INFRA-RED and ELECTRO-OPTICS

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BARNES ENGINEERING COMPANY

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BEC-4674

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Test and Evaluation of an ULTRAVIOLET OBJECTIVE SPECTROGRAPH Fabricated under Contract NAS 5-1897 for the GODDARD SPACE FLIGHT CENTER

Prepared by

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Test Conducted by

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Approved by

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January 10, 1962

ABSTRACT

The following is a report of the procedures involved in the fabrication, testing and evaluation of an ultraviolet objective spectrograph as fabricated by Barnes Engineering Company for the NASA Mercury program.

TABLE OF CONTENTS

ILLUSTRATIONS

I. INTRODUCTION

The task was to fabricate a small, lightweight, handheld, easily operated ultraviolet spectrograph. This instrument is to be utilized by the Mercury astronaut to photograph preselected objects while in orbit. As weight, size and other physical requirements were quite stringent, the following components were used.

1. A 105mm f/3.3 quartz-lithium fluoride refracting system achromatized for the region 2800 Å - 5200 Å. Tests have shown that this lens is capable of excellent coverage in the lower wavelength region 2000 Å - 3100 Å. The lens was designed by H. McKinley of Barnes Engineering Company. Upon reviewing the results obtained, we find this lens to be the logical choice for the collecting optics of this spectrograph.

2. A Bausch & Lomb reflection replica grating, No. 33-53-10-01, is used as the dispersing medium. This grating has the following specifications:

   a. 600 grooves/mm
   b. 3000 Å - blaze wavelength
   c. 5° 10' - blaze angle
   d. BSC-2 - grating material
   e. 100 Å/mm - dispersion with lens system used

3. The camera body used was a Canonflex R-2000 reflex 35mm camera. This camera was selected after running the gamut of several cameras, which all appeared to be well

suited to the task, but upon final evaluation proved unsuitable for the purpose. The Canonflex R-2000 was chosen for a variety of reasons ranging from its all around ruggedness to its complete adaptability in the short time scale involved. Some of this camera's more pertinent features are:

a. A film transport and shutter cocking mechanism, conveniently placed at the base of the camera and designed for fast, sequence-type photography.

b. The front aperture of this camera was easily modified to accept the extremely large rear lens element with a minimum of modification to the camera.

c. The instant return mirror, which made for easy sighting and immediate pickup of the subject material

d. Detent located shutter-speed mechanism, with all shutter speed positions linearly spaced.

4. A Barnes Engineering Company off-axis collimator was used as the source of parallel energy. A fine slit was placed at the focal plane of the primary reflector. As a spectral source, an Osram cadmium source was used, which proved to be especially useful in the region of interest. This source was photographed throughout a complete range of exposures from 5 seconds to 1/2000 of a second.

5. Eastman Kodak emulsion-type 103-0 spectrographic film was used both for the evaluation and for the final test of this optical system. The emulsion had been presensitized in a 2 per cent solution of sodium salicylate in methyl alcohol

so as to increase its sensitivity in the lower wavelength region.

II. CONCLUSION AND TEST REPORT

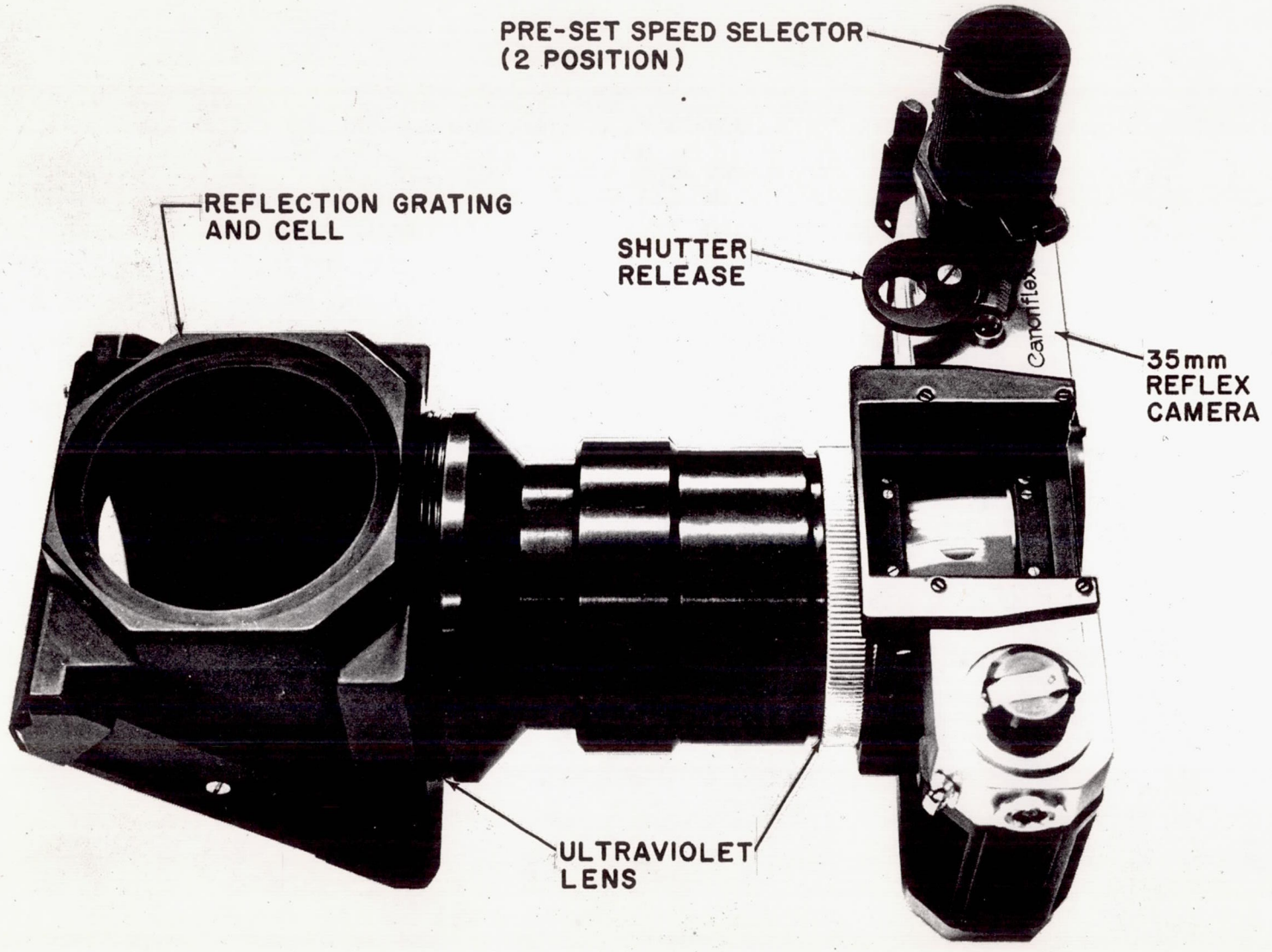
As there was at the time a limited amount of information concerning the sighting and aiming of the spectrograph, we proceeded to design a system that would encompass various modes of sighting. Of particular interest was the condition whereby we were required to use the longer portion of the format, 36mm in length, due to the dispersion of this system. The total wavelength coverage on this format size is approximately 34mm from central image to 3600 Å. There has been an allowance made for tracking and aiming error.

As the spectrograph now stands, there are two distinct positions that can be utilized for sighting, (1) eye level and (2) waist level. The spectrograph can be used on either its right or left side. The rotation of the grating cell makes for a variety of spectral displays, rendering this system versatile.

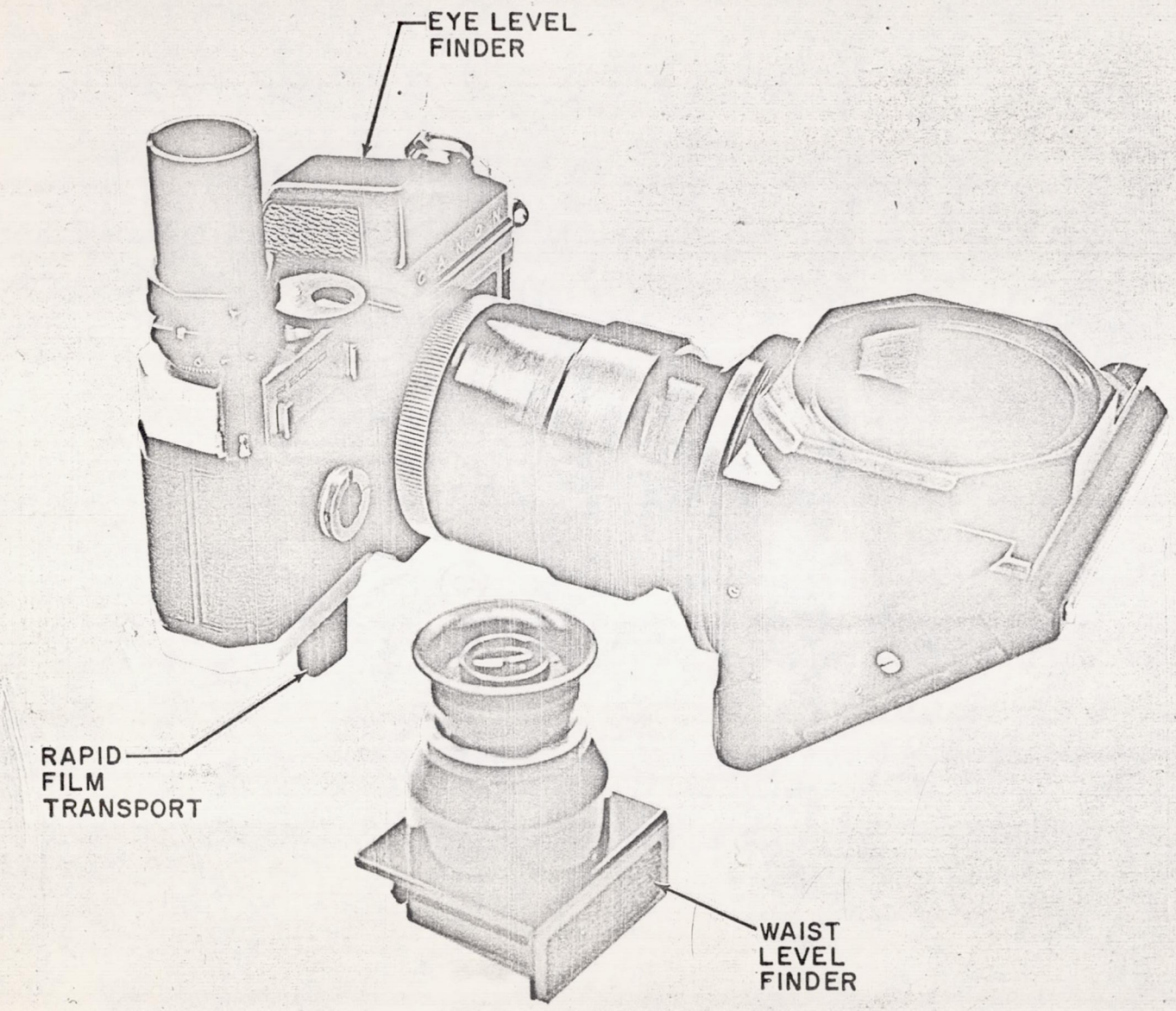
III. RESULTS OF TEST AND EVALUATION

Attached to this report is a reproduction of a photograph of a cadmium source as photographed through the Barnes ultraviolet spectrograph. This print illustrates the resolution attainable throughout 2100 Å - 3100 Å region. This print also shows the effectiveness of presensitizing the 103-0 emulsion with sodium salicylate in methyl alcohol. A set of curves are included showing the density differences obtained between two 103-0 emulsions, normal and presensitized.

A calibration curve showing wavelength vs position in a 35mm format is included. This curve depends, to a certain extent, on the position of the data in the format, since the instrument has a flat field of view.



PROJECT MERCURY ULTRAVIOLET CAMERA



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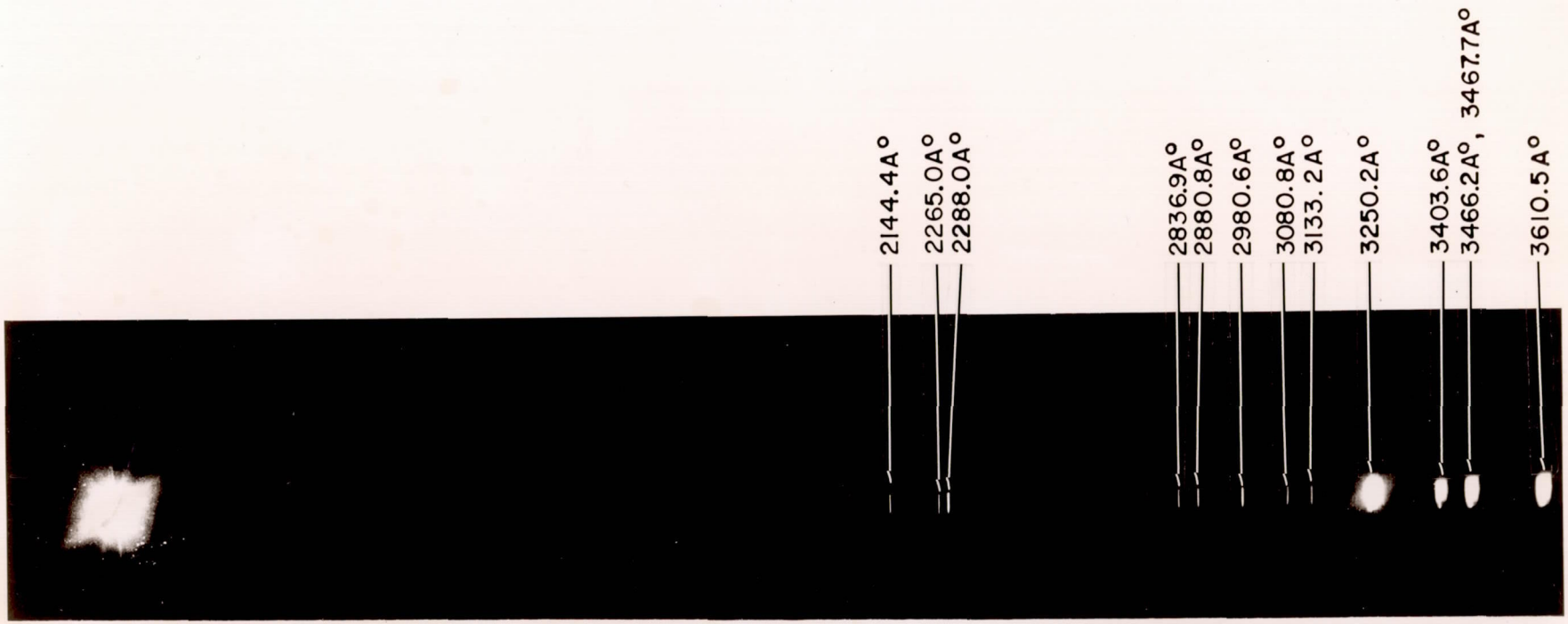
PROJECT MERCURY ULTRAVIOLET CAMERA



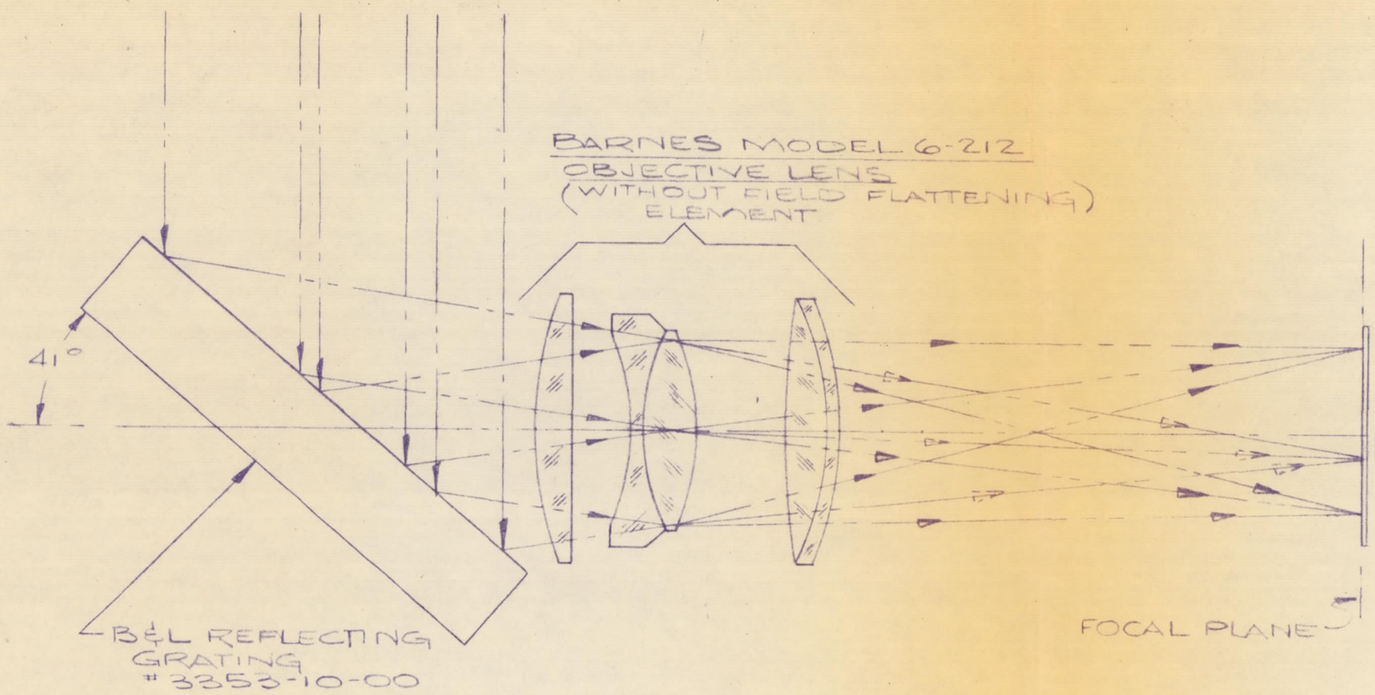
SPECTROGRAM OF CADMIUM SOURCE TAKEN WITH BARNES ENGINEERING COMPANY
ULTRA-VIOLET OBJECTIVE, 105MM, f/3.3

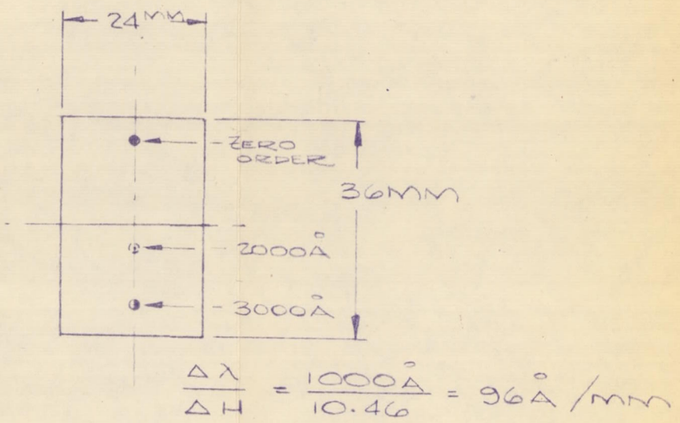
1266

A	1000-LO-00-4674

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL
A.	NOTE 4 REVISED. NOTE 5 ADDED		





$$\frac{\Delta\lambda}{\Delta H} = \frac{1000\text{Å}}{10.46} = 96\text{Å/mm}$$

NOTES:

1. ZERO ORDER:
   $u = 8°$, $H = f' \tan u = 102.1 \tan 8° = -14.35\text{MM}$
2. 1ST ORDER:
   2000Å: $\sin\theta = \lambda/d + \sin 41° = .120 + .65606 = .77606$
   $\theta = 50.901°$; $u = \theta - 49 - 1.901°$
   $H_{2000} = f' \tan u = +3.39\text{MM}$
   3000Å: $\sin\theta = .180 + .65606 = .83606$
   $\theta = 56.726°$; $u = \theta - 49 = 7.726°$
   $H_{3000} = +13.85\text{MM}$.
3. MOON SUBTENSE: $102.1 \times \frac{1}{2}° = .89\text{MM}$.
4. (A) ABERRATION: .006" = .15MM
5. TOTAL MOON IMAGE = 0.89+0.15 = 1.04MM = 99.8Å

SEP 28 1962

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
± 1/64	± .005	± 1/2°

MATERIAL

FINISH

APPROVALS
BARNES ENGINEERING CO.

DRAWN	EMP	12-12-61
CHECKED		
APPROVED		12-12-61
APPROVED		

OPTICAL BLOCK DIAGRAM, U.V. SPECTROGRAPH, 35MM

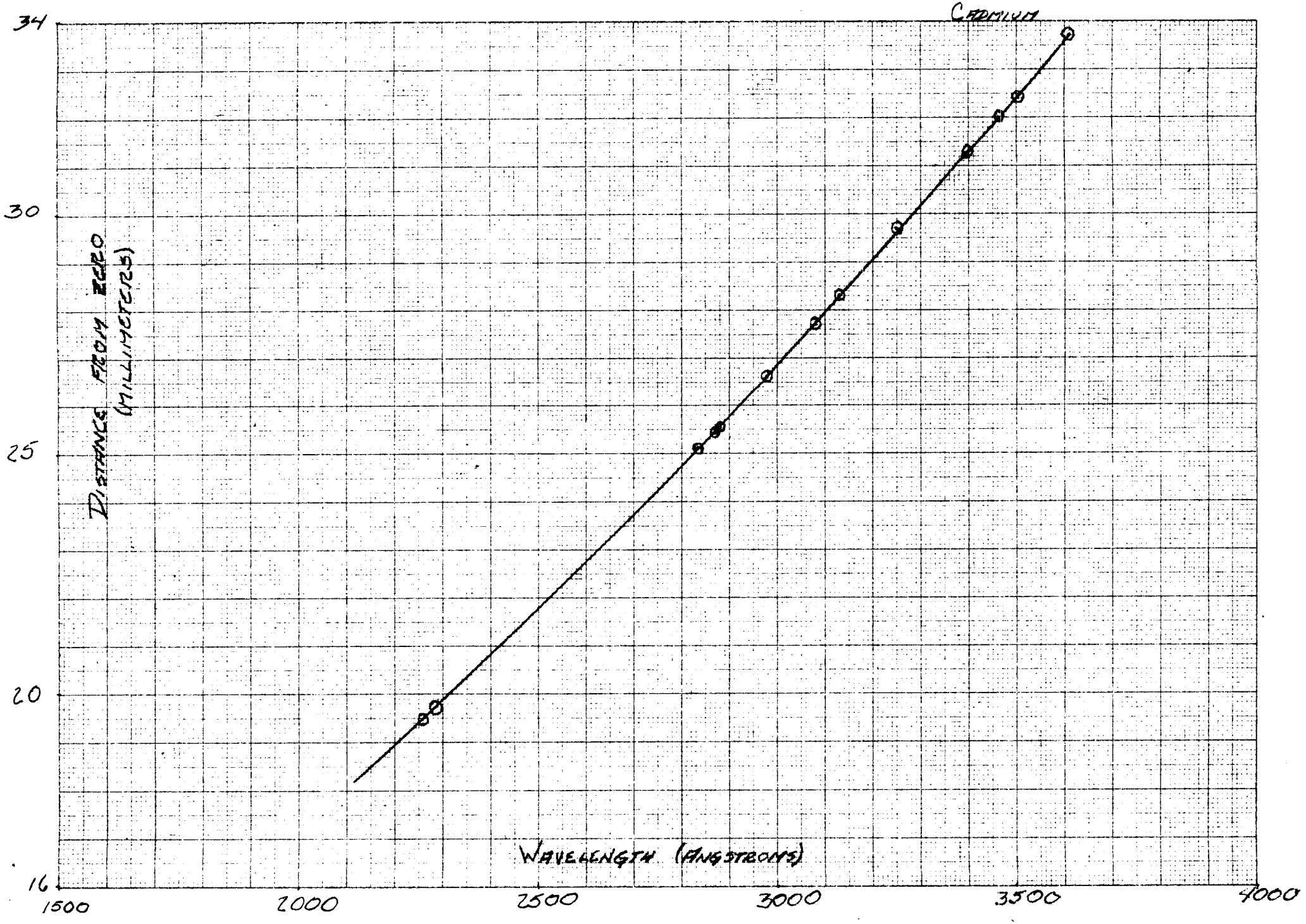
SCALE

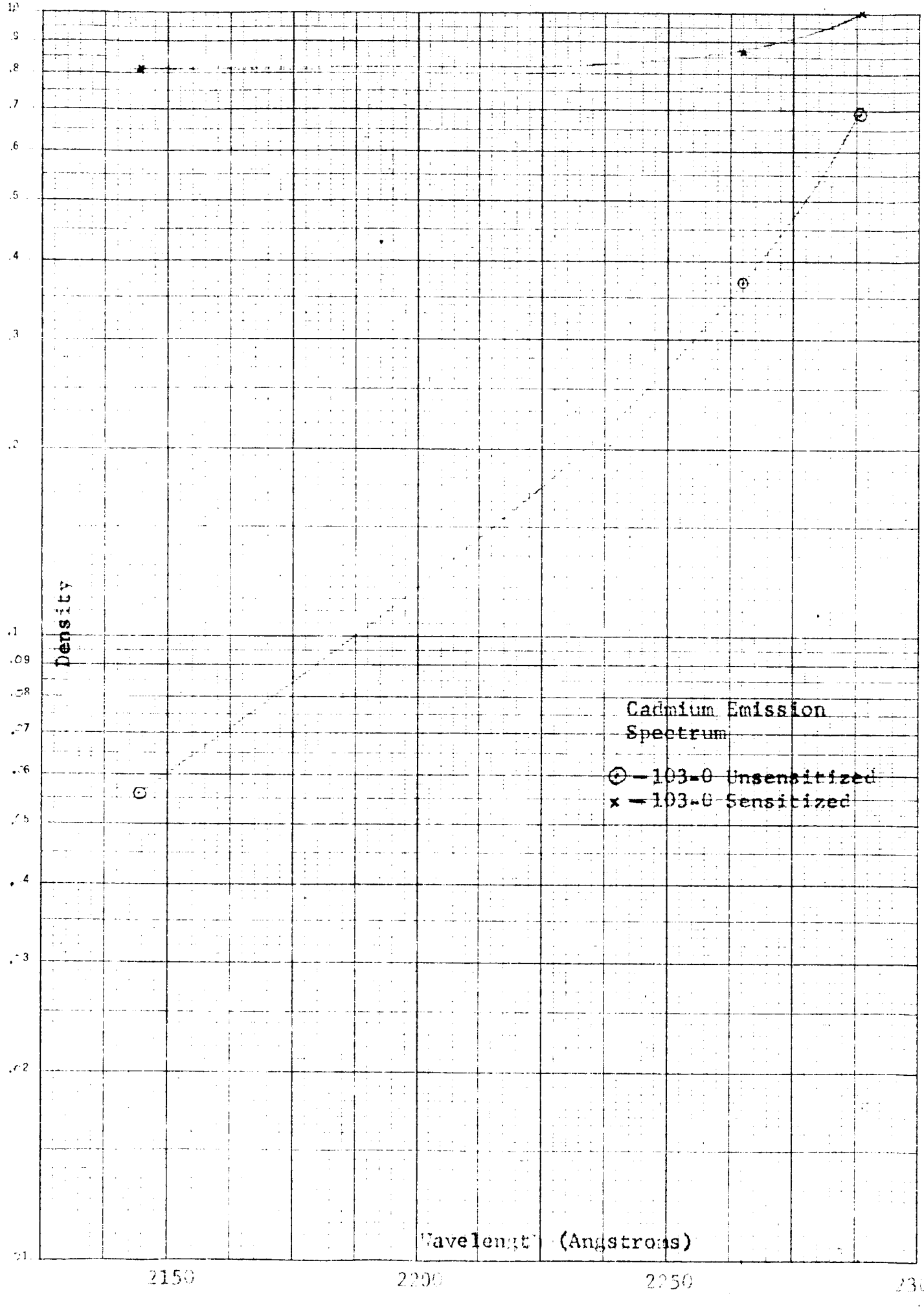
Barnes Engineering Company
Stamford, Connecticut

DWG SIZE B | 4674-00-07-0001 | A

CODE | SHEET OF

OGILVIE PRESS, INC., BROOKLYN 17, N. Y. 195M




Density
Cadmium Emission Spectrum
⊙ — 103-0 Unsensitized
× — 103-0 Sensitized
Wavelength (Angstroms)
2150
2200
2250
2300

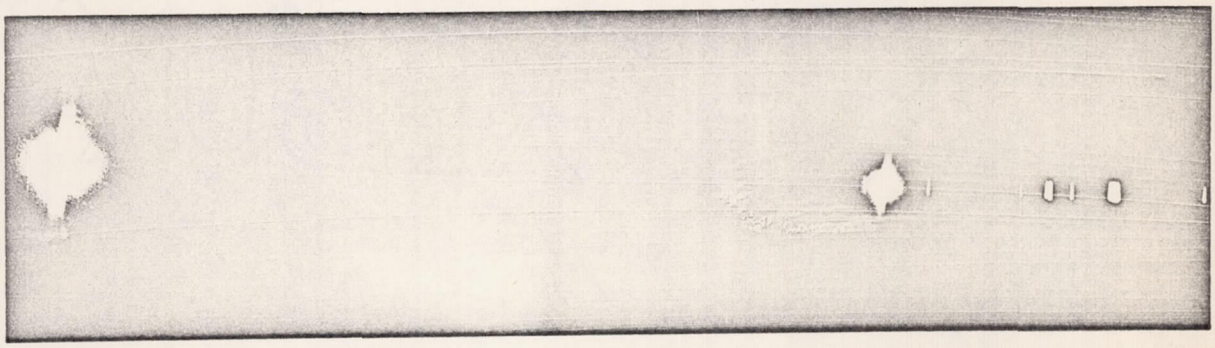
ADDENDUM

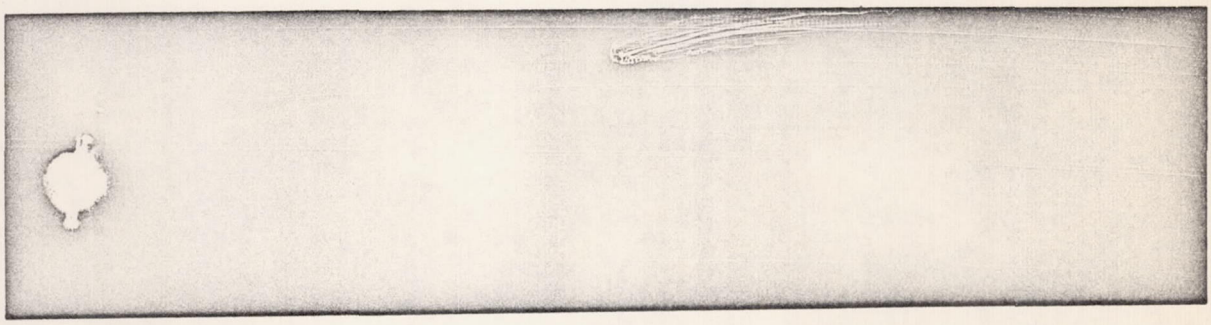
On December 19, 1961, representatives of Barnes Engineering Company carried out a test to evaluate the ultraviolet transmission and optical quality of the window in the Mercury capsule. An optical collimator with a low-pressure, quartz-jacketed Hg arc was the source of light, and it was photographed with the uv objective spectrograph both through the window and with the window out of the optical beam.

Attached to this report are two selected prints of the Hg spectrum as photographed directly and through the Mercury capsule window. The exposure time in both cases was one second.

The upper spectrogram as viewed shows a very dense central image and spectrum running to the edge of the format. This spectrogram was photographed with the camera directly in front of the collimator.

The lower spectrogram, taken through the window, shows a very dense central image only. None of the Hg lines below 3600 Å appear, indicating that the window transmission in the ultraviolet is extremely low. It is difficult to state quantitatively from these results; but it can be said that the transmission of the window is less than 0.005, or 1/2 of one percent, since an exposure of one second through the window showed absolutely no recorded spectrum below 3600 Å, while an exposure of 1/500 second with the window





NL

out of the beam produced an observable spectrum.

The conclusion is that one or more of the three sections that make up the window is composed of glass rather than fused quartz or Vycor. It was suggested that the polaroid filter was in place during these tests, but this is not the case. The polaroid filter was held back out of the way with masking tape and the window was absolutely clear to the eye.

No ultraviolet results can be obtained through this window. Before the uv spectrograph can be effectively used from the Mercury capsule, those sections of the window that are opaque will have to be replaced with fused quartz. Vycor may serve satisfactorily; but quartz is better, having a higher transmission.