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I. INTRODUCTION

A very large effort has been expended this quarter in developing techniques for producing CsTe cells for absolute measurements of UV radiation intensity. This work is covered in Section II. We are beginning to obtain encouraging results.

In Section III the results from the silver halides is summarized. A final report is being written on this work. When this is finished, work will begin on the preparation of articles for publication.

II. FURTHER DEVELOPMENT OF A Cs_2Te STANDARD CELL

G. B. Fisher

Our recent work at Stanford in developing standards of monochromatic light intensity in the near ultraviolet has been devoted to a cell convenient for astronomical research which is blind to scattered visible light but has a high sensitivity in the near ultraviolet ($3.5 \text{ eV} \leq h\nu \lesssim 11.0 \text{ eV}$). Cs_2Te was chosen as the photocathode material for its threshold near 4.0 eV and a MgF_2 window (10.8 eV cutoff) is used because it is less deliquescent than LiF. The cells conform to the same geometry and small size as the successful LiF-Cs_3Sb cells of this laboratory.

Several criteria for a useful standard were met quite early in our development. We routinely produce cells with a sharp threshold and a response greater than 0.10 electrons/incident photon from 5.0 eV to 10.7 eV (Fig. 1). The low energy response ($h\nu < 3.5$ eV) observed in our first prototypes has been eliminated by saturating the cathode with Cs vapor during processing at 150°C. This result refutes the explanation of low energy response based on excess Cs proposed by Taft and Apker.[1] Also dark or leakage current is less than 10^{-13} amp. and the forward/reverse current ratio is typically 300:1.

After the early successes, there have been several difficulties that have been overcome more recently in order to obtain useful cells. These problems have been mentioned previously (NASA Quarterly Status Report #9). I will detail our changes in usual processing procedures to accommodate the MgF_2-Cs_2Te cells and the motivations for these changes.

1. Brown spots found on the inside of the window after processing were found to be AgCl. When the oven is at 500°C the AgCl is melted onto the edge sealing area (tinning), and may splatter onto the middle of the window . A 0.700-in. metal disc covering the center of the window

during this step in the oven has eliminated these spots.

2. The loss in transmission above 6.5 eV by MgF_2 windows baked at 500°C seems to be due to a high temperature reaction with water vapor. Oven chamber (2.5 cu. ft.) is now purged at a rate of 10 cu. ft/hr. with argon that has passed through a dry ice-acetone cold trap to eliminate water vapor. Also both sides (if accessible) of the window are cleaned with acetone and polished for three minutes with 0.3µ alumina powder after each exposure to the oven.

Figure 2 shows the transmission curve of our most affected MgF_2 window when fresh (A), after baking at 500°C in air for three hours (B), and after polishing for one minute on each side (C). The desirability of some polishing is clear. The extent of success of our current technique can be seen in Figure 3 which gives curves before and after applying AgCl under our present procedures. (Note: Acetone is preferable to alcohol for degreasing MgF_2. The latter reduces UV transmission by as much as 3-4%, whereas the former has no noticeable effect.)

3. The problem of time stability of response seems to have been solved by heat-aging the cell after processing at a temperature above room temperature for at least half an hour to complete the Cs-Te reaction. Temperatures between 100°C and 170°C are being evaluated for any preference between their effects.

4. The majority of our efforts of the past months have gone towards improving the uniformity of response across the 0.725-in. diam. cathode of the cell. The major factor is to obtain a uniform layer of evaporated tellurium on the cathode. Our early work showed that the high vapor pressure of Te was causing the migration of visible amounts of Te to surfaces 180° from the direction of evaporation. This led to a magnetically removable shield to protect the window during evaporations and the narrowing of the exit of the

evaporation bucket to encourage a narrow angle evaporation. This has worked so well that high yields have been found only in the center of the cathode. We have recently obtained our most uniform response curve (Figure 4) by increasing the bucket-cathode distance from 0.250-in. to 0.360-in. and arranging the charge of indium telluride as nearly as we can to give a wide angle evaporation. Even with more tellurium on the side walls, the dark current is still less than 10^{-13} ampere.

We hope that the major difficulties with the MgFe-Cs_2Te cells have been effectively handled. Work continues to improve the reproducibility of the uniformity between cells along with a high photoelectric yield.

REFERENCES:

1. E. Taft and L. Apker, J. Opt. Soc., 43 81 (1953).

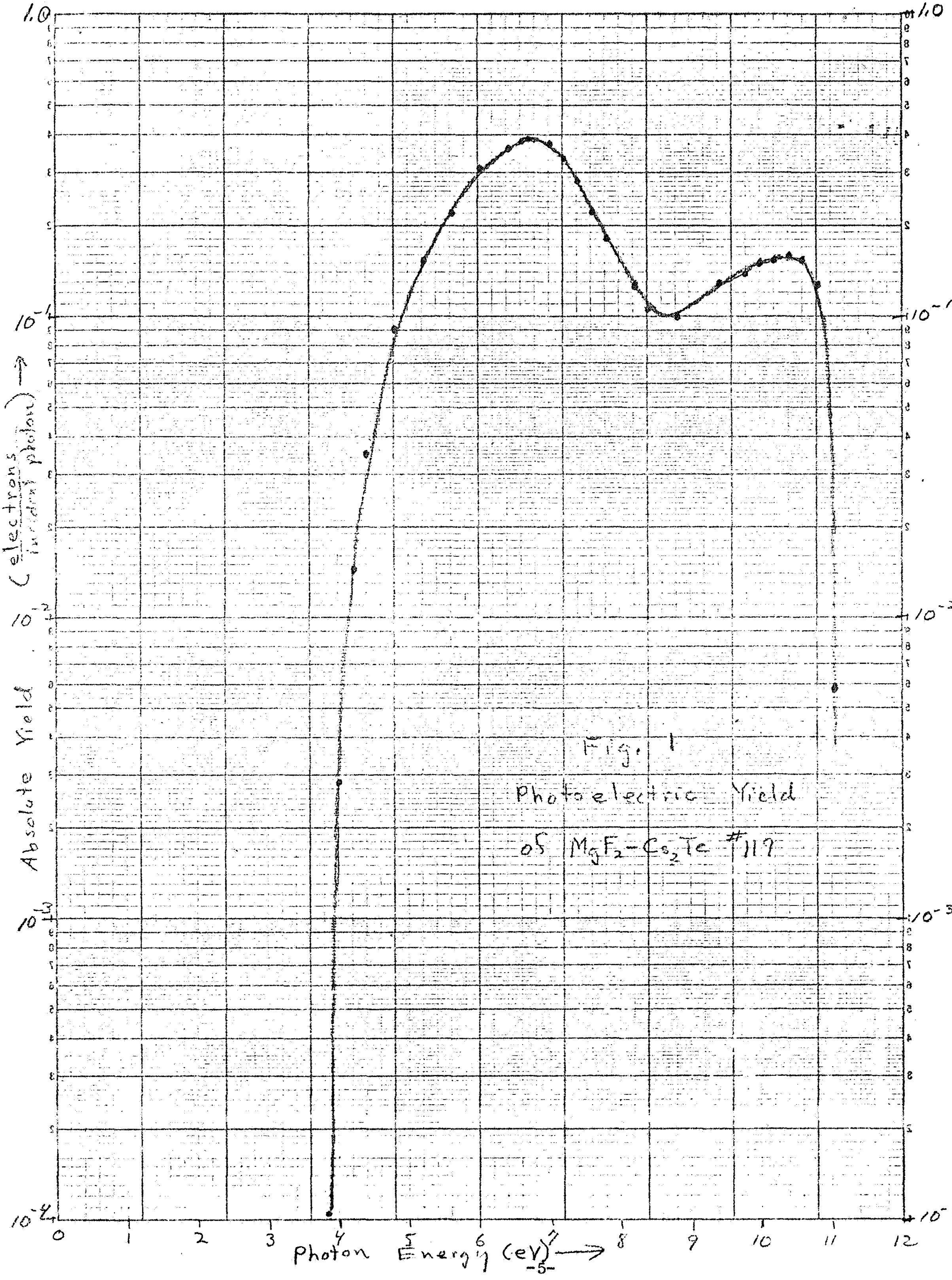


Fig. 1

Photoelectric Yield

of MgF_2-Cs_2Te #117

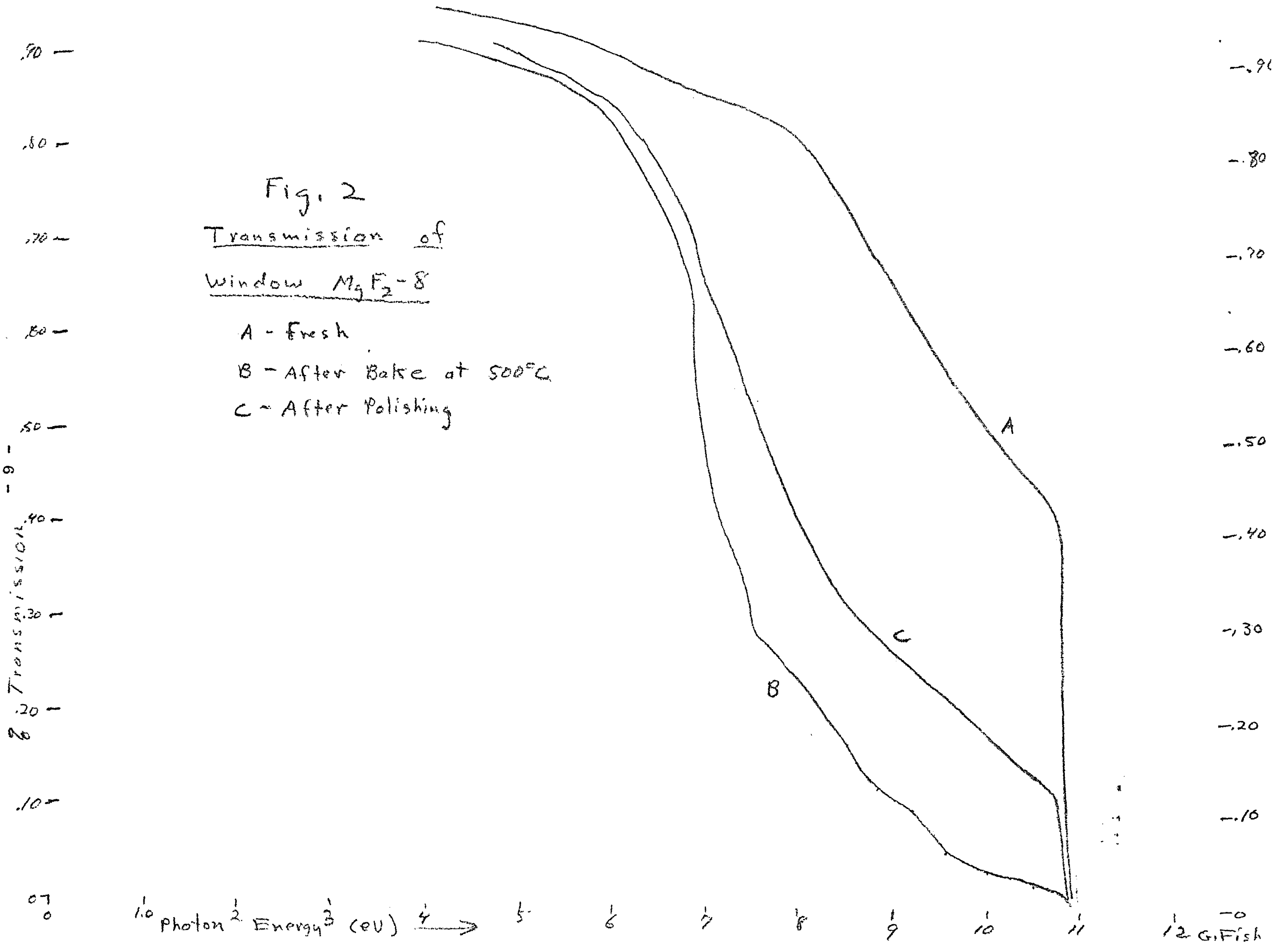


Fig. 2

Transmission of Window MgF_2-8

G. Fish

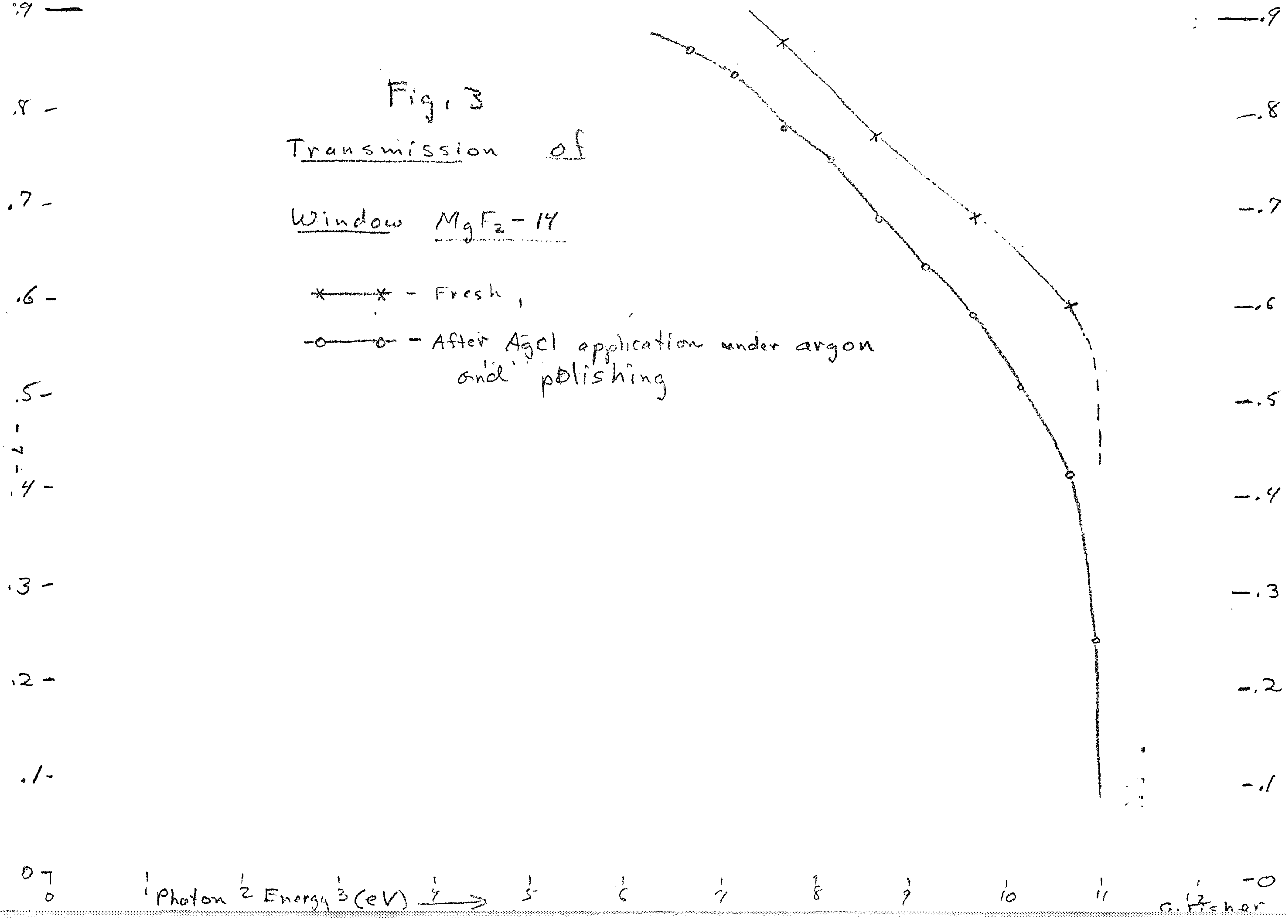


Fig. 3

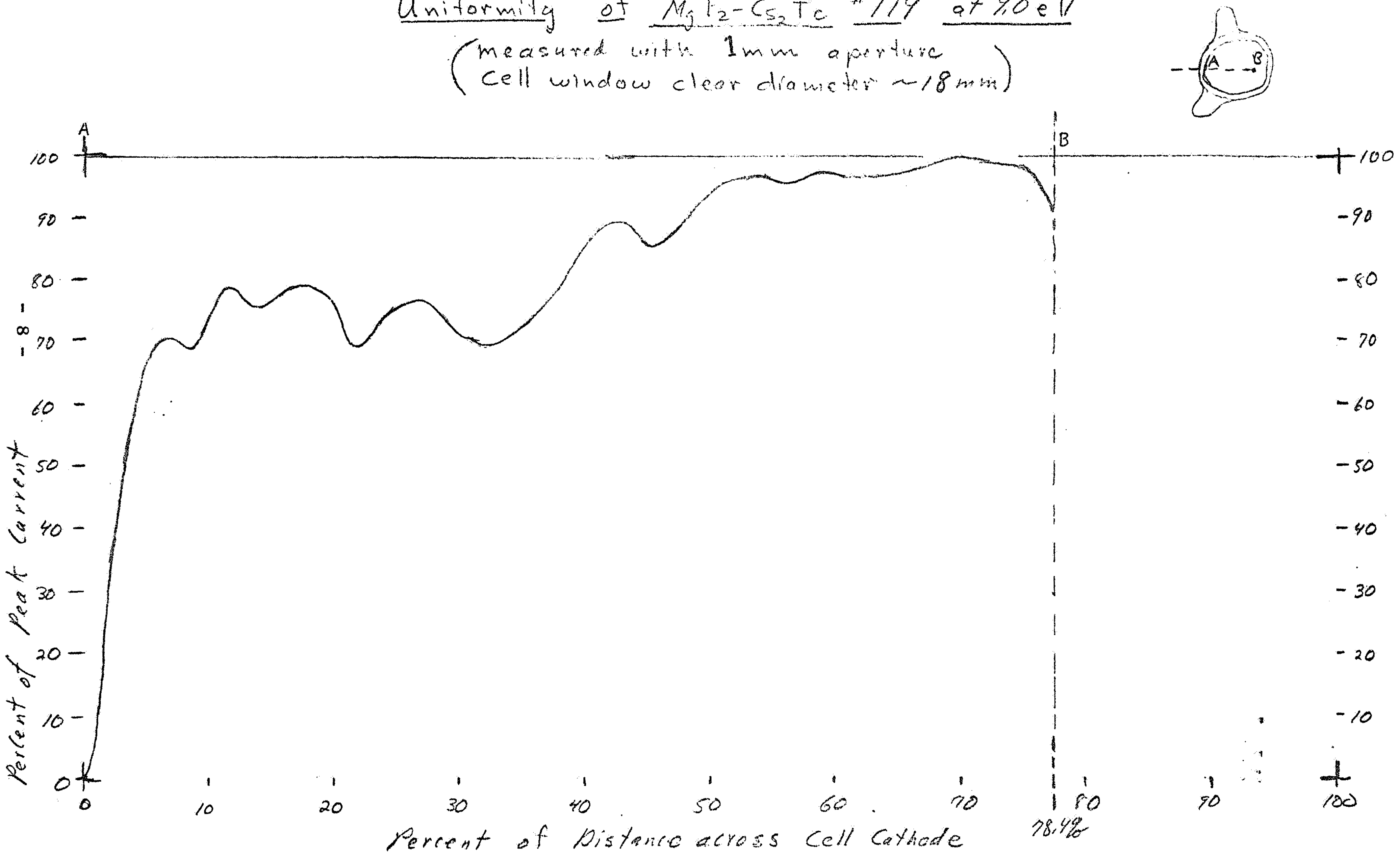
Transmission of Window MgF_2-14

G. Fischer

Fig. 4

Uniformity of MgF_2-Cs_2Te #119 at 9.0 eV

(measured with 1mm aperture
Cell window clear diameter ~18mm)



III. THE ELECTRONIC STATES AND ELECTRON-LATTICE INTERACTION IN THE SILVER HALIDES

R. S. Bauer

A. Introduction

The experimental part of this study has been completed and the results are being written up in thesis form at the present time. This should be completed and copies available in the form of a report at the end of the next quarter. In this report the main results of these studies are summarized.

B. Results

The major new feature of this work is the discovery of a temperature dependence of certain structure in the energy distributions of photoemitted electrons which is an order of magnitude greater than the change in thermal energy, k_BT. The features of the temperature dependent photoemission EDC data for AgCl and AgBr are summarized in Table I. This probably represents the first observation of what may prove to be a whole new class of effects in solids which satisfy the general criteria of: (1) a Debye temperature in the region of temperature variation; (2) electronic wavefunctions which are (a) fairly localized on the atomic sites, and (b) of two compatible species in close enough proximity in energy for the resulting hybridization to be a significant portion of the mixed state's energy; and (3) a large enough amplitude of ionic vibration above the Debye temperature to cause a significant modulation of the wavefunction hybridization. The temperature dependence of the EDCs is believed due to a very strong interaction of the electrons with the lattice, very much like the Jahn-Teller effect but many times stronger. A model referred to as "dynamic wavefunction hybridization" has been proposed in a very general sense to describe the manner in which the vibrations of the ions may effect the energies of the electronic states so strongly. Applying this model in a very general way, the silver states with almost pure 4d symmetry could be located by experiment with reasonable certainty for the first time; these locations were 3.7, 3.3, and 4.4 eV below the highest filled states in AgBr, AgCl, and AgI respectively. All the features of the electronic structure of all three halides which were experimentally located by this study are summarized in Table II along with suggested origins for the structure. By using a very simple approximation of $k = 0$ optical phonons and restricting the extent of the interaction to about one nearest neighbor distance, the proposed model was applied to the AgCl energy bands[1] and pressure dependent optical absorption data.[2] These computations demonstrate its plausibility by predicting the proper magnitudes for density of states peak broadenings and their temperature dependences. Of course, it must be emphasized that the physics is really much more complex. As in the case of the Jahn-Teller effect, the frozen-lattice approximation is not valid, and one must really consider wavefunctions of the entire solid (e.g., vibronic states) rather than separate electronic and nuclear parts. This further implies that the entire concept of an energy band structure is quite suspect. There is, therefore, much work to be done to theoretically account for such many-body interactions accurately. Doniach has begun a Green's function calculation of the problem which takes into account the randomness of the ionic motion.[3] His first results indicate that the dynamic hybridization picture is in general a proper representation for the physical phenomenon. Besides this basic conclusion and the probable location of the "pure" Ag 4d states, the other interpretive results of this work must be considered only first order attempts at explaining many complex data features. It is believed that the photoemission data itself, which was carefully and laboriously taken using newly developed techniques, is quite accurate. It should serve as a good storehouse of information for the many fascinating questions which remain to be answered.

REFERENCES

1. Reference R. S. Bauer, Last Quarterly.

2. R. B.Aust, Phys. Rev. 170, 784 (1968).

3. S. Doniach, Private Communication (1970).

TABLE I

Final State Energy* (eV)		EDC Structure		Suggested Interpretation
AgBr	AgCl	Character	$T \to 80^{\circ}K$	
<9.5	<10.2	Strong	3 highest sharpen	Hybridized halogen p-derived valence states
			Lowest (1) No sharpening	Localized Ag 4d-derived valence states
>9.5	>10.2	Weak	No sharpening	Forbidden halogen p→Ag 5p transitions?
8.8	8.1		Enhanced strength; some new	Hybridized halogen d-derived conduction states

* $0 = E_V$

TABLE II

	Energy (eV)	Suggested Origin	Degree of Mixing*
AgBr (±0.1)	>9.5	Ag (5p) ?	H
	8.8	Br (4d)	H
	7.15	Vacuum Level	
	0	Valence Band Maximum	
	-0.85	Br (4p)	H
	-2.9	Br (4p)	H
	-3.3	Bottom of Br (4p) Band	
	-3.7	Ag (4d)	P
	-5.0	Ag (4d)	H
	-6.0	Bottom of Valence Band	
AgCl (±0.1)	>10.2	Ag (5p) ?	H
	8.1	Cl (3d)	H
	7.55	Vacuum Level	
	0	Valence Band Maximum	
	-0.8	Cl (3p)	H
	-2.65	Cl (3p)	H
	-3.0	Bottom of p Band	
	-3.3	Ag (4d)	P
AgI (±0.2)	8.3→10.0 10.6→>11.8eV	Γ p States or No Γ States	
	7.8, 7.1	Ag (5p) or I (5d)	H
	6.6	Vacuum Level	
	0	Γ, Valence Band Maximum	
	-0.45	I (5p), Not at Γ	H
	-1.7	I (5p)	H
	-4.4 ± 0.1	Ag (4d)	P

* H = Hybridized, P = Pure