x9/16-inch angles and the web projects ¾ inch above the top flange angles to lock the ties in position. Panels from 2 feet 6 inches wide at the ends to 3 feet 8 inches wide in the center are made by pairs of 3x5x⅜-inch vertical stiffener angles riveted to the opposite sides of the web, with filler plates at sway brace points only, and fitted ends. These girders extend across the full width of the tower caps and their end panels are notched from the top flange to the center line to form seats 16 inches long to receive the ends of the connecting span girders which have the lower sides notched to correspond. The lower halves of the end panels of



Erecting a Complete Tower Bent.



Erecting Upper Section of a Tower Bent.



Erecting a Deck Span.

the webs are reinforced to a thickness of 1½ inches and have ten vertical stiffener angles riveted to them to form a sort of pedestal on the center line of the tower column for the seat of the supported girder.

The regular connecting girders are 76 feet 3 inches long over all, 75 feet long on centers of bearings and 73 feet 7 inches long on the lower flange. They are made like the 38-foot girders, except for the dimensions of the materials. The web is made in three lengths and both top and bottom flanges are reinforced by three cover plates of different lengths. The ends are notched on the lower side to correspond with and be the reverse of those in the 38-foot girders and are similarly reinforced, except that the outside web plates extend the full depth of the girder. The drop ends are seated, as indicated in the view at the top of the tower post, on the ends of the 38-foot girders, and the top flanges of both girders are connected by cover plates, which are generally field-riveted to the long girders and bolted through slotted holes to the short girders at expansion joints and riveted to them at fixed joints. At their bearings the girders are bolted together with four bolts which, at the expansion joints, engage slotted holes in the lower flanges of the long girders. This arrangement permits the 75-foot girders to expand and contract freely with temperature changes, the tower girders being riveted fast to the towers at both ends.

At the towers nearest the truss spans the 75-foot girders have expansion joints at the tower girders at both ends. In all other cases the 75-foot girders have expansion joints at one end of the tower girders and fixed joints at the other ends. At the east end of the viaduct the girders connecting the tower to the abutment are 38 feet 9½ inches long over all and resemble the 75-foot girders, except that the ends are not notched at the abutments, but are full depth there and are seated on special cast-steel pedestals with transverse ribs engaging holes mortised in their base plates.

At the west end of the viaduct the abutment girders are similar to those at the east end, except that they are 75 feet 9½ inches long over all. In both cases they are anchor-bolted through the pedestals to the abutment masonry and have expansion joints on the tower girders. The girders at both ends of the truss spans are also special and are like the regular 75-foot girders at the ends away from the spans. At the ends adjacent to the spans they are made full length and are seated on cross girders connected to the end posts of the trusses. At this point the end sway brace frame consists of three horizontal struts and two panels of X-bracing. Near the center line of the girder there are horizontal angles riveted to the outsides of the web about 6 feet from the ends of the girders, which diverge to connect with the top chords of the trusses, which are spaced about twice as far apart as the girders are.

The adjacent ends of the trusses and girders both have fixed connections to the tower and the arrangement of braces makes the lateral system continuous between the viaduct and the span. The braces are pairs of 6x6x7/16-inch angles and are calculated for a tensile or compressive stress of 66,500 pounds. At the river ends they are connected directly to the top lateral system of the spans and at the shore ends they distribute their stresses to both top and bottom lateral systems of the viaduct through the intermediate cross struts made of two 6x6x⅜-inch angles which connect the webs of the girders at their extremities.

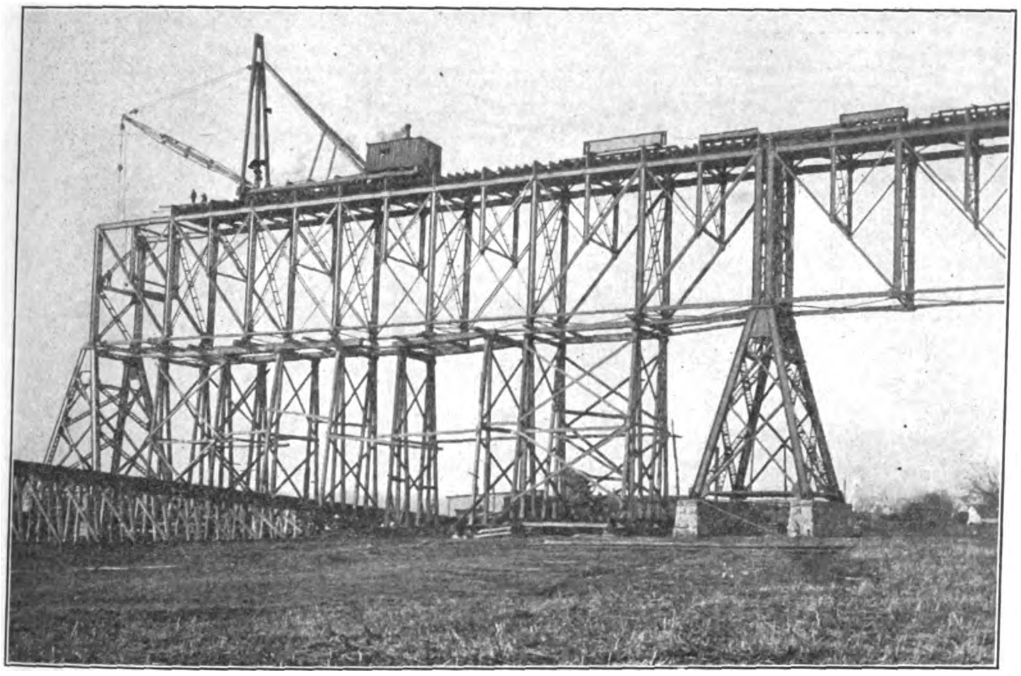
Five hand-car retreats 12 feet long and about 9 feet wide outside of the track were placed at intervals of about 500 feet and were supported on angle-iron brackets riveted to the girders opposite the sway frames, and on the trusses they were supported directly by the floor-beams. All of them were covered by a solid plank floor and protected by a hand rail which extended the full length of the viaduct, offsetting at the hand-car retreats.

All steel was delivered at the east end of the viaduct and stored outside of and between the tracks, where it was handled by a derrick car on a standard-gauge track, which served as a tender and delivered it from the storage yards to the traveler. The traveler was essentially a large derrick car with a long timber platform mounted on ten wheels running on a track of 10-foot gauge. At the rear of the platform the hoisting engine, boiler and coal and water supplies were located in a small house and at the front of the platform there was a three-post vertical bent about 45 feet high like a shear frame. The vertical middle post of this bent served as a mast and terminated about 10 feet from the top of the two battered side posts. At the foot of it was pivoted a 64-foot trussed boom with three spreaders and a 4x12-inch Douglass fir truss plank on each of the four sides. The boom had a capacity of 52,000 pounds at full radius. It was rigged with eight-part wire rope hoisting and topping-lift tackles, and the latter was connected to the top of the mast, where it was braced by a pair of stiff-legs which spread out to the full width of the derrick platform near the rear end. For light work the rope was reeved through only four or six sheaves. A horizontal beam about 6 feet long was attached to the boom about 15 feet from its point and to its extremities four-part Manila rope tackles were attached which were also secured to the ends of the transverse sill at the forward end of the derrick platform. These tackles were operated by the hoisting engine to swing the boom about 20 feet from the center laterally and enable it to set the tower columns and the members of the trusses.

Material was delivered from the storage yards by the derrick car on a standard-gauge track concentric with the 10-foot track of the traveler. As near as possible to the required place it was unloaded on the ground or on the ends of the truss-span floor-beams outside the rails of the 10-foot track. After the derrick car had been removed, the traveler lifted the material and carried it to place.

The first tower bent of the viaduct was assembled on shore, lowered to position by the traveler and guyed until the girders of the first span were connected to it and the floor was built. The traveler then moved out of this span and erected the second bent and its girders and so on until the truss spans were reached. When the tower posts were in single lengths, the transverse bents were assembled together horizontally on the ground and revolved up into position on their pedestals by the traveler boom, the lifting tackle being attached to a bridle connected to the tops of both posts. The first bent of each tower was a little beyond the reach of the boom so that when it was revolved nearly into position, it was necessary to pull it forward to a vertical plane by hand guys assisted by runners from the hoisting engine on the traveler. When the tower posts were spliced in the field, the lower sections of the first bent were assembled and set on the masonry, as above described, and guyed with the tops inclined a little backwards towards the traveler. The top sections were then assembled and connected to them and the floor erected before the second bent was raised. When this bent had spliced posts, the lower sections were erected separately and braced together and afterwards the upper section of the bent was assembled horizontally on the ground fully bolted, except for the lower diagonal braces, and lifted by the derrick and set in position, it being possible to spring the posts sufficiently to make the splice connections. The ends of the girders adjacent to the first truss span were temporarily supported on falsework bents, while the traveler moved out on them and erected the A-towers which carried the ends of the truss spans. The traveler then erected and braced two bents of falsework on which the end panels of the trusses were assembled.

In order to erect the second sections of the top chord readily (the splice being just a little toward the end from the second full panel point), a temporary bent was added upon the falsework to support the top chord and allow the floor-beams and stringers to be put in up to the middle of the second panel, when a third bent of falsework was put out and the second section of the chord and the third vertical were bolted together and raised, coupled to that which had been previously put up, and braced; and so on, completing to the third panel. In this way each truss was erected until the last full panel point was reached, when the next tower was raised and braced before the last panel of the truss was put in place. The same



Falsework and Trestles for Erecting a Deck Span of the Des Moines River Viaduct.

falsework was used for all the truss spans, each bent as wanted being taken from its position under the completed span, raised at the side of the truss (guys being carried out on the opposite side from the point of the boom to prevent overturning) and carried forward above the deck and launched into its new place.

The study of the site was commenced in July, 1901. Sub-structure work was commenced in October, 1901, and finished in June, 1902, and included the building of about 3,900 yards of stone masonry and about 9,300 yards of concrete. The superstructure weighed about 3,350 tons and its erection was commenced October 8, 1902, and finished March 10, 1903. The 220-foot spans weighed about 341 tons each, and the heaviest pieces in the viaduct were the 75-foot girders which weighed 36,000 pounds each.

It is an unusual fact, and extremely creditable to the supervision of the work, that from beginning to end of its construction, a period of about seventeen months, while there were from 50 to 200 men constantly employed, working in dangerous positions and handling heavy materials in inclement weather, that no serious accidents of any nature occurred, the most important one being the loss of a finger. The difficulties encountered in the exposed situation are indicated by the fact that when the viaduct was painted, splashes of the black paint were carried by the wind along the track of the Minneapolis & St. Louis Railroad 300 feet away and 100 feet below.

Mr. H. C. Keith, bridge engineer of the Mason City & Ft. Dodge Railroad, was in direct supervision of the design and construction, and to him acknowledgment is made for data. The Bates & Rogers Construction Company, of Chicago, was the contractor for the substructure. The American Bridge Company was the contractor for the superstructure, and the 38-foot girders and towers were built at their Milwaukee plant, the 75-foot girders at the American shops, Chicago, and the truss spans and towers in the Detroit plant, except the eye-bars, which were made at the Pencoyd plant. The Kelly-Atkinson Construction Company was the sub-contractor for the erection of the steel-work.

Notes on Railway Construction from the Resident Engineer's Standpoint.

A paper read before the Iowa Engineering Society by F. C. French. Continued from page 134.

Masonry.—In staking out masonry, the stakes for the neat lines should be set far enough back from the work to permit of its being carried on without interference with the stakes and in such a position that lines stretched between tacks will intersect at the neat corners. The working plan furnished the contractor's foreman must show locations of all stakes. The slope stakes should be set at such points as will reasonably prevent caving during construction, and the cross-sections taken in squares over a larger area so that in case caving occurs a complete record of the surface is at hand. Stakes should not be set on these squares, but the slopes set independently.

All foundation courses must be spread well below the frost line, unless placed on solid rock, and in concrete foundations without grillage the excavation should be of dimensions equal to the footing course, while in stone masonry excavation should be made one foot larger each way than the dimensions of the footing course.

A complete record and sketches of all masonry must be kept, particularly of the foundations which will be covered up later on. The depth in every case must be given below some fixed point such as the coping or bridge seat. In all cases of uncertain foundations, special instructions will be issued by the chief engineer.

Culverts.—All culverts should be laid out at right angles to the center line when possible and have their foundations below the frost line and at sufficient depth and grade that the culvert will drain itself and, in general, the borrow bits adjacent. Every culvert must be placed so that it may safely work under a moderate head without injury to itself, and at as large a grade as the nature of the ground and its safety will admit. Both ends should be protected by a sunk wall extending at least three feet below the floor and the lower end must be protected by an apron or some arrangement to prevent undermining by the backwash.

Vitrified pipes, when used, must be at least 3 feet below sub-grade and crowned a few inches at the center. The bottom of the trench for pipe must be rounded and holes dug for the sockets. In case the foundation is poor, it must be excavated and suitable material placed. Stone must never be permitted in contact with the pipe. When filling over pipe use drag scrapers to build up walls parallel to pipe and as close as possible to each side, giving the space over the pipe a more moderate packing. This will imitate to a degree the usual practice of pipe laying in trenches. When two rows of pipe are used, they should be far enough apart to admit of thorough work between them.

Blind drains are sometimes made of rough stones thrown in without particular order and covered over with brush and sod. Their use is objectionable, however, and should be restricted to few cases.

Piling.—All pile bridges should be staked out ahead of the driver, setting a hub for the center of each bent and a stake for each pile, being careful to use the near face of the pile for the station, as centers can then be plumbed up from the hubs without the continual use of an instrument.

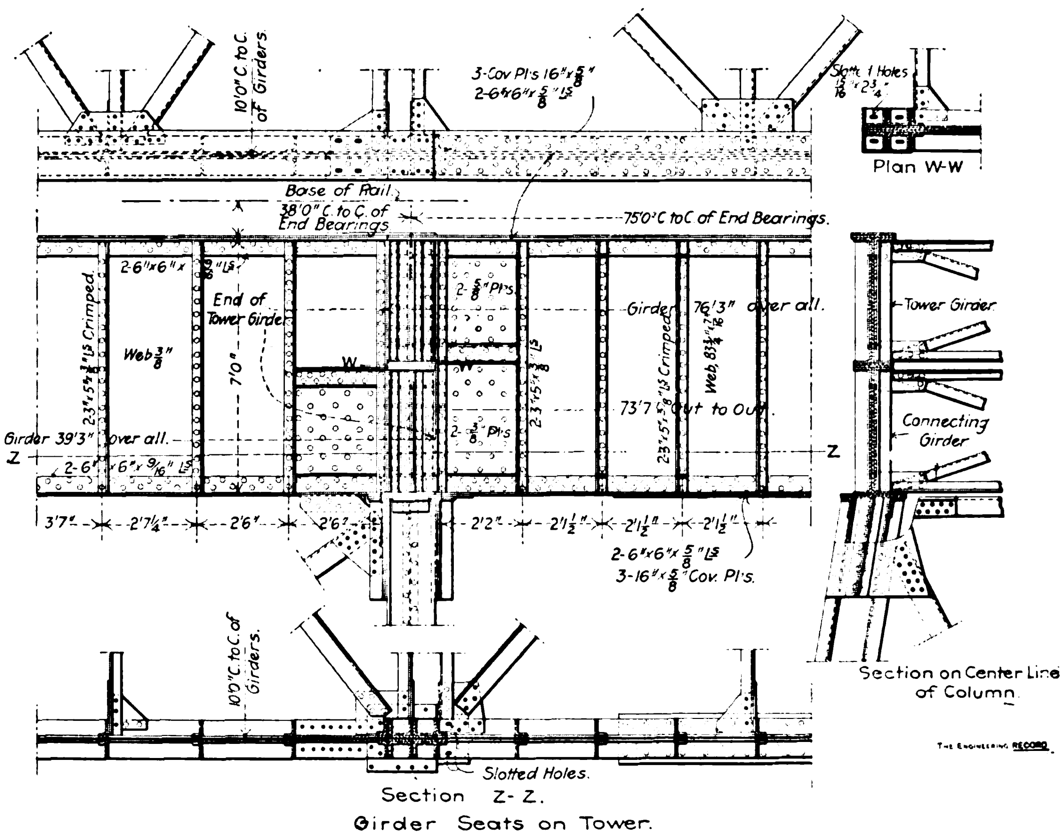
Pile inspectors should be appointed by the engineer, whose duties are to watch the driving of all piles and keep a record of each, seeing to it that every pile is driven deep enough to be secure against wash and scour as well as against sinking under the load. The inspector should be provided with a pile record book in which to keep a careful record of the bent number of each pile, and the pile letter, together with sketches of all pile foundations other than trestles, in order that the piles in the record may be identified. The bents are numbered consecutively, the bank bent being (1) and so on, and the piles in each bent lettered A, B, C, D, etc., from left to right when looking with the stationing. The pile record will then show on the left hand page: First, station; second, bent number and pile letter; third, length put in leads; fourth, kind of pile and whether treated or untreated; fifth, penetration below surface; sixth, length below cut off, to be filled in later; seventh, penetration under last five blows; eighth, weight of hammer and last drop in feet. On the right hand page all remarks on the progress and method of conducting work should be made.

The pile inspector will see that long piles are not used where shorter ones are ample, and that due precautions against brooming are used by having the heads well chamfered or pile rings used. In hard driving, piles should be shod. A good formula for safe load in pounds is $2\ WH \div (S + 1)$, where W is the weight of the hammer in pounds; H the fall in feet; S the set of the pile in inches under last blow.

When leaving a residency, the inspector will turn over the records to the resident engineer, who will hand them in with his final notes. Where piles are driven by the company, the company foreman will keep the records of the inspector.

Cut-Offs.—In setting cut-offs on curves drive a tack in the pile under the inside rail at some convenient whole number of feet below the cut-off, blazing the pile around tack and marking on it the number of feet up to the cut-off, the distance being recorded in the notes. The outside pile is treated in the same way, allowing for the elevation.

On tangents, drive a tack in the two outside piles in a similar manner and let the sawyers line up the remaining inside piles. In every case the distance from the cut-off to the top of the pile must be noted, as this with the pile record fixes the length of the pile in bents.



The Des Moines River Viaduct: Details of Girder Seats on Towers.