National Radio Astronomy Observatory
Green Bank Telescope
Small Subreflector Specification (M2)

Specification No. A35102N006
July 18, 1990

1.0 General

This specification covers the furnishing of labor, materials, services, drawings, data, test documents, and other items required for the detail design, manufacture, testing, packing and shipping to NRAO Green Bank, West Virginia.

The subreflector will be used in a Gregorian feed system for a 100-meter diameter offset feed radio telescope. The feed system to be used is offset from the antenna axis by 1.957°.

To enable the beam of the antenna to be rapidly switched between two points in the sky, the subreflector will be "nutated" (periodically and repeatedly tilted) about an axis approximately 60° from the ellipsoid axis. Nutation is a square-wave modulation between two angular positions separated up to 2.5°. The positions are at constant elevation angles. This requires that the subreflector be strong enough to withstand the large accelerations needed to give switching rates of up to one cycle per second.

2.0 Design

2.1 Physical Description

The subreflector surface is an offset portion of an ellipsoid. The parameters of the parent ellipsoid are:

Eccentricity	0.680
Distance between foci	10.30 meters (405.51 inches)

The subreflector rim is defined by the intersection of the ellipsoid and a cone with a half angle of 9.15°. The axis of the cone is tilted 10.246 degrees, relative to the ellipsoid axis, and whose apex is located at the focus furthest from the subreflector. The resulting subreflector has the following dimensions and is shown on Drawing B35102M034.

Rim Extents (elliptical)	150.16 x 159.68 inches
Rim Perimeter	40.6 feet
Surface Area (approximate)	138 ft2
Maximum Depth, Normal to Subreflector Aperture	17.1 inches

2.2 Antenna Parameters (Reference Only)

Diameter	100 meters projected aperture
Focal Length	60 meters
Sky Coverage	Elevation + 5° to + 95°
	Azimuth -270° to + 270°
Antenna Drive Velocity (max)	Elevation 20 deg/min
	Azimuth 40 deg/min

The antenna will be exposed to the elements and climatic conditions typical to Green Bank, West Virginia. No damage should occur due to these environmental factors.

2.3 Surface Accuracy

The RMS surface deviation from the design ellipsoid, due to manufacturing, gravity, wind, and thermal effects, shall be less than 0.003 inches. This specification shall hold for all elevation angles in wind speeds up to 7 miles per hour. Peak deviation from the design surface shall be 0.009 inches. Manufacturing errors shall be measured at surface points no more than 3 inches apart. The manufacturer shall, during the design, submit an error budget, and measurement and acceptance procedures to AUI for its approval.

2.4 Operating frequency

The subreflector will be used between 5 GHz (6 cm) and 100 GHz (0.3 cm). The reflection loss at the subreflector surface must be less than 0.05 dB (1 percent power loss) for frequencies of 5 GHz to 44 GHz. Vendor shall provide a finished sample of the reflector surface material for testing by AUI, a 3 inch square minimum size is required.

2.5 Operating Conditions

The subreflector shall meet all specifications under the following conditions.

Temperature Range:	-34° C to +38° C
Relative Humidity:	0-98%
Temperature Gradient:	A temperature difference between the front and rear surfaces of the subreflector of up to 5° C
Rain Rate:	Up to 2 inches per hour
Ice or Snow Load:	None

Wind:	Must meet accuracy requirement in winds to 7 miles per hour, but must operate (with reduced accuracy) in winds to 40 miles per hour with gusts of 5 miles per hour superimposed. Winds may be from any direction with antenna in any attitude.

2.6 Survival Conditions

The subreflector must survive, without damage, the following environmental conditions with the antenna in the stow position. In this position the rim of the parent parabola is horizontal, or at an antenna elevation of approximately 66°. The rim of the subreflector makes an angle of approximately 126° with the horizon when in this position.

Survival Wind:	94 miles per hour
Survival Snow Load:	Back or front surface of subreflector loaded with 20 psf snow.
Survival Ice Load:	1 cm (.40 inches) of radial ice on all exposed surfaces.

2.7 Material

The manufacturer shall use a suitable material and surface treatment to meet reflector loss specification, Section 2.4. Adequate drainage holes to be provided to prevent accumulation of water in subreflector backup structure. The weight of the subreflector shall be dependent on the material of fabrication, but weight shall not exceed 450 pounds. If material chosen is composite, then seal to water.

2.8 Alignment Mirror

To allow correct alignment of the subreflector, a 0.75 inch diameter optical mirror with cross hairs must be located at the point where the offset centerline intersects the front surface of the subreflector, point indicated by I2. Coordinates for I2 are X = 0 Z = -1.344. The y axis coordinate shall depend on the manufacturer's design. The cross hairs of the installed mirror shall lie within 0.010 inches of the pt. X = 0 Z = -1.344. The face of the mirror shall be perpendicular to the xz plane to within 8 arc seconds. The origin of the subreflector is located on the plane of and at the center of the mounting ring. This allows symmetry about the z-axis.

2.9 Mounting Interface

The interface between the subreflector and its support shall be a pattern of 4 through-bolt holes, equally spaced in the subreflector, lying on a 60.00 inch diameter bolt circle. The interface holes shall be concentric to the y-axis to within 0.030 inches. Also, two locating pins, 0.750 inches in diameter on a 64.000 inch diameter bolt circle located along a plane perpendicular to the x-axis to within 30 minutes of arc (0.50°). The mounting shall lie in the xz plane to within .010 inch to minimize possible distortion from mounting. See Drawing B35102M35. The mounting ring shall allow for 52 inch diameter by 12 inch minimum clearance between the mounting surface and the rear surface of the subreflector. If the hole diameter shown is not sufficient, then the manufacturer shall notify AUI 30 days after contract placement.

2.10 Finish

The manufacturer must use a suitable material and surface finish to minimize loss and resist corrosion. If subreflector surface is machined all burrs and sharp edges shall be removed prior to finish treatment. All surfaces (except bolted interface surfaces) shall be primed with a suitable primer and given a 3 mils thick finish coat of Triangle No. 6 white paint. The exact finish specification shall be prepared by manufacturer and approved by AUI.

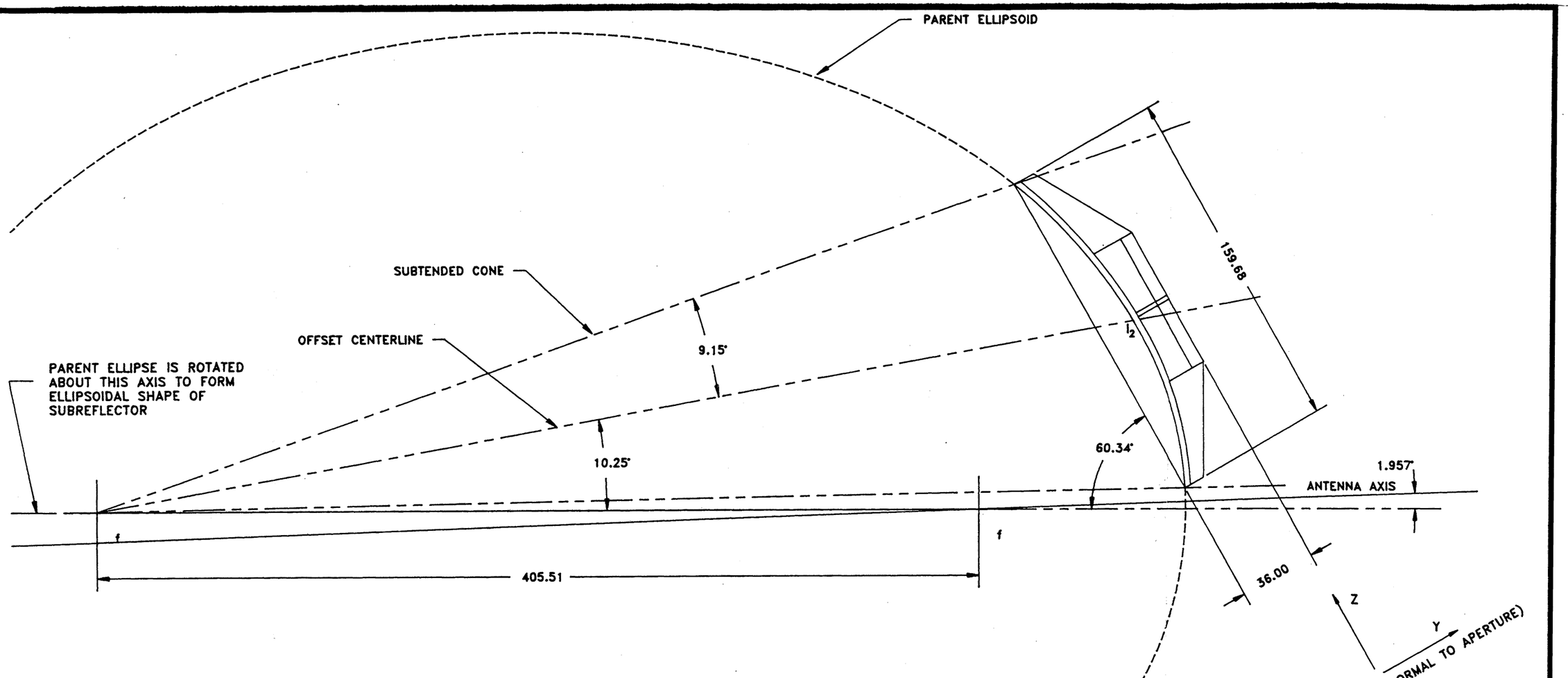
3.0 Periodic Tilting (Nutating)

The subreflector will be periodically tilted at rates up to 1 Hz. The subreflector will be tilted about the z-axis at a point 6 inches from the mounting interface. The subreflector shall be tilted through angles up to 2.5°, with transition times of 0.10 seconds. Figure 2 shows typical switching cycle. To tilt the subreflector, a maximum applied torque of 4,000 ft. lbs. will be applied. The center of gravity shall be so located as to not require a higher applied torque, and the moment of inertia shall not exceed 225 lb. ft. sec^2. The torque shall be applied via a 4 point yoke assembly, attached to the subreflector, as shown in Figure 3.

The yoke will rotate by hydraulic rotary actuators, or cylinders, and position control through a closed-loop servo system.

The subreflector must have a life of not less than 4,000 hours when switching through 2.5° at a rate of 1 Hz.

The surface accuracy specification, Section 2.3, need not be met while the subreflector is in motion (parts AB or DC of switching cycle on Figure 2), but this specification must be met within 0.05 seconds after the subreflector has come to rest, i.e., the reflector surface must be sufficiently damped within 0.05 second of parts BC or DE of the cycle.



AXIS ORIENTATION

NOTES:

1. THE SUBREFLECTOR SURFACE IS AN OFFSET PORTION OF AN ELLIPSOID. THE PARAMETERS OF THE PARENT ELLIPSOID ARE:

ECCENTRICITY	0.680
DISTANCE BETWEEN FOCI	405.51 INCHES
RIM EXTENTS (elliptical)	150.16 X 159.68 INCHES
RIM PERIMETER	40.6 FT
SURFACE AREA (approx.)	138 FT^2
MAXIMUM DEPTH, NORMAL TO APERTURE	17.1 INCHES

NO.	DATE	BY
REVISIONS		

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

TITLE

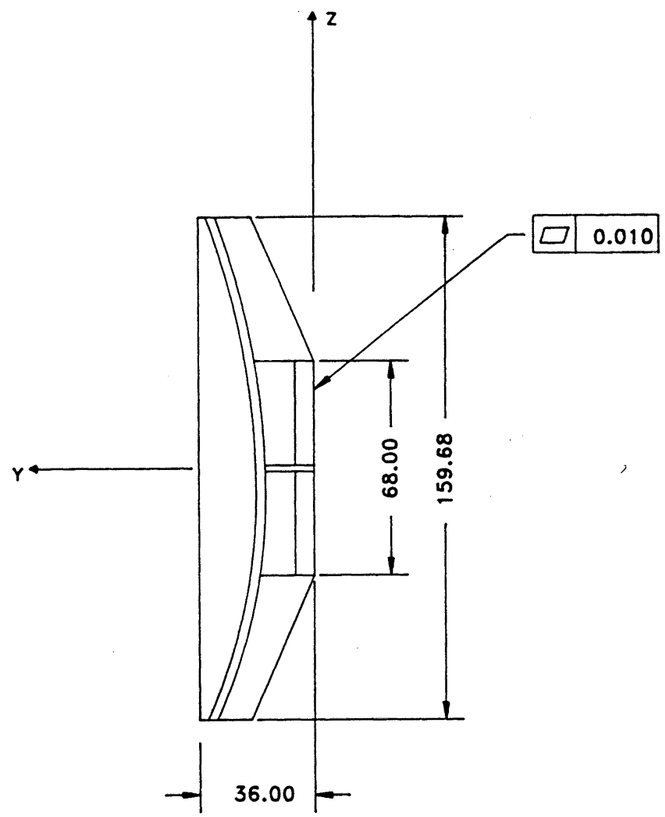
GBT

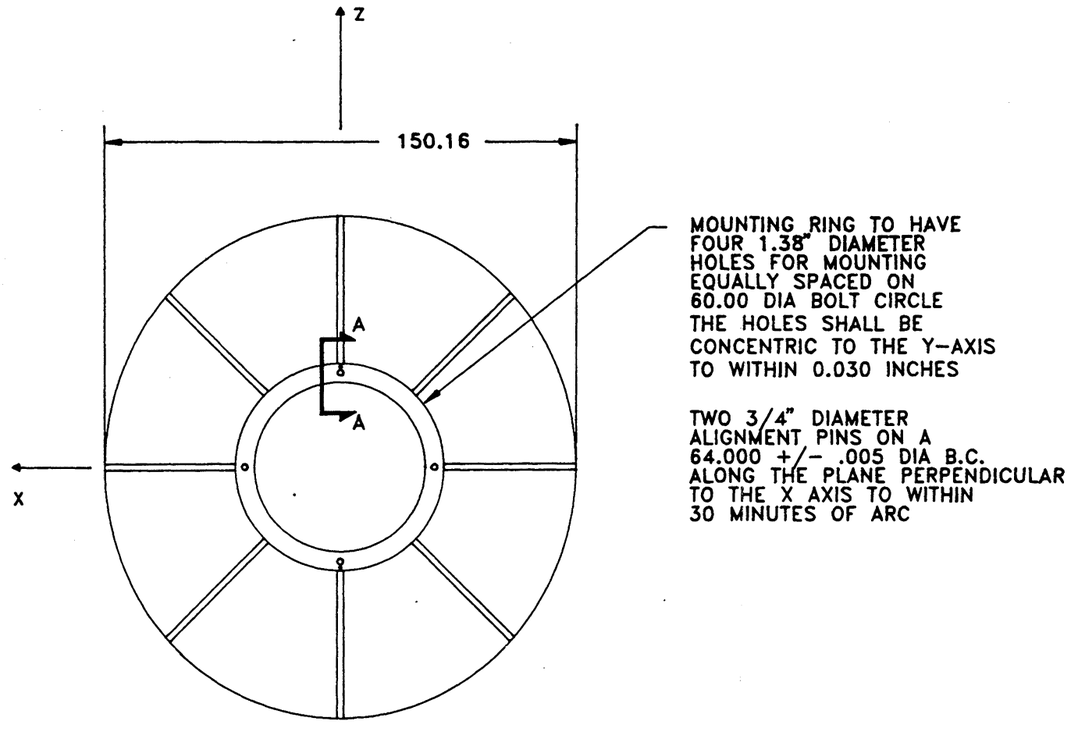
DESIGN	RNORROD	3/6/90	RECOMMENDED BY	RNORROD	3/6/90
DRAWN	DSEAMAN	6/8/90	ENGINEER	RNORROD	3/6/90
CHECKED			APPROVED		
	NAME	DATE		SIGNATURE	DATE

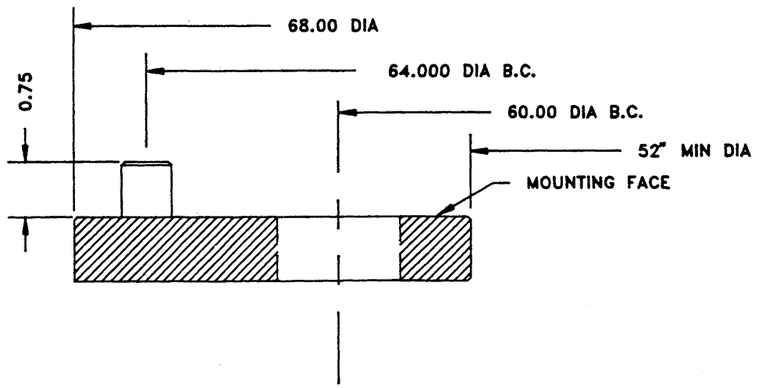
SCALE 1 = 48

NO. B35102M034

REVISION







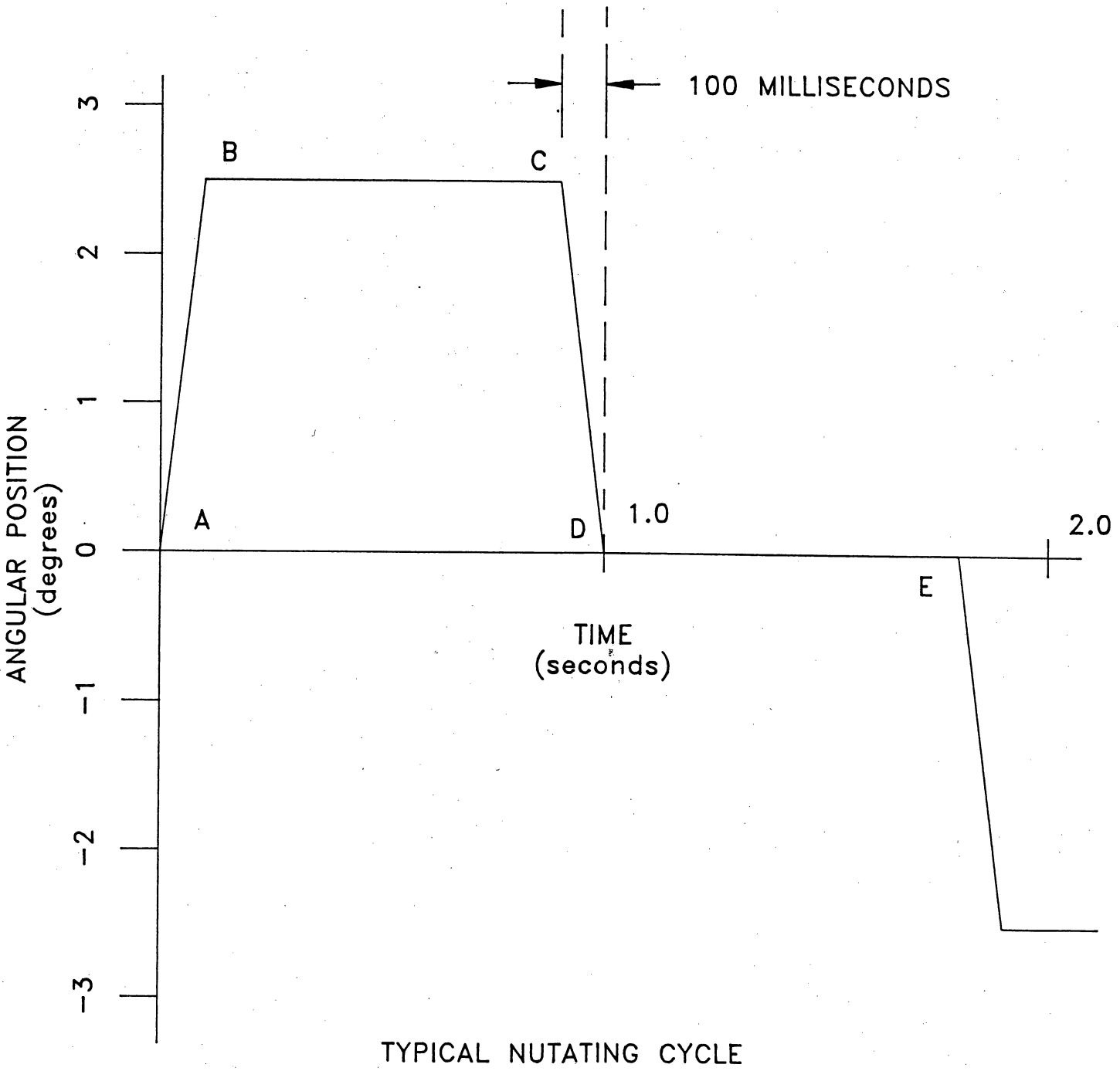
SECTION A-A
(NOT TO SCALE)

NO.	DATE	BY
REVISIONS		

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

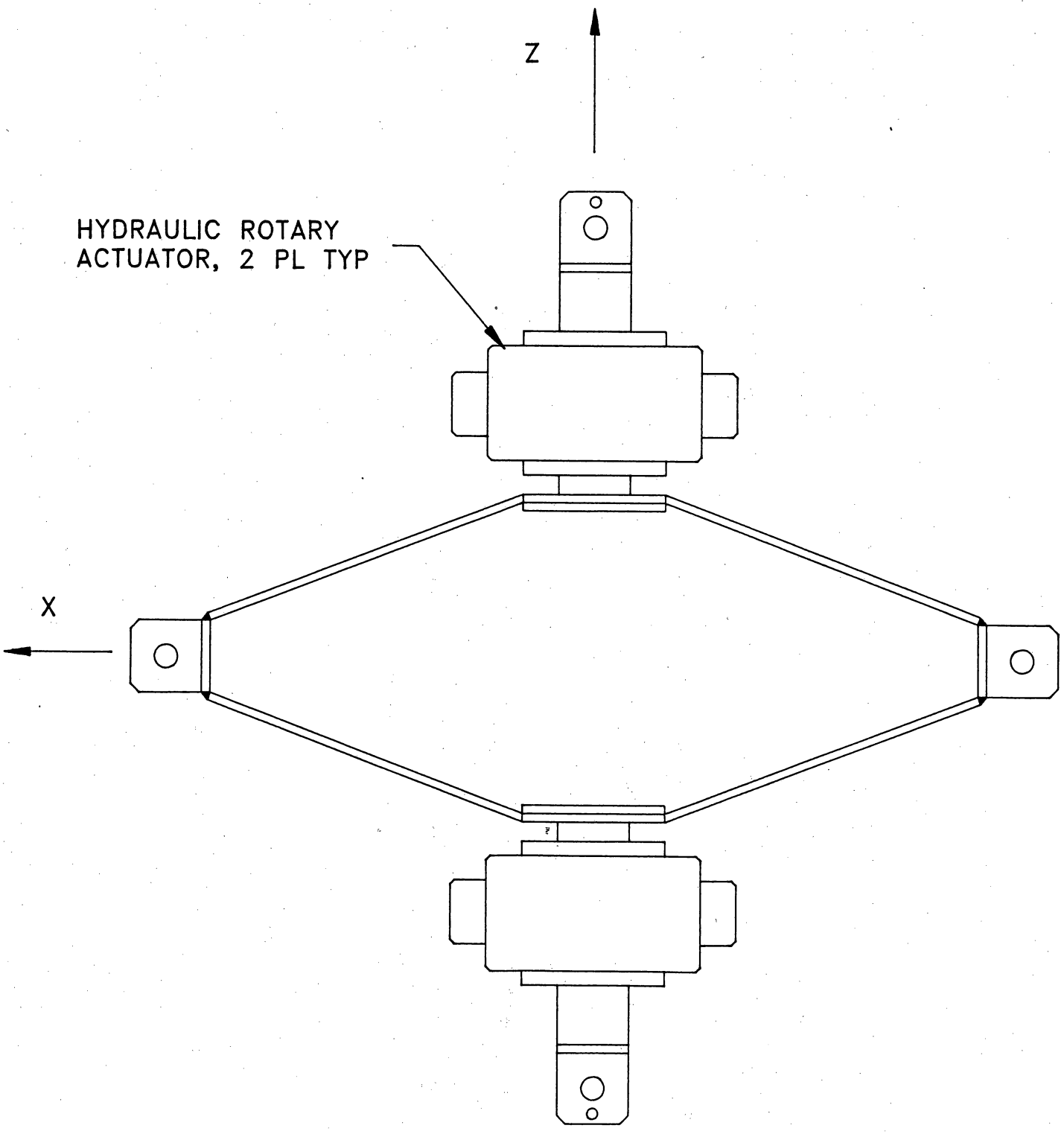
TITLE
SMALL SUBREFLECTOR MOUNTING RING
GBT

DESIGN	DSEAMAN	6/8/90	RECOMMENDED BY		
DRAWN	DSEAMAN	6/8/90	ENGINEER	DSEAMAN	6/8/90
CHECKED			APPROVED		
	NAME	DATE		SIGNATURE	DATE
SCALE	1 = 48		NO. B35102M035		REVISION



TYPICAL NUTATING CYCLE

FIGURE 2
M2 SPECIFICATION



TYPICAL MOUNTING YOKE

FIGURE 3
M2 SPECIFICATION