which have a reasonably uniform and small rate of error should be accepted, so that a table of such errors can be prepared and used in conjunction with actual readings taken. Aneroids in high altitudes are often much in error, and generally speaking, should be used to obtain *differences* in elevation rather than actual ones. If a barometer is read at the same spot every hour for a day, a continual fluctuation will be noticed, even during bright dry weather and very much more so during periods of storm or change; these readings if plotted may be termed the *diurnal gradient*. It is evident, therefore, that readings from an aneroid taken at various places, at different times, even during the same day, will not be reliable, and in order to make such readings of value, there should be another stationary aneroid read at regular intervals, and the readings of the moving aneroids corrected according to the fluctuations observed at the central point. Should only one aneroid be available, it would be better, where possible, to make two or more determinations of the same points at different times, to get an average, and to work only when the atmosphere is in a settled condition. Equipped with the above-mentioned instruments and one or two assistants, the engineer on reconnaissance should go into the field free from prejudice; the well-known wagon road or trail may be very convenient to travel along, but not necessarily in the vicinity of the best railway location; the river flowing between or in direction of the termini may have precipitous, treacherous banks, be crooked in alignment, and afford not nearly so feasible a route as the upland country adjacent; just beyond a certain forbidding range of hills may lie a direct and cheap route, and a pass through the barrier may really exist, being hid in the distance by an overlap. In fact, the frame of mind suitable for such an undertaking should be optimistic, ready to believe that if only time enough is available, the best route can be found, but at each moment doubting that such a route is yet discovered.

In addition to those general economic considerations which have been touched on in previous chapters, it is well to remember, amongst other things,

(*a*) That lines following large streams will usually require heavy bridge work and masonry in crossing tributaries.

(*b*) That one bank of a river may be much better than the other, and that it may even pay to cross the river at rare intervals to secure alternately favorable stretches of construction.

(*c*) That lines on side hills are more costly to maintain than those through level country, owing to the sliding and washing that takes place.

(*d*) On the other hand, that a cross-country line, usually, will cross many summits, and even when skilfully located, and often at a considerable loss in distance, will abound in curvature and maximum grades.

(*e*) That in each locality will be met men who have an intimate knowledge of the minutiæ of the surrounding country. Many of these look on themselves as born locating engineers, and while their ideas on grades and curves are usually misty, every shrewd engineer will not be averse to the valuable aid which such men voluntarily offer; the only difficulty lies in sifting the wheat from the chaff without giving personal offense.

(*f*) That the engineer of reconnaissance and afterwards of surveys is the first officer of the railway company to be thrown in contact with the people who are to become the future patrons of the road, and, as such, his manifest duty is to make as many friends for his company as he can, consistently with his other duties, and enlist their sympathies in its favor; in this way a much more reasonable spirit will be created which will display itself when right-of-way questions begin to arise.

After a complete study of the intervening country has taken place, a rough sketch map should be made from the notes taken, and other existing ones, on which will be shown the positions of all streams, summits, etc., with elevations marked at critical points, then possible routes will be indicated, calculations made of the length of lines, maximum grades, probable amounts of curvature, approximate cost of constructions, present and future traffics, etc., all of which, although much in error, will usually narrow down the question to two or three routes which are selected as the most likely and suitable ones for instrumental surveys.

Article 13.—Preliminary or Trial Line Surveys.

The roughest class of preliminary survey may be an amplification of reconnaissance, in which a small party of three or four men pass rapidly over several proposed routes at a rate of five to fifteen miles per day to determine what grades can be obtained before more accurate survey begins. In open country rapid progress can be made, using stadia for distances and using vertical angles for elevation or depression, which are checked by an aneroid barometer. In a wooded country the distances will be determined more rapidly by chain and compass, and heights by aneroid. Side slopes may be noted at difficult spots by some form of clinometer. What is usually wanted is to know what grades can be obtained at certain critical points, in order to adopt a ruling grade for the route. The instruments required are a light transit with stadia hairs, compass and vertical arc, a stadia rod, an aneroid barometer, a clinometer, a 100 ft. steel chain and 50 ft. linen tape. On this class of work the error of stadia measurement should not be more than 1 in 1,000, which is more accurate than rough chaining. When a full survey party for instrumental work is to be equipped, a variety of causes tend to determine the men and instruments required.

(*a*) In an open rolling country. If contour lines are not needed, the party will usually consist of—

Chief of party, Transitman, Leveller.	Engineers, preferably all experienced.
Rodman, Front Picketman, 2 Chainmen.	Active young men, preferably educated college graduates, not afraid of work.
2 Axemen, 1 Stakeman.	Seasoned workingmen, used to bush life, axes, and hard work.

If under canvas, add one cook and one assistant cook, and in this kind of country always use a transit.

(*b*) In thickly wooded country, without iron ore, better results, for the same labor, will be obtained by using a 12-inch to 16-inch compass, instead of a transit, avoiding many detentions, useless cutting of trees, etc. The compass has no cumulative error, and will give good results where no contours are taken; if contours are to be taken, it is better to establish transit line for future use. In a wooded country two or three extra axemen will be needed to make rapid headway; the front picketman also, in this case, should be an expert axeman, and lead the others.

(*c*) If the country is much on side-hill, another party is needed in addition to the transit and level parties, whose duty it is to take contours. In the past contouring has often been omitted, and although there have been some men of great natural talent and long experience who have been able to locate well, even through very rough side-hill country, by eye alone, yet even to such men a properly conducted contour survey would have been of great advan-