12 METER MILLIMETER WAVE TELESCOPE
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SETTING THE SURFACE OF THE 12 METER TELESCOPE

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1. Introduction

This note is intended to outline the method which is presently preferred for measuring and setting the surface plates. I shall describe the operation as I see it at Green Bank, but the modifications needed for the final setting on Kitt Peak are not large. There are two parts to the setting program: establishing and maintaining a precise reference system and then setting the shape of the reflector surface. I do not separate the tasks of measuring and setting, but regard them as a single operation.

2. The Reference Plane and Reference Axes

See Figure 1. We are very experienced in using the Wild N-III level and know it can be used under good conditions to give readings at 6 meters range

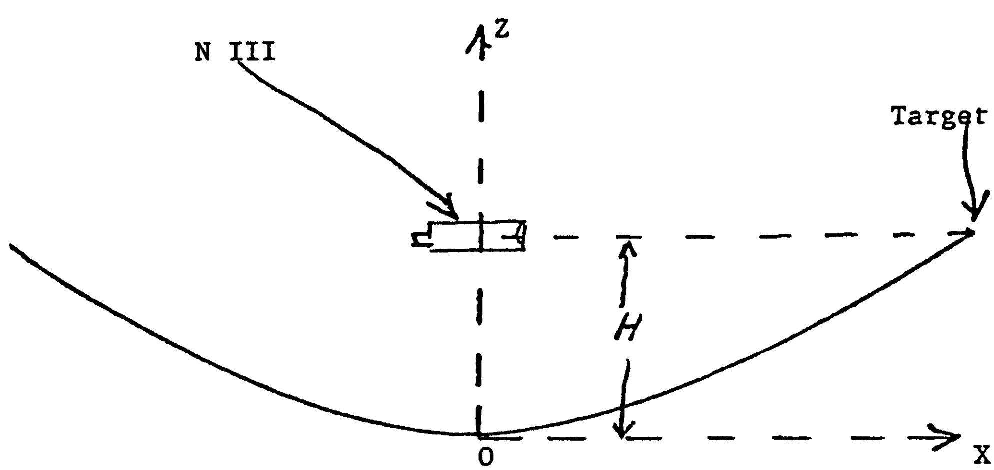

Figure 1

accurate to 20 microns. So we choose as the origin of our reference system the point O. This should be well defined--a large steel ball is my present choice--and positioned at the nominal center of the dish structure close to the surface vertex. The point O has two uses. The N-III is to be mounted a known and measurable height H vertically above O. The measuring template uses O to support its inner end as it is rotated. We return to this later.

The height H is so chosen that the N-III can observe a ring of edge targets; these are to be adjusted to lie in a plane and are to be equidistant from O. I want them to be supported by the back-up structure (BUS), but they must be visible also when the surface is installed.

The reference system is then given by OX, OY, and OZ where OX and OY lie in the plane parallel to the target ring plane and OZ is perpendicular to that plane. H has to be measured; so also does the radial distance to the edge targets.

The edge targets are to be set and then regularly monitored by the N-III. The edge targets are used as follows:

(a) We intend to monitor the BUS as soon as it is built to check its behavior under various temperature regimes. We may, if it is desired, test the edge deflexions by loading the BUS--thus confirming the computations and ensuring that the BUS is well-built and without hysteresis.

(b) The outer edge of our measuring template is carried on the edge targets. Thus the template is supported at both ends at known points. (We leave for the present a discussion of the deflexion of the BUS by the template loading and the detailed design of an edge target to serve both as an N-III target and a precise template support.)

3. The Setting Template

This is shown in Figure 2 in a very preliminary design due to W-Y. Wong. In principle it is a stiff plate carrying 12 Schaevitz depth sensors. We already have and can use 9 of these from our plate measuring machine; they cost about $600 each. We have a 16-channel multiplexer, and we shall read all 12 sensors with it into the HP 9825A.

We imagine the template to be supported in a vertical plane, with its ends resting as already described. We would display from the 9825A the departure in microns of each of the 12 sensors from their desired position. We would adjust each radius with this display continually available. We will check adjacent radii also, so that if we find non-independence (or "cross-talk") between adjustment screws we can overcome it by trial and success methods.

My present plan is to place this template along each line of adjusting screws (see Fig. 3). There are 48 outer panels, thus 96 template positions.

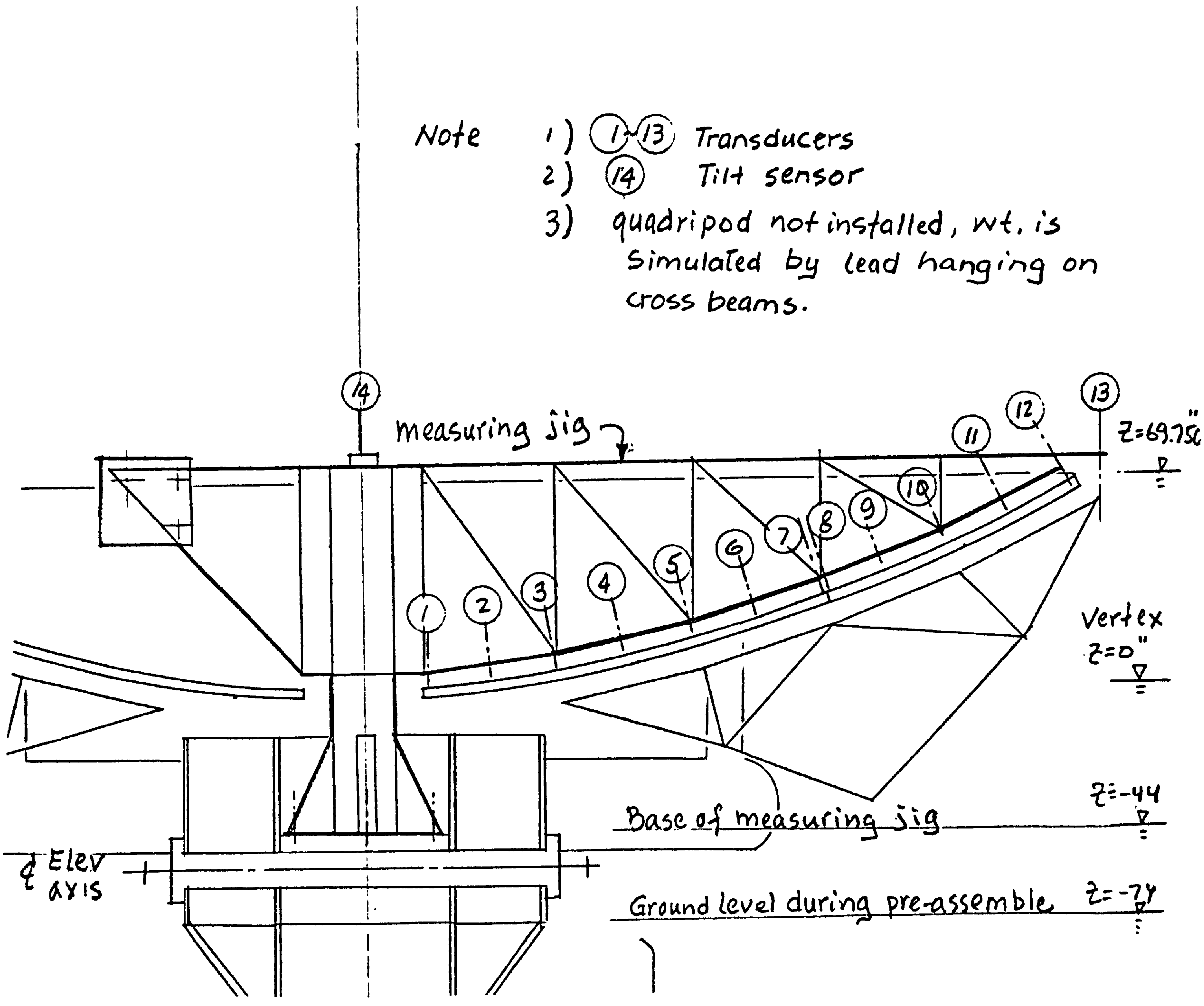
Note 1) 1~13 Transducers
2) 14 Tilt sensor
3) quadripod not installed, wt. is simulated by lead hanging on cross beams.
14
13
12
11
10
9
8
7
6
5
4
3
2
1
measuring jig
Z=69.75"
Vertex
Z=0"
Z=-44
Base of measuring jig
Ground level during pre-assemble
Z=-74
℄ Elev axis

Figure 2

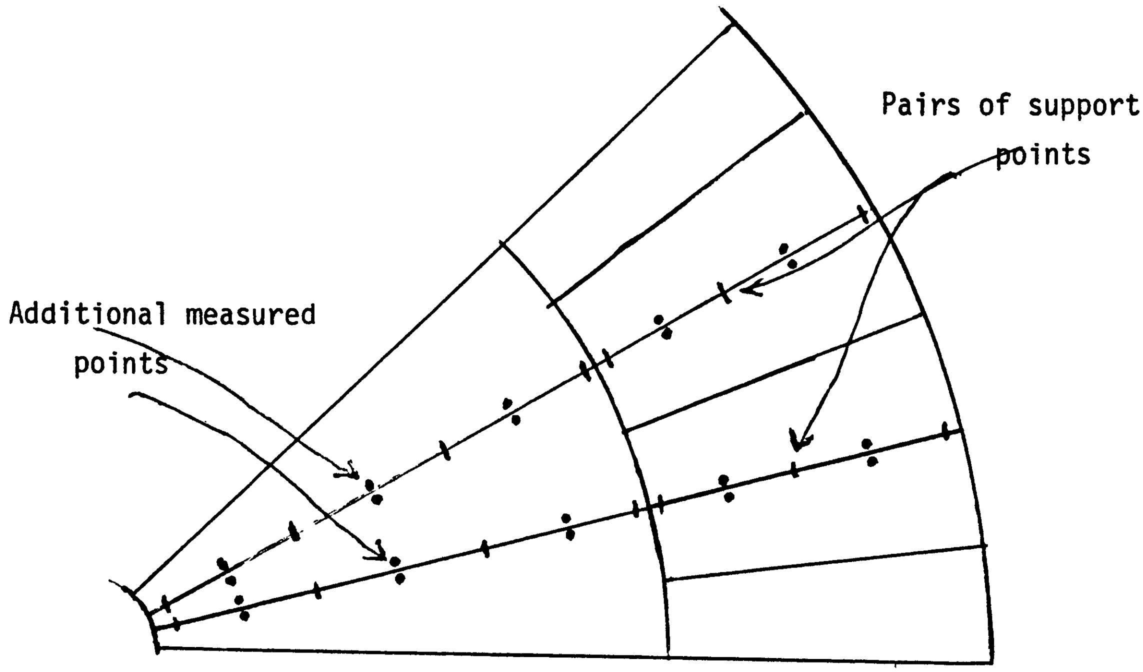

Figure 3

But I would like perhaps to measure the outer panel center lines also--giving 48 more radii, for a total of (144x12) = 1728 measured points.

I can only guess how much time is needed--but I believe we should allow a few hours to set each radius of adjusting screws. So for 96 lines of screws at 3 hours per line we get 36 working days. So our PERT in Green Bank should give me more like 8 weeks instead of 4.

I would plan after setting to mark (and epoxy) all panel attachment screws, so that in the final assembly we could expect to be nearly OK. Thus for the present the PERT at KPNO could stay at 4 weeks.

All measurements must be read from the 9825A to the IBM 360 so that Lee King's program can be run. I have spoken to Richard Lacasse about this.

Before we discuss the difficult subject of how to make and measure the template, let us list some of the ways this plan impacts the BUS design.

4. Impact on the BUS Design

(a) The point O and the edge targets have been discussed. But how to arrange for O to support the template and to have the N-III also available is not yet known.

(b) We need access to the N-III and a platform supported from the ground for the N-III observer. Can we mount O and get to the N-III from below?

(c) We shall step the template around by working from some simple moving platform running on the floor around the edge of the dish. (At KPNO we rotate the dish.)

(d) Have we good access to the panel adjusting screws? We need a design of a screw adjustment.

(e) I propose not to mount the feed legs on the BUS at Green Bank. But how do we get the template past the legs at KPNO? I think I want to be able to lift it off O and the edge target to allow it to pass a leg by swinging it horizontally toward the dish center.

5. Measuring the Template

It is clear to me that if we have a good template our setting task is going to be much easier. And when we have measured the template it will automatically make our distance measurements (O to the edge target, for example) for us. But of course we have only transferred our measuring task from the dish to the template. I have considered several ways of measuring the template, and have concluded that we should transfer the measuring task even one step further. Thus my plan now is:

(a) Build what I call a reference jig (RJ). This is a simple, sturdy steel structure which carries precision steel balls at very closely the same positions and heights as the distance sensors on the template (see Fig. 2). We then make careful measurements to determine the (X,Z) values for these steel balls.

(b) Having measured the 12 balls on the RJ, we place the template on the RJ and read its 12 sensors. This calibrates the template.

(c) Then the template is used to set our surface. At regular intervals it is replaced on the RJ to check that all is well. We would, perhaps, from time to time also re-measure the RJ as a check.

(d) The RJ and template would be used at Green Bank and at KPNO; both would remain at KPNO for later surface checks.

(e) This method has several advantages over other possibilities. I note particularly:

(i) The RJ is likely to be a very stable structure.
(ii) It will be cheap to build.
(iii) It can be designed and built so that it can be easily, accurately and quickly measured by our standard methods.

(iv) The template is used only as a transfer tool. Although the depth sensors ae quite stable, this does mean that we can be less concerned about possible sensor drifts and perhaps also less affected by thermal distortions of the template.

6. Measuring the RJ

I propose two methods:

(a) Use the N-III and precise distance rods in a conventional way. We do this for surface shape measurements. J. Ralston is working out a plan.

(b) Use the stepping method. We have chosen steel balls as targets to be convenient and accurate for stepping. We might expect a random error of about 3 microns a step, so in 11 steps we could be within 10-15 microns. But we can test these estimates as soon as an RJ is built.

7. Conclusions

I propose to leave this topic for 3 weeks or so for any comments that come in. Then, if we are clearly going to use ESSCO, I shall get an RJ designed and built. (Perhaps 500 pounds of steel and 12 tooling balls). Then I shall measure it and test my measurement accuracy.