THE BOONE VIADUCT.

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The large double track steel viaduct just completed across the Des Moines river on the Chicago and North-Western Railway Company's new short line between Boone and Ogden, is not only the most important of the many improvements made by this company in transforming its roadway from Chicago to Council Bluffs from a single to a double track system, but will rank as one of the most important structures of its kind in the world. The building of this structure had been in contemplation ever since the road was first constructed across this part of the state; but it was only a few years ago, when the extension of double track drew near to this point, that its construction became an immediate necessity.

The structure may be briefly described as follows: Beginning at the east end we have two 75 ft. plate girder spans on a rocker bent; then six 45 ft. plate girder spans, alternating with six 75 ft. plate girder spans; then one 300 ft. pin connected truss span; then thirteen 75 ft. plate girder spans alternating with twelve 45 ft. plate girder spans; the total length out to out of steel work being 2,685 feet. The 45 ft. plate girder spans are carried on and form the tops of towers consisting of four columns each, rigidly braced together on all sides. The 75 ft. plate girders span the opening between consecutive towers. This form of tower and girder construction constitutes the type of structure known among engineers as the *viaduct*.

It may be stated in a general way that the viaduct is that form of bridge construction evolved in accordance with a minimum of limiting conditions. It is usually employed in building structures over deep and wide chasms where the question of waterway is only of secondary importance,—where the designer can place his piers wherever he wishes, make his spans of any length he desires, and where there are no limits imposed except those of safety and economy. The common practice in viaduct construction is to make the tower span about half the length of the open span,—30 and 60 feet respectively being very generally employed. One difficulty which designers have always met where the tower span is made half the length of the open span is in the question of depth of girder. The longer the span the deeper it must be made for economy. Therefore it is necessary to make a 60-foot span much deeper than one 30 feet in length. This usually involves objectionable details in connecting the two spans to the same column. It is, however, possible to vary the depth of a girder a half foot or even one foot from the theoretical economic depth with a very slight sacrifice of material; and by reason of this fact it was sought to overcome this objectionable feature by adopting the 45 and 75 ft. lengths. The girders were made uniformly seven feet deep, which is a medium between the economic depths of each.

Another reason for adopting the 45 ft. tower span was to give a sufficient spread at the base, so the effect of traction resulting from the sudden stopping of a train on the structure would produce no uplift at the foot of the columns. The columns batter laterally at the rate of two inches per foot, which makes the distance apart, in a line at right angles to the axis of the bridge, 70 ft. for the highest towers. This is sufficient to prevent any uplift from the effect of wind pressure on the sides.

The tower columns are made of three I-beams placed together in the form of the letter H. Two 20-inch beams form the sides, and one 15-inch beam makes the connection between the sides. The longitudinal and sway braces are all stiff members made of two 12-inch channels laced together. The system of bracing is that of the Warren Girder type, i. e., all braces are diagonal and intersect each other at the center.

There are no horizontal struts, except at the bottom of the tower, where all four columns are connected by 15-inch channel struts.

The span across the river channel is 300 feet long, 60 feet deep and divided into five sub-divided panels. It is carried on A-shaped towers at the ends, which are supported by steel cylinder piers ten feet in diameter. The truss span presents no unusual features except in the matter of providing for expansion and contraction. This is done by making the end posts at one end a rocker bent, and allowing the pins at the foot of these posts to slide in slotted pin holes of the bottom chord. The floor beams rest upon the top chord, and the stringers are placed on top of the floor beams. This was done in order to reduce the height of the towers supporting the span to a minimum.

Work in preparation for actual construction was begun in the spring of 1899. Three gasoline engine drilling machines were put to work drilling test holes for the purpose of determining the actual character of the underlying material upon which foundations would have to be built. All stratifications were carefully traced throughout the entire length of the bridge and for a considerable greater width than that to be occupied by the foundations. Great care was taken to determine accurately the amount and character of surface deposit; and especially to locate the "surface of erosion" between the surface deposit and stratified material beneath. This surface of erosion is a very important element; if inclined, a pier founded on the super-imposed surface material, might induce a slip or slide which would be disastrous.

The character of material encountered was that usually found in bituminous coal regions,—clay, shales of all colors, sandstone, fire-clay and coal. At the ends of the structure, the stratified material was overlaid to so great a depth with hard blue and yellow clay, that it was not deemed advisable to go such great depth for foundations. So for the abutments and piers supporting the low towers pits were dug in the clay to a depth of twelve or fourteen feet and beds of concrete from four to six feet in depth were deposited as a foundation for the stone work. The area of the concrete base was made such that the pressure per square foot would not exceed two tons. Farther down the hill where stratified material was nearer the surface, the excavations were carried down into the stratified material and foundations made usually on black shale, and never on fire clay or coal. The foundations were prepared in the same way as for clay,—three tons pressure per square foot being allowed. Near the river, where a large mass of sand overlaid the stratified material, and where the surface of erosion was approximately level, piles were driven, cut off at the water surface, and concrete deposited around and on top of them for the masonry foundation. Fifteen tons pressure per pile was allowed.

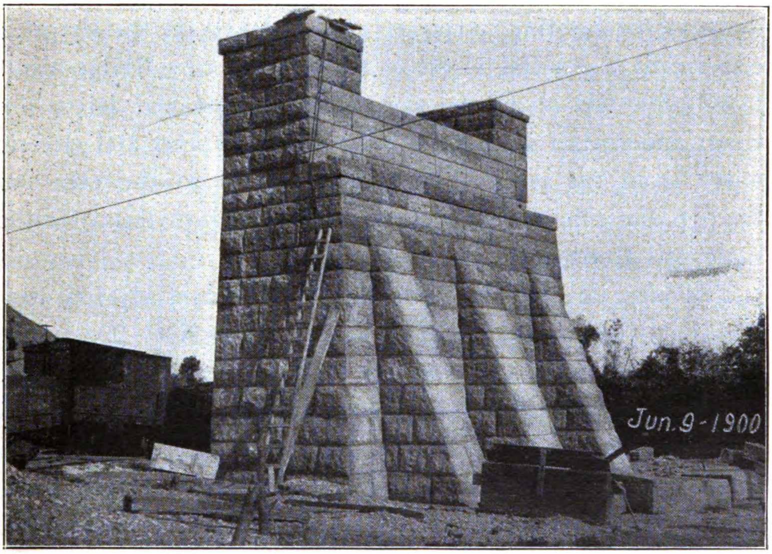

FIG. 1.

The abutments were rectangular blocks of masonry, fifty feet by thirty feet at the base, with reinforcing buttresses in front. The earth filling was carried round in front of them, so that when finished the only portion left in view was that from the coping of the bridge seat up. Fig. 1 shows a completed abutment before filled around with earth. The piers supporting viaduct towers are five feet square on top. They are built with a batter of two inches per foot, and the bases vary from twelve to twenty feet square, according to their height or the pressure they exert on the foundation material. The masonry was all of Mankato limestone laid in portland cement mortar. The pedestal blocks supporting the steel columns on top of the piers are of Ableman's sandstone.

The steel cylinder piers supporting the 300 foot span are eight in number,—four under each end of the span. They were sunk by the pneumatic process. A compressor plant consisting of two 60 horse-power boilers, two Ingersoll-Sergeant air compressors, the necessary pumps and an electric dynamo for lighting purposes, was installed on the shore as convenient as possible to the work. A temporary bridge about twenty-five feet above the water had been erected across the river, underneath the floor of which the air pipes and electric wires from the power plant were carried to the piers on the opposite side of the river, and over which material for the same was transported.

The piers are ten feet in diameter and consist of a steel shell five-eighths of an inch thick, made in sections five feet in height, which were added and rivetted as the piers were sunk. The bottom section was eight feet in height, with a steel diaphragm framed in one foot from the upper edge, which formed the roof of the working chamber below,—making the working chamber seven feet high. Fig. 2 shows one of these working chambers before it was placed in position. Through the center of the diaphragm is a hole three feet in diameter,

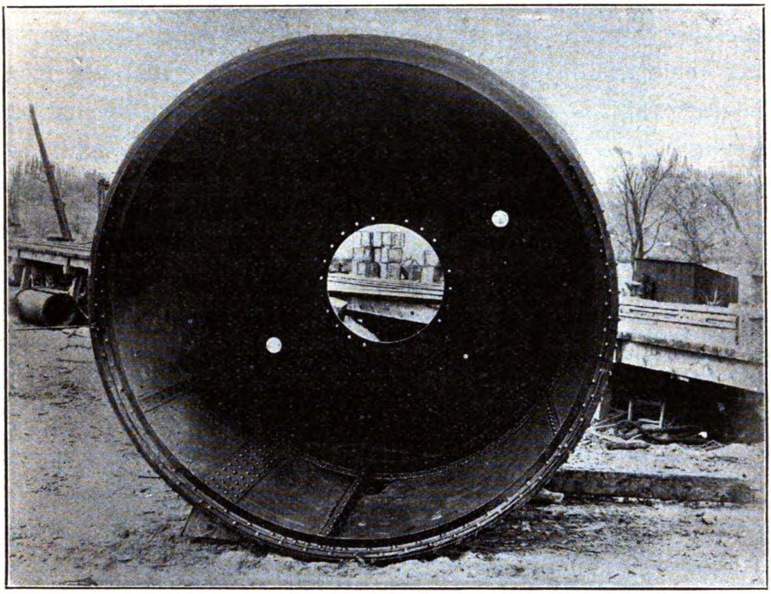

FIG. 2.

where the air shaft, which was a steel tube of same diameter, was connected. At the top of the air shaft was connected a Moran air lock, through which material excavated from below was hoisted, and through which the men passed from the open air to the working chamber below and out again. The Moran lock is especially adapted to pneumatic work, where only one air shaft can be used, as it is a double lock; that is, one compartment for passing out material and one for the men. In large caissons two air shafts are usually used with an air lock on each.

The method of work was as follows: The working chamber was placed in position, a section of the air shaft was then bolted in place with the air lock at the top. A section or two of the outer steel shell was rivetted on, and the air pipes connected. Concrete was then filled in between the outer shell and the air shaft, and on top of the roof of the working chamber, sufficient to give the proper weight for sinking. The air pressure was then turned on, and workmen entered the working chamber through the air lock, dug up the material from beneath and shoveled it into buckets, which were hoisted out through the other compartment of the air lock. Usually for a short distance the whole mass would follow down as the material was excavated; but as the working was carried to greater depths, the friction of the earth on the sides was so great as to hold it up till a considerable amount was excavated, when by a sudden release of air pressure the pier would settle till the cutting edge of the working chamber rested on the bottom again.

When one pier had been sunk till the top of the concrete filling was about to the water surface, the air lock would be removed and placed on another pier, while additional sections of the outer shell and air shaft were being put on, and more concrete put in place,—it being necessary at all times to keep the air lock, outer shell and top of concrete above the water.

The piers were all sunk to a stratum of sandstone which lay from forty-two to forty-six feet below the surface. A maximum air pressure of twenty-three pounds per square inch in addition to the normal pressure was used. This is not a difficult pressure to work under, and any man of sound physical condition can easily remain in it for several hours without feeling any detrimental effects. A rate of progress as high as sixteen feet per day was made through the sand that lay near the surface, but an average of about two feet per day was all that could be made through the hard shale and other stratified material encountered at greater depth. The work was begun on the 7th day of February, 1900, and was all completed, including the sinking to position, rivetting up of steel shells, filling of the working chamber, air shaft and all spaces whatever with concrete, and setting the anchor bolts and coping

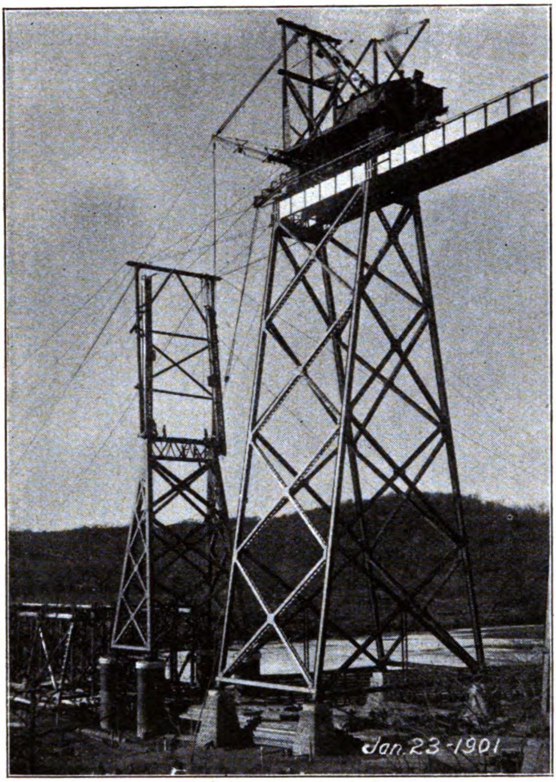

FIG. 3.

stone to receive the metal superstructure of the bridge, on June 6th of the same year.

The appliances for the erection of the steel work consisted of four derricks for unloading the material from cars as it arrived,—two at each end of the bridge; two travelers for lifting and lowering the steel into position; two gasoline air compressors for running the pneumatic rivetting machines, and numerous tools, push cars, etc. The most important of these was the travelers, which are shown very clearly in Figs. 3 and 4. They are simply traveling derricks, which were moved along as the work progressed. There was one on either side of the river, as the work of erection was carried on from each end,

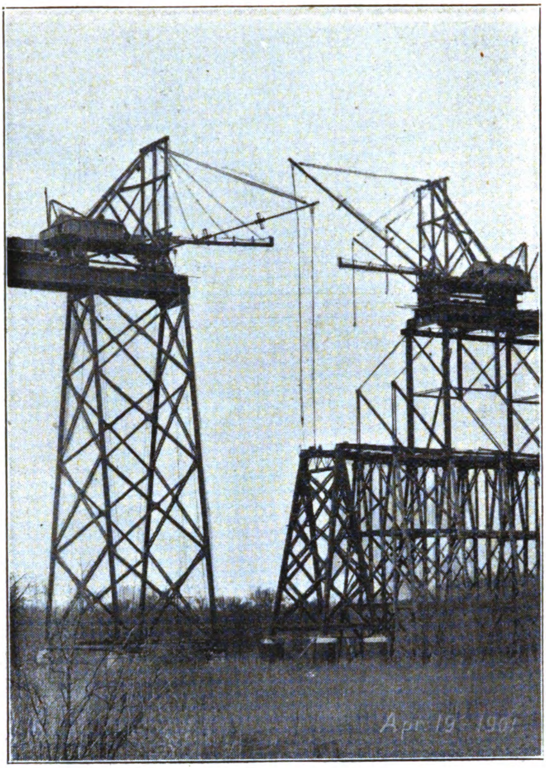

FIG. 4.

and the two travelers met, as shown in Fig. 4, at the west end of the 300 foot span. The traveler consisted of a steel framed bent, or mast, about fifty feet high, made of three posts braced together, mounted on a platform which carried a hoisting engine, and which formed a place for the engineer, signalman and men operating the lines to work; and which also formed a place for the storage of coal, water and the hundreds of feet of rope used in handling the steel. At the bottom of this bent were attached two booms,—one called the 90-*foot boom,* the other the *trolley boom.* The 90-foot boom, so called because it was ninety feet long, was made of two nine-inch channels laced together, and stiffened against buckling vertically and sidewise by longitudinal truss rods. It was made to swing from a horizontal position through a vertical arc of 75 degrees; and also had a horizontal swing of about the same amount. It was raised and lowered by means of blocks and tackle connecting the end of the boom with the top of the mast, and operated by the hoisting engine. The side movement was controlled by hand lines attached at the end of the boom and operated by men on the ground. The trolley boom was fifty-one feet long, and always remained in a horizontal position, although it had a lateral swing of about 30 degrees. It was made of two 18-inch I-beams, the upper flanges of which formed a track upon which were run two carriages or trolleys. Its lateral movement was controlled in the same manner as the 90-foot boom, and it was supported in the horizontal position by means of rods extending from the end and two intermediate points to the top of the mast. From the top of the mast back stays were run to the rear end of the platform where they were connected with heavy anchor rods which were securely clamped to the girder underneath to prevent the entire traveler tipping forward when a heavy load was being lifted. The 90-foot boom and trolley boom were designed to carry ten and sixteen tons respectively at their extreme ends. The entire traveler was carried on four pair of trucks, which ran on standard gauge tracks thirteen feet center to center, and was elevated on these tracks so that the platform stood about nine feet above the rail. This provided a passageway underneath and between the two tracks for bringing material forward where it could be reached with lines from the trolleys. The trolley boom was used for lowering and setting the girders in place and also for lowering material for the towers from the deck of the structure to the ground, whence it was picked up with the 90-foot boom and raised to its place in the tower.

No falsework was used in raising the viaduct, but the 300-foot span was built on a very heavy falsework made of 8x16 Oregon fir timber. The construction of this falsework is shown in Fig. 5.

The structure is finished with a very substantial floor, consisting of eight-inch square yellow pine ties, twelve feet long and spaced one foot center to center. To their ends are bolted yellow pine guard rails ten by twelve inches, and on either side of each rail is spiked a four by ten plank longitudinally. Between the rail and the inner plank is spiked a six by four by one-half-inch angle, which will serve as a protection to the ties in case a derailed truck crosses the bridge.

The erection work was commenced in November, 1900, and was finished and the first train passed over May 19, 1901.

A great many erroneous statements have been made in regard to the magnitude of this structure, and of the engineering problems connected with it. Taken all in all it is perhaps the greatest railroad viaduct in the world, although not by

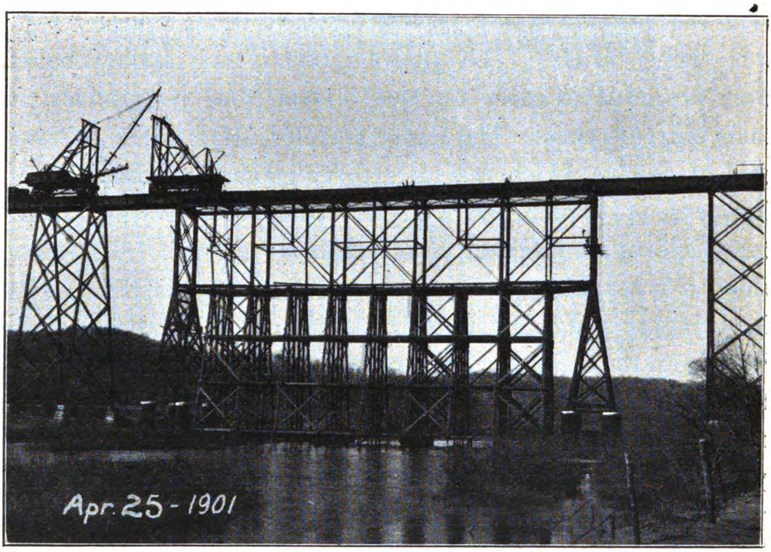
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FIG. 5.

any means the highest. But a viaduct is very simple construction and does not involve such engineering skill as some of the great arch, cantilever or truss span bridges. The great arch bridge across the Mississippi river at St. Louis, the fam-

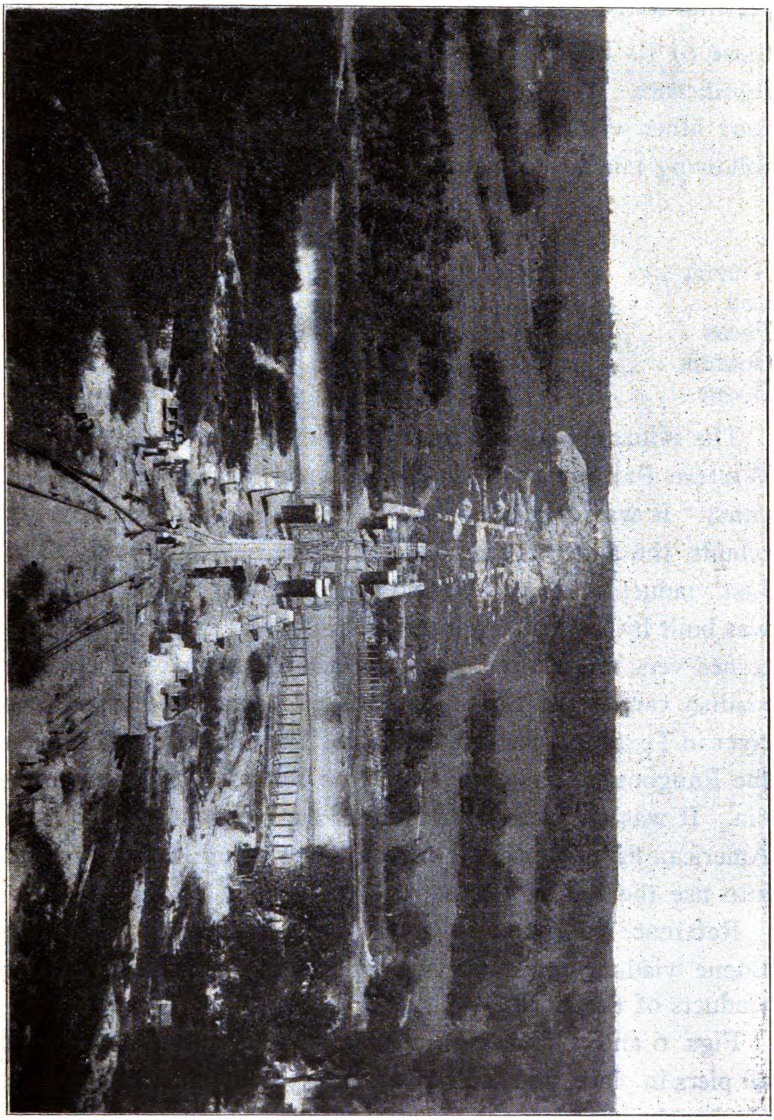

FIG. 6.

ous suspension bridge at Brooklyn, or the wonderful cantilever bridge across the Firth of Forth in Scotland, are immensely more difficult than any railway viaduct in existence.

In order to show a comparison of this structure with other existing structures it will be necessary to compare it only with those of its kind; otherwise the comparison would have no significance. I will only attempt to make a comparison with four other viaducts. Comparative figures are given in the following tabular form, all dimensions being given in feet:

	Length.	Height.	Tons Metal.	No. Tracks.
Kinzua	2050	302	3350	1
Loa	800	336	1115	1
Pecos	2180	321	1820	1
Gokteik	2260	320	4852	2
Boone	2685	185	6196	2

The Kinzua viaduct carries the New York, Lake Erie and Western Railway over the Kinzua creek in Eastern Pennsylvania. It was originally built in 1882, but has been recently rebuilt, the above figures being for the new structure. The Loa viaduct is on the Antofagasta Railway in Bolivia, and was built by English engineers in 1889. In design it was patterned very much after the old Kinzua structure. The Pecos viaduct carries the Southern Pacific Railway over the Pecos river in Texas. It was built in 1892. The Gokteik viaduct is on the Rangoon—Mandelay line of the Burmah Railways in India. It was designed by American engineers and built by an American firm of bridge builders. It was finished and turned into use the fall of 1900.

Reference to the table above will show the rank of the Boone viaduct in comparison with the four other greatest viaducts of the world.

Figs. 6 and 7 show respectively the site of the bridge with all piers in place, and the viaduct nearly complete, the travelers placing the last pieces of the steel-work.

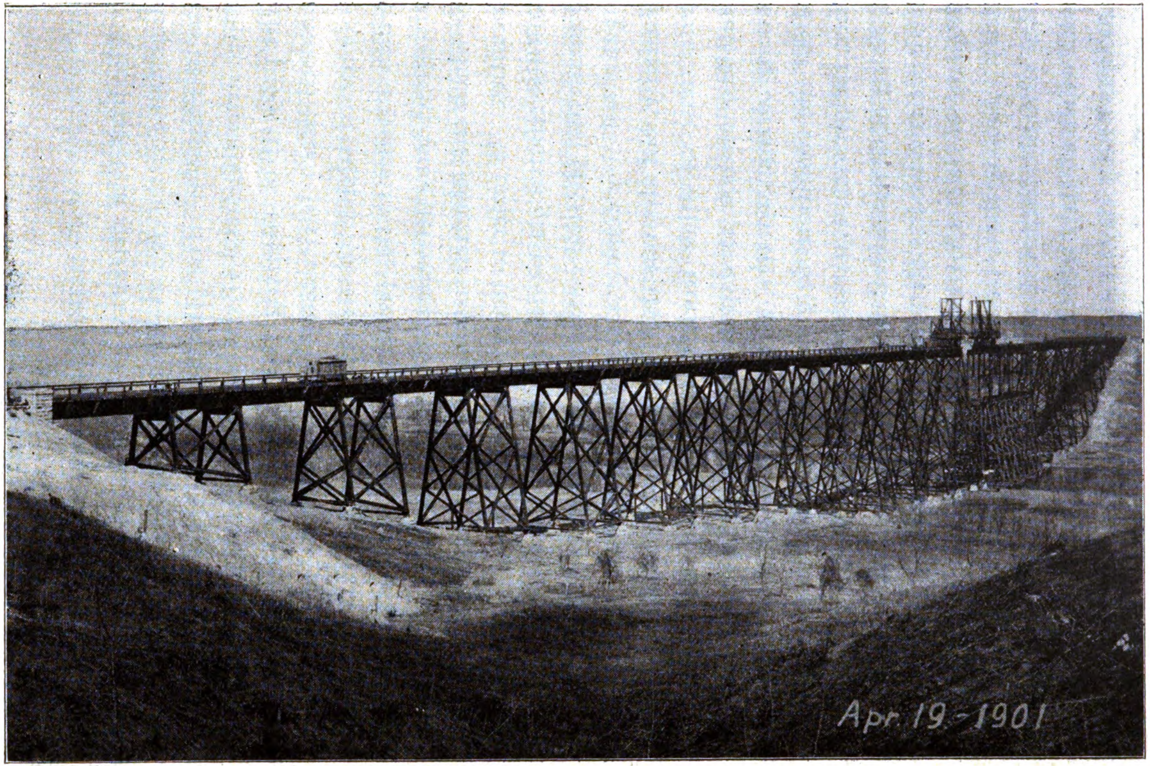

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FIG. 7.

THE CHICAGO & NORTHWESTERN VIADUCT AT BOONE, IA

In the issue of the Railway Age of March 8 a short descriptive article and an engraving from a photograph were given, showing the progress of work on the large, double-tracked viaduct for the Chicago & Northwestern Railway over the Des Moines River on the new line between Ogden and Boone, Ia. This viaduct, which is said to be the largest double-tracked structure of its kind in the world, has since been completed and is now in service.

The advantages of the new line over the old in grade, curvature and distance are well shown in the accompanying map and profiles given herewith. The distance from Boone to Ogden on the old line is about ten and one-half miles and on the new line it is little more than seven miles. The new line is practically straight with but two easy curves, while the old, for its entire length, is a series of curves varying from .5 to 6 per cent. in curvature. The greatest advantage gained is in the reduction of grades. The old line dips to near the level of the river forcing the trains to climb the bank on either side and making a difficult grade in each direction. By means of the bridge the new line is carried across the river 185 feet above the low water mark, thus saving a descent and climb of 158 feet and greatly reducing the percentage and length of the grades. For west bound trains on the old line the maximum grade was 1.5 per cent. and for east bound trains 1.4 per cent., while on the new line for west bound trains the maximum grade is .63 and for east bound trains .6 per cent. These facts, however, represent but a small part of the advantage gained as the new grades are less than one-half as steep as those of the old line, while the grades of the latter are more than four times as long.

VIADUCT AT BOONE, IOWA, CHICAGO & NORTHWESTERN RAILWAY—VIEW OF WORK AFTER COMPLETION.

The Boone bridge is of the viaduct type and work on it was started on April 23, 1899. The structure was opened for traffic May 18, 1901. The bridge is 2,685 feet in length, is 185 feet in height at its highest point and contains 5,680 tons of metal. With the exception of the span over the river channel, which is 300 feet long, the bridge is composed of spans alternately 45 and 75 feet in length; the 45-foot spans being the tops of the steel towers of that length and the 75-foot spans being the distance between these towers.

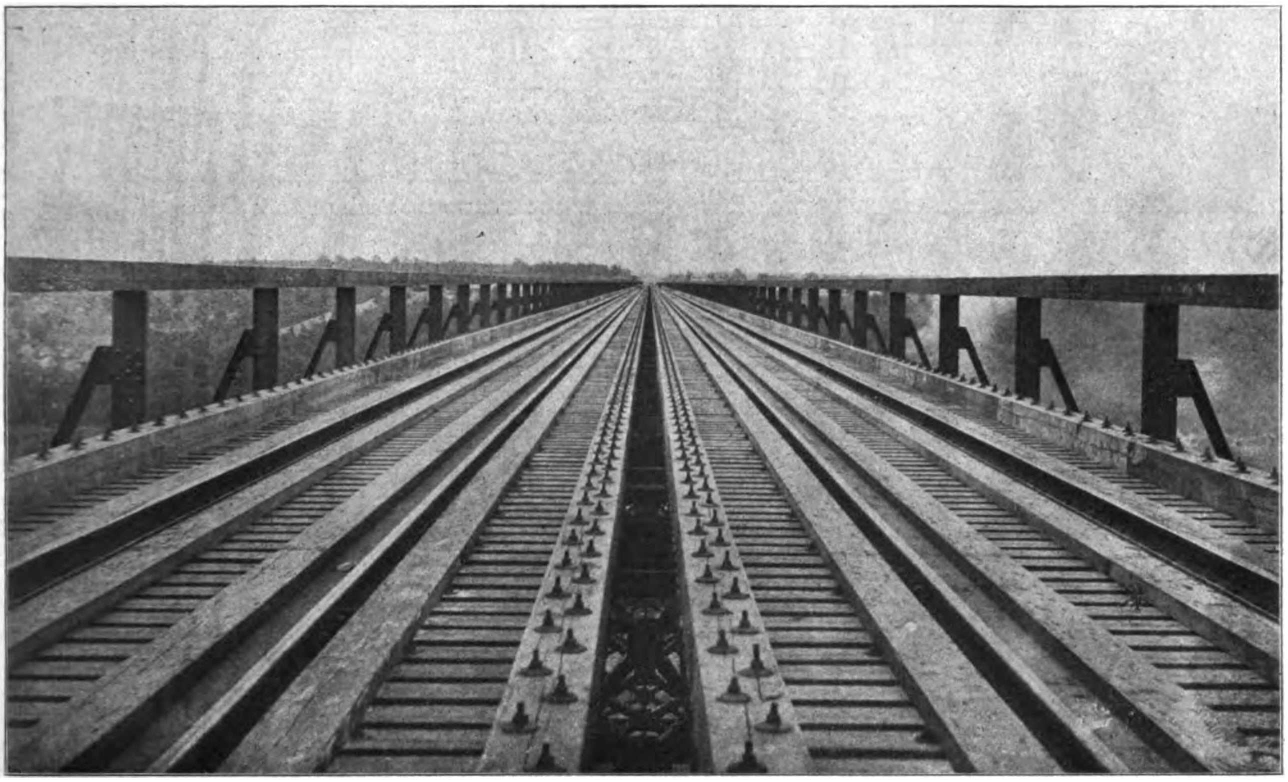
While the Boone bridge can hardly be compared to the greatest bridges of the world, including such structures as the Eads, Forth and Brooklyn bridges, it is undobutedly one of the greatest bridges of the viaduct type ever built. Some idea of its proportions may be obtained from the following comparison with other noted railroad viaducts, including the Kinzua, Loa and Pecos structures:

	Kinzua.	Loa.	Pecos.	Boone.
Length, ft.	2,050	800	2,180	2,685
Height above water, ft.	302	336	321	185
Greatest width at base, ft.	103	124	90	70
Width at grade, ft.	18	13	16	27
Number of tracks	1	1	1	2
Tons of metal	1,400	1,115	1,820	5,680

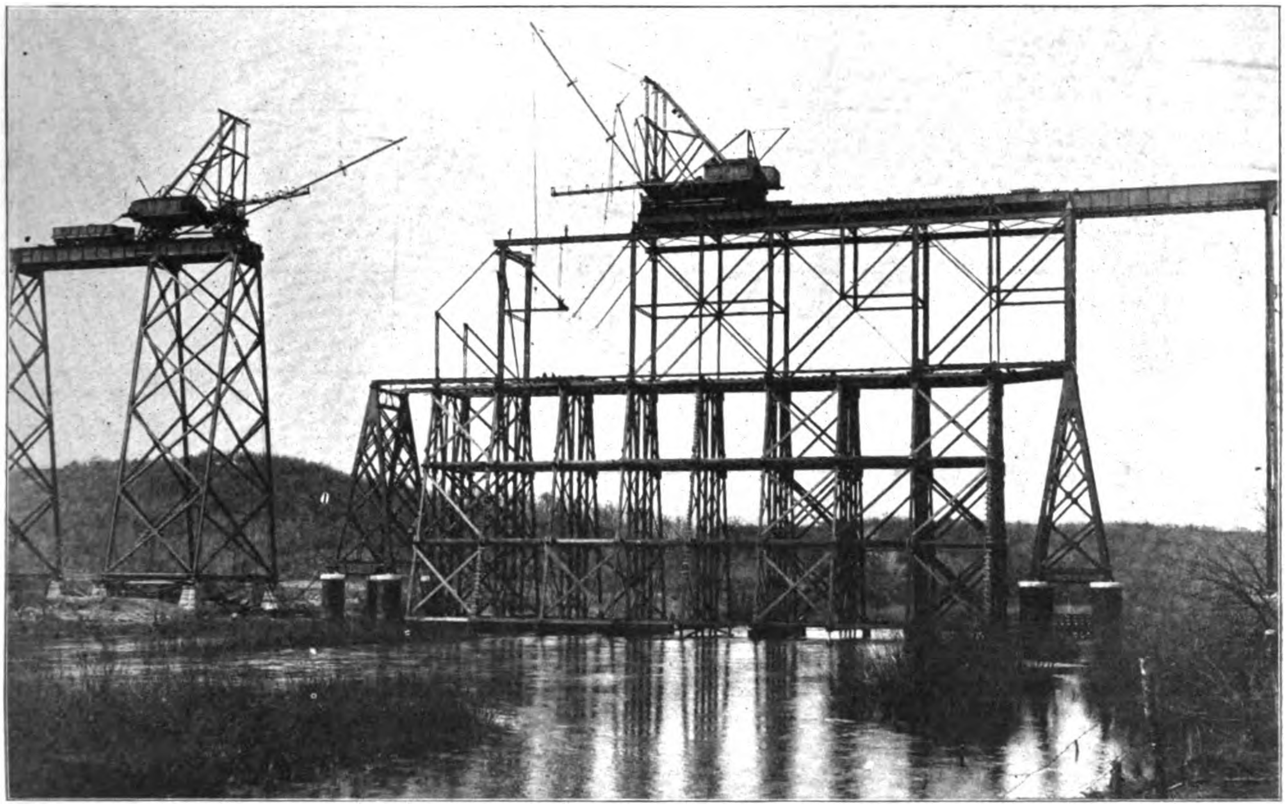
In addition to these might be included the Crumlin viaduct situated on the Taff vale extension railway in South Wales. It is 1,500 feet long, 200 feet high and contains about 3,000 tons of metal. It is a double track structure and was built in 1857.

For uniformity the girders used for both the 45 and 75-foot spans were made 7 feet in depth though the economic depth of the girders for the 45-foot spans would be slightly less and for the 75-foot spans slightly greater than this. The use of 45-foot tower spans gave a sufficient spread at the base to allow of no uplift at the foot of the columns as a result of the sudden stoppage of a train on the bridge. The columns in the towers were given a batter of 1 in 6 making the distance between the feet of the columns 70 feet, in the direction at right angles to the length of the bridge. This gave the towers a base of sufficient width to resist the pressure of the wind on the sides. The columns were made up of two 20-inch and one 15-inch I beams riveted together in the form of the letter H. These were braced with diagonal compression members, no horizontal struts being used except at the bottom of the tower where all four columns were connected by 15-inch channel struts.

The channel span which is 300 feet in length and 60 feet deep is divided into five panels and is supported at either end on A-shaped towers which in turn rest on steel cylinder piers 10 feet in diameter. The span is of the ordinary truss type, the expansion and contraction being allowed for by making the end posts at one end of a rocker bent, and allowing the pins at the foot of these posts to slide in slotted pin holes in the bottom chords. The floor beams were placed upon the top chords and the stringers on top of the floor beams so as to reduce to a minimum the height of the towers supporting the span.



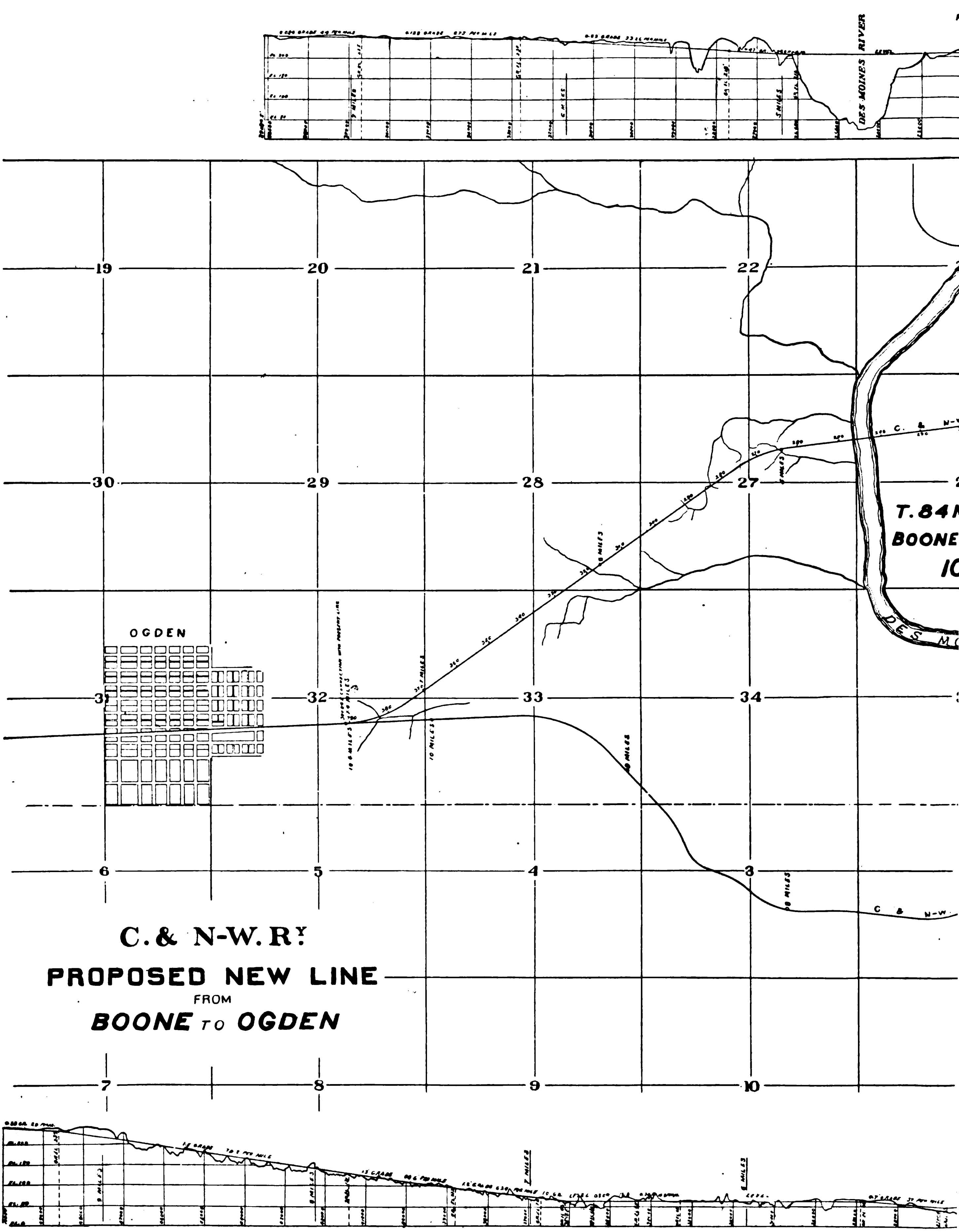
VIADUCT AT BOONE, IOWA, CHICAGO & NORTHWESTERN RAILWAY—VIEW LOOKING EAST SHOWING FLOOR AND SIDE RAILS OF COMPLETED BRIDGE.



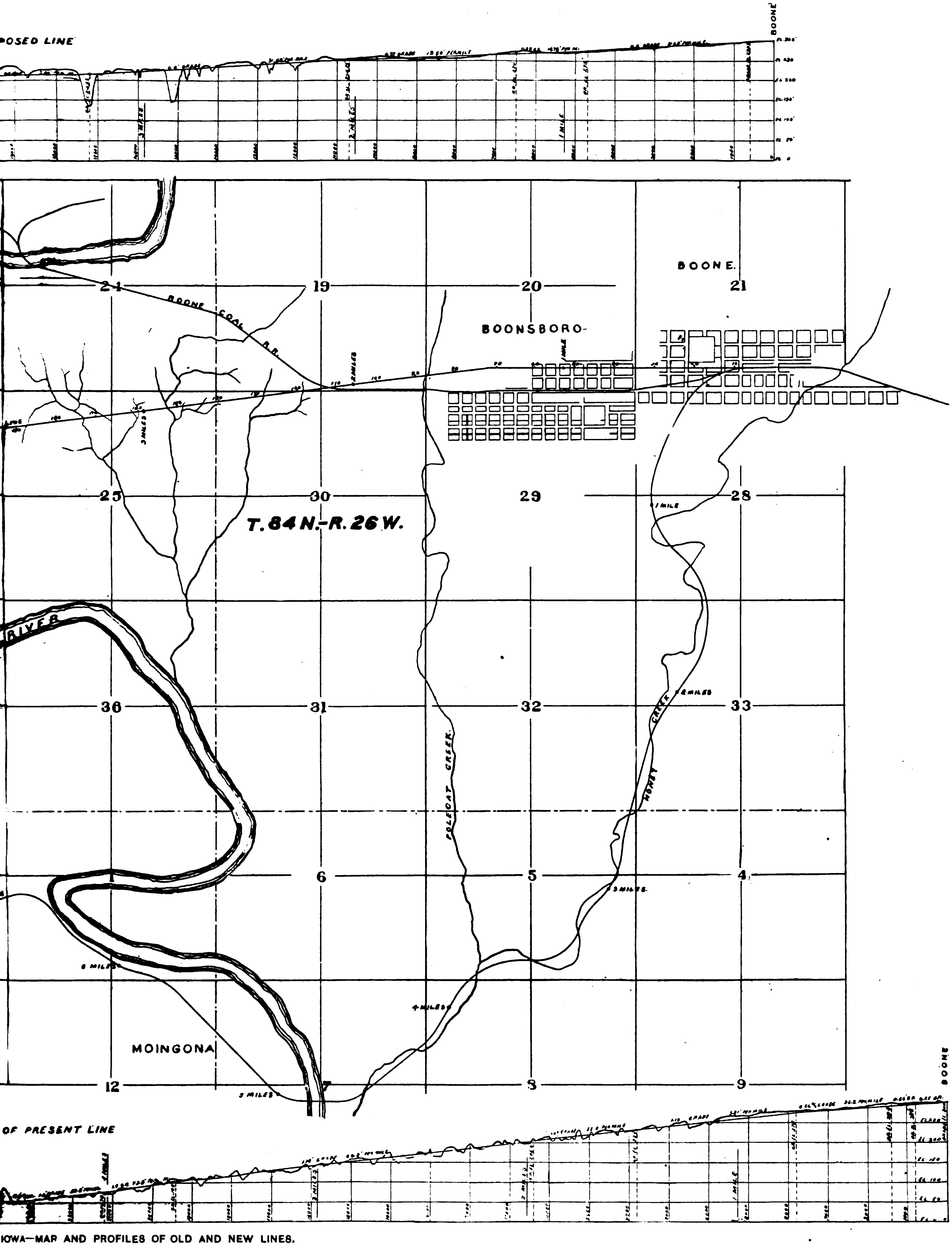
VIADUCT AT BOONE, IOWA, CHICAGO & NORTHWESTERN RAILWAY—VIEW OF TRAVELER ON CHANNEL SPAN.
From photograph taken April 17, 1901.

Each of the towers supporting the channel span rests on four steel cylindrical piers which were sunk by the pneumatic process. The piers are 10 feet in diameter and consist of steel shells five-eighths of an inch thick, made in sections five feet high which were riveted together as the piers were sunk. The bottom section of each pier was eight feet in height and one foot from the top edge of these sections a steel diaphram was framed in, forming the roof to a working chamber below, seven feet in height. At the center of the diaphram a hole three feet in diameter was left for the air shaft. At the top of this air shaft a Moran air lock was provided allowing the material excavated to be hoisted out and the workmen to pass into and out of the working chamber below. The Moran lock was used as it contains a double lock, one of which was used for the excavated material and the other for the passage in and out of the men. The compressor plant used consisted of two 60-horsepower boilers, two Ingersoll-Sergeant air compressors in addition to the neecssary pump, dynamos for lighting purposes, etc.

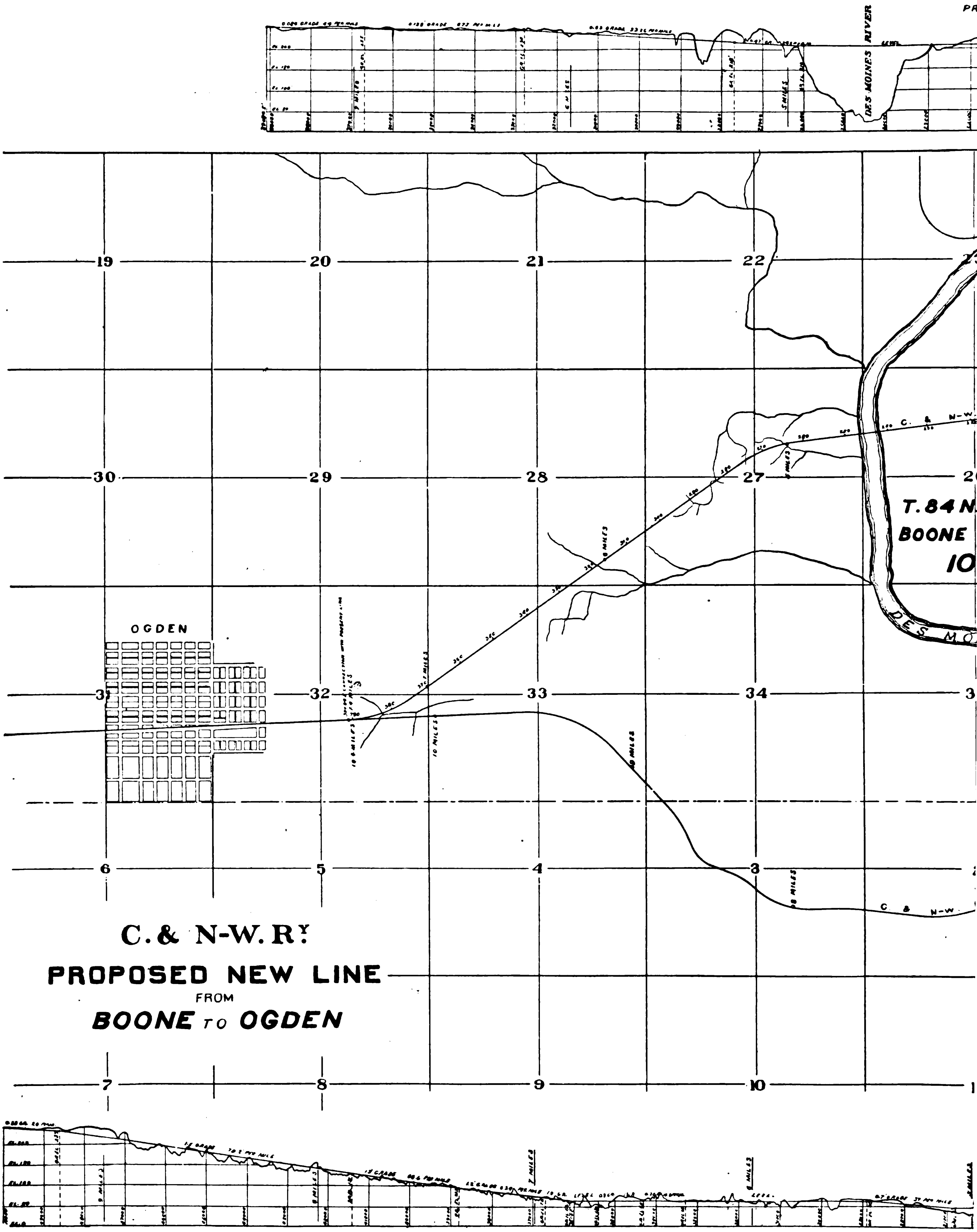
The piers were sunk to a stratum of sandstone underlying



CHICAGO & NORTHWESTERN RAILWAY IMPROVEM



IOWA—MAP AND PROFILES OF OLD AND NEW LINES.



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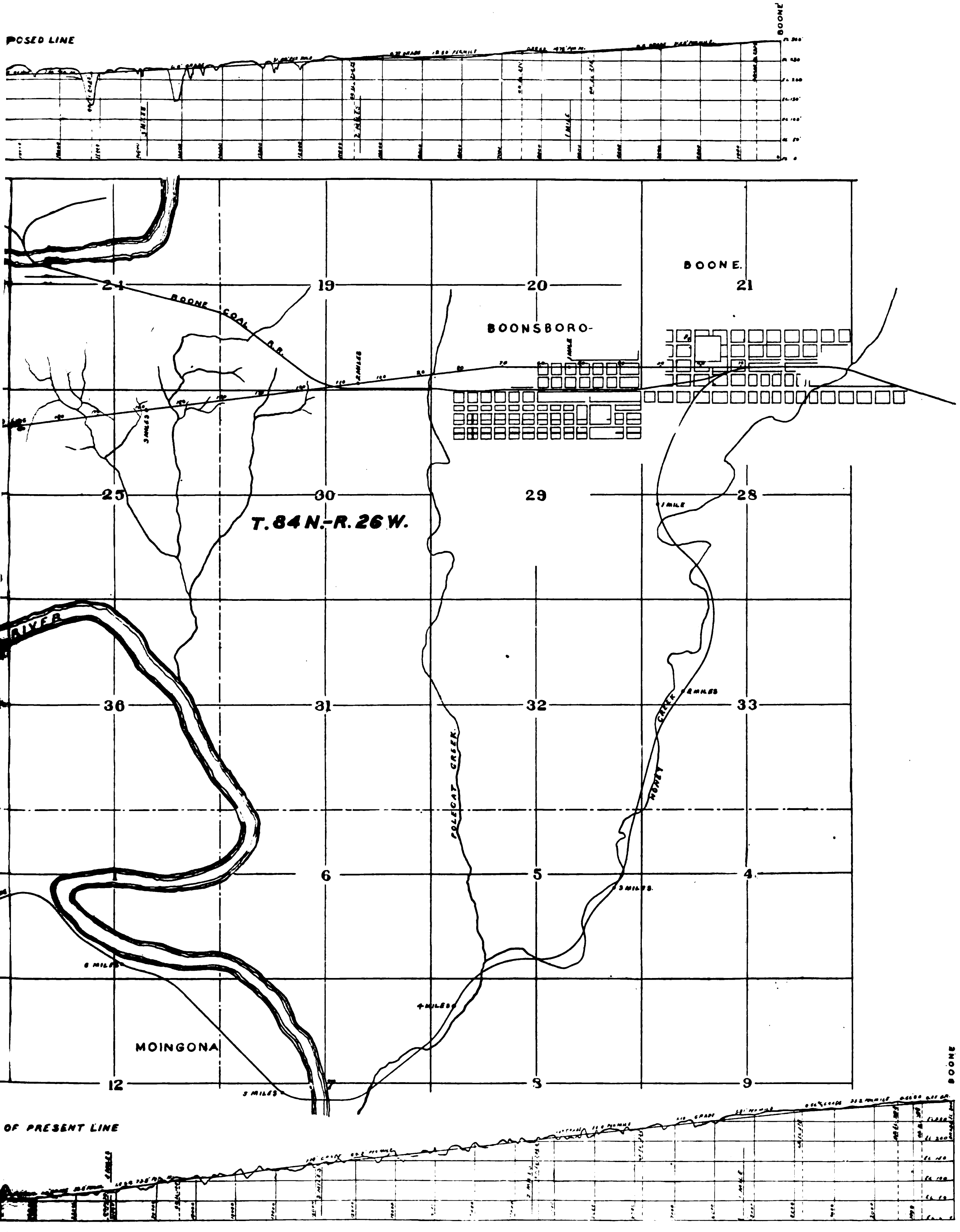
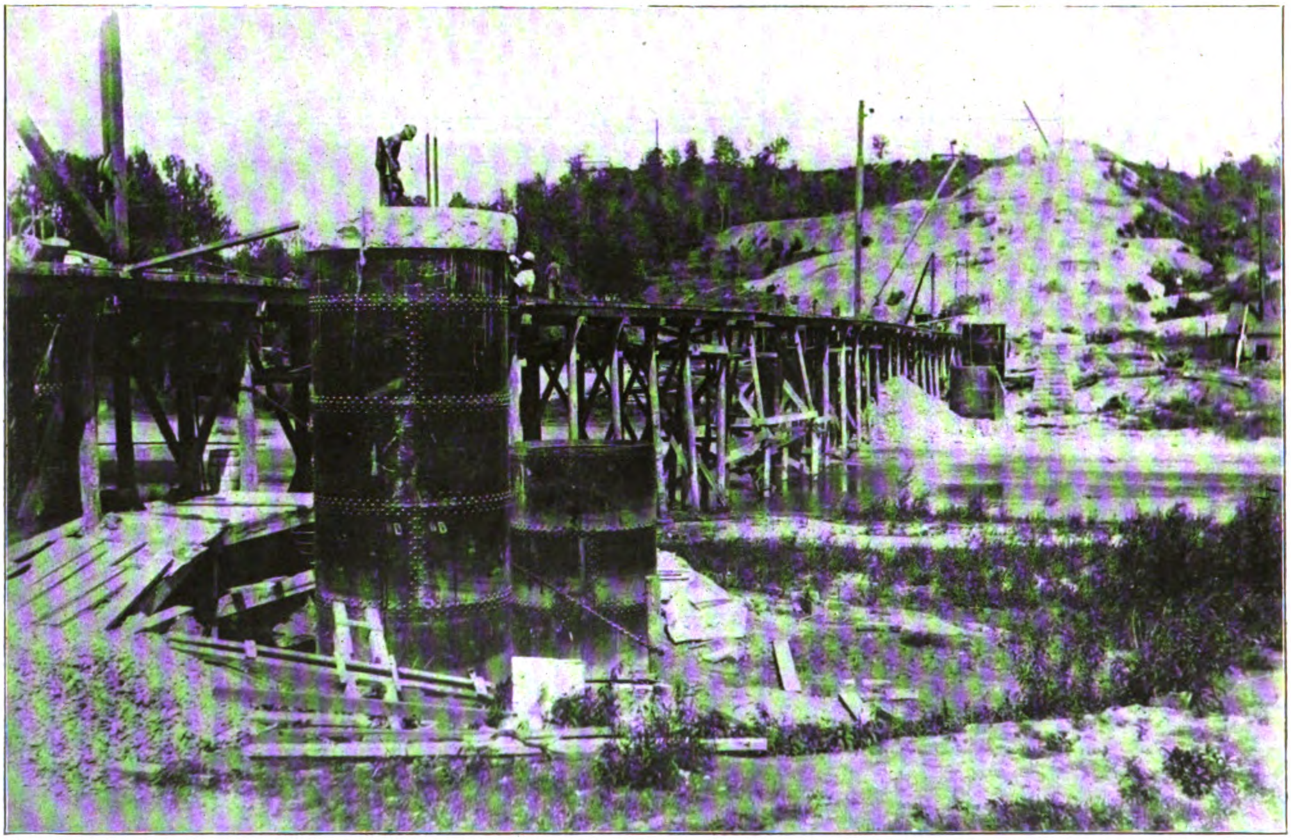


IOWA—MAP AND PROFILES OF OLD AND NEW LINES.

the ground at this place at a depth of from 42 to 46 feet below the surface. In addition to the normal pressure a maximum air pressure of 23 pounds per square inch was used in the working chamber. Near the surface a sandy material was encountered and through this a progress of as much as 16 feet per day was made, but at a greater depth where hardpan and other more solid materials were encountered an average of but two feet per day was made. After the piers had been sunk to the required depth the working chamber, air shaft and all other spans were filled with concrete. The entire work of building the piers complete was accomplished in about four months.

VIADUCT AT BOONE, IOWA, CHICAGO & NORTHWESTERN RAILWAY—SHOWING TRAVELERS AND FALSE WORK IN PLACE PREPARATORY TO ERECTING CHANNEL SPAN.
From photograph taken March 18, 1901.



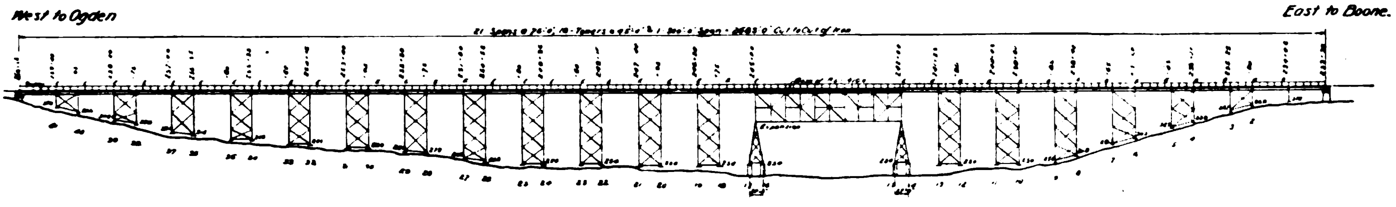
VIADUCT AT BOONE, IOWA, CHICAGO & NORTHWESTERN RAILWAY—STEEL CYLINDRICAL PIERS FOR TOWERS OF 300-FOOT SPAN.
From photograph taken in May, 1900.

The abutments were built of solid masonry, 50x30 feet at the base and reinforced with buttresses in front. The piers supporting the viaduct towers as shown were five feet square at the top and made with a batter of 1 in 6 giving the bases an area of from 12 to 20 feet square according to the height of the pier. In all of the masonry Mankato limestone laid in Portland cement mortar was used with Ableman's sandstone for the pedestal blocks supporting the steel columns on top of the piers.

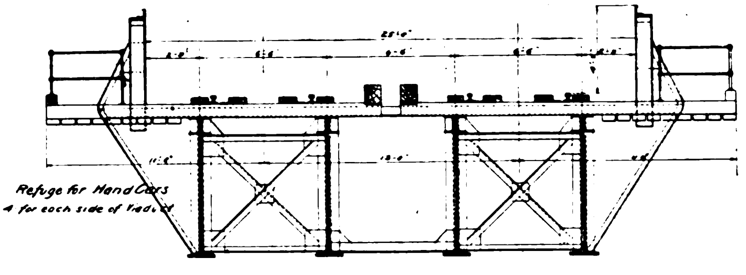
The materials encountered in the building of the piers and abutments were for the most part clays, shales, sandstone and coal. On the higher ground at the ends of the structure the sandstone was found to be overlaid to a considerable depth with a thick layer of blue and yellow clay and not being deemed advisable to sink the foundations to so great a depth, pits were dug 12 to 14 feet deep in the clay and beds of concrete from 4 to 6 feet in depth were deposited as a foundation for the stone work for the abutments and piers at these points. The area of the base of the concrete was made sufficiently large so that the pressure would not exceed two tons per square foot. At other points the foundations were carried to the stratified materials and a pressure of three tons per square foot was allowed. Near the river piles were driven into the sandy earth prevailing there, and the tops of the piles were then cut off at the level of the water and concrete deposited around and on top of them for a masonry foundation. A pressure of 15 tons was allowed for each pile.

The travelers used in the work are well shown in the accompanying engravings which describe the work on the channel span. Two travelers were employed, one on each side of the river span and consisted of a steel framed bent about 50 feet in height, made of three posts braced together and mounted on a platform which carried a hoisting engine. In connection with each traveler were two booms known as the 90-foot and the trolley boom. The former was made of two nine-inch channels laced together and stiffened against buckling and so pivoted that it could be swung vertically or horizontally through an arc of 75 degrees. The vertical movement was obtained by means of block and tackle operated by the hoisting engine, and the horizontal movement was controlled by hand lines by men on the ground on either side. The boom was designed for a load of

VIADUCT AT BOONE, IOWA, CHICAGO & NORTHWESTERN RAILWAY—VIEW SHOWING STONE PIERS FOR TOWER FOUNDATIONS.
From photograph taken March 10, 1900.



General Elevation



General Cross Section

VIADUCT AT BOONE, IOWA—CHICAGO & NORTHWESTERN RAILWAY—ELEVATION AND CROSS SECTION.

ten tons and was used particularly for raising the material from the ground to its place in the tower. The trolley boom, 51 feet long, was fixed horizontally, but arranged to allow a lateral movement of 30 degrees, which was controlled in the same manner as that of 90-foot boom. The trolley boom was made up of two 18-inch I beams and was designed for a lifting capacity of 16 tons at its extreme end. The boom was held in horizontal position by means of stays fastened to the end and two intermediate points and extending to the top of the mast. To strengthen the mast, stays were run backward from the top to the rear end of the platform where they were connected to heavy anchor rods which in turn were securely clamped to the girder underneath to prevent the traveler from tipping forward when lifting a heavy load. The trolley boom was used for lowering and setting the girders in place and also for lowering the structural material from the deck of the bridge to the ground, from which point it was placed in position by the 90-foot boom.

The entire traveler was carried on four pairs of trucks which ran on standard gauge tracks and which were elevated nine feet above the rail and spaced thirteen feet center to center. The elevation of the traveler allowed space beneath for the various materials to be brought forward where they could be reached by lines from the booms.

The floor of the bridge is constructed of eight-inch square yellow pine ties, twelve feet long and spaced one foot center to center. Yellow pine guard-rails 10x12 inches are bolted to the ends of the ties, and on either side of each rail a 4x10-inch plank is spiked. To serve as a protection to the ties of the bridge in the case of a derailed truck, a 6x4½-inch angle is placed between the rail and the inner plank.

The bridge, with the exception of the 300-foot span, was built without the use of falsework. For the river span a heavy falsework of 8x16-inch Oregon fir was used.

The superstructure of the bridge was contracted for with the Union Bridge Company of Athens, Pa., which company sublet the work for the 300-foot span and the girders to the Lassig Bridge and Iron Company of Chicago, and for the bents and towers to the Milwaukee Bridge Company of Milwaukee, Wis. All of these companies are branches of the American Bridge Company.

The bridge was designed by the engineering department of the Chicago & Northwestern and it is to Mr. E. C. Carter, chief engineer, that we are indebted for the photographs and maps shown. The work of construction was under the immediate supervision of W. C. Armstrong, resident engineer at Boone, Ia.

Railroad Construction in Texas.

R. A. Thompson, engineer of the Texas Railroad Commission, furnishes the following preliminary statement of the railway mileage constructed in Texas during the six months ending June 30, 1901:

	Miles.
Beaumont & Sour Lake	3.5
Beaumont & Northern	0.5
Cane Belt	13.7
Chicago, Rock Island & Mexican	78.7
Denison & Sherman	9.8
Eastern Texas	0.5
Gulf, Beaumont & Gt. Northern	9.0
Gulf, Colorado & Santa Fe	40.0
Jefferson & Northwestern	5.0
Missouri, Kansas & Texas	39.0
International & Gt. Northern	15.0
Moscow, Camden & San Augustine	3.0
San Jacinto & Southern	8.0
St. Louis, San Francisco & Texas	6.4
Texas & Louisiana	5.5
Texas & New Orleans	31.6
Texas Southern	17.0
Timpson & Northwestern	8.0
Total	294.2

The railway constructed in the state during the same period of 1900 was 133 miles and for the entire year 1900, 272.7 miles. The mileage in operation of January 1, 1901, was 10.022 miles and the approximate mileage in operation on June 30, 1901, will be 10.316 miles.

Personal Mention.

OBITUARY.

George W. Armstrong, president of the Armstrong Transfer Company of Boston, died on June 30.

William B. Litchfield, formerly president of the Ulster & Delaware, died at Brooklyn, N. Y., on June 30, aged sixty-two years.

H. L. Preston, master car builder of the Chicago St. Paul Minneapolis & Omaha, died suddenly at Hudson, Wis., on June 28.

Henry W. Remington, formerly president of the Wisconsin Valley, died at his home near Babcock, Wis., on July 2, at the age of seventy-seven years.

Oscar O. Esser, formerly superintendent of the Pennsylvania & New York division of the Lehigh Valley, died at his home in Tunkhannock, Pa., on June 26, at the age of fifty-one years. He was born at Mauch Chunk, Pa., on January 25, 1850, and entered the service of the Lehigh Valley in 1862 as water boy. He served successively as messenger, telegraph operator, yardmaster, train dispatcher, trainmaster and superintendent of the Wyomington division until January, 1884, when he was appointed superintendent of the North Branch division. In October, 1894, he was made superintendent of the Pennsylvania & New York division, which position he held until January 15 of the present year, when he retired.

Mr. J. M. Plummer has been appointed roadmaster of the New Orleans & Northwestern, in place of Mr. A. G. Brush, resigned.

Mr. S. M. Hibbard has resigned as general baggage agent of the Kansas City Fort Scott & Memphis, to take effect on August 1.

President Ramsey of the Wabash announces that the office of general manager has been abolished and that its duties have been assumed by the president.

Mr. James Neville, who was recently appointed a member of the Illinois Railroad and Warehouse Commission, has been elected chairman of the commission.

Philip B. Winston, of the well-known railway contracting firm of Winston Bros. of Minneapolis, died suddenly in Chicago on July 1, aged fifty-five years.

Mr. F. C. Webb has resigned as assistant superintendent of the Willmar & Sionx Falls to accept a position with a railway supply house at Denver, Colo.

Mr. J. J. Whittaker has been appointed master mechanic of the Jacksonville & Southwestern, with headquarters at Jacksonville, Fla., in place of Mr. G. W. Eaves, resigned.

Mr. L. A. Downs, roadmaster of the Illinois Central at Louisville, Ky., has been appointed roadmaster at New Orleans, La., in place of Mr. L. L. Dagson, transferred.

Mr. B. F. Yoakum was on July 1 elected president of the Fort Worth & Rio Grande, in place of Mr. H. C. Wicker, and Mr. W. B. King was elected vice-president and superintendent.

Mr. H. B. Helm, chief clerk to the auditor of freight receipts of the Kansas City Southern, has been appointed auditor of the Shreveport & Red River Valley, with headquarters at Shreveport, La.

Mr. E. F. Serviss, commercial agent of the St. Louis & San Francisco at Kansas City, Mo., has been appointed commercial agent of that road and the Kansas City Fort Scott & Memphis at Omaha, Neb.

Mr. James E. Howard, paymaster and cashier of the Pere Marquette, has been appointed auditor of that road, with headquarters at Detroit, Mich., succeeding Mr. H. C. Potter, Jr., whose title was comptroller.

The office of passenger trainmaster of the Erie has been abolished, and Mr. J. R. Dearth, who has held that position, has been appointed chief train dispatcher of the Cincinnati division, with headquarters at Galion, O.

Mr. George A. Gould, superintendent of bridges and buildings of the Chicago Rock Island & Pacific at Davenport, Iowa, has tendered his resignation to accept a position with a construction company at Davenport.

Mr. J. J. Campion, heretofore traveling freight agent of the Cincinnati Hamilton & Dayton, has been appointed general agent at Toledo, O., to succeed Mr. John H. Hyland, assigned to special duties on account of ill health.

Mr. John Kilkeny has retired from the position of division passenger agent of the Louisville & Nashville at New Orleans, La., and is succeeded by Mr. J. K. Ridgely, heretofore northwestern passenger agent at Chicago.

Mr. G. T. Taylor, assistant superintendent of the Cape Cod division of the New York, New Haven & Hartford, has been appointed superintendent of the Plymouth division, with headquarters at Boston, to succeed Mr. J. H. French, who has resigned after a service of forty-seven years with that road and through chutes to the two mixing plants near the invert. In one plant, of which an illustration is shown, the broken stone was delivered through an open slide and the sand and cement through a covered chute alongside. They were received by men on a small working platform, who shoveled them into a tilting measuring box, from which they were dumped into a chute leading to a Ransome concrete mixer. This mixer was driven by a traction engine. The second plant had a cubical mixer set at a little higher level. All the materials for it were measured on the top of the hill and sent down together through a chute to the charging platform, where they were delivered to the mixer, which was driven by a small gasoline engine. The mixer discharged into a tilting box mounted on a flat car, which was pushed a few feet to the edge of a wheeling platform. The box was fitted with a spout on one side through which its contents were dumped into the wheelbarrows on the platform below. This platform was above the springing line of the arch and the concrete was dumped directly into the molds from the barrows. Each of the mixing plants had a capacity of about 50 cubic yards in 10 hours.

About 1,400 feet of the tunnel running from the purification works to the Western pumping station in Cincinnati have now been driven, and the lining completed for about 900 feet. The shaft at the California end is about 167 feet deep below the natural ground surface, and consists of a 12-foot steel shell down to the rock and a 12½-foot shaft the rest of the way. Both shell and rock shaft are lined with concrete and two rings of shale brick, the clear diameter being 10 feet. At two different elevations nozzles have been placed. One of these nozzles connects with the pipes through which water will be admitted to the shaft from the clear-water reservoir, and the other with a canal passing around the clear-water basin and enabling it to be put out of service in case of emergency. The shell willl be carried up to a height of 8 feet above the water-level in the clear well but the brick lining will stop 6 feet below its top.

At one of the intermediate working shafts a pit was dug 20 feet deep in the dry, hard, yellow clay, and thoroughly timbered and sheathed. The steel shell was built in it and sunk by men excavating in the open pit through blue clay and then gravel until water was encountered. The excavation was then continued without pumping by a clam-shell dredge, the shell descending very regularly, 1 inch for every bucketful of earth removed. The steel plates were riveted on two courses at a time, and the brickwork which was built up to keep even with the top of the steel provided sufficient weight to sink the shell without other ballast. The shell was wedged against the timbering in the pit to guide it.

The tunnel running from the foot of the California shaft to the foot of one of similar construction at the Western pumping station, will be about 22,700 feet long. There are three intermediate working shafts along its line, and operations are now being carried on at one shaft under compressed air, and in the open at the others. The excavation is being kept as close to a 9½-foot circle as possible, and the lining will be concrete and two rings of shale brick with a fire-glazed surface for the part forming the surface of the tunnel. The conduit will have a grade of 1 in 2,000 toward the pumping station shaft, and will deliver water to the pumps by gravity, thus avoiding any suction lift here as well as at California. The construction of the tunnel has offered no serious difficulties yet, but it is possible that there may be some trouble in crossing below the bed of the Little Miami River. At this place it is proposed to hoop the brickwork with ¾-inch steel rods spaced 2 feet apart.

The steel shell of the shaft at the west end of the tunnel will be carried about 90 feet above ground, but the nozzles of the suction pipes of the pumps will be attached 93 feet below its top. There will be two sets of three pumps each, for which bids were opened a few days ago. The pumps of one set will have a capacity of 25,000,000 gallons each, while those in the other set are to be of 12,000,000-gallons capacity. All will be of the vertical triple-expansion crank-and-flywheel type.

The new works are constructed under the direction of a special Board of Trustees, "Commissioners of Water-Works," of which Mr. August Herrmann is president, and Mr. G. Bouscaren is chief engineer. The intake tunnel, pier and pump pit were under the direction of the late Alfred Petry, as resident engineer, until his death and since then under Mr. Wm. C. Jewett; the contractors were F. H. Kirchner & Company, of Cincinnati. The resident engineer at the settling reservoirs is Mr. Jewett and the contractor is Mr. August Henkel, of Cincinnati. The resident engineer on the tunnel from the clear well to the Western Pumping Station was Mr. Petry until his death, and is now Mr. John A. Hiller; the contractors are W. J. Gawne & Company, of Cincinnati. Mr. C. N. Miller is the assistant engineeer in charge of the engineering offices.

The Boone Viaduct.

The Boone viaduct carries the new short line of the Chicago & North Western Railway between Boone and Ogden, across the Des Moines River. It is a double-track steel structure, 2,685 feet in length, 185 feet maximum height, and weighs 6,196 tons. It has a 300-foot deck channel span and thirty-six viaduct trestle-bents, braced together in pairs to make towers 45 feet long and 75 feet apart, which are 19½ feet wide on centers at the top and batter 1 : 6 transversely on each post, giving a width of 69 feet 7 inches between centers of pedestals of the tallest tower. There are four lines of plate girders of a uniform depth of 7 feet. The tracks are 13 feet apart on centers, and it is 35 feet from out to out of the two cantilever sidewalks and refuges. The length and weight of this structure gives it first place among all viaducts which have yet been built. The single-track Loa viaduct in Bolivia is the highest of all, 336 feet, but it is much shorter and lighter. The new Kinzua and the Gokteik viaducts are higher than the Boone viaduct and are nearly as long. They are comparable in weight, and are both very recent structures with similar features.

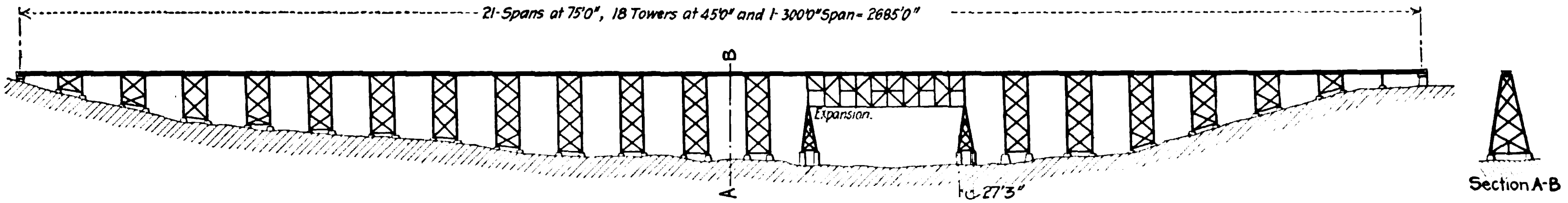
The old and new single-track Kinzua viaducts, 2,053 feet long and 301 feet high, were illustrated in The Engineering Record of December 1, 1900. They were both built on the same foundations and each had forty trestle bents about 10 feet wide on centers at the top, with colums battered 1 : 6 transversely, and about 103 feet apart on centers at the bottom of the tallest bent. They were braced together in pairs to make towers 38½ feet long and 61 feet apart. The old viaduct had lattice girder spans 6 feet deep, was proportioned for an engine load of 161,340 pounds and weighed about 3,500,000 pounds. In the new viaduct the towers have X-bracing in the longitudinal planes and horizontal braces but no diagonals in the transverse vertical planes. There are two lines of longitudinal plate girders 9 feet apart, those in the tower spans being 5 feet deep and those in the connecting spans 6 feet deep. The viaduct weighs 6,700,000 pounds and is proportioned for two 247,000-pound locomotives, a train load of 4,000 pounds per lineal foot and a track weighing 600 pounds per lineal foot. It was erected from both ends simultaneously by movable combination spans 208 feet long, which extended over one tower and two adjacent spans and from which the members of the old viaduct and the new one were hoisted and lowered.

The double-track and roadway Gokteik viaduct for the Burmah Railways Company is about 400 miles from Rangoon, and was fully illustrated in The Engineering Record of January 12 and 26, 1901. It is 2,260 feet long, 320 feet in maximum height, and weighs about 9,700,000 pounds. There are thirty-two trestle bents with the posts 24½ feet apart on centers at the top and battered transversely 5 : 24 so as to make them over 156 feet apart at the piers for the tallest bent. Fourteen pairs of trestles are braced together to make towers 40 feet long and 60 or 120 feet apart. Three bents are braced together to make a double tower in the deepest part of the valley, and there is one single bent at the end of the viaduct. The towers are built in stories about 40 feet high, and are braced in transverse and longitudinal planes with horizontal struts and stiff diagonals in every panel. All the connections, like those of the Kinzua viaduct, are riveted solid. There will eventually be four lines of main longitudinal girders, only enough of which for one track and the roadway are yet in place. For the 40-foot and 60-foot spans respectively these are plate girders 3½ feet and 5 feet deep, and for the 120-foot spans they are lattice girders about 12 feet deep. The roadway platform is decked over solid with steel plates, and the viaduct is proportioned for a load of 1,712 pounds per lineal foot on each track. It was erected from one end by a trussed steel pin-connected traveler, over 220 feet long and 60 feet high. The trolley hoists moved on the 166-foot overhanging arm and handled the viaduct members which were delivered to the rear of the traveler on top of the finished structure.

In designing the Boone viaduct such dimensions were chosen for the towers as would assure a base large enough for the resultants of all applied external forces to fall within it. This prevents any uplift at the feet of the columns either from brake action or wind pressure. The lengths of spans are such that the uniform depth of longitudinal girders is a mean between the greater theoretical economic depth of the long girders and the smaller one of the short girders. The 75-foot spans are proportioned for live and dead loads of 6,100 pounds and 1,400 pounds, respectively per lineal foot, and the 45-foot spans for 7,600 pounds and 1,250 pounds per lineal foot. Soft steel was used throughout, and it and the workmanship was as required by the specifications of the Chicago & Northwestern Railway Company. The trestle columns are made up of three I-beams riveted together with four lines of rivets to form an H-shaped cross-section and spliced in lengths of from 30 to 42 feet with web and flange plates. Between splices the flanges on each side of the column are stayed together by two 22-inch batten plates, with double rows of rivets, but they are not latticed together. The flange splice plates extend to form gusset connection plates for the field rivets of the diagonal braces in the transverse vertical planes. The diagonal tower braces in longitudinal planes are field riveted to jaw plates which are bent around the flanges of the columns and shop-riveted to their webs.

Transverse plate girders 4 feet deep are seated on side bracket shelves near the tops of the trestle columns, and are riveted across both the column flanges on both sides, thus making double girders on top of which the longitudinal girders are seated. Base plates are riveted to the foot of the columns and take bearing on cast-iron shoes 15½ inches high and 3½ feet square at the bottom. The columns are secured to the shoes by four bolts which, on one side of the tower, pass through close-fitting holes and retain it in a fixed position; on the other side of the tower these bolts pass through slotted holes which allow the column to slide transversely on a planed ⅜-inch phosphor-bronze plate which is there interposed between the base plate and the shoe.

Each shoe is anchored to the coping by four 1¼-inch wedge bolts nearly 3 feet long, and has in the center a long 1½-inch vertical bolt which engages a heavy bearing-washer built into the concrete footing under the pier masonry. This bolt has an upper nut bearing on a washer in the bottom of a hole countersunk below the top of the shoe, as shown in the sectional detail, so as to clear the base plate of the column. There are no horizontal struts in the towers except one on each side at the bottom. These and the X-braces are made of pairs of channels, latticed. Four longitudinal plate girders 7 feet deep and 6½ feet apart on centers, are seated across the top flanges of the transverse girders in each tower. Each girder has a 7/16-inch web and two 8 x 8 x ⅝-inch bottom chord angles 50 feet long, which overhang the outsides of the transverse girders about 1 1/3 feet clear at each end. The top flange is composed of two 6 x 4 x ⅜-inch angles 47 feet 10 inches long, with their horizontal flanges up, and two 6 x 3½ x ⅜-inch angles, about 45 feet long, with their horizontal flanges down. The upper half of the web is notched out at the ends of the 6 x 4-inch angles and the lower part is reinforced by a pair of ⅝-inch plates. Five pairs of vertical stiffener angles are riveted on to it, and across them a pair of horizontal shelf angles make a seat, at the outer end of which there is a beveled steel casting to receive the bearing of the drop-ended connecting girders.

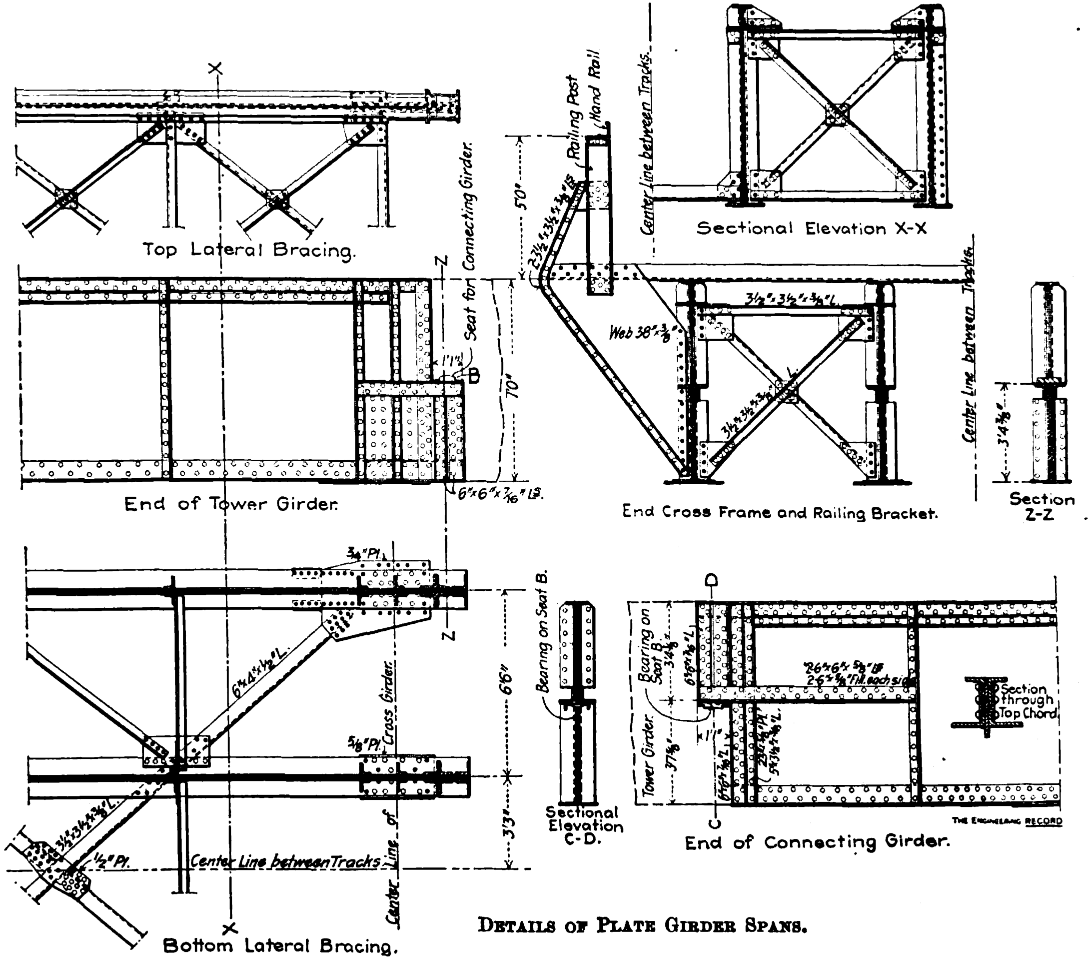


GENERAL ELEVATION OF THE BOONE VIADUCT, CHICAGO & NORTH WESTERN RAILWAY.

The girders are divided into intermediate panels about 7 feet long by pairs of 5 x 3½ x ⅜-inch vertical web stiffener angles which are milled to end bearings on the horizontal flanges of the 8 x 8-inch and the 5 x 3½-inch flange angles. These stiffeners are continued to the upper edge of the girder by short pieces about 9¼ inches long which are lined in with them and fitted in between the 6 x 3½-inch and 6 x 4-inch flange angles. The girders of each pair are braced together by transverse struts and X-bracing of single angles in the vertical transverse planes at each panel point, and by zig-zag lateral bracing in every panel in the planes of the top and bottom flanges.

The inside girder of one pair is braced to the inside girder of the other pair by two panels of X-brace angles and five transverse angles at the intermediate panel points in the plane of the bottom flanges. At each end of the span a 6 x 4-inch angle, 29 feet 4½ inches long, is riveted across the top flanges and to the upper edge of a solid-web knee brace on the outside of each outer girder. This knee brace receives the 10-inch channel vertical post for the hand rail, which consists of a 10-inch horizontal channel, with the flanges turned down, and a bulb angle riveted to the upper side of the web, as shown in cross-section.

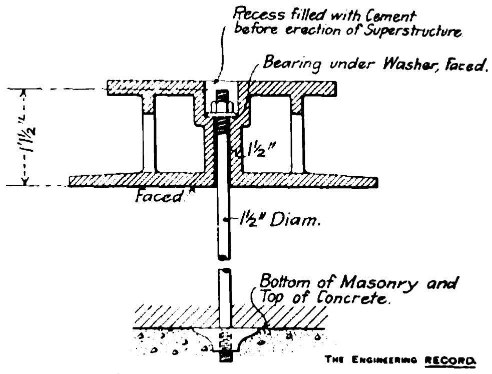
The 75-foot spans are similar to the 45-foot spans, except in the details of the end bearings of the girders, the dimensions of materials and the sections of the flanges. The 8 x 8 x ⅝-inch lower flange angles are 69 feet 11 inches long, and are reinforced by two 18 x ½-inch cover plates, one of them 50 feet 6 inches long and the other 36 feet 5 inches long. The top flange has two 6 x 4 x ⅝-inch angles, 72 feet 1 inch long, two 7 x 3½ x ⅝-inch angles 68 feet 2½ inches long, and two 8¼ x 9/16-inch side plates 39 feet 11 inches long, which cover the middle parts of the vertical flanges of the top flange angles. The lower part of the ½-inch web is notched out at both ends of the girder even with the ends of the bottom flange angles, and the overhanging upper ends are reinforced with four pairs of vertical web stiffener angles. The under side of the drop end has a forged steel bearing to be seated on the cantilever end of the lower girder. Vertical flanges are riveted on all four sides of each bearing plate to lock it over its support and prevent lateral or longitudinal displacement.



DETAILS OF PLATE GIRDER SPANS.

In the spring of 1899 field work was commenced with three gasolene engines operating drills with which test holes were made to explore the site for a considerable width on both sides of the center line of the viaduct from end to end. Clay, shales, sandstone, fire clay and bituminous coal were encountered. At the ends of the viaduct the foundation pits were dug about 14 feet deep in a very thick deposit of hard blue and yellow clay, and concrete footings from 4 to 6 feet deep were laid in them of such dimensions that the pier load above them would not cause a foundation pressure greater than 4,000 pounds per square foot. Nearer the river where the clay stratum was not so deep the excavations were carried through it and the footings generally laid on black shale on which a pressure of 6,000 pounds per square foot was allowed.

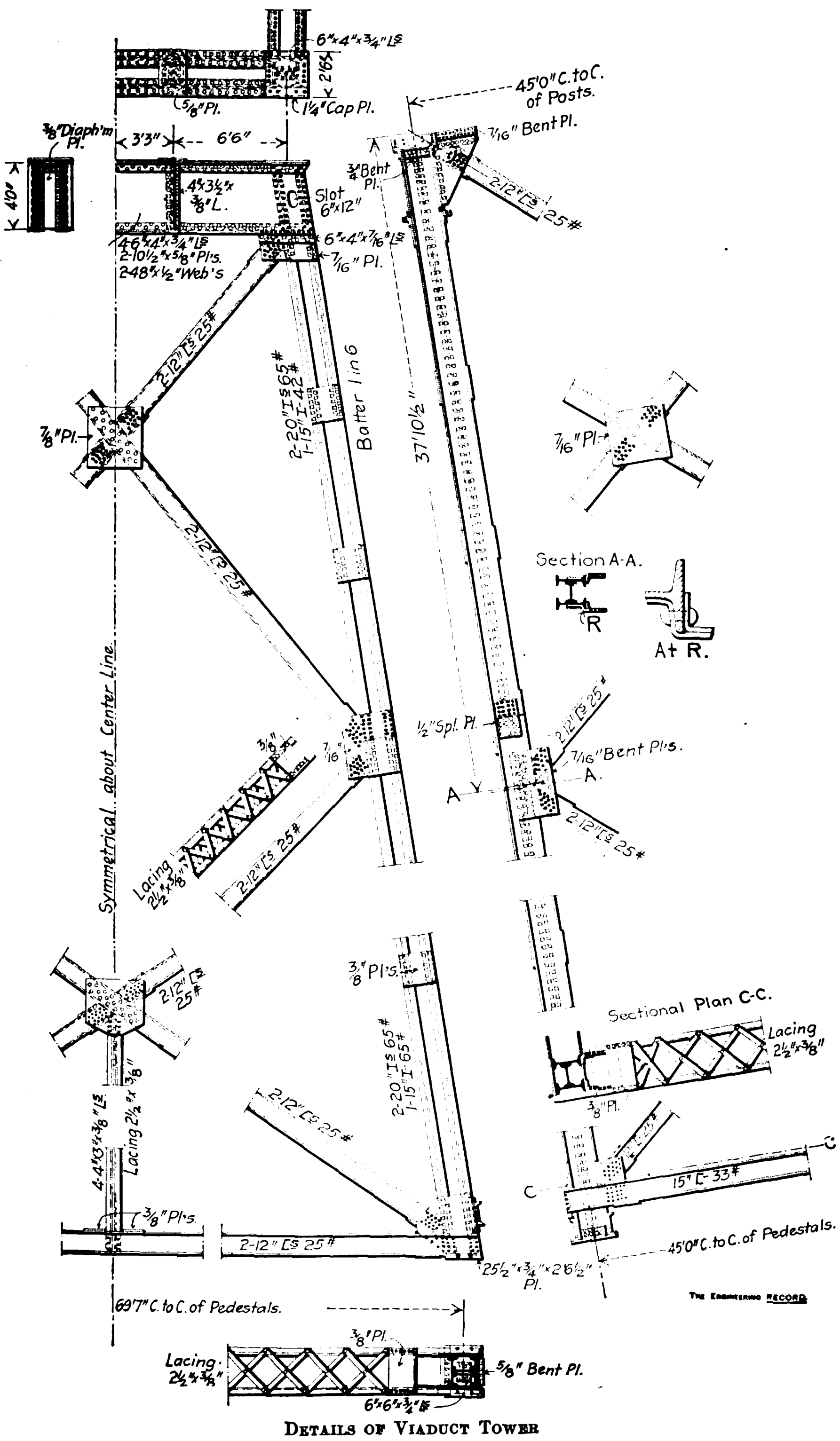
Beyond these piers piles were driven in a deep deposit of sand, cut off at water level, capped with concrete, and loaded up to 30,000 pounds each. Square piers of Mankato limestone, laid in Portland cement mortar were built on all the concrete footings. Each side was battered 1 : 6 to a top width of 5 feet and pedestal blocks of Ableman's sandstone were set on top of the coping and secured to it by anchor bolts through the column bases. The abutments have 50 x 30-foot rectangular bases and battered faces, reinforced, on the front side with three wide wedge-shaped buttresses. When first built they rose 30 or 40 feet above the surface of the ground, but afterward the embankment was filled in around them up to the coping in front.



ANCHORAGE OF PEDESTAL.

The 300-foot channel span is supported at each end on a wedge-shaped steel tower, with longitudinal and transverse center lengths of about

27¼ feet and 43¾ feet at the base. Each of the four inclined columns is supported by a separate cylindrical pier, 10 feet in diameter, which is founded on sandstone from 42 to 46 feet below water level. The piers are of concrete enclosed in a steel shell ⅝ inch thick, which was built in successive sections 5 feet high. The lower section of each is 8 feet high with a steel diaphragm 1 foot below the upper edge to form the roof of a working chamber when the section was sunk as a pneumatic caisson. A 3-foot steel air shaft was built up from the middle of the diaphragm and the space between it and the steel shell was filled with concrete to sink the caisson. The upper sections of the 10-foot shell thus served as a cofferdam, and with the sections of the air shaft were successively added as the caisson sunk, so as to keep the upper edge always above water level.



Details of Viaduct Tower

A Moran air look was used on top of the air shaft and was shifted from pier to pier when the shafts were extended. The excavated material was hoisted from the working chambers in buckets and the caissons were sunk as much as 16 feet a day through sand and an average of 2 feet a day through hard shale. The caisson work was commenced February 7, 1900, and the piers were all completed and the coping set June 6. A temporary service bridge on pile and trestle bents was carried across the river, about 25 feet above water level, alongside the permanent structure, and served for the distribution of materials. A power plant with two 60-horsepower boilers, pumps, electric light dynamo and two Ingersoll-Sergeant air-compressors was established on one side of the river and the pipes and wires were carried across to the opposite pier under the roadway of the service bridge.

The viaduct was designed and constructed under the direction of Mr. E. C. Carter, chief engineer, and Mr. W. H. Finley, principal assistant engineer of the Chicago & North Western Railway Company, and Mr. G. S. Morison consulting engineer, and was built by the Chicago Branch of the American Bridge Company. This description has been prepared from the official blue prints and from an article by Mr. W. C. Armstrong in "The Iowa Engineer."

An Interesting Old Suspension Bridge.

The highway suspension bridge across the Guyan River at Guyandotte, W. Va., was built about 53 years ago, and its design includes some quaint details very different from present standards of construction. It has a span of about 450 feet and an 18-foot roadway, which is suspended from four main cables about 3 inches in diameter, passing over stone towers. Each cable is made of straight charcoal-iron wires about ⅛ inch in diameter, laid continuously around U-shaped shoes similar to those now used. At each splice, the ends of the wires were flattened like the shanks of a fish-hook, and after being lapped past each other were tightly wound with fine wire, which made a strong joint. The cables were laid on shore and then carried across the river on men's shoulders and erected on falsework built for the purpose. The cable shoes engage flat pins about 3 x 6 inches in cross-section, and were adjusted by driving several pairs of iron wedges, if necessary, between the pin and the end of the shoe. The pin engages two iron loops which in turn are pin-connected to a single eye-bar, and that is connected at the opposite end to two eye-bars, and so on, down into the masonry anchorage.

The top of each tower is capped by a flat cast-iron plate about 6½ feet square with vertical flanges enclosing the top of the masonry on each side. On the upper surface of the plate are two longitudinal flat ribs on which three transverse pins roll between projecting tranverse guard ribs front and back. The middle pin is 12 inches and the two outside pins are each 6 inches in diameter, and all of them have flanges at both ends. The two cables are flattened to a width of about 9 inches each at the towers, where they take bearing on these pins instead of on expansion saddles. The main cables are wrapped for lengths of about 3 inches a foot apart, and all their wires are clamped together with flange collars which have a horizontal bolt through the lower ends to receive the upper end of the suspender. The suspenders are ¾-inch wire ropes made like the main cables, of continuous straight wires wound around beckets at both ends. At the upper end there is a single becket engaging the bolt in the cable collar, but at the lower end the wires are divided into two equal strands, each of which is laid over a separate becket. These strands are separated to form a forked end which engages the eye of a vertical bolt with a nut on the lower end to support the floorbeam and provide vertical adjustment for it.

Some fighting was done around the bridge in the civil war, and many of the cable wires are flattened and marked where they were struck by bullets. The bridge was recently examined by Mr. S. A. Cooney, engineer of the bridge department of the John A. Roebling's Sons Company, which has repaired many similar suspension bridges in that section of the country, evidently designed and built by the same people and of the same materials. Mr. Cooney reported the bridge as safe and serviceable and in excellent preservation. There was no serious corrosion and the wires appeared to be the same as those of some of the other bridges mentioned which he had tested after many years service and found to have a breaking strength of 88,000 pounds or over per square inch and to develop 95 per cent. of the strength of the wire in the splice.

Wood Block Pavement on 6 inches of concrete and 1 inch of sand will be laid on the leading street of Springfield, Mass., at a contract price of $2.85. The blocks will be treated by the creo-resinate preserving process at the plant of the United States Wood Preserving Company, described in The Engineering Record of September 2, 1900.

the two legs of the siphon was provided an enlarged chamber in which the air separated from the water. The water was then led off from the lower part of this air chamber and passed off through the short leg of the siphon, the pressure of the air accumulated in the air chamber being therefore due to the height of water maintained in the shorter leg of the siphon. This application of carrying upward the water, after the air was separated from it, so as to produce a considerable pressure upon the air, seems to have been original with Mr. Frizell, and in this feature his device differs from the old trompe.

Mr. Frizell made two working models of this type of apparatus. In the first the legs of the siphon were 3 inches in diameter, the head of water being 25 inches, and an efficiency of 26½ per cent. was obtained. The second model has already been mentioned.

Another air compressor, differing somewhat from that of Mr. Frizell, was invented by A. Baloche and A. Krahnass in 1885, and consisted of a siphon carrying water from an upper to a lower reservoir, the lower end of the siphon being projected through an inverted vessel placed nearly at the bottom of the second reservoir. Just beyond the bend of the siphon, and in line with the vertical axis of its longer leg, an air pipe projected into the descending leg of the siphon, thus entraining the air with the descending column, which carried it down into the inverted chamber, from which the air escaped at the top, while the water passed out from the bottom into the lower reservoir. This apparatus produced pressure on the air in the top of the inverted chamber, due to the height of the water column upon it. Another device patented by Thomas Arthur in 1888 dispensed with the siphon and had the air pipe rising through the vertical pipe down which the water passed to the chamber at the bottom of the shaft.

A number of patents on apparatus of this type were issued to Charles H. Taylor in 1895. His inventions consisted principally of a down-flow passage having an enlarged chamber at the bottom and an enlarged tank at the top. A series of small air pipes projected into the mouth of the water inlet from the large chamber at the upper end of the vertically descending passage, so as to cause a number of small jets of air to be entrained by the water, Taylor seemingly having been the first to introduce the plan of drividing the air inlets into a multiplicity of smaller apertures evenly distributed over the area of the water inlet. Taylor at first seems to have attempted to utilize centrifugal action in causing the separation of the air from the water in the larger chamber at the bottom of the compressed column; but he afterward abandoned this scheme and used, instead, deflector plates in combination with a gradually enlarging section of the lower end of the down-flow column, in order to decrease the velocity of the air and water and cause partial separation to take place. The deflector plates changed the direction of flow of the water. This was evidently intended to facilitate the escape of the air.

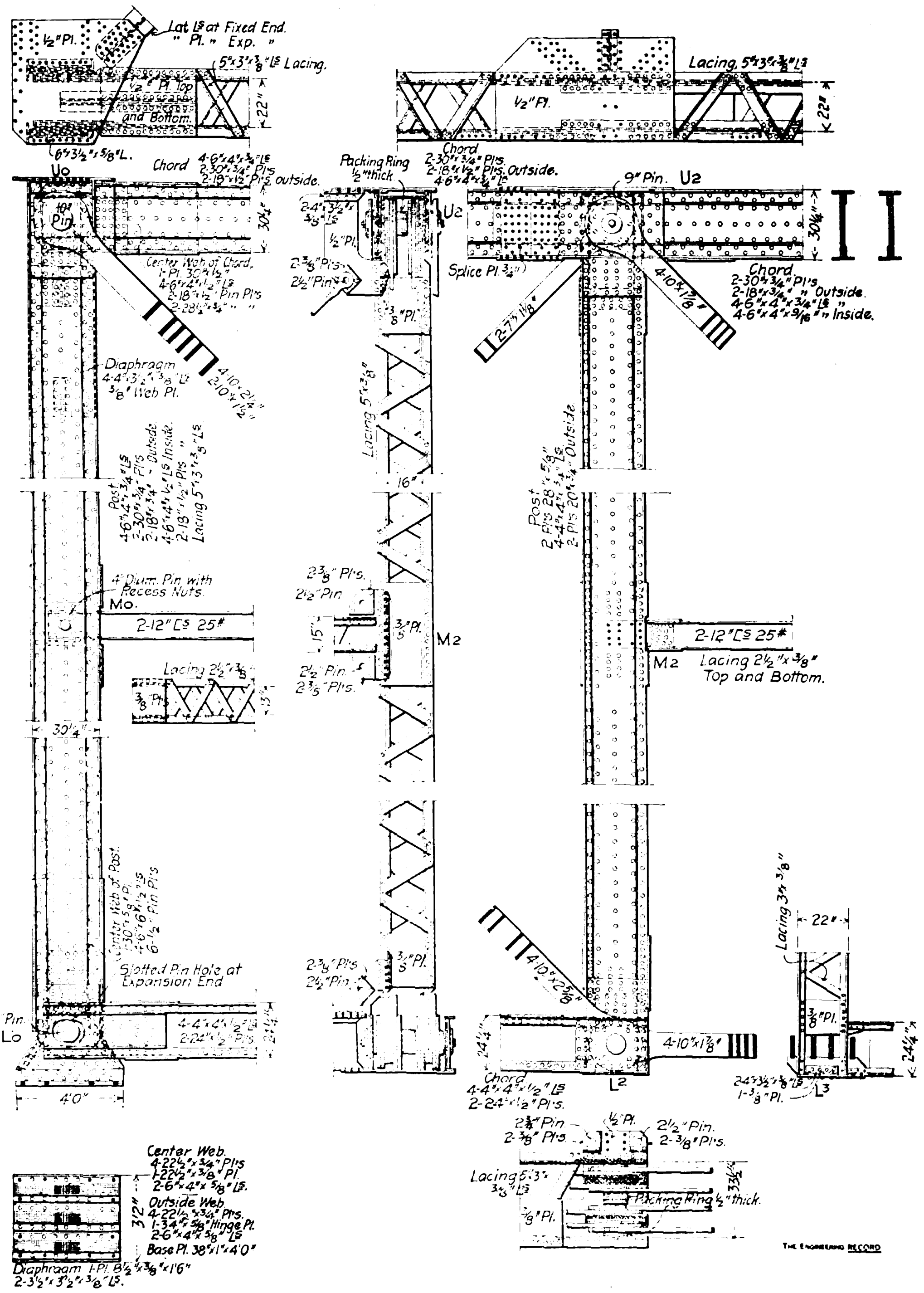
The latter improvements on this device have been in the method of introducing the air into the mouth of the downwardly flowing water column, so as to insure the largest proportion of air being taken down with the water, and in methods of decreasing the velocity of the combined air and water at the bottom of the descending column, causing the water to part more readily with the air, the water then passing out at the bottom of the enlarged chamber into an ascending shaft, maintaining upon the air a pressure due to the height of water in the uptake, the air being led off from the top of the enlarged chamber by means of a pipe.

The Boone Viaduct.

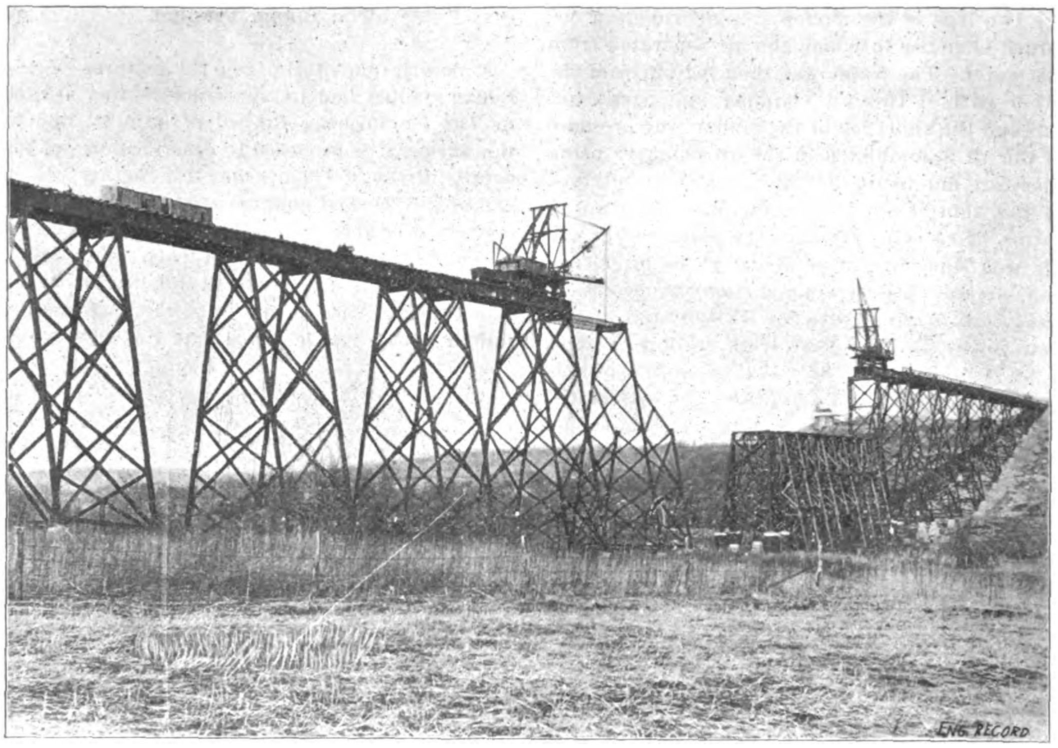
A description of the general features of the Boone viaduct and its substructure was printed in The Engineering Record of July 13, and in this article it is proposed to describe some of the details of the steelwork and its erection. Each end of the 300-foot channel span is supported on a steel tower about 80 feet high, which has a pair of columns in the plane of each main truss. These columns are battered longitudinally so that they are 27¼ feet apart at the base and are united with a single cap at the top. Each column has a rectangular cross-section, nearly 2 feet square, made with three cover plates and four corner angles, inside, with one face of the column latticed. At intervals of 9 feet or more, each column is stiffened by an interior horizontal diaphragm, which is an octagonal plate connected to the four faces of the column with pairs of angle clips. In the lower parts of the columns these plates are solid, but in the upper parts of the columns they have a 15-inch hole in the center, leaving merely a ring connected to the column sides at four equi-distant points. Projecting gusset plates are riveted in pairs to both sides of the columns to receive the field-riveted connections of the X-braces in all four faces of the tower. These braces are all pairs of 12-inch channels, latticed together and having at intersection pairs of rectangular plates which are shop-riveted to the continuous brace, and field-riveted to the ends of the other brace, which is cut to clear it.

The two columns in each longitudinal bent are connected at the top by two cover plates 16 feet deep, between which there is a center vertical transverse diaphragm made with a vertical plate and four 6 x 6-inch angles. The cap is a ¾-inch plate about 4 feet square which receives the tower girders and the top chord of a double transverse lattice girder 8 feet deep and 5 feet wide at the bottom, the two webs of the girder lying in the planes of the batter posts. At the base of the tower there are longitudinal and transverse horizontal struts and the pedestals are shop-riveted to the columns and are provided with vertical angles and bent plates forming pockets, on the upper edges of which the anchor bolts have nut and washer bearings.

The 300-foot channel span has two deck Pratt trusses with the panels divided by sub-verticals which support the middles of the top-chord sections. The main diagonals are made in two



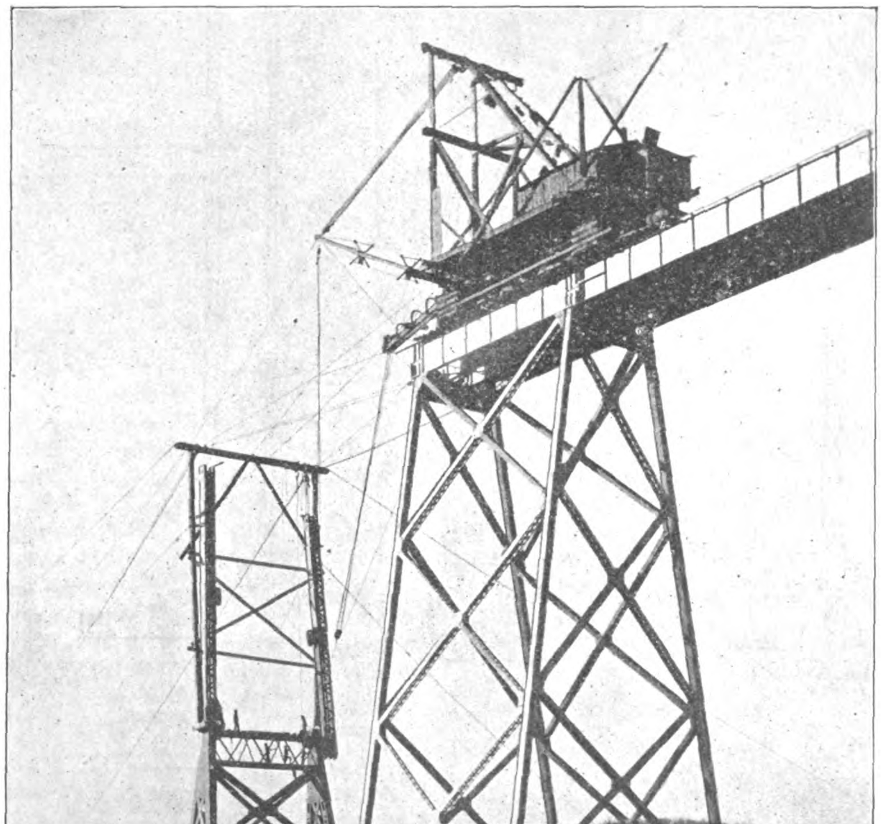
Details of the 300-Foot Channel Span.



The Boone Viaduct During Erection.

lengths, pin-connected to the sub-vertical posts, struts and floorbeam suspenders, and having increased cross-section in the upper bars. All panel and sub-panel points are pin-connected, but the horizontal longitudinal struts in the centers of alternate panels are riveted to the main vertical posts. The top chords have no cover plates, but are latticed top and bottom and are field-spliced 3 feet from the main panel points. At each end of the bridge there is a stiff bottom chord, similar in cross-section to the top chord and extending for two panels; the remainder of the bottom chord is composed of 10-inch eyebars in double panel lengths with 9-inch pins. The middle of each eyebar is supported on a notched plate riveted across the bottom of a vertical suspender connected to the middle of the main diagonal. The suspender is made of two pairs of angles latticed and braced at the bottom by a light transverse strut.

The floorbeams are seated across the top chord to which they are knee-braced by bent angles riveted to each side at both ends, and their bottom flanges are riveted to horizontal tie-plates projecting inside the top chords and receiving the pairs of angles which form the top lateral diagonals. The main vertical posts are braced at the middle points by horizontal transverse struts with vertical end plates field-riveted to the post webs. The bottoms of the main vertical posts are braced by transverse struts which have at each end a horizontal bottom-flange plate riveted across the lower end of the post outside the lower-chord eyebar heads, and a vertical gusset plate which is riveted to its upper flange and to the inside web of the post.

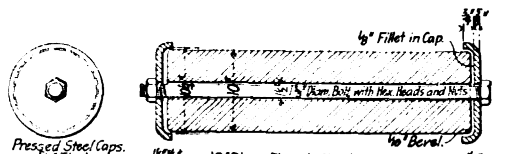


Erecting the End Post of the 300-Foot Span.

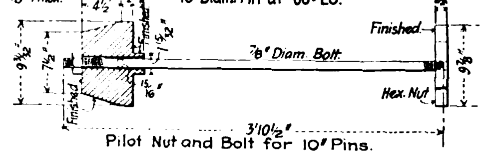
The lower lateral rods are pin-connected to the plates on the bottoms of the main posts, and the sway-brace rods are pin-connected to the connection plates at the ends of the transverse struts. At the upper end of the vertical post there is no transverse strut and the sway rods are connected there to a U-shaped vertical transverse plate, cut to clear the top chord and riveted with flange angles to the web of the vertical post and to the lower flange of the floorbeam.

The trusses are seated on ordinary shoes, which are pin-connected to the lower ends of the end vertical posts and are riveted to the tops of the steel towers. The ends of the stiff lower chords engage the 10-inch shoe pins with slotted holes 14½ inches long which permit temperature elongations. The end longitudinal struts have also slotted holes for the pins through the middles of the vertical posts, but there is no provision for expansion adjustment in the top chords. The end posts of the trusses therefore act as rocker bents, fixed at the bottom and moving longitudinally back and forth at the top.

Each of the main truss pins has a 1½-inch hole drilled through the center from end to end, and through it passes a 1⅜-inch bolt with a nut at each end. The nut secures a flanged steel disk which covers the end of the pin instead of a nut and leaves the pin a plain cylinder without shoulders or threads. For erection purposes the disks were removed and at one end of the pin a short frustum of a cone was set with a shoulder fitting the center hole to serve as a pilot nut. It was secured to the pin by a ⅞-inch bolt with an ordinary nut bearing on its point and a large, thin hexagonal nut on the opposite end which bears on the end of the pin.



10" Diam. Pin at Uo-Lo.

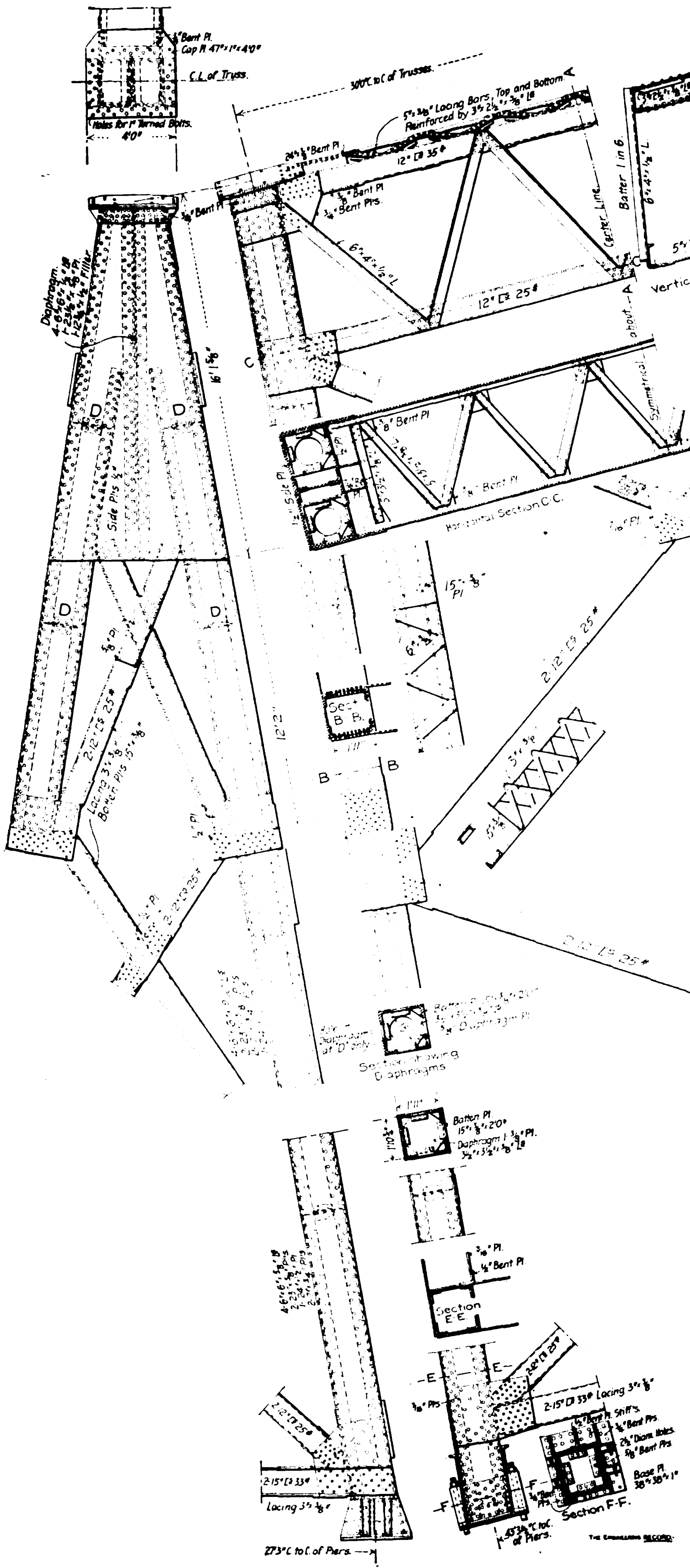


Pilot Nut and Bolt for 10" Pins.

The Engineering Record

The viaduct was erected from both ends simultaneously by overhead travelers running on top of the completed structure and assembling it one panel in advance in the usual manner.

The travelers were alike and each had a horizontal floor platform elevated 9 feet above the rail level on four pairs of standard-gauge trucks on tracks 13 feet apart on centers. At the forward end of the platform there was a transverse bent with three vertical steel posts 50 feet high, capped and braced to the rear of the platform by two inclined posts from near the middle of the cap, and by guy rods from the ends of the cap. An intermediate horizontal strut, with inclined posts from the ends to the rear of the platform, divided the bent into two vertical panels, each of which was braced by sway diagonals. A boom was seated on the sill of the vertical bent on each side of the center post. One of them, 90 feet long, was made of two 9-inch channels, latticed together and trussed by rods running from end to end over two sets of intermediate spreaders on each of the four sides. This boom was raised and lowered by a topping lift and could swing through about 75 degrees horizontally and vertically. It was swung by hand lines and had a capacity of 10 tons. The other boom was made of two 18-inch I-beams 51 feet long, on the upper flanges of which were two trolley hoists. It had a capacity of 16 tons at the extremity and was swung about 30 degrees horizontally by hand lines. It was not adjustable vertically but was supported at the end and at two intermediate points by fixed guys to the top of the vertical bent. The traveler was counterbalanced by the hoisting engine, boiler, coal, water, etc., and when in service was blocked up off the wheels and anchor-bolted to the girders of the assembled viaduct. The viaduct members were received at grade at both ends of the structure and brought on cars which ran underneath the traveler platform and delivered to the trolley hoists of the 51-foot boom, which set the plate girders in position and lowered the tower members to the ground, whence they were raised and set in place by the 90-foot boom.



Tower of 300-Foot Span.

For the erection of the 300-foot channel span transverse rows of six vertical piles each were driven in the river bed under each panel point, and capped just above water level. On these caps were set three-story framed bents of Oregon fir with four vertical and two batter posts each. Each bent had transverse X-bracing, and was held longitudinally by the 8 x 16-inch stringers and by lines of horizontal timbers at the bottom of each story. The two end panels and one intermediate panel of the falsework were farther braced by single crossed diagonal struts in each story in the planes of the batter posts, thus making three towers and five unbraced panels, one of the latter having X-bracing in the lower story only. The span was erected on top of the falsework by one of the viaduct travelers running on the top chords of the assembled trusses and setting two panels in advance. The field rivets were driven by pneumatic hammers operated by air provided by gasoline compressors.

The bridge was designed and constructed under the direction of Mr. E. C. Carter, chief engineer, and Mr. W. H. Finley, principal assistant engineer of the Chicago & Northwestern Railway Company, and Mr. G. S. Morison, consulting engineer. It was built by the Chicago Branch of the American Bridge Company, and was erected under the supervision of Mr. T. W. Cartledge.

A Gauging Orifice is used in the Albany filter plant for measuring the effluent of each filter. It is 4 inches high and 24 inches long, and is made in a ¼-inch brass plate, the sides of the opening being beveled away to a 1/32-inch edge. A year ago, Mr. G. I. Bailey, superintendent of the Water Bureau, and Mr. Allen Hazen, designer of the filters, made a series of gaugings of the discharge of the orifice. It was found that with heads of 6 to 18 inches, averaging 1 foot, the coefficient of discharge was very close to 0.630, whether the discharge was free or submerged.

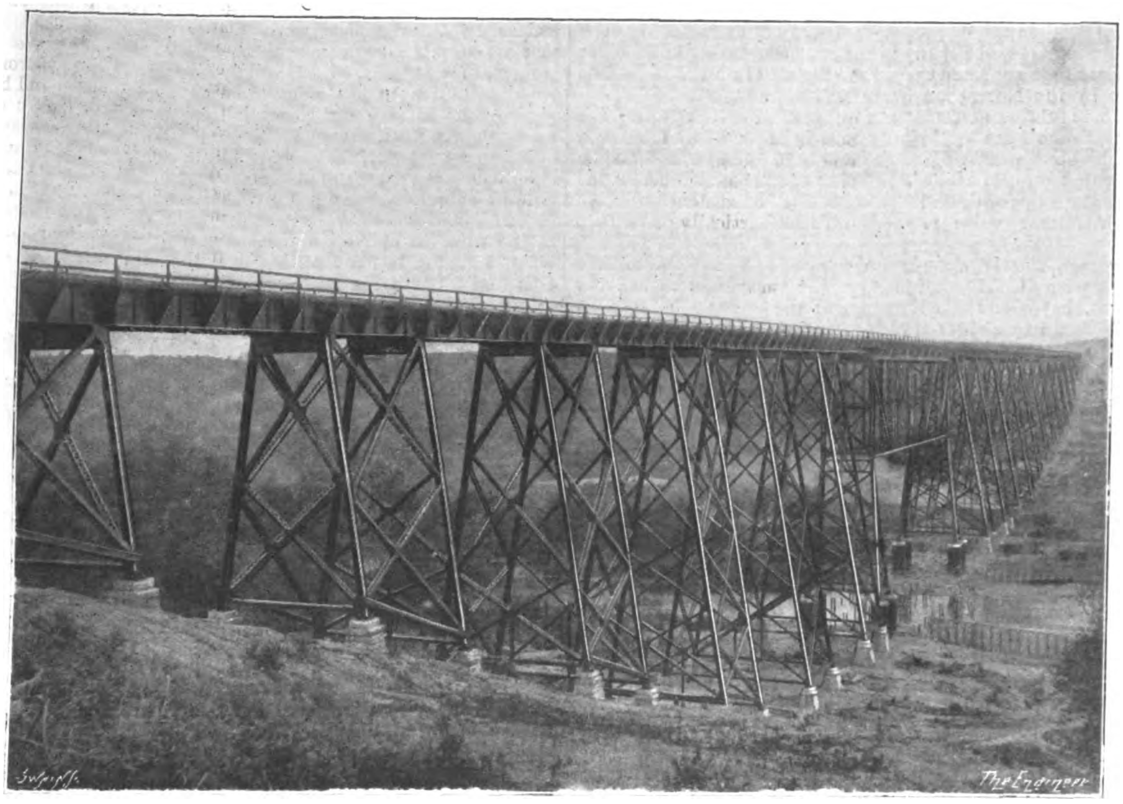
The Driving of the Simplon Tunnel kept pace with the contract requirements up to the close of last year, according to a report just published by the State Department. At that date the permanent ventilation system was installed at the southern portal, but the northern plant was unfinished; a temporary plant had been installed, however. The total work in feet done up to the beginning of the current year was as follows:

End.	North.	South.	Total.
Tunnel 1	13,510	10,325	23,835
Tunnel 2	13,395	10,332	23,727
Complete excavation, 1	10,667	7,708	18,375
Complete lining, 1	9,423	6,626	16,0[illegible]

The advance in tunnel 1 during 1900 was 30.5 feet daily, half a foot less than in 1899. There was a working force in December, 1900, of 1,252 men outside and 2,663 inside the tunnel. The total expenditure up to the end of the second working year on September 30, 1900, was $3,474,000.

THE DES MOINES STEEL VIADUCT.

Among the numerous improvements upon the Chicago and North-Western Railway, U.S.A., is the construction of what is known as the Boone cut-off—a short high-level line crossing the valley of the Des Moines River and superseding the original line which ran down the valley to a low-level bridge and ascended again to the level of the main plateau. The reconstruction of this part of the line is warranted by the great growth of traffic and the enormous increase in train loads, the operation of which will be greatly facilitated. The financial conditions of the company also warranted the expenditure of the money involved in the construction of the line and its heavy works, which would have been out of the question at the time the line was originally built.



THE DES MOINES STEEL VIADUCT

The new line is 7½ miles long—a saving of three miles in distance—and its maximum gradients are 1 in 160, as compared with 1 in 66 on the old line. The sharpest curves also are of 2865ft. radius instead of 955ft.; while the total length of the curves aggregates only half a mile, instead of nearly six miles. The curves on the new line also aggregate an angle of only 67½ deg., while those on the old line aggregated about 900 deg. These figures will give some idea of the much better facilities for operating traffic on the new line, and point to the advantages which are likely to accrue from the change of route. This work is characteristic of a large amount of work now in progress on many of the great railway systems in the United States.

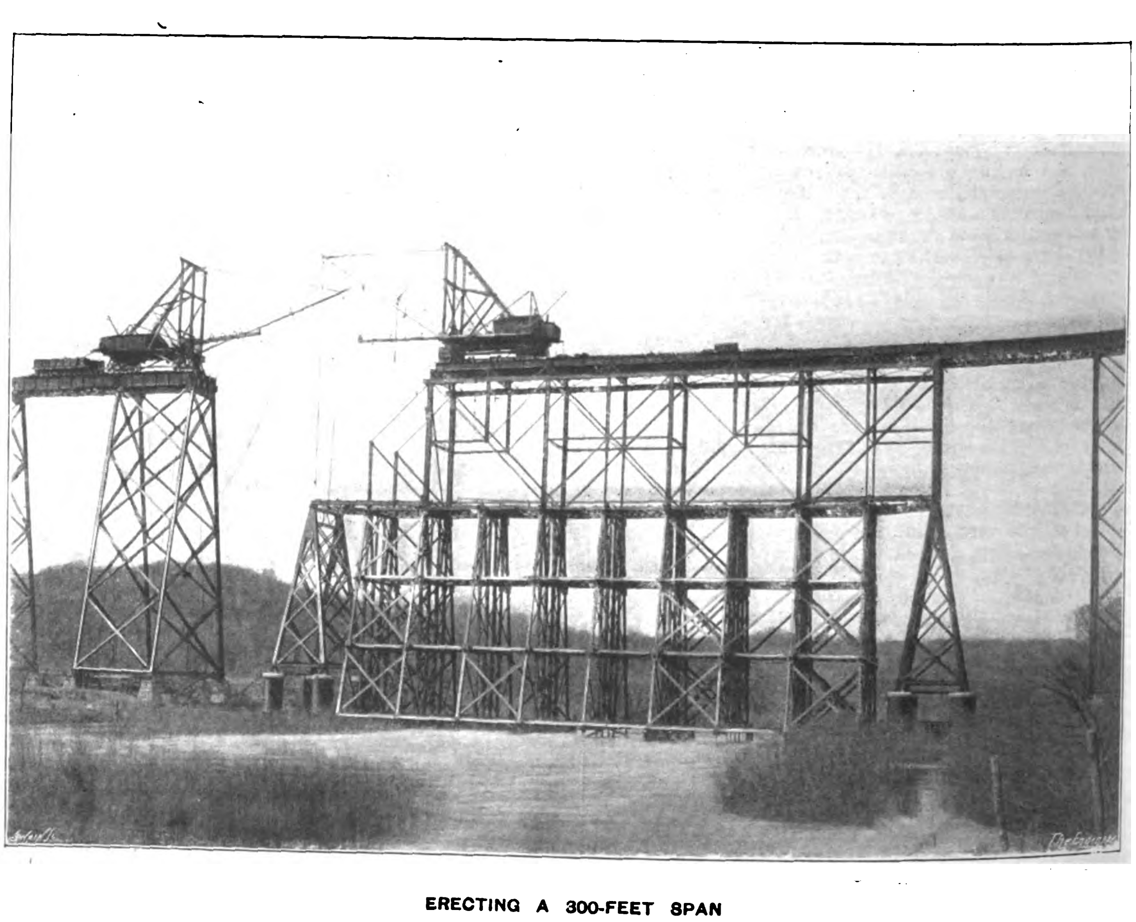
The most important structure on the line is a double-track steel viaduct, 2685ft. long, across the valley. This has a 300ft. span over the river, the rails being 210ft. above the water level, as compared with 58ft. at the low-level bridge on the old line. The viaduct consists of twenty-one plate girder deck spans of 75ft., alternating with 45ft. spans on the tops of the steel towers which form the supports. The 300ft. span is a steel truss, resting upon steel towers of triangular form in side elevation. The structure is double track throughout, with tracks 13ft. between centres, and it is the longest structure of its kind in existence, although several other steel viaducts exceed it in height, as will be seen by the following table of viaducts. The weight of metal is about 5680 gross tons, exclusive of foundation cylinder piers, hand railing, guard rails, and extra material for widening the floor for four refuges on each side. The viaduct was designed under the direction of Mr. E. C. Carter, chief engineer of the Chicago and North-Western Railway, and Mr. W. H. Finley, bridge engineer. It was built by the American Bridge Company. Erection was commenced in November, 1900, and the first train passed over on May 19th, 1901.

The abutments and the pedestals for the legs of the steel towers are of stone masonry. The abutments and the pedestals for the shorter towers were built in pits excavated in hard clay, and given a foundation bed of concrete 4ft. to 6ft. thick, the pressure on the base of the concrete being limited to two tons per square foot, or three tons in some cases. For the higher towers, near the river, piles were driven, cut off at the water level, and capped with a bed of concrete. A pressure of 15 tons per pile was allowed. All the piers or pedestals are 5ft. square on top, with a batter of 1 in 6, and the base area varies from 12ft. to 20ft. square.

The two towers carrying the 300ft. span are each supported by four steel cylinder piers, sunk by the pneumatic process. Each pier is 10ft. diameter, built of ⅜in. plates 5ft. high, riveted on as the piers were sunk. The bottom section was 8ft. high, with a steel roof, giving a working chamber 7ft high. They were all sunk by the pneumatic process, the concrete filling giving the necessary weight, and an air pressure of about 23 lb. in excess of atmospheric pressure being used. The progress varied from 16ft. per day through the sand near the surface to 2ft. per day in the stratified material at greater depths. All the piers were sunk to a sandstone stratum, about 45ft. below the surface.

Each of the two towers for this 300ft. span consists of two triangular or A-shaped frames, 81ft. 1½in. high, with a spread of 27ft. 3in. between centres of legs at the base. The two frames are 43ft. 3½in. apart at the base, but are not vertical, having an inward inclination or batter of 1 in 6, so that their tops are directly under the trusses, which are 30ft. apart. The columns are of rectangular box section, 23in. square, with four steel angles and three cover plates; the fourth side has two narrow plates with lacing bars across. The legs are formed together at the base by horizontal members consisting of double 15in. channel bars with lacing over the flanges. At the apex, a ½in. triangular plate is riveted over the columns of each A frame, and between these are two transverse Warren trusses 8ft. deep. All the diagonal members consist of pairs of 12in. channel bars, laced over the flanges, and having ample connection and intersection plates.

The 300ft. span is composed of two rectangular deck trusses of pin-connected construction, 60ft. deep, and spaced 30ft. apart. There are five main panels 60ft. long, divided into 30ft. sub-panels. The three middle panels have the bottom boom composed of eye-bars, while in the end panels this boom is of box section, with two web plates 24½in. deep, 33½in. apart, with outside flanges and top and bottom lacing. The top boom is of similar construction, but with web plates 30¼in. deep, and 22in. apart. The end posts are 29in. by 30¼in., with three web plates, all having double flange angles. Between the intersection points run longitudinal struts of 12in. channels in pairs, while to the intermediate verticals forming the sub-panels are attached the bottom transverse struts. In order to allow for expansion and contraction, one of the end posts is formed as a rocker, with slotted holes for the pins in the bottom boom and longitudinal strut, in which the pins can slide. To keep the height of the towers as low as possible, the transverse floor beams are set on top of the upper boom, and upon these again are the plate girder longitudinals carrying the sleepers and permanent way.



ERECTING A 300-FEET SPAN

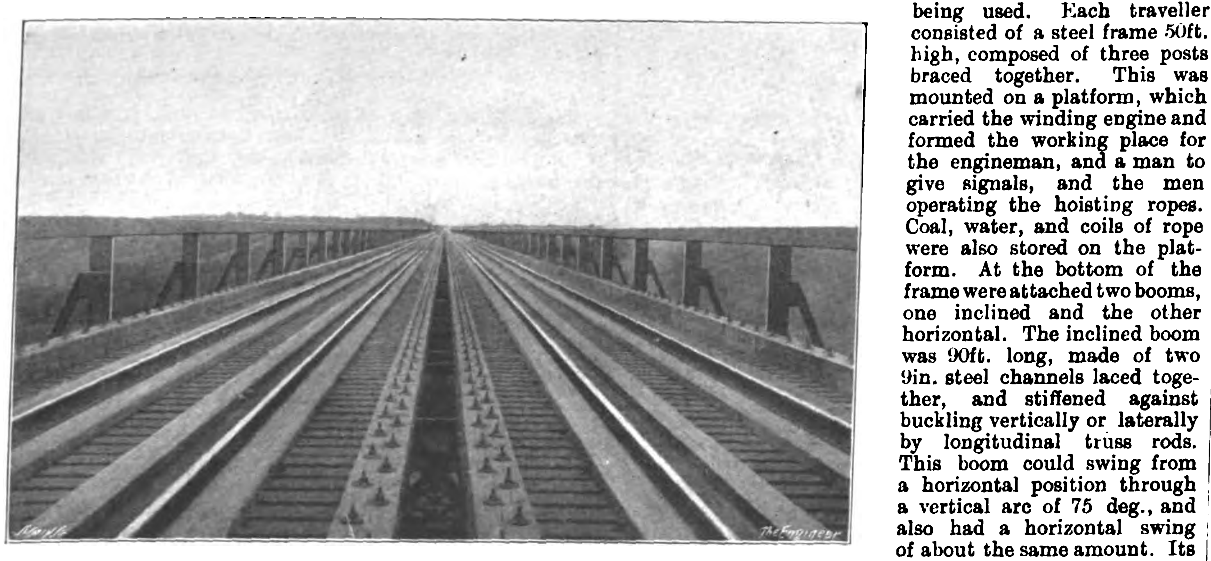
The steel towers carrying the viaduct spans are of the four-post type, 45ft. long, parallel with the railway, the two posts, or legs, on each side being parallel. They are 19½ft. apart transversely at the top, and batter outwards with an inclination of 1 in 6, so that the highest towers have the legs about 70ft. apart at the base—in a plane transverse to the line of the bridge. In a paper describing this structure, Mr. Armstrong, the resident engineer, pointed out that the usual practice in viaduct construction is to make the tower span about half the length of the open or intermediate spans; 30ft. and 60ft. respectively are very generally adopted. One difficulty met with in this arrangement is in regard to the depth of girder. The longer the span the greater must be the girder depth, for economy. It is therefore necessary to make the 60ft. girders much deeper than those of 30ft., but this usually involves objectionable details in connecting the two girders of different depth to the same column. It is, however, possible to vary the depth of a girder 6in. or even 12in. from the theoretical economic depth with a very slight sacrifice of material. For this reason, and to overcome the objectionable feature of varying depth, the lengths of 45ft. and 75ft. were adopted for the tower and intermediate spans respectively of the Des Moines viaduct; the girders were then all made of a uniform depth of 7ft., which is a medium between the economic depths for each. Another reason for adopting the 45ft. tower span was to give a sufficient spread at the base, so that the sudden stopping of a train on the viaduct would produce no uplifting strain at the base of the columns. The transverse spread, due to the batter, is sufficient to prevent any uplifting tendency from the effect of transverse wind pressure.

Each column of the tower is composed of two 20in. steel joists and a 15in. steel joist riveted between, forming a column of H section, with the web transverse to the centre line of the viaduct. Batten plates are riveted across the flanges at intervals. Between the tops of the columns are two pairs of transverse plate girders resting on angle brackets. These girders are 20ft. 9in. long and 40ft. deep, and those of each pair are connected by batten plates, or distance plates, giving a width of 30in. over the outer flange angles. At the base the columns are tied together by four horizontal struts, each composed of a pair of 12in. channel bars, set with flanges inward, and having intersecting lattice bars riveted to the flanges. These are the only horizontal struts. The diagonal members in both planes are all of similar construction to the above, except in having single lacing bars in place of lattice bars. They have square plates at the intersections, and the ends are riveted to heavy connection plates on the columns.

The foot of each column rests on a cast iron shoe 15in. high, 31in. square on top, and 42in. square at the base, where it rests on the stone cap of the masonry pier or pedestal. Two diagonally opposite shoes of each tower are fitted with expansion bearings, to allow of horizontal movement of the base of the column, a bronze bearing plate ⅜in. thick and 25¼in. by 30½in. being placed between the foot of the column and the shoe. For the expansion bearings, the holes for the bolts attaching the column to the shoe are 2½in. diameter, while the holes at the fixed bearings are $1\frac{1}{16}$in. diameter. Each shoe is anchored to the masonry by five bolts. Through the middle of the casting passes a 1½in. bolt, which extends down to the concrete, and has a cast washer under the masonry. At each corner of the casting is a 1¼in. bolt 34in. long, with a split end.

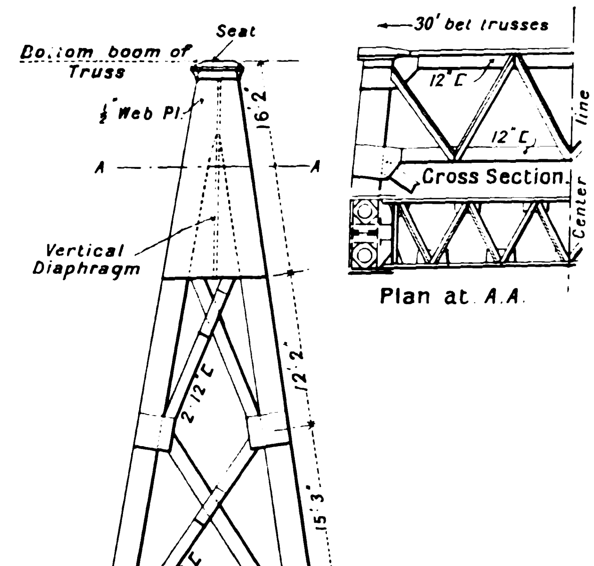
The superstructure consists of four lines of deck plate girders all 6½ft. apart between centres. Each pair has diagonal bracing frames, while bottom horizontal bracing extends across the four girders. The girders are of 45ft. and 75ft. span alternately, but are all 7ft. deep, as already noted. The ends are halved, the projecting upper part of each 75ft. girder resting on the projecting lower end of the adjacent 45ft. girder. The longer spans have ½in. web plates and the shorter spans $\frac{7}{16}$in. plates. The bottom boom is formed by two flange angles 8in. by 8in. The top boom is of channel section; it has two flange angles 7in. by 3½in.—with the short flange horizontal; and two flange angles 6in. by 4in.—with the long flange horizontal just below. This forms a channel 9in. deep on each side of the girder, and $\frac{9}{16}$in. plates 8¼in. deep are riveted over the vertical legs of the angles and through the web. Outside of the outer girders are triangular ⅜in. bracket plates to support the footwalks. Horizontal angle iron 6in. by 4in., 29ft. 4½in. long, extend across the tops of the girders, and carry the 10in. channel steel posts for the side railing, 4ft. 8in. high. These posts are capped by a heavy bulb angle top rail, and have outside braces. Besides this, there is a gas pipe hand railing, which extends out around four refuges on each side of the viaduct. These refuges are large enough to receive a platelayer's lorry.

The permanent way is laid with 90 lb. flange rails on cross ties or sleepers 8in. by 8in., 12ft. long, 4in. apart. Inside each rail is an angle iron guard rail 6in. by 4½in., bolted to the sleepers, and backed by a guard timber 4in. by 10in., laid flat. A similar guard timber is laid close against the outside of each rail. Between the two tracks are two additional lines of guard timbers 10in. by 12in.



DECK OF THE DES MOINES VIADUCT

All material, including rivets, is of soft steel, conforming to the railway company's specifications, and all rivets are ⅝in. diameter. For the 75ft. spans the live load is taken as 6100 lb., and the dead load as 1400 lb. per foot of track. For the 45ft. spans the live and dead loads are taken as 7600 lb. and 1250 lb. respectively per foot of track.



SIDE ELEVATION OF PIER

The 300ft. span was erected on a very heavy falsework, built of Oregon fir timbers 8in. by 16in.

The erection of the viaduct portions was accomplished by means of two travellers, or travelling derricks, one on each side of the river, no falsework being used. Each traveller consisted of a steel frame 50ft. high, composed of three posts braced together. This was mounted on a platform, which carried the winding engine and formed the working place for the engineman, and a man to give signals, and the men operating the hoisting ropes. Coal, water, and coils of rope were also stored on the platform. At the bottom of the frame were attached two booms, one inclined and the other horizontal. The inclined boom was 90ft. long, made of two 9in. steel channels laced together, and stiffened against buckling vertically or laterally by longitudinal truss rods. This boom could swing from a horizontal position through a vertical arc of 75 deg., and also had a horizontal swing of about the same amount. Its reach or radius was controlled by blocks and tackle connecting the head of the boom with the top of the frame, the line being led to the winding engine. The lateral movement was controlled by hand lines attached to the head of the boom and handled by men on the ground. The horizontal boom was 51ft. long, and remained always horizontal, although it had a lateral swing of about 30 deg., this movement being controlled in the same way as that of the 90ft. boom. It was made of two 18in. steel joists, upon the upper flanges of which ran two carriages or trolleys. It was supported by three rods radiating from the top of the frame, from which also back stays were run to anchor rods at the rear of the platform. These rods were clamped to the girders of the completed part of the viaduct on which the traveller stood, so that the machine would not tip forward when raising a heavy load. The 90ft. and 51ft. booms were designed to carry loads of 10 and 16 tons respectively at their extreme ends. The traveller was carried on eight bogies running on two standard gauge lines 13ft. between centres. The platform was about 9ft. above the rails, so that there was a passageway underneath, and between the lines of rails, for bringing material forward to where it could be reached by the lines from the trolleys. The trolley boom was used for lowering and setting the girders in place on the towers, and also for lowering material for the towers from the deck of the viaduct to the ground. This material was then picked up by the 90ft. boom and set in place.

Notable Steel Railway Viaducts.

Viaduct	Des Moines	Gokteik	Pecos	Old Kinzua	New Kinzua	Panther Creek	Loa	Old Verrugas	New Verrugas
Country	United States	Burmah	United States	United States	United States	United States	Bolivia	Peru	Peru
Railway	Chicago and N.W.	Burmah State	Southern Pacific	Erie	Erie	Erie	Antofagasta	Lima and Oroya	Lima and Oroya
Gauge	4ft. 8½in.	3ft. 3⅜in.	4ft. 8½in.	4ft. 8½in.	4ft. 8½in.	4ft. 8½in.	2ft. 6in.	4ft. 8½in.	4ft. 8½in.
Number of lines	Two	One	One	One	One	One	One	One	One
Length	2685ft.	2260ft.	2180ft.	2053ft.	2053ft.	1650ft.	800ft.	575ft.	575ft.
Height, maximum	210ft.	335ft.	321ft.	301ft.	301ft.	161ft.	336¼ft.	252ft.	252ft.
Width between girders	19½ft.	11ft.	10ft.	10ft.	9ft.	7ft.	9ft.	—	—
Width of floor	25ft.	—	20ft.	18ft.	18ft.	—	13ft.	—	—
Width at base, maximum	70ft.	156ft.	90¼ft.	—	102¾ft.	—	124ft.	—	58½ft.
Weight of metal	5680 tons	4310 tons	1820 tons	1400 tons	3352 tons	830 tons	1115 tons	—	—
Length of tower spans	45ft.	16 of 40ft.	35ft.	88½ft.	38½ft.	30ft.	32ft.	50ft.	60ft.
Length of intermediate spans	75ft.	7 of 60ft. and 10 of 120ft.	65ft.	61ft.	61ft.	40ft., 60ft., 65ft.	80ft.	100ft. and 125ft.	235ft. centre 140ft. end
Maximum span	(Truss) 300ft.	120ft.	185ft.	61ft.	61ft.	65ft.	80ft.	125ft.	235ft.
Date of construction	1901	1900	1891-92	1882	1900	1893	1888	1872	1890

ANALYSIS BY ROTE.

THAT desire for uniformity undiversified by intelligence, now prevalent in many fields has appeared with much virulence among chemists. The complaint commonly takes the form of promulgating "standard" methods of analysis on the plea that by their use discrepancies between the results of different analysts will be avoided, the advocates for such methods overlooking the fact that two accurate results cannot be discrepant, and that if a result is accurate, the method by which it is obtained is a matter of indifference. But as it seems that such axiomatic truths are in danger of being set aside in favour of more ornamental dogmas, the appearance of a paper treating of the subject as a whole. maintaining what we conceive to be a sound view of the matter, must be considered timely.

The paper in question was read by Mr. Bertram Blount, before the Chemical Section of the British Association, at the recent meeting of that body at Belfast. Naturally, it is addressed primarily to chemists, but in view of the fact that the engineer has frequent need to seek the aid and advice of the chemist, and is directly and keenly concerned in the accuracy of the analyses supplied for his information, we have prepared this digest of those parts of the paper which more particularly concern our readers.

In the first place, Mr. Blount draws attention to a point often overlooked when questions of standardisation are discussed. The "principle of standardisation" simply means the idea that all things of a kind should be referred to a fixed example of that kind—which may be good or bad, or more probably mediocre. "Standardisation" has so imposing and attractive a sound that it is often implicitly understood that the standard is the best thing of its kind; this is by no means the case, it is only a fixed thing. The necessity for standard weights, measures and money is universally admitted, though even here the standard is an arbitrary thing, is not necessarily the best for its purpose, and differs in different countries almost as widely as do standards of right conduct, which are notoriously numerous and much influenced by latitude. Various mechanical standards, such as gauges for wire and sheet, screw threads, and the like, are also practically necessities, but it may well be debated whether structural metals should be moulded into standard forms and sections. If this were generally adopted, it would result in an engineer specifying rails of a particular weight per yard being confronted with the choice of accepting the standard section, or putting down his own rolling plant. A good deal is to be said for mechanical standardisation; by the use of few and fixed sizes production is undoubtedly cheapened and quickened, and the establishment of metal standard sections would be welcomed by most manufacturers. But the engineer who is responsible for the ultimate behaviour of the material is by no means so sure of the advantages thus to be gained. He is aware that a standard section will not be best in every case, and must from the nature of things be regarded as a compromise, and he may, singular as it must appear in these days of collective activity extending even to the realm of thought, actually prefer his own judgment to the combined wisdom of a number of other people. Coming to the question of standardising mechanical tests, instead of sections of materials, more difficulty is encountered. Already in mechanical testing there is too great a disposition to rely on stereotyped tests, and not to consider intelligently what it is that it is desired to ascertain. Thus, in the case of a rail, test pieces are almost invariably cut from the head in a direction parallel to the length of the rail, although these on breaking will not reveal weakness of the metal due to longitudinal flaws, which would be detected at once by the use of test pieces cut at right angles to the length of the rail. This is a simple instance of the errors which may occur when mechanical tests are made according to rule, without regarding each case on its merits. But on passing from mechanical testing to chemical analysis, the objections to standardisation become much stronger. Our author says:—"In mechanical testing it is recognised that the values obtained for strength in tension and compression, for elongation of a ductile test piece, for resistance to shock and the like, are appreciably influenced by the conditions of the test, and in consequence there is something to be said in favour of standard methods of applying the tests. But there is no such justification for the adoption of standard methods in chemical analysis, where the object in view is the determination in a given material of a definite substance; in such a case all methods which are chemically sound must give the same result."

The history of the various attempts which have been made in this country to standardise methods of chemical analysis has a certain sameness. These efforts have been uniformly unsuccessful, perhaps from an innate objection in the English mind to be coerced. But in America a different temper has been shown, and for a long time past the idea of standardising methods of analysis has there been favourably received. When, in 1888, the British Association undertook to determine the composition of sundry samples of steel which were ultimately to serve as standards in themselves, the American Committee were far more interested in the device of standard methods. Later the use and enforcement of standard methods for the analysis of coal, sugar, manures, feeding stuffs, cement and cement materials, have been freely advocated in the States, and in some cases processes for the examination of these substances have been set forth and published by authority.

It would seem to be incomprehensible that chemists, knowing their work to be based on science, and not on rule, should countenance these attempted regulations, but the fact that there is a respectable body of opinion in favour of reducing analysis to the level of cookery makes it necessary to examine the grounds for this strange belief. To quote from this paper, "It will be seen that there are in this matter two schools of thought sharply differentiated. On the one hand, we have chemists so impressed with the necessity of avoiding discrepancies, that they are anxious to set up standard methods, stated in such detail that a faithful observance of the prescriptions by two workers cannot fail to secure identical results. And there are others less confident of the success of this system. This conflict of opinion arises in great measure from confusion of thought. There are many operations performed by the chemist which are from their nature arbitrary. To take an extreme case, it is evidently impossible to carry out the Maumené test for oils, or to determine the flashing point of petroleum, and to obtain concordant results without having recourse to a fixed procedure. In the examination of potable waters, such arbitrary methods are in wide and general employment, and yield much useful information. Feeding stuffs and manures afford a similar case." . . . "But this kind of codification, though useful and necessary, has nothing to do with analysis. The object of the analyst is to determine, with the best precision in his power, the constituents of the substance which he is analysing. Sometimes he cannot do this, and is forced to have recourse to the determination of the properties of the substance, that is to say, he is compelled to apply to the material under examination various arbitrary tests. Standardisation of these tests is legitimate enough; standardisation of analysis implies that analysis is an arbitrary procedure not based on ultimate chemical facts; this view is too grotesque for discussion."

all the way, and a dining car added part of the way, went from St. Louis to Buffalo in fifteen hours and fifty-four minutes, breaking the record between the cities. Returning, that record was further lowered one hour, the running time being fourteen hours and fifty-five minutes, including all stops. For many miles the speed exceeded seventy miles an hour and for a few miles reached seventy-seven miles an hour. The distance from Mount Olive to Carpenter, sixteen miles, was covered in thirteen minutes, an average of seventy-four miles an hour. The 105 miles between Decatur and Granite City was covered in 104 minutes, including a stop of three minutes for water at Litchfield and a stop of six minutes at Edwardsville, while a car with a hot box was being cut out. Including stops consuming nine minutes, the average speed was 60.6 miles an hour; excluding stops, 66.34 miles an hour. The passengers state that the swaying of the train was not perceptibly more severe than in trains making only twenty-five miles an hour. The visitors were cordially received and hospitably entertained at Buffalo. The information obtained by inquiry and observation must be of great value to them in their future work. On the return trip there was the usual appreciative speech making and resolutions and Mr. Ramsay is now wearing as a memento a valuable scarf-pin.

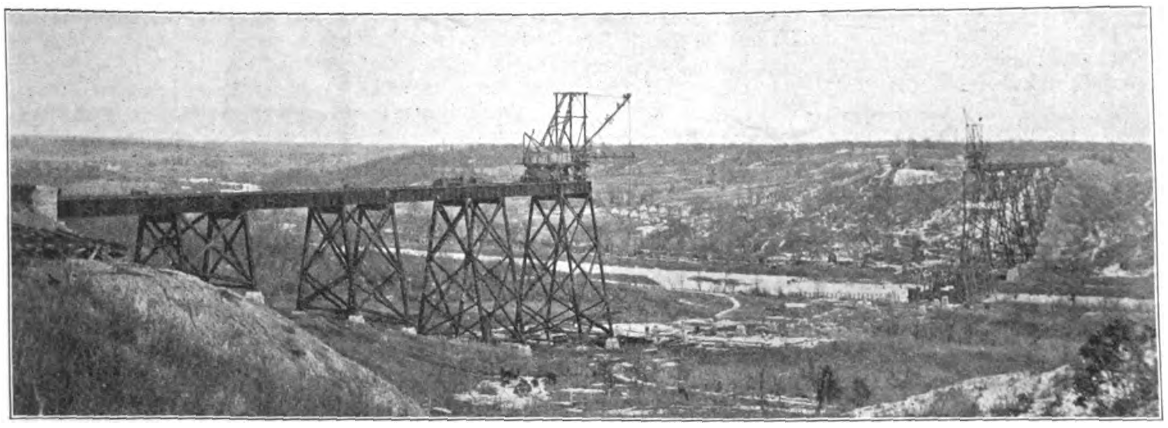


FIG. 1—BOONE VIADUCT, C. & N. W. RY., IN PROCESS OF ERECTION; WEST END TO THE LEFT.

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The Boone Viaduct, Chicago & Northwestern Ry.

On Sunday, the 19th inst., the Chicago & Northwestern Ry. opened to traffic a diversion of its line, west of Boone, Ia., known as the Boone-Ogden cut-off. The event marked not only the culmination of an important engineering undertaking in the way of grade reduction, improved alignment and reduced distance, but also the putting into service of a remarkable structure—a long, high viaduct over the Des Moines river, four miles west of Boone. The Chicago & Northwestern Ry., as originally constructed and operated until the present week, bore to the southwest from Boone, descending into the valley or depression which follows the river, so that, from the river to the tops of the bluffs on either side, there were heavy grades both ways, requiring helper engines for the heavy trains; and, besides, the route was circuitous, the distance from Boone to Ogden being 11.3 miles. By way of the cut-off just completed the distance between the two places is something over seven miles, the new line saving between three and four miles of distance. The immediate necessity for the change of location was the progress of double-tracking the road westward. When this work came to be taken up the time was at hand for selecting a more feasible route directly west of Boone. These, in brief, were the conditions which impelled the construction of the cut-off, with the extensive engineering work involved.

The new line runs directly west from the depot at Boone and strikes the bluffs at a point where the distance across the depression is about 3000 ft. This depression (Fig. 1) is crossed by the new viaduct, the exact length of which is 2685 ft. At the highest point the structure is 185 ft. high. Except for the river span of 300 ft., the structure consists of two-bent braced towers of 45 ft. span, with intermediate spans of 75 ft. carried by plate girders.

The work of construction began in the fall of 1899. A temporary structure was first built across the river, this being a pile bridge, which was used to transport material from one side of the river to the other, as all material was first unloaded on east side of river. The end abutments are stone masonry over concrete footings. The stone piers upon which the towers rest are built upon rock, hard-pan, or some other equally hard foundation. The river span, which is of the subdivided Pratt truss type (Fig. 3), is supported upon A-towers resting upon caissons 10 ft. in diam. filled with concrete. These caissons were sunk to bed rock by the pneumatic process.

The erection was by the ordinary methods with traveling derricks. All material was placed at the ends of the structure and from there run out as needed and lowered to position. These derricks had two booms, one being horizontal, and 75 ft. in length, the other, a diagonal, 90 ft. in length. All riveting on the structure was done by compressed air tools. The work of construction was in charge of Mr. W. C. Armstrong, who is also resident engineer in charge of second track between Boone and Ogden.

The accompanying illustrations convey a good idea of the general features of the structure. Figure 2 is a view from the under side looking east, showing the character of the bracing between the legs of the towers. Figure 3 is a view of the river span taken while the structure was under test. The view of the completed structure, Fig. 4, shows to good effect the heavy character of the work. This structure is said to be the longest double-track viaduct of its hight, as well as the heaviest viaduct, ever built. In the superstructure there are 5680 tons of metal, and in the foundations 400 tons more, making the total weight of metal in the entire structure 6080 tons. The cost of the bridge proper was $625,000, and the total cost, including the approaches, was $1,250,000. The building of the approaches involved some heavy earthwork, there being two embankments about 85 ft. high across ravines 400 ft. long, requiring the moving of 223,000 cu. yds. of material.

The construction of the Boone-Ogden cut-off eliminates the famous Kate Shelley bridge across the Des Moines river, where a young girl, 20 years ago, saved a passenger train from wreck by crawling over the bridge during the night and warning the approaching train of a washout into which an engine had already run and been wrecked. According to accounts in the local newspapers this lady still lives within sight of both the old bridge and the new viaduct, and was in attendance at the ceremonies which marked the occasion of the opening of the new structure last Sunday. It is further reported that out of consideration of the heroic act of this girl the new viaduct will, in her honor, continue to bear the name of the old bridge.

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Engineering Theses at Lehigh University.

Following is a list of the subjects of the theses of engineering students who will graduate at the Lehigh University, South Bethlehem, Pa., in June, 1901:

Percy L. Reed, C. E., New Bedford, Mass., "The Abolition of Railroad Grade Crossings in the United States, Particularly in Massachusetts."

Winter L. Wilson, C. E., Bethlehem, Pa., "A Study of Virtual Profiles on the Lehigh and New Jersey Divisions of the Lehigh Valley Railroad for Freight Trains Running Eastward."

Charles Enzian, Weissport, Pa., "Analyses of Sands of the Lehigh Valley and a Comparison of Their Efficiencies for Water Filtration."

Ernesto Franco, Quito, Ecuador, "Designs and Comparative Estimates for Stand Pipes and Trestle Tanks 150 Feet High."

Webster N. Haas, Hepler, Pa., "Design for a Bridge Connecting Bethlehem and South Bethlehem, Pa."

Frederick A. Hausman, Allentown, Pa., "Review of the Water Supply System of Allentown, Pa., with Plans for Its Extension."

Louis G. Krause, Absecon, N. J., "Plan and Estimate for a Sewerage System for West Bethlehem, Pa."

Charles J. McGonigle, Allentown, Pa., "Plan and Estimate for Sewers and a Sewage Filtration Plant for Allentown, Pa."

Conrado E. Martinez, Habana, Cuba, "Engineering Literature and Technical Education in Cuba."

Luther D. Menough, York, Pa., "Plan and Estimate for a Sewerage System for York, Pa."

Walter H. Rodney, Fort Riley, Kan., "The Strength and Weathering Qualities of Roofing Slate."

Herbert S. Stauffer, South Bethlehem, Pa., "Plan and Estimate for a Filter Plant for the Water Supply of South Bethlehem, Pa."

Grandison G. Underhill, East Aurora, N. Y., "Determination of the Errors of the Weighing Apparatus of Two Testing Machines."

T. C. S. Yen, Shanghai, China, "Design for a Steel Bell Tower to Replace the Wooden one in Shanghai, China."

Arthur R. Young, West Bethlehem, Pa., "The Investigation and Design of Cantilever Conveyor Cranes.'

Joaquim G. de Andrade, Manaos, Brazil, "Design for a Tugboat for the Amazon."

Charles E. Barba, Allentown, Pa., "The Adoption of Jigs in Machine Shops as a Labor Saving Device."

Timothy Burns, Yankton, S. D., "The Mechanical Fallacies Involved in 'Poleforcia.' "

Francis Donaldson, Baltimore, Md., "A Gravity-driven Electric Power Plant."

William A. Ehlers, Hernwood, Md., "Plans and Estimate for Construction and Equipment of a 1000 K. W. Railway Power Station."

Cadwallader Evans, Jr., Pittsburg, Pa., "Design of an Air Compressor Plant for the Foundry and Machine Shop of Monongahela Manufacturing Company."

Thomas M. Girdler, Jeffersonville, Ind., "Piece Work System."

Samuel T. Harleman, South Bethlehem, Pa., "Design of a 600-Ton Coaling Station for the Lehigh Valley Railroad at South Easton, Pa."

Edmund P. Jump, Easton, Md., "Modern Methods for the Utilization of Waste Gases."

Samuel T. Laubach, Northampton, Pa., "Design of a Rotary Cement Kiln."

Albert R. Laubenstein, Ashland, Pa., "Test of the Manufacturing Plant of A. L. Laubenstein, Ashland, Pa."

Edward T. Murphy, Brooklyn, N. Y., "Comparative Cost and Efficiency of Compressed Air as Motive Power."

John J. Nolan, Carbondale, Pa., "Design for a Bevel Gear Planer."

Everett J. Peck, Plainfield, N. J., "Rock Drills."

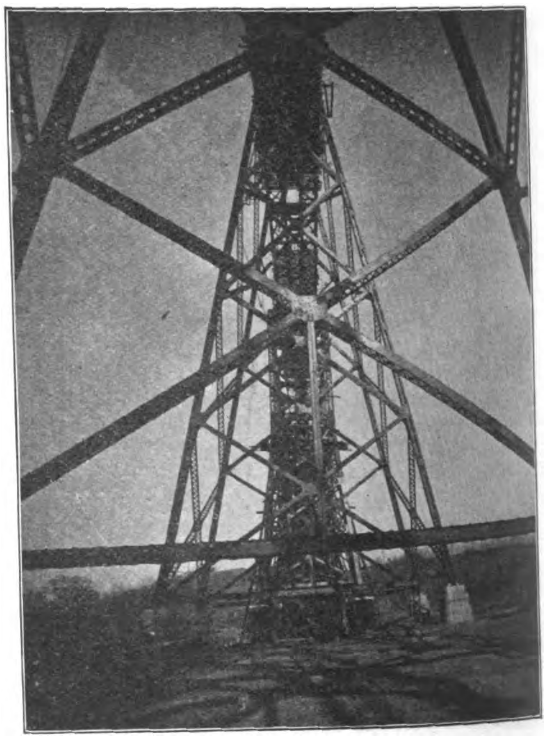

FIG. 2—BENEATH THE VIADUCT LOOKING EAST.

John W. Shaeffer, Fleetwood, Pa., "Duty Test of the Marden Creek Pumping Plant, Berkley, Pa."

Ferdinand N. Roebling, Jr., Trenton, N. J., "Plans for Hauling Ore from Friedensville to the Lehigh Valley Railroad."

John F. Symington, Baltimore, Md., "Tool Steel."

Henry D. Wilson, Pittsburg, Pa., "Design and Discussion of a Tower Condenser, Capacity 550 Pounds of Steam per Minute."

Morris W. Garman (with H. J. Moore), Nanticoke, Pa., "Investigation of the Working of a Blast Furnace at Hellertown, Pa."

Samuel R. Alder (with E. T. Thornton), Redlands, Cal., "Manufacture of Spelter as Carried on by the New Jersey Zinc Company."

David M. Barry, Agawam, Mass., "Investigation of Casting Machines at South Bethlehem and Hellertown, Pa."

Joseph W. Burke, B. S. (with A. Sanchez), Sheuau-

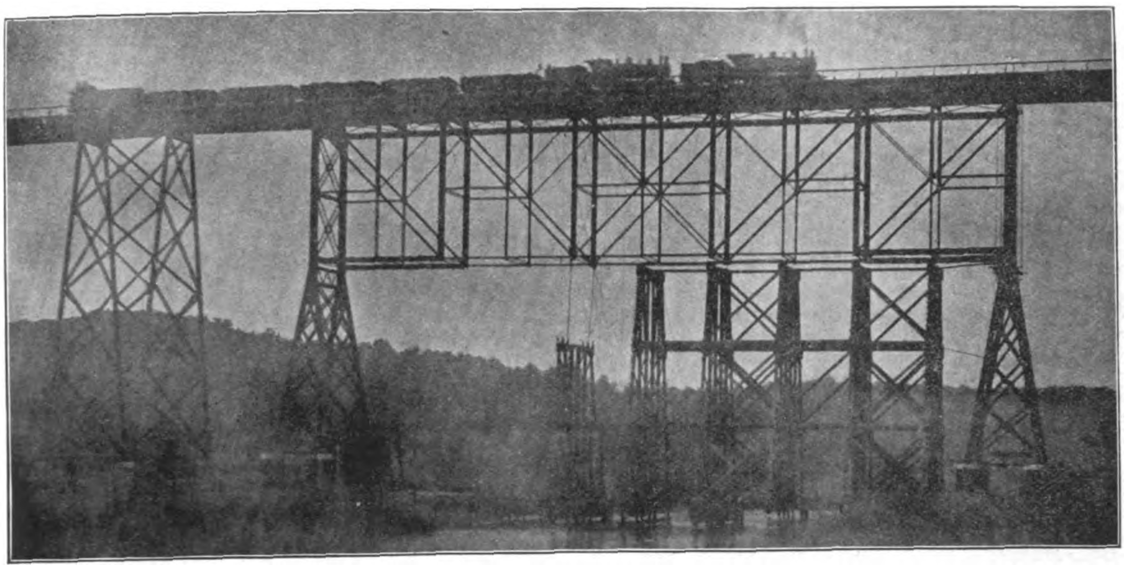

FIG. 3—RIVER SPAN OF BOONE VIADUCT, CHICAGO & NORTHWESTERN RY.

doah, Pa., "Compressed Air Haulage at the Anthracite Collieries."

John H. Crane, (with W. W. Graff), Chicago, Ill., "Study for the Utilization of Blast Furnace Waste Gases Directly in Gas Engines at the Blast Furnaces of the Bethlehem Steel Company."

Wilbur W. Graff, (with J. H. Crane), Rushville, Ill., "Study for the Utilization of Blast Furnace Waste Gases directly in Gas Engines at the Blast Furnaces of the Bethlehem Steel Company."

John G. Heintz, Louisville, Ky., "Forepoling in the Mammoth Bed at Hazleton, Pa."

Henry J. Moore, (with W. W. Garman), Gill, Mass., "Investigation of the Working of a Blast Furnace at Hellertown, Pa."

Armande Sanchez (with J. W. Burke), Nuevitas, Cuba, "Compressed Air Haulage at the Anthracite Collieries."

Edward T. Thornton, (with S. R. Adler), Philadelphia, Pa., "Manufacture of Spelter as Carried on by the New Jersey Zinc Company."

Paul L. Anderson, (with L. A. Freudenberger), Somerville, N. J., "Theory and Calculation of the Induction Motor."

William D. Cassin, (with J. C. Ryan), Washington, D. C., "Induction Wattmeter Tests."

John H. Flory,; (with C. W. Startsman), Ashley, Pa., "Theory and Calculations of Alternating Current Transmission Lines."

Lewis A. Freudenberger, (with P. L. Anderson), West Bethlehem, Pa., "Theory and Calculations of the Induction Motor."

Elwood S. Harrar, (with G. W. Welsh), Allentown, Pa., "Conductivity Tests of Copper."

James C. Ryan, (with W. D. Cassin), Harrisburg, Pa., "Induction Wattmeter Tests."

Albert C. Savidge, (with J. S. Van Alen), Sunbury, Pa., "Resistance Standards."

Charles N. Startsman, B. S. (with J. H. Flory), Iowa City, Ia., "Theory and Calculations of Alternating Current Transmission Lines."

James S. Van Alen, (with A. C. Savidge), Northumberland, Pa., "Resistance Standards."

George W. Welsh, (with E. S. Harrar), Hanover, Pa., "Conductivity Tests of Copper."

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Railway Notes from Central and South America.

NICARAGUA.

Consul Donaldson, of Managua, recently reported that the Nicaraguan government had placed an order with its agent in New York for 2400 tons of steel rails for the new central branch of the National Railroad, which is being constructed by a German engineer, Mr. Julio Wiest. "Considering the fact that Nicaragua has always purchased rails in Germany and England," says Mr. Donaldson, "and that the contractor for the present railroad is a German, the placing of this order in the United States is an item of considerable importance in the growth of our trade with Central American countries."

President Zelaya has promulgated a decree authorizing the acceptance by the government, from either national or foreign capitalists, of a voluntary loan of $1,000,000, 65 per cent of which is to be in legal-tender money and 35 per cent in consolidated customhouse bonds. The government will issue railway bonds of different denominations to cover the amount of the loan and the proceeds will be used in the prosecution of railway and other public works now in course of construction. Information sent from Managua on May 10 states that the Nicaraguan government has floated this loan. The bonds which were taken up by local merchants and business men, are guaranteed by 40 per cent of the customs duties collected ata ports on the Atlantic coast and 10 per cent of those at ports on the Pacific coast.

GUATEMALA.

The contract for the building of the railroad from Cocales and Mantenango, uniting the Southern with the Western Ry., has been made without the granting of a subvention, and the National Ry. of Los Altos is actively engaged in arranging for the necesary funds for the completion of this work.

"El Gualtemalteco," official organ of the Republic of Guatemala, recently published the contract entered into by the government and Senor Don Ramiro Fernandez, in representation of the Urban Ry. Co., authorizing the establishment of a tramway between the capital of the nation and the city of Guarda Viejo. The concession carries with it the right to import the necessary cars for the exploitation of the tramway free of municipal duties. The company is obligated to complete the line within five months from the approval of the contract by the government.

COLOMBIA.

According to official information, there were in the Republic of Colombia, at the close of the year 1900, 376 miles of railroad, distributed as follows in eight of the nine Departments:

Department of Antioquia.—A constructed line 42 miles long from Puerto Barrio, on the Magdalena river, to Caracoli. This railroad is being built by the departmental government of Antioquia, assisted by the national government, and is destined to reach Medellin, capital of the department and a center of much commercial importance. The length of line as surveyed between Puerto Barrio and the city of Medellin is 118 miles. It has already been constructed beyond Caracoli, but that city is the present inland terminus of operations. The main office of the company is at Medellin. This railroad was located and in part constructed by the late Francisco J. Cisneros, a citizen of the United States, and its manager and chief engineer until recently was Mr. Whitteken, also a citizen of the United States.

FIG. 4, BOONE VIADUCT, CHICAGO & NORTHWESTERN RY.—COMPLETED STRUCTURE.

Department of Bolivar.—A railroad 66 miles long between the city of Cartagena and the port of Calamar, on the Magdalena river, constructed and operated by the Cartagena-Magdalena Ry. Co., an American corporation, of which Francis R. Hart, of Boston, is president and J. T. Ford, of Cartanega, Colombia, is vice-president and general manager. In the same department, a railroad 28 miles in length connects the city of Barranquilla with Puerto Colombia, also known by the name of Sabanilla, through which port Barranquilla's ocean shipments are made.

Department of the Cauca.—A government railroad 25 miles in length, running from Buenaventura, on the Pacific ocean, to San Jose. The road is intended to reach the city of Cali, 86 miles from Buenaventura. The work of constructing the railroad goes on, but it is not expected to be completed to Cali before the expiration of about seven years. This line already renders very valuable services, and its importance will be very considerably increased when it shall have reached the last-named city, the heart of the rich valley of the Cauca.

Department of Cundinamarca.—This department, in which is situated the capital city—Bogota—has four railroads in operation. The Savanna R. R., between Bogota and Facatavia, is 25 miles in length. Passengers and freight between Bogota and the Atlantic coast make use of this line, which forms an indispensable link in the chain of communication. The road is the property of the national government. The Northern R. R. connects Bogota and city of Zipaquira, where are located some of the most remarkable salt mines in the world. Its length as constructed and in operation is 37 miles. The Southern R. R., between Bogota and Soacha, has a completed length of 7 miles. The Giradot R. R. is in operation from the port of that name on the Upper Magdalena river to Juntas de Apulo, a distance of 25 miles. Bogota is contemplated as the interior terminus of this road, which would make the total length of line 96 miles. Construction work has already been effected as far as Hospico, and would have been carried farther if the war had not interfered.

Department of the Magdalena.—A railroad 41.6 miles long, extending from the city of Santa Marta, on the Atlantic coast, to the Sevilla river. The contemplated interior terminus of this line is El Banco, on the Magdalena river, a distance of 233 miles.

Department of Panama.—The Panama R. R., between Colon and the city of Panama, 48 miles in length, owned by an American corporation, with headquarters in the city of New York.

Department of Santander.—The Cucuta R. R., between San Jose de Cucuta and Puerto Villamizar, on the Zulia river, on the Venezuela frontier. This road is 34 miles in length.

Department of the Tolima.—The Ladorada R. R., between Ladorada and Arrancaplumas, 21 miles in length. This road is the property of an English corporation and was built to avoid a dangerous stretch of river navigation in the vicinity of Honda. Arrancaplumas is a suburb of Honda. The Tolima R. R., which has 1.8 miles, is constructed and in operation, is intended to connect the city of Ibague with the port of Giradot, 37 miles distant, on the Upper Magdalena river. There are no indications of an early resumption of work.

The annual report of the Panama Railroad and Steamship Co. was issued from the offices of the company in New York on April 1. This shows that the total earnings for the year 1900 were $2,655,196, or an increase over 1899 of $460,152. The total expenses were $1,727,403, an increase of $385,020 over 1899. The net income (6 3-8 per cent of the capital stock) for the year was $446,764. The net gain in income over 1899 was $151,532. The traffic statistics show that the total numbers of tons of west-bound freight transported was 153,758, divided as follows: From New York to San Francisco, 33,555; New York to Panama, South Pacific, Central America, and Mexico, 26,963; Europe to Panama, South Pacific, Central America, Mexico, and San Francisco, 54,905; Colon to Panama (local), commercial freight, 16,217; company's freight, 22,118. The total number of tons of east-bound freight carried was 203,619, divided as follows: From San Francisco to New York, 30,624; South Pacific, Central America, Mexico, and Panama to New York, 88,046; South Pacific, Central America, Mexico, San Francisco, and Panama to Europe, 77,219; Panama to Colon (local), commercial freight, 3,198; company's freight, 4,532. The total number of passengers carried to Panama was 41,656, and to Colon, 41,576. The president of the company says in his report: "The year has been one of the most important in the history of the company. The new 4½ per cent first-mortgage gold-bond issue has been