Title

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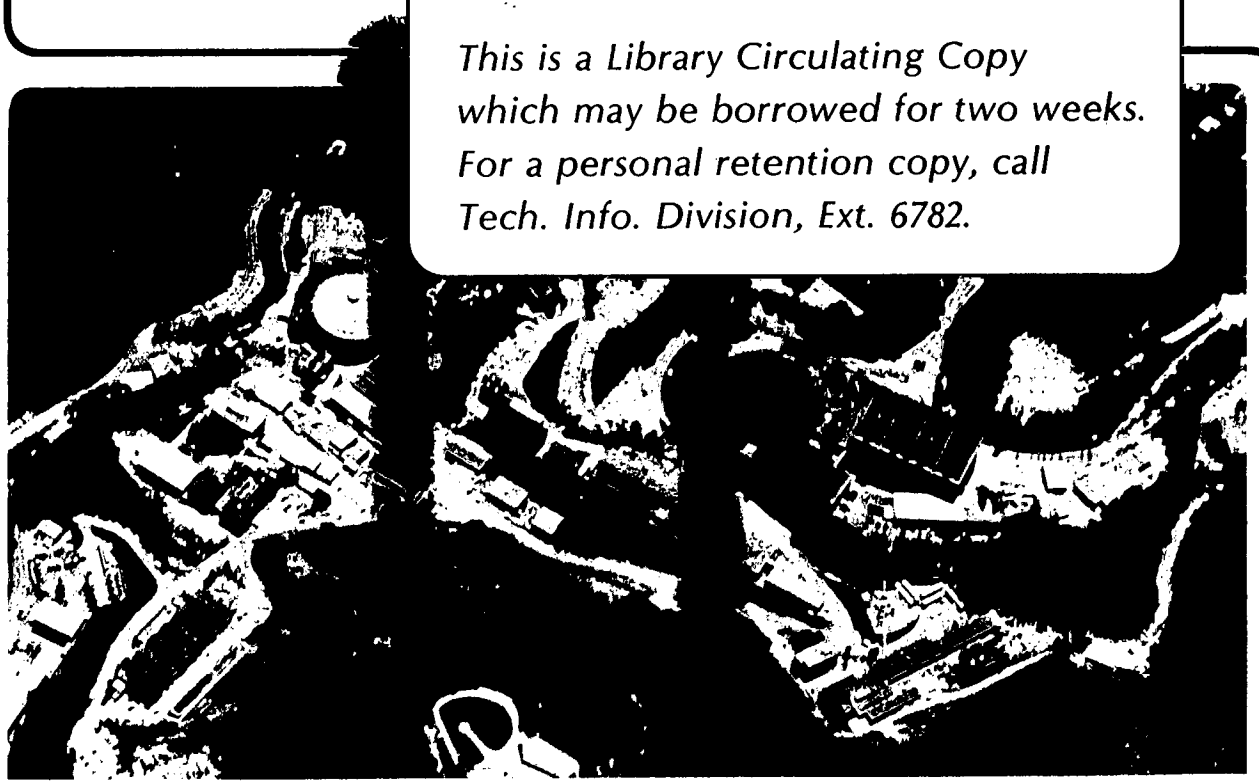

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DISCLAIMER

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OBSERVATION OF LARGE SATURATED PULSES IN WIRE CHAMBERS FILLED WITH ARGON-CARBON DIOXIDE MIXTURES*

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Large saturated pulses of the type referred to as "self quenching streamer" discharges have been observed in argon-carbon dioxide mixtures. This type of gas mixture may have some advantages over previously studied gases (1-3). Data on the behavior of these pulses as a function of voltage, anode wire diameter, and carbon dioxide concentration are presented.

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In recent years the observation of anomalously large pulses in proportional counters with thick anode wires has been reported, first in "magic gas" (1) and then in other mixtures of argon with large amounts of hydrocarbon quenchant (2,3). These signals, having amplitudes intermediate between the proportional and the Geiger-Muller mode, have comparitively fast rise times and short durations and are not followed by a large dead time. The discharges producing these signals are limited to small distances along the anode wires allowing good spatial resolution in this direction. This mode of operation has been referred to as "limited Geiger" and more recently as "self quenching streamer" behavior. We have observed this type of behavior in mixtures of argon with large quantities of carbon dioxide. We feel that these mixtures may have advantages in comparison to those containing hydrocarbons for reasons of safety and chamber longevity since carbon dioxide is both non-flammable and does not dissociate into substances which might coat the anodes.

The measurements reported here were made in a small test chamber consisting of 2 cm spaced anode wires sandwiched between cathode foils with a cathode-anode gap of 2 cm. The cathode foils were grounded and the anode wire was raised to positive high voltage and read out via a coupling capacitor. Several wire diameters were used and several mixtures of argon and carbon dioxide were circulated. Some measurements were made using a mixture of 50% argon 50% ethane to facilitate comparison with earlier work (3).

Pulse shapes and sizes were studied using a Tektronix 475 fast oscilloscope and a LeCroy 3001 multichannel analyzer. All measurements were made into an impedance of 50 Ω. A fast amplifier with a gain of 10 was employed when necessary to observe small signals.

Using anode wires 75 μm in diameter, a gas mixture of 50% argon-50% carbon dioxide and an operating voltage of 5000V, chamber signals like that shown in

Figure 1 were produced by 5.9 KeV x-rays from an ^{55}Fe source. The signals were the same shape as those produced when the chamber was filled with a 50% argon 50% ethane mixture, i.e. a risetime of 4 nsec and a duration of 100-150 nsec, and are about 20% smaller in amplitude at this operating voltage. As the operating voltage is varied, the transition, reported by others in argon-hydrocarbon mixtures (1-3) between the proportional mode and the large pulse mode of operation was observed.

The large pulses were almost completely saturated in the sense that the pulse size was independent of the initial charge deposited by the ionizing radiation but did continue to increase with operating voltage. The pulse height spectra observed with three types of radiation, the 5.9 KeV and 22 KeV x-rays from ^{55}Fe and ^{109}Cd and the spectrum of β-rays from ^{90}Sr, are shown in Figure 2. These spectra are also shown with the chamber filled with a 50% argon - 50% ethane mixture and operated at the same voltage (5000V.) The pulse heights in argon-carbon dioxide, though smaller, appear to be more completely saturated. The secondary peak at higher pulse height, described in reference (3) as being due to double streamer formation, was not seen with the argon-carbon dioxide filling. Electrons from ^{90}Sr following trajectories inclined along the anode wires at angles of up to 60^{o} from the vertical produced no change in pulse height.

The effect of different anode wire diameters and different argon-carbon dioxide mixtures was studied and the results are summarized in Figure 3.

When smaller anode diameters were employed the discontinuous transition to the large pulse mode of operation was not observed. Pulse height increased continously with voltage. In most cases a very narrow region of saturated behavior was seen just before the onset of continuous discharge. Only when anode diameters of 75μm or larger were employed did one see the discontinuous

transition. In fact over a narrow range of voltage both the proportional mode pulses and the large saturated pulses were seen. Increasing the wire diameter to 125μm resulted in pulses of comparable amplitude appearing at a voltage approximately 500 v. higher. These pulses appeared to have slightly longer rise times than those seen with 75 μm wire. No signals were seen with still larger anode diameters at any voltage below the onset of continuous discharge.

Varing the relative amounts of argon and carbon dioxide in the gas mixture has a marked effect on the shape of the large saturated pulses while leaving the shape of the proportional mode pulses essentially unchanged. Large pulses are shown in Figure 4 for five different concentrations of carbon dioxide. At the lowest concentration, 10% carbon dioxide, standard Geiger-Muller behavior was seen with slow (~75 nsec) rise times and long (~1 μsec) pulse duration. As the carbon dioxide concentration was increased the pulses shortened and the rise times became faster until signals like those shown in Figures 1 and 3c were seen at a concentration of 50%. When the carbon dioxide concentration was increased further, the rise time remained about the same (approximately 4 nsec) but the pulse length continued to shorten, finally reaching a length of approximately 35 nsec for a 90% concentration. In pure carbon dioxide, the large saturated pulses to not appear at any attainable voltage.

Large, fast, saturated pulses have been observed in wire chambers filled with argon-carbon dioxide mixtures. In agreement with earlier work (2-3) with hydrocarbon mixtures, we find that this behavior is favored by the employment of thick anode wires and large quenchant concentrations. The use of carbon dioxide rather than hydrocarbons as quenchant should have advantages in terms of safety and chamber longevity for many applications. Further studies of these phenomena are planned.

References

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(3) M. Atac, A.V. Tollestrup and D. Potter, IEEE Trans. Nucl. Sci. NS-29, 388 (1982)

Figure Captions

Figure 1 Large pulse behavior in 50% argon-50% carbon dioxide. 20 mV/div. into 50Ω, 50 nsec/div.

Figure 2. Pulse height spectra for different types of ionizing radiation.

Figure 3. Effects of anode diameter and gas mixture on chamber performance. The cross hatched portions of the curves indicate the regions in which ^{55}Fe and ^{90}Sr produce the same size pulses. The curves terminate at the voltages where the chamber begins to discharge spontaneously.

Figure 4. Effect of carbon dioxide concentration on pulse shape (a) 10%, (b) 33%, (c) 50%, (d) 66%, (e) 90%, balance argon. Operating voltages were chosen to give comparable pulse heights. 20 mV/div. into 50Ω, 50 nsec/div.

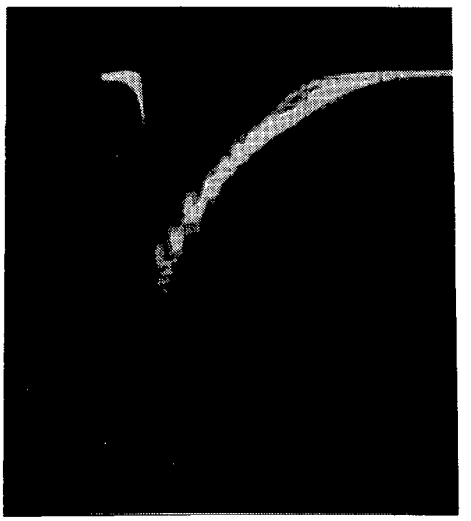

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Figure 1 Large pulse behavior in 50% argon-50% carbon dioxide. 20 mV/div. into 50Ω, 50 nsec/div.

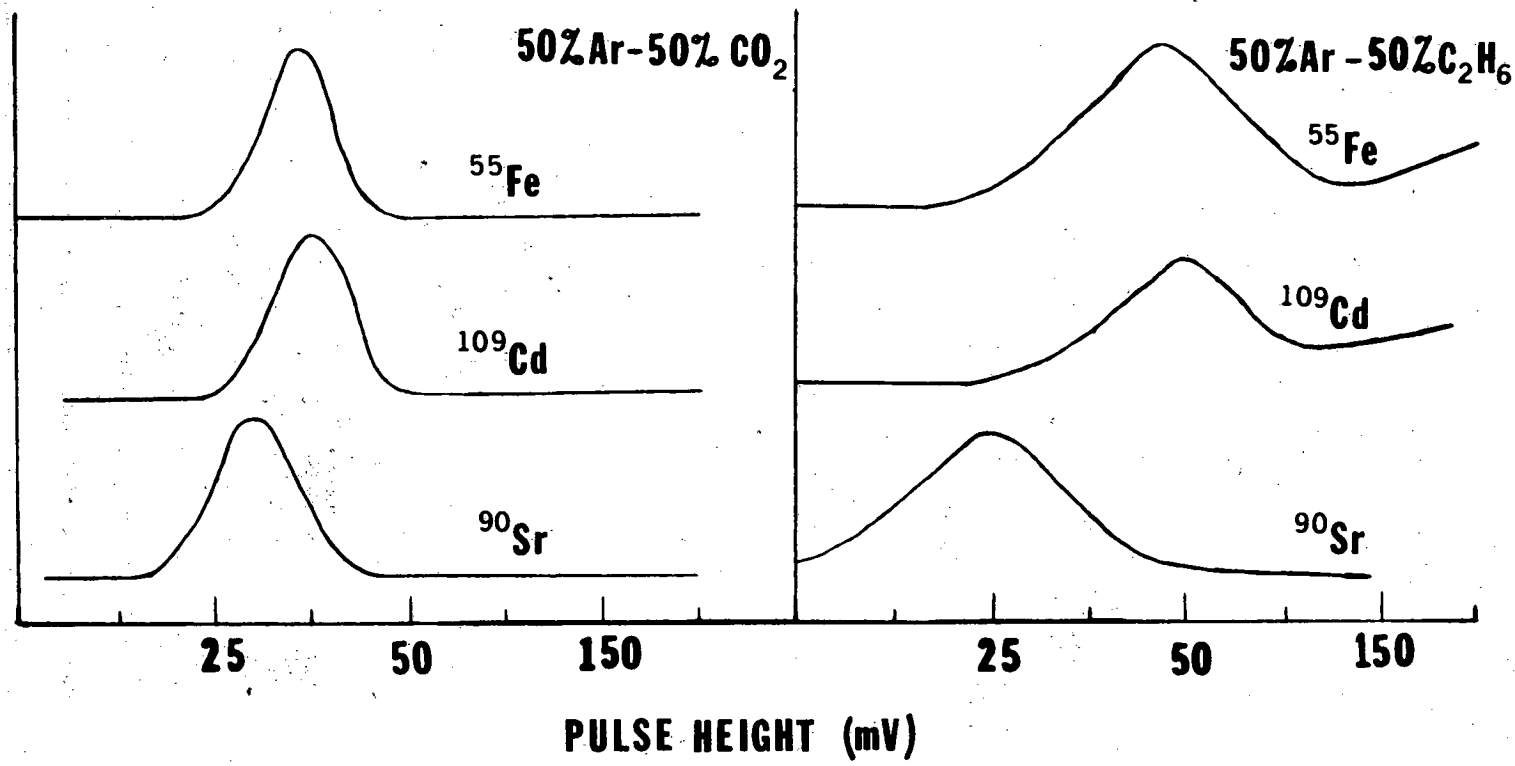

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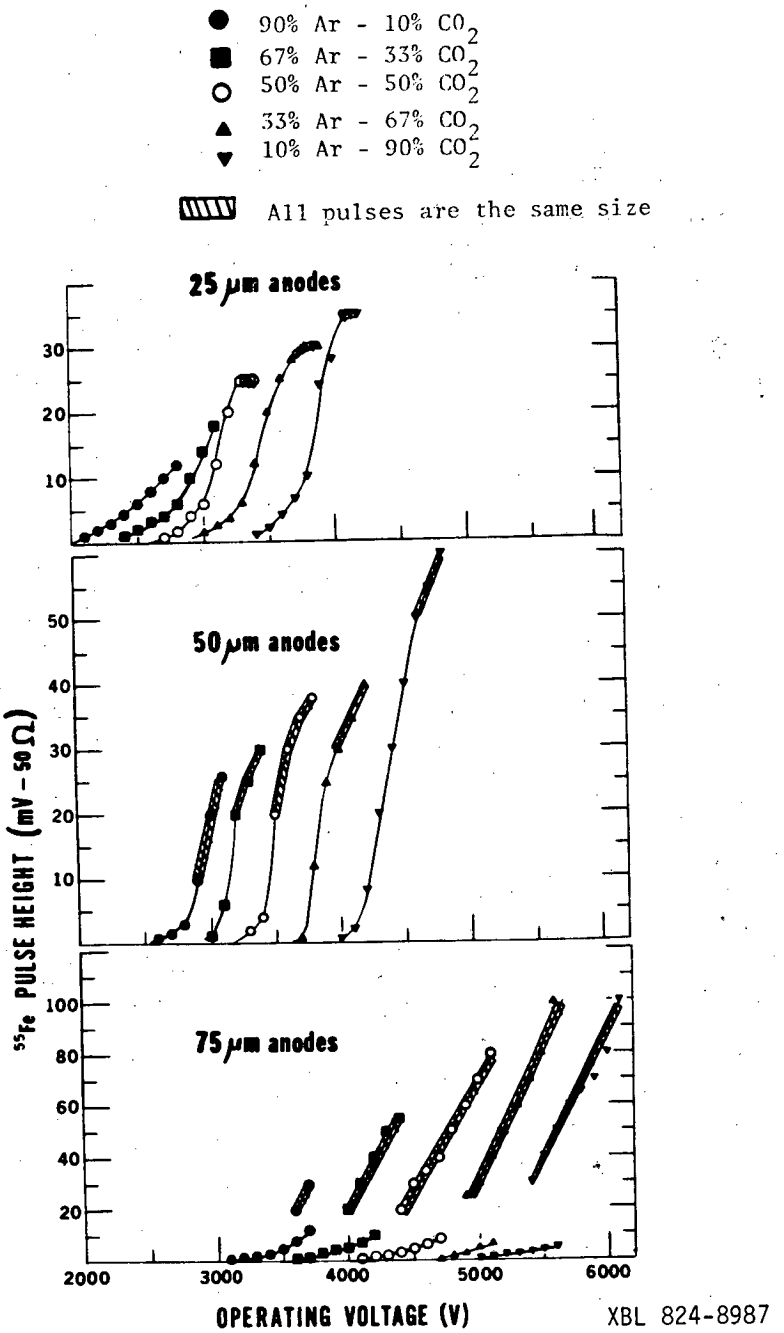
Figure 2. Pulse height spectra for different types of ionizing radiation.



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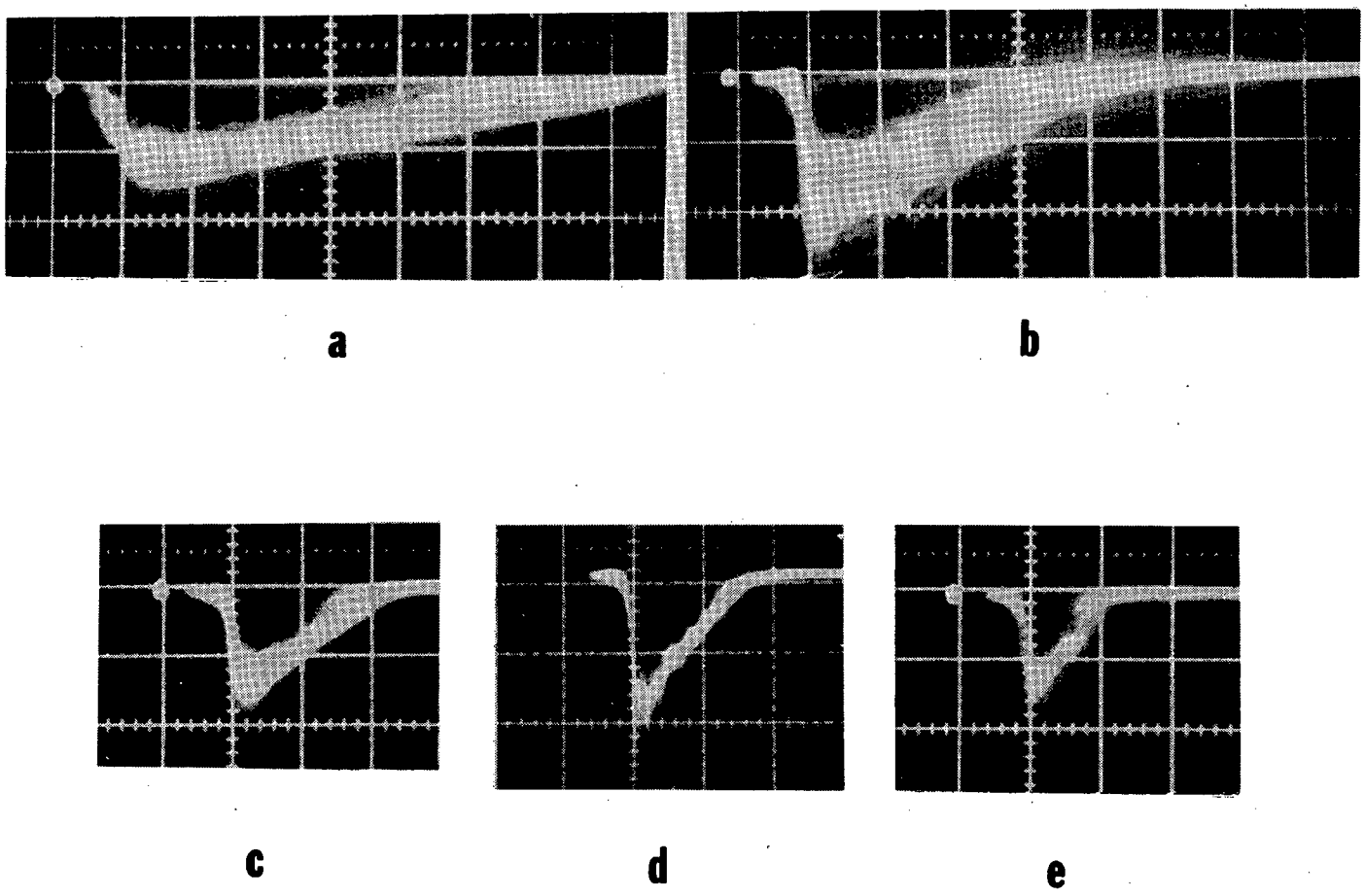

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