Railroad Curves and Earthwork.

The operations of "locating" a railroad, as commonly practised in this country, are three in number:—

I. Reconnoissance.
II. Preliminary Survey.
III. Location Survey.

I. Reconnoissance.

The reconnoissance is a rapid survey, or rather a critical examination of country, without the use of the ordinary instruments of surveying. Certain instruments are however used, the Aneroid Barometer, for instance. It is very commonly the case that the termini of the railroad are fixed, and often intermediate points also. It is desirable that no unnecessary restrictions as to intermediate points should be imposed on the engineer to prevent his selecting what he finds to be the best line, and for this reason it is advisable that the reconnoissance should, where possible, precede the drawing of the Charter.

The first step in reconnoissance should be to procure the best available maps of the country; a study of these will generally furnish to the engineer a guide as to the routes or section of country that should be examined. If maps of the Geological Survey are at hand, with contour maps and other topography carefully shown, the reconnoissance can be largely determined upon these maps

Lines clearly impracticable will be thrown out, the maximum grade closely determined, and the field examinations reduced to a minimum. No route should be accepted finally from any such map, but a careful examination should be made over the routes indicated on the contour maps. The examination, in general, should cover the general section of country, rather than be confined to a single line between the termini. A straight line and a straight grade from one terminus to the other is desirable, but is seldom possible and is in general far from possible. If a single line only is examined, and this is found to be nearly straight throughout, and with satisfactory grades, it may be thought unnecessary to carry the examination further. It will frequently, however, be found advantageous to deviate considerably from a straight line in order to secure satisfactory grades. In many cases it will be necessary to wind about more or less through the country in order to secure the best line. It can be expected when a high hill or a mountain lies directly between the points that a line around the hill, and somewhat remote from a direct line, will prove more favorable than any other. Unless a reasonably direct line is found to satisfactory the examination should embrace all the section of intervening country, and all feasible lines

should be examined.

There are two features of topography that are likely to prove of especial interest in reconnoissance, ridge lines and valley lines.

A ridge line along the whole of its course is higher than the ground immediately adjacent to it on each side. That is, the ground slopes downward from it to both sides. It is also called a water shed line.

A valley line, to the contrary, is lower than the ground immediately adjacent to it on each side. The ground slopes upward from it to both sides. Valley lines may be called water course lines.

A pass is a place on a ridge line lower than any neighboring points on the same ridge. Very important points to be determined in reconnoissance are the passes where the ridge lines are to be crossed; also the points where the valleys are to be crossed; and careful attention should be given to these points. In crossing a valley through which a large stream flows, it may be of great importance to find a good bridge crossing. In some cases where there are serious difficulties in crossing a ridge, a tunnel may be necessary. Where such structures, either bridges or tunnels are to be built, favorable points for their construction should be selected and the rest of the line be compelled to conform.

Distances may be determined with sufficient accuracy in many cases from the map where a good one exists. Where this method is impossible or seems undesirable, the distance may be determined in one of several different ways. When the trip is made by wagon, it is customary to use an Odometer, an instrument which measures and records the number of revolutions of the wheel to which it is attached, and thus the distance travelled by the wagon. There are different forms of odometer. In its most common form, it depends upon a hanging weight or pendulum, which is supposed to hold its position, hanging vertical, while the wheel turns. The instrument is attached to the wheel between the spokes and as near to the hub as practicable. At low speeds it registers accurately; as the speed is increased, a point is reached where the centrifugal force neutralizes or overcomes the force of gravity upon the pendulum, and the instrument fails to register accurately, or perhaps at high speeds to register at all. If this form of odometer is used, a clear understanding should be had of the conditions under which it fails to correctly register. A theoretical discussion would closely establish the point at which the centrifugal force will balance the force of gravity. The wheel striking against stones in a rough road will create disturbances in the action of the pendulum, so that the odometer will fail to register accurately at speeds less

than that determined upon the above assumption.

Another form of Odometer is manufactured which is connected both with the wheel and the axle, and measures positively the difference in the relative motion between the wheel and axle, and which ought to be reliable for registering accurately. Many Engineers prefer to count the revolutions of the wheel themselves, tying a rag to the wheel to make a conspicuous mark for counting.

When the trip is made on foot, pacing will give satisfactory results. An instrument called the Pedometer registers the results of pacing. As ordinarily constructed, the graduations read to quarter miles and it is possible to estimate to one tenth that distance. Pedometers are made which register paces. In principle the pedometer depends upon the fact that with each step, a certain shock or jar is produced as the heel strikes the ground, and each shock causes the instrument to register. Those registering miles are adjustable to the length of pace of the wearer.

If the trip is made on horseback, it is found possible to get good results with a steady-gaited horse, by determining his rate of travel and figuring distance by the time consumed in travelling. Excellent results are said to have been secured in this way.

It is customary for engineers not to use a

a compass in reconnoissance, although this is sometimes done in order to more accurately trace upon the map, the line traversed. A pocket level will be found useful. The skillful use of pocket instruments will almost certainly be found useful, in fact of great value to the Engineer of reconnoissance.

It may in cases occur that no maps of any value are in existence or procurable. It may be necessary in such a case, to make a rapid instrumental survey, the measurements being taken either by pacing, chain or stadia measurements. This is however unusual.

The preliminary survey is based upon the results of the reconnoissance, and the location upon the results of the preliminary survey. The reconnoissance thus forms the foundation upon which the location is made. Any failure to find a suitable line and the best line constitutes a defect which no amount of faithfulness in later work will rectify. The most serious errors of location are liable to be due to imperfect reconnoissance; an inefficient Engineer of reconnoissance should be avoided at all hazards. In the case of a new railroad, it would in general be proper that the Chief Engineer should in person conduct this survey. In the case of the extension of existing lines, this might be impracticable or inadvisable, but an assistant

of known responsibility, ability and experience 8.
should in this case be selected to attend to the work.

References

Reconnoissance.

Searles' Field Eng. p. 1
Wellington Ec. Theory Railway Location p. 831.
Beahan Assn. Eng. Societies 1888
or R.R. Gazette 1888 p. 366 June 8.
McElroy " " 1888 p. 445 July 6
Jameson R.R. & Eng. Journal 1887 and 1888.

Aneroid Barometer Use of

Searles' Field Eng. p. 4 to 7
Godwin Eng. Hd Bk p. 165
Van Nostrand Science Series No. 35.

Aneroid Barometer Tables.

Searles' Field Eng. Tables XV and XVI
Henck's Field Book " VIII and IX

Tables XV and XVI of Searles' are applicable to the formula $D = 60384.3(\log h_0 - \log h_1)\left(1 + \frac{t_0 + t_1 - 64^\circ}{900^\circ}\right)$

where D = difference in Elevation between two stations 0 and 1

h_0 = ht. of barom. Sta. 0 h_1 = ht. of barom. Sta. 1
t_0 = temp Fahr. Sta. 0 t_1 = temp Fahr Sta. 1

For use with Table XV the formula becomes

$$D = 60384.3(\log h_0 - 1 - \overline{\log h_1 - 1})\left(1 + \frac{t_0 + t_1 - 64^\circ}{900^\circ}\right)$$

Table XV gives values of $60384.3(\log h - 1)$
Table XVI " " " $\frac{t_0 + t_1 - 64^\circ}{900}$

Preliminary Survey.

The Preliminary Survey is based upon the results of the Reconnoissance. It is a survey made with the ordinary instruments of surveying. Its purpose is to fix and mark upon the ground a first trial line approximating as closely to the proper final line, as the difficulty of the Country and the experience of the Engineer will allow; further than this, to collect data such that this survey shall serve as a basis upon which the final Location may intelligently be made. In order to approximate closely in the trial line, it is essential that the maximum grade should be determined or Estimated as correctly as possible, and the line fixed with due regard thereto.

It will be of value to devote some attention here to an Explanation about grades and "Maximum Grades"

Grades.

The ideal line in railroad location is a straight and level line. This is seldom if ever realized. When the two termini are at different elevations, a line straight and of uniform grade becomes the ideal. It is commonly impossible to secure a line of uniform grade between termini. In operating a railroad, an engine division will be about 100 miles, sometimes less, often more. In locating any 100 miles of railroad, it is almost certain than a uniform grade cannot