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Author
Perez-Mendez, V.

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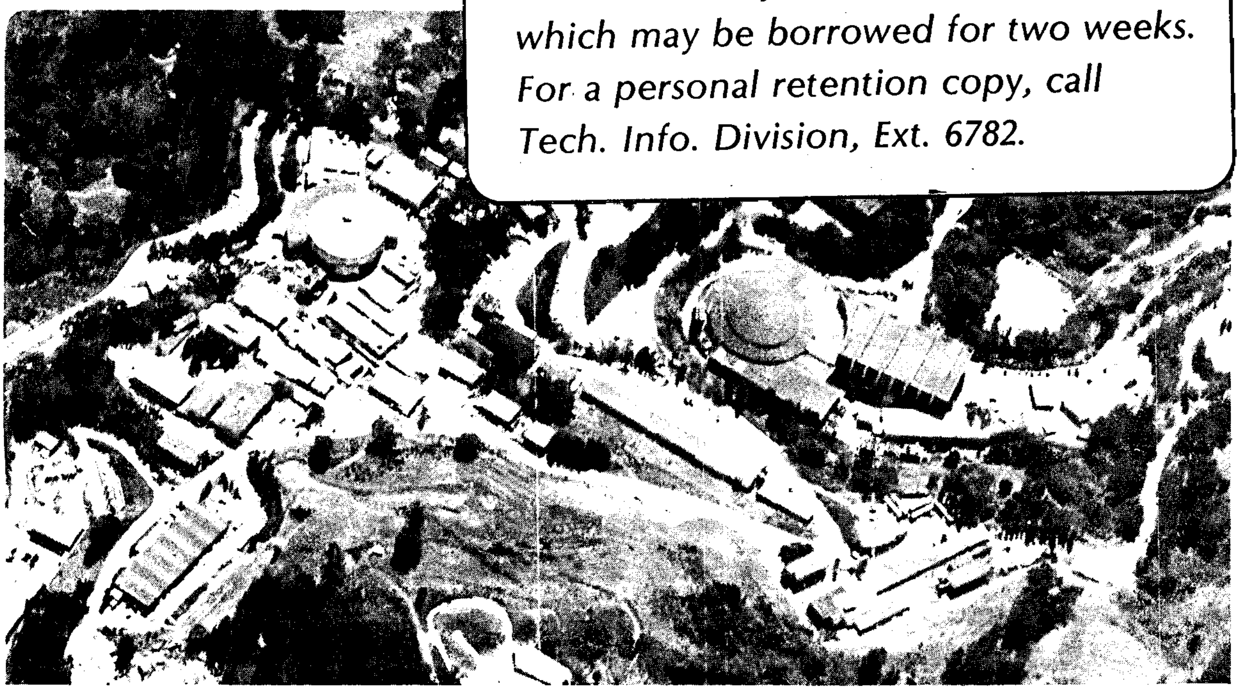

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CURVED ANODE WIRE CHAMBERS FOR X-RAY DIFFRACTION APPLICATIONS

V. Perez-Mendez, [1] P. Wiedenbeck, [1] C. N. J. Wagner, [2] and E. Wölfel [3]

[1] Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720
[2] Materials Science and Engineering Department, University of California, Los Angeles, CA 90024

[3] Darmstadt Technical University and STOE Gmbh. Darmstadt, Germany.

I. INTRODUCTION

Position-sensitive proportional detectors have been used for detecting x-rays in small angle scattering [1] and residual stress measurements [2]. In these applications, the parallax present in a straight linear detector is not of grave concern because of the limited 2ϑ-range required in these measurements. However, when position-sensitive detectors are used in powder diffractometry, EXAFS and similar biological applications, a large angular range, greater than 45° in 2ϑ, would be highly desirable. This can easily be accomplished by a curved one-dimensional detector which is parallax-free [3].

In the design of our curved detectors, a second condition was introduced, i.e., the quantum efficiency should be as high as possible for x-ray energies up to 60 KeV. This requires a relatively large x-ray path in the detector coupled with a high pressure of the Xe-CO_2 gas mixture. This higher pressure also contributes to a good position accuracy, since it limits the range in the gas of the emitted K and Auger electrons from the photon interaction with the xenon.

The combination of large angular range and high counting efficiency of the detected x rays will permit us to apply this device in experiments on the large-angle scattering from non-crystalline materials such as liquids and glasses using mono-energetic x rays of high energy E to cover a large range in $K = (r\pi/\lambda) \sin\vartheta = (4\pi e/hc)E \sin\vartheta$ necessary for the evaluation of the radial distribution function. It is also highly suitable, for example, for retained austenite measurements with MoKα radiation (17.5 KeV) which permits the registration of several diffraction peaks for both austenite and ferrite, thus reducing the influence of preferred orientation on the evaluation of the amount of retained austenite in the sample.

II. CHARACTERISTICS OF SINGLE WIRE CURVED ANODE CHAMBERS

We describe below the main characteristics of two curved chambers. The first has a radius of curvature of 135 mm and a 2ϑ range of 60° (Fig. 1); the second has a radius of curvature of 360 mm and a 2ϑ range of 45° (Fig. 2). The anode wires are suspended in circular arcs by the interaction of a current flowing through them and a magnetic field provided by two permanent magnets placed above and below the wire running parallel to it over the full length of the curved chambers. The permanent magnets are made of Plastiform [4], a rubber-bonded Barium Ferrite which can readily be machined and bent to fit on an arc of the circle. With the iron return yokes as shown in the cross sectional views of the sensitive region of the chambers, the magnetic field is ≈700-800 gauss at the center of the gap. A current of 100-200 mA flowing through the anode wire keeps it well centered. The cathode planes consist of the bare metal helical winding of the delay line, the iron yoke on which the magnet slabs are mounted and the beryllium pressure window in front. Further specifications are given in the table below.

CHAMBER CHARACTERISTICS		
	STOE, Darmstadt	UCLA - Materials Science
Radius of curvature	135 mm	360 mm
2ϑ range	60°	45°
Anode wire	35 μm gold-plated tungsten	38 μm gold-plated tungsten
Sensitive volume	12.5 mm × 12.5 mm	25 mm × 25 mm
Gas filling	90% Ar-10% CH_4 (4 Bar) 90% Xe-10% CO_2 (" ")	90% Ar-10% CH_4 (8 Bar) 90% Xe-10% CO_2 (" ")
Delay line Time delay Impedance D.C. resistance	Bare copper wirewound 400 ns 400 Ω 20 Ω	Plated plastic 203 ns (1.1 ns/mm) 135 Ω 35 Ω
Spatial resolution	120 μm	350 μm

The problem of the stability of the anode wire under the combined action of the magnetic and electrostatic forces has some similarities to MWPC wire stability [5] and is solved differently in the two chambers. In the 135 mm chamber, which operates at gas pressures requiring an anode voltage less than 5 kV, the destabilizing electrostatic force between the wire and the return path iron poles of the magnet, which are at ground potential, is minimized by spacing them out to 6.5 cms and filling part of the gap with the non-conducting Plastiform magnet (Fig. 1b). In the case of the 360 mm chamber which was specifically designed for x-ray energies up to 60 keV, the higher operating pressure of 7-8 Bar requires voltages in excess of 8 kV on the anode wires. The electrostatic destabilizing force on the longer anode wire is too large for stability with the same pole piece configurations as in the smaller chamber. The solution we adopted (shown in Fig. 2b) was to embed two insulated 0.5 mm wires on the front surface of the Plastiform magnet pieces which are kept at the same potential as the anode wire. The diagrams in Fig. 3b show that this is a basically stable electrostatic force equilibrium. Additional equilibrium in the horizontal plane is obtained by making the anode-to delay-line spacing smaller than the anode-to-Be-window spacing.

When the appropriate voltage on the anode is selected for the particular gas composition and pressure, the signal amplitudes on the anode wire produced by 6 KeV γ rays are in the 10-60 mV range with rise times of ≈ 7 ns. The corresponding pulse amplitudes on the delay line are ≈ 20% of the anode signal. The lower amplitudes are in the proportional regime and suitable for energy discrimination. More accurate timing is obtained at the higher anode voltages which produce larger amplitude self-quenched streamer mode signals in the 30-60 mV range [6]. Fig. 5 shows these anode pulse shapes at various positions of the chamber wire in the 360 mm chamber.

The delay lines are of the type described in [7]. The combination of the specific capacity to ground, compensating pad capacity and plated windings/cm produces overall delays of 200-400 nsec. These relatively short total delays imply that, with suitable digitizing electronics, event rates in excess of 10^6/sec can be accepted.

The chamber electronics is shown in Figure 4. Figure 4a shows the circuit diagram for the anode wire current and high voltage filter. Figure 4b shows the readout electronics for the delay line. Position is determined by digitizing the difference in arrival times of the signal from an interaction event to both ends of the delay line. This time is selected by the fast AMC 680 comparators [8] which produce shaped pulses. Time jitters due to signal amplitude variations are minimal since the shape of the signal on both ends of the lines are almost identical and compensate each other. The shaped comparator output timing signals serve as the start and stop signals to a TAC (Time to Amplitude Converter) which is then digitized by a conventional ADC (10 bit accuracy).

Fig. 6 shows photographs of the complete 360 mm radius chamber. The assembly consists of two metal aluminum boxes; the front one with the beryllium window is the pressure vessel. The rear one holds the delay line amplifiers, anode wire current source, electrical filters, and the gas fittings. By placing the low signal level electronics in a shielded container in close proximity to the pressure vessel, we can minimize electrical noise problems. The output signals that go to the digitizing electronics are at NIM levels (−850 mV) on 50 ohm shielded cables and hence are not too susceptible to extraneous electrical noise.

Applications of the STOE 135 mm chamber to various crystallographical problems are given elsewhere in this volume.

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[6] T. Mulera and V. Perez-Mendez, N.I.M. *208*, 609 (1982); M. Atac, B. Tollestrup, D. Potter, N.I.M. *200*, 345 (1982).

[7] P. LeComte, V. Perez-Mendez and G. Stoker, N.I.M. *153*, 543-547 (1978).

[8] Made by Advanced Micro Devices, Sunnyvale, CA. Similar performance circuits also made by PLESSEY.

Figure Captions

Fig. 1. (a) Plan view of 135 mm radius of curvature chamber showing pressure container, anode wire, delay line and Be window.
(b) Cross sectional view showing Plastiform magnets, anode wire and shape of sensitive region.

Fig. 2. (2a) Cross sectional view of 360 mm radius of curvature chamber showing Plastiform magnets with electrostatic stabilizing wires, anode wire and shape

of sensitive region.

(2b) Cross sectional view showing pattern of stabilizing electric and magnetic forces.

Fig. 3. Chamber electronics.

(a) Schematic of floating current supply for anode wire.

(b) Schematic diagram of position readout electronics.

Fig. 4. 135 mm chamber measurements.

(a) Resolution curve measured on P.H.A. with 5.9 keV photons. R = 350 μm FWHM.

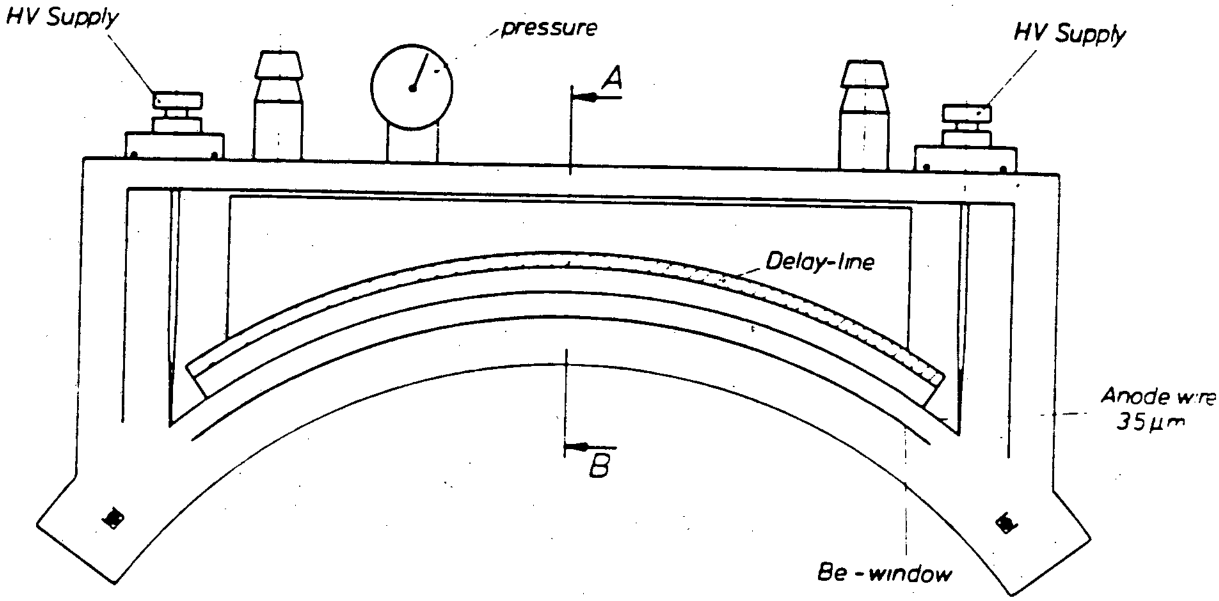
(b) Shape and amplitude of anode pulse taken at various positions on chamber window.

Fig. 5. Photograph of 360 mm chamber assembly showing:

(a) Beryllium window assembly and pressure vessel

(b) Iron yoke with Plastiform magnets and anode wire

(c) Electronics box assembly showing anode supply, and amplifier comparator cards.



Section A-B

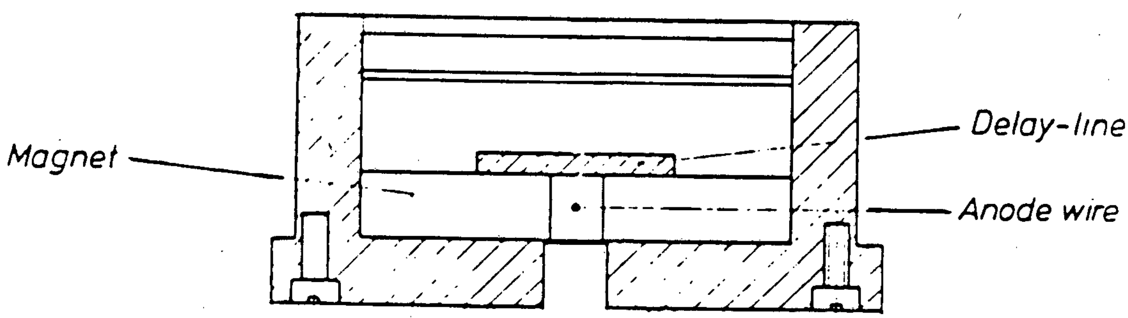


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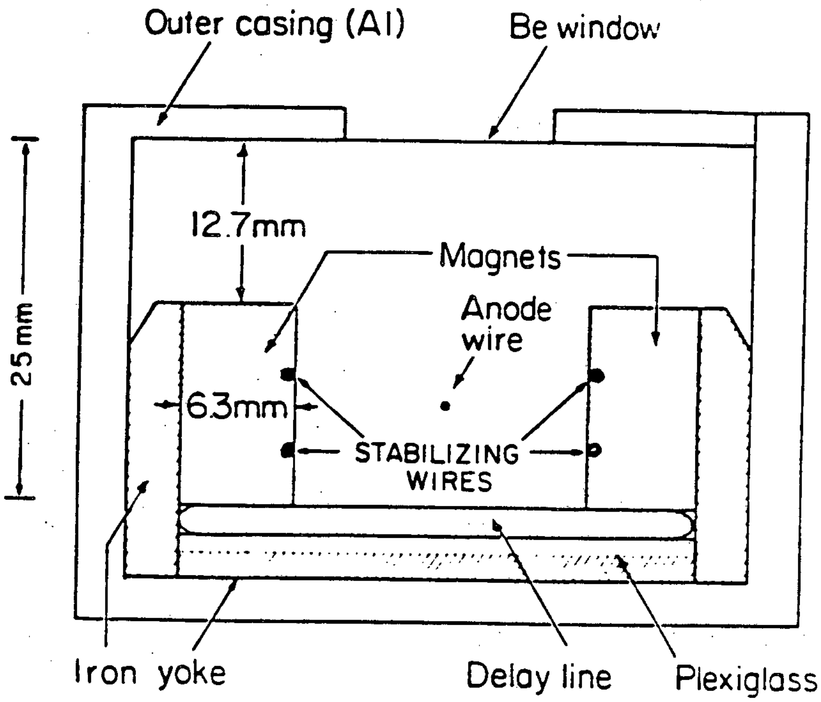
Fig. 1



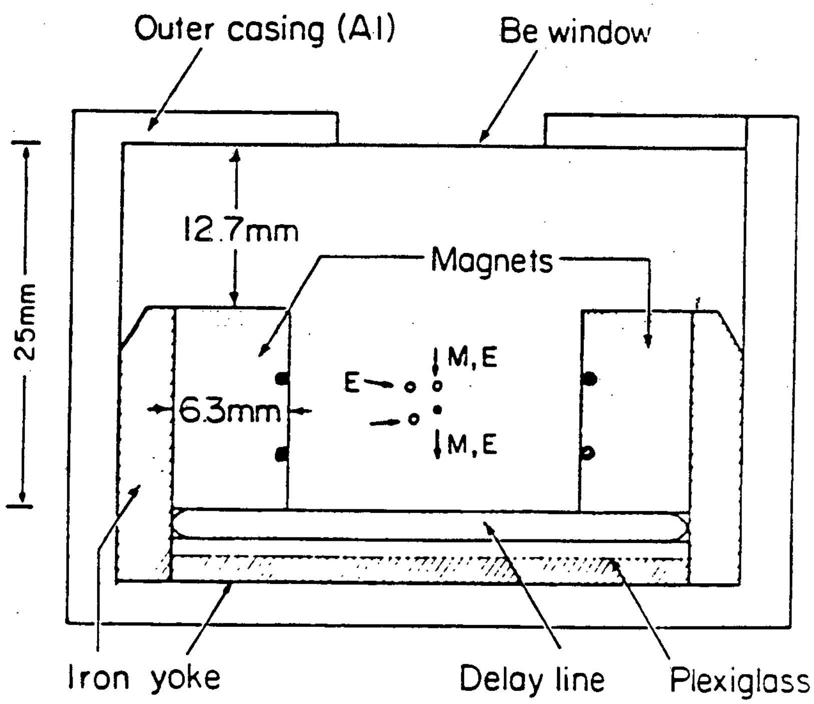


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Fig. 2

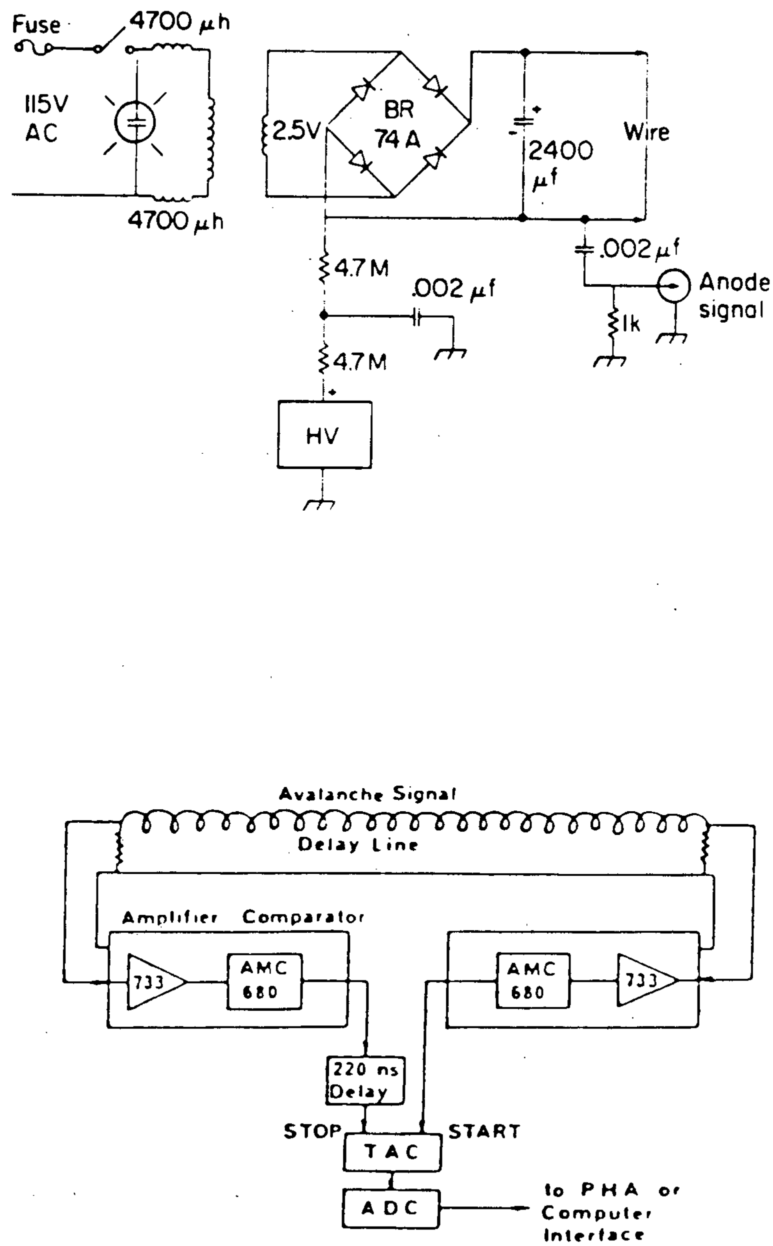

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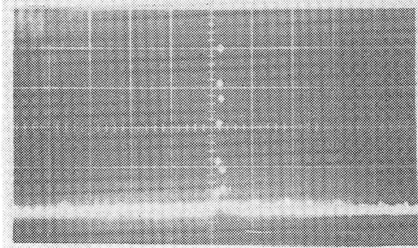
Fig. 3

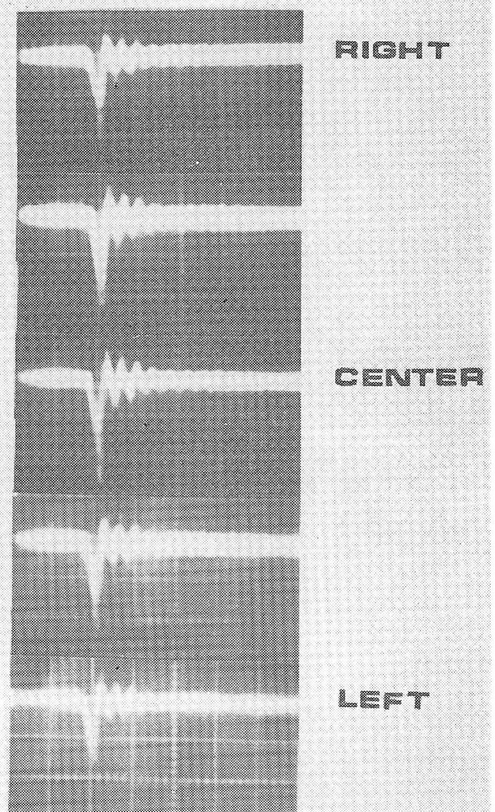
POSITION RESOLUTION



Horizontal - 100 ps/channel
Vertical - 1000 counts/channel
Resolution - FWHM = 300 μ

A

ANODE SIGNALS



Horizontal - 50 ns/cm
Vertical - 20 mV/cm
^{55}Fe source - 100 psi 90%Ar-10%CH_4

B

Fig. 4 XBB 820-10259

XBB 826-5013

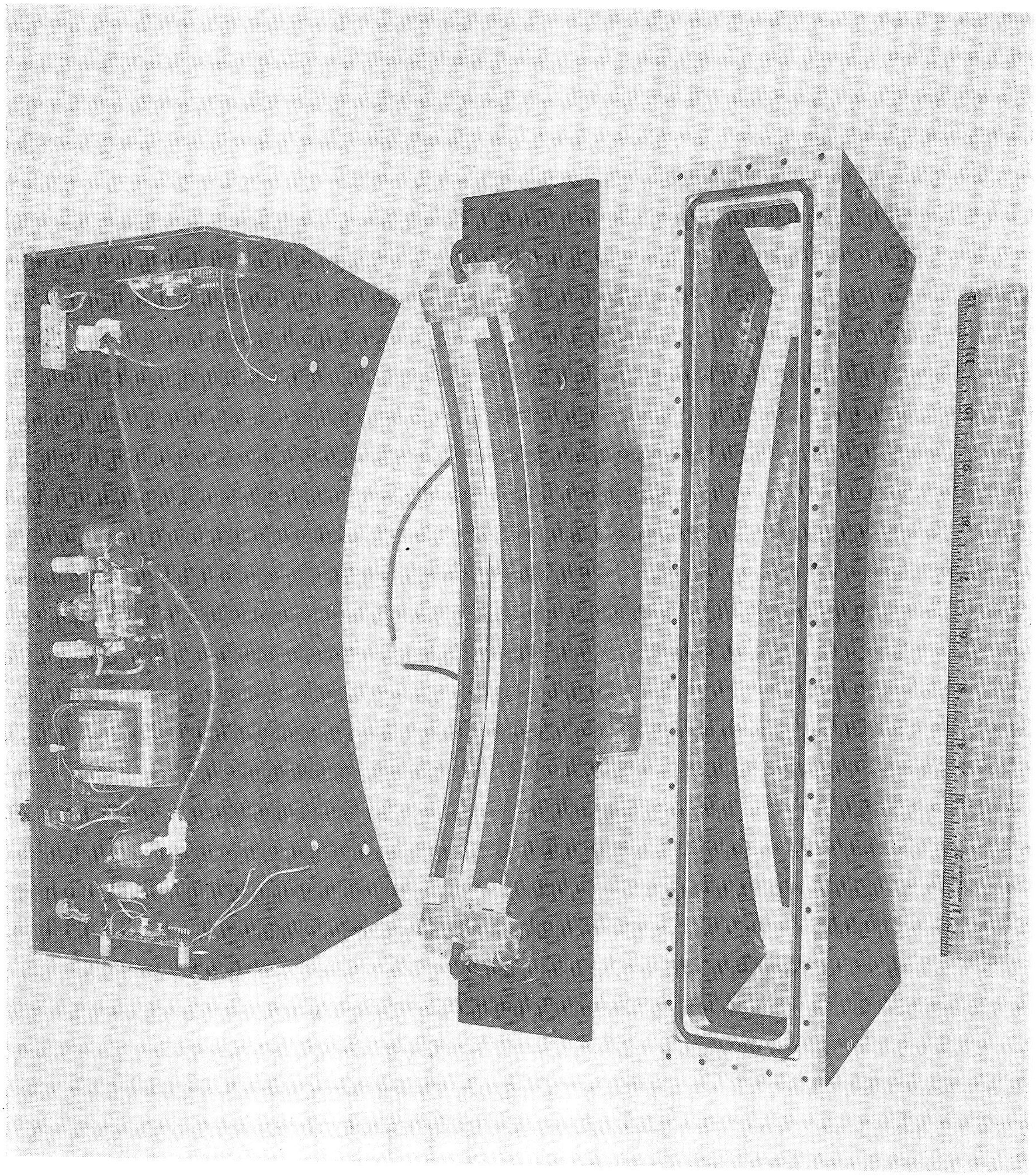


Fig. 5

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LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720