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PERFORMANCE OF A PRESSURIZED XENON-FILLED MULTIWIRE PROPORTIONAL CHAMBER

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Authors

Kaufman, L.

Perez-Mendez, V.

Stoker, G.

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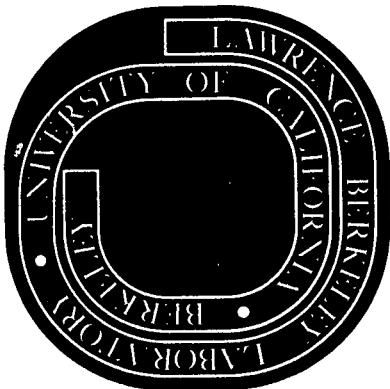
L. Kaufman, V. Perez-Mendez, and G. Stoker

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PERFORMANCE OF A PRESSURIZED XENON-FILLED
MULTIWIRE PROPORTIONAL CHAMBER

L. Kaufman,* V. Perez-Mendez*† and G. Stoker†

Lawrence Berkeley Laboratory
Berkeley, California

October, 1972

Summary

We describe the performance of a multiwire proportional chamber filled with Xenon (93% Xe, 7% CO₂) to a pressure of 60 psi absolute. The readout is by the electromagnetic delay line method. Measurements taken at 60 keV and 140 keV show that 1 mm and 2 mm lead grid patterns can be resolved. MTF curves are given for both these energies and the projected performance for clinical work with ⁹⁹Tc is described.

I. INTRODUCTION

In a previous paper, we have described a multiwire proportional chamber (MWPC) designed for nuclear medicine applications.¹ This chamber was operated at atmospheric pressure and, hence, its useful imaging range was limited to energies below 100 keV. Imaging with higher energy gamma rays showed a loss in spatial resolution due to the increased range of the photoelectrons produced in the gas, as well as decreased efficiency due to the smaller photoelectric cross-sections at the higher energies, and the low mass of the gas. At atmospheric pressure we worked

† Lawrence Berkeley Laboratory.

* University of California, San Francisco.

extensively with radioisotopes such as ^{125}I , ^{133}Xe , ^{197}Hg , and more recently with ^{131}Cs and ^{151}Dy . Figures 1 and 2 show images taken under these conditions.

In order to optimize the MWPC as an imaging device for higher energy gamma rays, specifically the 140 keV gamma from ^{99}Tc , we constructed a pressurized Xenon-filled MWPC for the Veterans Administration Hospital in San Francisco. This chamber is being operated at a pressure of 60 psi absolute and will be used for thyroid and other imaging procedures using ^{123}I , ^{125}I , and ^{99}Tc .

II. DESCRIPTION OF THE MULTIWIRE PROPORTIONAL CHAMBER.

The MWPC has an area of 20×20 -cm² and a total thickness of 6.4 -cm. The center plane (anode) consists of a grid of 12.5 μm gold-plated tungsten wires, with spacing of 1.5 mm tied to a common bus bar and operated at 5400 V. The outside (cathode) planes are made of 50 μm tungsten wire with spacings of ~ 1 mm, tied in pairs to common bars through 200 k Ω resistors and are operated at +900 V. These planes have their wires oriented at 90 degrees to each other and are on opposite sides of the anode, at a distance of 0.3 cm from it (fig. 3); they are operated at a positive voltage relative to the enclosing metal container so that drift regions of 1 cm in front and 4.8 cm in back are used to increase the detection sensitivity.

The chamber is filled with a 93% Xe-7% CO₂ gas mixture at a pressure of 60 psi absolute with a total mass of 0.105 g/cm² in the 6.4 cm sensitive region. The conversion efficiency of the gas as a function of gamma energy is shown in fig. 4.

Coordinates of the photoelectrons produced in the sensitive gas volume are obtained by the delay-line method as described previously.^{1,2,3}

The configuration of the electronic display package is similar to that used in our previous work. This system is shown in fig. 5.

III. RESULTS

Figure 6 shows transmission bar-patterns obtained with ^{241}Am (60 keV) and ^{99}Tc (140 keV) sources. It can be seen that 1 mm and 2 mm bars are resolvable at 60 keV and 140 keV respectively. The fine grid observed in the pictures obtained from ^{241}Am represents the location of each individual anode wire. A ^{99}Tc -filled Picker thyroid phantom is shown in fig. 2b, and is compared to a ^{131}Cs -filled phantom. Both of these were obtained using a Nuclear- Chicago Low-Energy High-Resolution collimator.

The Modulation Transfer Function for this chamber is shown in fig. 7. The MTF at 140 keV is quite similar to the MTF previously obtained at 22 keV for a MWPC operated at atmospheric pressure.²

IV. CONCLUSIONS

The pressurization of Xenon-filled MWPC's allows the extension of the useful imaging range of these devices to 140 keV, the gamma-ray energy produced by ^{99}Tc .

While the sensitivity is less than that of the commonly used scintillation cameras, the improved resolution reduces the amount of data points needed to detect a certain feature in the object being studied, thus compensating for the efficiency loss.

Further work is continuing to characterize the instrument in a clinical setting.

Acknowledgements

We would like to acknowledge the help received from Drs. R. Cavaliere and L. Blumin of the Nuclear Medicine Section, Veterans Administration Hospital, San Francisco, in providing grant support and defining the clinical applications of this chamber.

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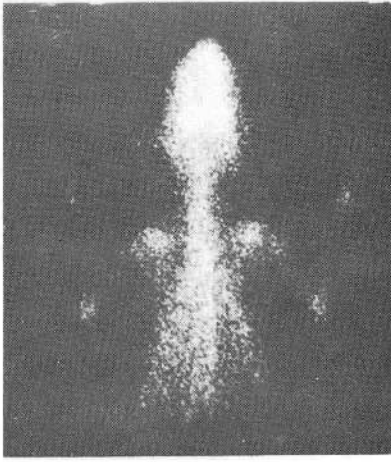
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FIGURE CAPTIONS

- Fig. 1. Ten minute images of a rabbit injected with ^{159}Dy obtained with the chamber described in reference 1.
- Fig. 2a. Picker phantom filled with ^{131}Cs , obtained at atmospheric pressure (500k counts).
- 2b. Same phantom, filled with ^{99}Tc , as imaged by the pressurized MWPC (500k counts).
- Fig. 3. Schematic of the pressurized chamber.
- Fig. 4. Stopping power for 0.105 g/cm^2 of Xenon as function of gamma energy.
- Fig. 5. The pressurized MWPC imaging system.
- Fig. 6. Transmission bar-patterns. These were obtained at 60 keV, (a) 10 mm, (b) 4 mm, (c) 2 mm, and (d) 1 mm patterns; and at 140 keV, (e) 10 mm, (f) 4 mm, and (g) 2 mm patterns.
- Fig. 7. Modulation Transfer Function for the pressurized MWPC measured at 60 keV and 140 keV.

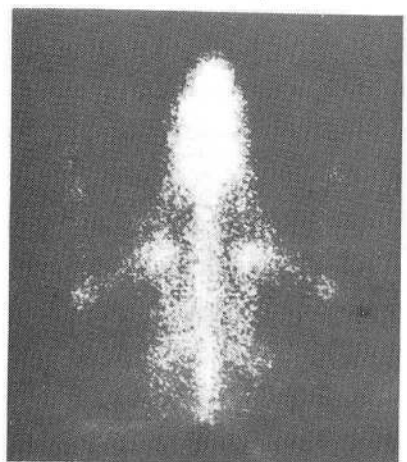
¹⁵⁹Dy-HEDTA in
Oryctolagus cuniculus

24hrs. post

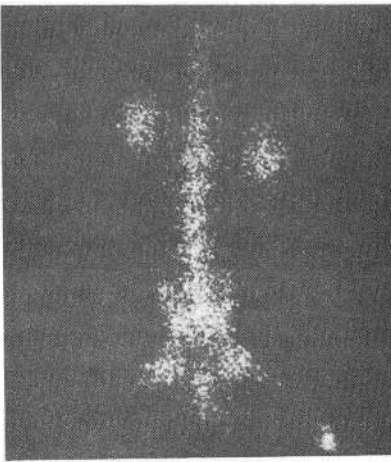


Ventral 145K/10min.

24hrs. post

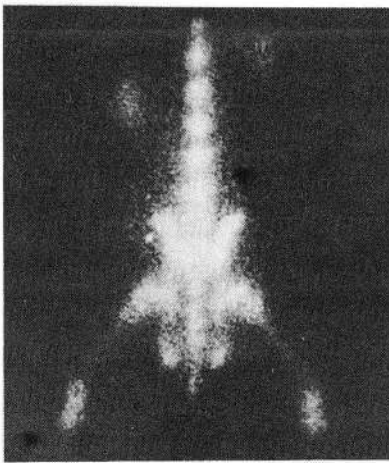


Dorsal 148K/10min.



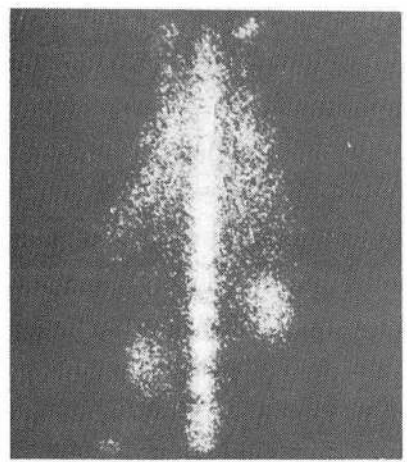
Ventral 102K/10min.

140hrs. post

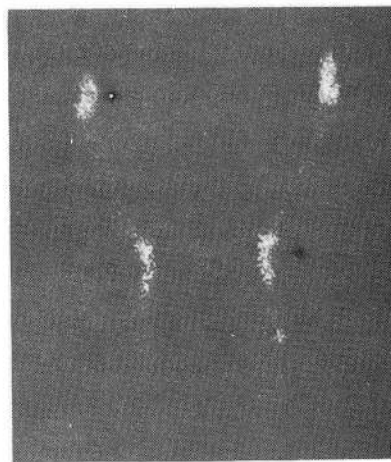


Dorsal 520K/182min.

LOW SENS. COLL.

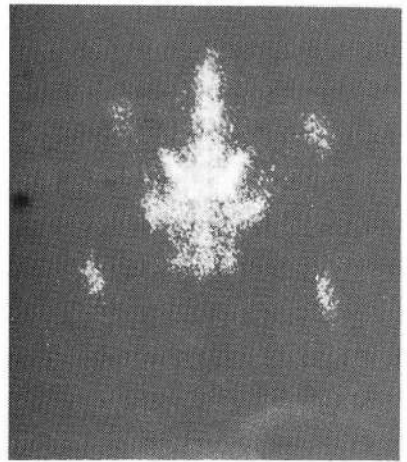


Dorsal 158K/10min.



Ventral 57K/10min.

HIGH SENS. COLL.



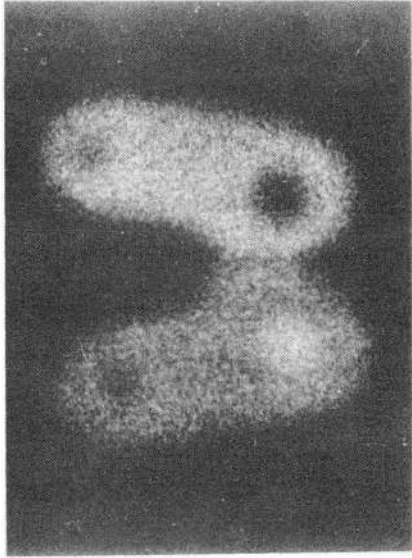
Dorsal 105K/10min.

HIGH SENS. COLL.

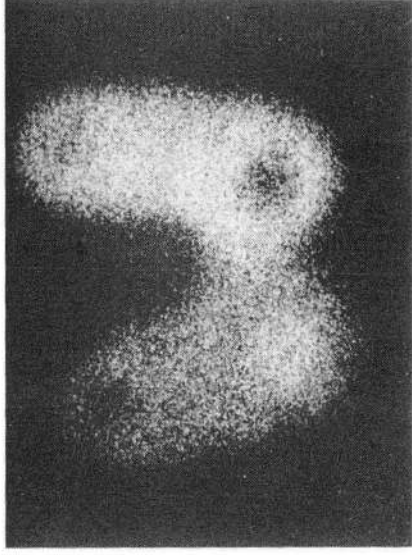
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Figure 1.

A



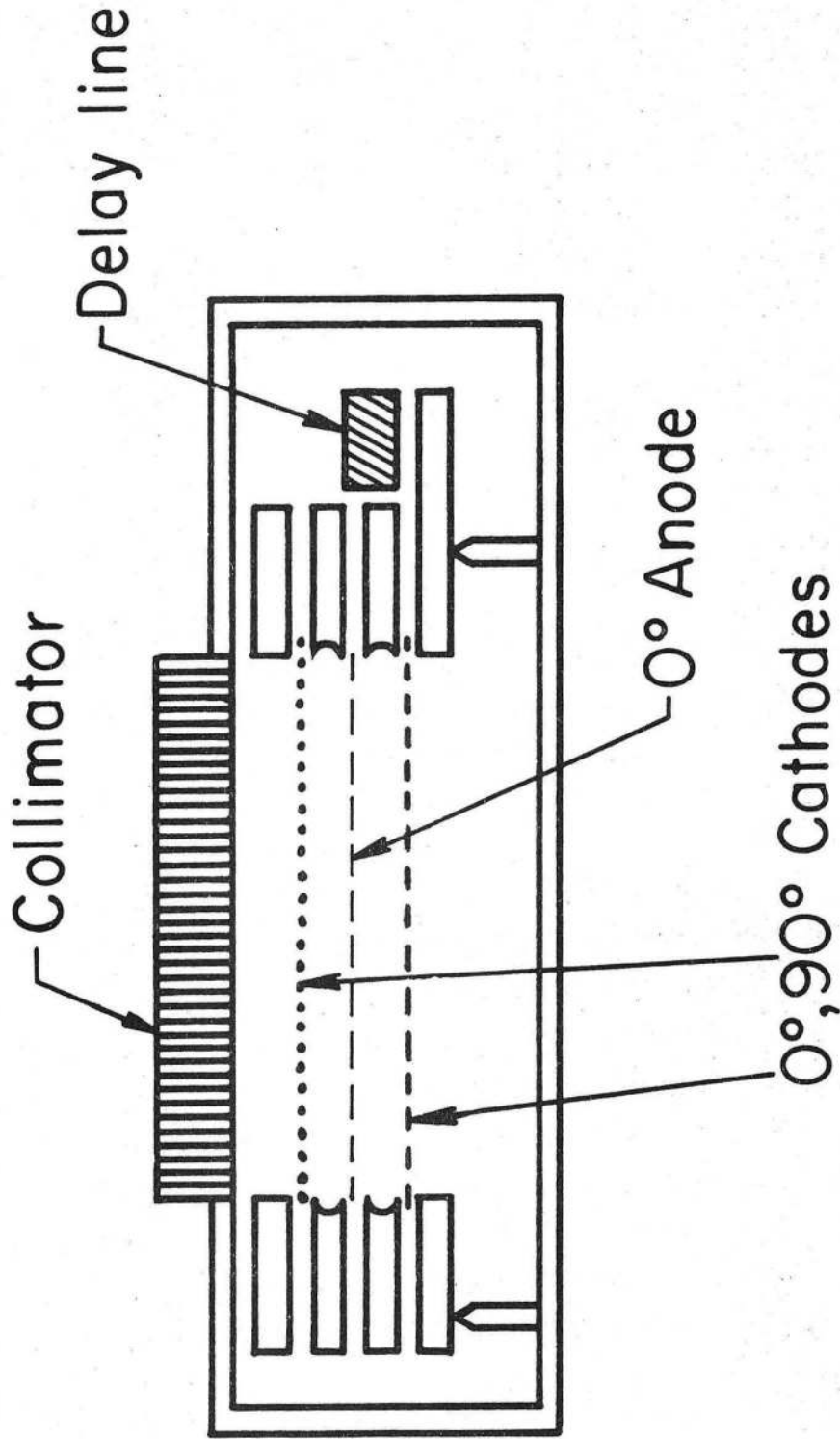
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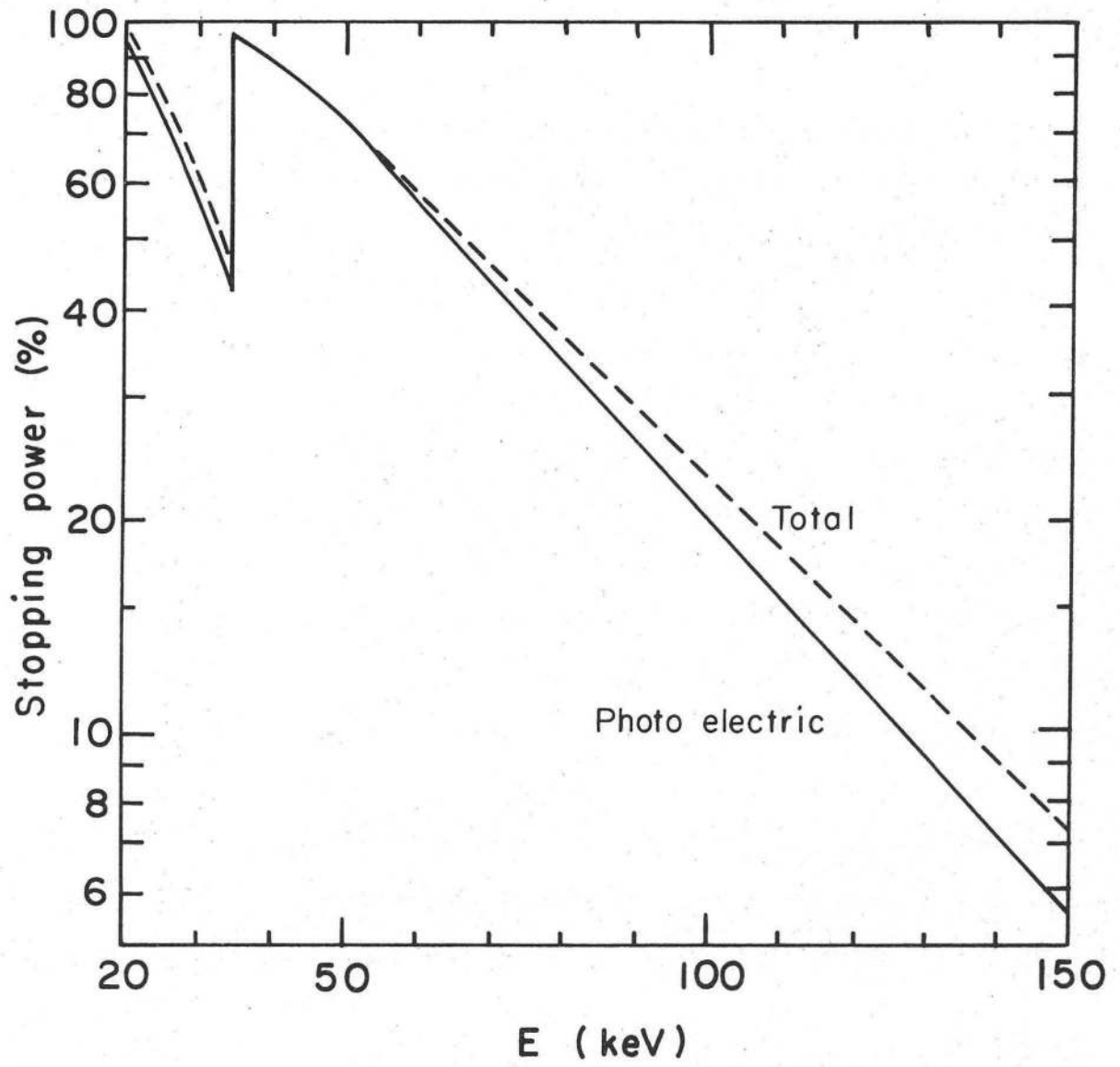
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Figure 2.



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Figure 3.



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Figure 4.

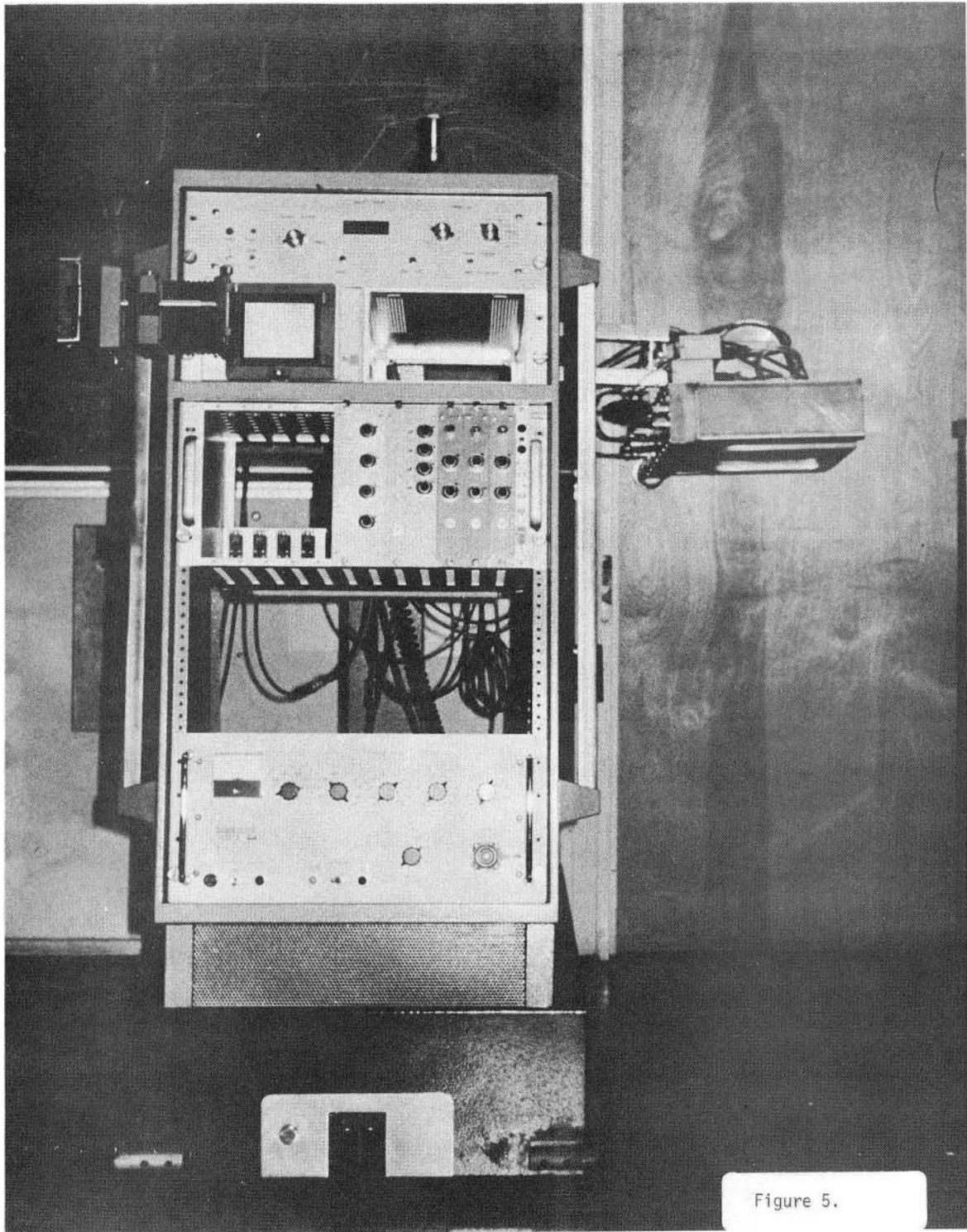
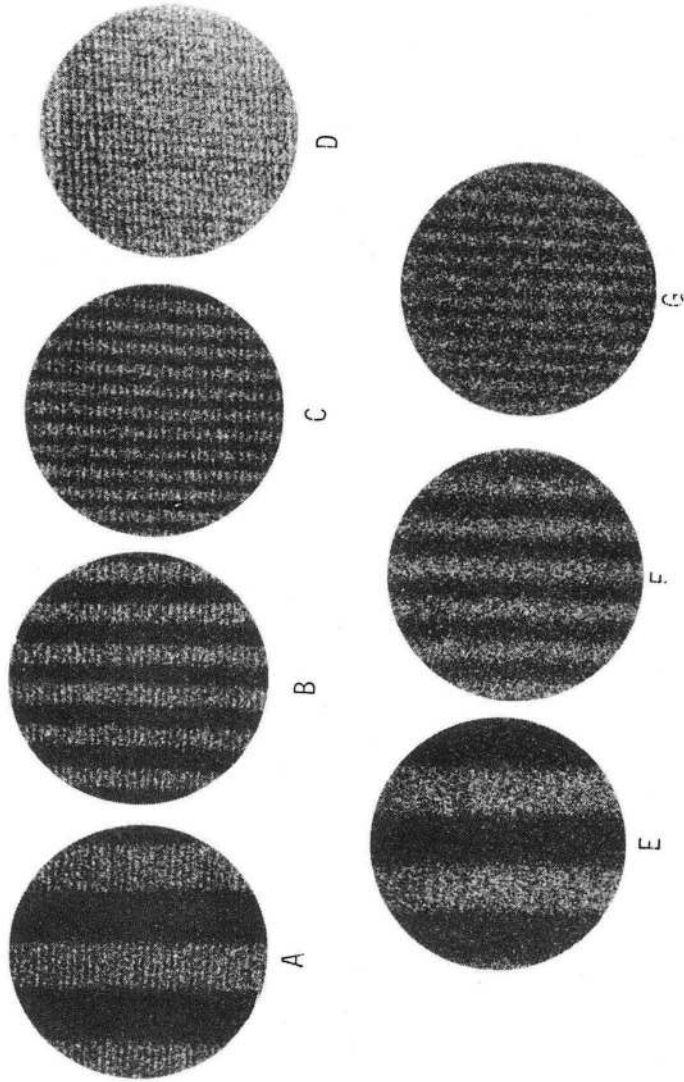


Figure 5.

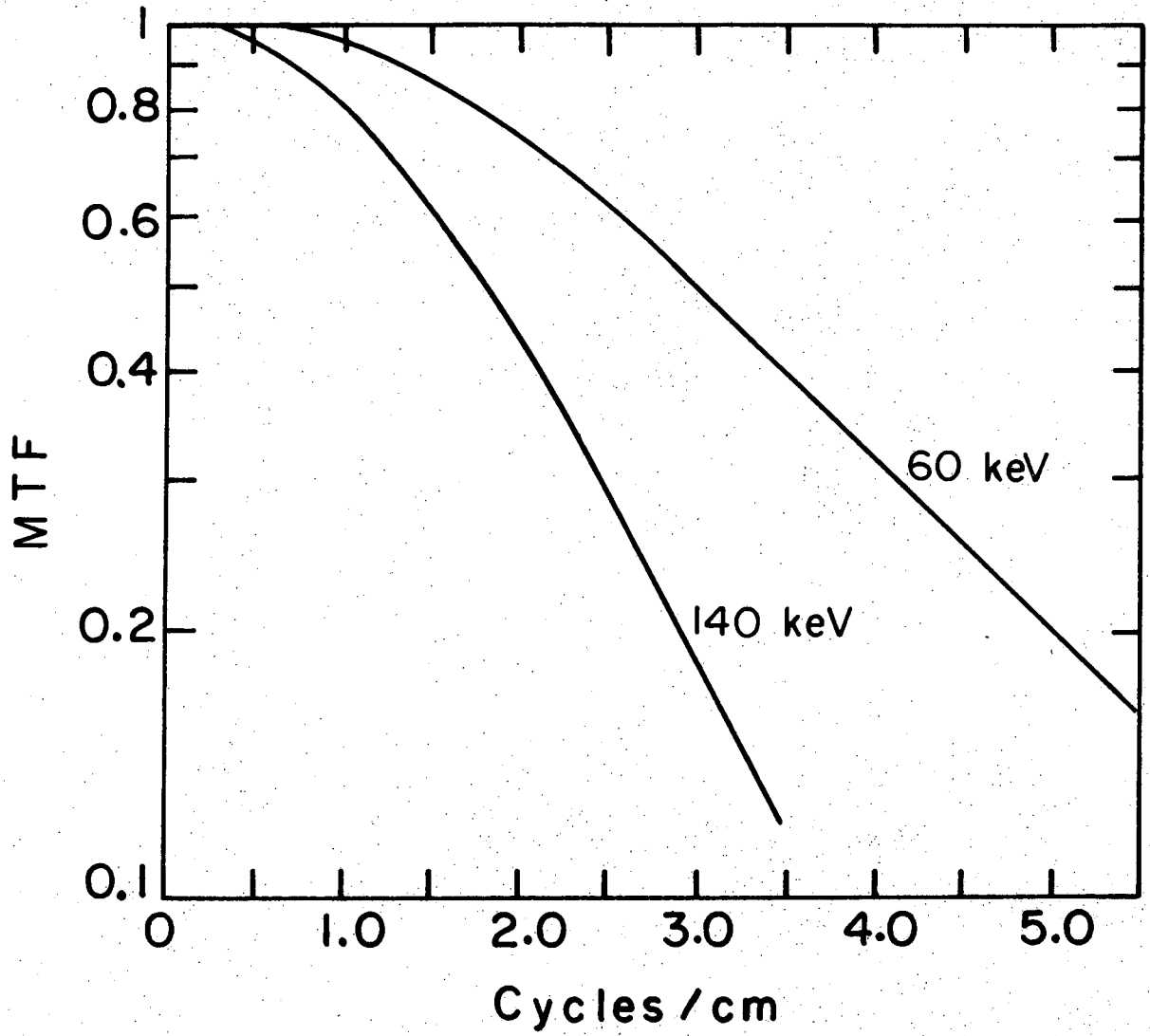
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Fig. 5



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Figure 6.



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Figure 7.

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