SELECTION OF LENGTH OF TRANSITION SPIRAL.*

In fixing the alinement of a projected fast interurban electric railway recently, the writer was confronted with a dearth of information concerning either theory or practice for rigorously selecting proper lengths of easement or transition curves. The only line of thought or suggestion on the subject which could be found was that outlined by Prof. Talbot in his work on the transition curve, and that appeared to be more or less specially applicable to his particular spiral. Because of the fact that standard spirals of the Searles type had been adopted and were in use on the road in question, it seemed inadvisable to make any radical change in the type of easement curve. None of these standard easement curves, however, were of a length greater than 100 ft., while the theory which is presented herewith demands lengths up to and in some cases exceeding 300 ft.

The old spirals having chord lengths of 10 ft. were adopted as "base tables," and new easement curves were developed from these by merely increasing the chord lengths to 20, 30, 40 and 50 ft., maintaining the same central angles with, of course, the same "angle of increment," which term will be readily understood by those familiar with the Searles spiral. For the benefit of those not familiar with this type, the Searles spiral may be defined as a compound curve with successive equal chord lengths sub-tended by 2, 3, 4, 5, etc., times the angle sub-tended by the first chord length, which latter, of course, may then be defined as the "angle of increment."

The determination of the proper length of transition, however, was as far from a reasonable solution as ever. Further search was then made of printed information on the subject, and a practically complete bibliography of existing English literature on the proper lengths of transition curves and rate of rise of superelevation of outer rail was compiled together with brief synopses of the main features in each article.

Almost on the day of the completion of this compilation, and while the writer was engaged in an attempt at a rigorous solution of the problem, with practically his only suggestion a mass of "rules of thumb" or tracklayer's experiences, there appeared a very creditable report of the Committee on Track of the American Railway Engineering Association and published in Bulletin 108 of that body. The report is replete with compiled information, some, it is true, of the "rule of thumb" order, but with a principle, new to the writer, from several of the roads, namely, a length of curve dependent upon the rate of rise of the outside of a train on a curve (at the rail) in inches per second. There were letters from two roads with diagrams from one, both very suggestive of a method of attacking the problem; namely, the Cleveland, Cincinnati, Chicago & St. Louis Ry., and the Pittsburg & Lake Erie R. R.

With this new material, it proved to be an easy matter to establish a relation between superelevation of outer rail, radius of the central curve, speed of the train, rate of rise of train on outer rail in inches per second, and the proper length of transition curve, on a scientific basis. The result of these computations and a brief discussion of the basic principles involved, with reasons for their adoption, are presented as follows:—

* A paper by Frank H. Carter, in Appendix B. Report of Committee on Track, American Railway Engineering Association.

The rate of rise of superelevation on easement curves is largely, if not entirely, a question of its effect on passengers as to whether the rapidity of vertical rise of one side of the train produces a disagreeable sensation. An attempt to formulate the proper length of transition curve from the rate of rise of rail in inches per 100 ft. without regard to the speed of the train, is approaching the problem from the wrong standpoint. In any formula of type $I = C\,D\,V^2$ the constant C, as will be shown, fixes the rate of rise of superelevation of rail; therefore, but one curve and one speed will satisfy this equation in regard to rapidity of rise of train in inches per second. All other curves or speeds will convey different sensations of ease of riding to the passenger. The average rate of rise of the outside of the train (at the rail) in inches per second should be the governing function for the determination of the length of transition curve, as will be discussed a little later. In fixing alinement, smoothness of riding is all important for comfort; hence, the same rate of rise of superelevation on curves in inches per second should govern for the entire road, where a schedule can be predicted with any degree of certainty; a difficult matter, of course, in most cases for new roads, but almost always capable of realization in realinement, when timetables are established.

It appears to the writer that the clause for insertion in the Manual of the American Railway Engineering Association, viz.: "that the length of the curve should not be less than thirty times the elevation in inches for the ultimate speed" (literally meaning that no rise of superelevation shall be greater than 1 in. in 30) is a wise provision for places where the speed cannot be predicted, but that is not the best practice, in that the rate of rise of transition will not in that case depend upon the speed of the train.

The last clause of the paragraph for the Manual of Recommended Practice of the American Railway Engineering Association, concerning the length of easement curve, viz.: "that the curve should not be less than two-thirds the ultimate speed in miles per hour times the elevation in inches," places a more rapid rate of rise of the car in inches per second than has been considered best practice for steam roads, according to available information in the hands of the writer. By this rule the rate of rise would amount to about 2.1 ins. per sec., while the common practice appears to be from 1¼ to 1½ ins. per sec. rise.

The length of easement curves used on the Cleveland, Cincinnati, Chicago & St. Louis Ry. is apparently based on an assumed rate of rise of 1¼ ins. per sec., and the practice of the Delaware, Lackawanna & Western Railroad is given as 1½ ins. per sec.

It is true that cases may be cited where faster rates of rise have been used; notably a local fast urban electric railway has several spirals where the rate of rise is 1 in. in 20 ft., corresponding to 2.20 ins. per sec. vertical rise at 30 miles per hour.

These curves are said to be easy riding curves from the standpoint of electric road practice, but jolts and roughness of riding which might be tolerated by passengers on an urban electric road or an elevated road, would not be considered good practice for steam roads, where the demand is for smooth riding, such, for instance, that passengers might be able to write a letter comfortably while on a car in motion. It may be of interest to note at this point that this same railway has lately made radical changes in increasing its length of transition curve.