national accelerator laboratory

FN-237
2521.000

WIRE COUNTERS WITH A NEW GAS MIXTURE

M. Ataç

September 13, 1971

ABSTRACT

A multiwire chamber using a gas mixture of argon, isobutane and α-trichlorethane-1, 1, 1 ($CH_3.CCl_3$) has been successfully operated. Although this chamber does not operate in the proportional mode--pulse height is not a linear function of the primary ionization--we feel it has a substantial advantage over conventional proportional chambers especially when it is used to detect high energy particles. We call these detectors wire counters; their unique feature is in the use of a highly electronegative substance, ($CH_3.CCl_3$), to limit the electron avalanche. These counters with wire spacing of 1 mm can provide gas multiplication factors between 10^5 to 10^7 without going into spark formation or breakdown. Their detection efficiency approaches 100% with large high voltage plateaus. We have obtained a time resolution of ± 6 nsec at FWHM from pulses with rise times between 6-10 nsec.

In an earlier report[1] we have shown that good efficiencies and spatial resolutions (± 0.5 mm) can be obtained from wire counters with 1 mm wire spacing. However, using 90% argon and 10% methane (CH_4) we could not achieve a voltage plateau and the efficiency was a strong function of the high voltage. We also had to use rather sensitive amplifiers to detect pulses as small as 0.5 mV across 2kΩ input impedance. The sensitive area of the detector was 10 cm^2.

In the following we will report some interesting results obtained from our wire counter of 80 cm^2 sensitive area and 1 mm wire spacing using 80% argon and 20% isobutane mixed with a small amount of trichlorethane.[2] $CH_3.CCl_3$ is a liquid at room temperatures and atmospheric pressures as is used commonly as a solvent. To add a small amount of trichlorethane to the gas mixture we bubble a part of the argon-isobutane mixture through trichlorethane at 0^oC temperature. Thus the amount of trichlorethane vapor can be easily controlled using two sensitive flow meters.

A cross-sectional view of the counter is shown in Figure 1. Wires of 10 μm gold-plated tungsten (the wire was electropolished before gold plating) were wound on an epoxy-glass frame with a spacing of 1 mm. Our special winding machine[3] kept the spacing uniform to ± 12 μm and the tension controlled to within ± 5%. The wires were then glued to the frame with a uniform thickness of epoxy. The completed counter consisted of a total of 124 such wires of which the middle 64 were connected to amplifiers.

The negative electrodes of 25 μm thick aluminum foils were glued to a pair of dish-shaped aluminum disks and the spacing of the cathode planes was increased outside of the sensitive area to prevent unwanted end effects and corona discharge. This allows us to have a 2 mm gap between the positive wire plane and each of the negative aluminum foil electrodes. A narrow gap reduces the probability of having simultaneous pulses from adjacent wires. Brass guard rings were added between the wire plane and the negative electrodes to eliminate the field gradient at the wires.

The detector and 64 amplifier circuits are placed in an aluminum shielding box. The signals from each of the 64 wires is readout from one end of the chamber and the rest of the wires (60 wires) are kept at ground potential. The signals are amplified by dual-in-line TTL integrated circuits.[4] These are arranged onto four cards each of which has 16 amplifier and gate channels plus dual 8-fold OR's contained in an 11 x 15 cm^2 area. The signal separation between the amplifier channels is 47 db.

We have used a collimated Ru^{106} β-source (E_{max} = 3.5 MeV) with minimum ionizing electrons selected by a beam defining plastic scintillator to obtain the following results. Figure 2 shows some pulses resulted from this counter when 35% of the argon-isobutane mixture was flowed through $CH_3.CCl_3$ at 0^oC. We see that pulses rising with 6-10 nsec to 20 to 120 mV are observed when 3,000 v is applied to the counter (Figures 2a and 2b). To observe the pulses before the amplifiers individual wires were connected to ground through 4.7kΩ resistors. Rather large pulses can be observed (Figure 3C) when 3,200 v applied.

The counter does not go into breakdown or spark formation and show no observable number of spurious pulses at these high voltage levels.

Discriminator levels of the amplifier channels were set to accept pulses of (4 ± 1) mV. Pulses from 16 adjacent wires, which are in the collimated beam, were then OR'ed. Figure 3 shows a time distribution of pulses from the 16-fold OR output. A 35-40 nsec coincidence gate needed to obtain efficiencies approaching 100%. A time to amplitude converter was used to store this spectrum into a multichannel analyzer. The scintillation pulses initiated the time to amplitude converter and the pulses from the counter stopped the converter.

For comparison some efficiency curves were obtained using other gas combinations with the same chamber and readout electronics. Figure 4 shows that the efficiency approaches 96% when 90% argon and 10% CH_4 is used. Above 2,450 v the quenching is not sufficient, therefore the counter goes into breakdown. With 80% argon and 20% i-C_4H_{10} there is a very narrow plateau ($\sim$50 v), but the counter is unstable beyond 2,700 v (Figure 5).

We see from Figure 6 that about 300 volt wide plateau is reached when 20% of the 80% argon + 20% i-C_4H_{10} is bubbled through liquid $CH_3.CCl_3$ at 0°C. The lower curve shows the probability of simultaneous pulses obtained from any two adjacent wires. The plateau is widened to 400 volts when 35% of the same gas mixture is bubbled through the liquid $CH_3.CCl_3$ at 0°C (See Figure 7).

This counter has been exposed to over 10^{11} counts with a rate of 2×10^5 pulses per second and has shown no detectable deterioration in performance. After this continuous operation the chamber was disassembled and traces of light brown deposition was observed on the aluminum foils facing the wire plane. This deposition had the same pattern as the wires. There was no obvious damage to the wires and no observable corrosion of the counter due to trichlorethane.

We note that as we increase the concentration of CH_3CCl_3 our efficiency begins to drop. We believe this is due to the highly electronegative nature of this compound which is exhibited in the capture of primary electrons. In Figure 8, which shows a noticeably lowering of the efficiency, 50% of the argon-isobutane mixture is bubbled through $CH_3.CCl_3$ at 0^oC. For high concentration of CH_3CCl_3 the sensitive regions around the wires may be reduced; hence, smaller concentration of this gas should be used for larger wire spacings.

We conclude from the results obtained with and without $CH_3.CCl_3$ that breakdown, spark formation and spurious counts due to the field emission are greatly reduced or eliminated with the addition of this polyatomic gas.

We hope that this new gas mixture will enable us to operate larger area counters with 1 mm wire spacing. This development opens the possibility of counters with even smaller wire spacings.

The author expresses his appreciation to Dr. J. Lach for many useful discussions and to R. Labotka for his help in taking the data.

REFERENCES

[1]M. Ataç and J. Lach, Nucl. Instr. and Meth. 86(1970)173-176.

[2]$CH_3.CCl_3$ was supplied by Producers Chemical Co. with additives which prevent HCl formation.

[3]M. Ataç and E. Scholefield, NAL Internal Report TM216.

[4]M. Ataç and R. G. Martin, 1971 Particle Accelerator Conference, IEEE Transactions Volume NS-18 No. 3, Pg. 435.

CAPTIONS

Fig. 1. A cross-sectional view of the counter.

Fig. 2. Pulses observed from the counter at different voltages when 35% of the argon-isobutane mixture was flowed through $CH_3.CCl_3$ at 0^oC.

Fig. 3. Time distribution of pulses.

Fig. 4. Efficiency curve when 90% argon and 10% methane is used.

Fig. 5. Efficiency curve obtained from a mixture of 80% argon and 20% isobutane.

Fig. 6. Efficiency curve when 20% of the (80% argon + 20% isobutane) is bubbled through liquid $CH_3.CCl_3$ at 0^oC.

Fig. 7. Efficiency curve when 35% of the argon-isobutane mixture bubbled through the liquid $CH_3.CCl_3$ at 0^oC.

Fig. 8. Efficiency begins dropping when 50% of the mixture is bubbled through $CH_3.CCl_3$ at 0^oC.

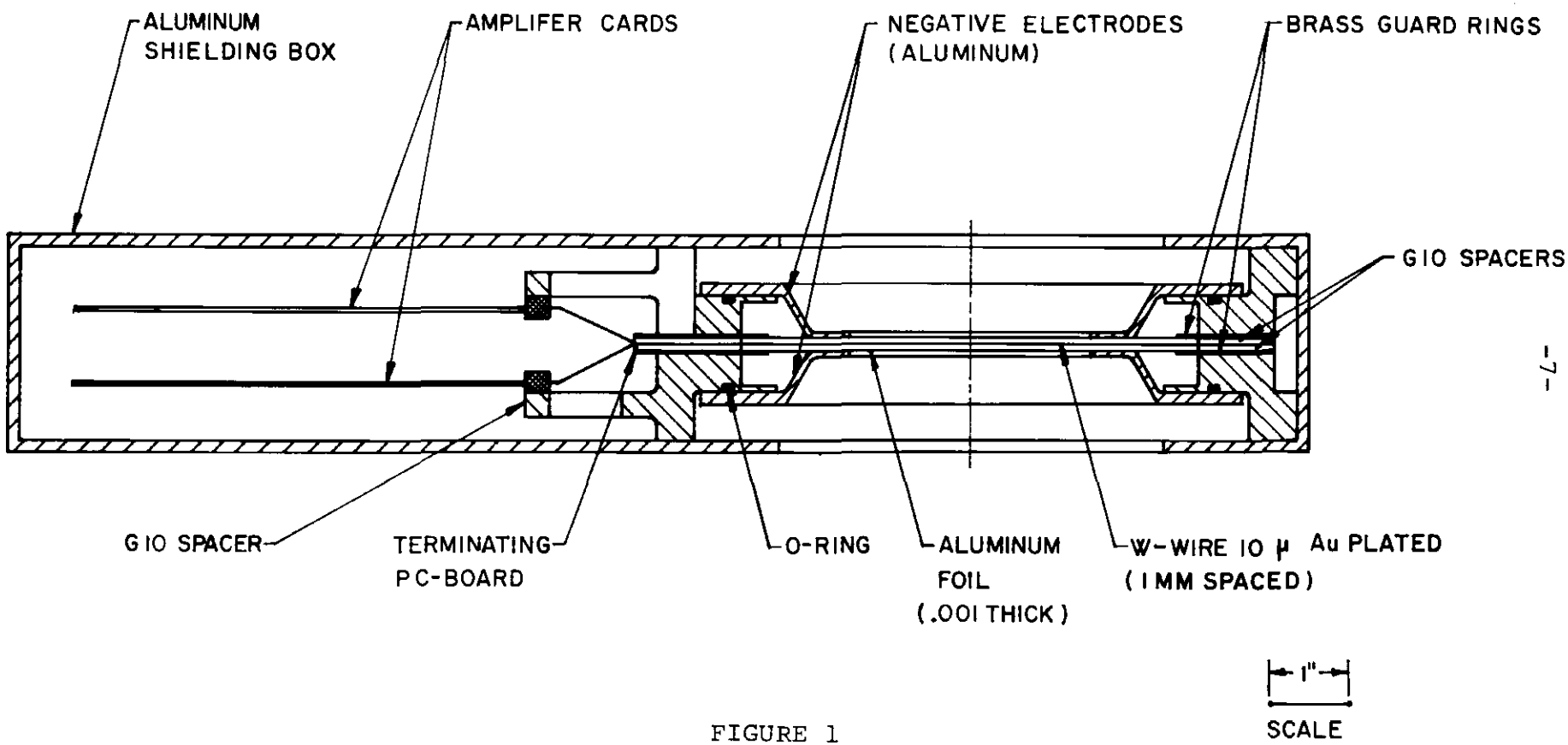
ALUMINUM
SHIELDING BOX
AMPLIFER CARDS
NEGATIVE ELECTRODES
(ALUMINUM)
BRASS GUARD RINGS
G10 SPACERS
G10 SPACER
TERMINATING
PC-BOARD
O-RING
ALUMINUM
FOIL
(.001 THICK)
W-WIRE 10 μ Au PLATED
(1MM SPACED)
1"
SCALE

FIGURE 1

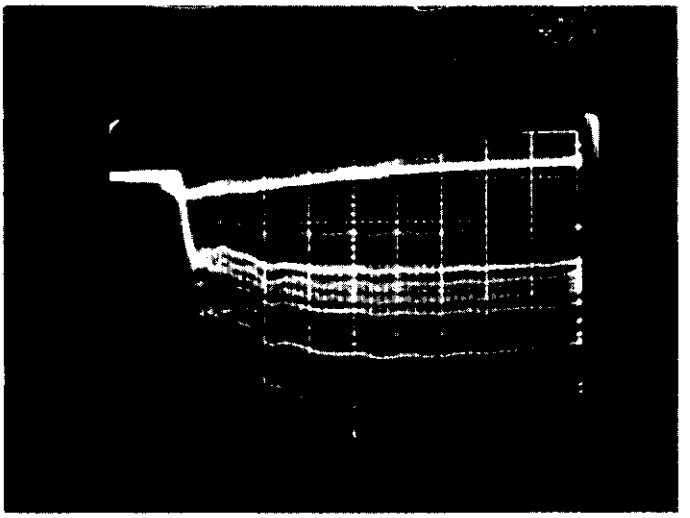

Figure 2.a
Horizontal scale is 20 nsec per large division.
Vertical scale is 20 mV per large division.
HV = 3,000 v

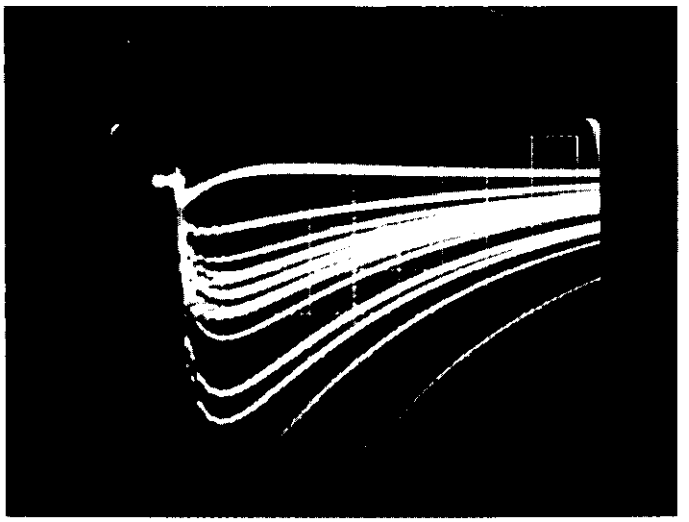

Figure 2.b
Horizontal scale is 100 nsec per large division.
Vertical scale is 20 mV per large division.
HV = 3,000 v

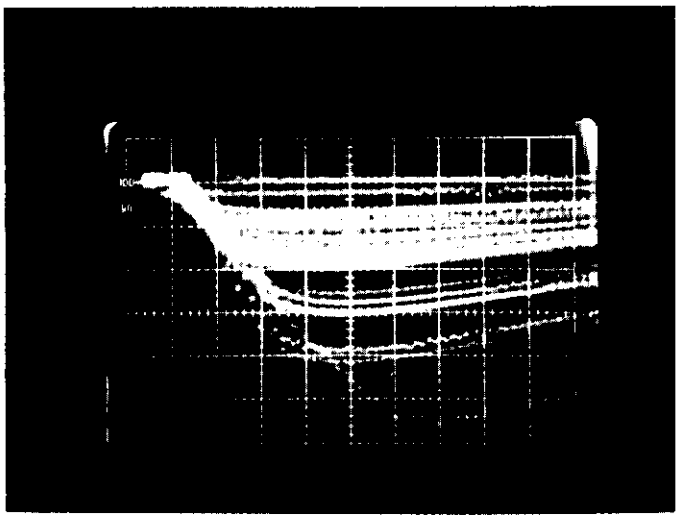

Figure 2.C
Horizontal scale is 50 nsec per large division.
Vertical scale is 200 mV per large division.
HV = 3,200 v

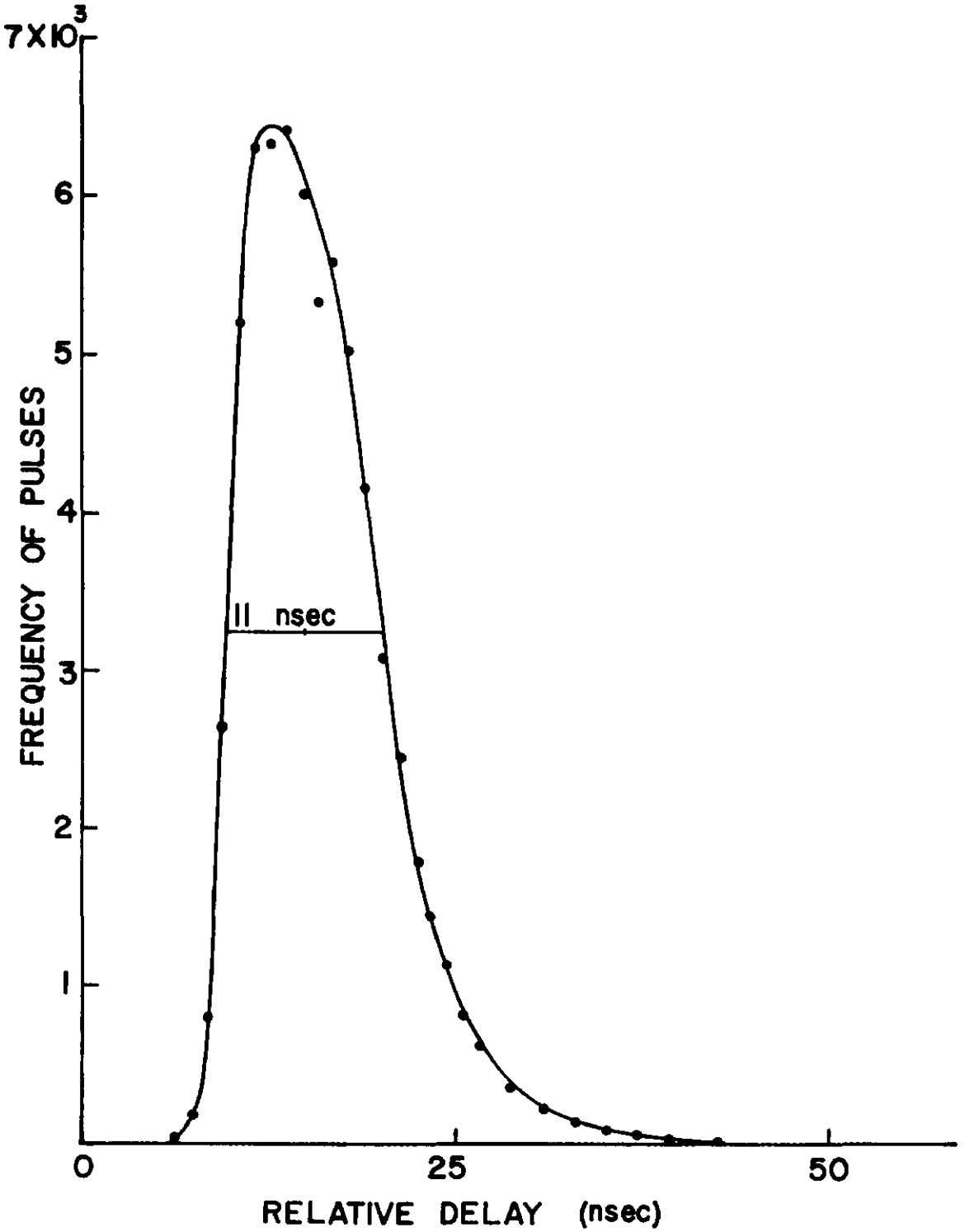
7X10³
6
5
4
3
2
1
FREQUENCY OF PULSES
11 nsec
0
25
50
RELATIVE DELAY (nsec)

FIGURE 3

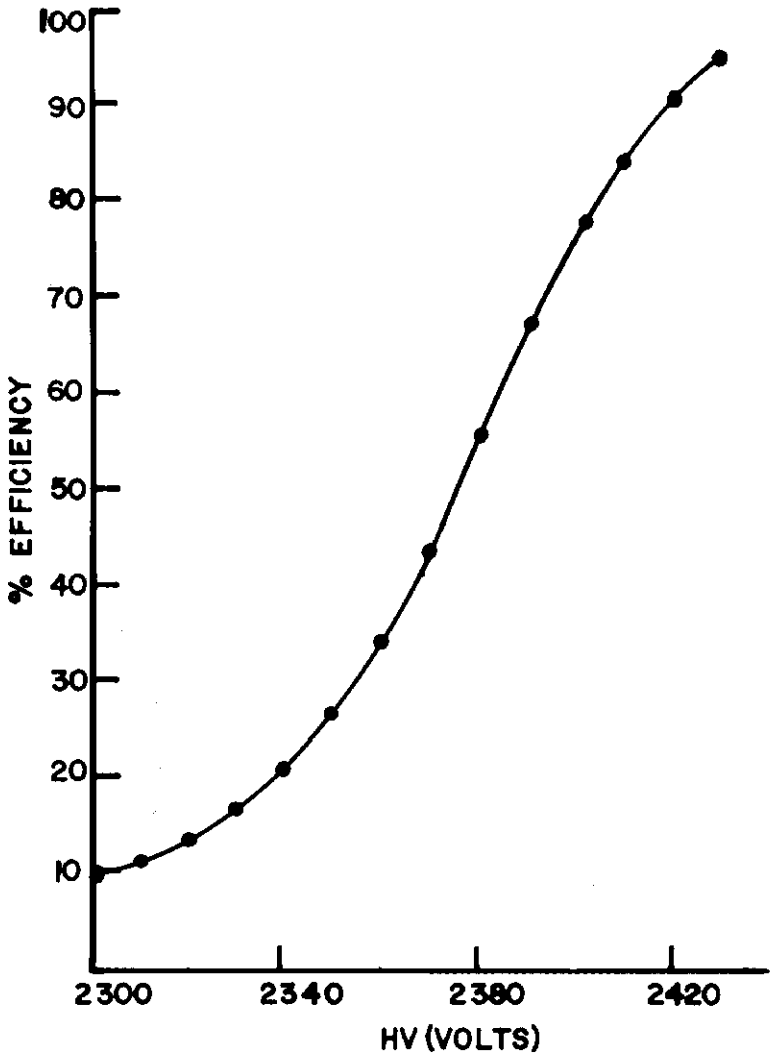
100
90
80
70
60
50
40
30
20
10
% EFFICIENCY
2300
2340
2380
2420
HV (VOLTS)

FIGURE 4

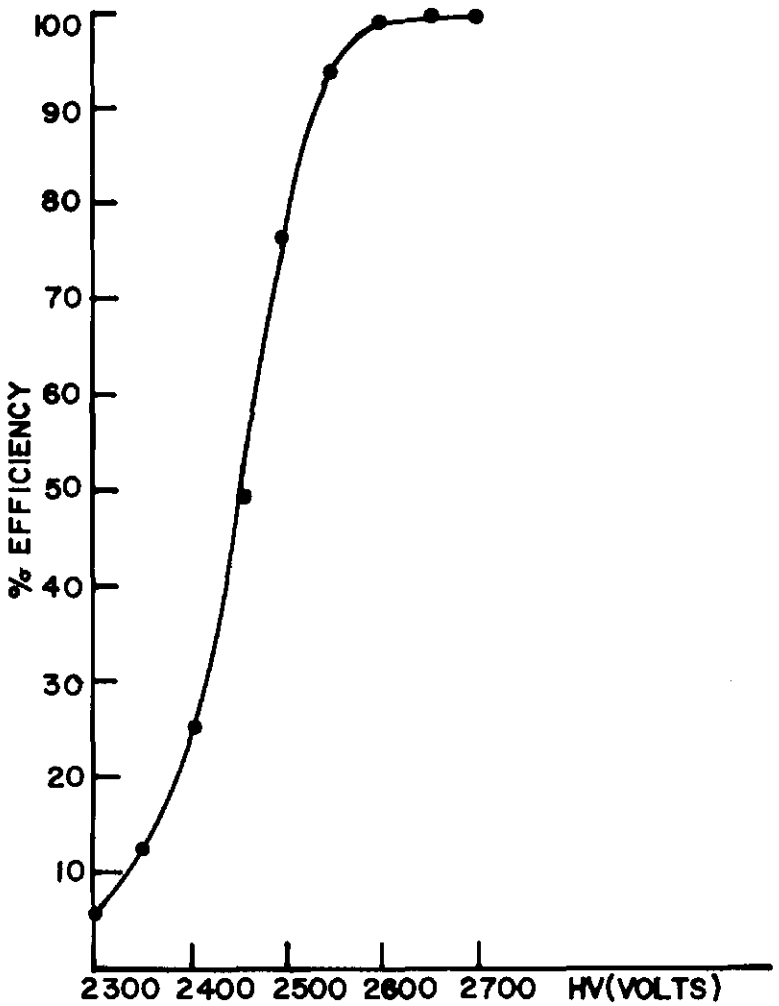
100
90
80
70
60
50
40
30
20
10
% EFFICIENCY
2300 2400 2500 2600 2700 HV(VOLTS)

FIGURE 5

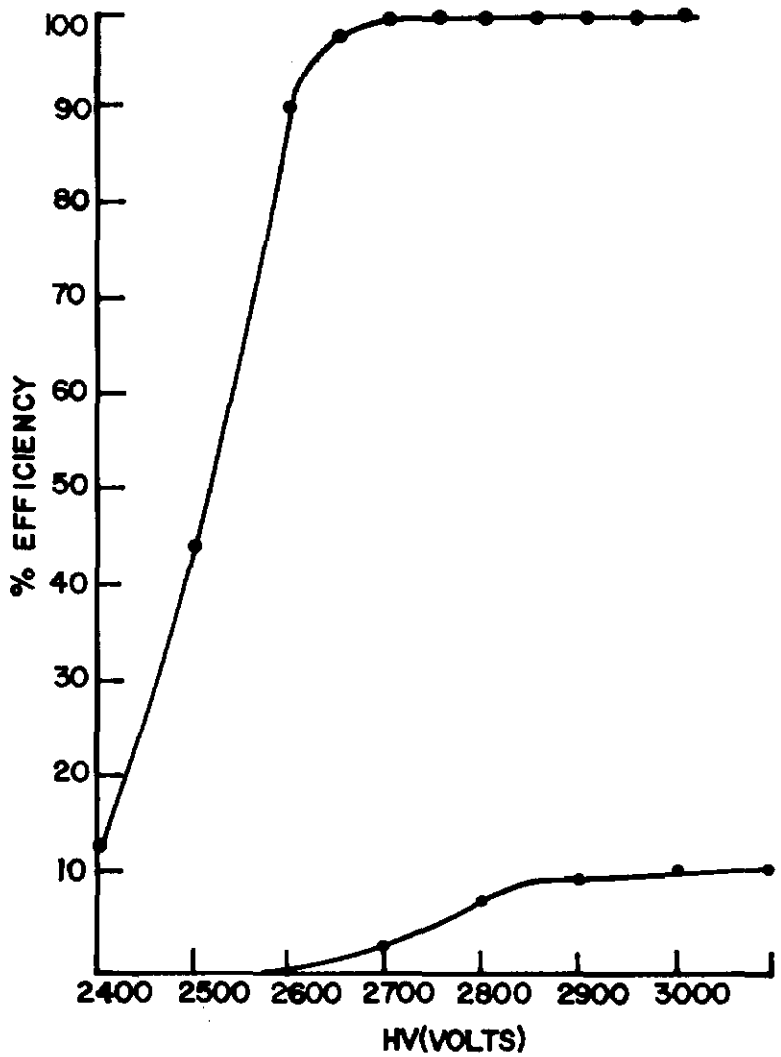
100
90
80
70
60
50
40
30
20
10
% EFFICIENCY
2400
2500
2600
2700
2800
2900
3000
HV(VOLTS)

FIGURE 6

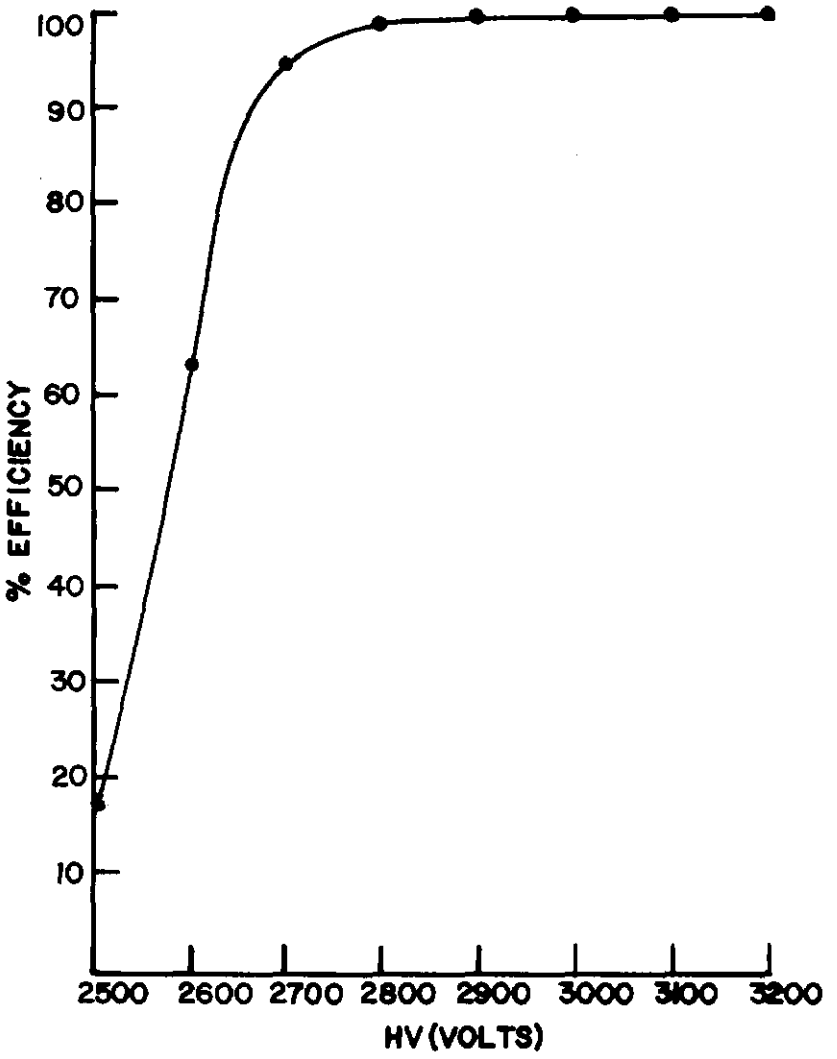
100
90
80
70
60
50
40
30
20
10
% EFFICIENCY
2500
2600
2700
2800
2900
3000
3100
3200
HV (VOLTS)

FIGURE 7

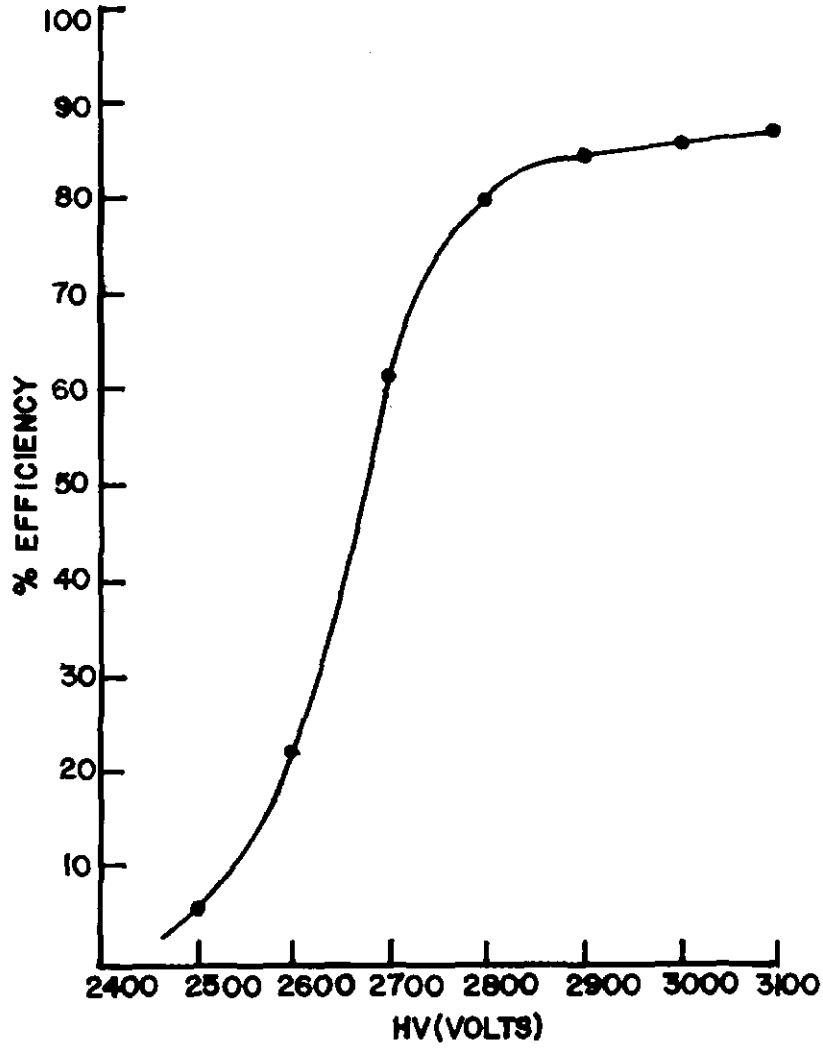
100
90
80
70
60
50
40
30
20
10
% EFFICIENCY
2400
2500
2600
2700
2800
2900
3000
3100
HV(VOLTS)

FIGURE 8