NATIONAL RADIO ASTRONOMY OBSERVATORY

25-Meter Millimeter Wave Telescope Memo No. 95

THE STEPPING METHOD ON THE TEST TRACK

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1. INTRODUCTION

This is the final note in the series (68, 70, 82 and 94) on tests of the stepping method for surface profile measurements. The same bar and LSOC inclinometer have now been used to demonstrate the reproducibility and accuracy of the method on the indoor test track. The results show that the method will meet the 40 micron accuracy requirement for measuring the 25-meter telescope.

2. REPRODUCIBILITY

A line of holes was drilled along the 12.5 meter track, to establish the step lengths. The hole separations were measured using the bar and its micrometer. These lengths (nominally 650 mm) were thus known to about 25 microns. Twenty steps were used, starting and ending on the granite end slabs.

Five runs were made; each took about 15 minutes. Each was reduced to give 20 (x,y) values, using the same value of θ_o and the same LSOC calibration for each run. (θ_o is the angle the LSOC reads with the bar on a true horizontal, and a good estiamte of it could be made.) Table I below summarizes the runs; the main importance is the last column, showing the estimated measurement reproducibility (RMS) at each distance. The RMS has been calculated using:

$$\mathrm{RMS} = \left\{ \frac{\sum_{1}^{5} (y_i - \bar{y})^2}{5} \right\}^{1/2}$$

Table 1. The Estimated Measurement Reproducibility of the Stepping Method

$\bar{x}$ mm	$\bar{y}$ mm *	RMS Microns
0.00	0.000	0
650.11	-1.968	2
1300.22	-1.976	3
1950.23	-2.500	6
2600.44	-2.582	6
3250.66	-2.691	7
3900.16	-3.046	9
4549.89	-2.512	11
5200.39	-2.233	14
5850.50	-2.085	17
6500.51	-2.522	22
7150.32	-3.377	22
7800.51	-3.416	23
8450.83	-2.979	23
9100.56	-2,715	26
9750.57	-1,984	28
10400.50	-1.876	30
11050.44	-2.313	31
11700.30	-2.558	33
12350.15	-1.105	38

3. ABSOLUTE ACCURACY

An attempt was made to compare the track profile derived from a single stepping run with the profile measured by a good optical level. Unfortunately, this test showed the optical level to have a focal-distance-dependant error. The track profile was thus measured by mounting a good alignment telescope at the end of the track with its axis roughly horizontal, looking along the track. Readings were taken, using the micrometer eyepiece of the telescope, of the graduations on a precise centimeter scale, which was held vertically

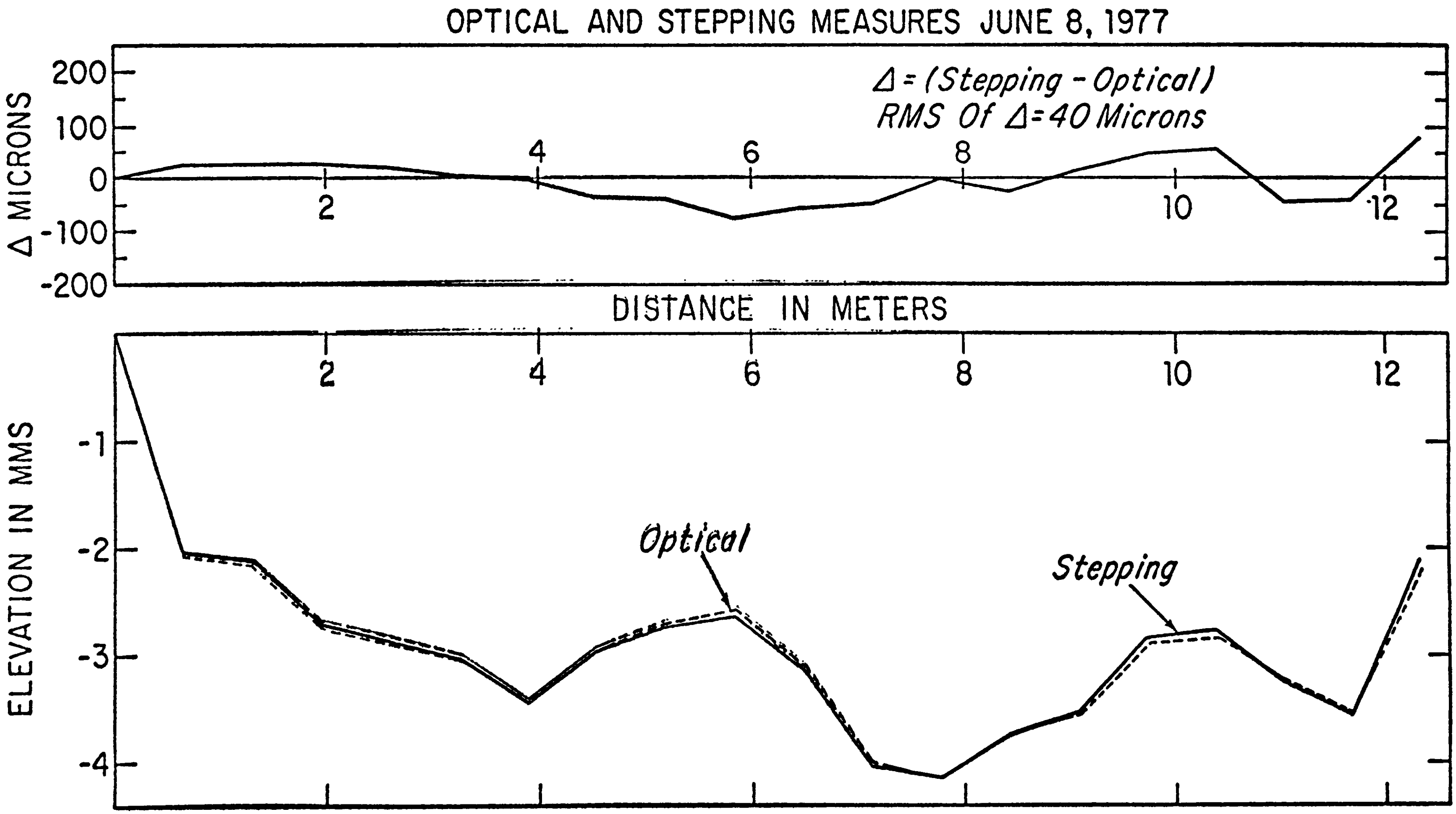
* In computing these $\bar{y}$ values, no great care to choose θ_o correctly was taken. Thus they differ from the values of Figure 1.

at each point to be measured along the track. This method became progressively less accurate at the longer ranges. Also, to derive the profile, it was necessary to know the actual telescope axis angle to the horizontal; this could only be got by best-fitting the results.

Despite these difficulties, Figure 1 shows that the two methods agree well. We are unable to make a good estimate of the accuracy of the optical method, but think it may be as poor as ± 50 microns at a range of 12.5 meters.

4. CONCLUSION

The method will be later developed into a system which will make the measurements more automatic and easier. (See Memo No. 94, paragraph 5.) We believe that it will meet our requirements for measuring the 25-meter telescope.



OPTICAL AND STEPPING MEASURES JUNE 8, 1977
Δ = (Stepping - Optical)
RMS Of Δ=40 Microns
Δ MICRONS
200
100
0
-100
-200
2
4
6
8
10
12
DISTANCE IN METERS
ELEVATION IN MMS
-1
-2
-3
-4
Optical
Stepping