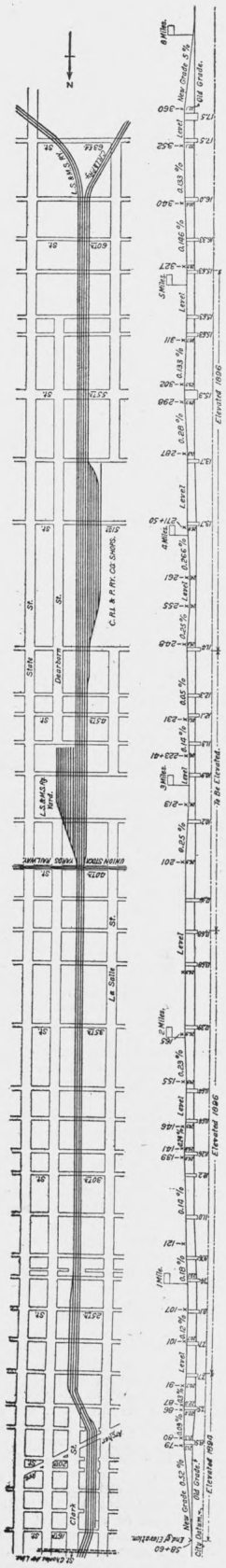

Fig. 1.—General Plan and Profile of the Track Elevation of the Lake Shore & Michigan Southern, and the Chicago, Rock Island & Pacific, in Chicago.

stability of parts which entirely prevent, or at least minimize, independent movements. The roadbed is drained to increase the stability of the tie embedment and prevents the churning movements of the ties in their beds. Ballast is used to facilitate such drainage and provide a more stable support for the tie.

The failure to provide accurate gage, correct line or true surface must result in transverse movements and impacts, which will still further derange the condition and distort the materials in the track. It is not the weight of the train which primarily injures the track, but the damage is done by heavy weights moving at high speeds striking irregularities and making the track worse and worse. The advantage of heavy rails is not so much to secure additional wear and life, but that in affording a stiffer beam there is less flexure of the rail, the conditions of the line, surface and gage are better preserved and much labor is saved.

The restriction of independent movements, so far as labor will accomplish this result, should be the constant aim of track men. The hook-head spike in common use, so far as holding the rail securely down to the tie is concerned, is a very imperfect fastening and there is always more or less vertical play of the rail between the spikes and the tie, causing the rails to cut down into the tie. It is at this point that tie plates are introduced to prevent the wear of the tie and to a certain extent restrict the movements of the rail.

It is a mistake to apply the word "elastic" to track, as only such materials are selected as are not elastic and the object is to absorb and not amplify original movements. The important point in track construction and maintenance is to reduce all independent movements to a minimum. It is necessary to work to exact gage, to perfect level and true line, with correct spiking, thorough tamping, good drainage and other details essential to their preservation, and the refinements of track will surely follow such efforts.

Mr. Reece's discussion of the engineering side of the tie plate is interesting and valuable, but of that we shall make no abstract here. The readers who wants it should address the Q & C Company.

Mr. Wallace, Mr. Harahan and others took part in the discussion, which was a novel and instructive feature of an inspection trip.

Track Elevation in Chicago.

Quite the largest work so far undertaken in track elevation about Chicago has been the raising of the joint tracks of the Lake Shore & Michigan Southern and the Chicago, Rock Island & Pacific Railways. Through the courtesy of Mr. L. H. Clark, Engineer of track elevation for both of the above-mentioned roads, we are enabled to describe this work, and give some of the important details of construction. This we do in continuation of several articles which appeared on this subject in the *Railroad Gazette*, in 1894, the most important of which was a description of the Archer avenue subway, which was given on page 718, in the issue of Oct. 19 of that year.

An ordinance passed the Chicago City Council, July 9, 1894, providing for the elevation of these tracks, the work to be done jointly by the two roads, starting at a point on the south side of the right of way of the St. Charles Air Line, near Sixteenth street, and extending south to a point beyond Sixty-first street, where the roads diverge. From the point of divergence the Lake Shore & Michigan Southern must continue the elevation of its tracks beyond the crossing of State street; while the Chicago, Rock Island & Pacific must extend its work, meeting the old grade at Seventy-second street. South of Sixty-first street each road is obliged to conduct the work of elevating tracks independently. The ordinance further provides for the construction of subways at the various intersecting streets.

By the terms of the ordinance, all expense must be borne by the railroad companies except claims for damages caused by changing the grade of streets or alleys, which are to be paid by the city. In the case of nonperformance of the terms of the ordinance, the railroad companies are required to pay the city $50,000, and a payment of $100,000 is also required as a contribution to the city toward liabilities for land or business damages which may be incurred by reason of the work. The payment of this amount releases the railroad companies from all claims for damages, excepting from negligence on the part of the companies' employees. The time set for the completion of the work is Aug. 1, 1899. In return for the changes made by the railroad companies, the city releases them from all regulations governing speed at crossings as soon as trains are run on the elevated tracks.

Fig. 1 is a profile and plan of the tracks between the crossing of the St. Charles Air Line, at Sixteenth street and Sixty-third street. The plan shown provides for the raising of six miles of roadbed, carrying in most cases four or six tracks, while at Forty-third and Fifty-first streets, yards 15 and 12 tracks wide are raised.

Nothing has been done north of the St. Charles Air Line crossing, as the plans for raising the tracks at Sixteenth street have not yet been definitely settled, the two roads in question being here crossed by the Chicago & Western Indiana, and the Atchison, Topeka & Santa Fe, as well as by the St. Charles Air Line.

In 1894, the work was begun and the tracks were elevated as far south as Twenty-third street, which included the building of three subways. In 1895, the work was continued as far as Thirty-eighth street, 12 subways being built. During the present year the tracks from Forty-seventh to Fifty-ninth street were raised to the new grade and seven subways built. This leaves a small section unfinished between Thirty-eighth and Forty-seventh streets, as no agreement has been reached between the city and the Union Stock Yards Railway which crosses the work at Fortieth street. There also

Name of street.	Number of tracks.	Width of subway between walls.	Clearance.	Depression of subway.	Elevation of tracks.
		Ft.	Ft.	Ft.	Ft.
*Archer avenue.	5	80	12	4	9
*22d street.....	4	66	13.5	5	9.5
23d street.....	5	66	12	4.4	8.6
24th street.....	5	66	12	4.6	8.4
25th street ..	5	66	12	4.3	8.7
*26th street.....	4	66	13.5	5.8	8.9
27th street.....	4	60	12	3.7	9.3
29th street.....	4	66	12	2.7	10.3
30th street.....	4	66	12	1.5	11.8
*31st street.....	4	66	13.5	2.6	12.0
32d street.....	4	66	12	2.4	10.8
33d street.....	4	66	12	2.6	10 7
*35th street.....	4	66	13.5	3.0	11.5
37th street.....	4	66	12.0	2.5	10.7
38th street.....	4	66	12.0	2.4	9.8
*39th street.....	4	66	13.5	3.4	11 1
*Root street....	12	66	13 5	5.2	9.6
43d street.....	15	66	12	5.0	8.0
44th street.....	6	66	12	4.2	8.9
45th street	6	66	12	3.9	9.1
45th court.	6	66	12	3.2	10.1
*47th street.....	7	66	13.5	4 3	10.3
51st street.....	12	66	12	3 0	10.1
53d street.....	6	66	12	2.9	10.2
55th street (Garfield Boulevard).....	6	200	13.5	3.7	10.9
57th street.....	6	66	12	1.1	12.0
58th street.....	6	66	12	1.3	11 8
*59th street.....	6	66	12	3.2	10.0
60th street.	6	66	12	2.5	10.5
*61st street.....	6	66	13 5	4.9	9.7
*†63d street.....	6	60	13.5	4.5	10.1
*State street....	—	60	13.5	5.3	9 3
*Wentworth avenue and 65th street.....	3	63	13.5		
66th street.....	3	66	12		
67th street.....	3	66	12		
Normal Parkway.....	3	73	12		
*69th street.....	3	66	13.5		

*Electric line crosses here.
†North approach—C., R. I. & P. and P., F. W. & C. South approach—L. S. & M. S.

remains about half a mile of joint tracks between Fifty-ninth and Sixty-first streets, and short sections beyond Sixty-first street, which will be carried on independently. It is the plan to complete all the work in 1897 and '98.

As will be seen from Fig. 1, the new grade is reached at Archer avenue, from which point south the new track is practically level, the maximum grade being 0.3 per cent. for a distance of about 400 feet. At all other points, the grades range from 0.3 per cent. to a true level

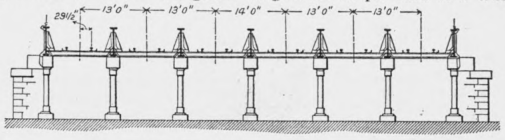

Fig. 3.—Section of Bridge at Garfield Boulevard.

Excepting through the yards shown, the right-of-way is uniformly 100 ft., so that where six tracks occur, retaining walls are necessary, and walls have also been built at a number of points where four tracks were raised.

The table shows the various intersecting streets at which subways are built, the number of tracks carried over each subway, width of subways between walls, clearance or headroom, depression of subways and elevation of tracks. It will be seen that to carry out the whole plan will require the construction of 37 subways to comply with the terms of the ordinance, and at 14 of these subways electric street-railway lines cross.

The new roadbed is made of white sand to within eight in. of the surface, coarse gravel being used for the remaining distance. The railroad companies build the embankments and the masonry work on the abutments of the bridges. Limestone is used for abutments and retaining walls. The iron bridges are furnished by the American Bridge Company, which also does the work of erecting and the field riveting. The retaining walls are built, and the paving at the subways is done, by contract, by Kimbell, Cobb & Co., of Chicago.

The tracks are brought up gradually on either side of a street crossing. Two tracks at least are left open for traffic, the others being blocked and the masonry foundations put in and abutments built. Timber false work is erected upon which the girders are unloaded. These are then lined up carefully and the floor beams put in at four points to hold the girders in place, after which the complete floor is put in, the riveting done and rails laid. By the time the tracks are laid on the bridge the embankments on each side have been brought up and trains are then run over the elevated track, while the remaining tracks are brought up to grade. While the work on the bridge is going on, the excavation is made for the subway, so that by the time the superstructure is finished the subway is paved and completed.

The subways are built with a clear headroom of not less than 12 ft. over the roadway, and 7½ ft. over the sidewalks. The roadways are paved with a single

course of vitrified brick, laid at right angles to the curb and, resting on a foundation of hydraulic cement concrete 9 in. deep. The paving extends 10 ft. from the bridge portals on either side. The approaches to the subways are graded and paved with whatever material is used on the particular street. In the subways, stone curbs are placed and Portland cement sidewalks laid. One or more catch basins are placed at the lowest points in the subways, to provide for drainage, which discharge into the city sewers. Water pipes, electric conduits and sewers, which on account of the depression at the subway are brought too near the surface, are carried back of the abutments and through the embankment. The abutments rest on concrete foundations varying in depth from 3 to 6 ft., depending upon the material encountered, the concrete being brought to within 6 in. of the surface; upon this foundation the stone is laid. The abutments are built of hard limestone cut to dimensions at the quarry; the abutments, back wall and coping are rock-faced, while the bridge seats are dressed.

Fig. 2 shows the elevation of the subway at Fifty-fifth street (Garfield Boulevard). This differs from the other subways in that it is a three-span bridge, with ornamented iron work. The other subway bridges are not ornamented and in the majority of cases are single span. In this instance there are two driveways, one at either side.

Fig. 4 shows portions of the iron work for a 66-ft. clear span bridge. Where six tracks are carried, the two middle tracks are 14 ft. center to center, all other tracks being spaced 13 ft. center to center. Where the distance between the faces of abutments is 66 ft. no intermediate column supports are used, and the girders measure 70 ft. from end to end.

The bridges are all of the plate-girder type with solid floors made of 59 12-in. I-beams, weighing 32 lbs. per lineal foot, spaced $13\frac{7}{16}$ in. center to center and covered with a continuous sheet of $\frac{5}{16}$-in. steel plate. The plate girders are so spaced that they are each in the center between adjoining tracks. All girders are of the same sectional area and detail, so that at any time additional tracks may be provided and added to the bridges without re-inforcement or change in the existing work. The girders are all five feet deep over the chord angles, with rounded corners at the ends, the radius of the curve, $30\frac{5}{16}$ in., being central over the end floor beams. The girders rest on 21-in. × 21-in. × $3\frac{5}{16}$ in. wall plates made up of ¾ in. top and bottom plates with fillers between, the top plate being planed true; these plates, in turn rest on the abutments and are carefully bedded in cement. The whole is bolted to the masonry with 1¼-in. anchor bolts, split and driven over steel wedges and cast in the bolt holds in the stone with Portland cement. The anchor bolts fit the holes in the wall plates closely, but the holes in the girders are two inches in diameter to provide for expansion, both transversely as well as longitudinally. All girders have ½-in. web plates re-inforced at the top chord by two 12-in. × ⅜-in. side plates and at the bottom chord by two 17-in. × ⅜-in. side plates, all side plates being continuous from end to end without splice. The web plates are in three approximately equal sections, the splices being covered with 7-in. × ⅜-in. plates on each side.

The top chords of the girders are made up of two 6-in. × 6-in. × ⅜-in. angles, and five 16-in. × ⅜-in. cover plates, the angles being spliced at the tangent points of the curves at each end and covered with 5⅝-in. × ⅝-in. plates. The first cover plate starts at the end of each girder upon the lower chord, leads up, forming the end posts, is bent around at each end and is spliced below the second cover plate, a distance of 28 ft. each side of the center of the girder. The second cover plate is 58 ft. 6 in. long, covering the splice of the first plate 15 in. at each end; the third cover plate is 49½ ft. long, the fourth 41 ft. and the fifth 30½ ft. The bottom chord is made up of two 6-in. × 6-in. × ⅜-in. chord angles, of one 21-in. × ⅜ in. cover plate 70 ft. long, and of four cover plates 16 in. × ⅜ in.; the first plate is 56½ ft. long, the second 49½ ft., the third 41 ft. and the fifth 30½ ft. All rivets in the girders are ⅞-in., and over the bed plates at each end they are counter sunk and driven flush. All rivets in the attachments between the floor beams and the larger plates are ¾-in., and where the floor beams are connected to the girders ⅝-in. rivets are used. The 70 ft. girders are constructed so as to have a camber of ⅝ in. in the center.

The floor system used on these bridges is entirely new, and is the design of Mr. Clark. No stringers are used and the whole forms a waterproof floor, which, while stiff, is still sufficiently elastic. All parts act together under a load instead of the various members acting separately, as in the old construction.

The weight of a four-track, 70-ft. girder bridge with the design of floor shown in Fig. 3, is 200 tons, and of a six-track bridge of the same length, 300 tons.

The floor beams are cut to a level with a cold saw, and are riveted in the shop to 9-in. × ½-in. hanger plates by means of two 3½-in. × 3½-in. × ⅜-in. angles using four ¾-in. rivets each. The hanger plates are riveted, in the field, to the webs of the girders with five ⅞-in. rivets each and to the 21-in. cover plates of the bottom chord with three ¾-in. rivets each, through the 9-in. × ½-in. bent plates. The $\frac{5}{16}$-in. floor cover plates are dressed to leave a seam not more than ⅛ in. open, and are connected on their under side by 5-in. by ⅜-in. batten plates riveted to the flanges of the floor beams; the cover plates are also connected to the web plate of the girders by means of 6-in. × 4-in. × ⅜-in. flange angles. The seams, where the floor plates are joined, are filled with hot asphaltum before painting.

The rails, which weigh 80 lbs. per yard, are placed on ⅜-in. rail plates, one over the center of each floor beam. The plates are 16¼ in. long, alternating 10 in. and 6 in. in width; the 10-in. plates are bolted with four 1-in. bolts passing through the cover-rail plate, and a cast-steel rail clip, which fits closely to the foot of the rail. The 6-in rail plates are merely bearing plates and are without bolts.. On the outside of the rail and resting upon the same rail plates are 6-in. × 4-in. × ½-in. angle iron guard rails, which are riveted through the rail and floor plate to the flanges of the floor beams, with four ⅝-in. rivets at each intersection.

At the shops the bridges are given one coat of refined raw linseed oil, and after erection the ironwork is cleaned and given two heavy coats of bridge paint. All the material used in the bridges is open-hearth steel.

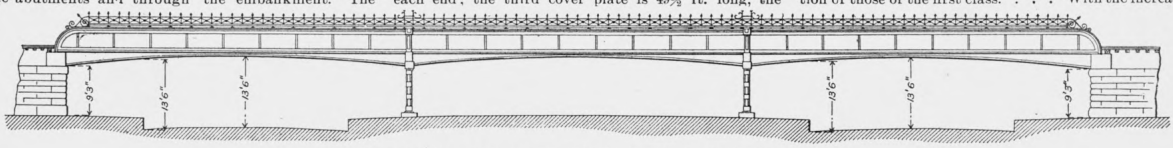

Fig. 2.—Elevation of the Bridge at Garfield Boulevard—Track Elevation in Chicago.

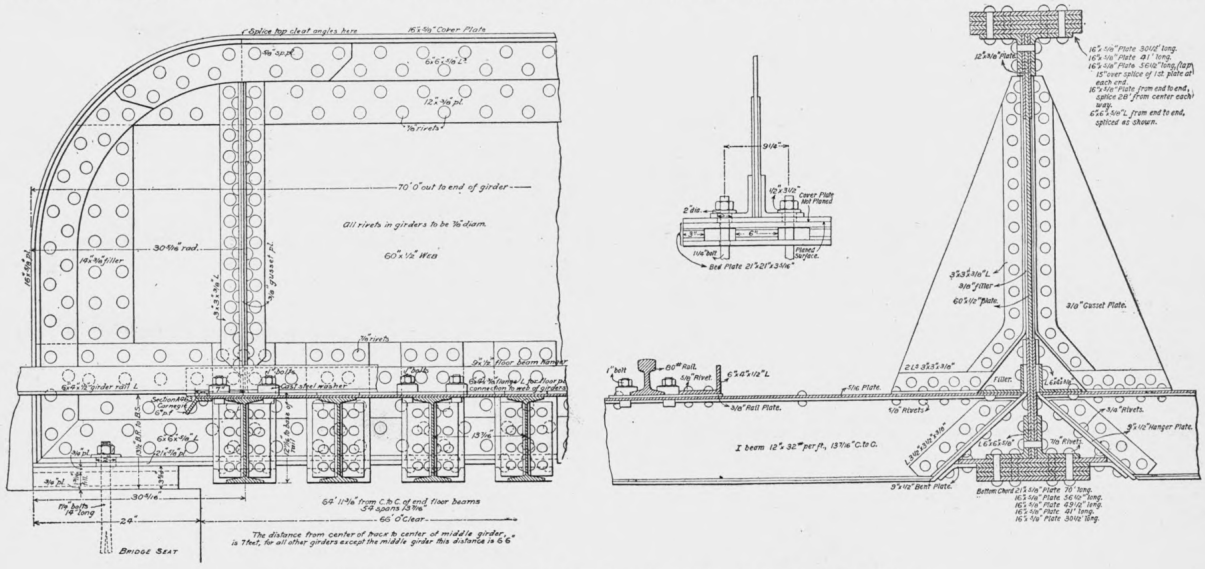

Fig. 4.—Partial Elevation and Section of 66-Ft. Clear Span Bridge—Track Elevation in Chicago.

Railroad Terminal Stations.*

BY MR. E. K. TURNER.

Terminal stations are of two general classes, those for the accommodation of passenger traffic and those for freight. The subject is so extensive, that, in the present paper, the writer will confine himself to the consideration of those of the first class. . . . With the increase in population and changes in its distribution in and around the cities, and with the growth of traffic on the railroads, has come the imperative need of better terminals, and within the last few years many of the most important railroads have rearranged or relocated their terminal passenger stations.

The passenger movement, so far as it concerns terminal stations, is composed of three classes: Through or long distance, suburban or short distance, and excursions or irregular travel . . The conditions governing the movements of the three classes of passengers noted, with their baggage and appurtenances, are very different, and the accommodations, which it is necessary to provide for them, vary widely.

The long distance passengers have a large amount of baggage, some of which can be taken directly to or from the train, but a large proportion requires provision for storage, and all requires provision for handling while at the station, for the reception and delivery of the baggage and room for storage of checks and for the clerical work necessary for the proper recording and accounting. Passengers of this class usually visit the city at long intervals, and upon arrival must go to their destination by some conveyance, either carriage or street car, so that the location of the station is of less importance to them than to those of the second class. Its arrangement as to comfort of waiting-rooms and convenience of baggage rooms is of greater importance. Many passengers of this class wish to take the cars of some railroad other than those of the road upon which they arrive. If the trains of both railroads are in the same station, with convenient provision for the prompt transfer of the passengers and their baggage from one to the other, their comfort and convenience are served in the best manner. This result is reached in many of the "union stations" which have become common within the last few years.

The second class noted above, containing the greatest proportion of passengers using the terminal station, including all passengers whose work calls them to the city daily, covering the large number whose place of business is in the city and residence is outside, have very different requirements. They do not need such provision for baggage or waiting-rooms. They reach the station just before the time of departure of their trains and hurry from their trains immediately on arrival. Inside the station, convenient ways for the quick ingress and egress are the primary requirements, with a good system of running and despatching trains, and conspicuous and plain indicators showing destination and starting time of trains.

To this class the location of the station is of the greatest importance. For them, on general principles, the station should be as near the business center as possible. If this class of business is to be attracted to the railroad, the facilities offered and cost of transportation must be as favorable as those of competing lines. The majority of this class are people with small incomes, to whom the addition of a street-car fare daily to the steam-car fare, is a serious, if not impossible, expense,

* Extracts from a paper read before the New England Association of Railroad Superintendents Oct. 12.

UNIVERSITY OF MICHIGAN