

is found by reading upon a light hand marked rod, the difference in elevation between the center line at the stake, and the required contour.

A cloth tape held by the assistant topographer will serve the purpose of a rod. The next contour to the right can be readily found owing to the fact that the topographer's eye is nearly 5 feet above the ground, making leveling easy. An allowance should be made for the difference between 5 feet and the height of the eye. Sections both right and left should be taken as often as necessary, the distances to each contour measured, and the lines sketched in on the ground, between the points thus determined. Books of convenient size, are made and divided into small cross sections to facilitate sketching. Cross section blocks or pads will be considered equally good by some engineers. The distance to which contour lines should be taken depends on the character of the country. The object should be to take contours as far from the line as is necessary in order to furnish contours requisite for determining the position of the located line.

Instead of a hand level, some engineers use a clinometer and take and record side slopes.

Topography can be taken rapidly and well by use of stadia, or of plane table. This is seldom done, as most engineers are not sufficiently familiar with their use.

Some engineers advocate making a general topographical survey of the route by stadia, instead of the survey above described. In this case, no staking out by "stations" would be done, all points occupied by the transit should be marked by plugs, which can be used to aid in marking <sup>the</sup> "location" on the ground after it is determined on the contour map. This method has been used a number of times and is claimed to give economical and satisfactory results. It is probable that this method will have constantly increasing use in the future, and will prove the best method in a large share of cases.

### 3. Location Survey.

The location survey is the final fitting of the line to the ground. In location, curves are used to connect the straight lines or "tangents", and the alignment is laid out complete, ready for construction.

The party is much the same as in the preliminary, and the duties substantially the same. More work devolves upon the transitman on account of the curves, and more skill is useful in the head chainman in putting himself in position on curves. He can readily range himself on tangent. The form of notes will be shown later. The profile is the same, except that it shows for alignment notes the P.C. and P.T. of curves, and also the degree and central angle, and whether to the right or left.

It is well to frequently connect location stakes with preliminary stakes, when convenient, as a check on the work.

In making the location survey, two distinct methods are in use among Engineers.

#### 1<sup>st</sup> Method.

The preliminary survey and preliminary profile as guides in reading the country, and locate the line upon the ground. Experience in such work will enable an engineer to get very satisfactory results in this way in nearly all cases.

The best engineers, in locating in this way, as a rule, lay the tangents first, and connect the curves afterwards. It will appear how this is done later.

### 2<sup>nd</sup> method.

Use preliminary line, preliminary profile, and especially the contour lines on the preliminary map, make a paper location, and run this in on the ground. Some go so far as to give their locating engineer a complete set of notes to run by. This is going too far. Whether it is best to go farther than to fix in the map the location of tangents and specify the degree of curve is a question. A conservative method is to do no more than this, and in some cases, leave the degree of curve even an open question. The 2<sup>nd</sup> method is gaining in favor; but the 1<sup>st</sup> method is even now much used.

It is well accepted among engineers that no reversed curve should be used; 200 feet of tangent at least should intervene. Neither should any curve be very short, say less than 300 feet in length.

A most difficult matter is the laying of a long tangent, so that it shall be straight. Lack of perfect adjustment and construction of instrument will cause a "swing" in the tangent. The best way is to run for a distant foresight. Another way is to have the

transit as well adjusted as possible, and even then change ends every time in reversing so that any error will not accumulate. It will be noticed that the preliminary is run in without curves, because more economical in time. Sometimes curves are run in here, either because the line can be run closer to its proposed position, or sometimes in order to allow of filing plans with the U. S. or separate States.

In location, a single tangent often takes the place of a broken line in the preliminary, and it becomes important to determine the direction of the tangent with reference to some part of the broken line. This is readily done by finding the coordinates of any given point with reference to that part of the broken line, assumed temporarily as a meridian. The course of each line is calculated, and the coordinates of any point thus found. It simplifies the calculation to use some part of the preliminary as an assumed meridian, rather than to use the actual bearings of the lines. The coordinates of two points on the proposed tangent, allow the direction of the tangent to be determined with reference to any part of the preliminary. Where the angles are small, an approximation sufficiently close will be secured, by assuming in all cases that the cosine of the angle is 1.000000 and that the sines are directly proportional to the angles themselves. In addition to this, take the distances at the nearest even feet, and the calculation becomes much simplified.

The located line, or "Location", as it is often called, is staked out ordinarily by center stakes which mark a succession of straight lines, connected by curves to which the straight lines are tangent. The straight lines are by general usage called "Tangents".

The curves most generally in use are circular curves, although parabolic and other curves are sometimes used. Circular curves may be classed as Simple, Compound, Reversed, or Spiral.

A Simple Curve is a circular arc, extending from one tangent to the next. The point where the curve leaves the first tangent is called the "P.C.," meaning the point of curvature, and the point where the curve joins the second tangent is called the "P.T.," meaning the point of tangency. The P.C. and P.T. are often called the tangent points. If the tangents be produced, they will meet in a point of intersection called the "Vertex," V. The distance from the vertex to the P.C. or P.T. is called the "Tangent Distance," T. The distance from the vertex to the curve (measured towards the center) is called the External Distance, E. The line joining the middle of the Chord, C, with the middle of the curve subtended by this chord, is called the Middle Ordinate, M. The radius of the curve is called the Radius, R. The angle of deflection between the tangents is

called the Intersection Angle, I.

The angle at the center subtended by a chord of 100 feet is called the Degree of Curve, D.

A chord of less than 100 feet is called a Sub-Chord, c, its central angle a Sub-Angle, d.

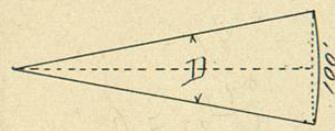
The measurements on a curve are made (a) from P.C. by a sub-chord (sometimes a full chord of 100 ft.) to the next even station, then (b) by chords of 100 feet each between even stations, and finally (c) from the last station on the curve, by a sub-chord (sometimes a full chord of 100 ft.) to P.T. The total distance from P.C. to P.T. measured in this way, is the Length of Curve, L.

The degree of curve is here defined as the angle subtended by a chord of 100 feet. Some engineers define the degree of curve as the angle subtended by an arc of 100 feet. Either assumption involves the use of approximate methods either in calculations or measurements, if the convenient and customary methods are followed. It is believed that on the merits of the question, it is best to consider the degree of curve as the angle at the center subtended by the chord of 100 feet, as here defined. In addition to this, "Henck's Field Book," published in 1854 and for 25 years from that time the field book most widely

used, has so defined it, and the almost universal practice in this country is in harmony with this definition.

Outside of the United States, a curve is generally designated by its Radius  $R$ . In the United States for railroad purposes, a curve is generally designated by its Degree  $D$ .

Problem. Given  $R$ . Required  $D$ .



$$R \sin \frac{1}{2} D = \frac{100}{2}$$
$$\sin \frac{1}{2} D = \frac{50}{R} \quad (1.)$$

Problem. Given  $D$ . Required  $R$

$$R = \frac{50}{\sin \frac{1}{2} D} \quad (2.)$$

Example. Given  $D = 1^\circ$

$$R_1 = \frac{50}{\sin \frac{1}{2} D}$$

	50	log	1.698970
	$0^\circ 30'$	log sin.	7.940842
$R_1 =$	5729.6	log	3.758128

Problem. Given  $R$ , the radius of  $1^\circ$  Curve (or  $D_1$ )

Required  $R_x$  the radius of any given Curve of degree =  $D_x$ .

$$R_1 = \frac{50}{\sin \frac{1}{2} D_1} \quad R_x = \frac{50}{\sin \frac{1}{2} D_x}$$

$$\frac{R_x}{R_1} = \frac{\sin \frac{1}{2} D_x}{\sin \frac{1}{2} D_1} \quad R_x = R_1 \frac{\sin \frac{1}{2} D_1}{\sin \frac{1}{2} D_x} \quad (3.)$$

In the case of small angles, the angles are proportional to the sines (approximately.)