American Railway Engineering and Maintenance of Way Association

BULLETIN No. 64 JUNE, 1905

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Protecting and Water-Proofing Solid Floor Bridges

By W. C. CUSHING,

Chief Engineer Maintenance of Way, Pennsylvania Lines, Southwest System.

Published under Direction of the Committee on Publications

W. D. PENCE, Prof. of Civil Engineering, Purdue University, Lafayette, Ind., *Editor.*

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E. H. FRITCH, *Assistant Secretary,*
1562 Monadnock Block.
Chicago

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American Railway Engineering and Maintenance of Way Association.

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PROTECTING AND WATER-PROOFING SOLID FLOOR BRIDGES.

By W. C. Cushing, Chief Engineer Maintenance of Way, Pennsylvania Lines, Southwest System.

The work of separating street and railway grades in Chicago during the past 13 years has stimulated among railway engineers the study of a suitable design for a bridge floor, which will be practically water-tight, and at the same time afford reasonable protection to the metal work of the structure, because the cost of reprotecting a ballasted solid-floor bridge is very large.

In the earlier days, when the Illinois Central became the pioneer of "track elevation," preparatory to the removal of the railroad track obstruction to the Columbian Exposition, the term "solid-floor" was considered synonymous with "shallow-floor," and the bridges were constructed with such floors till it was found to be practically impossible to comply with the conditions of water-tightness, steel preservation and noiselessness. The latter condition has become a very important one, and has been a very considerable cause for the abolition of the shallow-floor, as it was necessary to put ballast between the cross-ties and the steelwork, in order to deaden the sound.

The change in style of construction has led to new problems in water-proofing and steel preservation, and it is the object of the writer to explain some of the plans used on the P., C., C. & St. L. Railway at Brighton Park and Englewood, in 1904, while at the same time as clear a comparison of results as possible will be given.

BRIGHTON PARK BRIDGES AT THIRTY-FOURTH, THIRTY-FIFTH AND THIRTY-SIXTH STREETS

Each of these bridges has 9 tracks, as follows:

No. 1, No. 2, No. 3, No. 4	P., C., C. & St. L. Railway.
No. 5, No. 6	Chicago Terminal Transfer Railroad.
No. 7, No. 8, No. 9	Chicago Junction Railway.

In type, they are half through, single span, plate girders, 55 ft. long at Thirty-fourth Street, and 71 ft. long at the other two, with a double track between each two girders, except in the case of Track 9. (Photo. Fig. 1.)

The floor system, illustrated in Figs. 2 and 3, consists of 6 by 10 in. creosoted pine timbers laid closely together, parallel with the track, on the bottom flanges of heavy cross box-girder floor beams. The drain water is carried through these box girders in 2-in. pipes, calked in like boiler tubes, and in gutters cut in the creosoted timbers, to the low end of the bridge back of the ballast wall.

METHOD USED FOR TRACKS 1 AND 2.

A Portland cement mortar layer, 4½ in. thick at the center, and sloping to the drain pipes at the sides, where it is about 2 in. thick, was first laid on the creosoted timbers, the proportions used in the concrete being 1 cement to 5 torpedo sand, except at Thirty-fourth Street, where it is 1 cement to 6 limestone screenings. Then, on this cement layer, and on the steelwork, a layer of hot asphalt was poured and swabbed on till it became a ½-in. thick.

The work was done very early in 1904, when the temperature was below freezing every night, and frequently during the day. Owing to conditions of construction, the time could not be chosen. The bridge erectors were waiting for the next bridge, and the work, therefore, had to be hurried.

The asphalt did not adhere well to the cement, presumably on account of the moisture in the cement.

Considerable difficulty was also experienced in getting the asphalt to adhere to the steel, on account of the shop coat of oil. An attempt was made to remove this coat by burning benzine, which was lightly poured over the oil, but with poor results.

When the test was made by standing water on the bridges before use, they were all found to leak, principally around the pipes in the box girders, but were patched till entirely water-tight before being put in service under traffic.

METHOD USED FOR TRACKS 5, 6, 7, 8 AND 9.

Owing to the poor adhesion between the asphalt and the cement, it was decided for the next work to omit the cement, and substitute asphalt mastic. After considerable study, specifications for the asphalt were prepared, which, after some changes, finally took the form submitted in the Appendix. The writer is indebted to Mr. W. H. Finley, then Principal Assistant Engineer of the Chicago & Northwestern Railway, for the matter contained in them. The asphalt was purchased under the specifications from different manufacturers, and, after receipt of a shipment, samples were taken to a testing laboratory and tested.

The steelwork was first thoroughly cleaned with concentrated lye, and then painted with asphalt paint. A layer of pure asphalt gum ¼-in.

thick was poured over the creosoted timbers and top of the steel box girders, and mopped on the sides of the latter till of the same thickness, after which a layer of asphalt mastic (made in the proportion of 1 asphalt to 4 of limestone screenings) was put on 4½ in. thick at the center and about 2 in. thick at the side drains. Finally, on top of all was poured a ¼-in. thick layer of pure asphalt, which, of course, had to be mopped on the sides of the girders.

All of the bridges were made water-tight under test by patching where necessary. The work was performed in July and August.

METHOD USED FOR TRACKS 3 AND 4.

The difficulties experienced with the asphalt mastic at Englewood, which will be described later, and the good results from the protection for Tracks 1 and 2, which were apparent after an inspection September 14th, succeeding a heavy rain, led to a return to the cement undercovering instead of asphalt mastic for these tracks.

A Portland cement concrete layer, 4 in. thick at the center, and about 2 in. thick at the side drains, in the proportions of 1 cement, 3 torpedo sand, and 3 crushed limestone broken to 1 in. size, except that at Thirty-fourth Street the proportions were 1 cement to 6 limestone screenings, was placed on the creosoted timber and well troweled on top, to a smooth sidewalk finish, after which it was allowed to dry thoroughly.

The steelwork was cleaned with concentrated lye and water, and the parts of steel and concrete intended to be covered with asphalt were painted with two coats of liquid asphalt, after which a ¼-in. layer of pure asphalt was poured on, then the asphalt mastic, in the proportions of 1 asphalt to 4 parts of sand and screenings, hot from the kettle, was packed and rammed, and the whole, including the box girders, covered with a finishing coat of pure gum asphalt, ¼-in. thick. The mastic was not carried over the tops of the box-girder floor beams.

Fig. 4 shows the concrete in place, and Fig. 5 a completed portion of one of the bridges. The work was done in August and September.

ENGLEWOOD BRIDGES.

These are single-track half through plate-girder bridges of one span, each 72 ft. long (Fig. 6), except that the Murray Street bridge has two tracks, with three girders, while the one at Wallace Street is a steel trough floor bridge 25 ft. long, with the troughs running parallel with the track. The floor systems of the other bridges are of the same type, except that the troughs are at right angles to the track. The design is shown in Fig. 7.

On account of the intention to add a second track to these bridges in the future, it was decided to use the asphalt mastic instead of concrete for filling the troughs, the latter being completely filled so as to carry the drain water to one or both ends of the bridge.

METHOD USED AT WRIGHT, WALLACE AND LOWE STREETS.

A ¼-in. layer of pure hot asphalt was poured all over the steel-work to be covered, mopping being resorted to in the case of vertical surfaces, and the troughs were then filled with hot asphalt mastic, mixed in the kettle in the proportions of 1 asphalt to 5 parts of sand and screenings. This mastic was carried over the tops of the troughs, crowned in the center and sloped to the sides, which were built up in the form of gutters. On level track the gutters were sloped to each end of the bridge from the center. On the mastic was poured a ¼ to ⅜-in. layer of pure hot asphalt, over which, while hot, was scattered a half-inch layer of clean gravel.

It developed during the progress of the work that the mastic, while cooling, contracted, and pulled away from the sides of the troughs, but the cracks were filled again as completely as possible with the liquid asphalt. On test, when the work was completed, the bridges were water-tight, but, in the light of subsequent effects, the cooling must have continued, resulting in very fine cracks, which caused leaks.

METHOD AT MURRAY AND UNION STREETS.

In order to avoid the contraction of the asphalt recited above, mastic blocks were molded in the proportions of 1 asphalt to 4 lime-stone screenings and allowed to cool. They were of such size as would just fit between the rivet heads of the troughs, and were set in place after the usual ¼-in. coat of pure asphalt had been put on the steel. The spaces were poured full of pure hot asphalt, but it was evident, during the pouring, that the cool blocks absorbed a good deal of the liquid, and it is considered possible that some voids remained near the bottom. The top was finished in the same manner as the other bridges.

Subsequent results seem to indicate that the new method did not entirely correct the old.

BRIGHTON PARK BRIDGES AT ARCHER AVENUE.

This matter deals only with the 4-track, single span, half through plate-girder bridge (Figs. 8 and 9), of the P., C., C. & St. L. Railway. There is only one track between each two girders, which are 68 ft. long, and on skew.

The floor system consists of square steel troughs, illustrated in Fig. 10, and are similar to the ones used on the Englewood bridges.

Some new methods of waterproofing having been proposed, it was decided to try a different one for each track of this bridge, but in each case, the shop coat was removed with concentrated lye, at a cost of about one cent per sq. ft. of surface.

METHOD FOR TRACK 1, FIGS. 11 AND 12.

The troughs were filled to the top with Portland cement concrete, mixed in the proportions of 1 cement, 3 torpedo sand, and 3 crushed stone, after which a galvanized wire netting of No. 10 wire, with 2-in. mesh, and costing 5 cents a sq. ft., was spread over the tops of the troughs, so as to rest on the rivet heads. This was then covered with cement mortar, mixed with 1 cement to 3 sand, 2 in. thick in the center, and sloping to the sides, where it is about 1¼ in. thick, thus allowing the water to drain to the sides, and thence to one end, as the bridge is on grade.

METHOD FOR TRACK 2, FIGS. 13 AND 14.

The troughs were filled with Portland cement concrete, as above, except that it was carried above the troughs, as in Fig. 13, crowned at the center and sloped to the sides. A pocket was made at the top edges, where they joined the main girders, and the surface was troweled to a sidewalk finish.

On this was placed 3 layers of Hydrex Felt, laid transversely with the track, and lapped like shingles, with 12 in. exposure, starting at the lower end of the bridge. The Hydrex is a patent saturated felt, made by Hydrex Felt & Engineering Co., in rolls 36 in. wide, and about 66 ft. long. Before placing, the concrete is swabbed with hot "Hydrex Compound," and the felt then smoothed down on it. The felt is turned into the pocket at the girders, and the cavity filled with the "Compound."

On top of the felt a ¾-in. layer of cement mortar was placed to prevent the puncturing by ballast of the waterproof felt covering. It was laid in blocks and troweled as in sidewalk work.

METHOD FOR TRACK 3, FIG. 15.

This is the same method used for track 2, except that the top layer of concrete has been omitted. This is to determine whether the Hydrex Felt will be punctured by the stone ballast or not.

METHOD FOR TRACK 4, FIGS. 16 AND 17.

The concrete filling was carried up to the top of the rivet heads, except that the surface was sloped from the center to the sides, and on it was placed a 1½-in. layer of asphalt. This was made by first painting the dry concrete surface with liquid asphalt, made of asphalt and benzine, after which hot asphalt was poured on to a depth of ¼-in. The liquid layer was followed by 1 in. of asphalt mastic, in the proportions of 1 asphalt to 4 limestone screenings, and this by another ¼-in. liquid layer, on top of which torpedo sand was sprinkled to harden the top.

P., F. W. & C. RAILWAY BRIDGES.

METHODS USED AT FIFTY-FIRST AND FORTY-SEVENTH STREETS.

These are steel trough floor bridges, square in section, and supported parallel with the tracks on transverse girders, standing on columns on the curb lines, and in the center of the streets, a total clear length of 68 ft., in two 11 ft. sidewalk spans, and two 23 ft. roadway spans (Figs. 18 and 19).

For the first track, the troughs were filled with asphalt mastic without either painting the steelwork, or pouring on a coat of pure asphalt; this being done at the expressed wish of one of the asphalt manufacturers, who was given charge of this to do in the best way he could recommend. The mastic, mixed in the proportions of 1 asphalt, 3 torpedo sand, and 2 limestone screenings, was built up to 2 or 3 inches over the tops of the troughs, the center being higher, and the surface sloping to each end of the bridge. On top, a layer of pure asphalt gum ¼ to ⅜-in. thick was poured, and then sprinkled with sand to harden it. On test, immediately after its completion, the bridge was found to leak badly.

It developed during the progress of the work that the shrinkage of the asphalt when cooling was such as to leave the metal practically unprotected, and the method was abandoned.

The bridges for the remaining tracks, 10 in number, and for Forty-seventh Street, were done as follows:

(Fig. 20.) The steelwork, after being cleaned, was painted with hot asphalt and benzine, and ¼-in. layer of hot asphalt poured on and thoroughly mopped over, after which the troughs were filled to within about 3 in. of the top with cement concrete in the proportions of 1 cement to 6 limestone screenings. When this was thoroughly set and dry, the remaining depth of the troughs was filled with asphalt mastic, which was carried over their tops in a layer of 2 to 3 in. thick, somewhat thicker at the center than at the ends, and this was in turn covered with a ¼ to ⅜-in. thickness of pure gum.

There are six different bridges at Fifty-first Street. No attempt was made to remove the shop coat of oil from Nos. 1 and 2, and on No. 3 most of the experiments for removing the shop coat, which will be described later, were tried, after which it was decided to paint the steelwork of the remaining bridges with liquid asphalt, without removing the shop coat.

METHODS USED AT FORTY-SIXTH STRRET.

This is a 4-track half through plate-girder bridge with a steel trough floor like that at Archer Avenue.

All the troughs were filled with Portland cement concrete made in the proportion of 1 cement to 5 parts of limestone screenings.

At Track 3, the concrete was carried up over the tops of the troughs, and a finishing coat of asphalt, as in Figs. 16 and 17, for Archer Avenue, was put on.

Tracks 1 (the most easterly one) and 2 and 4 were finished in the same manner as in Figs. 11 and 12 for Archer Avenue, but the depth from bottom of tie to top of trough, about 8 in., is greater at Forty-sixth Street and permitted a greater thickness of mortar layer on top of the troughs, 3 in., with the wire netting in the center. This top layer of mortar was composed of 1 cement to 2 parts of limestone screenings.

RESULTS OF EXAMINATION MADE ABOUT JAN. 1, 1905.

BRIGHTON PARK BRIDGES.

Archer Avenue: No indications of leaks on any of the bridges. Thirty-fourth, Thirty-fifth and Thirty-sixth streets: Leaks showed plainly at every track of each bridge, but Tracks 3 and 4 showed the fewest. The asphalt examined when the temperature was about 0° Fahr. showed it to be hard, glassy, and easily shattered by a blow.

ENGLEWOOD BRIDGES.

Every bridge, with the single exception of the one at Wallace Street, showed leaks along the girders. As the troughs are practically water-tight, the only place where leaks can show is at the junction point between trough and girder, but it does not prove that the water finds its way down between the asphalt and the girder; it may occur at any other point, but the drip will always show on the girder line.

P., F. W. & C. RAILWAY BRIDGES.

All the bridges at Fifty-first and Forty-seventh streets showed leaks at the post lines, because the concrete, as well as the asphalt, cracked at those places, on account of lack of steel reinforcement. One bridge protected with asphalt was not put into service for several weeks after completion, but there was no difference in the result.

At Forty-sixth Street, up to the time of the inspection, the bridges for tracks 1 and 4 seem to be water-proof, but that at Track 2, done late in the fall, showed leaks. The top layer of the concrete, in which the wire netting was imbedded, froze during the work, which may be responsible for the trouble. At Track 3, where a concrete filling with asphalt top was used, leaks appeared along the girders, which may have been due to the asphalt pulling away from the girders.

GENERAL INFORMATION AND COMMENTS.

CLEANING THE STEEL.

Right from the start difficulty was experienced in obtaining a satisfactory adhesion of the asphalt to the steel. As soon as it became cold, it could be peeled off like paper. After a good deal of experimenting it was found that asphalt would adhere to steel in about the following order:

(1) Rusty steel; no adhesion.

(2) Shop coat of red lead or oil; slight adhesion.

(3) Shop coat covered with liquid asphalt; slightly better than 2.

(4) Shop coat burned by pouring benzine over the steel and burning it; about the same as 3.

(5) Perfectly clean bright steel; excellent adhesion.

In order to have the fifth condition, a sand blast is probably necessary, but as there was none available, other means of removing the shop coat were resorted to. The bridges had all been given a shop coat of oil, and on some parts, red lead. The usual wire brushes and scrapers were expensive to use, and not satisfactory.

Burning benzine over the shop coat had little effect on the oil, except to soften it. It, therefore, required a number of repeated burnings to remove it entirely, which was expensive.

A paint burner, similar to the Buckeye Burner and Wells Light, was tried to a small extent, but it was slow, on account of being necessary to concentrate the flame on a small area in order to soften the oil sufficiently to be easily removed with scrapers. It was thought when this burner was made that the heat would be great enough to burn off the oil coat completely, without scraping, but it did not prove to be the case.

Cleaning with concentrated lye and lime was tried at Fifty-first Street with good results, so far as removing the shop coat was concerned, but it was found so difficult to remove entirely the lime and lye from the steelwork that the method was given up as impracticable. The lime stuck to the steel in spite of the frequent washings, and small particles would lodge in uneven surfaces around the rivet heads, where it was next to impossible to remove it.

The best results were obtained by using concentrated lye and water, in the proportions of 1 pound of lye to 1½ gallons of water. This solution was swabbed on the steel, wire brushes and scrapers were then used, and finally the steel was thoroughly washed until all the lye had disappeared. The cost was about one cent per sq. ft. of surface.

After the above methods were tried, and it was found that pretty good adhesion between the asphalt and metal was obtained by painting over the shop coat with liquid asphalt made by pouring hot asphalt into benzine, or obtaining it from the manufacturer, this plan was generally followed. When the liquid asphalt was applied, the benzine evaporated, leaving a thin layer of asphalt on the steel. A pretty thick mixture was used, and after applying two coats, the layer was about $\frac{1}{16}$-in. thick.

LABORATORY TESTS.

As it was desirable to purchase asphalt in a competitive market, the specifications in the Appendix were prepared, and the orders were based on the manufacturer's agreement to comply with them. Samples were then taken and sent to a testing laboratory for determination of qualities. The requirements were purposely made severe, as the office the asphalt had to perform was severe.

The product of only one of three concerns fulfilled specification No. 1, the volatile test, while all stood the acid test. All but one sample did not flow at 212° Fahr. and that one did so only at 196° Fahr. At 15° Fahr. below zero, about half the samples were brittle and one-half were not. This was a very severe requirement, coupled with a high temperature flow point. The requirement for supporting power, No. 7 (b), 15 lbs. per sq. in. at 130° Fahr., was made because the provision for depth of ballast between the bottom of the tie and the asphalt was small, and there would be great danger of pressing the ballast through the asphalt if too soft. All of the mastic tested stood this requirement.

EQUIPMENT AND FORCE REQUIRED.

When one track at a time was being done, the force required was about 12 men and a foreman. It took the time of 3 or 4 of them to keep up fires, cut wood, and cut asphalt, while the rest were busy heating sand and screenings, mixing mastic, and depositing it in place, and painting, cleaning, etc. When there were several bridges to be done, 7 or 8 more men were necessary to clean and paint the next one ready for the asphalt.

The equipment for one gang was as follows:

	Each.
1 Asphalt Heater, 3 bbls. capacity	$ 62.50
1 Mastic Heater	165.00
2 Sand and Screening Heaters	20.00
Shovels, spuds for stirring mastic, brooms, wire brushes, smoothing irons.	
2 Pay-off Pails	5.00
1 Dipper	2.00

The asphalt mastic mixer was 8 ft. long, and had doors for firing at one end and on both sides. Anything longer was found to be impracticable. The sand heaters were made of sheet iron. Some of this equipment shows in Fig. 5.

COST.

During the progress of the work, the cost of asphalt fell from $60.00 to $40.00 and even $35.00 per ton, due to the competition. This, as well as other matters, caused the unit price to vary considerably. The information is presented in Table A.

TABLE "A."

BRIGHTON PARK.

	THIRTY-FOURTH STREET.				THIRTY-FIFTH STREET.				THIRTY-SIXTH STREET.			
Track No.	1 and 2	3 and 4	5 and 6	7, 8 and 9	1 and 2	3 and 4	5 and 6	7, 8 and 9	1 and 2	3 and 4	5 and 6	7, 8 and 9
Price of Asphalt, per ton	60	40	40	40	60	40	40	35	60	40	40	†35 & 60
Area bridge, square feet	1581	1581	1430	2145	2041	2041	1843	2769	2041	2041	1846	2769
Total cost	$403.28	$309.11	$294.78	$356.23	$501.64	$344.05	$361.60	$610 82	$456.27	$335.46	$440.19	$665.95
Cost per square foot	.255	.195	.206	*.167	.246	.168	.196	.220	.223	.164	.238	.240
Protection	Concrete bottom. Asphalt top.		All Asphalt.		Concrete bottom. Asphalt top.		All Asphalt.		Concrete bottom. Asphalt top.		All Asphalt.	

	ARCHER AVENUE				ENGLEWOOD.							
Track No.	1	2	3	4	Streets.	Wright.	Wallace.	Lowe.	Union.	Murray,	....	....
Price of Asphalt, per ton	....	....	....	40	....	35	35	35	40	40	....	....
Area bridge, square feet	871	871	871	871	....	936	486.5	936	936	2376	....	....
Total cost	$326.78	$366.78	$366.78	$370.36	....	$295.34	$165.89	$305.32	$515.6	$1526.98	....	....
Cost per square foot	.375	.420	.420	.425	....	.316	.341	.326	.550	.642	....	....
Protection	Concrete Wiremsh	Hydrex. Con. top.	Hydrex on Con.	Con. bot. As. top.	All Asphalt.							

P., F. W. & C. RAILWAY.

	FORTY-SIXTH STREET.				47TH STREET.	FIFTY-FIRST STREET.						
Bridge No.	1	2	3	4	....	1	2	3	4	5	6	....
Price of Asphalt, per ton	....	....	40	....	40	35	35	....	40	40	40	....
Area bridge, square feet	520	520	520	520	5531	3349	2292	2074	2278	2156	2521	....
Total cost	$175.69	$144.92	$226.72	$176.50	$1976.61	$1414.45	$850.09	$754.10	$785.70	$604.76	$913 69	....
Cost per square foot	.338	.279	.435	.439	.357	.422	.370	.360	.344	.280	.362	....
Protection	Concrete and Wire mesh		Concre,e Asphalt	Concrete Wiremsh	Con. bot. As. top.	All Asphalt.	Concrete bottom, Asphalt top.					

*The cost on this bridge is low due to fact that considerable material was used which was furnished by Asphalt Company by mistake, for which no charge was made. †6.102 tons at $35.00; 2.85 tons at $60.00.

Archer Avenue: Track No. 1, E. B. Freight. No. 2, E. B. Passenger. No. 3, W. B. Passenger. No. 4, W. B. Freight.

CONCLUSIONS.

(1) Asphalt mastic is not suitable for filling the troughs of solid floor bridges, because of its shrinkage when cooling, thus defeating the objects of its use, protection of the steel, and the formation of a solid, compact mass, with such close adherence to the steel as to be water-tight.

It is felt that ample trial was made of it, and that, too, with different mixtures of the best asphalt to be found. The advice of the manufacturers or dealers was freely accepted, till it was discovered that they were simply experimenting as well as ourselves.

(2) It is quite within reason to consider, in the light of the tests, that an asphalt covering next below the ballast, either over mastic or concrete, is not an efficient water-proof coating.

When the inspection was made in January only one bridge (Track 4 at Archer Avenue), prepared with this, was not leaking, but it is entirely reasonable to doubt that it is the asphalt rather than the concrete which is performing the satisfactory service.

The requirements of ductility and hardness conflict. When the asphalt is made soft enough to resist tearing apart under temperature changes, it is too soft to bear the load of traffic, a fact which has been also proved on other railroads. It is impossible to provide for a sufficient depth of ballast to overcome this objection.

(3) Ordinary concrete has not sufficient strength in itself to resist the forces tending to tear it apart at the column lines of bridges in two or more spans. Consequently leaks developed at every place of that kind.

Although it has not been proved by trial, it is quite likely that reinforced concrete will prove effective, and it will probably be tried this year.

(4) Concrete is an effective filling material for troughs, because it adheres firmly to the steel, protects it from corrosion, and can be made practically water-tight, either by the use of concrete rich in mortar, or by a solution of soft soap and alum.

Its objections are that it is:

(a) Difficult to remove in case repairs are necessary, or in view of the replacement of, or addition to, the bridge, on account of constant improvements in the property.

(b) Heavy, and adds considerable dead weight to the bridge.

(c) Costly, on account of the quantity, and the great care necessary to make a satisfactory job.

(5) Something more than filling the troughs is necessary, however. A top surface is required, graded to carry the water to the sides and to the ends of the bridge. Concrete alone is not suitable, unless in considerable thickness. To meet this condition, it must be reinforced. Nothing definite in regard to the woven wire mesh used at Archer Avenue has yet

transpired, because the track, No. 1, where it was used, has not yet been put in service for traffic.

Similar construction at Forty-sixth Street on the Pittsburg, Fort Wayne & Chicago Railway was effective up to January, except in the case where the concrete was frozen.

The writer is inclined to favor the use of small rods, from ¼ to ⅝-in. thick, rather than the wire, on account of making better use of the steel, and, quite likely, greater economy.

(6) The Hydrex Felt covering, Track No. 3, at Archer Avenue, has as yet given no cause for complaint, but this is a case where time is especially needed to determine the result, because its effectiveness depends on its strength against puncture by the ballast, which is a very thin layer under the ties. It has been much used by the Chicago & Western Indiana.

(7) If, however, the Hydrex Felt should be broken up by the ballast, there is a remedy, where there is a sufficient depth of ballast, by laying a concrete sidewalk on top of it, as at Track 2, Archer Avenue, to bear the loads transmitted by the rolling stock. This concrete need not be water-proof.

(8) In the case of trough floors transverse with the tracks, there seems to be no help for it except to fill them up with a rich concrete, unless indeed a drain hole is cut in each, and a gutter underneath be provided, a plan which should not be resorted to except in case of necessity for a long bridge.

After this is done, one has the choice of several different ways for providing a water-proof covering.

(9) When the troughs are placed parallel with the track, a much less thickness of concrete filling can be used, if a suitable method for protecting the portions of the troughs sticking up above the concrete can be devised. It is quite certain, where columns are used, that the concrete must be reinforced at the column lines, and other expansion places.

If a plaster of cement is put over the exposed troughs, it may possibly have to be reinforced also, on account of its thinness.

The work described in the foregoing was performed under the direction of Mr. N. Neff, Engineer Maintenance of Way, and his assistant, Mr. C. L. Barnaby, Chicago Terminal Division, and they also furnished the data for the compilation of this article.

APPENDIX.

PENNSYLVANIA LINES WEST OF PITTSBURG.

SOUTHWEST SYSTEM.

SPECIFICATIONS AND INSTRUCTIONS FOR WATER-PROOFING METAL AND MASONRY STRUCTURES.

August, 1904.

I. PURE GUM ASPHALT.

Volatilization.

1. Asphalt shall be used which is of the best grade, free from coal tar or turpentine, and which will not volatilize more than ½ of 1 per cent. under a temperature of 450° Fahr., for 10 hours.

Acid Test.

2. It must not be affected by a 20 per cent. solution of ammonia, a 25 per cent. solution of sulphuric acid, a 35 per cent. solution of muriatic acid, nor by a saturated solution of sodium chloride.

Extremes of Temperature Test.

3. (a) For metallic structures exposed to the direct rays of the sun, the asphalt should not flow under 212° Fahr., and should not become brittle at 15° Fahr. below 0° when spread in a layer of ⅛-in. thick on thin glass.

(b) For structures underground, such as masonry arches, abutments, retaining walls, foundation walls of buildings, subways, etc., a flow point of 185° Fahr. and a brittle point of 0° Fahr. will be required.

II. PREPARATION OF SURFACE OF STRUCTURE.

Cleaning Metal.

4. (a) Before applying the asphalt to a metal surface, it is imperative that the metal be cleaned of all rust, loose scale and dirt; and, if previously coated with oil, this must be entirely removed. When the asphalting is done during the summer months, between May and September, the clean, dry metal shall be painted with two coats of cold asphalt paint, free from oil, made by thinning pure gum asphalt with benzine, before the hot asphalt is applied. When the asphalting is done during the winter months, this coating will be omitted, but the metal shall be warmed to the satisfaction of the Engineer, before the hot asphalt is poured on. The warming is best accomplished by covering the metal with hot sand, which should be swept back as the hot asphalt is applied.

Masonry.

(b) When water-proofing masonry structures, if the surface cannot be made dry and warm, it should be first coated with the asphalt paint applied cold. This is particularly necessary for vertical surfaces.

III. APPLICATION OF COATING.

Heating Asphalt.

5. The asphalt should be heated in a suitable kettle to a temperature not exceeding 450° Fahr. If the temperature should run above 450°

Fahr., for any length of time, it will result in "pitching" the asphalt. Before the "pitching" point is reached, the vapor from the kettle is of a bluish tinge, which changes to a yellowish tinge after the danger point is passed. The asphalt has been sufficiently cooked when a piece of wood can be put in and withdrawn without the asphalt clinging to it.

6. (a) The first coat shall consist of a layer not less than ¼ in. thick of pure asphalt poured from buckets on the prepared surface and thoroughly mopped over. **First Coat.**

(b) The second coat shall consist of a mixture of clean sand or screenings, free from earthy admixtures, previously heated and dried, and asphalt, in the proportion of 1 asphalt to 3 of sand or screenings by volume; this is to be thoroughly mixed in the kettle and then spread out on the surface with warm smoothing irons, such as are used in laying asphalt streets. **Second Coat.**

(c) The third or finishing coat shall consist of pure hot asphalt spread evenly in a layer not less than ¼ in. thick over the entire surface, and then sprinkled with washed roofing gravel, torpedo sand, or stone screenings, to harden the top. **Third Coat.**

7. (a) The built-up thickness of the three coatings described in Section 5 should be 1½ in. at the thinnest place for steel bridges and 2 inches for masonry arch bridges. **Thickness.**

(b) This built-up asphalt covering must not perceptibly indent when at a temperature of 130° Fahr., under a load at the rate of 15 lbs. per sq. in., and it must remain ductile at a temperature of 15° Fahr. below zero on metal structures, and at 0° Fahr. on masonry structures under ground. **Load Test.**

IV. CONCRETE FILLER.

8. In the case of steel trough floors, the trough will first be filled with Portland cement concrete, mixed in the proportions of 1 cement, 3 sand and 3 broken stone, and the surface will be finished 1½ in. below and to the same shape as the asphalt surface. The concrete is to be placed against the clean steel, free from rust, oil, paint or dirt. A plan for drainage may be necessary in each case, because that is affected by the length and grade of bridge and by the direction of the troughs. **Concrete Mixture.**

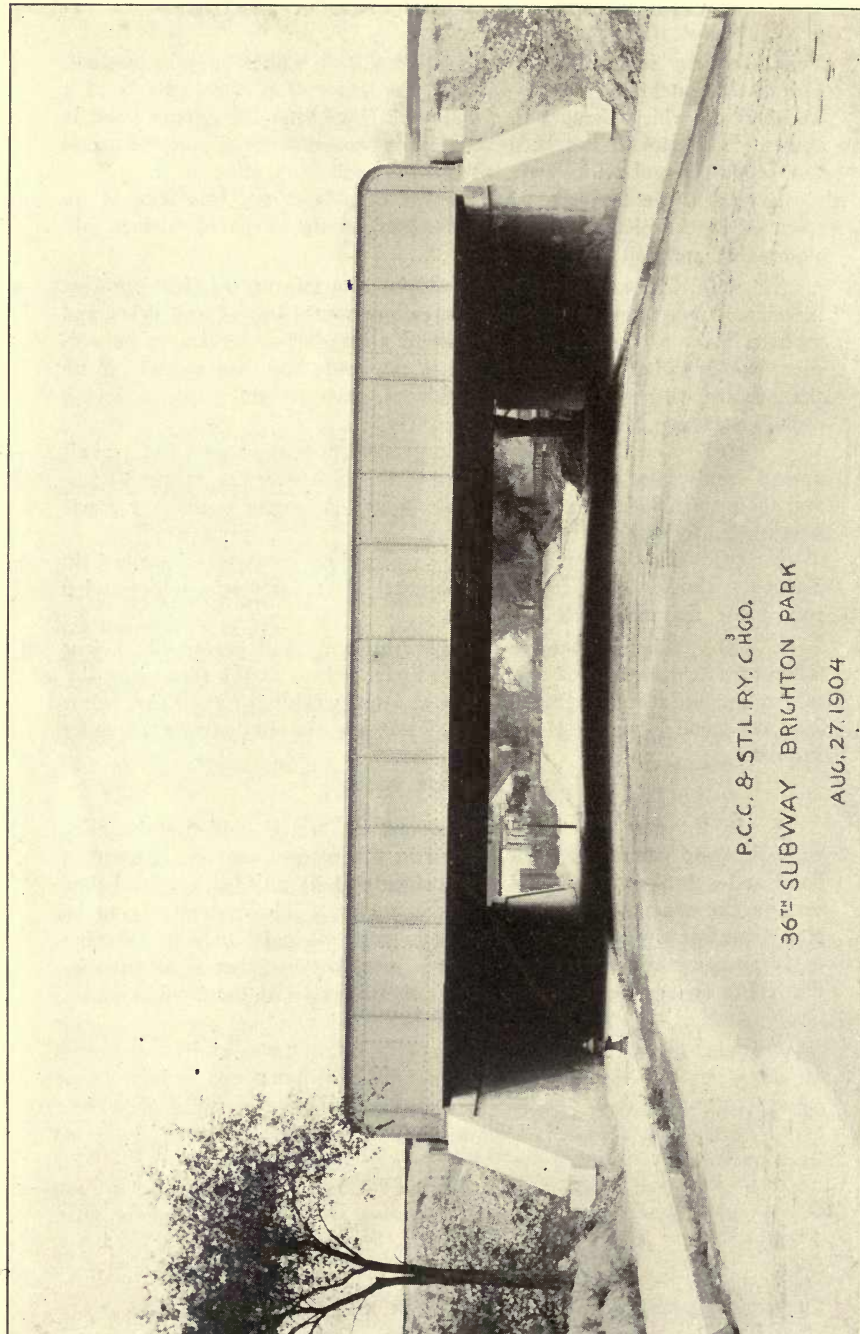


FIG. 1.

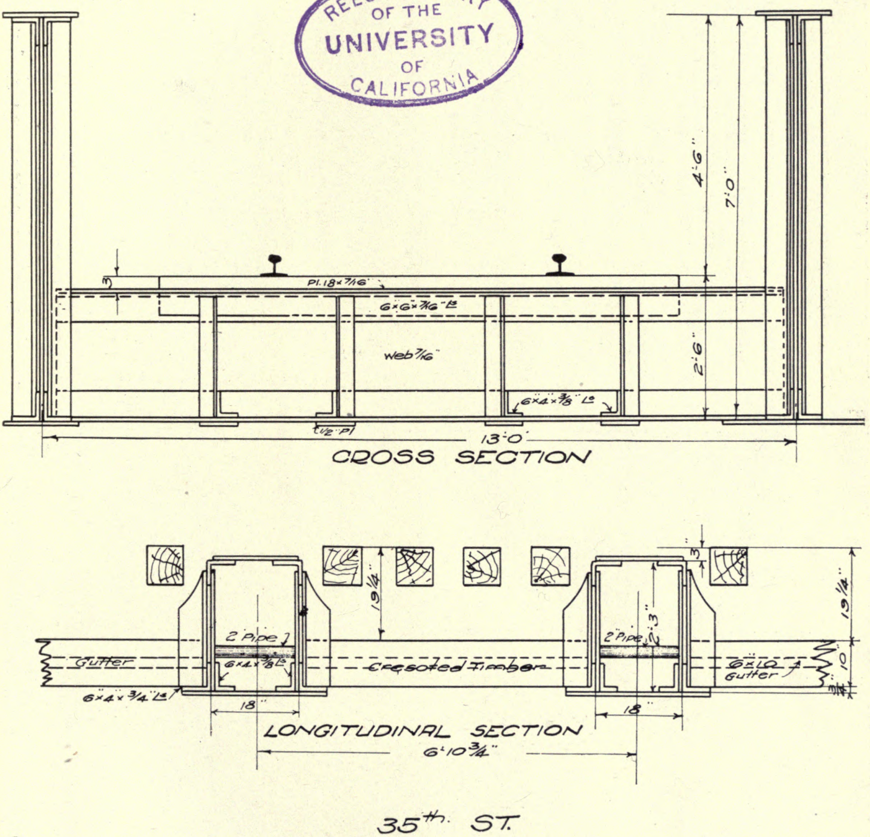
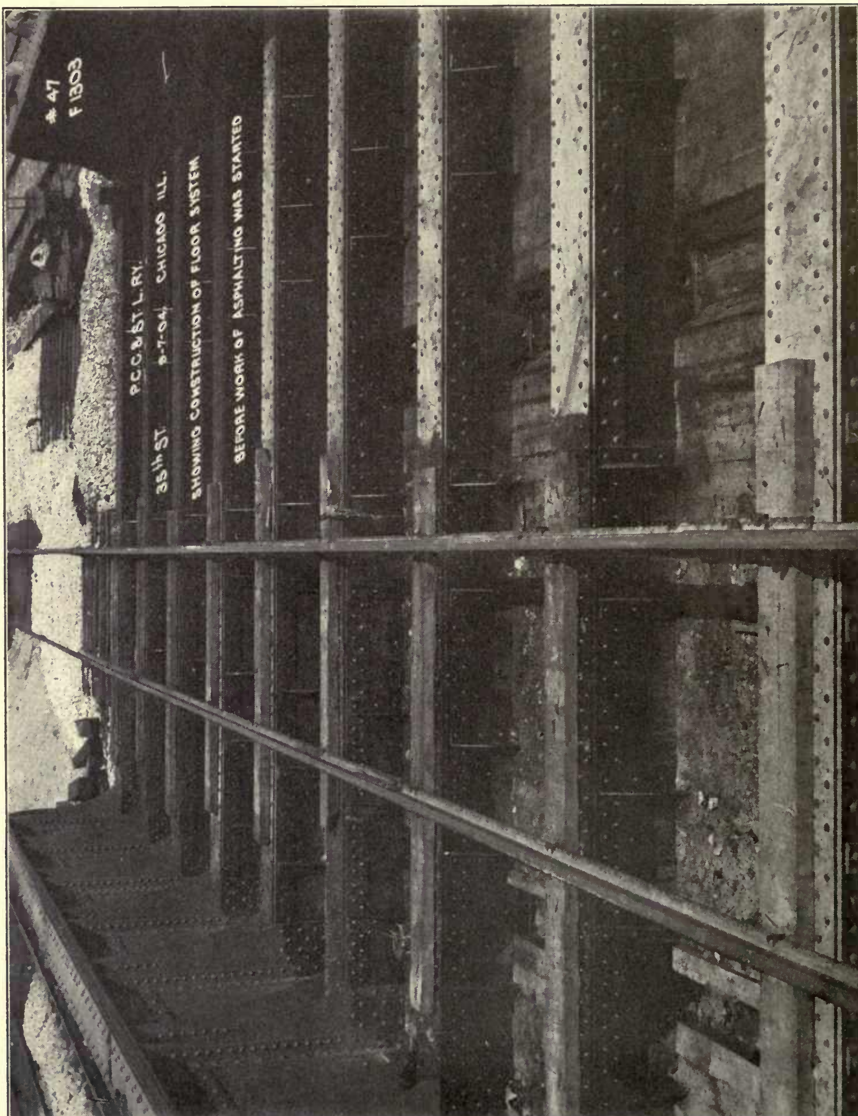

Pl. 18×7/16"
6×6×7/16" Ls
Web 7/16"
6×4×3/8" Ls
1/2" Pl
13'-0"
4'-6"
7'-0"
2'-6"
CROSS SECTION
2" Pipe
Gutter
Creosoted Timber
6×4×3/4" Ls
18"
19 1/4"
2'-3"
6×10
Gutter
10"
LONGITUDINAL SECTION
6'-10 3/4"
35th ST.

FIG. 2.



47
F 1303
P.C.C.&St.L.RY.
35th ST. 5-7-04 CHICAGO ILL.
SHOWING CONSTRUCTION OF FLOOR SYSTEM
BEFORE WORK OF ASPHALTING WAS STARTED

Fig. 3.

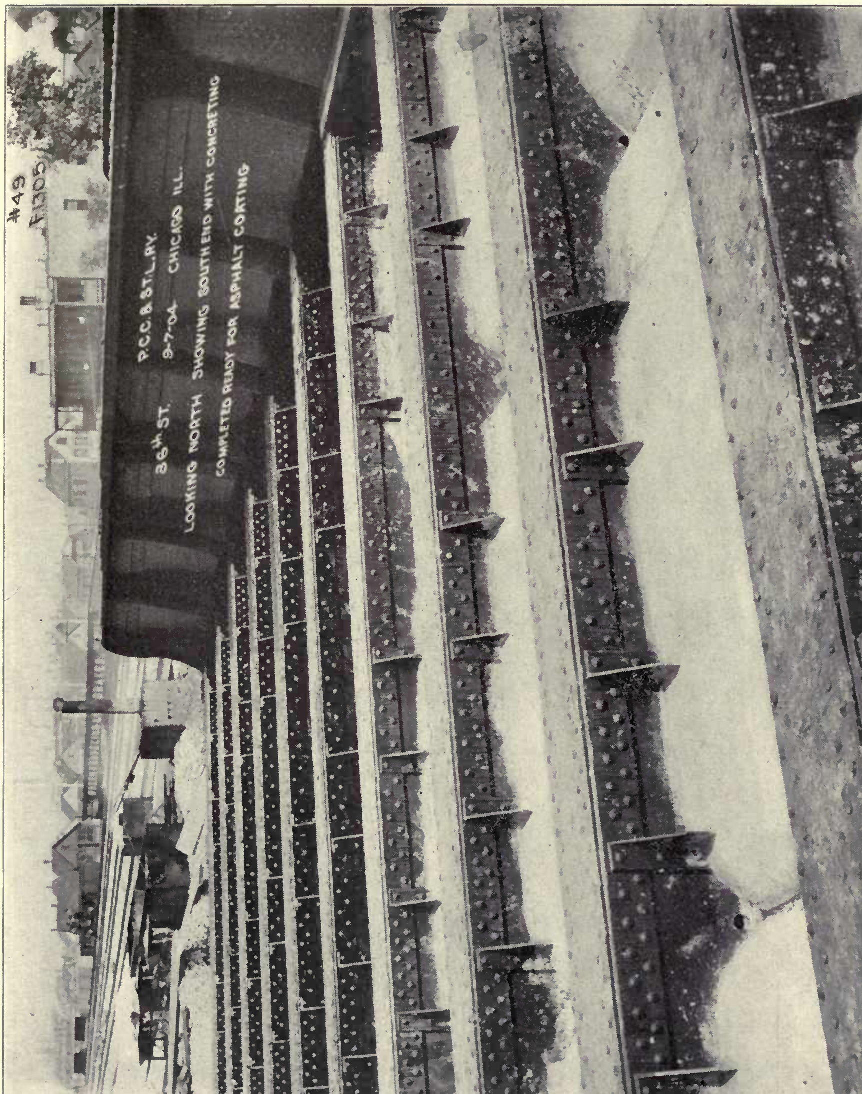

#49
F1305
P.C.C.&St.L.RY.
36th ST. 9-7-04 CHICAGO ILL.
LOOKING NORTH SHOWING SOUTH END WITH CONCRETING
COMPLETED READY FOR ASPHALT COATING

Fig. 4.

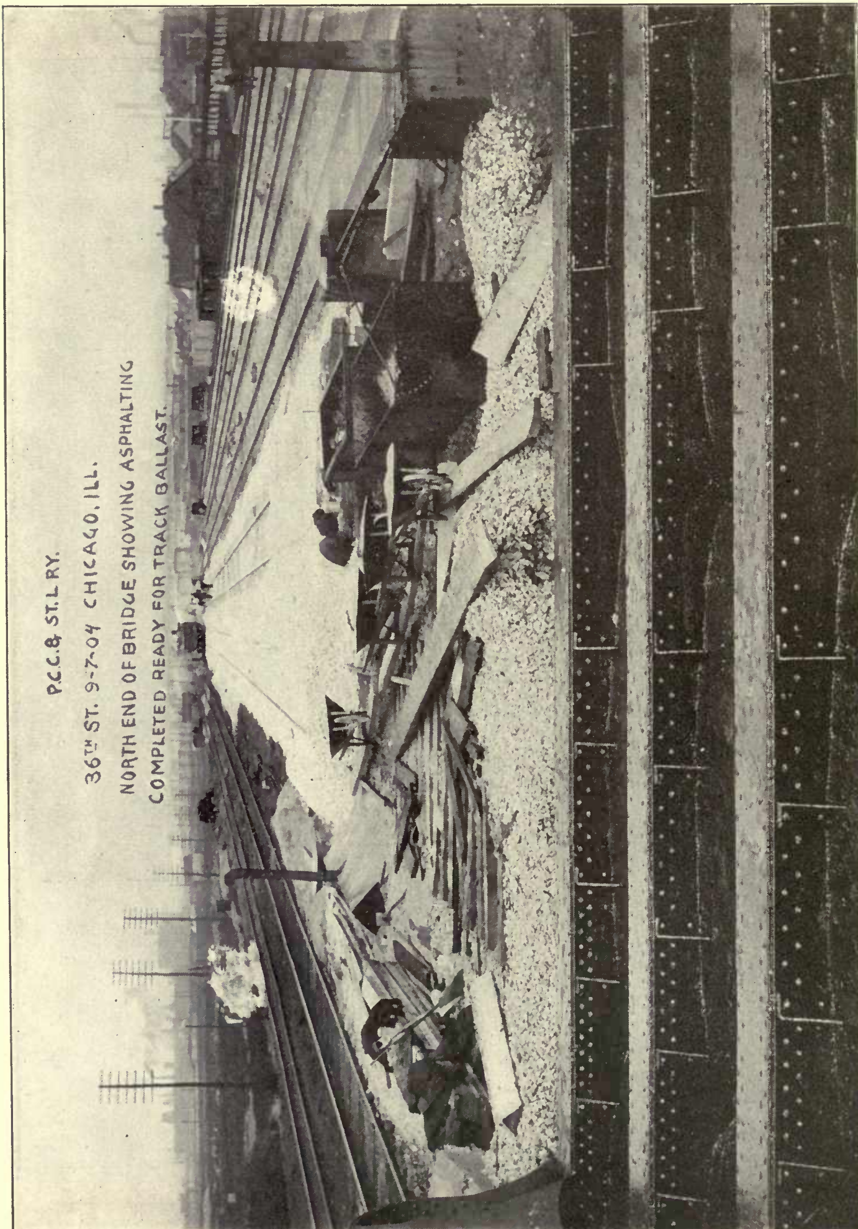

P.C.C.& ST.L RY.
36TH ST. 9-7-04 CHICAGO, ILL.
NORTH END OF BRIDGE SHOWING ASPHALTING
COMPLETED READY FOR TRACK BALLAST.

Fig. 5.

Fig. 6. Normal Ave. or Wright St.

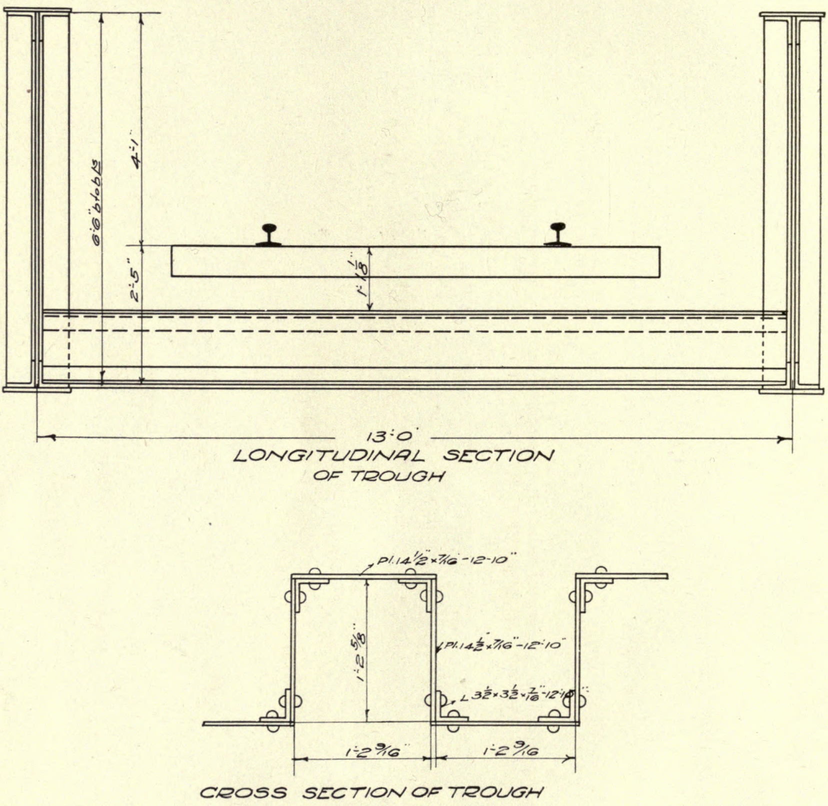

4'1"
2'5"
1'1⅛"
13'0"
LONGITUDINAL SECTION
OF TROUGH
PL.14½"×7/16"-12-10"
1'2⅝"
PL.14½"×7/16"-12'10"
L 3½×3½×7/16"-12'10"
1'2 9/16"
1'2 9/16
CROSS SECTION OF TROUGH
WRIGHT ST.

Fig. 7.

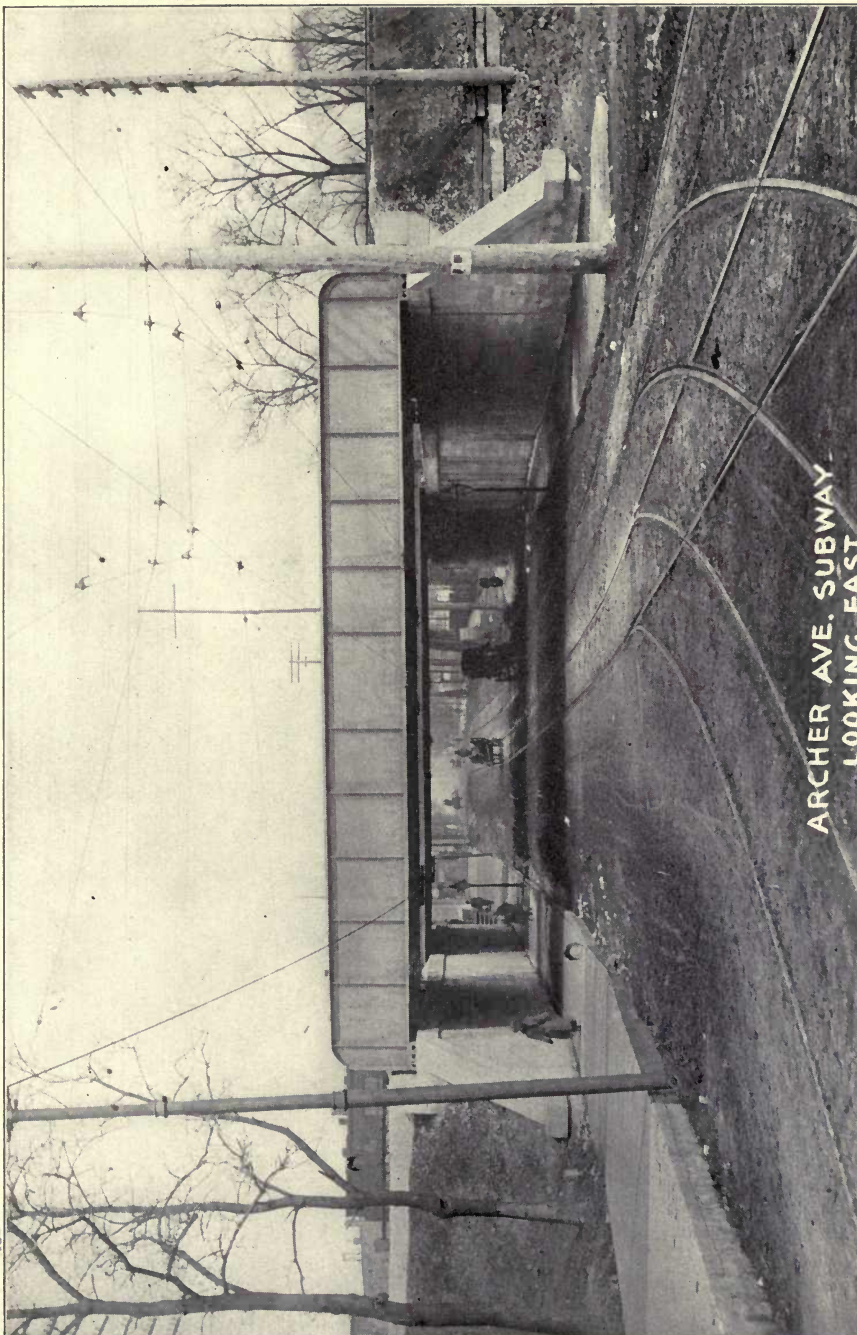


Fig. 8.

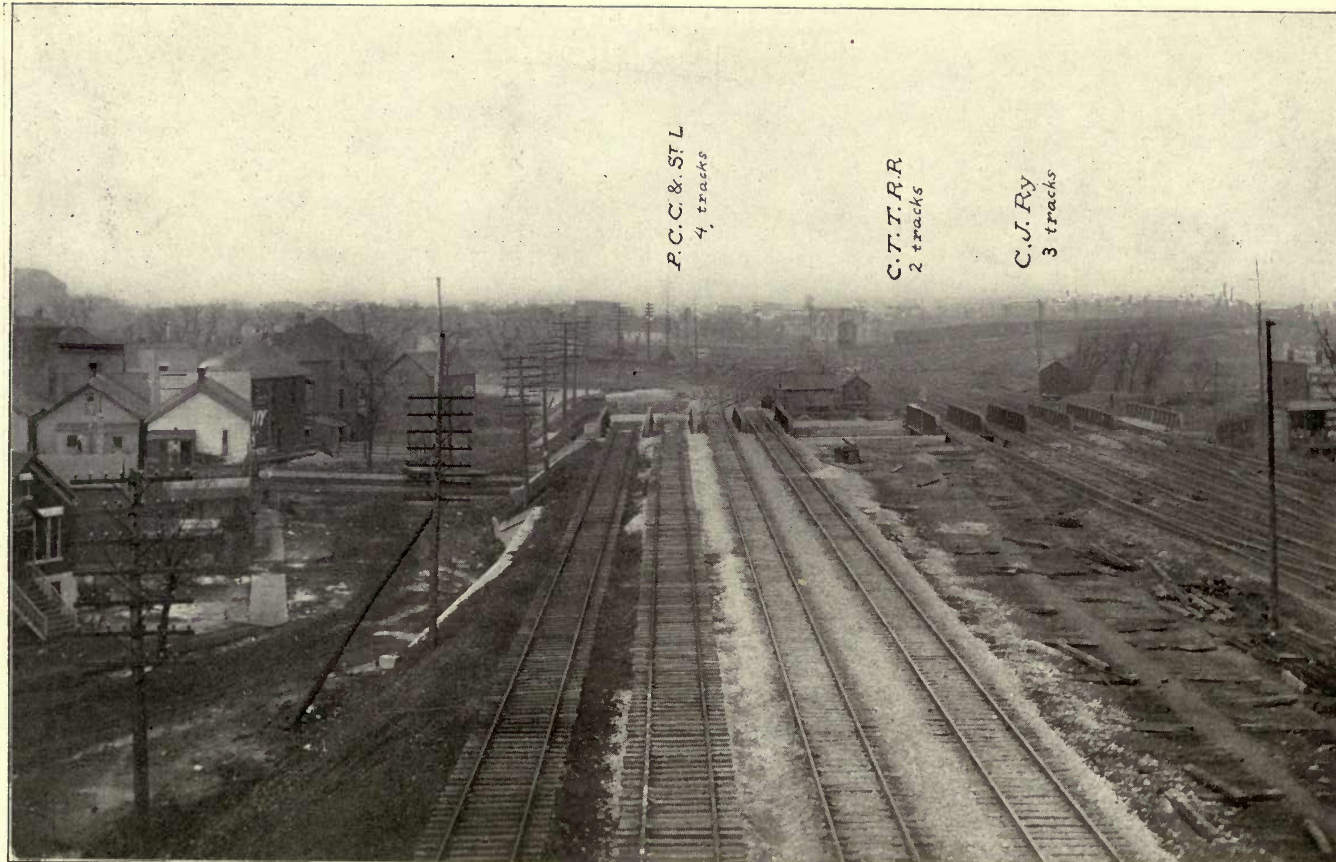


Fig. 9. Archer Ave. Subway—Track View Looking North.

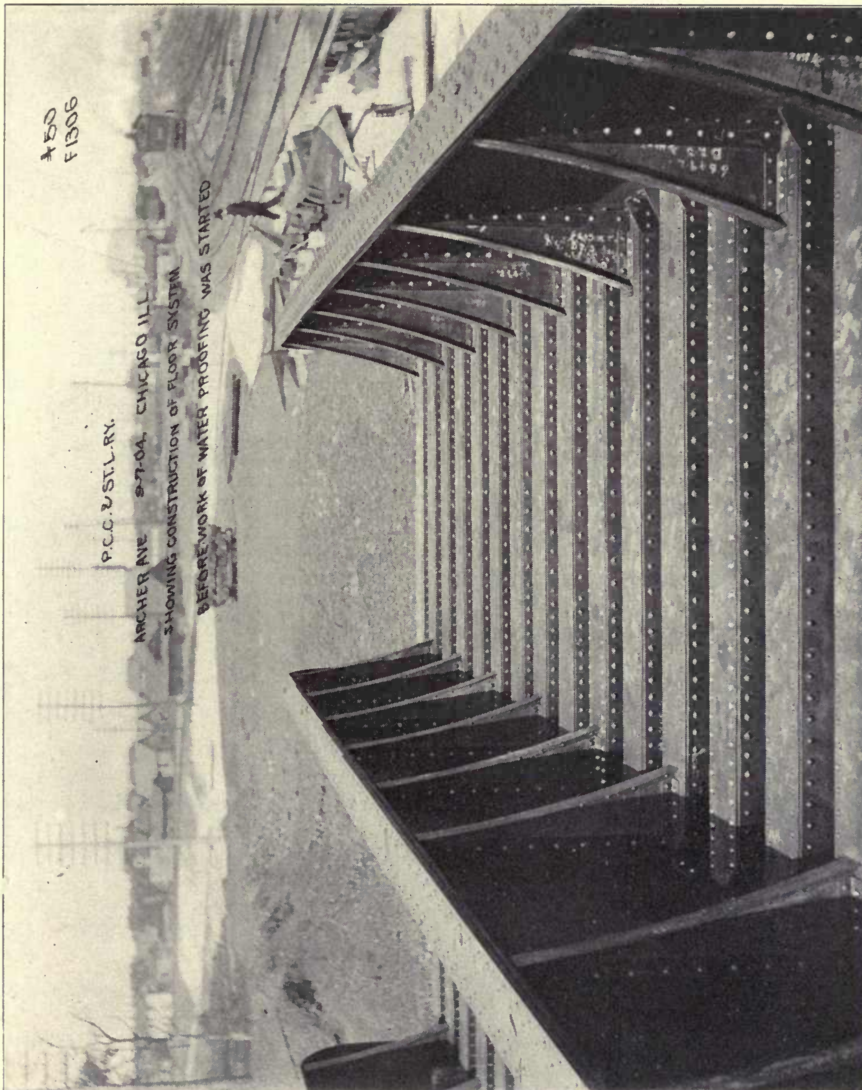

*50
F1306
P.C.C.& ST.L.RY.
ARCHER AVE 9-7-04. CHICAGO ILL.
SHOWING CONSTRUCTION OF FLOOR SYSTEM
BEFORE WORK OF WATER PROOFING WAS STARTED

Fig. 10.

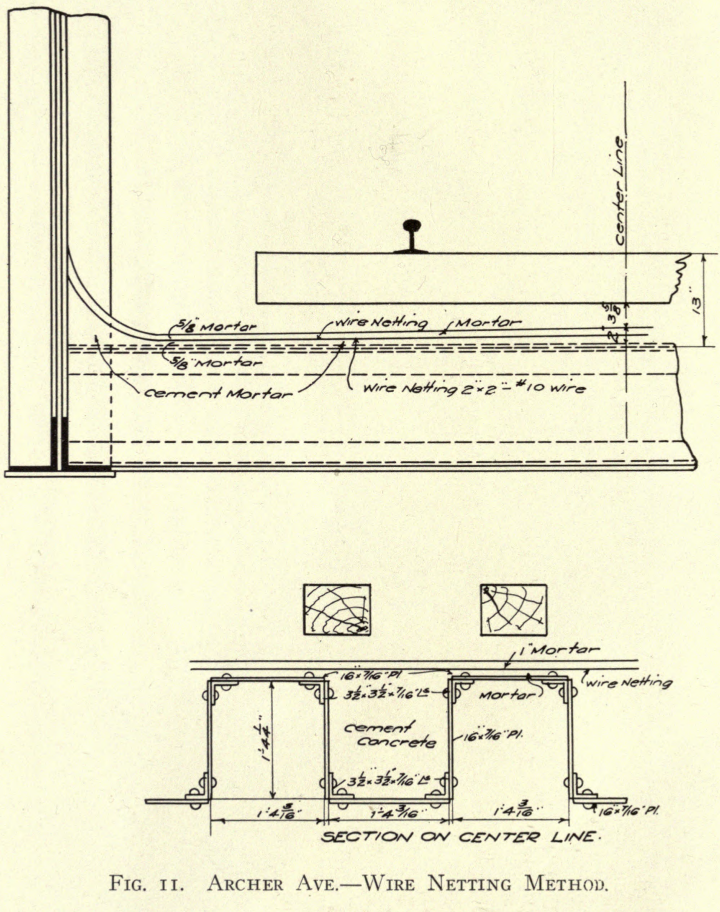


FIG. 11. ARCHER AVE.—WIRE NETTING METHOD.

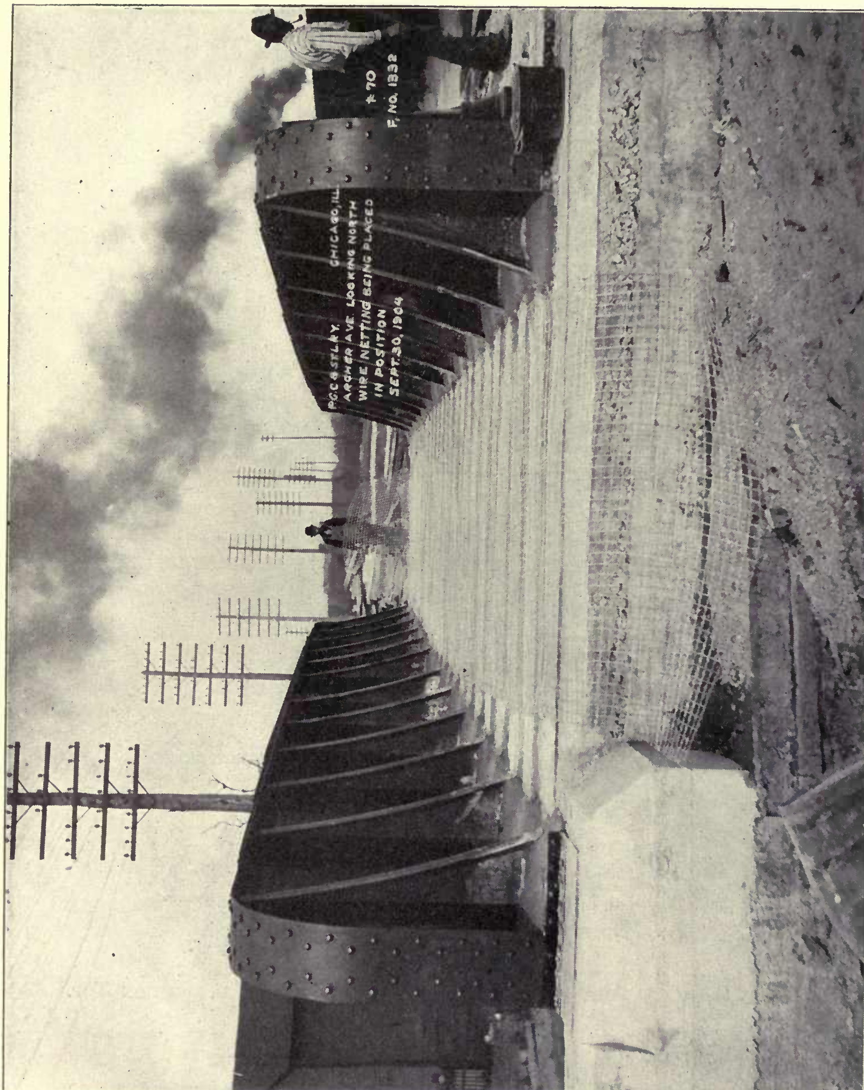

P.C.C.&St.L.RY. CHICAGO, ILL.
ARCHER AVE. LOOKING NORTH
WIRE NETTING BEING PLACED
IN POSITION
SEPT.30,1904
#70
F. NO. 1332

FIG. 12.

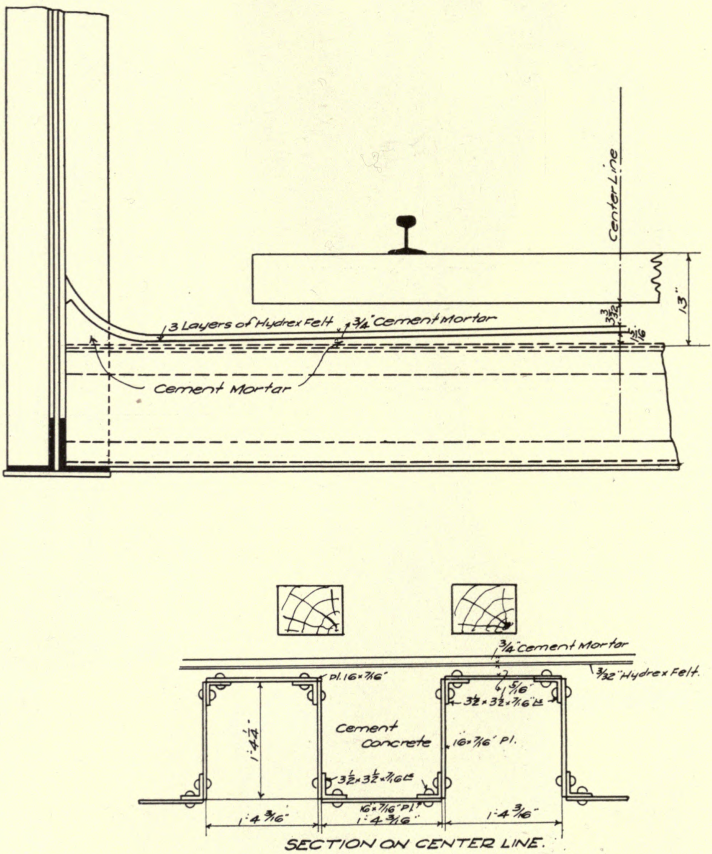


Fig. 13. Archer Ave.—Hydrex Felt Method, With Concrete on Top.

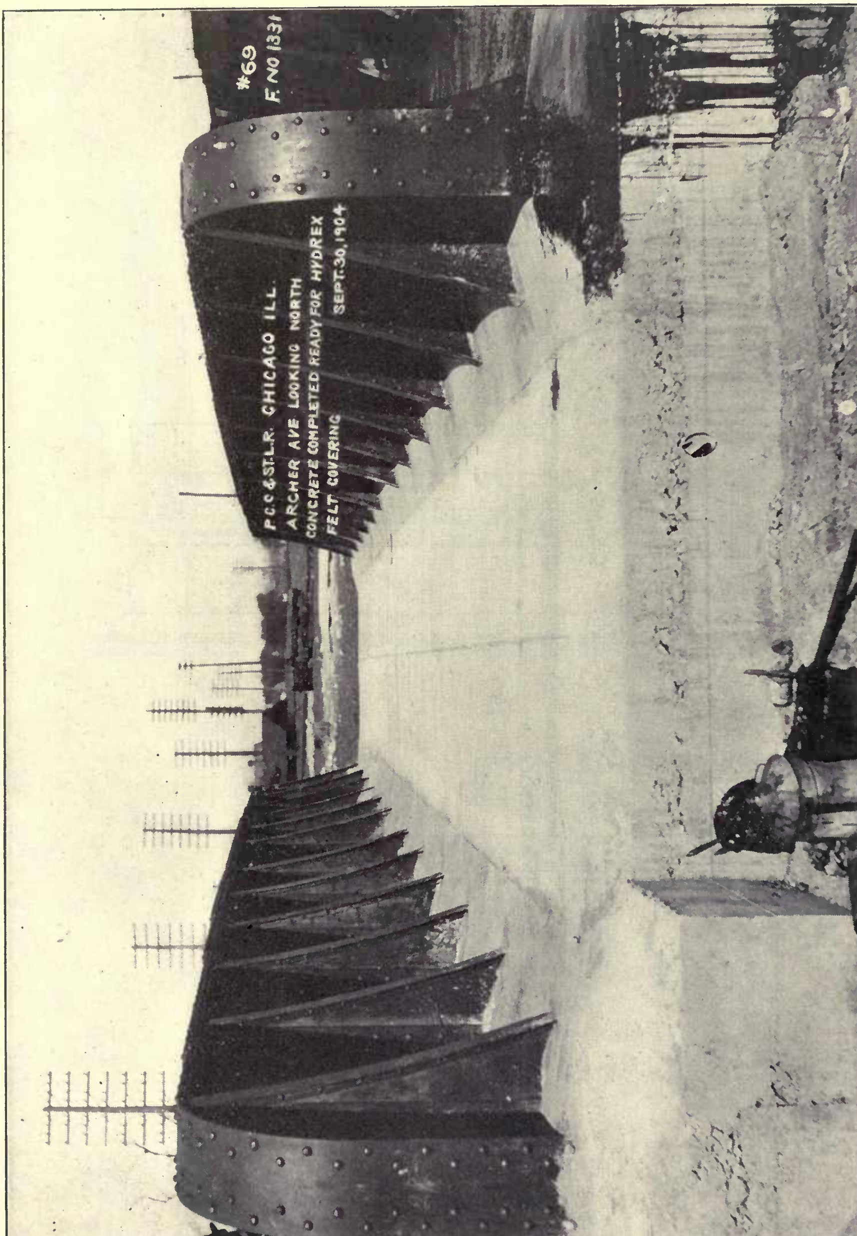

#69
F. NO 1331
P.C.C.&St.L.R. CHICAGO ILL.
ARCHER AVE LOOKING NORTH
CONCRETE COMPLETED READY FOR HYDREX
FELT COVERING
SEPT. 30, 1904

FIG. 14.

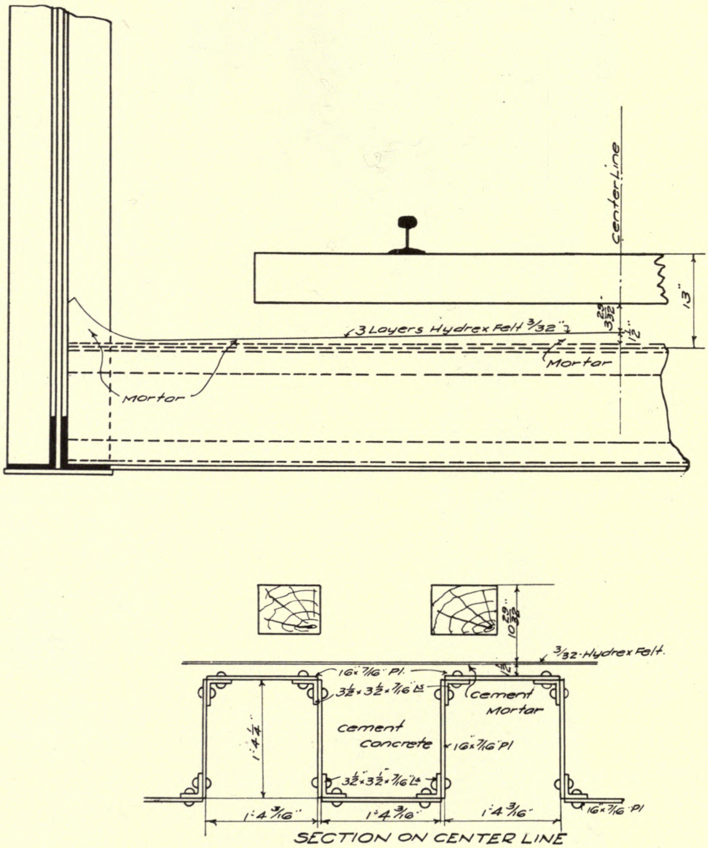


FIG. 15. ARCHER AVE.—HYDREX FELT METHOD.

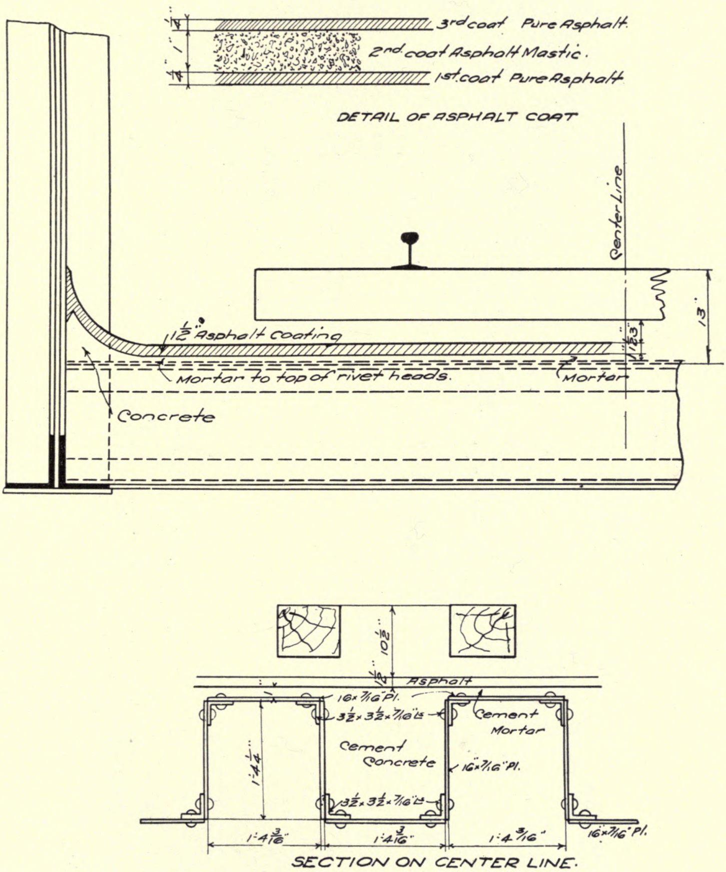


FIG. 16. ARCHER AVE.—ASPHALT METHOD.

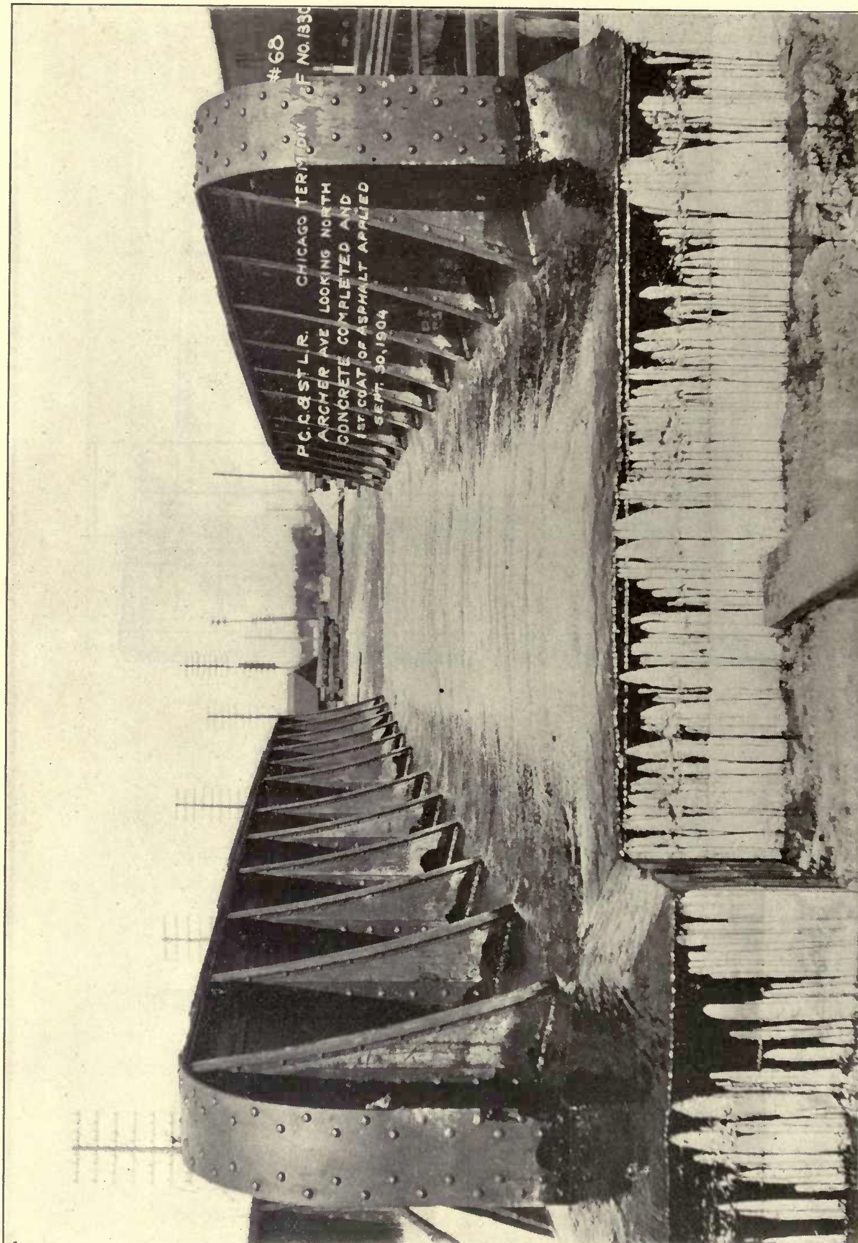

#68
P.C.C.&St.L.R. CHICAGO TERM DIV
ARCHER AVE LOOKING NORTH
CONCRETE COMPLETED AND
1ST COAT OF ASPHALT APPLIED
SEPT. 30,1904
F NO.133

Fig. 17.

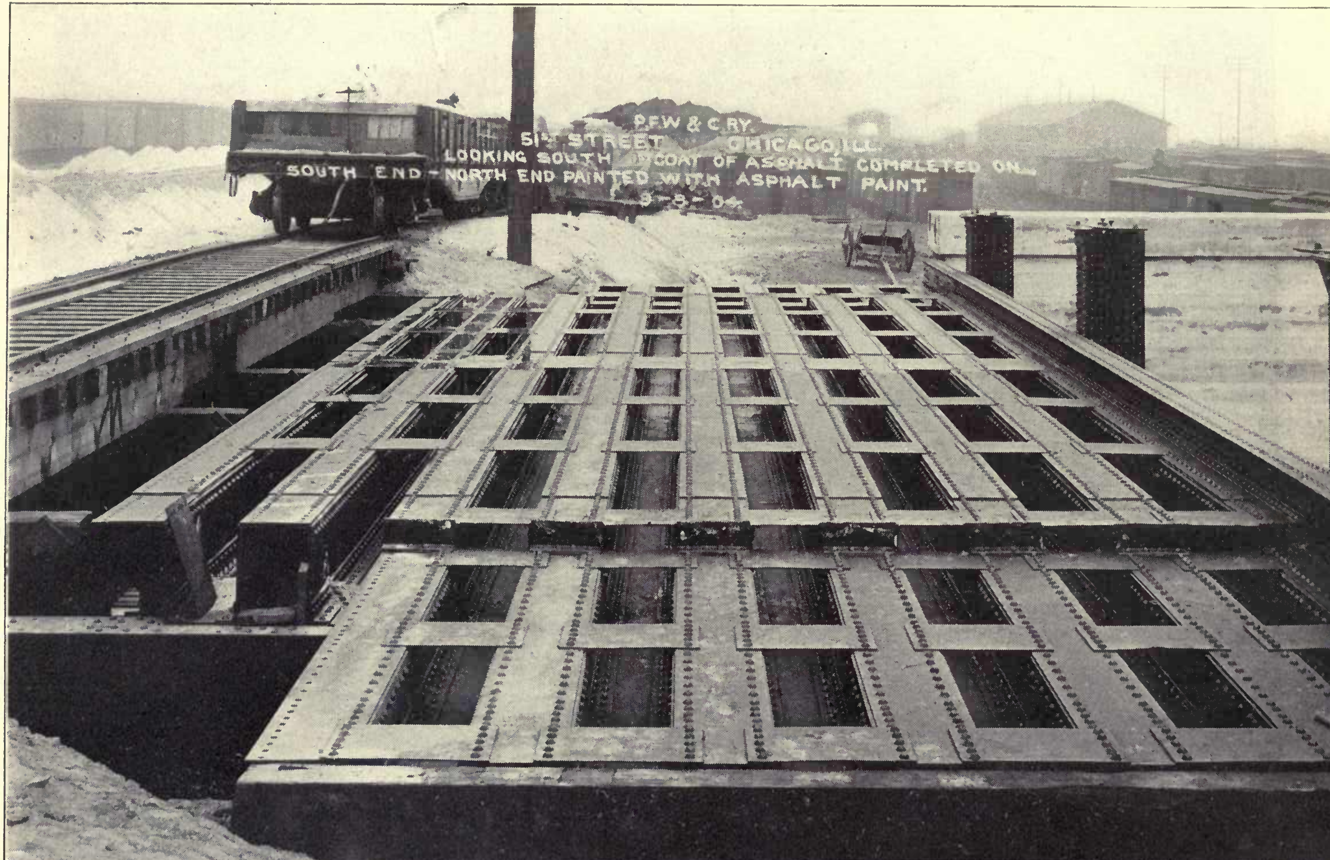

P.F.W. & C. RY.
51st STREET CHICAGO, ILL.
LOOKING SOUTH COAT OF ASPHALT COMPLETED ON
SOUTH END - NORTH END PAINTED WITH ASPHALT PAINT.

FIG. 18.

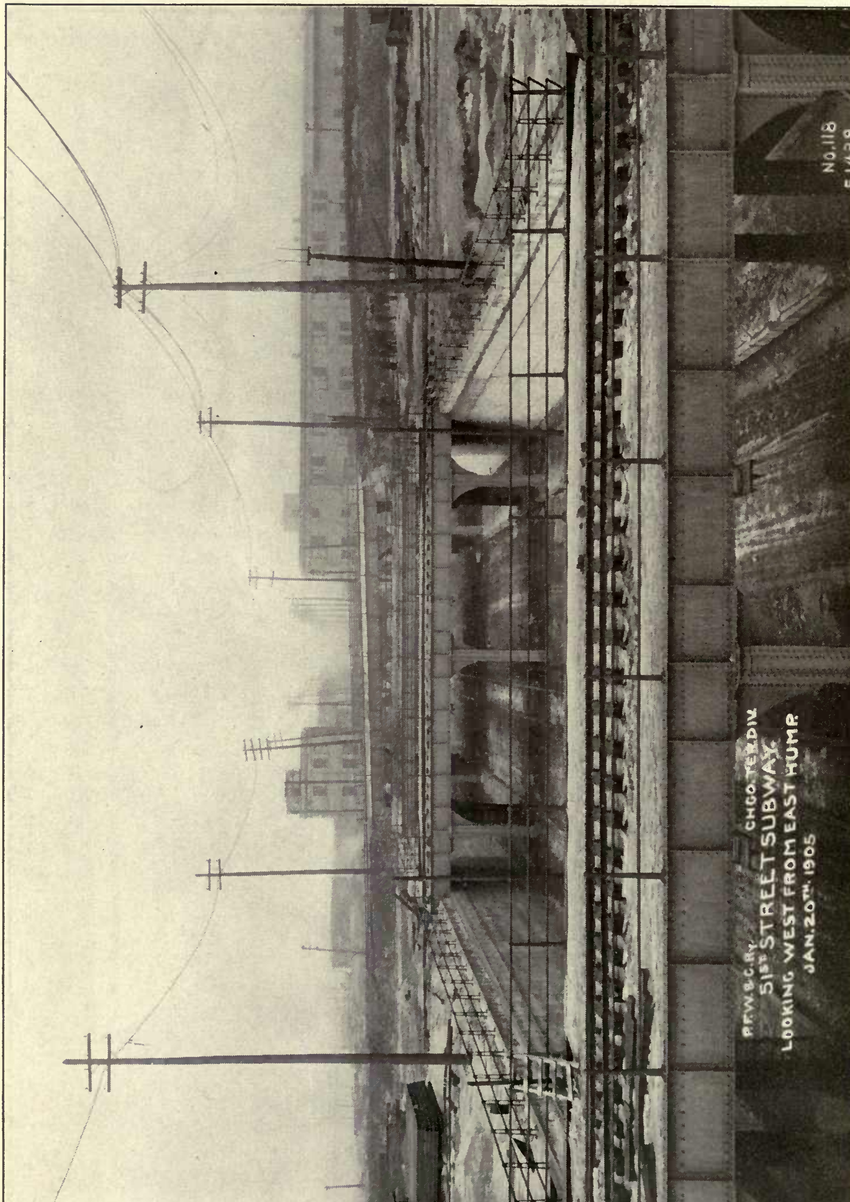

No. 118
F1438
P.F.W.&C.RY. CHGO. TER. DIV.
51ST STREET SUBWAY
LOOKING WEST FROM EAST HUMP
JAN. 20TH 1905

FIG. 19.

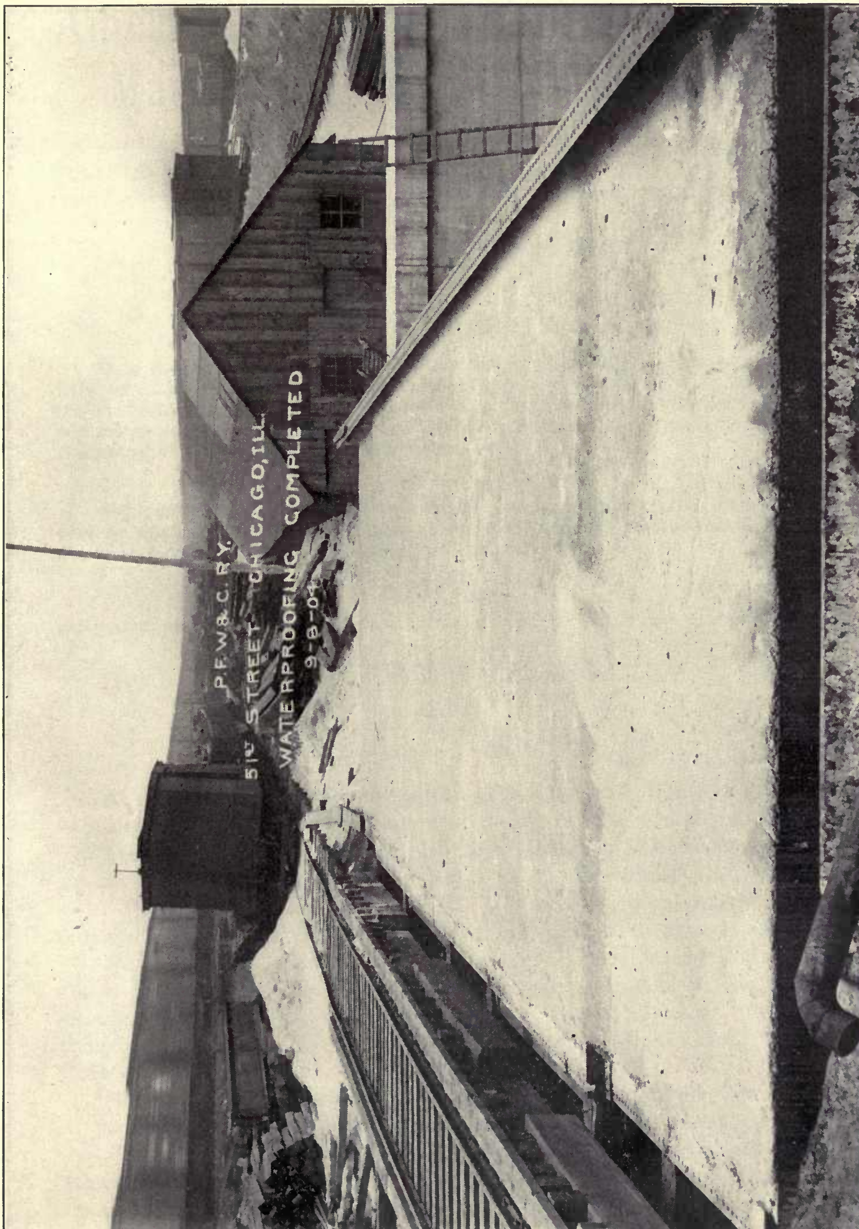

P.F.W.&C.RY.
51ST STREET CHICAGO, ILL.
WATERPROOFING COMPLETED
9-8-04

FIG. 20.

American Railway Engineering and Maintenance of Way Association.

BULLETIN NO. 64 — JUNE, 1905

ASSOCIATION AFFAIRS.

ANNOUNCEMENTS.

It is the desire of the Board of Direction to make this feature of the Bulletin as interesting as possible, and committees are requested to make use of the announcement department whenever anything of interest regarding their committee work is to be reported, and especially with a view of securing advance discussion of subjects under consideration.

Communications from members relative to the affairs of the Association, past or current work of committees, or any matters of professional interest, theoretical or descriptive, are always acceptable.

COMMITTEE MEETINGS.

SIGNALING AND INTERLOCKING.

A meeting of the Committee on Signaling and Interlocking was held at the office of the Association at Chicago, June 7th, the following members being present: Messrs. Charles A. Dunham, Chairman; W. A. D. Short, Vice-Chairman; G. E. Ellis, H. H. Knowlton, J. C. Mock, J. A. Peabody and Thos. S. Stevens. The meeting discussed the work outlined by the Board, and the following sub-committees were appointed:

No. 1: The Committee to take up detail questions of Automatic Block Signals, to handle slotted signals in interlocking plants, and also electric blocking as applied to interlocking in automatic signal territory; composed of Messrs. W. A. D. Short, Chairman; J. C. Mock, J. A. Peabody and A. H. Rudd.

No. 2: Telegraph and Controlled Manual Blocking; the Committee to make detailed circuit plans, to elaborate on what has been done by the Committee as a whole; to treat on rules of operation; to make drawings of mechanical details, and to consider the question of proper location; composed of Messrs. Thos. S. Stevens, Chairman; H. H. Knowlton and C. L. Addison.

No. 3: Committee to formulate complete specifications for Mechanical Interlocking and submit detail plans of mechanisms and leadouts, machine framing in towers and outline of standard tower; composed of Messrs. Charles A. Dunham, Chairman; G. E. Ellis and F. H. Alfred.

The meetings of sub-committees to be called from time to time at the direction of sub-committee chairmen.

The Committee decided to hold meetings of the General Committee at the following times and places: August 15th, Association rooms, Chicago, Ill.; October 9th, Niagara Falls, N. Y.; December 5th, Association rooms, Chicago, Ill.

MASONRY.

A meeting of the Committee was held at Cleveland, Tuesday, June 20th, and was continued on the 21st. Messrs. Brown, Beckwith, Hanlon, Schaub, Scribner and Swain were present. The appointment of Messrs. Boynton (Chairman), Cunningham and Swain to be the sub-committee to attend the meetings and co-operate with special committees of the American Society of Civil Engineers, the American Society for Testing Materials, and the American Association of Cement Manufacturers, on Concrete and Reinforced Concrete, was approved. Messrs. Beckwith and Scribner were appointed additional members of this sub-committee with voting privilege at the joint meetings only in cases of absence of regular members. This action was deemed wise, since our Association is entitled to but three voting members on the Joint Committee, and it is desirable that we be fully represented at all meetings. Mr. J. W. Schaub (representing the A. S. C. E.) is Secretary of the Joint Committee.

Upon motion the chairman was authorized to divide up the General Committee into sections or sub-committees for carrying out the work to be done this year, and to obtain an expression from each as to preference, first and second. The work of the Committee remaining to be provided for is as follows:

(1) Waterproofing Masonry—methods, results, cost and recommended practice.

(2) Specifications for bridge and culvert stone masonry.

(3) Waterway for culverts.

(4) Collection of data and reports upon failures of concrete structures.

All members will be expected to discuss by letter or in meeting the criticisms or discussions of definitions as presented by members of the Association.

MEMBERSHIP—ADDITIONS.

597. KENDRICK, J. W.,
Third Vice-President, Atchison, Topeka & Santa Fe Railway System, Railway Exchange Building, Chicago.

598. Kenney, E. F.,
Engineer of Tests, Pennsylvania Railroad, Philadelphia, Pa.

599. Taylor, W. B.,
Division Engineer, Erie Railroad, Buffalo, N. Y.

600. Van Houten, R. A.,
Division Engineer, Erie Railroad, Susquehanna, Pa.

601. Beckwith, Frank,
Engineer of Bridges and Structures, Lake Shore & Michigan Southern Railway, Cleveland, O.

602. Pratt, R. B.,
Railway Architect, Canadian Northern Railway, Winnipeg, Manitoba.

603. Ross, D. A.,
Terminal Engineer, Canadian Northern Railway, Winnipeg, Manitoba.

604. Blinn, R. S.,
Assistant Engineer, Illinois Central Railroad, Bloomington, Ind.

605. Fritch, E. H.,
Assistant Secretary, American Railway Engineering and Maintenance of Way Association, Chicago, Ill.

CHANGES OF TITLE AND ADDRESS.

384. Abbott, F. E.
Lackawanna Steel Company, Buffalo, N. Y.

369. Abbott, J. H.,
Bridge Engineer, Spokane International Railway, Spokane, Wash.

537. Bond, B. F.,
Superintendent of Construction, Jacksonville & St. Louis Railway, Jacksonville, Ill.

422. Cassell, J. F.,
Engineer of Construction, Indianapolis Extension, Southern Indiana Railway, Terre Haute, Ind.

565. Dickson, J. B.,
Chief Engineer Maintenance of Way, Baltimore & Ohio Railroad, Baltimore, Md.

326. Dixon, J. M.,
Assistant Engineer, Great Northern Railway, Fremont, Neb.

493. Dunham, Chas. A.,
Signal Engineer, Great Northern Railway, St. Paul, Minn.

558. Elmore, B. T.,
Assistant Chief Engineer, Tidewater Railway, Norfolk, Va.

547. Endo, Tokichi,
Engineer, Military Railway Department, Chemulpo, Corea.

175. EWING, C. H.,
Engineer Maintenance of Way, Philadelphia & Reading Railway, Reading, Pa.

560. FINE, JOHN H.,
524 Land Title Building, Philadelphia, Pa.

589. FORBUSH, E. C.,
Resident Engineer, Chicago, Burlington & Quincy Railroad, Herrin, Ill.

511. GRAY, J. C.,
6437 Woodlawn Avenue, Chicago, Ill.

374. HARVEY, A. E.,
Division Engineer, Illinois Central Railroad, Indianapolis, Ind.

41. HENDRICKS, V. K.,
Division Engineer, Baltimore & Ohio Railroad, Baltimore, Md.

189. JAMES, L. C.,
Assistant Engineer, Baltimore & Ohio Railroad, Bridgeport, O.

253. JONAH, F. G.,
Terminal Engineer, New Orleans Terminal Company, New Orleans, La.

541. LAGRON, A. P.,
A. P. & G. A. Lagron, Builders' Supply, Lorain, O.

408. LANGDON, A. H.,
Assistant Engineer, Wisconsin Central Railway, Milwaukee, Wis.

449. LEE, W. I.,
Resident Engineer, Tidewater Railway, Jarratt, Va.

313. MORSE, GEORGE F.,
Assistant Engineer, New York Central & Hudson River Railroad, 42 Pine St., New York, N. Y.

375. NORTON, A. G.,
Engineering Department, Erie Railroad, New York, N. Y.

504. PUDER, F. R.,
Assistant Engineer, Chicago Southern Railway, 219 Grand Central Pass. Sta., Chicago, Ill.

524. SCRIBNER, GILBERT H., JR.,
Contracting Engineer, 184 La Salle Street, Chicago, Ill.

386. SESSER, JOHN C.,
Engineer of Construction, Chicago, Burlington & Quincy Railroad, Centralia, Ill.

66. WHITE, I. F.,
Superintendent, Cincinnati, Hamilton & Dayton Railroad, Dayton, Ohio.

HYDREX

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of the Pennsylvania Railroad
New York**

The fifty feet deep retaining walls around this vast excavation are being made **permanently waterproof with**

Hydrex Waterproofing Felt

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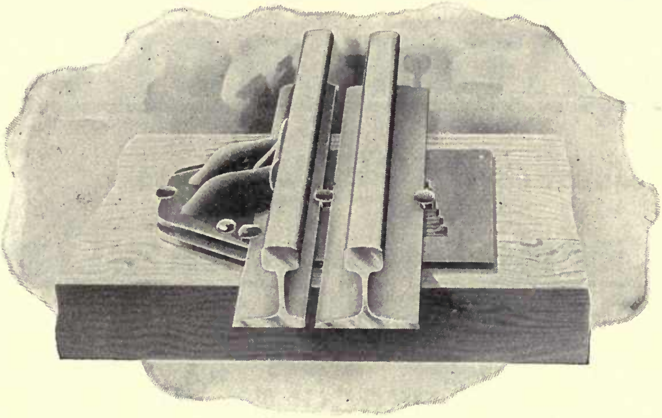
Hamilton, Ontario**

(Continued page following)

American Guard Rail Fastener



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Gold Medal Louisiana Purchase Exposition

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Tonneau Car

Will carry six to eight persons. Tonneau can be removed and platform added when desired.

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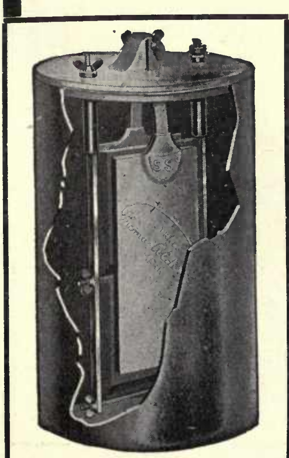

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Chicago, 304 Wabash Avenue

American Bridge Company of New York

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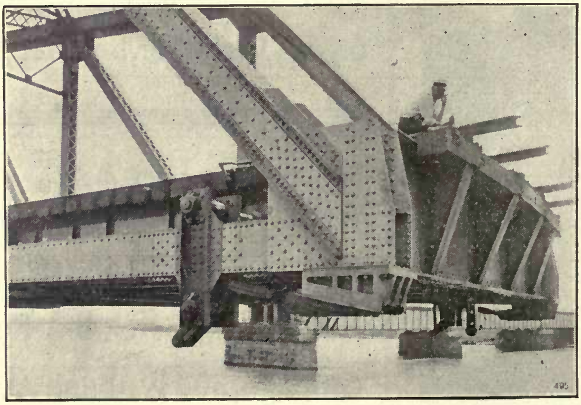


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