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XLVII.

TRACK ELEVATION OF THE CHICAGO & NORTHWESTERN RAILWAY.

By Louis H. Evans, Mem. W. S. E.*

Read October 5, 1898.

The Chicago & Northwestern Railway terminal in Chicago consists of three distinct entrances to the city: The Galena Division, from the west; the Wisconsin Division, from the northwest; and the Milwaukee Division, from the north; as shown on the map, Fig 443.

The Wisconsin and Milwaukee Divisions come together at Clybourn Junction, about 2½ miles from Wells Street Station on to a common right of way, one hundred feet wide, but will be two double track systems from there to one-half mile from the depot.

Besides the three systems above mentioned the road owns and operates a belt railway from North Evanston to the south branch of the Chicago River at 16th St., and a one-fourth interest in the Air Line which continues this belt line to a connection with the Illinois Central Ry. This belt line crosses every railway entering Chicago.

The Chicago terminal comprises 768 acres of land; $36\frac{73}{100}$ miles of double track railway used as running tracks, and $159\frac{69}{100}$ miles of track in yards for storage tracks, team tracks, etc.

With a terminal as extensive and valuable as this, the question of track elevation was a very serious one on its first appearance. In fact, the estimated cost of elevating the terminal to comply with the terms of the O'Neill ordinance was about $65,000,000, an estimate properly made, too, as it consisted of raising the terminal entire, buildings and all, sixteen feet and building a wall around it. Opposition to such a proposal was justly very strong; but when the city showed a disposition to compromise and write ordinances that were for part of the terminal at a time, thereby rendering the outlay for elevation each year within the reach of a prosperous railway, it was a different question, and in the investigation that followed it was discovered that this railway could pay for elevating its Galena Division from Sacramento Ave. to 40th St., both inclusive, and still remain solvent.

After considerable discussion, an ordinance was drawn by the city, February 18, 1895, to elevate the Galena Division as above defined, giving twenty-seven months in which to do the work; the distance to be elevated being about $1\frac{8}{10}$ miles, the right of way 100 feet wide, six subways to be built, five tracks to elevate, and

*Engineer of Track Elevation C. & N. W. Ry. Co.

FIG. 443. MAP OF CHICAGO TERMINAL OF C. & N. W. RY.

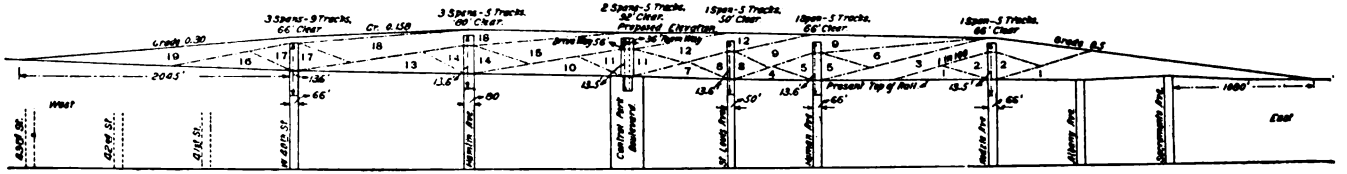

FIG. 444. PROFILE OF GALENA DIVISION ELEVATION FROM SACRAMENTO AVENUE TO 43D ST., SHOWING PROGRESS OF FILL.

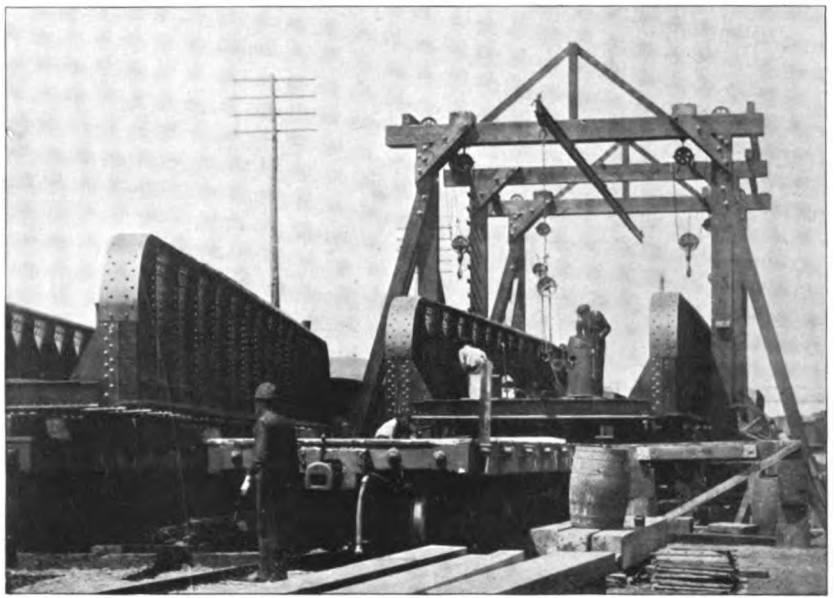

FIG. 445. DERRICK USED FOR ASSEMBLING BRIDGES.

EVANS
TRACK ELEVATION
C. & N. W. RY.

considerable work at each end in changing yards to fit the condition incident to elevated tracks, see profile, Fig 444.

The plan of work accepted by this company was a new method, which consisted of assembling the manufactured girders and floors into complete bridges at a derrick, Fig. 445, at the end of section to be elevated, and moving the bridge thus assembled on special flat cars to the subway, where they were lifted free from the cars and landed on piles driven between tracks to temporarily support the bridge and traffic until stone abutments could be built. The method used on the Galena Division is shown in Fig. 446 (a), (b) and (c).

The completed bridge loaded on, Fig. 446 (c), two cars was a proper load, except as to its shape, the width being 14 ft. 8 in. made it appear very unstable when placed three or four feet above the car floor, which is nine feet wide and carried on a wheel base of only five feet. We never were able to throw a bridge off the cars, however, notwithstanding the fact that we had the cars (loaded with bridges) off the track several times. Our first bridge was moved one mile successfully and unloaded on to the piles in an hour, so we felt that the system of assembling the bridges at the end of the work, where we could arrange for and do field work, practically as cheap as shop work, was no mistake.

The five tracks on this section of the road required three bridges and two intermediate floors. To illustrate the time required to place the bridges and get the traffic over them, we will take Homan Ave., the second subway built: Two bridges were placed May 24. at eleven A. M., at Homan Ave., Fig. 447, the approaches were built during the afternoon, and a train of sand went over one of these bridges May 25, at seven A. M., and double track traffic went over these bridges May 25, at 12:30 P. M. The third bridge was placed May 25, 11:20 A. M., and the intermediate floor put in during the day of May 25, illustrating that the bridges could be placed and the approaches filled so that traffic could go over the elevation at a street in twenty-four hours. The bridges were not placed at the full elevation of ten feet at first, but were at about seven feet elevation and afterwards raised four feet more. The excavation of the street to the new grade and the foundations for the abutments could start at once, the work being entirely independent of the track raising after the bridges were placed. The two masonry abutments were built at this street from June 7th to the 13th; finally, the traffic was on the old grade May 24th, on the new grade on iron bridges May 25th, and on the new grade on iron bridges on stone abutments June 13th; in sixteen working days five tracks were permanently elevated eleven feet. This rate of progress was kept up until all the bridges were placed, which required until July 18. From May 11th, during this time 275,000 cu. yds. of sand were unloaded, 52,000 cu. yds. gravel, 7,300 cu. yds. of masonry in abut-

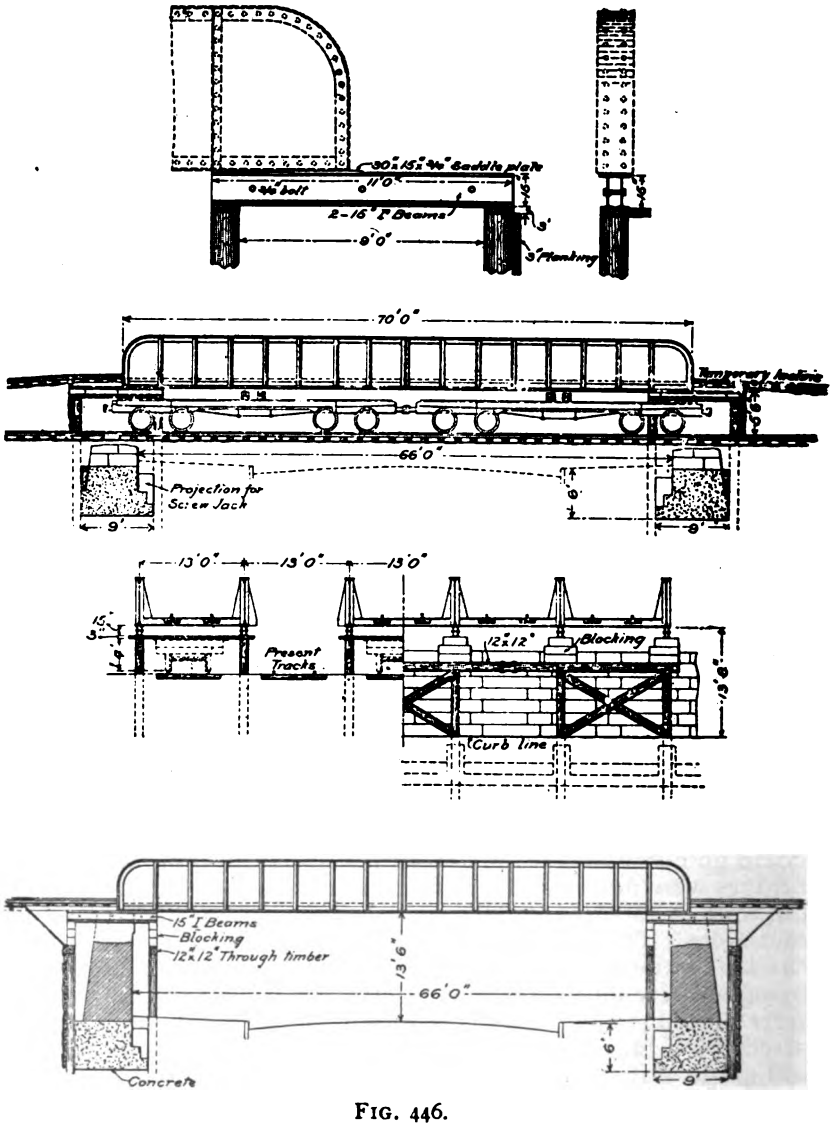

FIG. 446.

(a)—METHOD OF TEMPORARILY SUPPORTING SPANS, USED ON GALENA DIVISION.

(b)—COMPLETELY ASSEMBLED SPAN, ON CARS, READY TO BE LANDED ON TEMPORARY SUPPORTS.

(c)—CROSS-SECTION SHOWING ARRANGEMENT OF TRACKS DURING ELEVATION.

(d)- SPAN IN PLACE, SHOWING PILES, ABUTMENTS AND BACK WALL

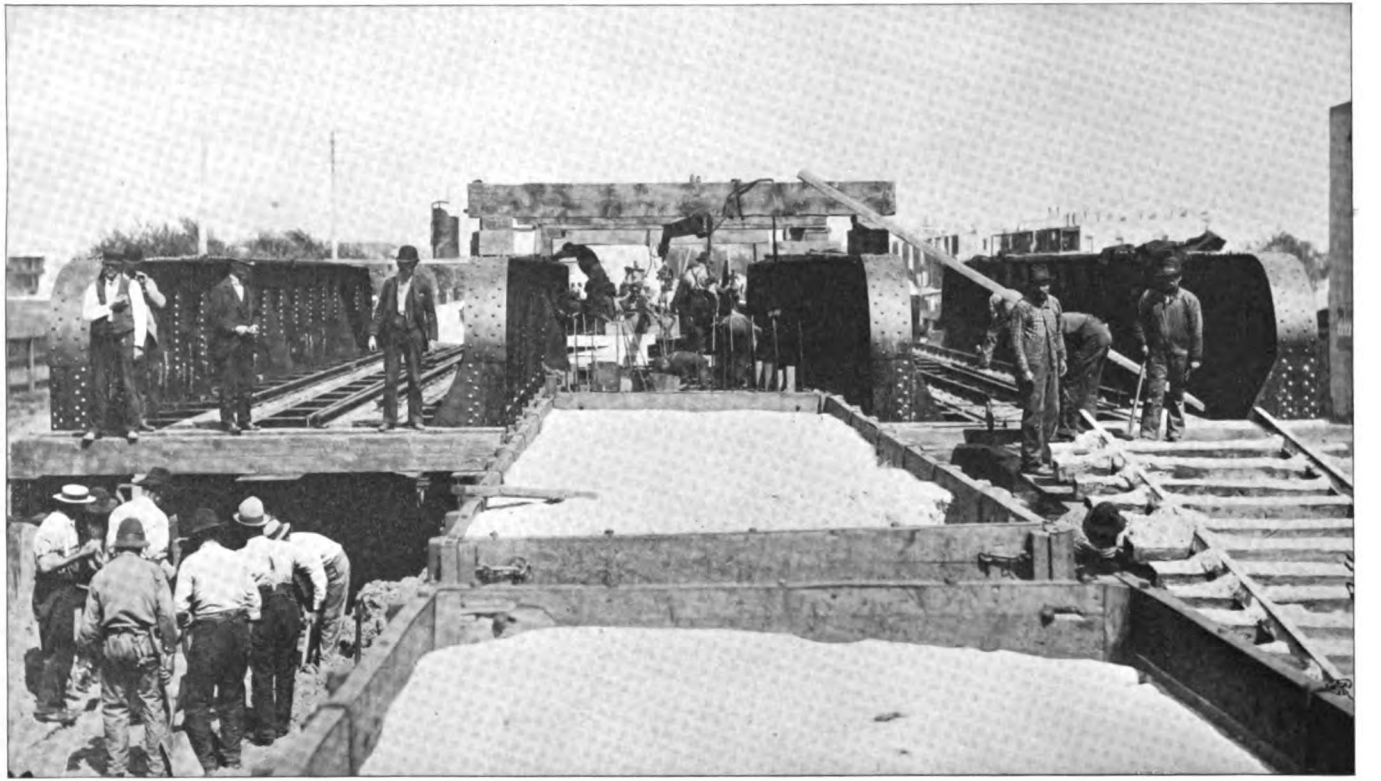

FIG. 447. INTERMEDIATE FLOOR BEING PUT IN BETWEEN TWO BRIDGES AT HOMAN AVE., ALSO SAND FILLING FOR APPROACHES.

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TRACK ELEVATION
C. & N. W. RY.

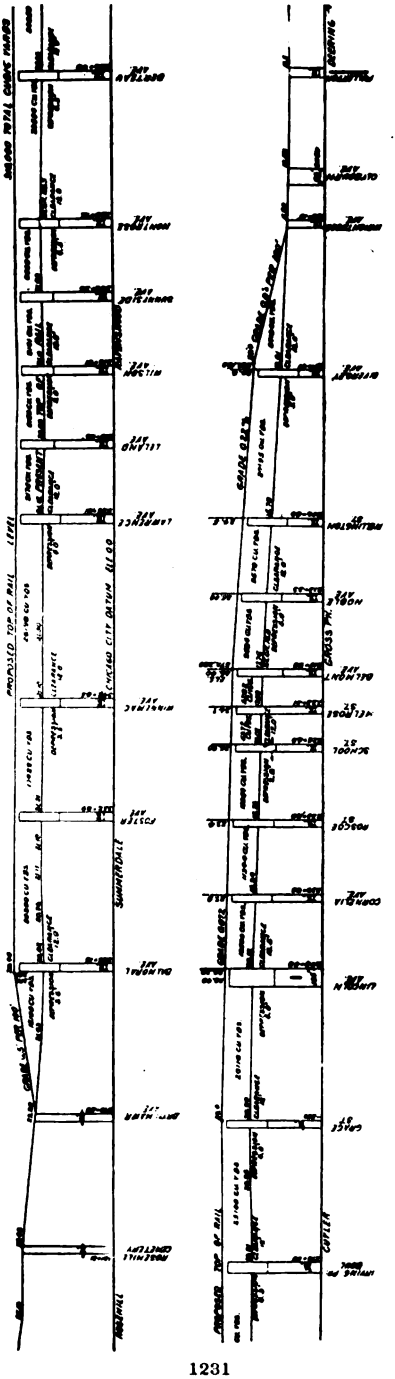

FIG. 448. PROFILE OF THE MILWAUKEE DIVISION ELEVATION, FROM DIVERSEY BOULEVARD TO ROSE HILL.

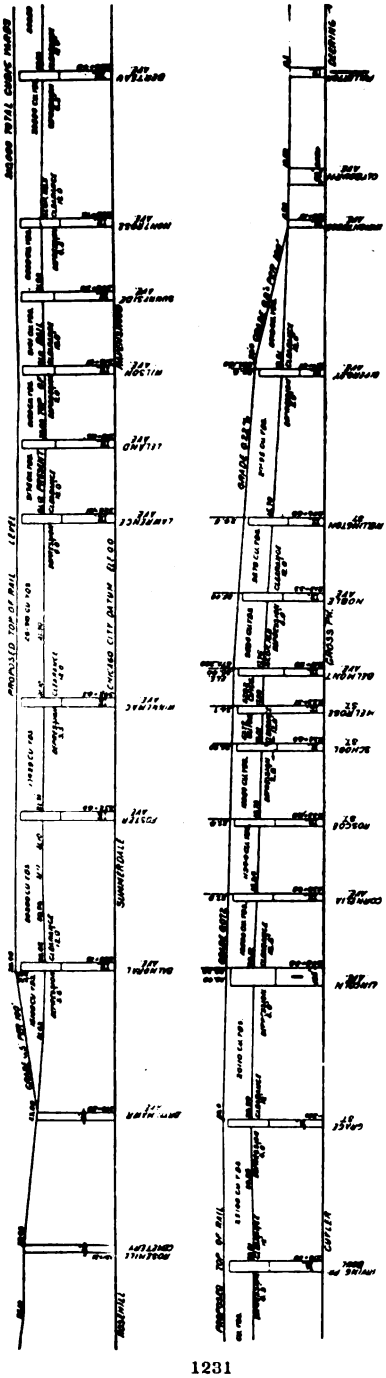

FIG. 448. PROFILE OF THE MILWAUKEE DIVISION ELEVATION, FROM DIVERSEY BOULEVARD TO ROSE HILL.

ments; 140 gondola carloads of sand were unloaded a day for a full month of this time.

This work was done in about four months and we had twenty-seven months in which to do it. The cost was only 70 per cent of the estimate, and work was so quickly done that it encouraged the company to discuss the question of elevating the other divisions, and an ordinance was agreed to for elevating the Milwaukee division between Diversey boulevard and Rosehill, Fig. 448, and the Wisconsin division between Clybourn Junction and Mayfair, $8\frac{35}{100}$ miles. (Profile shown in Fig. 449*). The ordinance was dated March 30, 1896, and had eight years to run, and it covered the outlying districts of these two divisions, and would require fewer subways than would be required if the elevation was delayed.

The work under this ordinance was started by the placing of the first bridge at Berteau avenue, on the Milwaukee division, on May 16th. The last bridge was placed at Diversey boulevard August 1st. In all 13 subways, three tracks each, in sixty-seven working days, the elevated section being $2\frac{25}{100}$ miles long. This was the portion to be elevated in 1896, and was the south end of the Milwaukee division elevation. The right of way on this division is sixty-six feet wide. The elevation was about eight feet. Two tracks were in use and a third track was laid; the two tracks were lined over about six feet as the work progressed, and the third track was laid just ahead of the elevation. Single track was maintained through the section being elevated; that is to say, about one-half mile of single track was necessary, with switches at each end, in the double track, at the north end, where it had been elevated, and into the double track at the south end just ahead of the elevation. These switches were moved as the elevation progressed; train dispatchers were at each end of the single track and prevented any delay to trains in passing over this single track section, except that the rate of speed was reduced to about ten miles an hour, making a delay to trains of not more than five minutes. The through Milwaukee trains were run via Mayfair during the progress of this work, but 76 passenger trains passed over it every day. The subways averaged about 1,000 feet apart, so the placing of bridges was not the controlling feature of this piece of work, but the unloading of sand (which amounted to 140,000 cu. yds.), as well as placing the street excavation into the fill, which amounted to 57,000 cu. yds. The cross-section of the bank was about 16 cu. yds. per lineal foot. We handled about 3,000 cu. yds. of material a day, and the work advanced at the rate of 200 lineal feet a day, necessitating the placing of a bridge every second day. This was done with regularity. On this division, as well as on the Galena Division, the streets crossed at right angles to track, with the exception of Lincoln Ave. Girders spanning the entire street, Fig. 450, were used, if the

*See folder at end of article.

FIG. 450. BRIDGE AT ROSCOE STREET, 66 FT. BETWEEN ABUTMENTS.

FIG. 451. BRIDGE AT MONTROSE AVE., 80 FT. BETWEEN ABUTMENTS, POSTS ON CURB LINE.

FIG. 452. BRIDGE AT LINCOLN AVE. AND ADDISON ST., LENGTH, 245 FT.

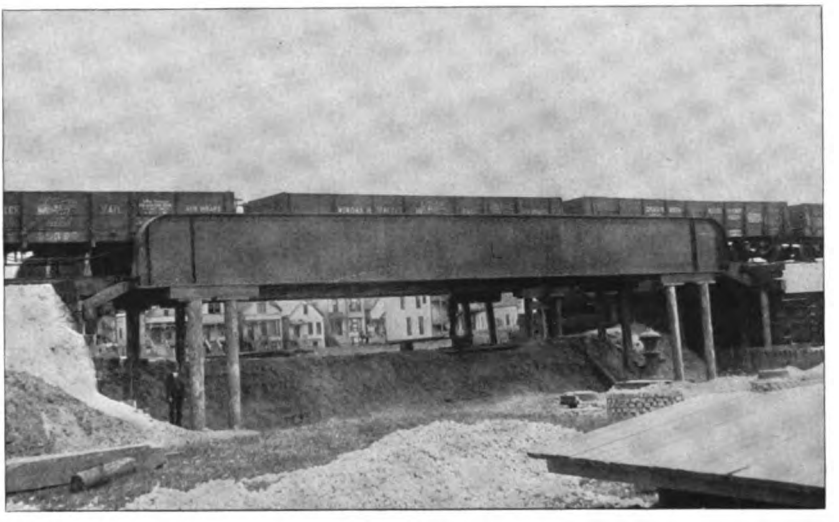

FIG. 453. METHOD OF TEMPORARILY SUPPORTING BRIDGES ON PILING, MILWAUKEE DIVISION.

FIG. 453a. LAKE STREET SUBWAY, LOWER LEVEL; ROCKWELL STREET ELEVATION, SECOND LEVEL; LAKE STREET ELEVATED, THIRD LEVEL.

street was 66 feet or less in width; when over 66 feet posts were used to divide the span, Figs. 551-452. The bridges were temporarily placed on piles, Fig. 453, and at the full elevation, a pier of four piles being placed under each end of a bridge. This did not load the piles but little more than piles are loaded in a pile bridge, unless you consider that the outside piles of a bent do more than steady the bridge. The piles did settle some, but not seriously, and it was a very small additional expense to put a post under the end of the girder where necessary. Double track over this 2¼ miles elevated was in use August 7th; therefore, in a little over twelve weeks 2¼ miles were elevated and the traffic was on the iron bridges on stone abutments.

At Lincoln Ave., Fig.452, we had a diagonal crossing and square crossing combined, making 245 lineal feet of bridge. This bridge was as awkward as could be, but was loaded on to cars at the derrick one mile south of there, taken over 15 degrees reverse curves to the main track, straightened up after getting on the straight track and landed on the iron posts between the hours of 4 and 9 P. M. Fig. 454. The fill was made both sides of the bridge during the next two days, traffic went over the bridge the second morning. Fig. 455. More concisely, the bridge was placed on west track at 6 P. M., July 6th, traffic over it July 9th, 8:40 A. M. Bridge placed in east track, Fig.456, July 9th, 6 P.M., center floor put in July 10th in the afternoon, stone abutments started July 16th, finished July 24th, electric cars started running July 26th. Fig. 457. This bridge was the length of three ordinary street crossings, and the elevating of the tracks at this busy crossing stopped wagon traffic from July 6th to the 26th. The tracks were elevated and on iron bridges, on stone abutments, in sixteen working days. (The piers had been put in previous to the placing of the bridge.)

At Belmont Ave. a sixty-six foot square crossing, the record was as follows: Placed the bridge on west track July 20th, 4 P. M.; placed the bridge on east track July 23rd, 11:00 A. M.; traffic run on west track July 22nd at noon; less than two days required to place the bridge and make the necessary fill and put the traffic on the elevation, the bridge being carried on piles until Aug. 14th, when the masonry was finished.

The building of stone abutments, Fig. 458, in no way interferes with the elevated tracks, as the work is all done from the street level, so that two to three days was the time required to change the tracks from the original level to the elevated level. The concrete foundations were put in ahead of the elevation proper, as this section of the city has quicksand under it, and it was not considered safe to take the chance of undermining the elevated tracks.

As to the balance of this division to be elevated, eight subways remained. The bridges were manufactured in the winter of 1896 and 1897 and were ready to place as soon as frost was out of

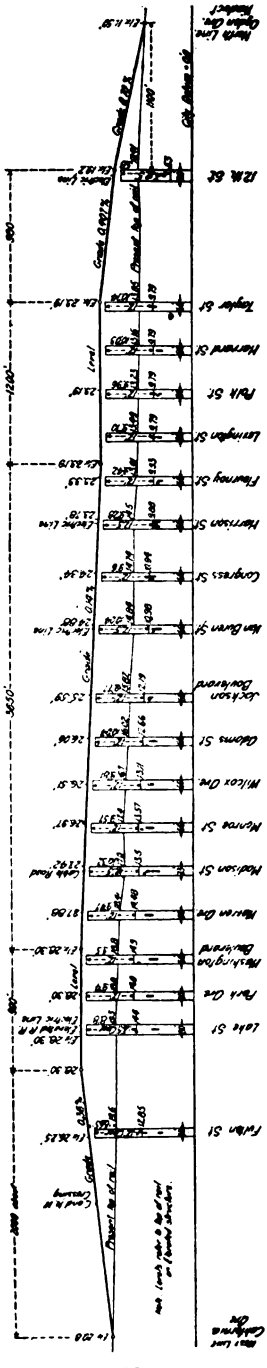

FIG. 459. PROFILE OF THE ROCKWELL STREET ELEVATION.

LINCOLN AVENUE AND ADDISON STREET.
(See also Fig. 452)

FIG. 454. WEST TRACK SPAN LOADED ON SUPPORTS JULY 6, 6:00 P. M.

FIG. 455. WEST TRACK SPAN CARRYING TRAFFIC JULY 9, 8:40 A. M.

FIG 456. DRIVING PILES FOR TEMPORARY SUPPORT OF EAST TRACK SPAN JULY 9.

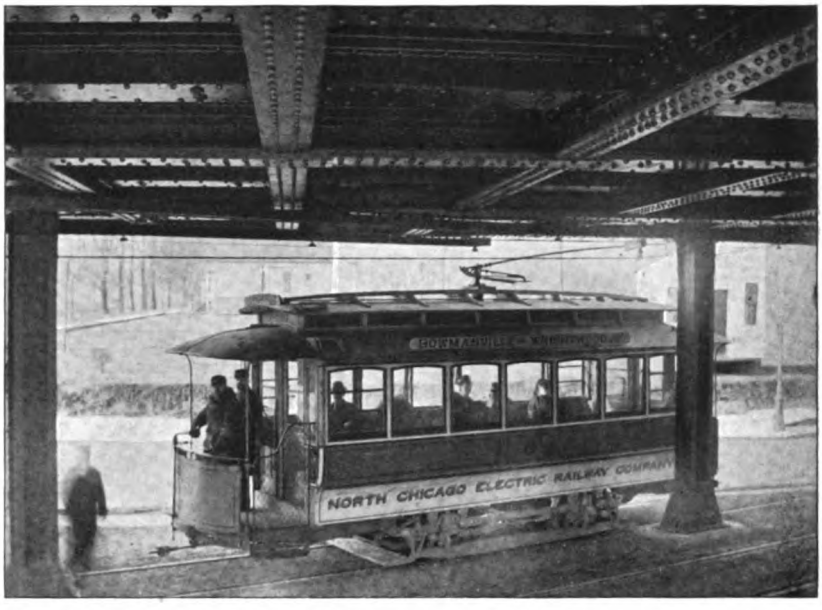

FIG. 457. ELECTRIC CAR CLEARANCE AND UNDER VIEW OF BRIDGE FLOOR AT LINCOLN AVENUE.

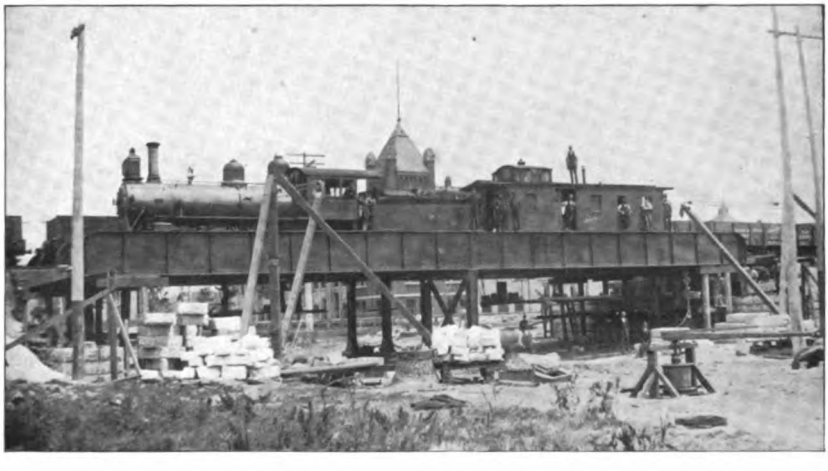

FIG. 458. IRVING PARK BOULEVARD 100 FT. CLEAR SPAN WITH CENTER POSTS. Shows also the building of stone abutments in progress.

the ground in the spring. Work was started April 14th by the placing of the first bridge at Montrose Ave., and was advanced rapidly toward Rosehill, where the 1st bridge was placed at Balmoral Ave. May 10th, or 21 working days for $1\frac{5}{10}$ miles of elevation. On this section of the work, and because of light travel on the streets, we placed three bridges on three successive streets, on the west track, in one day. The streets were: Montrose, Sunnyside and Wilson Aves.; distance between streets, 660 ft. We made the fill between them and put traffic over them in four days; then placed the bridges on the east track at these three streets in one day, and made the fill and put in intermediate floors so that traffic was on the east track in six days; that is, the bridges for three streets, three tracks at a street, were placed and the fill made between them and traffic put over them for a distance of $\frac{3}{4}$ of a mile, in ten days. See profile, Fig. 448.

We were 27 working days unloading sand, and averaged 146 cars, or 4,000 cu. yds. a day; 28,000 cu. yds. of street excavation was placed in the bank, which, with the 110,000 cu. yds. of sand, made the work advance about 340 lineal feet a day.

The month of May, 1897, finished this work on the Milwaukee Division, and the Rockwell St. work was ready for us, an ordinance having been passed January 18th, 1897, for elevating five or more tracks, $1\frac{7}{10}$ miles, to be finished in 1898. It was in a measure co-operative between the three Railways interested, C. &. N. W., P. C. C. & St. L. and C. & N. P. The profile, Fig. 459, and the maps, Figs. 460 and 461, show the location and conditions. By agreement I was formally engaged as Engineer of Track Elevation for the three Railway Companies, and contracts were made by each Company with the same firms for the different kinds of work to be done. The C. & N. W. R'y Co's outfit and men were to do the work and the pay roll to be pro-rated between the three Companies. No contracts or agreements were drawn between the three Railways, each road favored the work wherever necessary and it advanced rapidly. Starting June 4th, 1897, a string of bridges on two tracks (east and middle) were placed at four streets, Monroe, Wilcox, Adams and Jackson, Fig. 462; the fills were made and the intermediate floors put in and double track traffic put on this elevated section June 12th, 2 P. M. This first section elevated was about 1,800 feet long. The remaining bridges were placed on the west track June 13th, intermediate floors put in June 14th. Because of blocking four streets it was decided to make a temporary planked road at Wilcox, which was done June 17th. The street excavation started at once. Masonry started very soon and all branches of the work were well under way by the middle of June. The traffic was elevated over four streets, and it was decided to add a string of bridges on the west tracks over the next four streets to the north, Madison, Warren, Washington and Park Ave., so that with the next change of traffic to the west side of the elevated lines it would be over eight

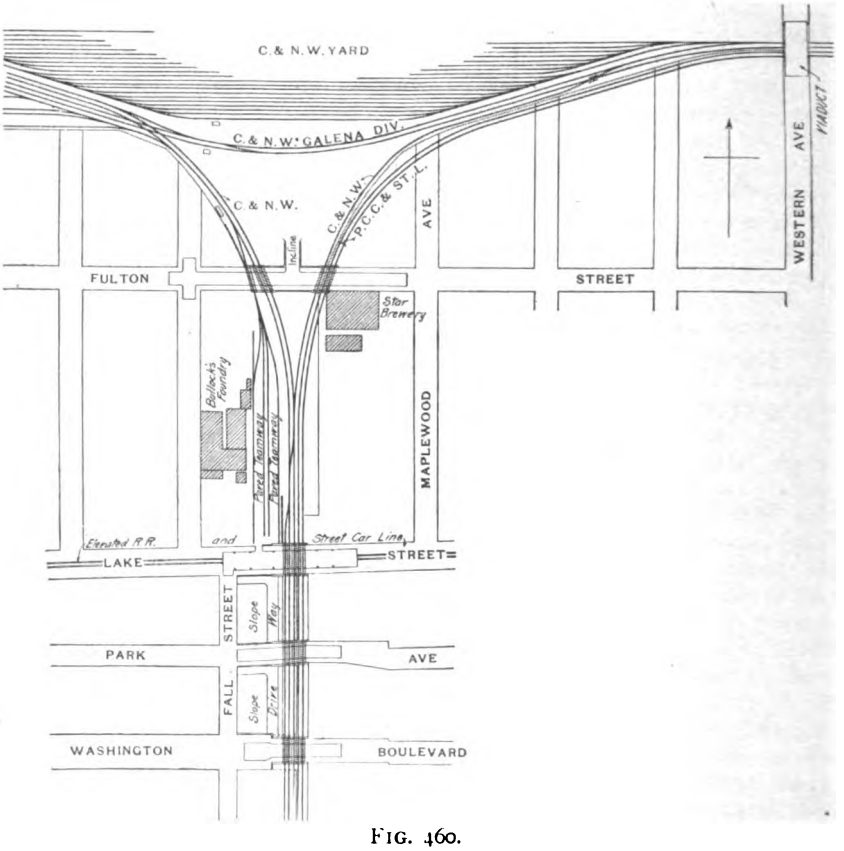

FIG. 460.

MAP OF THE NORTH END OF ROCKWELL STREET ELEVATION.

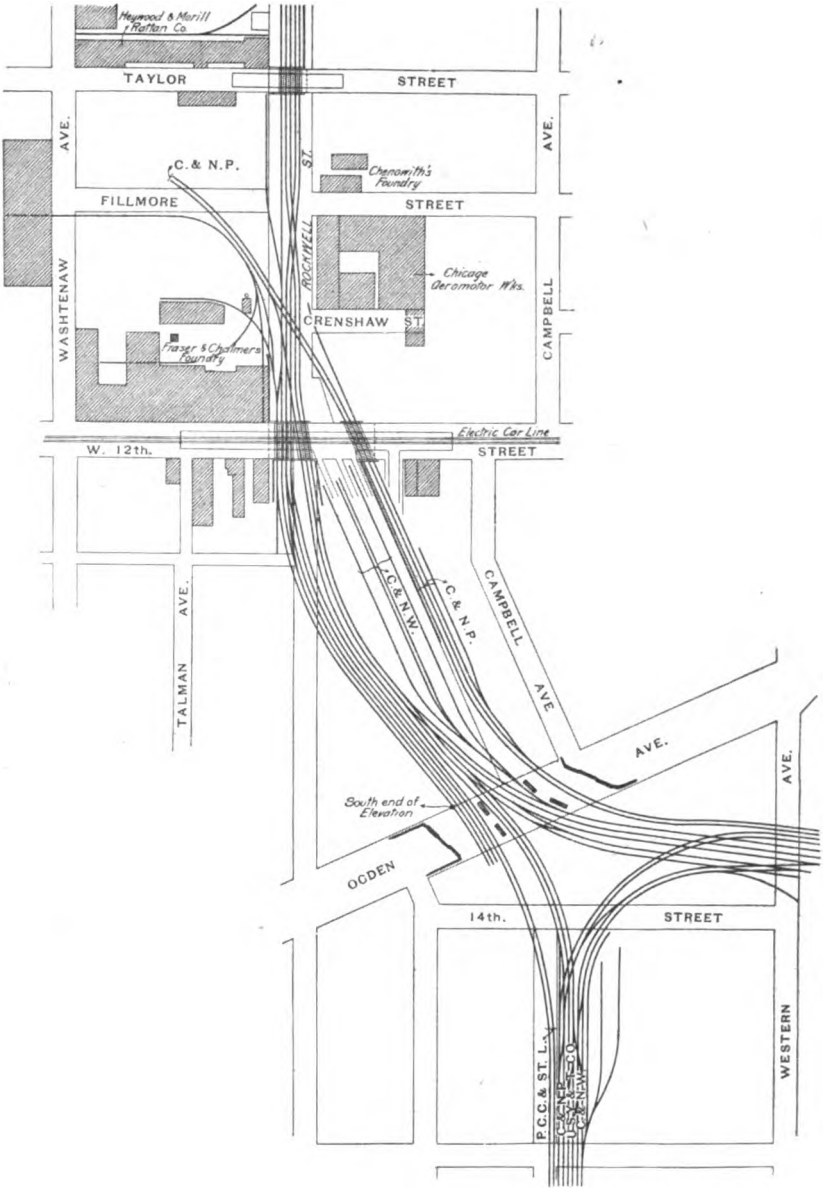

FIG. 461.

MAP OF THE SOUTH END OF ROCKWELL STREET ELEVATION, SHOWING CROSSINGS OF P. C. C. & ST. L. RY., C. & N. W. RY., AND C. & N. P. RY., NORTH OF TWELFTH STREET.

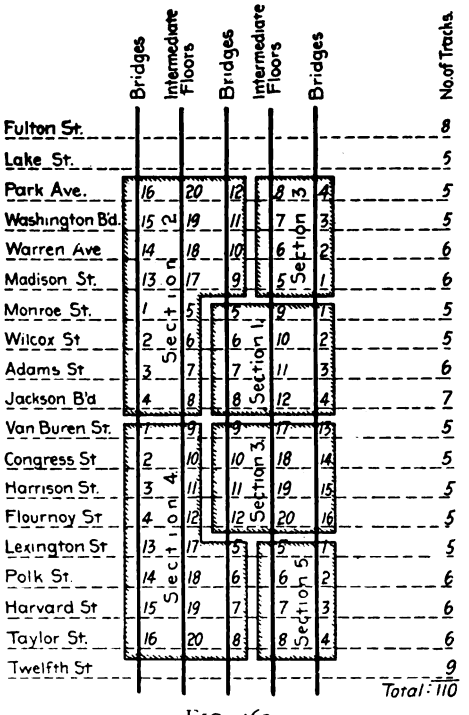

FIG. 462.

PLAN OF TRACK ELEVATION WORK ON ROCKWELL STREET LINE IN CHICAGO. C. & N. W. RY., SHOWING THE ORDER IN WHICH STRUCTURES WERE ERECTED.

bridges. In making this decision the cable line at Madison St. loomed up. The placing of the bridge at Madison St. would stop the cars. The first bridge was placed at Madison St. Friday, June 18th, at 5 A. M. An officer attempted to serve an injunction to prevent the placing of the bridge at 6 A. M., but he was too late. Saturday at 4 P. M. the injunction was dissolved, and the work started again after two days' delay. Had this injunction held, it would have stopped track elevation, except at a full elevation of 16 feet and no interference with street traffic. Traffic was placed on the west track elevated over eight streets June 25th; on the east tracks elevated over twelve streets July 12th; on the west tracks elevated over sixteen streets July 22nd.

In placing bridges at the above sixteen streets, from June 4th to July 22nd, bridges for 87 tracks were placed in 38 working days, or 2 3-10 tracks per day, and in this piece of work the rapid placing of the bridges meant rapid progress. The unloading of sand was of minor importance, but 72,000 cu. yds. of street excavation was placed in the fills, thereby making the expense of excavation for subways practically nothing. This covered sixteen

streets out of nineteen with bridges, and 12th St., the last street on the south, where there were nine tracks, was covered with bridges from July 31st to Aug. 6th.

The bridge for east C. & N. P. R'y Co's track was 125 ft. long and was landed on the temporary pile support Aug. 5th at 6 P. M.; the sand fill was made that night, so that on Aug. 6th at 6 A. M. the traffic went over the bridge single track. The girder that carried the west track was placed at 10 A. M. and the floor put in and fill made so that double track traffic was resumed at 6 P. M., thereby elevating their two tracks over 12th St. in twenty-four hours. The P. C. C. & St. L. R'y, the C. & N. W. R'y and the C. & N. P. R'y tracks cross each other about 200 feet north of 12th St. subway. This crossing was elevated eight feet and traffic maintained over the same amounting to 316 trains a day, or an average of 4,341 cars a day, all the work being done in the day time. See Crenshaw St. on map, Fig. 461.

After placing bridges at 12th St., the bridges were placed at Fulton and Lake Sts., the only streets remaining. Lake St. could not be placed at grade until the Lake St. "L" Road was remodeled. Fig. 453a. This delayed the finish until Sept 19, the men being employed from Aug. 15th to Sept. 19th in ballasting the tracks.

This section of the city has a large street traffic; bridges were only about 350 feet apart, and one street out of each four streets was made passable for teams by planking a roadway as soon as street was excavated to new grade. This proved satisfactory to the people and cost but little. By examining the table of quantities herewith submitted, it will be noticed that the nineteen subways required a large expenditure. The line being only $1\frac{7}{10}$ miles long cost as much to elevate as $4\frac{6}{10}$ miles that was elevated this year on the Wisconsin Division of the C. & N. W. R'y, between Clybourn Jct. and Mayfair. This latter line was covered by the ordinance of March 30th, 1896. It was an elevation of three tracks ten feet, and run in a northwest direction, crossing all the streets but one diagonally, increasing the street spans about 50 per cent. There are twenty-five subways and one footway on this line, as seen by the profile, Fig. 449.* Work was started by placing the first bridge on March 24th, 1898, or rather a string of three bridges on the same track, and was finished by the placing of the last bridge May 28th. Bridges for 77 tracks were placed in 58 days, or an average of $1\frac{1}{10}$ tracks per day. The unloading of sand was the item that would give rapid progress, and our record was 343,463 cu. yds. in 58 working days, or 5,800 cu. yds. a day; 98,000 cu.yds. of street excavation were put in the fill during this time at a cost to the company of 27c per cu. yd., including overhaul. This work progressed at the rate of exactly two miles of three track railway, elevated ten feet, in a month.

The men engaged in ballasting this work during June and the first of July, were put on to track work, between Diversey Boul. and Chicago Ave., where the foundations for bridges and

*See folder at end of article.

retaining walls are being built for the section to be elevated in the spring of 1899, under an ordinance dated December 29th, 1897, shown in the profile, Fig. 464*.

This work extends the elevation of the Wisconsin & Milwaukee Divisions, previously treated of, to Chicago Ave. viaduct, and will consist of fourteen full subways, four half subways and four footways. Five miles of retaining wall are to be built this fall, all the foundations put in for the subways. 90 lb. steel is being laid for a double track for each division from Clybourn Junction to Erie St., and an outside freight track on each side of the running tracks, giving six tracks every where and in some places seven. This work will take from March to June, 1899, at which time the Chicago & North-Western R'y will have elevated its tracks everywhere that they can be elevated independent of other roads, and will have elevated the Galena Division to Western Ave. viaduct, Rockwell St. on the Belt Line to Ogden Ave. viaduct, and the Wisconsin & Milwaukee Divisions to the Chicago Ave. viaduct. That is, they will have elevated until they reach the viaduct district in every direction, and can proceed no further until the city disposes of the viaducts that they ordered built and made the roads pay for.

June 1st, 1899, the road will have elevated 14½ miles of their terminal in Chicago; this will include 90 subways and five footways. (Seventy-two subways and one footway are now built and $11\frac{78}{100}$ miles are elevated.) This reduced to double track equals $27\frac{49}{100}$ miles, including 15,403 lineal feet of double track bridging.

There are two other small pieces of elevation that this Company has an interest in; one is for two subways near Mayfair made necessary on account of elevating the C. M. & St. P. R'y over Milwaukee Ave. and Irving Park Boul., and the other a one-fourth interest in the Air Line, where this Company's interest, since the plans were agreed to, seems to be only in a prompt payment of bills rendered. The first piece is to be elevated next year to suit the wish of the C. M. & St. P. Ry. Co., and the second is under way.

In the process of track elevation we have loaded on to cars, Fig. 466, 179 bridges and safely landed them on the temporary pile support or on the permanent iron posts, see Figs. 467-468, carrying some of them on cars as far as five miles, thereby proving the feasibility of the plan. As to the expense, the cost of the entire temporary work of placing bridges, building back walls (Fig. 469) driving piles where driven, putting track stringers where foundations precede the work of elevation, is less than one dollar per lineal foot of track, to be compared with the cost of temporary pile or trestle bridging, which costs at least five dollars per foot of track, since there would have been 44,800 lineal feet of temporary pile bridging necessary if the usual method had been followed; this saving is approximately $179,200. As to the chance

*See folder at end of article.

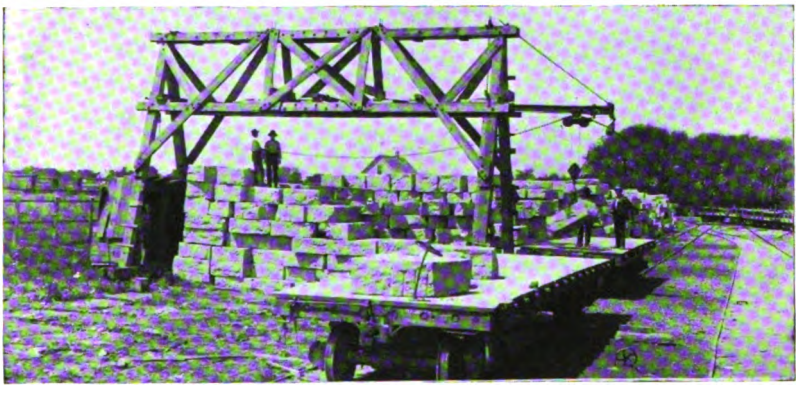

FIG. 465. STONE DERRICK IN STORAGE YARD.

FIG. 466. COMPLETE SPAN LOADED ON CARS FOR DELIVERY ON WORK.

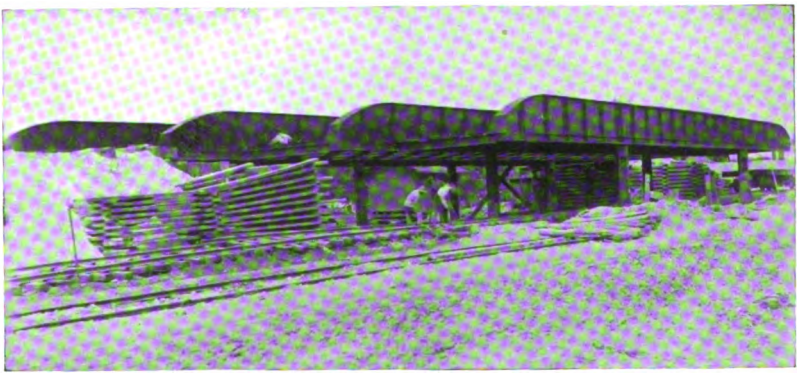

FIG. 467. LONG SPANS IN POSITION ON PERMANENT IRON POSTS.

FIG. 468. LOWERING BRIDGE SPAN ONTO PILE SUPPORTS.

FIG. 469. TEMPORARY END SUPPORT AND BACK WALL.

ot rushing the work (as the President of this Railway was anxious to do—considering the process of elevation a nuisance, and the shorter the nuisance the better), there is no questioning the fact that three tracks elevated ten feet for a distance of two miles in one month, is a more rapid progress than any other road has made to date, and this, too, at no additional cost.

Traffic over the Galena Division, the first piece elevated, was 294 trains a day, 2,619 cars. Traffic was interfered with from April 15th, 1895, to July 10th, 1895. Double track interfered with during elevation, 1.89 miles of five tracks interfered with 55 days.

On the Milwaukee Division the traffic consisted of 76 trains a day.

It was interfered with from June 16, 1896 to Aug. 7, 1896, 51 days.

It was interfered with from Apr. 12, 1897 to May 12, 1897, 30 days.

Single track interfered with during elevation, $3\frac{6}{10}$ miles, 3 tracks, interfered with 81 days.

On the Rockwell St. Line, $1\frac{7}{10}$ miles, the traffic is 195 trains, or 3,171 cars a day, except on the 12th Street crossing, where it equals 316 trains, or 4,341 cars a day.

While work was in progress the tracks of the C. & N. W. R'y were used in common by the P. C. C. & St. L. R'y and their tenants, the C. M. & St. P. Ry. Co., for 52 days; the P. C. C. & St. L. Ry. Co.'s tracks were used in common by the C. & N. W. Ry. Co. for 23 days—traffic being thus interchanged 75 days—but a double track was maintained all of the time. This arrangement started June 1st, 1896, and each road had a double track elevated Aug. 24th, $1\frac{7}{10}$ miles of 5 tracks in 80 days.

On the Wisconsin Division, $4\frac{6}{10}$ miles, the traffic is 55 trains a day.

Single track during elevation in mile sections was interfered with from March 24th to June 4th or $4\frac{6}{10}$ miles of 3 tracks, for 73 days.

The summary is, therefore, track elevated in four different parts of the terminal, covering a length of right of way of $11\frac{78}{100}$ miles, three and five track systems, which reduces to $21\frac{2}{100}$ miles of double track, having 10,655 lineal feet of double track bridging spanning 72 subways, with interference with traffic amounting to 289 days, or about ten months. The graveling of the elevation proceeded rapidly in each instance, so that with the above intervals excepted, a speed of 25 miles an hour could be maintained over the different portions elevated.

Regarding the bridge design. The floor, Figs. 470 and 471, is 12 inches thick and consists of floor beams built of two 10 inch channels with top and bottom plates connected to the girder, with a ½ inch gusset projecting two feet, that goes between the channels—a filling piece extends from gusset to gusset. These beams are about 5 feet apart and track stringers made of two "Z" bars about 16 inches apart, carrying an oak block 16 inches wide and 6 inches to 7 inches thick, connects them. The varying thickness of block

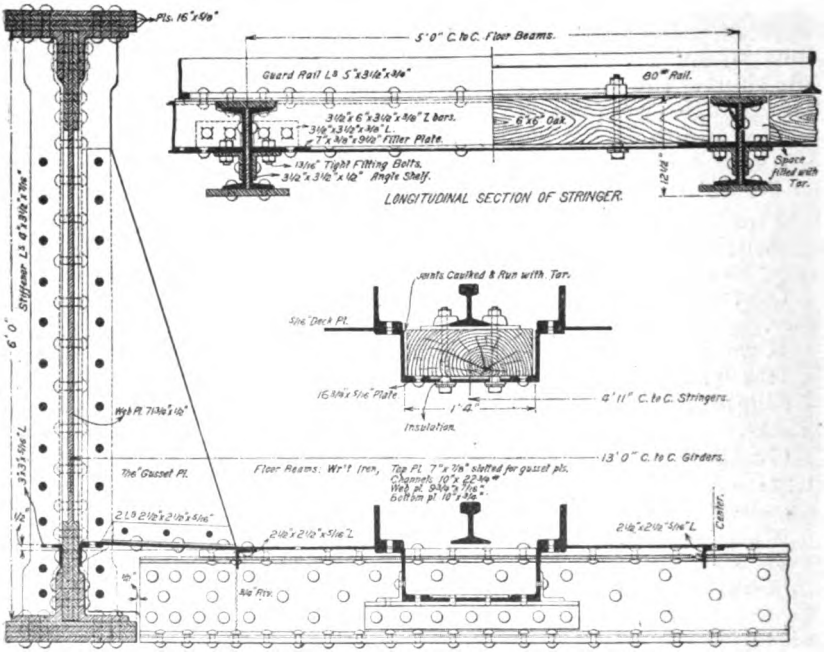

FIG. 470. SECTIONS OF BRIDGE FLOOR, C. & N. W. RY.

levels the rail and allows of one inch camber in girders for drainage. A 5 inch angle iron is riveted to the top of the "Z" bars on each side of track stringers to strengthen them, as well as to guide derailed wheels. The bridge floor is covered with $\frac{5}{16}$-inch plates which are stiffened by small angles breaking the large surfaces. This covering plate is covered with a coat of gravel roofing to protect the iron. The floor beam is designed for one axle 40,000 lbs., one panel floor 4,000 lbs., length 12 feet. This requires that the gusset shorten the span of floor beams one foot, and since each gusset projects two feet, I think the reasoning is correct—at any rate, the floor is very rigid.

The double track girders are designed for 4,000 lbs. per lineal foot plus 1,400 lbs. dead load, making 5,400 lbs. per lineal foot. The metal is strained 9,000 lbs. per sq. in. net section in tension. The outside single track girders are designed, 2,500 lbs. plus 850 lbs., making 3,350 lbs. per lin. ft. Weight of floor is 531 lbs. per lin. ft. of bridge; this does not include the gussets or guard rails.

A girder for double track 66 ft. square street crossing weighs 41,000 lbs. Amount of metal in C. & N. W. elevation, including work under process of elevation, 21,747 tons.

The abutments for bridges were of concrete foundations and Duck Creek dimension stone cut at the Company's quarry for face stone, with Lemont rubble for backing; the dimension stone

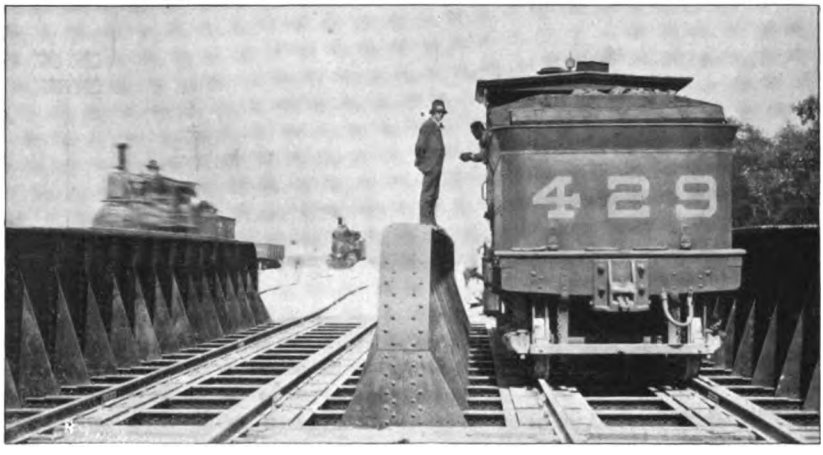

FIG. 471. SHOWING CLEARANCE AT BRIDGES WITH TRACKS 13 FEET CENTER TO CENTER. Top of highest Girder, 5 feet above top of rail, or 1½ feet below car window. Girder 16 inches wide. Clearance 10 inches.

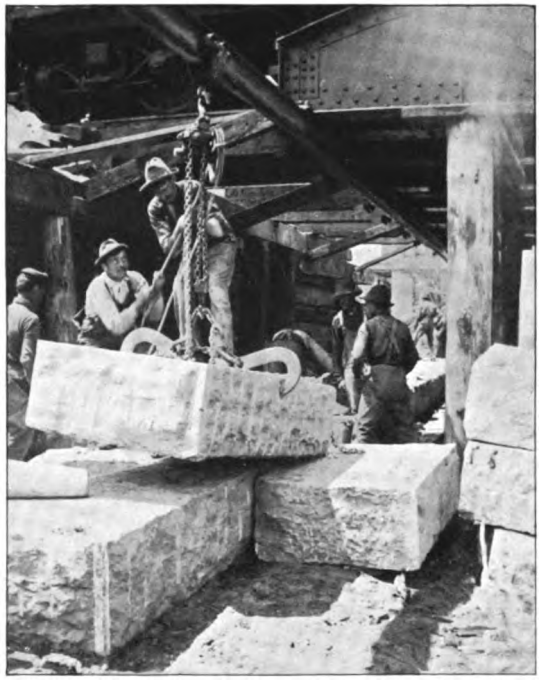

FIG. 472. EIGHT-INCH I BEAM, TROLLEY AND TWO-TON HOISTING BLOCK USED IN LAYING DIMENSION STONE IN ABUTMENTS.

was distributed for setting by a trolley, Fig.472, carried by an 8-inch I beam suspended from the lower flange of girders; this trolley carried a 2-ton Yale & Towne block. Stone was unloaded from cars on one piece of work by a derrick fixed to the outside of girder, having a boom swinging over the car; this required one track to work from; a horse-power on the street handled the stone being unloaded. 120 cubic yards per day have been laid in this way, in a good many consecutive days. The record on the Wisconsin Division—26 subways built this year—is as follows: Started work April 5th, finished 52 abutments July 7th, 9,397 cubic yards in abutments, or 117½ cubic yards per day, or one subway in 3$_{10}$ days.

On another piece of work we used a steam derrick instead of the fixed derrick. This requires a track for the derrick and another for the stone train, and was not as satisfactory.

The plan of abutment was a large pedestal block 5 ft., x5 ft., x1½ ft., carrying a casting about 18 inches high; this gave room to use the jacks under bridges on the stone work to line the bridge before being bolted to masonry.

The foundation concrete was made of American Portland cement for the piers, and of native cement for the abutments. The Railway Company furnished all the material used, so there has been no incentive to stint the work.

The responsibility of handling the work was arranged for as follows:—

Wm. Graham designed the bridges, arranged for their delivery on the work and assembling.

G. C. Chittenden had charge of all track work and train crews.

T. R. Philbin had charge of all work on subways.

T. Gilmore placed the bridges and maintained them until on permanent support.

C. H. Kilpatrick had charge of material and labor accounts.

All subway work was done under contract.

The sand filling was purchased f. o. b. cars C. & N.W. tracks.

Bridges were purchased erected.

The force of subway contractor averaged about 200 men.

Bridge erecters averaged about 50 men.

C. & N. W. R'y Co's force averaged about 350 men.

The following detail of the work may be looked into by any one specially interested:

	Galena Div.	Milwaukee Div.	Rockwell St. Line	Wisconsin Div. Clybourn Jct. to Mayfair.	Wis. & Milw. Divs. Wrightwood Ave to Chicago Ave.	Totals.
Miles	1.80	3.75	1.70	4.60	3.00	14.85
Tracks	5	3	5 & 6	3	6	
Cubic Yards						
Sand Filling	275,000	250,000	177,000	343,000	450,900	1,495,900
Street Excavation	30,000	85,000	72,000	98,000	76,000	361,000
Gravel Ballast	52,000	50,000	20,000	50,000	50,000	220,000
Masonry Abutments and Foundations	7,300	11,500	17,000	21,000	21,150	77,900
Rubble Retaining Walls & Foundns.	2,100	2,160	9,200	.....	50,000	63,460
Tons of						
Bridge Metal	1,645	3,114	5,540	5,598	5,650	21,457
Square Yards						
Paving	11,500	31,000	36,400	38,500	33,400	150,800
Sidewalks	7,000	13,000	14,700	17,000	24,300	76,000

Summary of all Track Elevation in Chicago to Date.

Lake Shore & Mich. Southern R'y Chicago, Rock Island & Pacific R'y	6.5 Miles	Elevated.	39	Subways.
Illinois Central R. R.	2.5 "	"	12	"
Pittsburg, Ft. Wayne & Chicago R'y	2.0 "	"	13	"
Chicago, Milwaukee & St. Paul R'y	2.0 "	"	12	"
Total by other Railways	13.0 "	"	76	"
Chicago & Northwestern R'y	11.8 "	"	72	"

Note.—Figs. 446, 448, 459, 460, 461 and 470 are reproduced from *The Railroad Gazette*, and Fig. 462 from *The Engineering News*.