Interoffice

National Radio Astronomy Observatory

Charlottesville, Virginia

January 20, 1976 memo no. 39

To: 25-Millimeter Telescope Design Group

From: W-Y Wong

Subject: A Proposed Design for Surface Plate Measurement

Enclosed is a preliminary design of a device to measure the surface of plates. The estimated cost is 9K$. The estimated schedule is six (6) months in construction - one (1) month in calibration. Time required for each measurement is about one (1) hour. The accuracy of the measurement is 20 micrometers.

This design is considered a compromise of cost and convenience. Using level and rod is a low cost but slow operation. Most sophisticated machines cost about 50K$.

This design is expandable and could be modified at a low cost into a device capable of measuring the deformable sub-reflector for the 140' telescope.

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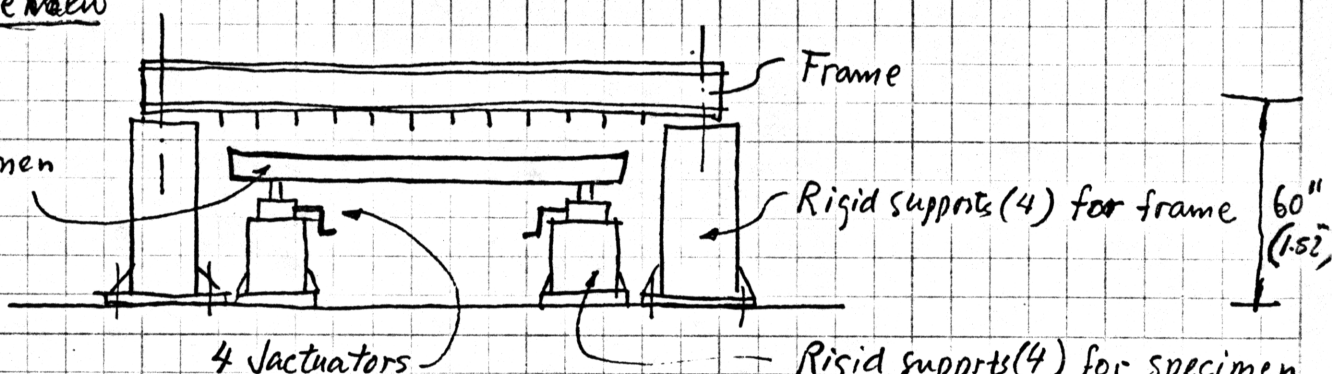
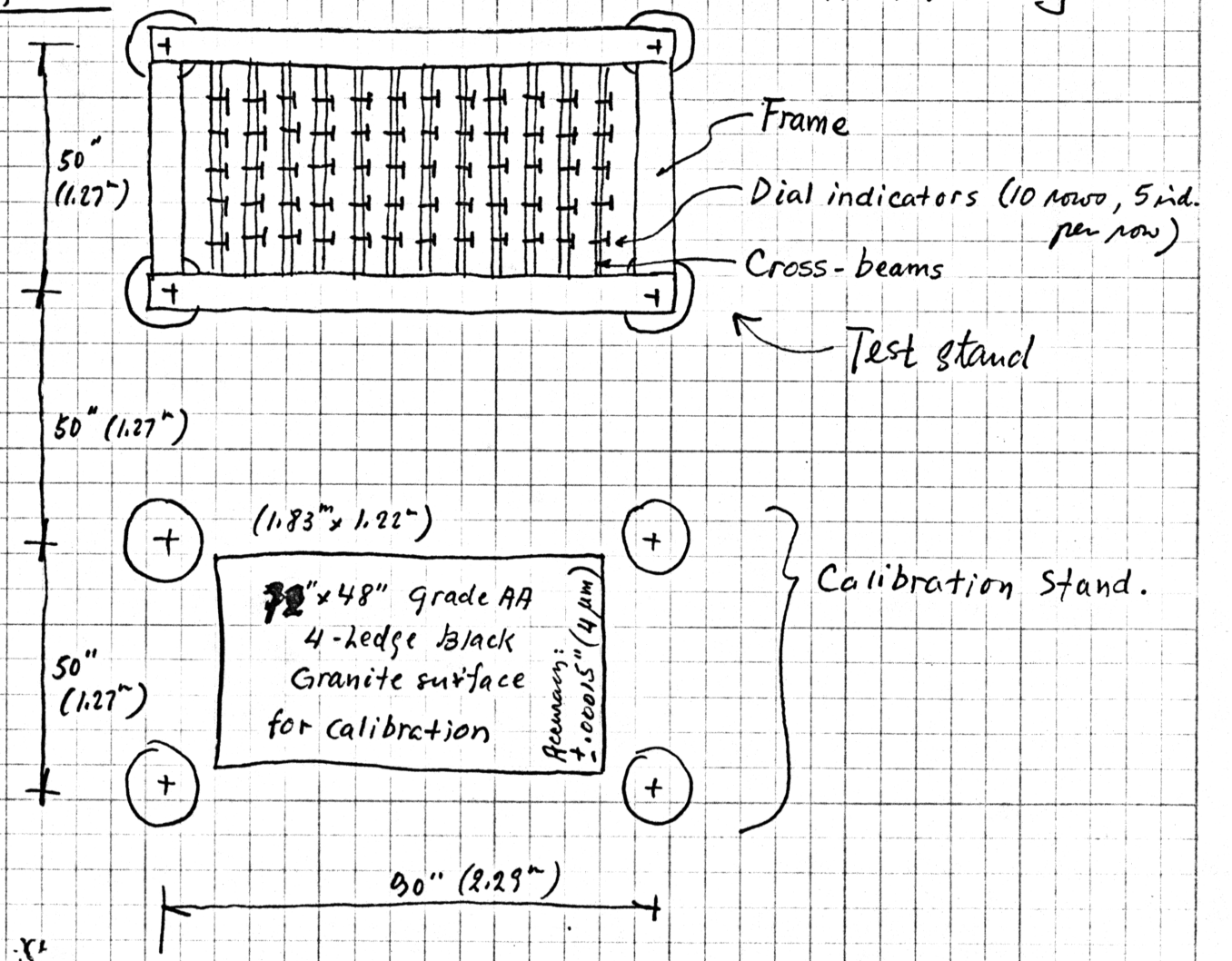
Design

Side view



Top view



machine shop has a 18x30" granite surface

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Material

Grid: Mem. #35 suggest 50 Hs.

For a 60" by 30" plate, meaning 36 sq.in/Pt, or 6"×6"/Pt.

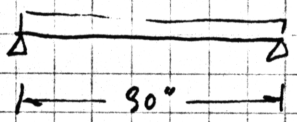
Use AGO group, .0001" graduation, jeweled and shock proof, 2 1/4" dia, ordering number: 599-8231-82H-942-HZ

Cost: ~$40 (.0005", 1" range) (13 μm)

40 $/dial × 50 dials = $2000.

Arranged in 10 rows, 5 indicator per row.

Frame:



demand: beam with double weight and deflection at center is .0001 inch.

$$\delta_{max} = \frac{5}{384}\,\frac{\omega \ell^4}{10^7 I} = .0854\,\frac{\omega}{I} \le .0001$$

$$\frac{\omega}{I} \le 1.17 \times 10^{-3}$$ un-realistic

demand $\delta_m \le .001$ in

$$\frac{\omega}{I} \le 11.7 \times 10^{-3}$$ use 12 I 10.99 6061 Al. Alloy

$$Wt = (2\times 50" + 2\times 90")/12 \times 10.99\ \#/_1 = 256.4\ \#$$

X-beam $\delta_m = \frac{5}{384} \times \frac{\omega \times 50^4}{10^7 \times I} \le .001$ in $\frac{\omega}{I} \le .123$

try 4" C 1.85 $\omega/I = .081$ OK

$$Wt = (10 \times 50" \div 12) \times 1.85\ \#/_1 = 77.1\ \#$$

Columns 8 - 12"ϕ × 60" wall thickness: .330"
8 - 12"ϕ × 40" (sch 30)

$$Wt = (8 \times 100"/12) \times 15.14\ \#/_1 = 1009.3\ \#$$

Total al. Wt = 256.4 + 77.1 + 1009.3 = 1342.8 #
use 1400 #

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Cost

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Cost: ① 72"×48 grade AA black granite surface		$1500 –
② 50 Dial indicators: Brown & Sharpe, .0005" grad. 2¼" dia:		$2000 –
③ Granite table stand		$ 200 –
④ Four Duff-Norton jactuators (M-3554)		$ 150 –
⑤ Aluminum structural shape, include O&P: $2.20/#		$ 3080 –
Total		$ 6930 –
Total +20% contingency:		$ 8316. –
Round off = $9,000		

Money saving alternative:

① No granite surface, use the old 65-m surface plate as reference.

② Structural shape can be ~~at~~ substitute by scrapes available in workshops area. The frame design is too conservative anyway!

Precision – No operation error allowed!

Demand: 20 μm (Error budget for plate manuf. 40 μm subtracting machine error 35 μm and √)

Contribution:

Calibration:	4 μm	20 μm OK
Dial indicators:	13 μm	
System*	15 μm	

* Including setting, temperature effect etc.

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Procedure

① Arrange dial indicators on the X-beams to positions but without high accuracy.

② Put the frame, which is an integral part of X-beam and the dial indicators, on the calibration stand.

③ Read off all values on the dial indicators, and 4 are chosen as controls.

④ Establish a X-Y coordinate system on the frame, measure the coordinates of all dial indicator with high precision.

To be done only once

⑤ Calculate the theoretical Z coordinate (shape of the test plate) of the specimen, based on the X-Y coordinates of the dials, ~~and the~~

⑥ Put the frame to the test stand.

⑦ Jack up the specimen until ~~all~~ the 4 control points reached the values measured from the calibration stand.

⑧ Read off all values on the dial indicators.

⑨ Compare the values of step ④ to step ⑤, and calculate the rms.

Step ① → ④ are done only once. Step ⑤ → ⑨ are steps required for each measurement.