RAILROAD ENGINEERING, PART I; INSTRUCTION PAPER

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WALTER LORING WEBB

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PART I

INSTRUCTION PAPER

PREPARED BY

WALTER LORING WEBB, C.E.

MEMBER, AMERICAN SOCIETY CIVIL ENGINEERS
CONSULTING CIVIL ENGINEER

AMERICAN SCHOOL OF CORRESPONDENCE

CHICAGO ILLINOIS
U. S. A.

RAILROAD ENGINEERING.

PART I.

RAILROAD SURVEYS.

1. General Principles. The engineer should have first, a thorough appreciation of the objects to be accomplished by the surveys. He should realize that, except in the rare cases where it is difficult to find *any* practicable line, very little engineering training or ability is required to lay out a line over which it would be physically possible to run trains. A line as laid out may violate all rules of location, may be expensive to operate and have disadvantages which will discourage traffic, and yet trains *can* be run over it. From the infinite number of possible locations, the engineer must select the location which best satisfies the various conflicting interests. His value as an engineer depends on his ability to interpret the natural conditions and design the line accordingly. This ability is only obtained by a thorough knowledge of the whole subject of railroad engineering, supplemented by practical experience. It is therefore true that many of the following statements will not be thoroughly appreciated until the student has covered the whole subject and then reviews it.

2. Conflicting Interests. There are several classes of interests, which are generally more or less conflicting, which affect the location of every line·

(*a*) *The initial cost should be a minimum*, but the cheapest road generally has sharp curvature, steep grades and inconvenient location.

(*b*) *The operating expenses per train mile should be a minimum*, which is generally equivalent to saying that the curvature should be light and the grades low, but this is usually unobtainable except at great cost.

(*c*) *The location should be convenient to sources of traffic* so that the maximum traffic will be obtained, but this is generally very costly.

A little study will show the frequent conflict of the above conditions. When a proposed location evidently combines the above interests advantageously, instead of bringing them into conflict, then there is no doubt as to the proper location, unless it affects unduly the adjacent location. The best engineering ability is a cheap investment when deciding on a location which requires a delicate balancing of the claims of several possible routes, each with its own combination of greater or less initial cost, greater or less operating expenses, and greater or less effect on the probable revenue of the road.

RECONNOISSANCE SURVEYS.

3. Essential Problem. From the above considerations it may readily be seen that the first survey to be made (called the reconnoissance survey) consists essentially of a broad examination of the country through which the road is expected to pass. Business considerations usually predetermine that the road is to connect certain termini and also pass through certain intermediate important towns or cities, but the problem consists in finding the best route between the predetermined points. When two consecutive predetermined points lie in the same valley or on the same bank of a river too large to be easily bridged, the location is self-evident. If the river is smaller, easily bridged, has sharp bends, with variable banks and important towns on either bank, it will usually require a close examination of each bank to determine where to cross if at all. When the two points are many miles apart, lie in different valleys, and are therefore separated by one or more summits, the selection of the best route becomes more and more complicated as the number of possible routes becomes greater. It is generally true, although not invariably, that a cross-country route which includes the lowest summits and the highest *low points* (such as river crossings) will give the best grades. Since the "ruling grade" is the most important physical consideration for the engineer, as will be developed later, the chief work of the reconnoissance survey (apart from considerations of probable traffic) is the determination of the elevations of summits and sags and the distance between them, together with the constructive character of the country.

4. Utilization of Existing Maps. The U. S. Geological Survey has already published contour maps of a large part of the country which enable an engineer to select a line with even greater ease and certainty than he can from a reconnoissance map made for the purpose (as usually made), since the U. S. G. S. maps show the *whole* country and enable the engineer to rapidly compare a dozen suggested routes instead of confining his attention to the (usually) limited area of the special map. The errors of the U. S. G. S. maps will seldom if ever be sufficient to vitiate the accuracy of the preliminary route laid out from them. Usually a brief study of the map will demonstrate that one (or perhaps two or three) general route has advantages so pronounced over all other possible routes that the choice is immediately made or is at least reduced to the comparison of two or three lines which are so nearly equal that closer and more detailed surveys are necessary to decide between them. County atlases are usually sufficiently accurate for reconnoissance purposes to the extent of giving the relative horizontal positions of governing points of the survey. Elevations may be determined (as described later) and plotted on these maps.

5. Surveying Methods. When reliable contour maps are unavailable, some of the following methods may be used to fill out existing maps or to make a complete reconnoissance survey. The essential point is the rapid determination of those details from which one route is shown to be superior to another. Nothing useless should be surveyed and no time should be wasted on an unnecessary degree of accuracy. The physical characteristics of two routes have usually such differences that they are apparent even with rapid and approximate methods of surveying. If two routes are so nearly equal that a decisive choice cannot be made from the results of reconnoissance surveys, it shows that a more accurate survey should be made of both routes.

6. Elements. The three elements of the survey of any line are (*a*) the length, (*b*) the direction, and (*c*) the slope or the relative elevation of the two ends. *Distance.* The length is sometimes determined with sufficient accuracy by pacing, the steps being counted with a pedometer. In an open prairie country, where a buggy may be run, an odometer attached to a wheel will count the revolutions. An odometer on a wheel, attached to a frame and trundled like a wheelbarrow, has been used for the same purpose. A large telescope, mounted with a universal joint on a very light tripod, and fitted with stadia wires so adjusted that distances of 2,000 or even 2,500 feet can be read to the nearest 10 feet on a 10-foot rod, will give the distances between widely separated stations with sufficient accuracy and extreme rapidity. *Direction* may be obtained with sufficient accuracy with a compass—even of the pocket type. *Leveling.* Spirit leveling is too slow and expensive for the rapid surveying here required. If stadia methods are used with an instrument provided for reading vertical angles, the inclination of all lines may be observed and the elevations of all stations computed. A still more rapid method of observing differences of elevation with sufficient accuracy for the purpose is found in the use of an aneroid barometer, supplemented by another aneroid or preferably by a mercurial barometer. The mercurial, or the office aneroid, is kept at some office whose elevation is known and observations are regularly taken (say every half hour) during the period when observations are being taken in the field with the field aneroid. The field aneroid is taken to each place, within a range of several miles, where elevations are desired. At each point there should be noted (see the form of notes below) the time, the described location, the aneroid reading and the temperature. If possible, duplicate readings should be taken on the trip to and from the office on all important points. The elevations of succeeding office locations made, may be determined with the field aneroid if necessary, but of course extra care should be taken with such work.

Aneroids are usually "compensated for temperature," *i.e.*, so adjusted that they will give a true reading regardless of temperature. If an aneroid has not been so adjusted, it should be carefully compared with a standard mercurial barometer under widely varying conditions of temperature and a tabular form should be made out for that aneroid showing the correction to be applied at any given temperature. On account of the expansion of mercury with temperature, and also the expansion (at a different rate) of the tube and cistern, all readings of the mercurial barometer must be "reduced to 32° F.," *i.e.*, reduced to the reading it would have, if the temperature of the instrument were 32° F. This is readily accomplished by means of Table XI.* At the office, each half-hourly observation should include the time, the reading of the scale showing the height of the mercury, the reading of the "attached thermometer" (the thermometer attached to the mercurial) and also the temperature of the external air. When the mercurial is indoors these two temperatures may differ somewhat. When reducing the observations interpolation should be made if necessary between the reduced office observations to determine the probable reading of the mercurial at the time of any given field observation. Determine from Table XII* the heights corresponding to the field reading and reduced office reading for each pair of observations. Their difference is the *approximate* difference of elevation of the office and of the place of the field observation. If necessary this may be corrected by an amount equal to the approximate difference of elevation times a coefficient derived from Table XIII.* This coefficient is found opposite the number which gives the *sum* of the temperatures in the field and outside the office. The correction is frequently too small to be noticed. An approximate calculation will often show this, or will give a solution to the nearest foot, which is amply accurate. An aneroid, no matter how perfect, will seldom agree exactly with a mercurial barometer, and even if adjusted to the same reading will soon indicate some discrepancy. It is therefore better to leave the adjustment undisturbed and apply corrections. The aneroid should therefore be compared with the mercurial before leaving headquarters for a day's work, and the readings of both and their *difference* should be recorded. Immediately after returning from the day's work the aneroid should again be compared. The absolute reading of the mercurial will probably be higher or lower, but the *difference* should be nearly the same, although it is found that an aneroid will lag somewhat behind its true reading, especially if it has been subjected to an extreme variation of pressure. All the field readings of the aneroid should therefore be corrected by the *mean* of the initial and final differences. The method and the above explanation may be illustrated by the following numerical examples:

7. Examples. 1. Given a reading of 28.692 on a mer-

*See Webb's "Trigonometric Tables," published by American School of Correspondence, Chicago, Ill. Price, 50c.