NATIONAL RADIO ASTRONOMY OBSERVATORY

March 14, 1978

ENGINEERING MEMO #121

Measuring 140' Telescope Surface by Stepping-Bar-Method

By J. N. Ralston

General Procedure

The following procedure will describe how we will attempt to measure the 140' telescope surface panels by employing the stepping bar method.

The stepping bar method has been proven by Dr. John Findlay during the 1977 year through many tests and has been tried on the 140' telescope (limited bases) with good results. (See 25-meter Millimeter Wave Telescope Memo No. 94 and 95.)

We will now extend our efforts and measure more than one radii since further design efforts have allowed us to accurately define the start points through the 64 inch stepping bar.

Further study and design effort has led us to the "washer-method" which is a very simple nylon washer glued to the surface panels with an inside diameter to allow the stepping-bar precision steel ball to seat in the same manner as the holes in the surface panels did during the test period. The "Washer-method" advantage is that we do no physical damage to the surface. The washer can be removed with little effort if short wavelength observing is required.

The installation period is very lengthy for forty-eight radii, so shut-down periods will be required but of no known magnitude.

To define the stepping-bar angle constant (tilt or change in tilt of antenna during measurements), we will follow the Dr. Findlay idea of establishing the end points of the 48 radii. This will require some scheduled time for Engineering (possibly two good maintenance days in stow position) to make this measurement as defined by pencil scribing the 48 radii end points and instrumentation atop the Cassegrain House.

Assuming that all hardware has been fabricated, we will need additional telescope time to install the vertex as described in the Outline. The vertex structure will have to be removable, therefore it will be indexed (with dowels) so we can replace it when required. Removal is required because access to Cassegrain House is in same area. Instrument work required to install and align the vertex is the Hilger-Watts theodolite mounted at the center line of the declination shaft directly under the Cassegrain Horn.

After the vertex has been established, we can employ the new 64-inch (nominal) stepping bar with optical inclinometer and linear micrometer to establish the start point. All 48 start points will be established and measured. This data will also be used to help define the angle constant of the antenna.

For test of reproducibility we will only measure four radii at 90^{o} apart. The thirty-two nylon washers will be installed on each of the four test radii only as described in the Outline.

From the test of the four radii, all facets of the method of measuring the 140' telescope will be analyzed, documented, changes made and studied very carefully before continuing. Even then more tests might be required before we attempt to measure the entire 48 radii.

In-House Effort

The following information roughly describes the effort each department is responsible for and correlates the different jobs with each other.

Engineering Effort:

(A) Design support for physically locating the vertex.

(1) Consist of aluminum frame (4 legs) that bolt to the existing Cassegrain House supports. (Will be removable.)

(2) Consist of a plate atop aluminum frame that can be adjusted vertically and horizontally to precisely locate vertex.

(B) Design wooden platform for access to vertex (or use step ladder).

(1) Consist of wooden platform or step ladder fixed independently of the aluminum frame of Cassegrain House supports. (Will be removable.)

(C) Design new stepping bar to locate start points.

(1) Bar will be 64 inch long (nominal) so will span from vertex to start point on inner panel. Exact distance for "x" is 62.038 inches.

(2) Fabricate from aluminum "TEE" section so bar will be strong in vertical plane and also with flat machined area on top of bar to hold "Optical Inclinometer."

(3) The vertex end of the bar will have a (spherical bearing with Teflon lining)/shaft connection so that it will pivot vertically and horizontally. The start point end will consist of a micrometer mounted vertically so that vertical adjustment can be made.

(D) Design the nylon washer with appropriate glue or epoxy (Eastman 910) for adhering to panels.

(E) Install length sensor and module on 650 mm stepping bar to accurately measure each step when making survey.

(F) Correlate the job with other departments.

(G) Check-out theodolite (Hilger-Watts) for zero-gravity using surface plate and Hilger-Watts level.

Electronics Effort:

(A) Interface the Length Sensor & Module. (See J. Findlay for details.)

Telescope Operations Effort:

(A) Schedule down time.

(B) Any telescope manpower to assist in preliminary work and during survey.

(C) Correlate survey work with any other work which might emerge.

Central Shop Effort:

(A) Fabricate components.

(1) New 64-inch stepping bar.

(2) Aluminum support to establish vertex.

(3) Nylon washers.

(4) Revision to 650 mm stepping bar.

Outline

(A) Introduction and Related Information

(1) Stepping Bar Method. (See Memo of 25 Meter Millimeter Wave Telescope No. 94 and 95.)

General results of testing and Dr. Findlay's comments.

(B) Criteria and New Procedures

(1) Invent method to accurately use stepping bar on solid surface antenna without drilling holes in surface.

(2) Use the nylon washer method which replaces holes in the surface.

(3) Accurately locating the start points on 48 radii from established vertex.

(C) New Design and Related Use

(1) Revision of 650 mm stepping bar. (Electronics and Engineering) (Revise to install nylon washer and Length Sensor with module.)

(2) Design of new 64 inch stepping bar and nylon washer. (Engineering) (To locate start points accurately.)

(3) Design of aluminum frame to support vertex hard point. (Engineering) (Support to locate start points accurately.)

(4) Design of temporary platform or step ladder around and independent of vertex frame. (Engineering) (So new 64" bar can be used easily and Inclinometer can be read easily.)

(5) Layout of 48 radii on surface panels with hard lead pencil. (Engineering) (Buck-in on known points.) (Smith/Ralston procedure.)

(6) Preliminary level's survey of the 48 outer points. (Engineering)

(a) Set up N-3 Level atop Cassegrain House under ideal conditions and read and record levels of the 48 radii outer points. (Engineering) (May not be feasible with R. Fisher's reflector on Cassegrain House to set-up on center line but can set-up off center line.)

(7) Test components and method. (Electronics and Engineering)

(a) Actual test on 140' telescope as in (D) Para (e).

(8) Review results of test and alter components or method as required.

(D) Actual Survey

(1) Prepare for survey by getting all equipment ready at telescope. (Similar to Dr. Findlay's test in May 1977.)

(2) Present efforts to B. Brown for telescope time.

(3) Correlate scheduled down time with Telescope Operations, Electronics, Engineering and Central Shops.

(4) Actual set-up on telescope after scheduled shutdown. (In stow indicated position.)

(a) Install vertex frame, temporary platform or ladder, Hilger-Watts instrument mount in the area of the declination shaft centerline. Install theodolite and planize to four hard points which will describe the mechanical axis of telescope with theodolite.

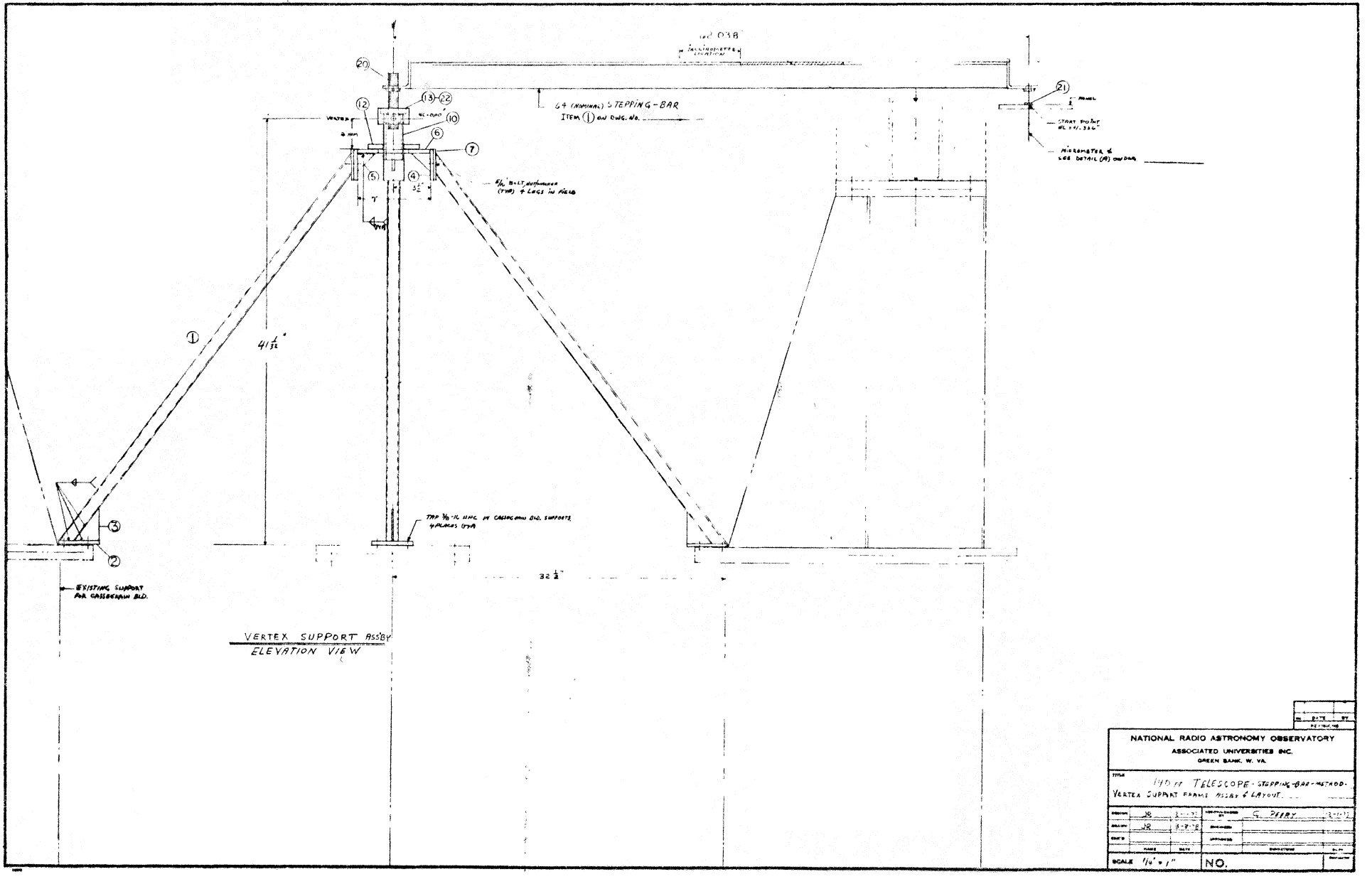
(b) Establish the vertex from an inner panel point and theodolite by trail and error. That is, with the new fixed dimension, 64-inch stepping bar and optical inclinometer, adjust the vertex point until it is correctly located with an inner panel point. Then measure the other inner panel points and record data. From this data we can establish the elevations of each point from a reference point.

(c) The (48) start points will be established by afixing the nylon washer at each point via the new 64-inch stepping bar.

(d) After the start point washers are installed and we are confident in their accuracy, we can install the other nylon washer on the other radii by using the 650 mm stepping bar. This job will be tedious since each washer has to be set with glue as we step along the radii.

Note: Only four (4) radii, 90^{o} apart will be surveyed so only the nylon washers for the four radii will be installed at first.

(e) Survey the four radii per Dr. Findlay's procedures and repeat until we are satisfied with the accuracy and reproducibility.

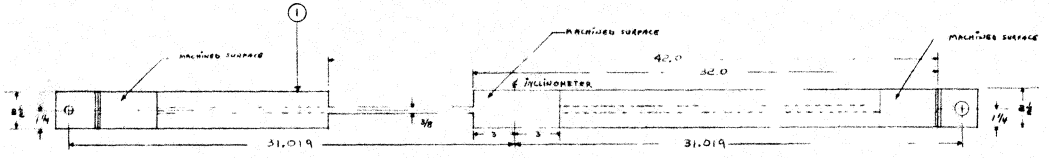


VERTEX SUPPORT ASSBY
ELEVATION VIEW

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

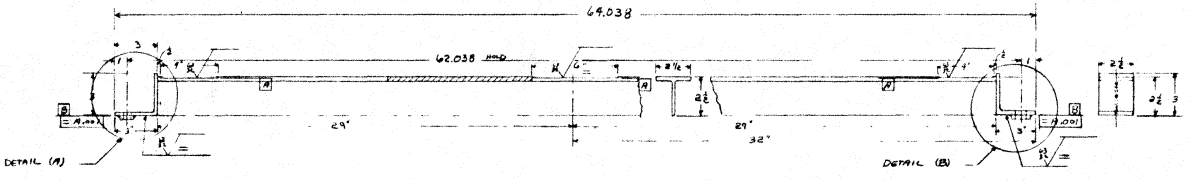
TITLE: 140 ft TELESCOPE - STEPPING-BAR-METHOD-
VERTEX SUPPORT FRAME ASSBY & LAYOUT

DESIGN JB 3-1-72 — DRAWN BY G. PERRY 3-21-72
ENGR JB 3-8-72 — CHECKED
CHK'D — APPROVED
SCALE 1/4" = 1" — NO.



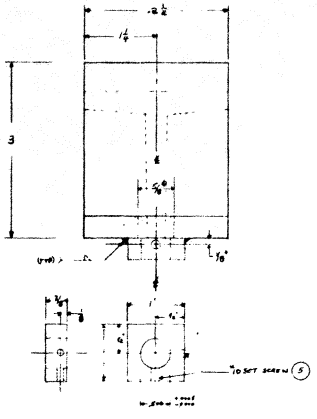
PLAN

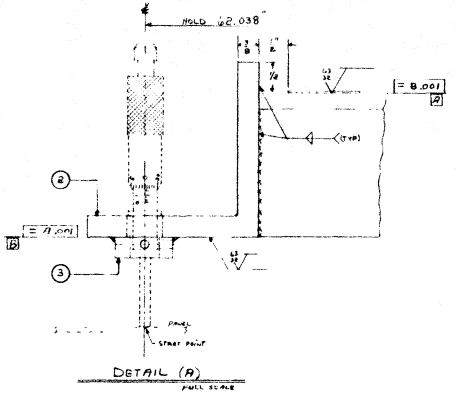
1/4" = 1"



ELEVATION

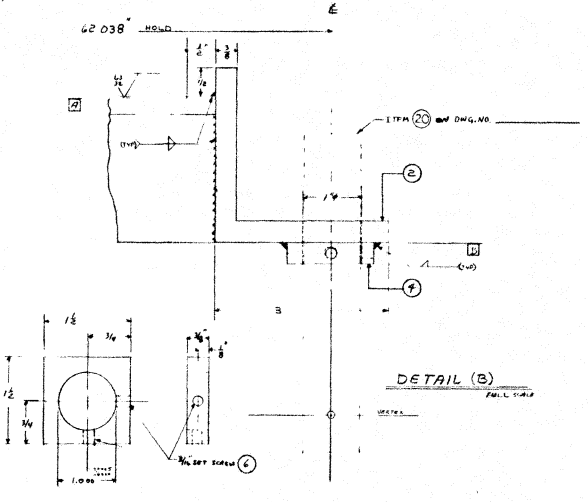
1/4" = 1"





DETAIL (A)

FULL SCALE



DETAIL (B)

FULL SCALE

B/M

ITEM	QNTY	DESCRIPTION	MATERIAL
1	1	2"x2"x3/16 TUBE @ 1.42 #/FT A500 GR B	ALUM
2	2	3"x3"x3/8 x 2 3/4 LG ANGLES	ALUM
3	1	1"x1"x3/8" BAR	ALUM
4	1	1 1/2" x 1/2" x 3/8" BAR	ALUM
5	2	#10 DIA. SET SCREW 3/8	STAINLESS STEEL
6	2	3/8" DIA. SET SCREW 3/8	"

NO.	DATE	BY
	REVISIONS	

NATIONAL RADIO ASTRONOMY OBSERVATORY

ASSOCIATED UNIVERSITIES INC.

GREEN BANK, W. VA.

TITLE

140 ft TELESCOPE - STEPPING-BAR-METHOD

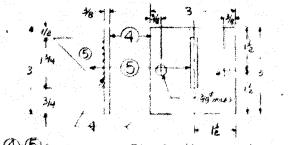
64 INCH STEPPING BAR FOR STEPPING-BAR-TECHNIQUE TO DEFINE JERTZ AND START POINT

DESIGN	JAS	12-1-77	C. DEAY 12-1-77
DRAWN	JAS	3-1-78	CHECKED
CHK'D			APPROVED
	NAME	DATE	SIGNATURE DATE

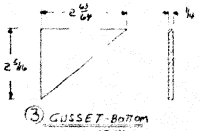
SCALE FULL & 1/16" = 1" NO.

(1) LEGS - 4 REQ'D

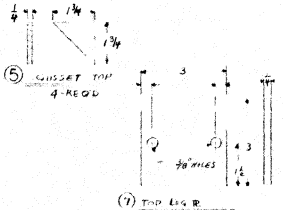
(2) BOTTOM LEG PLATE
4 REQ'D



(4)-(5) TOP CENTER PLATE w/GUSSET ASSY
4 - REQ'D

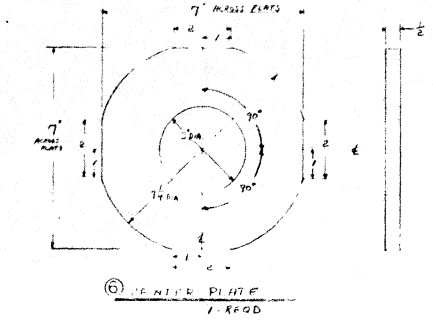


(3) GUSSET - Bottom
4 REQ'D

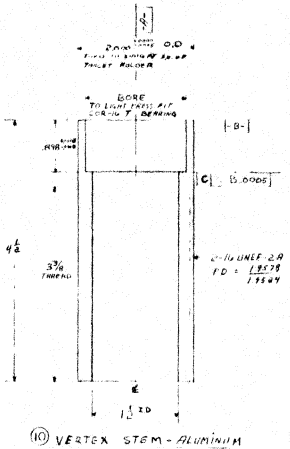


(5) GUSSET TOP
4 REQ'D

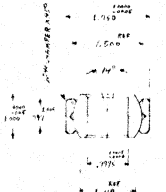
(7) TOP LEG R.
WELDED



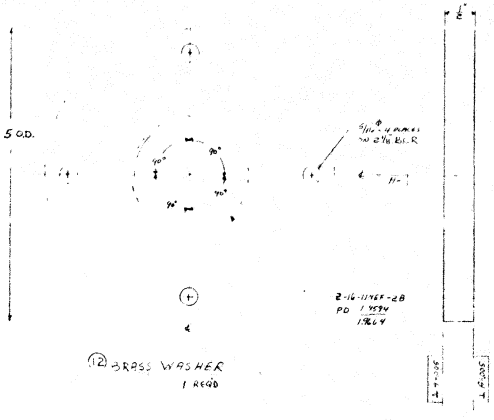
(6) CENTER PLATE
1 - REQ'D



(10) VERTEX STEM - ALUMINUM
1 REQ'D

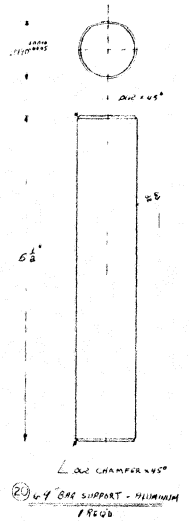


(11) COR-16 "T" BEARING - S.S.
1 - REQ'D



(12) BRASS WASHER
1 REQ'D

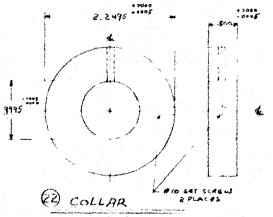
(13) TARGET HOLDER NOT SHOWN
1 REQD (EXISTING)



(20) 6'4" BAR SUPPORT - ALUMINUM
1 REQD

(21) WASHER NYLON
200 REQ'D

NOTE: PURCHASE FROM BOSTON PLASTIC PRODUCTS
NYLON THRUST WASHER NT312 w/188 I.D.
BORE HOLE TO DWG. DIMENSIONS



(22) COLLAR
1 REQD

B/M

ITEM	QUAN	DESCRIPTION	MATERIAL
1	4	LEGS - 48 3/64 x 1.74 OD TUBE w/.083 WALL	ALUMINUM
2	4	PLATE - 4" x 4" x 3/8"	"
3	4	GUSSET - 2 5/16" x 2 5/16" x 1/4"	"
4	4	PLATE - 3" x 3" x 3/8"	"
5	4	GUSSET - 1 3/8" x 1 3/16" x 1/4"	"
6	1	CENTER PLATE - 7 3/4" O.D. x 1/4" THK	"
7	4	TOP LEG R 3"x3"x1/4	"
10	1	VERTEX STEM - 4 1/8" x 2 1/2" STOCK	ALUMINUM
12	1	WASHER - 6" O.D. x 1/2" THICK	BRASS
13	1	TARGET HOLDER - 3" O.D. x 1 1/2" LG EXISTING (NOT SHOWN ON DWG.)	ALUMINUM
11	1	TRUNNION BEARING COR-16 "T" (EXISTING)	SS
20	1	ROD - 1" STOCK x 4 1/2" LG.	ALUMINUM
21	200	WASHERS - 7/8" O.D. x .188" I.D. x .062" THK BORE TO DWG. DIMENSIONS	NYLON
22	1	COLLAR 2.500 O.D. x 1.000" I.D. x 5" LG	ALUMINUM

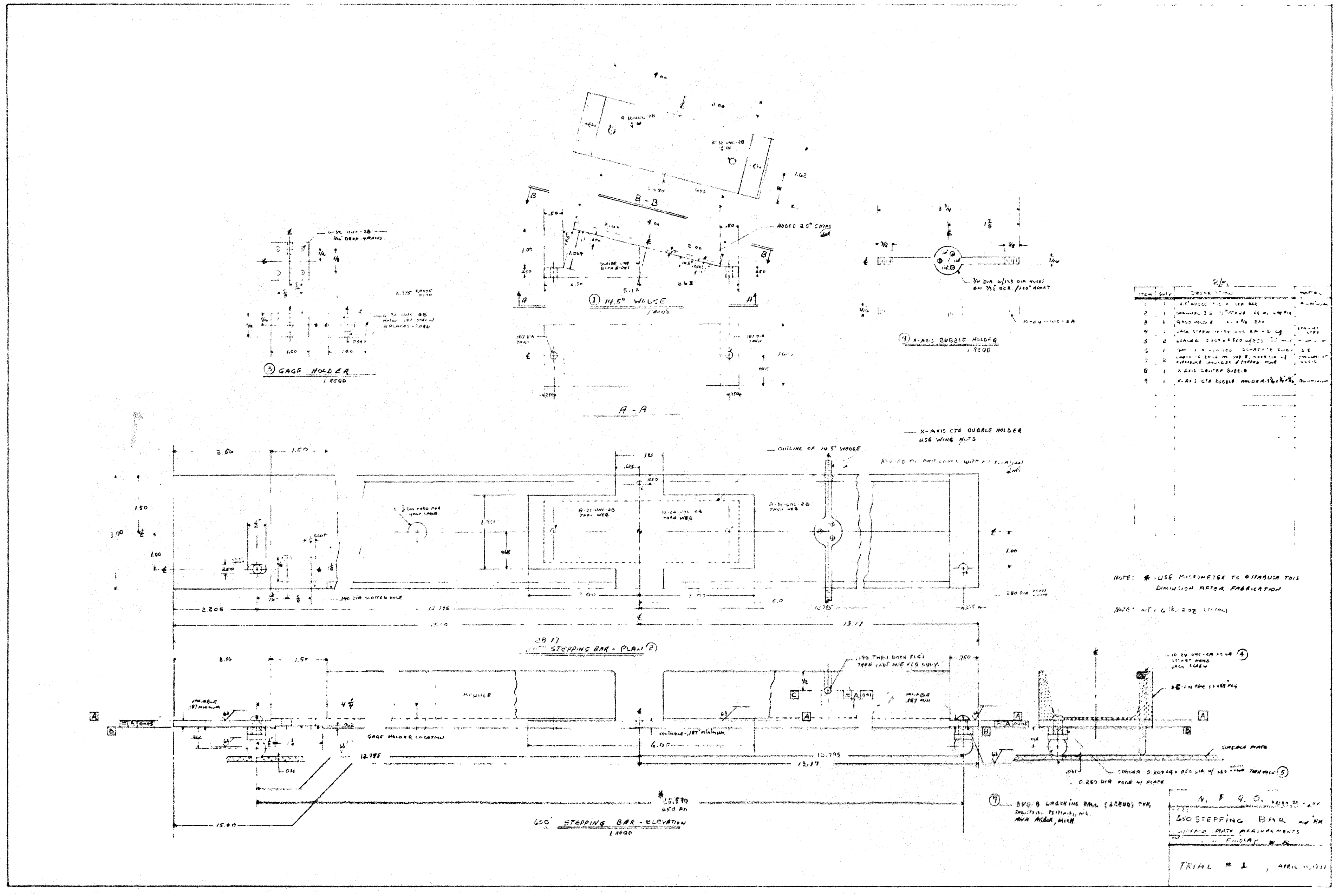
NO.	DATE	BY

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

TITLE: 140 ft TELESCOPE - STEPPING-BM-METHOD - MISC DETAILS AND PARTS FOR MEASURING SURFACE

DESIGN	NR	11-1-77	RECOMMENDED BY: G. PERRY 11-7-77
DRAWN	NR	11-7-77	DATE
CHK'D		DATE	APPROVED
NAME	DATE	SIGNATURE	DATE

SCALE: 1" | NO. | DWG NO.



B - B
① 14.5° WEDGE
1 REQD
③ GAGE HOLDER
1 REQD
A - A
X-AXIS BUBBLE HOLDER
1 REQD
X-AXIS CTR BUBBLE HOLDER
USE WING NUTS
OUTLINE OF 14.5° WEDGE
650 STEPPING BAR - PLAN ②
650 STEPPING BAR - ELEVATION
1 REQD
MODULE
GAGE HOLDER LOCATION
SURFACE PLATE
0.250 DIA HOLE IN PLATE
NOTE: * - USE MICROMETER TO ESTABLISH THIS DIMENSION AFTER FABRICATION
ANN ARBOR, MICH.
650 STEPPING BAR
TRIAL # 1