12 METER MILLIMETER WAVE TELESCOPE

MEMO No. 86

THE REFERENCE JIG

J. W. Findlay

October 8, 1981

1. The Design

The design of the reference jig (RJ), shown in Drawing No. 87D00005, is due to J. Ralston, T. Hamed and D. Stone. The drawing shown with this memo is not quite correct. The pin coordinates have been slightly changed; they are correct in Table 3. The jig will have a steel-framed stand to allow it to stand upright and level on the floor.

2. The Use of the RJ

The RJ is to be used to check the validity of the measuring template whenever it seems necessary to do this. The template is lifted from its task of setting the surface panels and rested on the RJ (see paragraph 5 of my May 14, 1981 memo, No. 36). The template on the RJ will rest on a steel ball close to dowel pin No. 0 and on a surface--yet to be designed--to the right of dowel pin No. 12. The dowel pins 1 through 12 will contact the 12 depth sensors on the template and these sensors will be read (multiplexed) into an Apple computer. The sensor readings will be nominally* identical to those expected when the template rests on a perfect reflector radius.

3. The Template/RJ Contact Problem

The template is being designed to carry 12 Schaevitz GCD-121-500 sensors. These give an output over a ±12.7 mm range of 1 millivolt per 1.27 μm displacement. This range is far greater than we need, but we have used 9 of these sensors in the plate-measuring machine and know how good they are.

We shall mount these sensors so that each is <u>normal</u> to the telescope surface (assumed perfect) at the points given in Table 1 below. (All dimensions are in inches and millimeters--we plan to make the RJ on a machine calibrated in inches.)

* By "nominally" I mean that various small but known differences will in fact exist.

Table 1. The radial distances (R) and the vertical distances (Z) of the contact points of the 12 template sensors on the telescope (assumed perfect with f = 200.000 inches).

Sensor No.	R inches	R mm	Z inches	Z mm	RE inches
1	24.2703	616.466	0.7363	18.702	24.27
2	46.0861	1170.587	2.6549	67.434	--
3	67.7677	1721.300	5.7406	145.811	70.63
4	89.2576	2267.143	9.9587	252.951	--
5	110.5052	2806.832	15.2643	387.713	111.86
6	131.4674	3339.272	21.6046	548.757	--
7	152.1089	3863.566	28.9214	734.604	151.28
8	154.8478	3933.134	29.9723	761.296	154.78
9	175.1852	4449.704	38.3623	974.403	--
10	195.1498	4956.805	47.6043	1209.149	203.38
11	214.7295	5454.129	57.6360	1463.953	--
12	233.9181	5941.520	68.3971	1737.286	234.60

The last column of this table gives (RE), the position on the surface directly above the ESSCO adjustment screw attachment nearest to our proposed measurement point.

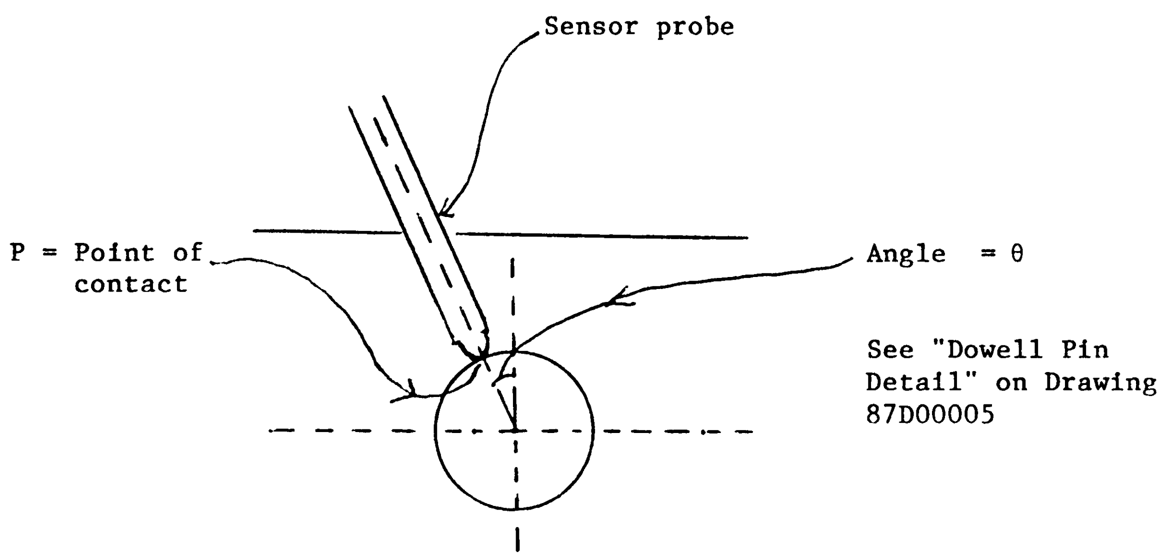
The panels edges fall at the following radial distances:

<u>Inner panels</u> - Inner edge = 23.98 inches or 609.1 mm
Outer edge = 153.10 inches or 3888.7 mm

<u>Outer panels</u> - Inner edge = 154.24 inches or 3892.3 mm
Outer edge = 236.2 inches or 5999.5 mm

I have good reason for choosing this array of sensors (see paragraph 5(c)), so note that sensors Nos. 3, 5, and 10 miss the tops of the nearest adjustment screws by more than 1 inch.

With the template in position on the jig, each sensor will contact its dowel pin as sketched below. Each sensor will contact the surface at normal incidence. We may put a small flat on the end of each sensor probe to make more definite the contact between sensor probe and dowel pin.



4. <u>The RJ Geometry</u>

Finally, I develop Tables 2 and 3 from Table 1, where Table 2 gives the coordinates of the dowel pin centers in the telescope coordinates and also the values of θ in degrees. Of course, the dowel pin centers do not lie on the exact parabola--we have arranged that the contact points P <u>are</u> on this parabola.

Table 2. The coordinates of the dowel pin centers (in the telescope coordinate system) and the angle θ in that same system.

Dowel No.	R inches	Z inches	θ degrees
0	0	0	0
1	24.2930	0.7370	3.4722
2	46.1290	2.6574	6.5724
3	67.8303	5.7458	9.6157
4	89.3393	9.9677	12.5791
5	110.6051	15.2778	15.4435
6	131.5845	21.6233	18.1941
7	152.2422	28.9459	20.8204
8	154.9832	29.9976	21.1624
9	175.3356	38.3938	23.6516
10	195.3142	47.6423	26.0066
11	214.9069	57.6806	28.2280
12	234.1074	68.4484	30.3189

In the following Table 3, we list (in inches and in millimeters) the positions of the dowell pin centers in the RJ coordinate system. We have rotated the coordinates through an angle of 17.88595 degrees to put dowels Nos. 1 and 12 at the same Y values*. We have also, in column 5, given the stepping bar lengths (see paragraph 5(c)) for the dowel pin distances we propose to measure by the stepping method.

* The proposal for an RJ is due to W-Y. Wong. Not only does it reduce the RJ in size, but it makes the measurement tasks easier.

Table 3. The coordinates of the dowel pin centers in the RJ reference system, and the stepping bar lengths.

Rotation angle = 17.88595 degrees

Dowel No.	X inches	X mm	Y inches	Y mm	Step No.	Step Length mm
0	0	0	0	0		
1	23.3453	592.971	-6.7596	-171.694		
2	44.7157	1135.779	-11.6384	-296.615	1-2	556.776
3	66.3167	1684.444	-15.3641	-390.248	2-3	556.766
4	88.0828	2237.303	-17.9523	-455.988	3-4	556.753
5	109.9517	2792.773	-19.4300	-493.522	4-5	556.737
6	131.8660	3349.396	-19.8344	-503.794	5-6	556.718
7	153.7743	3905.867	-19.2101	-487.939	6-7	556.697
8	156.7058	3980.327	-19.0511	-483.898		
9	178.6532	4537.791	-17.3114	-439.710	8-9	559.214
10	200.5067	5092.870	-14.6458	-372.003	9-10	559.192
11	222.2354	5644.779	-11.1100	-282.194	10-11	559.170
12	243.8150	6192.901	-6.7596	-171.694	11.12	559.148

5. Measuring the RJ

We discuss here briefly the methods available to us to determine the positions of the dowel pins on the RJ.

(a) The machine - We have reason to believe that the machine which bores the dowel pin holes may be in the ± 25 μm accuracy range. If so, this gives us an excellent start.

(b) J. Ralston and the NIII optical level - The dowel pin centers are being marked (see "Dowel Pin Detail"). JR will apply his best efforts using our NIII optical level and good distance micrometers to measure the RJ.

(c) Stepping bar measurements - The dowel pins and their positions have been chosen so that JWF can, with a single bar, measure all steps except 0-1 and 7-8. He will treat these separately.

For the first time we have a profile where the bar inclination passes through 0°. We can thus use a stepping bar both ways round and thus remove the (hard to find) zero point angle.

(d) The H-P interferometer - In planning the RJ we have kept in mind the value of this device, and it could well be applied. However, we shall see first how well the other methods agree. the instrument is in the $50k cost range and so we would try to rent/borrow one. I believe BNL/Isabelle has one.

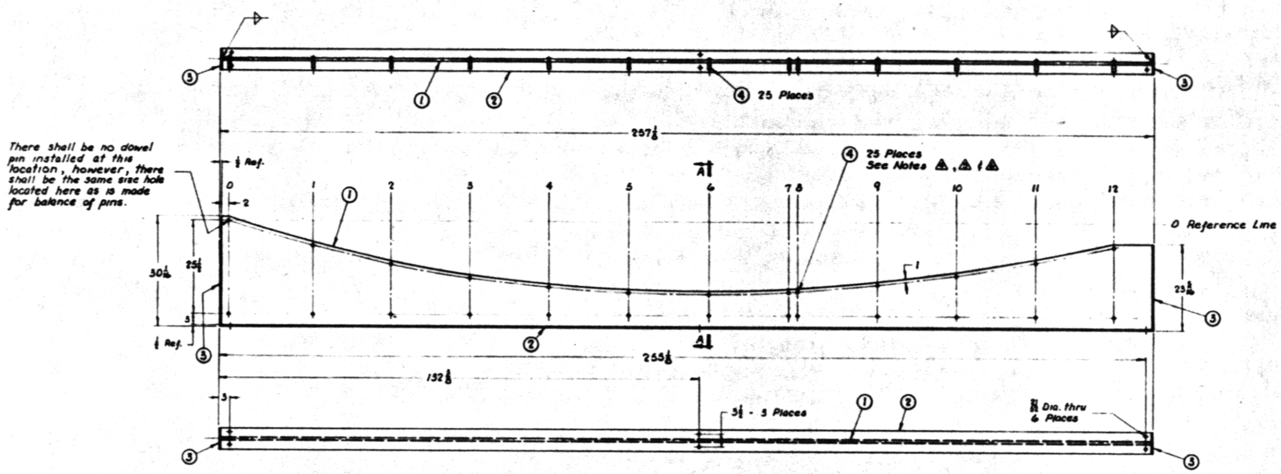
6. Accuracy, etc.

As soon as we have an RJ, we shall apply 5(a), 5(b), and 5(c) to it. This will tell us a great deal. We have issued a purchase order for the reference jig--the delivery is about December 1, 1981.

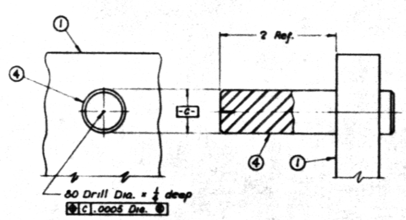
Material List			
Item	Quan	Description	Remarks
1	1	H.R. Steel ℞ - 3/4 × 29 9/16 × 256 1/8	See Assy.
2	1	" " " - 1/2 × 6 × 256 1/8	See Assy.
3	2	" " " - 1/2 × 6 × 23 5/16	See Assy.
4	26	18-8 Stainless Steel, Hardened & Ground Dowel Pin - .7502 ±.0001 Dia. × 3	See Note 3 & Dwl. Pin Detail

Ⓐ Dowel Pin Coordinates			
Pins*	x	y Parabolic Curve	y Bottom Row
0	0	*0	-25 1/2
1	23.3453	-6.7596	↑
2	44.8139	-11.6580	
3	66.5149	-15.3929	
4	88.3819	-17.9799	
5	110.3518	-19.4469	
6	132.3665	-19.8314	
7	154.3741	-19.1791	
8	156.7058	-19.0511	
9	178.6532	-17.3114	
10	200.5067	-14.6458	
11	222.2854	-11.1100	↓
12	243.8150	-6.7596	-25 1/2

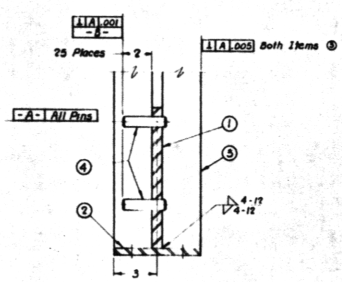
* No Pin - Hole Only



Assembly
scale : 1/4 size



Dowel Pin Detail
scale : Full



Section A-A
scale : 1/4 size

Notes

1. (Note 1) The Material List above represents the total amount of material required to fabricate one Reference Jig Assy.
2. (Note 2) All machining operations shall be done after all welding has been completed.
3. (Note 3) 25 Dowel Pins shall be installed as shown on assembly. Dowel Pin #26 to be furnished but not installed.
4. (Note 4) All Dowel Pins (Item ④) shall be located within .001 of the coordinate dimension shown in the table above from the 0 point.
5. (Note 5) All Dowel Pins (Item ④) shall be a medium drive fit into Item ① plate.
6. (Note 6) All Dowel Pins (Item ④) shall be parallel with each other within .0002 and the bottom row of Dowel Pins shall be parallel with the 0 reference line within .001.
7. (Note 7) Surface [-B-] of all Dowel Pins shall lie in a plane within .005.
8. (Note 8) Break and grind smooth all sharp corners of Items ①, ② & ③.
9. (Note 9) All parts except Dowel Pins (Item ④) to be shop primed with Sherwin-Williams E41-N1 - one coat. Shop finish primed parts with one coat White Enamel - Sherwin-Williams Metallastic B53W7 or Wisconsin Protective Coating Co. Plasite #2050 or equivalent.

No.	Date	By
Ⓐ	9-10-81	D.G.S.

REVISIONS

Unless Otherwise Specified Tolerances

- x/x = ± 1/32
- 0.00 = ± 1/64
- 0.000 = ± .005
- 0.0000 = ± .0005

All dimensions are inches

NATIONAL RADIO ASTRONOMY OBSERVATORY
ASSOCIATED UNIVERSITIES INC.
GREEN BANK, W. VA.

TITLE: REFERENCE JIG
12 METER ANTENNA - KITT PEAK

	Name	Date		Signature	Date
DESIGN	J.N.R.	8-17-81	RECOMMENDED BY	J.W. FINDLAY	8-10-81
DRAWN	D.G.S.	8-31-81	ENGINEER		
CHK'D			APPROVED		

SCALE AS NOTED | NO. 87D00005 | REVISION