

lever, the conditions are reversed; that is to say, tachcometer No. 115 is, as a rule, more advantageous than the ordinary instrument.

That the accuracy of distances measured with the aid of corresponding combinations of rod intervals determined with tachcometers No. 115 and No. 1, is invariably greatest in the case of the measurements made with the former may be demonstrated as follows*:

The errors we are liable to make under any circumstances are:—

1. Errors, Ec , of contact of the lever with each one of the butting pins, a , b , c and d .
2. The error, Ep , of the pointing made on the target line in the first position of the telescope, viz., say that determined by pin a .
3. The Errors, Er , in the rod readings for the other sights.

Let us consider the case of a rod observed on at a distance of 100 yards.

The error of contact may be estimated according to Porro at: $\frac{1}{200}$ part of $\frac{1}{1000}$ of a yard. The effect of this error is reduced in the ratio of the arms of the lever L , viz., as 8 to 1 on the ordinary instrument (No. 1) and as 10 to 1 in tachcometer No. 115; and it is amplified in the ratio of the space between the two points of suspension of the telescope, to the distance sought, viz., in the ratio of r to R , or of 0.1750 yard to 100 yards with tachcometer No. 1 and 0.2222 yard to 100 yards with No. 115. The mean error Ec on the rod caused by an error of contact between the lever and a butting pin is therefore in thousandths of a yard:

(a) With the ordinary tachcometer or No. 1:

$$Ec_1 = \frac{1}{200} \times \frac{1}{8} \times \frac{100}{0.1750} = \frac{100}{280} = 0.357 \text{ thousandths of a yard.}$$

(b) With tachcometer No. 115:

$$Ec_{115} = \frac{1}{200} \times \frac{1}{10} \times \frac{100}{0.2222} = \frac{100}{444.4} = 0.225 \text{ thousandths of a yard.}$$

The mean error of a pointing Ep , deduced from special experiments made by an experienced operator with a rod put up at a distance of 100 yards under ordinary conditions, appears to be about $\frac{1}{4}$ of a thousandth of a yard.

Finally, the mean error of a reading Er made under the same conditions, may be assumed at $\frac{1}{2}$ thousandth of a yard for tachcometer No. 1, and for No. 115 at say $\frac{1}{3}$ of a thousandth of a yard, when the interval which separates the cross wire from the centre of the next lower target line is estimated by the eye, and at less than $\frac{1}{4}$ thousandth when the said interval is measured with the aid of the micrometer screw, or say on an average at 0.375 of one thousandth of a yard.

That such a degree of accuracy can be attained without difficulty, appears from the following considerations.

* See "Les tachcomètres auto-réducteurs" par E. Prévot, Conducteur des Ponts et Chaussées, Paris 1895.