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THE CALIBRATION OF PHOTOGRAPHIC AND SPECTROSCOPIC FILMS

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RECIPROCITY FAILURE AND THERMAL RESPONSES OF IIaO FILM AT LIQUID NITROGEN TEMPERATURES

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SEMI-ANNUAL REPORT

APRIL 26, 1985

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L.M. CUNNINGHAM, and D.D. WRIGHT

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BALTIMORE, MARYLAND 21239

SUBMITTED TO NASA, LABORATORY FOR ASTRONOMY AND SOLAR PHYSICS

GODDARD SPACE FLIGHT CENTER, GREENBELT, MARYLAND 20770

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Abstract Submitted
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Geophysics, Astronomy
and Astrophysics

Reciprocity Failure and Thermal Responses of IIaO Film at Liquid Nitrogen Temperatures, E.C. HAMMOND, JR., K.A. PETERS, S.O. Gunther, L.M. CUNNINGHAM, and D.D. WRIGHT--Morgan State University--Reciprocity failure was examined for IIaO spectroscopic film. The results indicate reciprocity failure occurs at three distinct minimum points in time; 15 minutes, 30 minutes and 90 minutes. The results are unique because theory suggests only one minimum reciprocity failure point should occur. When incubating 70mm IIaO film for 15 minutes and 30 minutes at temperatures of 30°, 40°, 50° and 60°C and then placing in a liquid nitrogen bath at a temperature of -190°C the film demonstrated an increase of the optical density when developed at a warm-up time of 30 minutes. Longer warm-up periods of 1 hour, 2 hours and 3 hours yield a decrease in optical density of the darker wedge patterns; whereas, shorter warm-up times yield an overall increase in the optical densities.

Signature of APS Member

( ) Prefer Poster Session
( ) Prefer Standard Session
( ) No preference

Ernest C. Hammond, Jr.

Morgan State University
Baltimore, Maryland

ABSTRACT

Incubating a 70mm IIaO film for 15 minutes and 30 minutes at temperatures of 30, 40, 50 and 60 °C and then placing in a liquid nitrogen bath at a temperature of -190°C, demonstrated an increase of the optical density when developed at a warm-up time of 30 minutes. Longer warm-up periods of 1 hour, 2 hours and 3 hours yield a decrease in optical density of the darker wedge patterns, whereas shorter warm-up times yield an overall increase in the optical densities.

INTRODUCTION

35mm IIaO film flown on STS-7, STS-8 and STS-3 revealed that the film on board experiences a variety of thermal changes. During the flight the film was exposed to temperature ranges of (+) 22 °C to (-) 22 °C. Upon return, the film was exposed to uncertain thermal conditions as it remained on board the shuttle. Temperature ranges of (+) 40 °C to (-) 196 °C were established for the purpose of simulating the large range of temperature variations observed terrestrially and during orbital flight. Early results from the developed films of 30 °C and 50 °C incubation established an inconsistency in the relationship between optical density and temperature. It was necessary to broaden the range to include 40 C and 60 °C due to fluctuation and inconsistencies of the 30 °C and 50 °C incubation for optical densities of 30 minutes, 1 hour, 2 hours and 3 hours warm-up periods. The data generated at 40 °C and 60 °C provided evidence that indicated a consistent pattern between the warm-up times, whereby the lowest density pattern resulted from 2 hour and 3 hour warm-up periods, and conversely the highest optical density pattern resulted from the 30 minutes and 1 hour warm-up periods, respectively.

MATERIALS AND METHODS

In total darkness, a pattern consisting of thirty (30) wedges was placed upon sixteen (16) sections of 70mm IIaO spectroscopic film, by a sensitometer that produces the classical "S" shaped curve. A standard bulb with a 24 hour burnin was used to expose the film at ten (10)-second intervals.

The film was cut and placed in sixteen individual canisters. The films were then divided into four groups and labeled accordingly (Table I and Table II).

The temperature of the incubator was set at 30 °C. At time (T=0) groups I and II were placed in the incubator. Group I was removed from the incubator at T + 15 minutes, and placed into the liquid nitrogen bath at a temperature of -196 °C until T + 30 minutes. At T + 30 minutes, group II was removed from the incubator and placed in the liquid nitrogen bath, (liquid nitrogen was used after incubation of all films), while Group I was removed from the liquid nitrogen bath. Film sections from group I were removed from their canisters and permitted to warm-up to a room temperature of approximately 22 °C. The films were removed from their canisters in order to eliminate the buildup of moisture on the emulsion due to condensation, while still in total darkness.

At T + 60 minutes, group IA was developed using Kodak D-19 developer, rapid fixer, hypo-clearing agent, and photo-flo solutions which had been prepared prior to the experiment.

At T + 60 minutes group IA was placed in the developer for 4 minutes, washed for 1 minute in water and placed in rapid fixer for 4 minutes. The film was then removed from the darkroom in order to remove the anti-reflection coating without exposing the remaining films. It was then placed in the hypo-clearing agent for 1 minute, washed in water for 1 minute, placed in photo-flo for 1 minute and then hung to dry.

At T + 75 minutes groups IB and IIA were developed and each subsequent development was performed according to the warm-up period, following the same development procedures.

After the films had dried at a room temperature of 22 °C, the patterns were then read and recorded using a Macbeth densitometer.

RESULTS

Graphs depicting the optical density versus the wedge patterns indicate the relationship that exist between incubating temperatures and warm-up periods.

Graph A represents the optical density versus the wedge patterns for 70mm IIaO spectroscopic film exposed to a temperature of 60 °C with a 15 minute incubating period followed by 15 minutes in liquid nitrogen and varying warm-up periods of 30 minutes, 1 hour, 2 hours and 3 hours. This graph illustrates that the 30-minute warm-up period has the highest optical density followed by the 1-hour, 2-hour and 3-hour warm-up periods in decreasing order of optical density as shown on table III and graph A.

Graph B represents the optical density versus wedge patterns for the same type film exposed to a temperature of 60 °C with a 30-minute incubating period followed by 15 minutes in liquid nitrogen again with varying warm-up periods of 30 minutes, 1 hour, 2 hours and 3 hours. Again the 30-minute warm-up period had the highest optical density followed by the 1-hour, 2-hour and the 3-hour warm-up period in decreasing order of optical density. Table IV and graph B indicate this relationship.

Graph C represents the optical density versus warm-up periods for film exposed to a temperature of 40 °C with a 15-minute incubating period followed by a 15-minute exposure to liquid nitrogen with varying warm-up times of 1 hour, 2 hours and 3 hours. A similar pattern exists with regard to warm-up periods. The shorter the warm-up period the higher the optical density. Table V and graph C show the varying warm-up times in order of decreasing optical density.

Finally, graph D represents the same film exposed to a temperature of 40 °C with a 30-minute incubating period followed by warm-up periods of 30 minute, 1 hour and 2 hours. The results show that the 1 hour warm-up has the highest optical density followed by 30 minutes and 2 hours. Table VI and graph D indicate this relationship.

DISCUSSION

The experimental data show that warm-up times before development are crucial to the development process demonstrated by the data from warm-up periods of 30 minutes, 1 hour, 2 hours and 3 hours. Incubating the film, immersing the film to specified periods of warm-up for 30 minutes, 1 hour, 2 hours and 3 hours, would suggest that a stabilization of the optical density occurred for long warm-up periods. The implication of these results is that a weak image on the emulsion after the film has undergone thermal exposures similar to those in this study could gain enhancement by the film being developed shortly after it is received from the space shuttle or satellite, particularly if the image densities occurred near the upper half of the "S" shaped curve.

CONCLUSION

Longer warm-up periods produce a decrease in optical density as seen at temperatures of 40 °C and 60 °C, but the shorter warm-up periods produced higher optical densities for 40 °C and 60 °C. This higher optical density at shorter warm-up times may establish an amplification of optical density.

Table I

	Incubation Temp (°C)	Incubation Time (min)	Liquid Nitrogen Bath (min)	Warm-up Time (hrs)
GROUP I				
A	30	15	15	0.5
B	30	15	15	1.0
C	30	15	15	2.0
D	30	15	15	3.0
GROUP II				
A'	30	30	15	0.5
B'	30	30	15	1.0
C'	30	30	15	2.0
D'	30	30	15	3.0
GROUP III				
E	50	15	15	0.5
F	50	15	15	1.0
G	50	15	15	2.0
H	50	15	15	3.0
GROUP IV				
E'	50	30	15	0.5
F'	50	30	15	1.0
G'	50	30	15	2.0
H'	50	30	15	3.0

Table II

	Incubation Temp (C)	Incubation Time (min)	Liquid Nitrogen Bath (min)	Warm-up Time (hrs)
Group I				
AA	40	15	15	0.5
BB	40	15	15	1.0
CC	40	15	15	2.0
DD	40	15	15	3.0
GROUP II				
AA'	40	30	15	0.5
BB'	40	30	15	1.0
CC'	40	30	15	2.0
DD'	40	30	15	3.0
GROUP III				
EE	60	15	15	0.5
FF	60	15	15	1.0
GG	60	15	15	2.0
HH	60	15	15	3.0
GROUP IV				
EE'	60	30	15	0.5
FF'	60	30	15	1.0
GG'	60	30	15	2.0
HH'	60	30	15	3.0

Table III

TEMPERATURE	WARM-UP TIMES IN ORDER OF DECREASING OPTICAL DENSITY			
60°C	30min.	1hr.	2hr.	3hr.

* 15 minute incubation

Graph A

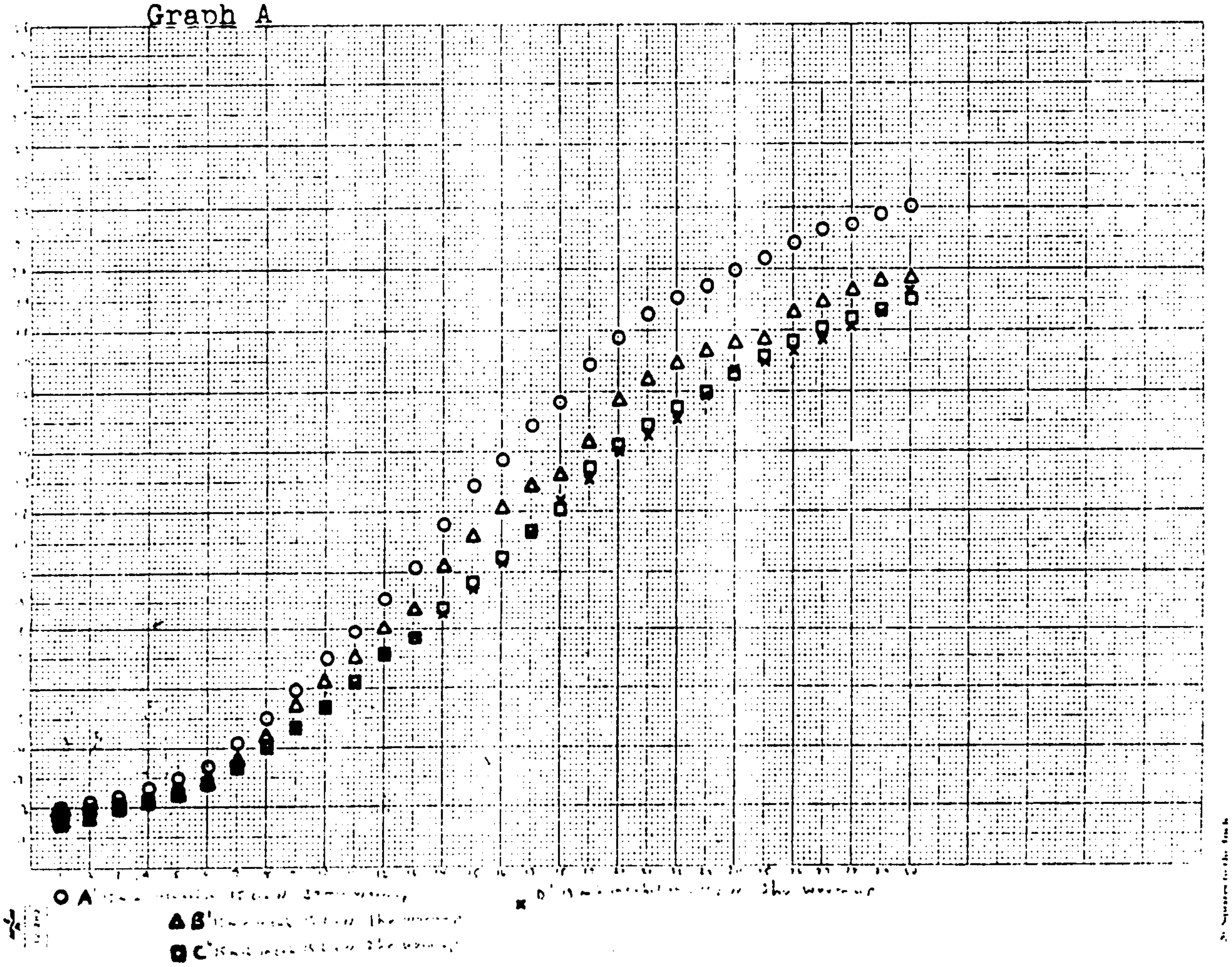

Table IV

TEMPERATURE	WARM-UP TIMES IN ORDER OF DECREASING OPTICAL DENSITY			
60° C	30min.	1hr.	2hr.	3hr.

- 30 minute incubation

Graph B

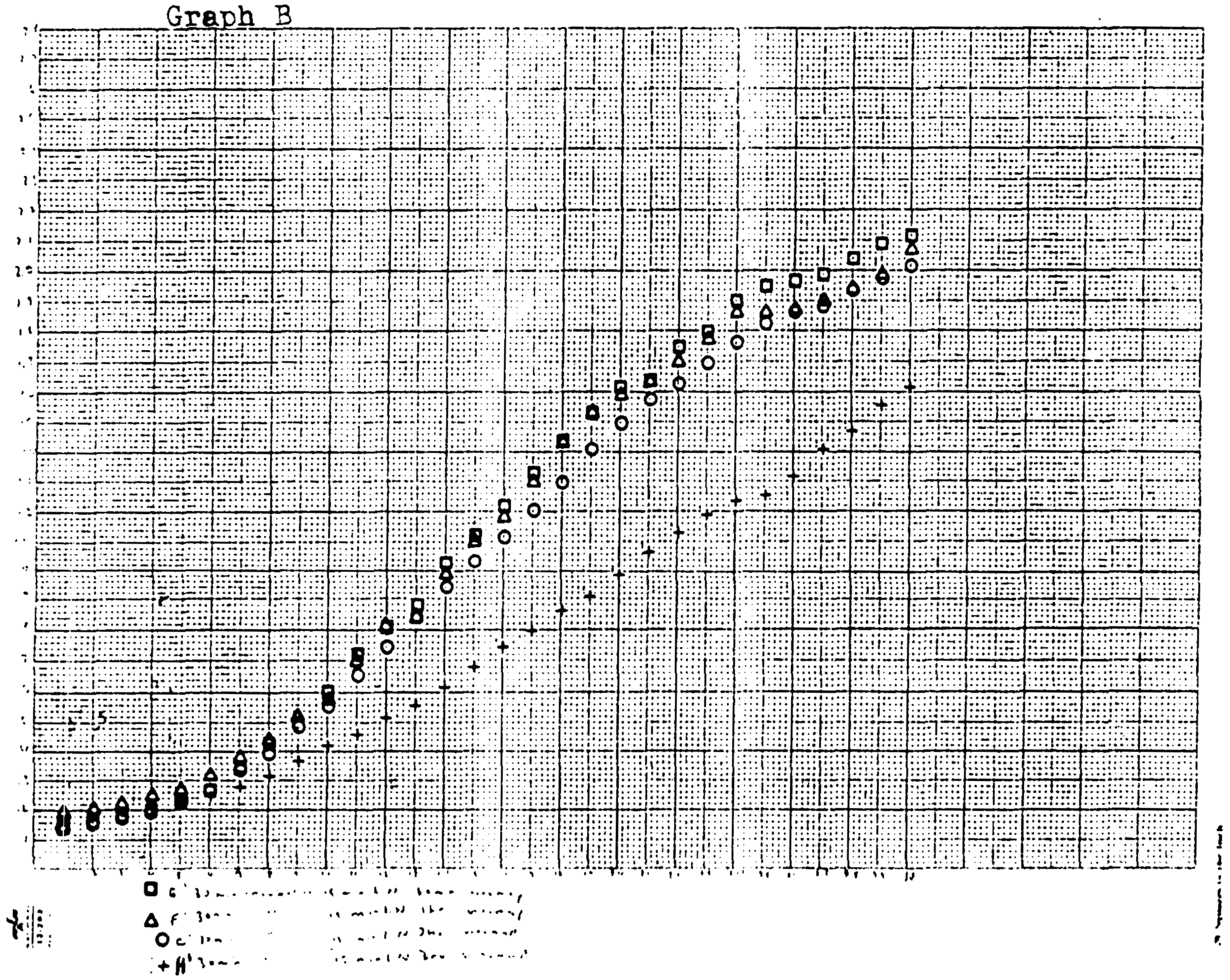

Table V

TEMPERATURE	WARM-UP TIMES IN ORDER OF DECREASING OPTICAL DENSITY			
40° C	30min.	1hr.	2hr.	

* 15 minute incubation

Graph C

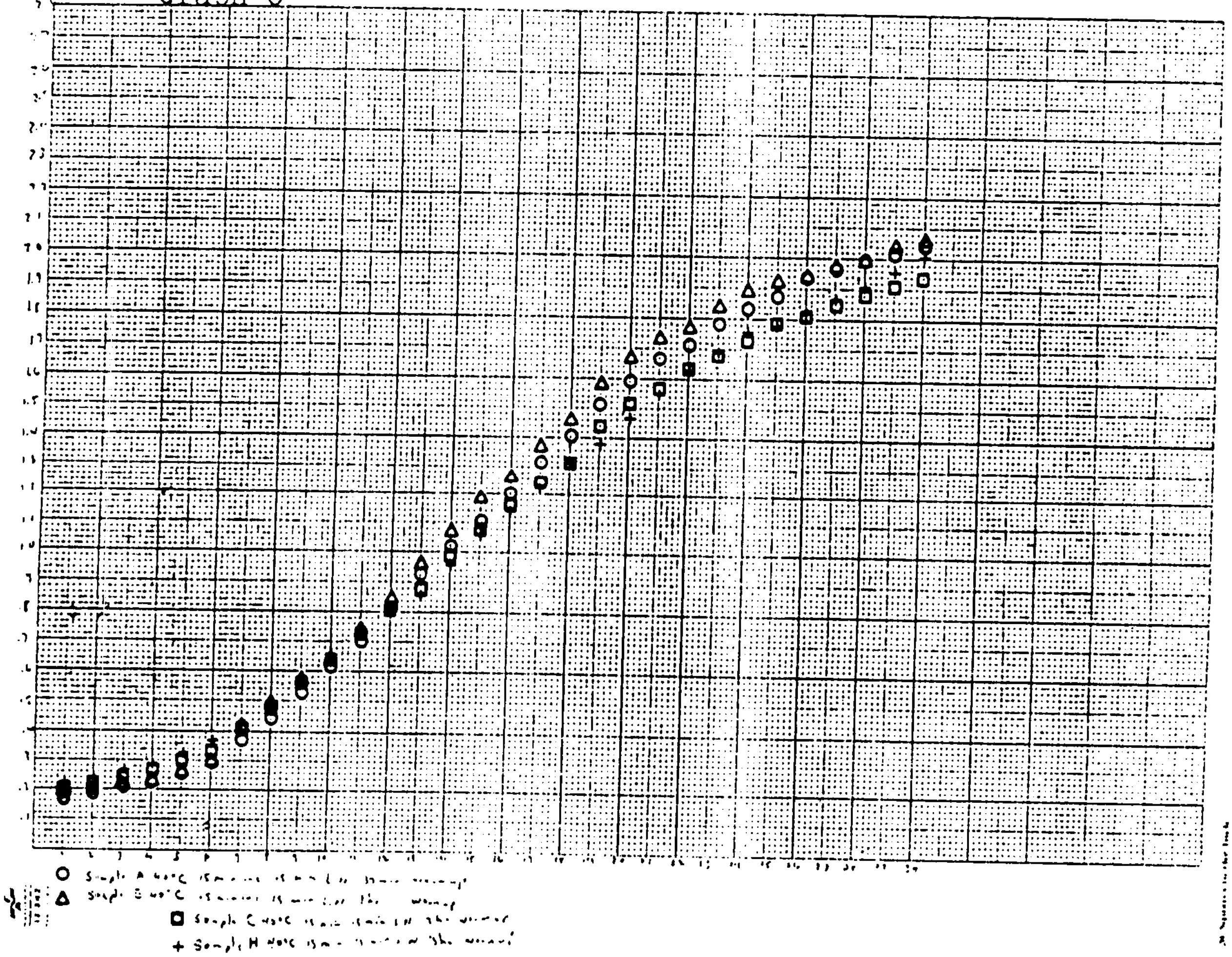

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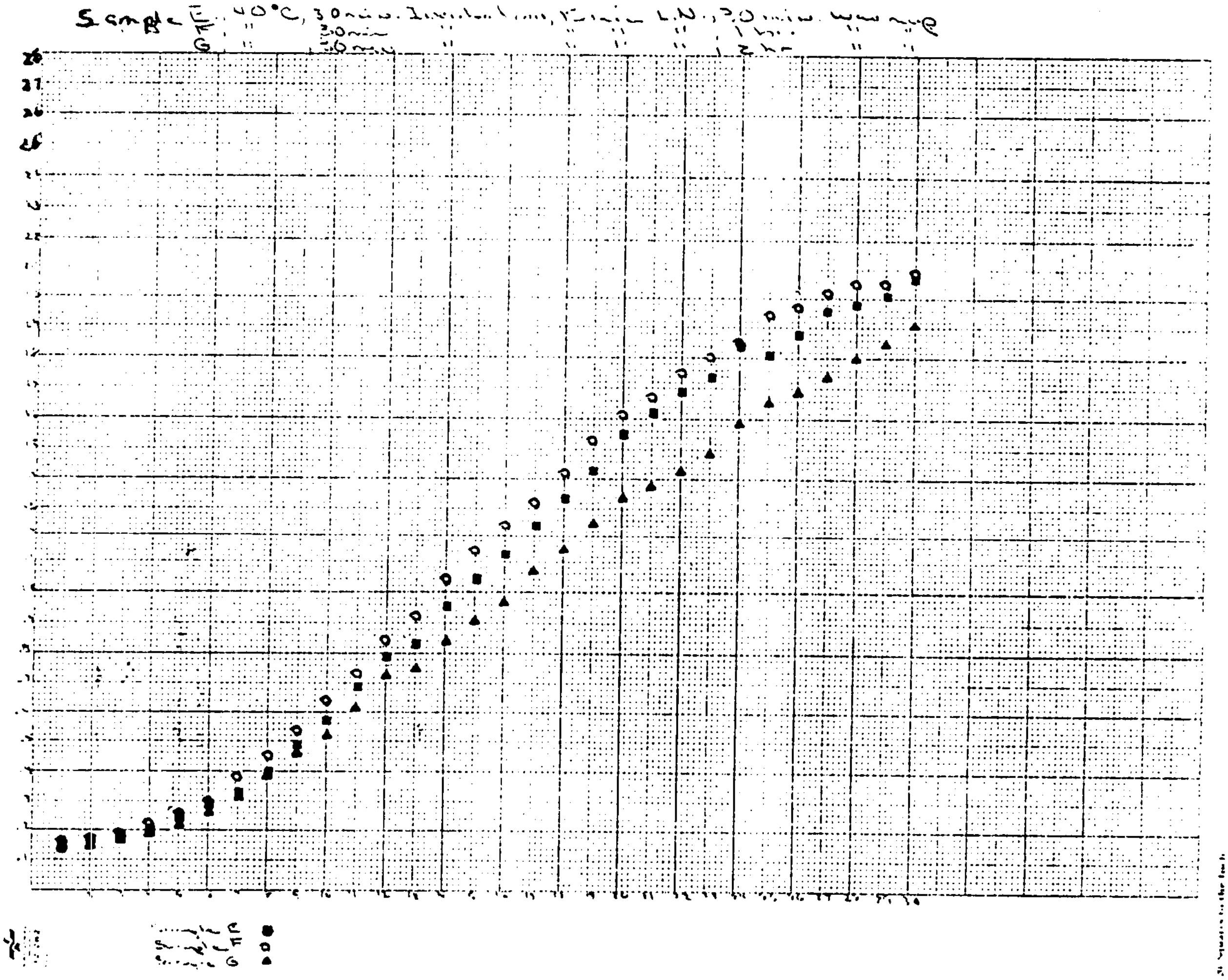
Table VI

TEMPERATURE	WARM-UP TIME IN ORDER OF DECREASING OPTICAL DENSITY			
40°C	1hr.	30min.	2hr.	—

* 30 minute incubation

Graph D



INTRODUCTION TO PRACTICAL SCANNING ELECTRON MICROSCOPY

This course is designed to provide the following experiences for the student in an introductory course. Topics will include 1) a study of the historical development of the scanning electron microscope, 2) a study of the practical and theoretical concepts of electron optics including the electron gun and electron lenses, 3) a detailed analysis of the interaction between electron beam and various biological and physical material samples, 4) an examination of the basic SEM image formation and associated processes such as image quality evaluation and aspects of stereo-microscopy, and 5) an analysis and discussion of relevant advanced topics of current interest in scientific literature about electron microscopy. Laboratory exercises will involve the use of the ISI Mini SEM 3 and the ISI-SS-40 Scanning Electron Microscope. Students will learn to prepare samples and analyze results.