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AX-122

PERKIN-ELMER
OPTICAL GROUP

AXAF
TECHNOLOGY MIRROR ASSEMBLY
PROJECT REPORT

AXAF/TMA PARABOLA AND HYPERBOLA GENERATING FINAL REPORT
(DR-7)

MARCH 1983

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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama
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Publication Review:

J. Russo, AXAF/TMA Program Director

Abstract:

This report describes the generation of the AXAF/TMA Hyperbolic and Parabolic optical blanks, the process used, and the final measurements.

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SECTION 1

INTRODUCTION

This report describes the generation of the AXAF/TMA Hyperbolic and Parabolic optical blanks on a specially designed grinder adapted to operate with features of the basic Perkin-Elmer overhead F-25 milling machine and roller polishing machine developed on the HEAO-B program.

Generating is the operation that proceeds fine grinding and polishing of the mirrors to the final dimensions shown in Report No. AX-121, and Drawing No. 899-1211-001. The object of generating is to convert the cylindrical blanks to the closest base cone leaving only the inside diameter (ID) to be polished to the final optical prescription shown in the referenced drawing. The finished dimensions on generating the ID of the cones are nominally 0.008 inches in excess of the final optical prescription. Figure 1-1 is a pictorial flow of the generation process.

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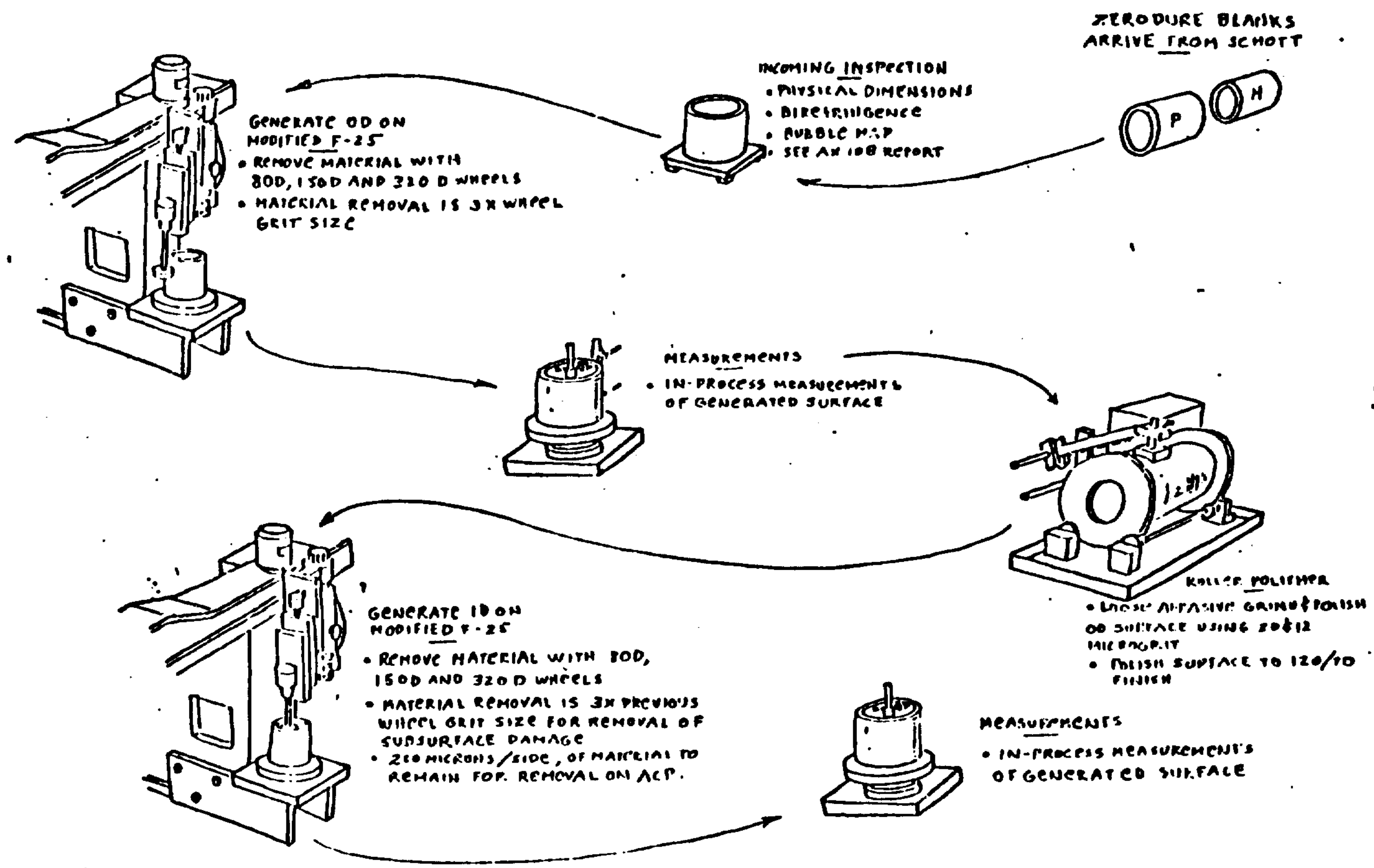


Figure 1-1. Generation Process Flow

SECTION 2

SPOT POLISH OF MIRROR BLANK OD IN PREPARATION FOR INTERNAL QUALITY INSPECTION

The mirror blanks were inspected as reported in the Incoming Inspection Report AX-108 dated 30 June 1982, and met the following requirements:

- Physical dimensions
- Birefringence (strain)
- Surface chips and fractures
- Internal bubbles and seeds.

The depth and size of the internal bubbles and seeds could not readily be measured due to the ground surface of the blanks as delivered from Schott. The significant seeds and bubbles could be seen through the oiled ground surface, and their locations were mapped using high intensity lights. Transparent chart paper was overlayed around the blanks and the bubble position marked on the paper. The position was converted to angle, documented, and preparation made for local polishing operations and inspections.

Select bubbles/seeds were measured by first polishing a half-inch area on the blank OD opposite the bubbles/seeds and measuring the depth and diameter using a depth microscope. This activity represents the first material removal on the optical blanks.

SECTION 3

PERKIN-ELMER F-25 MACHINE MODIFICATION

In order to generate the AXAF/TMA blanks, the Perkin-Elmer F-25 overhead milling machine was modified, as a Perkin-Elmer capital expenditure, to accommodate the programs generating requirements. The major portion of the modification and the specific accuracy of the components are shown in Figure 3-1. The basic components including features inherent in the basic F-25 machine are as follows:

- o Pope slide, to provide vertical feed rates and capable of being tilted to the required cone angle
- o Walter mechanical turntable, to rotate the mirror on its optical/mechanical axis
- o Pope spindle, provides high speed rotation of the diamond wheels and is secured to the Pope slide
- o Coolant system, provides a reservoir and pumping system for grinding wheel/glass interface cooling
- o Turntable support structure, to support the turntable and machinery controls
- o F-25 tilt control, allows the Pope slide and spindle assembly to be tilted from the vertical to the required mirror cone angle
- o F-25 lateral motion drive, allows feed rates in the direction normal to the mirror blank optical/mechanical axis, i.e., normal to the spin axis of the Walter mechanical turntable.

The basic components, with the exception of the F-25 tilt control and F-25 lateral motion drive, were integrated into the massive rigid F-25 basic machine structure. This allows considerable flexibility and utility of the machine and close operator observation and control of the generating process.

All generating, beveling and pending end cut-off has been and will be performed on this machine. The generation of the parabola and hyperbola has indicated it has the capability to prepare the blanks for subsequent Automated Cylindrical Grinding/Polishing.

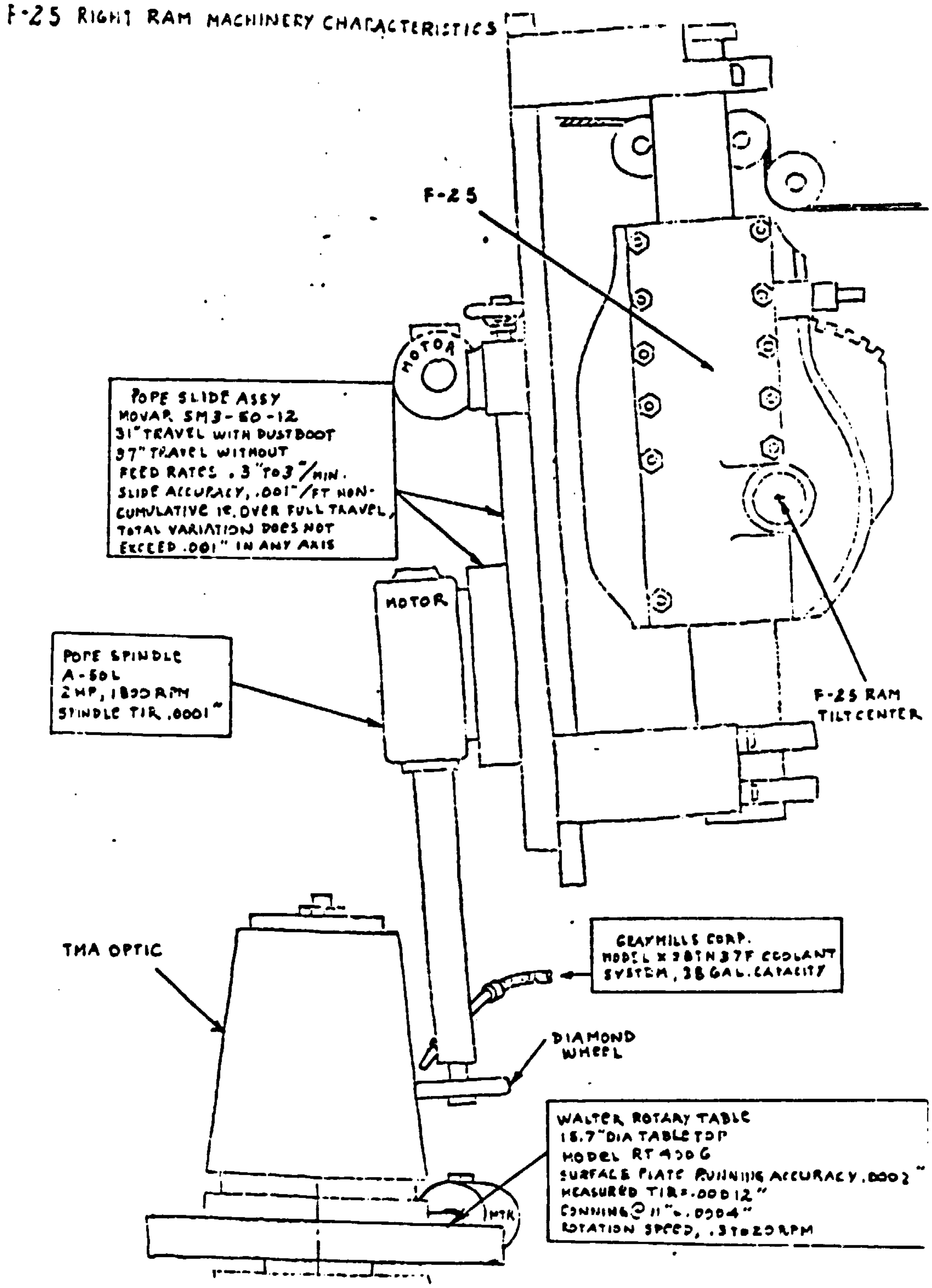


Figure 3-1. Component Accuracy

SECTION 4

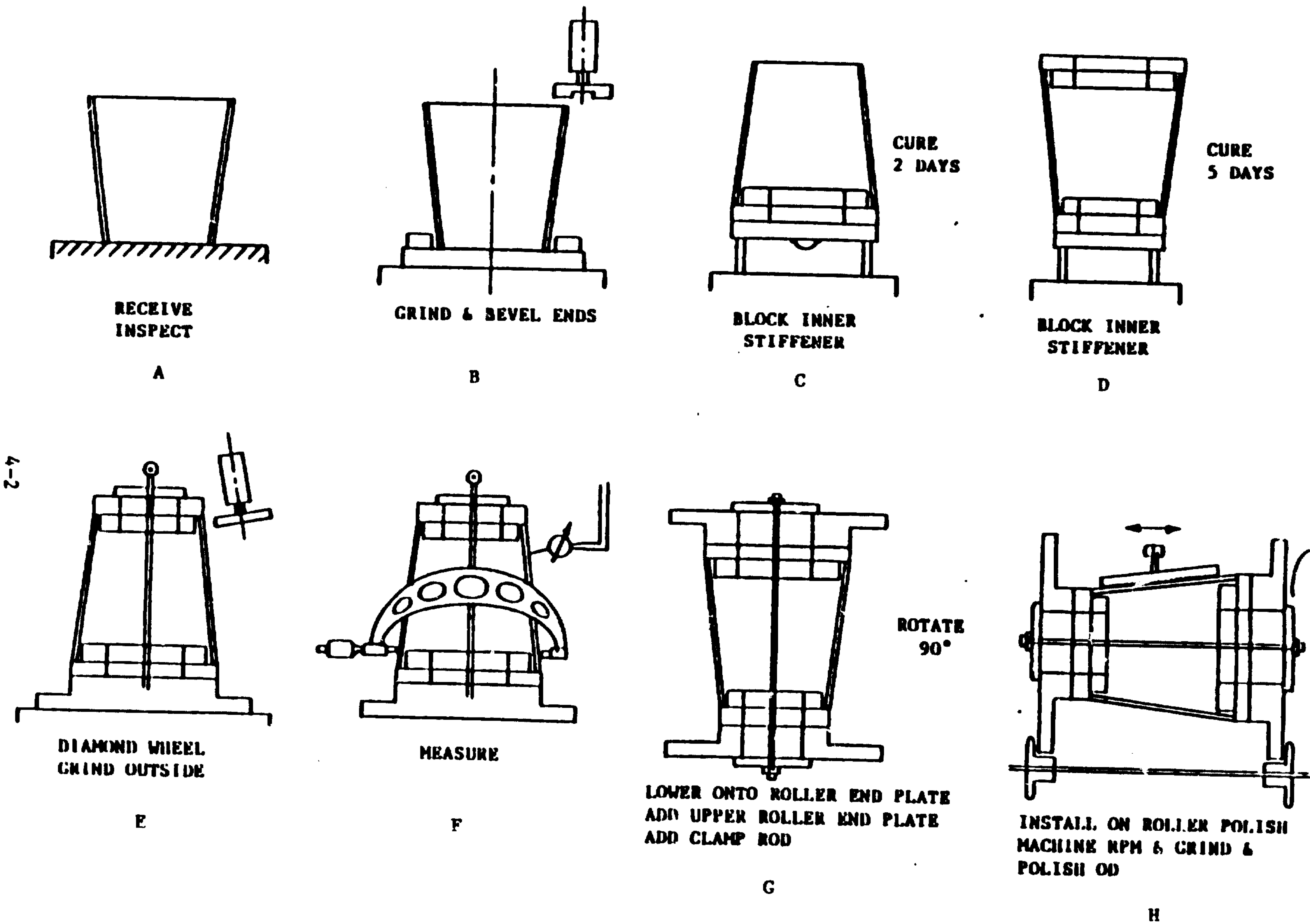
GRIND AND BEVEL MIRROR BLANK ENDS

Grinding and beveling of the mirror blank ends was accomplished utilizing a 4-inch diameter #80 diamond face wheel for edge grinding and a 1/2-inch x 45° #80 diamond beveling wheel. The beveling of the inboard and outboard cut end surfaces are for damage protection purposes during subsequent operations and handling.

The blank being generated was centered and secured on the Walter turntable with special tooling to prevent lateral motion and tilting of the blank during application of the tool forces. See Figure 4-1B.

After grinding and beveling of one is completed, the blank is inverted, realigned and secured and the operation repeated.

This process establishes a base from which orientation of the mirror can be maintained for the establishment of the mechanical axis during generating of the ID and OD of the blanks. See Section 8 for final measurement data.



AX-122

Figure 4-1. Fabrication Plan

SECTION 5

GRIND MIRROR OD ON F-25 (MODIFIED)

The mirror blanks are blocked as shown in Figures 4-1C, 4-1D, and 4-1E. This blocking creates the clamping rigidity for securing the blanks to the Walter turntable to prevent motion during application of tool forces during generating.

The forces generated by clamping are held to a minimum. The upper and lower blocking mechanisms consist of a fused quartz segmented disc with a plaster of paris interface between the TMA blank and the quartz. This thermally stable interface rigidly positions the mirror without inducing thermal stresses as a result of diurnal temperature variations and the introduction of the grinding coolants during generating.

The vertical center rod shown in Figure 4-1E has a spring-loaded nut that creates a moderate downward force on the blank and seats the base of the mirror through a thin neoprene sheet to the blocking structure.

The blocking devices hardware does not project beyond the anticipated final mirror OD at each end. From the figure, it can be seen that this clearance is necessary to allow the grinding wheel to generate the entire length of the OD. Prior to the generating operation, the F-25 tilt control is adjusted to establish the proper cone angle for the blank being generated. The blocked mirror is aligned and positioned in relation to the Walter table mechanical axis.

The OD surface is control ground to minimize residual stress in the blanks by removing nominally three times the last diamond wheel grit size used. The wheels for generating the OD and ID surfaces were 80, 180 and 320 grit diamond wheels. Figure 5-1 is the stock removal schedule, spindle feed rates and material removal per pass. See Section 8 for final measurement data and Figure 4-1F for typical measurement setup.

Mandatory Stock Removal Schedule						
Grit	Diamond Wheel Consentration	Bond	Mat'l Removal Per Pass	Min. Total Removal	Down Feed	No. Passes
80	50	Metal	⑦	See Ref.*	0.5 inch/min	As Req'd
180	50	Metal	0.011	0.0210	0.5	2
320	75	Metal	0.005	0.0100	0.5	2
12	Microgrit	Loose Abrasive		0.0052		

⑦ 0.015 Removal per pass unless otherwise specified by P-E- Specialist.

* 685-1033 HEAOB P3

Figure 5-1. Stock Removal Schedule

SECTION 6

FINE GRIND AND POLISH OD'S ON ROLLER POLISHER

Upon completion of OD grinding, the ID blocking hardware is modified by attaching large rings on each end of the mirror to engage the roller mechanism of the roller polishing machine. See Figures 4-1G and 4-1H for the blocking and roller polisher operations.

The outer surface was loose abrasive control ground with pyrex grinders and polished with pitch, felt and rug material to the final 120/70 OD surface scratch and dig requirements. See Section 8 for final measurement data.

SECTION 7

DIAMOND GRIND OD

After final completion of the OD, the blank is stripped of all blocking hardware and reblocked to allow ID generating. The blocked assembly is aligned, positioned, and secured to the Walter turntable by using the finished OD surface and the ground mirror end as reference surfaces for generating the ID.

The ID was control ground removing three times the previous wheel grit size. The wheels used, material removal and feed rates were the same as for OD generating and is described in Figure 5-1.

The final generated ID was nominally 0.008 inches per side wall in excess of the final optically finished mirror diameter. This excess was to insure leaving sufficient material for loose abrasive control grinding during subsequent ACP operations. Final inspection measurements are indicated in Section 8 of this report.

SECTION 8

MEASUREMENTS OF GENERATED SURFACE OF TMA OPTICS

The TMA blanks, as received, were ground cylinders with considerable excess material in terms of ID, OD, and length. Perkin-Elmer generated these cylinders to completion of the OD including polishing. The ID was generated leaving sufficient excess material for loose abrasive controlled grinding and polishing on the Automated Cylindrical Polisher. Both the ID and OD were generated to the base and cone shape. The ends of the mirror were generated nominally perpendicular to the mechanical/optical axis of optics. The measurements included in this section of the report include data for the hyperbola and parabola. The measurements required are as follows:

- OD measurements
- ID measurements
- Height measurements
- Wedge measurements

8.1 OD MEASUREMENTS

These measurements were taken using large OD ball micrometers and measured nominally two inches inboard from each end. Measurement results are shown in Figures 8-1A and 8-1B.

8.2 ID MEASUREMENTS

These measurements were taken nominally four inches apart along the five optic axis (A through E) as shown in the data sheets enclosed (Figures 8-1A and 8-1B). These measurements were made by inside measuring devices and supported by special tooling as shown in Figure 8-2A. The measurements were made in four orientations as shown.

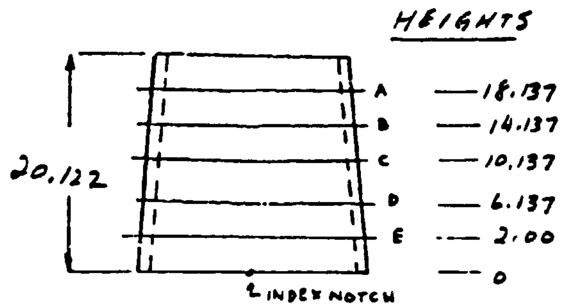
8.3 HEIGHT MEASUREMENT

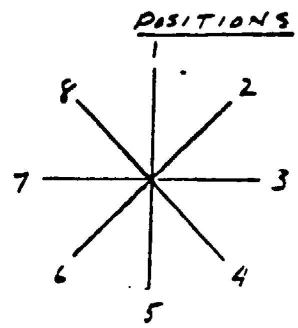
The mirror was seated on a surface plate and height measurements taken at the maximum and minimum positions as measured from the surface plate to the upper end of the mirror. See Figure 8-2B. Measured data is shown in Figures 8-3A and 8-3B.

8.4 WEDGE MEASUREMENT

Wedge was measured in terms of out-of-perpendicularity of the individual ends, relative to the ID rotational axis. The measurements were made on a precision air bearing table, with adjustable tilt as shown in Figure 8-2C. All data was recorded on-line, on polar charts. Measured data is shown in Figures 8-4, 8-5, and 8-6.

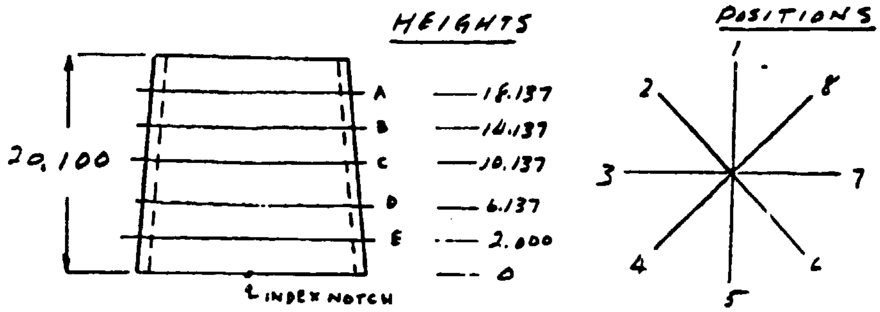
The hyperbola and parabola blanks were generated to desired dimensions for subsequent fine grinding and polishing operations on the Automated Cylindrical Polisher.





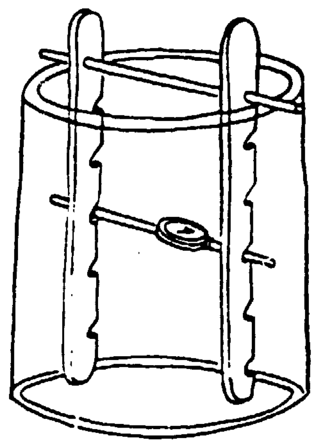
HEIGHT	DIAMETERS INSIDE 1-5	2-6	3-7	4-8	OUTSIDE (1-5)
A	16.5303	16.5302	16.5305	16.5307	17.745
B	16.6017	16.6017	16.6018	16.6019	—
C	16.6721	16.6721	16.6720	16.6720	—
D	16.7422	16.7419	16.7419	16.7419	—
E	16.8137	16.8134	16.8132	16.8132	18.026

Figure 8-1A. Diameters, Inner and Outer Parabola

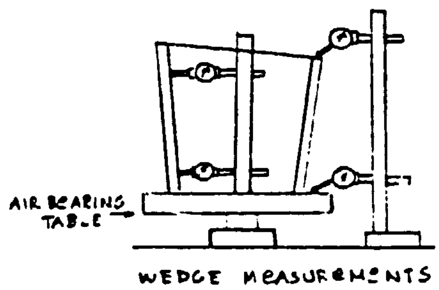


HEIGHT	DIAMETERS INSIDE 1-5	2-6	3-7	4-8	OUTSIDE (1-5)
A	15.6300	15.6296	15.6297	15.6300	16.853
B	15.8424	15.8422	15.8423	15.8424	—
C	16.0542	16.0537	16.0543	16.0542	17.278
D	16.2646	16.2644	16.2644	16.2649	—
E	16.4770	16.4767	16.4772	16.4770	17.7065

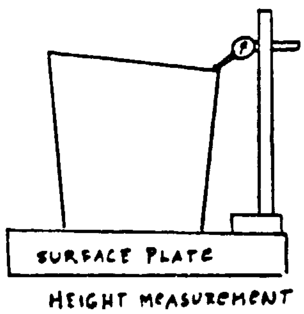
Figure 8-1B. Diameters, Inner and Outer Hyperbola



A



C



B

Figure 8-2. ID, Wedge, and Height Measurement Configurations

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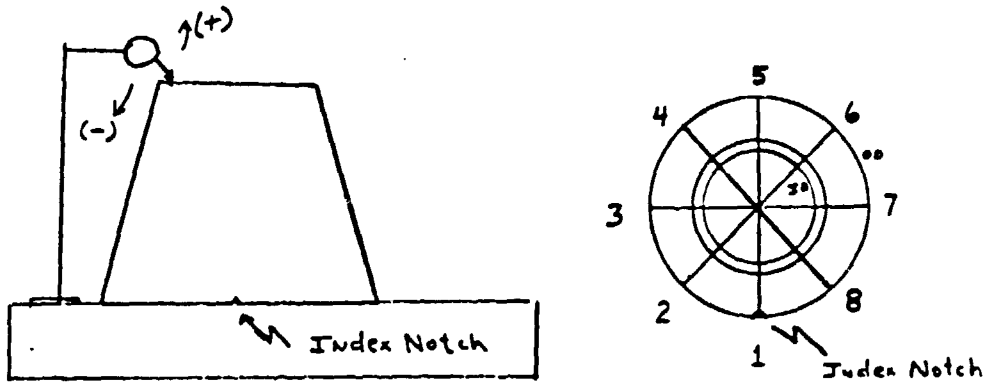
I.D Ground 320 Grit

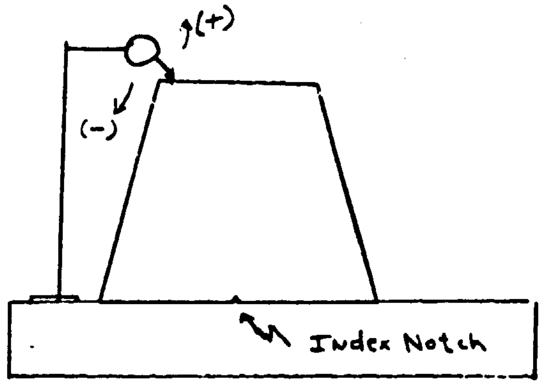


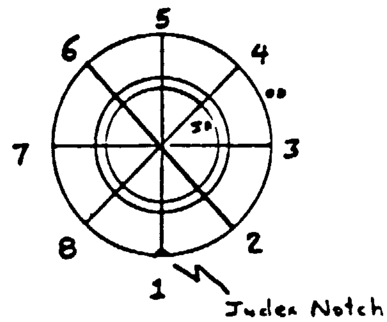
HEIGHT FROM Surface Plate

LOCATION	INCHES
1	20.1224
2	20.1222
3	20.1214
4	20.1198
5	20.1191
6	20.1193
7	20.1204
8	20.1216

Figure 8-3A. Parabola Height Measurements

I.D Ground 320 Grit

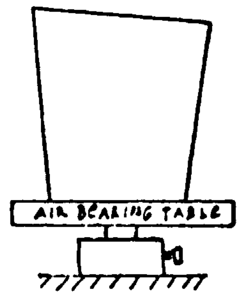


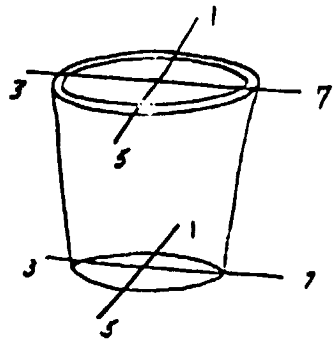


HEIGHT FROM Surface PLATE

LOCATION	
1	20.1000
2	20.1005
3	20.1005
4	20.1000
5	20.9990
6	20.9985
7	20.0990
8	20.9995

Figure 8-3B. Hyperbola Height Measurements





	POSITION	AMPLITUDE
LARGE END	8.5	.0025" LOW
SMALL END	—	—

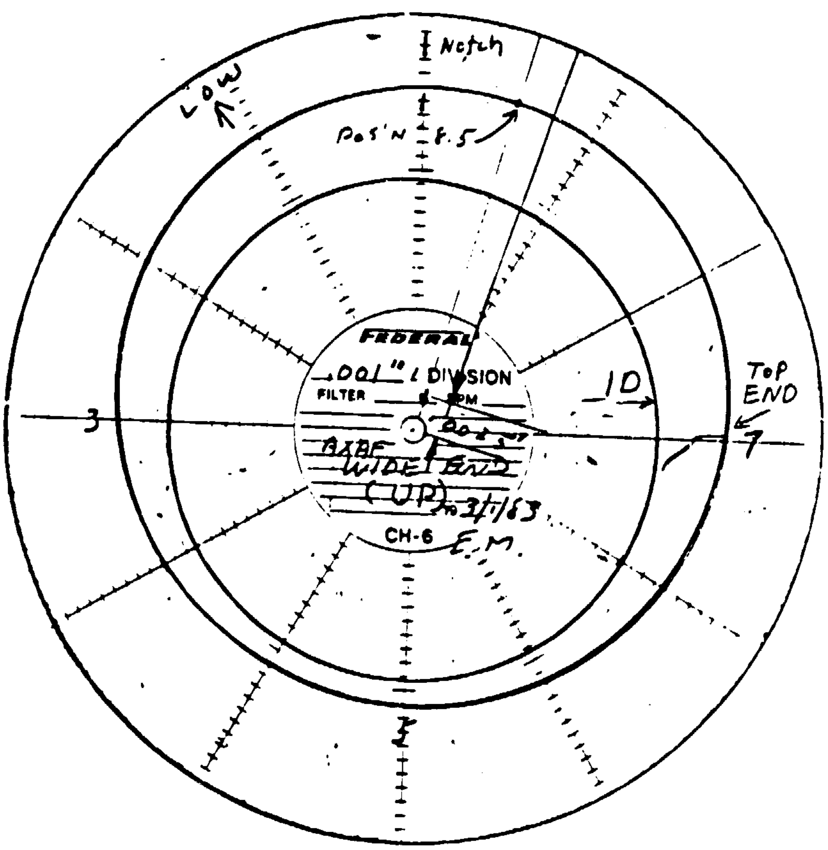
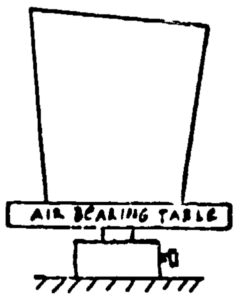
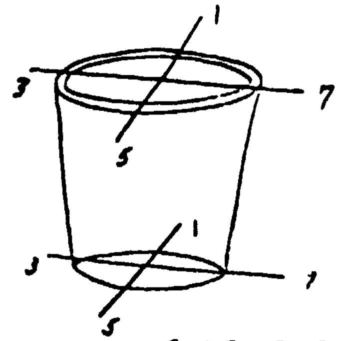


Figure 8-4. Parabola Wedge Measurements, Large End - Position 8.5





	POSITION	AMPLITUDE
LARGE END	—	—
SMALL END	1	.003" LOW

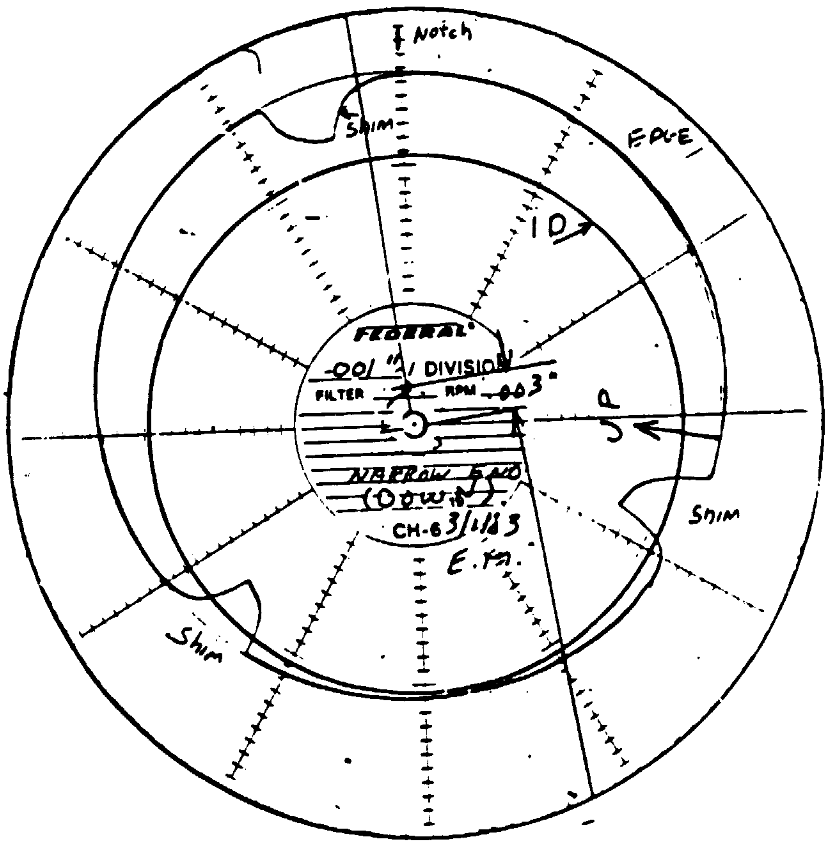


Figure 8-5. Parabola Wedge Measurements, Small End - Position 1

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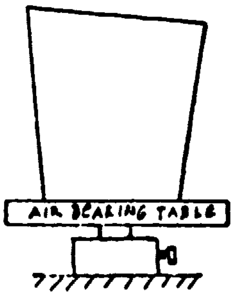

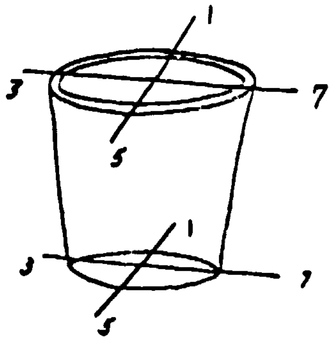

	POSITION	AMPLITUDE
LARGE END	6	.002" HIGH
SMALL END	5	.003" HIGH

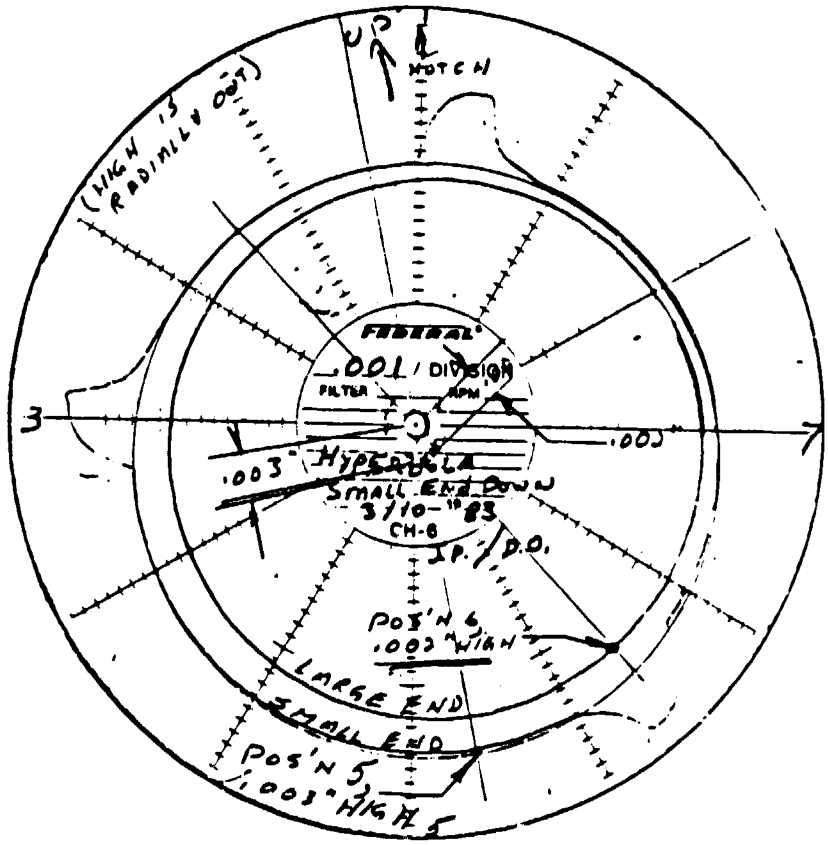

Figure 8-6. Hyperbola Wedge Measurements