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Grade Separation.

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Two bodies cannot occupy the same space. Of two intersecting lines of traffic on the same plane neither can be continuous; each must be intermittent, must stop, or change direction, while the other passes. And while each line may be naturally intermittent, may consist of detached units, if its units pass at variable and unrelated intervals, liability for two units, one on each line, to meet at the point of intersection remains unchecked. If either line is fixed in direction, as on a railway, and cannot turn aside, the danger of interference increases; and increases more if both lines are so fixed. The fact that the only safe crossing of street or highway and railway, or of railway and railway, is in placing one above the other, and thus giving each a free and unobstructed course, is an axiom. No so-called protected crossing—a grade crossing with gates, signals, derails and other appliances, or any of them, operated by attendants, or automatically—has been found to be ultimately safe. Separation of grades has in addition to safety, the further great advantage of elimination of delay and of maintenance and operating cost. This paper aims to give existing conditions governing the practicability of grade separation. The physical laws for grade separation are summed up in two:

1. The structure carrying the upper line of traffic must be sufficiently high above the lower traffic way to clear all objects passing on the latter.

2. The grade on either traffic way, approaching the crossing, must be practicable for the traffic thereon.

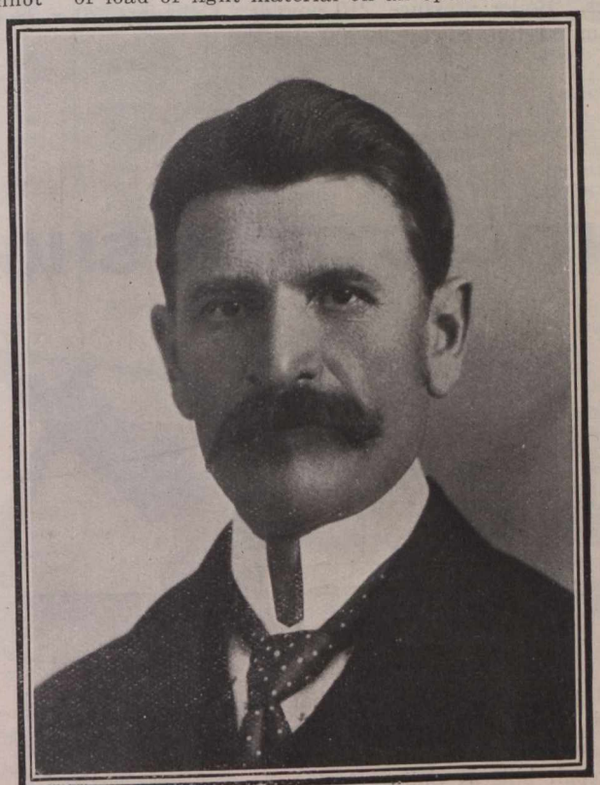
The maximum height of loaded vehicles and any objects thereon on city streets or country highways has been accepted as 14 ft. This height is also sufficient to clear regular street railway traffic. While higher objects are moved along roads occasionally, it is properly not considered necessary to endanger the practicability of crossings under railways to accommodate them. With the railway on moderate embankment, undercrossings of roads, subways as they are called, become readily practicable. In many cases it is possible to sufficiently change the grade both of railway and road to meet requirements for a subway. Sometimes a deviation of the road, or change of location for a short distance, is practicable, and greatly simplifies the desired grade separation.

The vertical clearance, top of rail to bridge, required over railway tracks is in most cases much higher than over roads, and this constitutes, in the great majority of cases, the insurmountable obstacle to grade separation. The highest fixed projection on an ordinary railway train is the locomotive smoke stack, and passenger cars project higher than the great bulk of freight cars; but some, comparatively extremely few, special freight cars are higher than either passenger cars or locomotive stacks. The extreme clearance requirement is for height, top of rail to running board, of highest car, height of brakeman added thereto, and a further allowance for contingencies, among which may be height of load of light material on an open car exceeding maximum box car height. There are on the railways of standard gauge in the United States, Canada, and Mexico, about 2,377,282 freight cars of all kinds. They classify as to height, rail to running board, as follows:

Under 12 ft. including flat, gondola, and tank cars	63.1	per cent.
12 ft. to 13 ft.	23.4	" "
13 ft. to 13 ft. 6 in. inclusive	11.9	" "
13 ft. 6 in. to 14 ft. inclusive	0.65	" "
Over 14 ft.	0.95	" "

Of the total number of freight cars 98.4% are 13½ ft. high or under, and only 1.6% are higher than 13½ ft.; and Canada, has not fixed a standard for box less than 1% higher than 14 ft. Considering main trunk lines, the Pennsylvania Rd., Baltimore and Ohio, Erie, Lehigh Valley, Great Northern, and a number of others, i.e., as far as known, with a small percentage of cars having dimensions not ascertained, among the latter the Grand Trunk and Canadian Pacific Railways, have either none or less than ¼ of 1% of freight cars over 13½ ft. to running board.

The M.C.B. Association, whose standards are adopted by railways on the North American continent and are recognized by the Board of Railway Commissioners for Canada, has not fixed a standard for box car dimensions, but adopted in 1904, as recommended practice, a height of 12 ft. ¾ in. to eaves, equivalent to less than 13 ft. height to running board. High standard cars are such as the G.T. Pacific series 300000—310824, 13 ft. 4 in., and the C.P.R. new steel frame box car series 130000—132998, 13 ft. 4¾ in. The highest regular C.P.R. freight cars are 13½ ft. to running board and this may be said of most of the main trunk lines of railways. The highest Pennsylvania Railroad freight cars are 13 ft. 4 in.



M. S. BLAIKLOCK
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Limits of car dimensions are fixed by clearance outlines on the various railways. A composite clearance limit diagram for 90 railways, including all Canadian trunk lines, has a height of 14½ ft., limiting "over all" height of cars to this figure and practically limiting height of top of running board of freight cars to 14 ft. In the G.T.R. St. Clair tunnel, the clearance height at width of 3 ft. is 14 ft. It is true that on many divisions or branches of the lines considered, the clearance is somewhat greater than shown in the composite diagram referred to, while on the other hand, it is less on a number of main lines, and on many branch lines. An empty freight car 14 ft. high will on 5 ft. (out to out of rails) transverse base not resist a 30 lb. wind pressure when standing alone.

The limit of grade, approaching crossings, can for railways be taken as between 0.5 of 1% and 1%. For city streets a grade of 5% is in most cases extreme and it should be so for main country highways. A preferable maximum grade for roads is 4%, and 3% is materially better. This works out as follows:

Five per cent. grade 20x2=40 ft. length of approaches for every vertical foot of clearance.

Four per cent. grade 25 x 2=50 ft. length of approaches for every vertical foot of clearance.

Three per cent. grade 33 ft. 4 in. x 2=66 ft. 8 in. length of approaches for every vertical foot of clearance.