

Rod 13,	from May 19 to Aug. 18	0.51 mm. per metre.
14	" " 20 " 15	0.46 " " "
9	" " 24 Sept. 6	0.37 " " "
10	" " 24 " 6	0.43 " " "

"It is quite possible that errors from this source may largely exceed the errors arising from the levelling itself. Each field party should therefore be provided with the means of making a daily comparison of the rods used, with a standard of length. A steel metre and a micrometer microscope mounted on a stand would be all that would be necessary."

The maximum expansion above quoted would amount to .007 of a foot in the length of a 14 foot rod. It will be noted that the variation of temperature is not given. Experiments conducted by Prof. Van de Sande-Bakhuyzen on the staves used in the Netherlands, give results of much less magnitude than the above. He found the rate of expansion for seasoned fir rods to be 4.4 micra per metre, per degree centigrade, and that other changes amounted in all to not more than .05 mm. per metre.

For ordinary work the self-reading telescope rod is almost universally adopted, on account of its portability and convenience in use. The rods of this form, though sold as "standard" by the makers, are liable to be most inaccurate. Of the seven 14 ft. self-reading rods in use at McGill College, four are within .002 of a foot of being correct, one is .006 too short, and two are .014 too long, at 62° Fah. There are then two of these rods, and surprising as it may seem, both from the same makers—a London firm of high repute—which differ between themselves to the extent of .020 of a foot. Two 12 ft. target rods by different American makers are within .002 of the correct length. Amongst a lot of five telescope rods, recently measured in the warehouse of a dealer, one was found to be .020 too long at 14 feet and .015 too long at 17 feet. In most of the above cases the total error was roughly distributed throughout the length of the rod. In that last mentioned, and in one of the College rods, the graduation was somewhat irregular.

Where rods are properly constructed they should not be influenced to any great extent by moisture. The utmost precaution should however be exercised to keep them dry. In the Swiss levelling the errors due to temperature and moisture are stated as being "small, slow in action, and somewhat irregular." The reports published from time to time of extreme changes from moisture are no doubt due to improper protection. Where rods are used under proper direction they are of course subject to careful comparison with the national standard, and any errors in their lengths allowed for.

Errors arising from *unstable supports* may occur through the instrument or the rod, and are usually of a cumulative character. The instrument may settle slightly between the reading of the back and fore sights, or the converse may occur, depending upon the character of the ground. Similarly, the turning points may settle or spring up between sights. In soft ground, settlement is likely to occur; while in stiff clay both instrument and rod—if the latter is supported on a peg driven in the ground—may spring back slightly. Pegs are preferred as turning points for soft ground and for hard soil or roads, plates having a projecting knob or spherical hole for the rod, as already explained. The rod should never be removed from the point until all the readings have been made, and the weight of the rodman should never be allowed to rest upon it. When both instrument and rod move in the same direction the effects are additive, and the character of the soil continuing the same over a considerable stretch of country, a large error may be accumulated. To obviate such a result, Colonel Walker adopted, in India, the plan of alternating the order of observations at successive stations of the instrument, by reading the back staff first on one station and the forward staff first on the next. The error may in part at least be eliminated by levelling between bench-marks in opposite directions. Duplicate levels in opposite directions between benches or along the whole length of line should completely eliminate it. This is indeed the sovereign cure for all errors of a cumulative character,

Mr. Hirsch, one of the Directors of the Swiss precision levelling.