25 METER - MILLIMETER WAVE TELESCOPE

MEMO # 32

Specification for Prototype Surface Panel for 25 m Diameter mm Wave Radio Telescope

September 15, 1975

I. General

The National Radio Astronomy Observatory (NRAO), is planning to design and build a 25 m diameter radio telescope for wavelengths as short as 1 mm. One critical element of such a telescope is the reflecting surface, which has to be manufactured to have and maintain a very high accuracy. It is desirable that the total telescope surface deviation from the theoretical parabolic shape be less than 75 μm rms. Many factors contribute to this error, one of them being the errors of a single surface plate of which there are 528 on the telescope. This requires that a single panel shall have manufacturing errors of less than 40 μm rms in order to achieve the 75 μm rms for the total telescope error and result in the required telescope performance. It is expected that this tolerance, along with other tolerances outlined in the specifications to follow, is close to the limit of what can be achieved with today's technology. NRAO wishes to enter into a contract with a suitable manufacturer for the purpose of developing, manufacturing, testing and reporting on one typical plate.

The proposed telescope will use a 25 m diameter paraboloid "dish." The dish will be supported by a special "homology" back-up structure which will adjust and retain a parabolic shape in all attitudes of the dish. The "dish" will be maneuverable for pointing toward any point in the sky above the horizon with a pointing accuracy of 1.2 arc seconds.

II. Scope of Work

Furnish design services, materials, equipment, labor, supervision, testing services and testing equipment to manufacture and test one prototype surface panel, with a detail report of the complete procedure, for a proposed mm wave receiving antenna.

III. Panel Parameters

The prototype panel shall be a typical ring 4 panel shown in the attached schedule having the dimension shown and meeting the following specifications when delivered.

1. Will properly fit into a paraboloid with 10.5 m focal length, 25 m diameter and the surface contour of the equation $x^2 + y^2 = 10500\ z$ mm (f/D = 0.42) when mounted at the four corners.
2. The statistical deviation of the final machined reflector surface from the theoretical paraboloid surface going through the reference points at the four corners of the panel should be less than 40 μm rms. The maximum allowable error of any point on the surface shall be less than 120 μm.
3. The analytical gravitational deflection, when the plate is horizontally supported at four corners shall be less than 25 μm rms from the final manufactured surface.
4. Have a maximum analytical deformation due to 30 km/hr. wind of 20 μm from the final manufactured surface.
5. Have a maximum thermal deformation of 25 μm, with a ΔT of 1°C between front and rear surface of panel.
6. Have machined edges with maximum dimensional error at any point of $\pm$ 0.2 mm.
7. Survive a wind load of 150 km/hr. without permanent deformation.
8. Survive a distributed load of 100 kg/m^2 or 115 kg over a 15 cm or a heavy man standing on the panel without permanent deformation.

9. Shall not have machining cusps of heights exceeding 15 μm.
10. Have a maximum weight of 20 kg/m^2 (4 lbs/ft^2).
11. Be equipped with a mounting receptacle in each corner machined to within 25 μm of the mounting plane and equipped with required receptacles to receive an adjustable mounting bracket as shown on attached sketches 1 thru 6.
12. The panel shall be solid surface having a nominal thickness of 3.2 mm in areas between reinforcing ribs (thinnest areas of the panel).

IV. Manufacturing

The panels shall be cast-machined aluminum using A 356 aluminum or better, stress relieved and aged to T51 conditions. Reflective surfaces shall be machined to grade C or better, while other machined surfaces on the panel shall be machined to grade D or better.

Casting shall generally follow the requirements of MIL-C-6021G specifications using wood patterns. Finished casting shall be carefully inspected for defects and dimensional errors before heat treating and aging. Heat treating shall continue for a minimum of 7 to 9 hours. Radio-graph the finished casting before machining.

The panel shall be machined with a numerically controlled machine equipped with separate read out instrumentation for checking the input instructions and machine operation. A special designed mounting fixture shall be used to support the panel, from the mounting pads on the panel, while machining. The cutting tool shall have a spherical cutting edge which has the capability of generating a curved surface in three dimensions. Extreme care shall be taken to control temperature and pressure while machining so as not to introduce distortion. The panel shall be allowed

to stand in a normal relaxed position for sufficient time between each machining to allow stabilization. Sanding of surface may be required to reduce heights of ridges developed in machining. The panel shall be stabilized and/or stress relieved by heat treatment after final machining and before testing.

The above specifications for manufacturing are to be considered as a general guide. The manufacturer shall develop detail procedures and submit them for review. The intent is to introduce areas where special attention should be exercised to be sure the final product, the prototype panel, will meet the accuracy and durability specified in section III above. Other approaches to the construction will be considered if proposed by the manufacturer.

V. Testing

A detail testing procedure shall be developed and carried out to prove the prototype panel meets the specifications set forth in section III and it has the durability to withstand expected environmental conditions. The tests shall include but not be limited to the following:

1. After the finished panel is stabilized or stress relieved the following steps 2 thru 7 shall be made in a controlled environment.
2. Make detail accurate measurements to prove the exact shape and size of the panel and tabulate them along side the specified or theoretical dimensions. This shall include weight.
3. Place panel in a properly designed fixture and measure the curvature and calculate the rms error from the theoretical. The panel shall be supported from the corner support points with a simple support simulating field support system and shall be in

the horizontal position. Error measurements and error calculations shall reference from a plane through the four points on the reflecting surface near the support points shown on sketches. Measurements shall be made on 25 mm centers, maximum, grid system, over the entire surface with electric transducers with an accuracy, linearity and repeatability required to prove the accuracy of the surface. First and last reading in all rows shall be at the edge of the panel.

4. Rotate the panel in its fixture 90° around its long axis and repeat step 3 under Testing.
5. Rotate the panel in its fixture another 90° around its long axis and repeat step 3 under Testing. In both steps 4 and 5 the measuring equipment shall be instrumented so as to correct for any movement or deflection of the measurement system.
6. Support the panel from its four support points, in a position approximating the position the panel would take if the telescope were in the zenith position, and load with a distributed load of 100 kg/m^2 and allow to remain in a normal outside environment for a period of 48 to 72 hours minimum. After removing the distributed weight, apply a load of 115 kg on a 15 cm square for a period of 30 minutes and remove. Repeat step 3 under Testing after the temperature of the panel has stabilized to the controlled temperature in the measuring area.
7. Repeat step 3 under Testing with an equally distributed load suspended under the panel. The load shall be the equivalent to the force on the surface of the panel with the wind blowing 30 km/hr. directly toward and perpendicular to the surface.

From these figures calculate the stress and deflection of the panel if it were to experience a similar wind at 150 km/hr.

8. Develop a heat differential, by using heat lamps or the sun on top of the reflector surface and cooled air on the bottom of the reflector surface of the prototype panel, and repeat step 3 under Testing. This should be done for a minimum of three stabilized temperature differences. Calculate the thermal deformation.

9. Place the panel alternately in an environment of 50°C and -30°C for a period of not less than 6 hours in each environment and repeat through a minimum of six complete cycles. Repeat step 3 under Testing.

10. Repeat steps 2 and 3 under Testing for at least three different ambient temperatures approximating the normal temperature range expected during operation (25°C to -20°C). Calculate physical changes per degree temperature change for width, length and depth at critical points.

11. Make such other tests as might be necessary to verify the data and resulting calculations in each of the above steps or to clarify questions raised by the tests above. If any of the above tests indicate the panel does not meet specifications, testing shall be stopped and corrective steps taken before proceeding.

VI. Report

A detail report shall be prepared to provide a complete history of the design, manufacturing and testing of the panel including a summary and conclusions. The report shall include, but not be limited to the following:

1. Complete design calculations, stress and deflection analysis.
2. All engineering drawings, sketches and specifications including patterns and shop drawings used in manufacturing and testing.
3. Detail description of manufacturing procedure and instructions including a description of machines used, including radiographs and subcontractor's instructions and drawings.
4. Complete description of testing procedures including copy of all test data, calculations and conclusions including a description of test equipment.
5. A brief summary and conclusions.
6. A copy of all computer programs, data and results used in the design, manufacturing and testing.
7. A cost estimate for manufacturing, testing and delivering 528 similar panels, in 1976 dollars, including an estimate of the time required (delivery time). The test procedure would be a modified version of the procedure called for above to establish quality control.
8. A copy of all purchase orders and sub-contracts' supporting costs and showing source of materials, tools, etc. for the prototype panel.

VII. Available Study

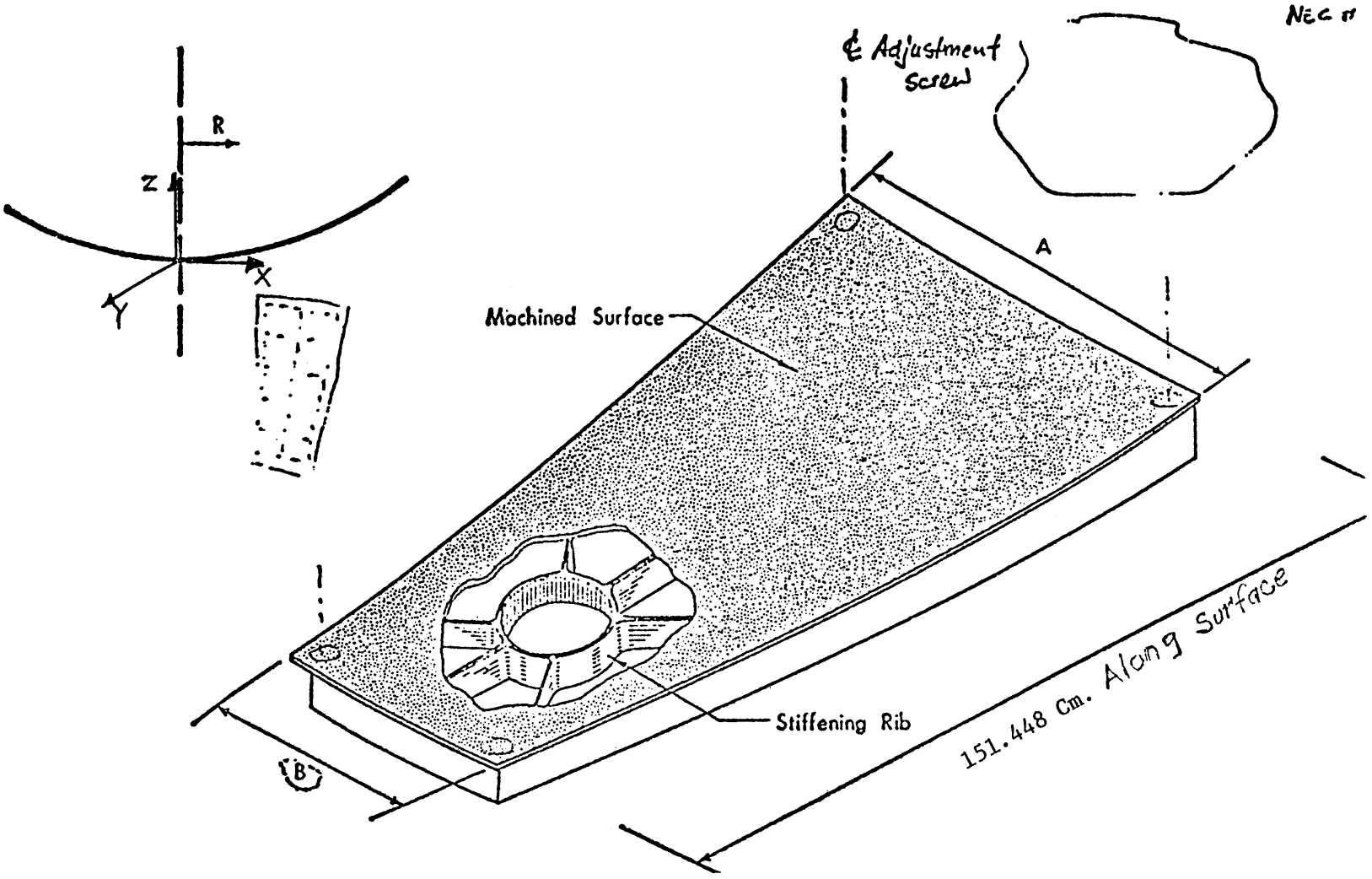
Associated Universities, Inc. has in hand a design, test and manufacturing study and report of a similar panel, of a larger size, for a larger telescope. The panel approaches but does not reach the specifications outlined for the panel called for under this RFP. The report and a typical panel described by the report will be made available to

the successful contractor for reference and possibly as a point of departure in their design, if they so desire.

VIII. Progress Reports

During design, manufacturing, and testing, regular letter progress reports shall be issued. Representatives of Associated Universities, Inc., will make frequent visits to the manufacturer's facilities for verbal reports and discussion, to observe tests, manufacturing procedures and results and to generally provide input as to what is required.

Fig. 11, Sec II



Sizes and Configurations of Surface Plates

Ring No.	R	A	B	No. Plates
1	107.429	67.605	29.472	24
2	258.227	106.771	67.605	24
3	555.513	72.718	53.386	48
→ 4	700.712	91.722	72.718	48
5	843.008	55.174	45.862	96
6	982.099	64.277	55.174	96
7	1117.793	73.160	64.277	96
8	1249.995	81.811	73.160	96
				528

R, A, and B are dimensions in centimeters.

SKETCH #1

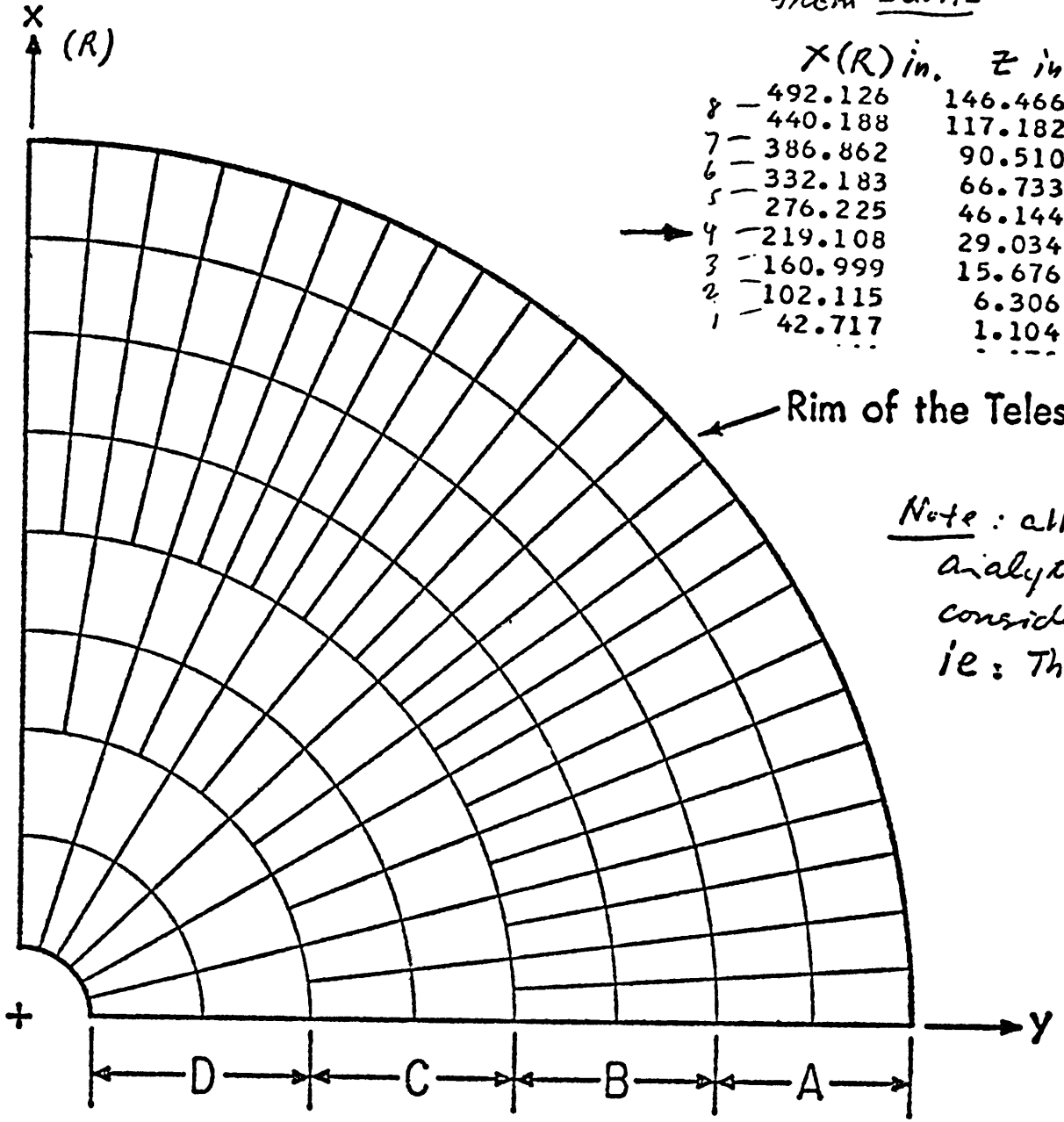
8/23/75

in D_1	D_2	No. of Pl.	Ring No.
32.210	18.810	96	8
28.810	25.320	96	7
25.320	21.741	96	6
21.741	18.075	96	5
36.158	28.681	48	4
28.681	21.075	48	3
42.143	26.734	24	2
26.734	11.183	24	

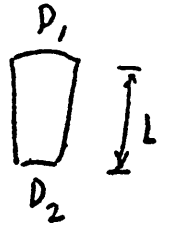
Σ : 528 plates

From EQUAL L

	X(R) in.	Z in.	(5/19/75) in
8	492.126	146.466	~~0.400~~
7	440.188	117.182	59.625
6	386.862	90.510	59.625
5	332.183	66.733	59.625
→ 4	276.225	46.144	59.625
3	219.108	29.034	59.625
2	160.999	15.676	59.625
1	102.115	6.306	59.625
	42.717	1.104	59.625



Note : all dimensions ar
analytical work out
consider. clearance
ie : They are coord. of w



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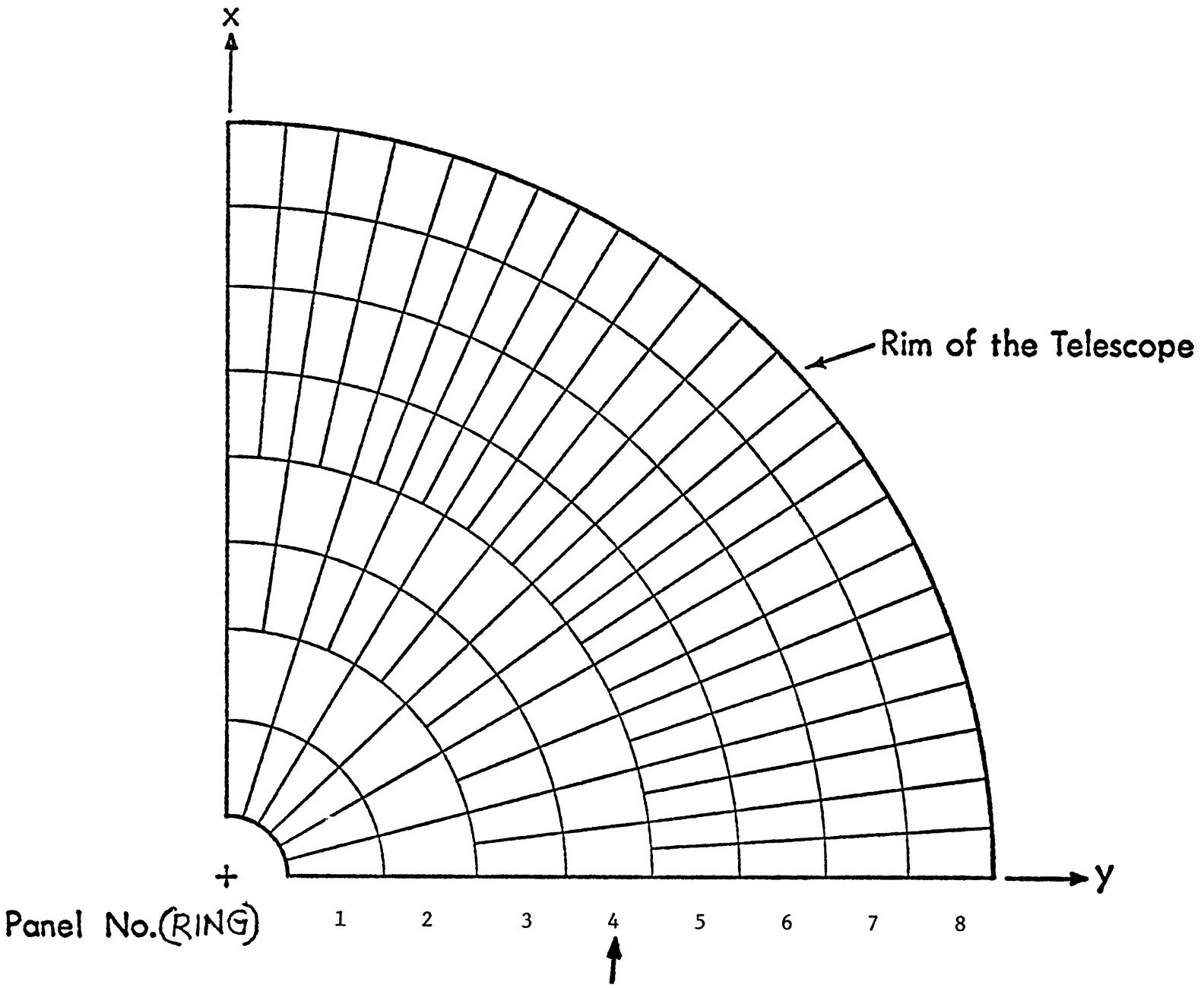
III.11 Surface plates arrangement on one quarter of the aperture.

SKETCH #2

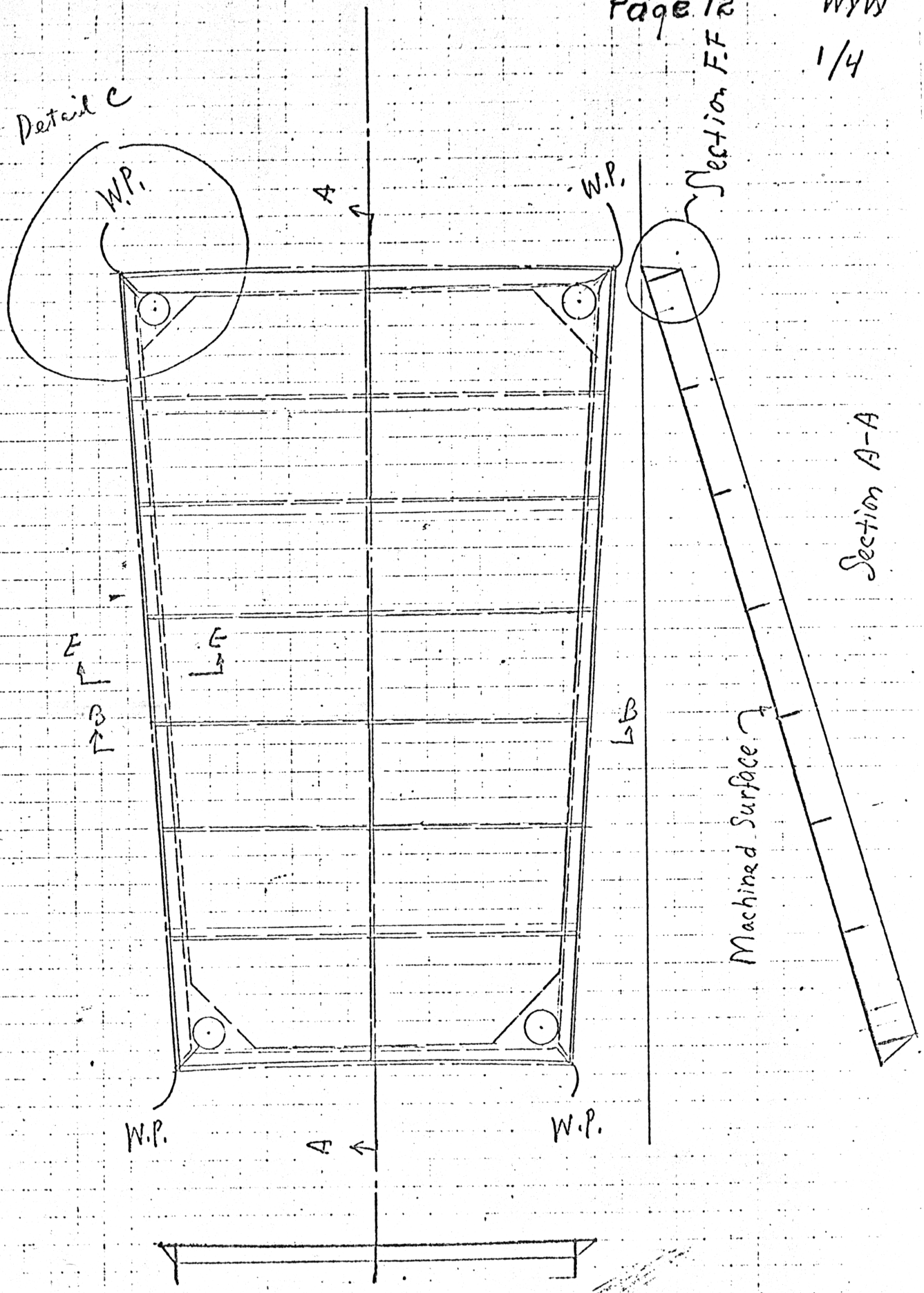


III.11 Surface plates arrangement on one quarter of the aperture.

SKETCH #3

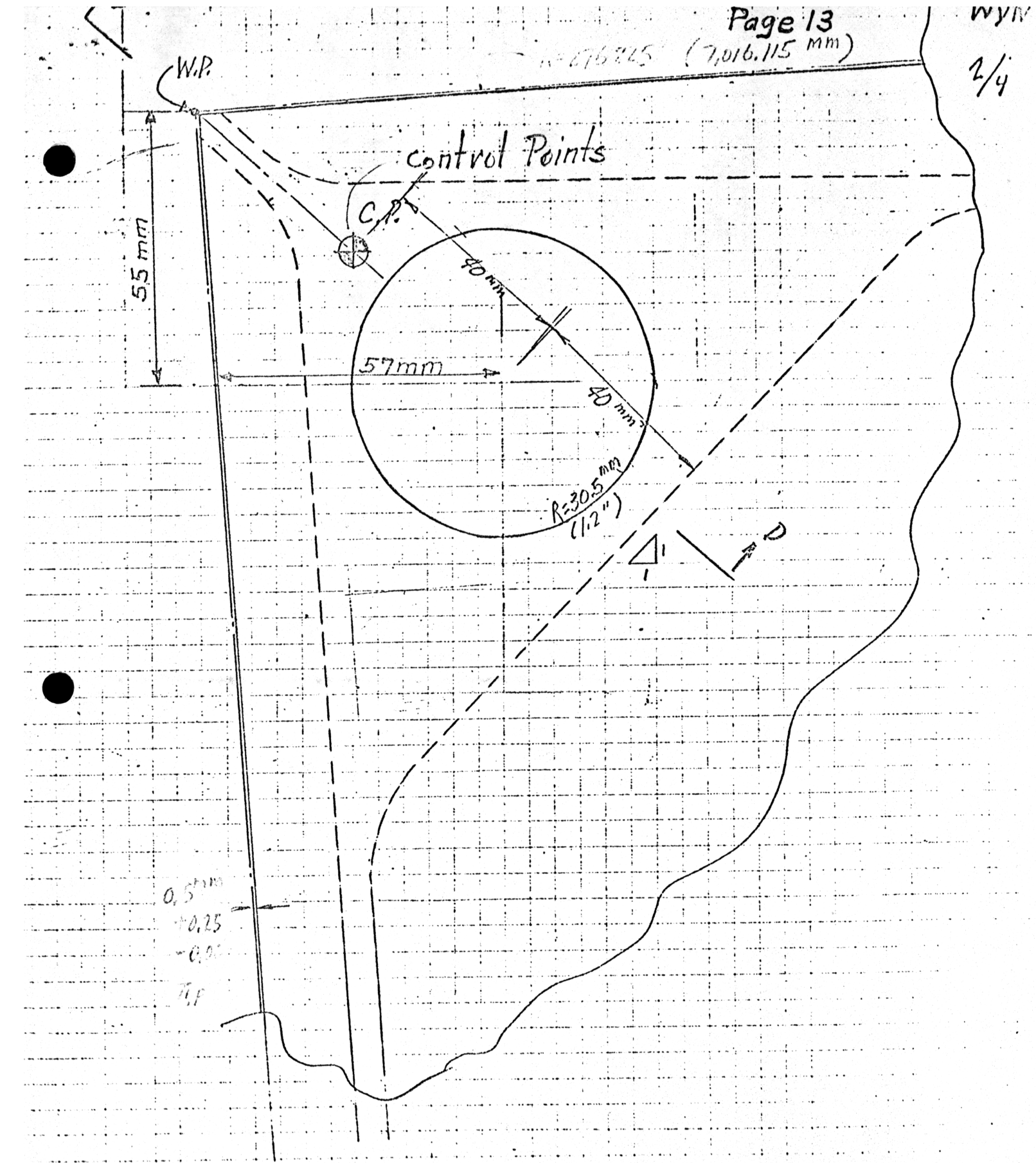
WYW

1/4



SKETCH # 4

1/10 in = 1 in.



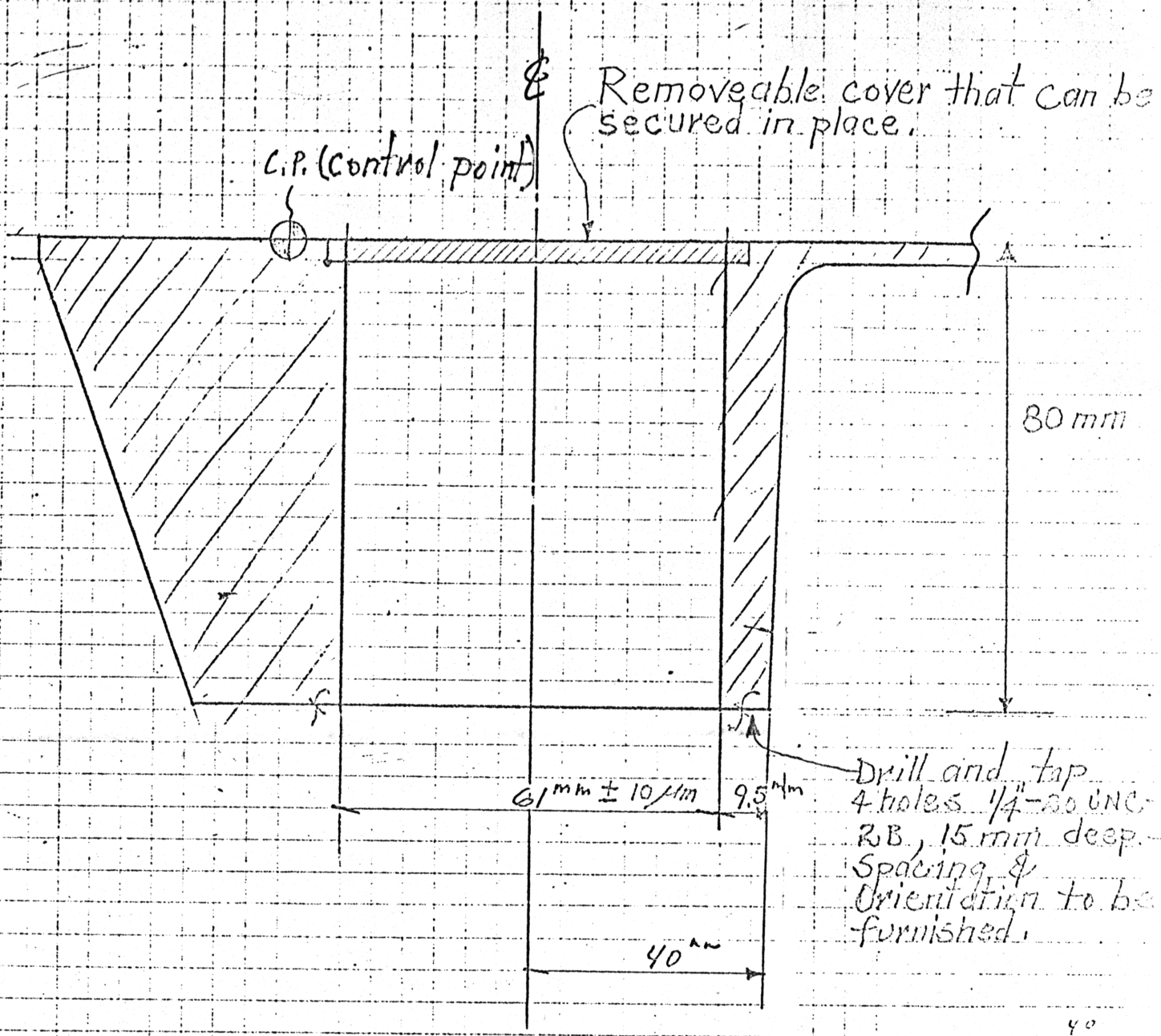
Detail C

SKETCH # 5

True Scale

WYW

3/4



Section D-D

Scale 1/1

Note: The alignments of ℄ for the 61 mm ℄ holes are 90° (±18 arc-sec.) to the plane defined by the C.P. (control point) at 4 corners.

SKETCH #6