

"time would have been lost from high winds without them. The rod-men supported their rods by sticks held in the hand and braced against the rod at an angle, resting on the ground. Care had to be exercised that the rods were not thereby lifted from their sockets in the foot plates.

"2. Tremulousness is caused by a difference of temperature between air and ground, and always occurs in clear weather after the sun is a few hours high. This causes the target, or figures on a speaking rod, to appear to move up and down, giving rise to what is known as "dancing" or "boiling." This simply causes an uncertainty in the reading, depending directly on the degree of unsteadiness. It is a compensating error, and the observer must be his own judge as to when he must stop work in order to obtain the required degree of precision. The only remedy is to shorten the length of sight; but as there are some errors that multiply directly with the number of sights taken in a given distance, there is also a limit to which this remedy may be profitably carried. I do not think it advisable to use sights less than 100 feet if the highest accuracy is sought, and perhaps never more than 400 feet, even when the atmosphere is perfectly clear and steady. In clear weather not more than 3 or 4 hours a day can be utilized for the best work.

"3. Variable refraction occurs when the sunshine suddenly comes up or leaves the line; this happens along the edge of timber or under the brow of a hill, as when the line rapidly emerges from or comes into the shade from the sun's movement, or on partially cloudy days, when the sun is alternately covered and clear. When from the first source, it occurs about 8 a.m. and 4 p.m. It is a peculiar phenomenon, and is more common in winter than in summer. The atmosphere is apparently steady and the sight well taken; but upon checking it, the reading has changed, and may be observed to change gradually or suddenly, and sometimes to recover a part or all of its original movement, when the instruments were known to be stable. I have seen these changes of reading amount to 5 millimeters, or 1-5 of an inch in a distance of 100 meters, or 328 feet. If the atmosphere is found to be in this condition, the work should be stopped for a while, as this state of affairs is not likely to continue long."

Errors due to carelessness—and their name is legion—need not be discussed. We can make no provision for the acts of the rodman, who, being sent to hunt up a turning point, triumphantly brings it to you in his hand; or yet for the leveller, who fails persistently to distinguish between a 6 and a 9.

Looking at the unavoidable errors of levelling in a more comprehensive manner, we may regard them as composed of three classes,—compensating errors, cumulative errors, and accidental errors. The first classes should be so manipulated as to eliminate themselves during the progress of the work. The second should be removed by the same observer repeating the work under as nearly as possible the same conditions, and in an opposite direction. Levels checked only in the same direction give fallacious results. The third are the legitimate errors inseparable from all observations, and are proportional to the square root of the distance. The errors of a properly conducted system of levels are usually considered to be of this character, and their precision tested accordingly.

The limit of error allowed in the..... Ft.

U. S. Coast and Geodetic Survey is.....	0.029	$\sqrt{\text{Dist. in miles.}}$
Lake Survey.....	.041	$\sqrt{\text{Dist. in miles.}}$
Mississippi River Commission.....	.021	$\sqrt{\text{Dist. in miles.}}$

between duplicate lines.

The following interesting table of the results of levelling in Great Britain, India and Switzerland has been compiled by Mr. Wilfrid Airy, M. Inst. C.E.

Average differences in a single mile of the results obtained by two observers, on ground of different degrees of inclination.