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MANUFACTURING METHODS AND TECHNOLOGY PROGRAM ZINC SELENIDE BLAN--ETC(U)
MAY 79 R N DONADIO , J F CONNOLLY
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MANUFACTURING METHODS & TECHNOLOGY PROGRAM
ZINC SELENIDE BLANKS FOR WINDOWS AND LENS ELEMENTS

Third Quarterly Progress Report
1 February 1979 to 30 April 1979

Object of Study

The objective of this manufacturing methods and technology program is to establish the capability to manufacture high volume zinc selenide blanks for infrared windows and lens elements.

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ABSTRACT

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TABLE OF CONTENTS

	<u>Page</u>
1.0 PURPOSE	1
2.0 NARRATIVE AND DATA	3
2.1 Confirmatory Sample Deposit	3
2.2 Pilot Production Run	3
3.0 MEETINGS.....	10
4.0 CONCLUSIONS	10
5.0 PROGRAM FOR NEXT INTERVAL	10
6.0 PUBLICATIONS	10
7.0 PERSONNEL	11

LIST OF ILLUSTRATIONS

	<u>Page</u>
1 Zinc Selenide Compensating Lens	2
2 Curved Mandrel	5
3 Thickness Profile, Plate A, Confirmatory Deposit	6
4 Infrared Transmittance, Confirmatory Deposit, Sample No. 1, $t = 0.373$ in.	7
5 Infrared Transmittance, Confirmatory Deposit, Sample No. 2, $t = 0.374$ in.	7
6 Visible Transmittance, Confirmatory Deposit, Sample No. 1, $t = 0.373$ in.	8
7 Visible Transmittance, Confirmatory Deposit. Sample No. 2, $t = 0.374$ in.	

GLOSSARY

Absorption Coefficient - Fraction of energy lost while traversing a pathlength of one centimeter through a material.

Chemical Vapor Deposition - A process by which chemicals are reacted in the vapor phase to form a compound.

Deposition Temperature - Temperature of the reaction zone in which the chemical vapor deposition takes place.

Evaporator - Apparatus used to form a vapor (or gas) from a solid (or liquid).

Flexural Strength - Maximum fiber stress a material will withstand before rupture in bending.

Image Spoiling Characteristics - That property of a transparent material that defines the ability to resolve discrete images.

Retort - High temperature container used to hold liquid zinc.

Substrate - A form on which material is deposited, sometimes called a mandrel.

Zinc Reservoir System - Apparatus containing one or several liquid zinc retorts and associated monitoring and controlling devices.

1.0 PURPOSE

The purpose of this manufacturing and methods technology program is to establish an automated production process for the fabrication of high optical quality zinc selenide.

The program is of seventeen months duration and is sponsored by the United States Army Electronics Research and Development Command. It addresses itself to the further automation of an existing production process for the chemical vapor deposition of zinc selenide. Raytheon Company has successfully developed the techniques and facilities to fabricate state-of-the-art CVD zinc selenide in large sizes. It is anticipated that with improvements in automated processing the price for standard size lens blanks will be reduced to 50 percent of the catalog price. In addition, the use of a curved substrate may further reduce the price of the color correcting lens blank shown in Figure 1 to less than \$200 each for large volume purchases.

The program has been divided into three phases. In the first phase, zinc selenide test blanks will be produced using the existing process. In Phase II of the program the zinc reservoir system will be replaced with an automated external zinc supply, and blanks will be deposited for confirmation of the optical and mechanical characteristics of the material. The third phase of the program will demonstrate the production capability of a pilot line to manufacture high-quality zinc selenide blanks at four-hundred and eighty-one (481) units per month.

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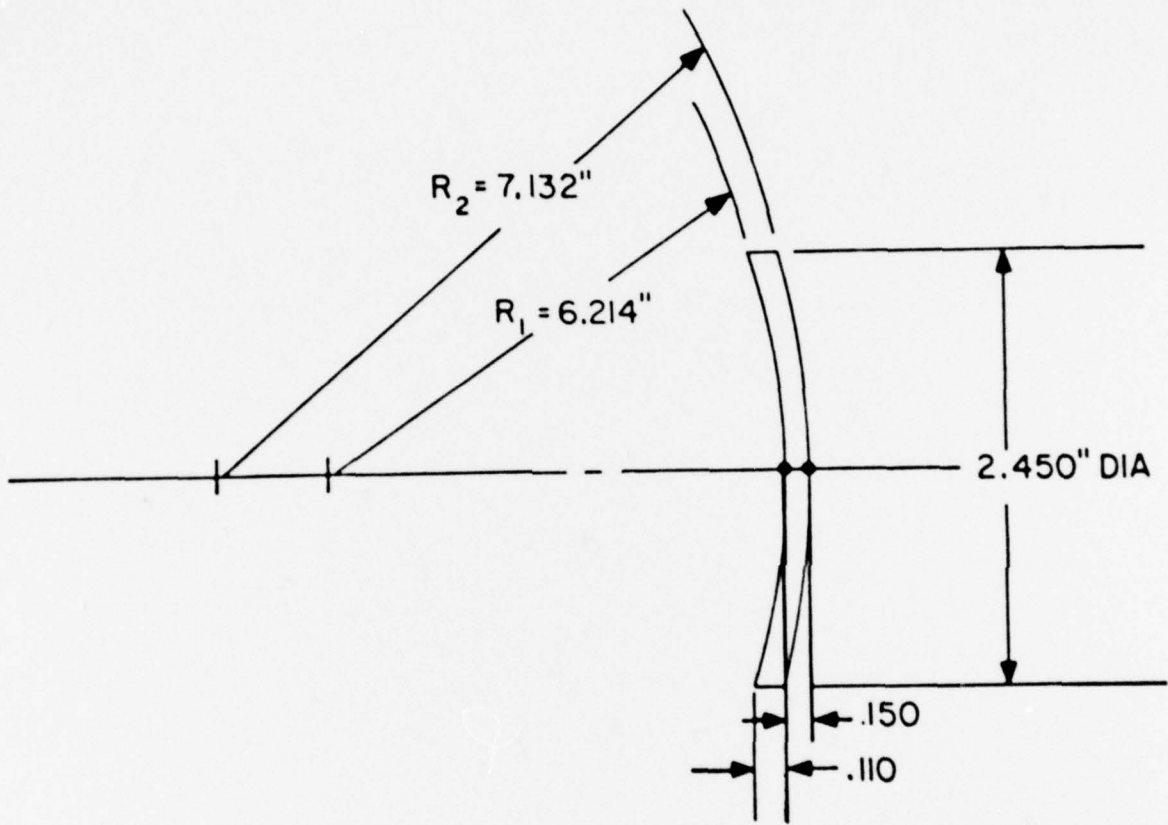


Figure 1. Zinc Selenide Compensating Lens.

2.0 NARRATIVE AND DATA

2.1 Confirmatory Sample Deposit

2.1.1 Deposition

A 143 hour zinc selenide deposit was conducted to yield the required confirmatory samples. (Table 1 presents the deposition conditions for this deposit.) The deposit was made in a graphite box mandrel of inside dimensions 12 X 22 X 63 inches. The curved mandrel concept was incorporated in the graphite substrate producing zinc selenide lenses to near finished dimensions on one side. Figure 2 displays the curved mandrel concept as described in a previous report.

The thickness profile for one of the deposited plates is presented in Figure 3 revealing adequate overall thickness and uniformity. Also shown is the location of the concave lens sites and the thickness of the lens blanks. Two witness samples were fabricated from the deposit for preliminary optical evaluation. The infrared and visible transmittance curves for these samples are shown in Figures 4 through 7 revealing transmittance values that meet the program requirements. The two samples were measured for absorption coefficient at $10.6 \mu\text{m}$, yielding a β (including surface absorption) = 0.0019 cm^{-1} .

Flexural test specimens approximately $1/4 \text{ X } 1/4 \text{ X } 2-1/4$ inch were prepared from the top and bottom of the deposit. Table 2 contains the data for this modulus of rupture test. All samples meet the minimum strength requirement of 6570 psi.

The zinc vaporization system performed well throughout the 143 hour deposit. No malfunctions of any kind were detected.

TABLE 1

Run No.	DEPOSITION CONDITIONS				
	Temp (°C)	Furnace Pressure (torr)	H ₂ Se Usage (lpm)	Zinc Usage (g/hr)	Deposition Time (hrs)
Pre-engineering	730	24	4.0	700	84
Engineering Deposit	730	24	4.2	735	327
Confirmatory Deposit	750	25	5.0	874	143

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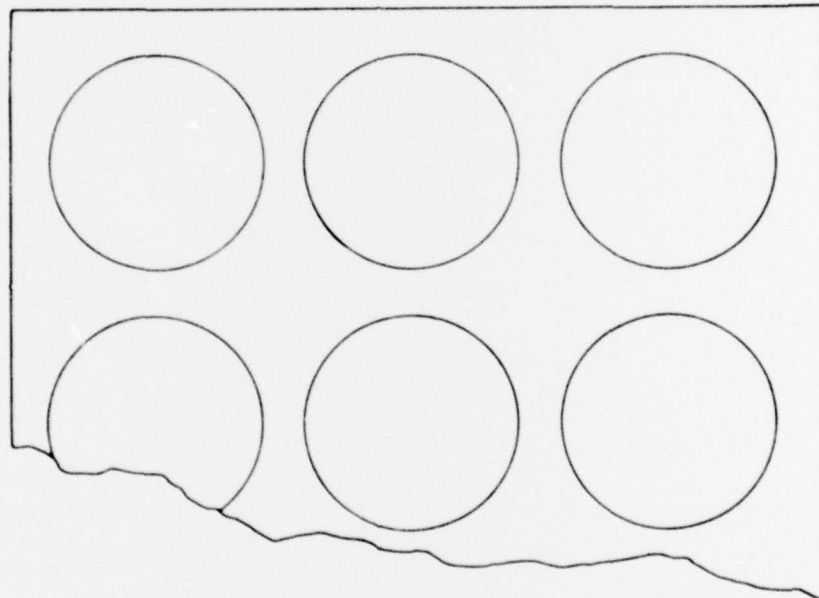
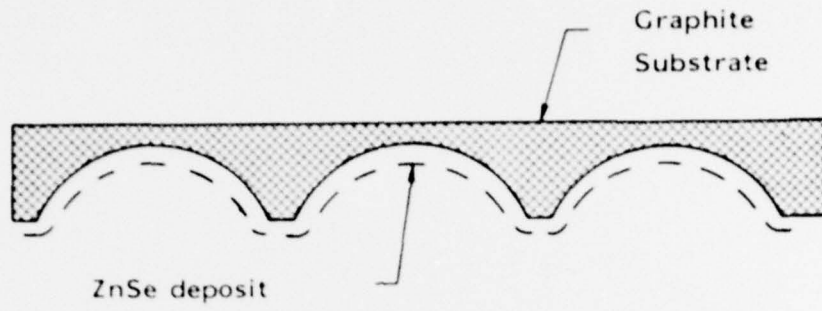


Figure 2. Curved Mandrel.

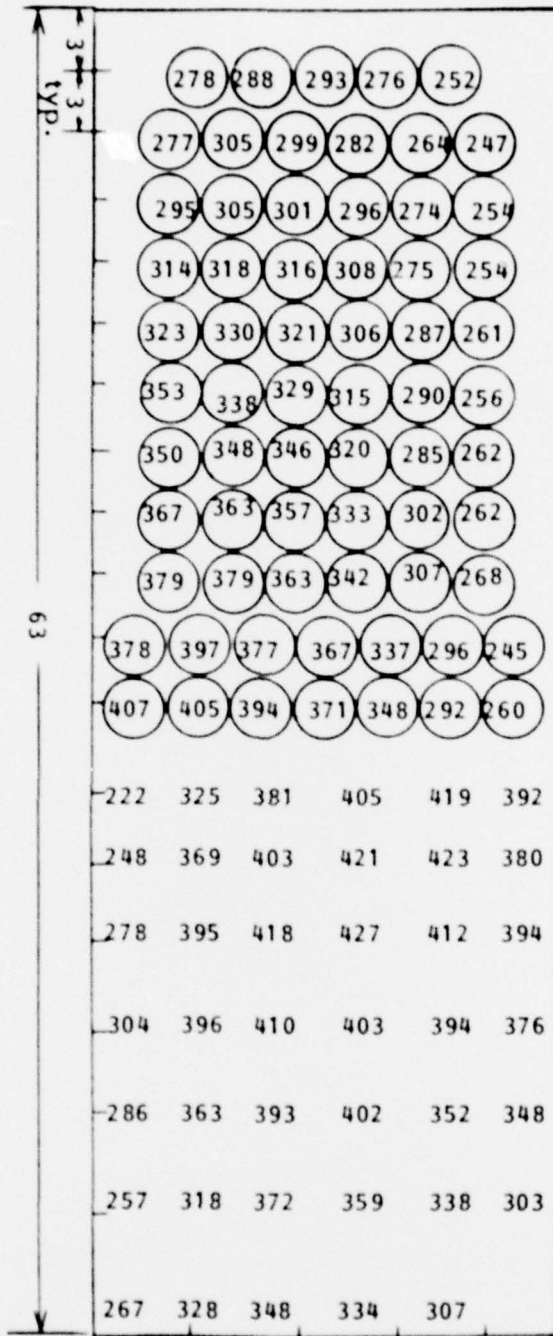


Figure 3. Thickness Profile, Plate A, Confirmatory Deposit.

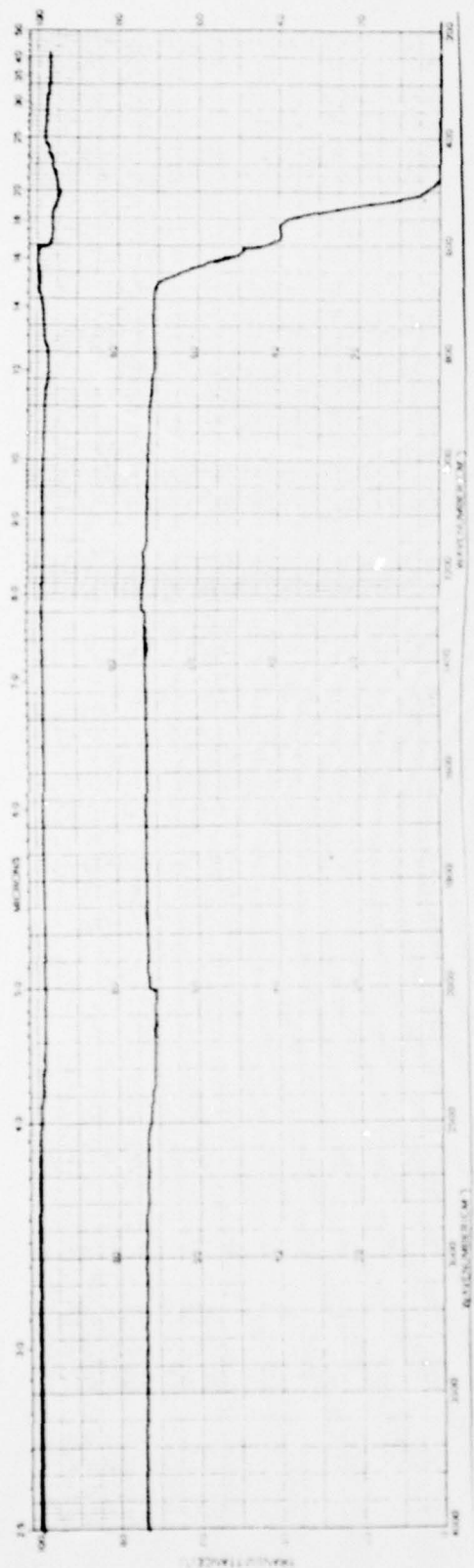


Figure 4. Infrared Transmittance, Confirmatory Deposit, Sample No. 1, $t = 0.373$ in.

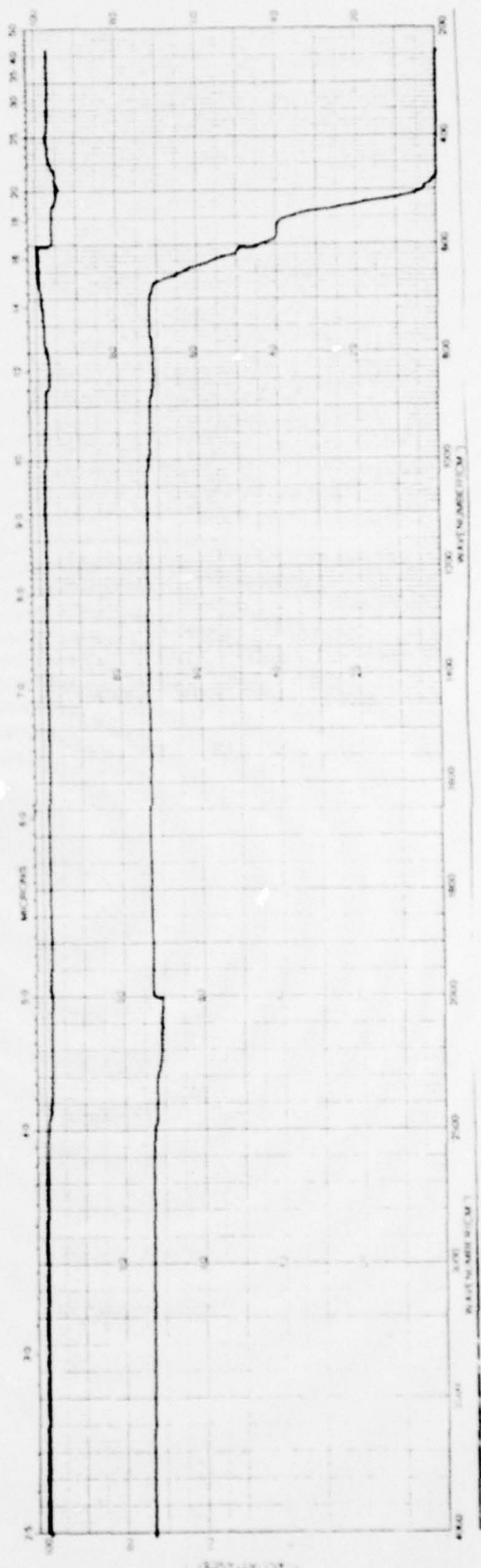


Figure 5. Infrared Transmittance, Confirmatory Deposit, Sample No. 2, $t = 0.374$ in.

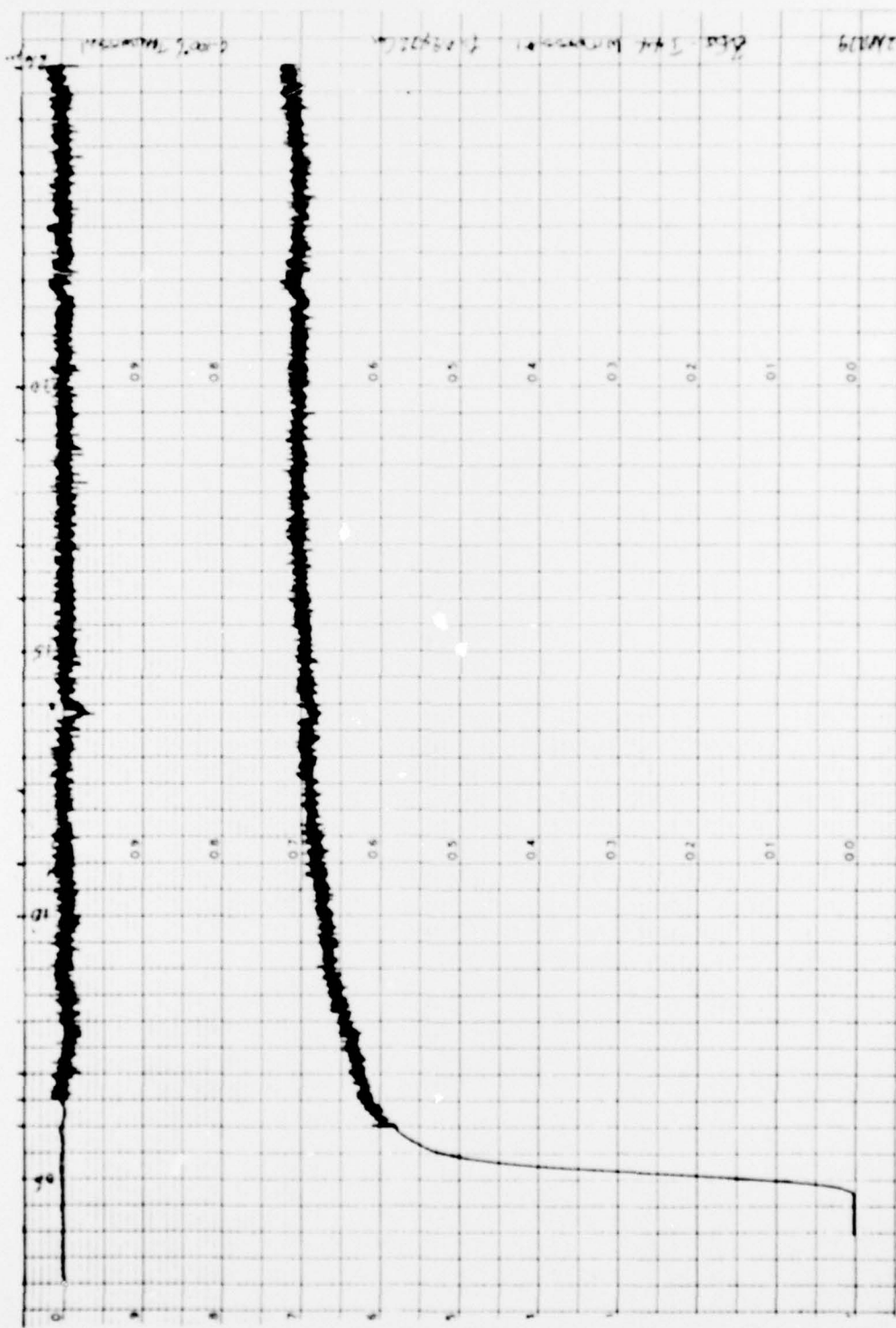


Figure 6. Visible Transmittance, Confirmatory Deposit, Sample No. 1,
 $t = 0.373$ in.

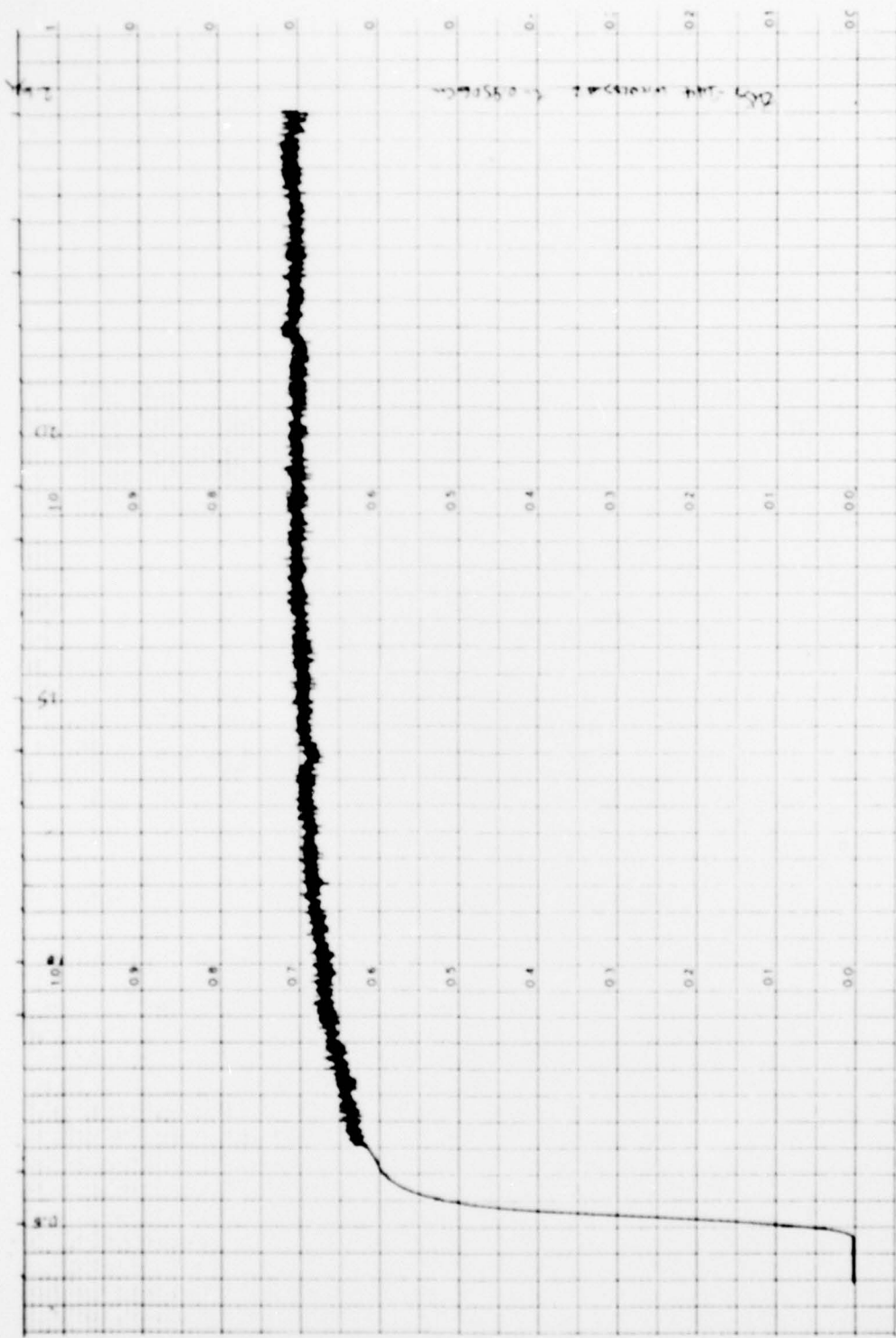


Figure 7. Visible Transmittance, Confirmatory Deposit, Sample No. 2,
 $t = 0.374$ in.

TABLE 2

MODULUS OF RUPTURE DATA FOR CONFIRMATORY DEPOSIT

4-Point Loading

TOP

<u>Sample No.</u>	<u>Strength (psi X 10³)</u>
1	9.57
2	9.60
3	9.27
4	8.11
5	6.61

BOTTOM

1	8.49
2	6.91
3	6.71
4	7.18
5	8.87

Avg. 8.13 ± 1.2

2.1.2 Sample Requirements

The zinc selenide from the confirmatory deposit shall be fabricated into: (20) lens blanks having sufficient material to yield the lens element as per drawing No. SM-C-804146, (2) 49 mm diameter X 6.35 mm thick, (2) 61 mm diameter X 6.35 mm thick, and (2) 67.5 mm diameter X 6.35 mm thick. These blanks or witness samples will be tested to meet the following specifications:

a) Transmission

The uncoated transmittance for a 6.35 mm thickness shall be greater than 58 percent over the wavelength region 8 to 13 μm at normal incidence. Over the wavelength region 0.6 to 1.1 μm the transmittance shall be greater than 43 percent.

b) Inclusions

The maximum size inclusion is 0.625 mm. The permissible number of maximum size inclusions is one per each cubic centimeter of material. The sum of the diameters of all inclusions in any given cubic centimeter of material shall not exceed 0.625 mm. Bubbles are classified as inclusions.

c) Surface Hardness

The Knoop, 50 gram, hardness rating shall be at least 100.

d) Absorption

The absorption over the 8 to 12 μm region will be less than 0.01 per centimeter. The absorption at 10.6 μm will be less than 0.005 per centimeter.

e) Scatter

The angular spread of a focused spot on a blank 6.35 mm thick shall increase by more than 15 percent over the angular spread of the same spot without the sample in the beam over the wavelength region 0.6 to 1.2 μm . The angular spread over the wavelength region 8 to 12 μm will be less than 2 percent.

f) Rupture Modulus

The modulus of rupture shall be an average 7300 pounds per square inch and a minimum value not less than 6570 psi.

g) Parallelism

The provided blanks shall have maximum allowable wedge of 10 minutes. The blank(s) used for image spoiling tests will have a maximum wedge of 0.5 minute.

h) Strain

The distribution of permanent strain shall be symmetrical, and the birefringence resulting from permanent strain will not produce more than 10 nanometers relative retardation or path difference per centimeter of a transmitted narrow-band light source.

i) Chips and Fractures

A vented fracture exceeding 10 mm in length or aiming at the center of the blank shall be rejected. Blanks having pressure or fire cracks deeper than 1 mm shall be rejected. Other surface irregularities, pits, or cracks shall not extend into 2.55 mm diameter of the blanks required to yield the lens, as per drawing No. SM-C-804146.

3.0 CONCLUSIONS

The confirmatory sample deposit was successfully completed yielding sufficient material to produce the required number of lens blanks. Initial testing for the optical quality of the zinc selenide shows good transmittance and low absorption coefficient. It is anticipated there will be no difficulty in meeting the program requirements for all properties of interest.

4.0 PROGRAM FOR NEXT INTERVAL

Testing and evaluation of the confirmatory deposit samples will be conducted. Preparations for the pilot product run will begin.

5.0 PUBLICATIONS

There were no publications during this reporting period.

6.0 PERSONNEL

The following are the worked manhours for key personnel on this program:

<u>Name</u>	<u>Manhours During Report Period</u>
Mr. R. Donadio	70.0
Mr. J. Connolly	324.0
Dr. T. Kohane	99.0
Mr. T. Varitimos	192.0
Research Technicians	442.5
Publications Specialists	17.5
Total	1,145.0

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