EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

For internal circulation only

NP Internal Report 69-29
30 October 1969

A STUDY OF THE PERFORMANCE OF A PROPORTIONAL WIRE CHAMBER WITH DIFFERENT DISTANCES BETWEEN WIRE- AND HIGH-VOLTAGE PLANE

P. Steffen and F. Vannucci

CONTENTS

G E N E V A
1969

1. PURPOSE

The purpose of these measurements is to study the influence of the gap width, the distance between wire plane and meshes (high-voltage planes), on the performance of a proportional wire chamber[1)] (PWC). The results lead to a selection of the best gap width suitable for operating a PWC.

2. THE APPARATUS

2.1 Geometry of the chamber

A special PWC with a variable gap width is used that allows widths of 2, 4, 5, 6 and 8 mm.

The chamber itself is 10 cm × 20 cm and contains 20 cm long molybdenum wires of 20 μ diameter spaced at intervals of 2 mm. Other dimensions are quoted in Fig. 1.

The gas flushing the chamber is a mixture containing 20% isobutane and 80% argon.

2.2 Set-ups for measurements

Two different set-ups are used.

2.2.1 A FET probe is directly connected to one wire of the chamber in order to measure, across a resistor of 10 kΩ, the maximum pulse height originating from the 5.9 keV photopeak of an ^{55}Fe source. All other wires are connected to ground as shown in Fig. 2. The pulse height is visually measured on a scope.

2.2.2 The efficiency is measured with a collimated ^{90}Sr β-ray source (set-up in Fig. 1). The signals arriving from four adjacent wires are fed into an OR-gate. These four wires define an 8 mm wide strip. Below this strip two counters, one thin ($1 \times 20 \times 50$ mm^3) and one thick ($10 \times 120 \times 120$ mm^3) allow a monitoring of the number of particles which go through the PWC.

The electronic scheme used for these measurements is shown in Fig. 3 and the efficiency is defined as the ratio between the number of counts in Scaler 2 and Scaler 1. The overlap time between the very short pulses (2 nsec) coming from the wires and the coincidence output of the two counters is fixed at 30 nsec by the shaper Sw.

2.2.3 The same set-up can be used to give the time distribution of one wire by means of a time-to-amplitude converter (TAC). The coincidence signal from the two counters starts the TAC, while the signal from the wire stops it. The TAC output feeds a multichannel analyser.

Figure 4a shows a typical time distribution (3.2 kV high voltage, 4 mm gap width). In this distribution one can distinguish three regions (Fig. 4b): the peak (A), the tail (C) and the boundary region (B) between. These time regions originate from electrons in different space regions of the chamber as shown in Fig. 4c.

The pulses in the regions A and B are sufficient to reach more than 99% efficiency. This is based on a measurement with an 8 mm gap PWC of which 32 wires were used. Only the first pulse was used for the coincidence with the scintillation counters within 30 nsec. This yielded an efficiency of 99.9%. On the other hand the time distribution of the 32 wires shows no tail, whereas the time distribution of one wire is similar to the one of this chamber with an 8 mm gap. These results are assumed to be true also for smaller gap widths. The pulses coming in time region C always have an additional pulse on one of the adjacent wires within the time regions A or B. These additional delayed pulses contribute to the accidental rate.

The accidental rate in the chamber depends on the length of the tail. Thus, it is essential to reduce, as much as possible, the length of the tail, and this is a criterion to choose the best gap width.

3. RESULTS

First, it should be noted that the chamber does not work with a 2 mm gap width, that is the gap equal to the wire spacing. This is due to the presence of a guard-strip connected to ground which is at a distance of 1 mm when the gap width is 2 mm.

3.1 Efficiency

The efficiency and pulse height curves are shown in Figs. 5 to 8 for four different gap widths. The maximum efficiency reaches at most 88%. The loss is due to the fact that we take into account only four wires so that a reasonable fraction of electrons go through the chamber outside this region. The decrease of the maximum efficiency from 4 to 8 mm gap width is due to the geometry of the set-up; the smaller the gap, the larger the solid angle of the apparatus.

Figure 9 shows the variation of the discharge voltage with the gap width. This voltage is defined as the voltage at which large pulses occur on the wires when the source is removed.

In Fig. 10 (upper curve), the length of the plateau of the efficiency curves is shown as a function of the gap width. The length of the plateau is defined as the range of voltage between discharge voltage and the voltage corresponding to 95% of the maximum efficiency.

One can see that this plateau decreases slightly as the gap width becomes smaller, but at 4 mm gap width the plateau is still more than 500 V long and the relative length (length/average voltage of plateau) is the largest for 4 mm gap (Fig. 10, lower curve).

3.2 <u>Time distributions</u>

The width of the peak depends very little on the gap width. It is always of the order of 30 nsec.

On the contrary, the total length of the time distribution (peak plus tail) varies with the gap width according to Fig. 11. The four points plotted are in good agreement with a linear variation.

The ratio (counts in tail/counts in peak), which is correlated to the accidental rate, varies with the gap width as shown in the following table:

Gap width	Ratio
4	0.45
5	0.57
6	0.69
8	0.95

This means that with an 8 mm wide gap, each particle that goes through the chamber yields two pulses on adjacent wires. The first comes during the first 30 nsec, while the second may come up to 200 nsec later. In order to compare with the result obtained in a beam perpendicular to the wire plane, the same ratio for a comparable amplifier and an 8 mm gap width was of the order of 0.25

The use of a 4 mm wide gap in an operating PWC does not lead to any particular trouble, and presents several advantages:

a) lower voltage is required;

b) the relative length of the plateau is better than with other gap widths;

c) the time distribution exhibits a shorter tail, that means a smaller accidental rate.

* * *

REFERENCE

1) G. Charpak, R. Bouclier, T. Bressani, J. Favier and C. Zupančič
Nucl. Instrum. Meth. 62, 262 (1968).

Figure captions

Fig. 1 : Set-up for measurements with β source.

Fig. 2 : Electronics for efficiency measurements (4 wires taken).

Fig. 3 : Electronics for pulse height measurements (1 wire taken).

Fig. 4 : Typical jitter spectrum taken at 3.2 kV with 4 mm gap width (1 wire only).

Figs. 5-8 : Efficiency and pulse height curves as function of high voltage for four different gaps of the chamber.

Fig. 9 : Discharge voltage and voltage at 60% of maximum efficiency in the efficiency curves versus the gap of the chamber.

Fig. 10 : Length of the plateau in efficiency curves as function of the gap. This plateau is defined down to 95% of maximum efficiency. Relative length means the ratio length/average voltage of the plateau.

Fig. 11 : Total length of the jitter spectrum given by the PHA as a function of the gap width (the time distribution is taken at the average voltage of the plateau).

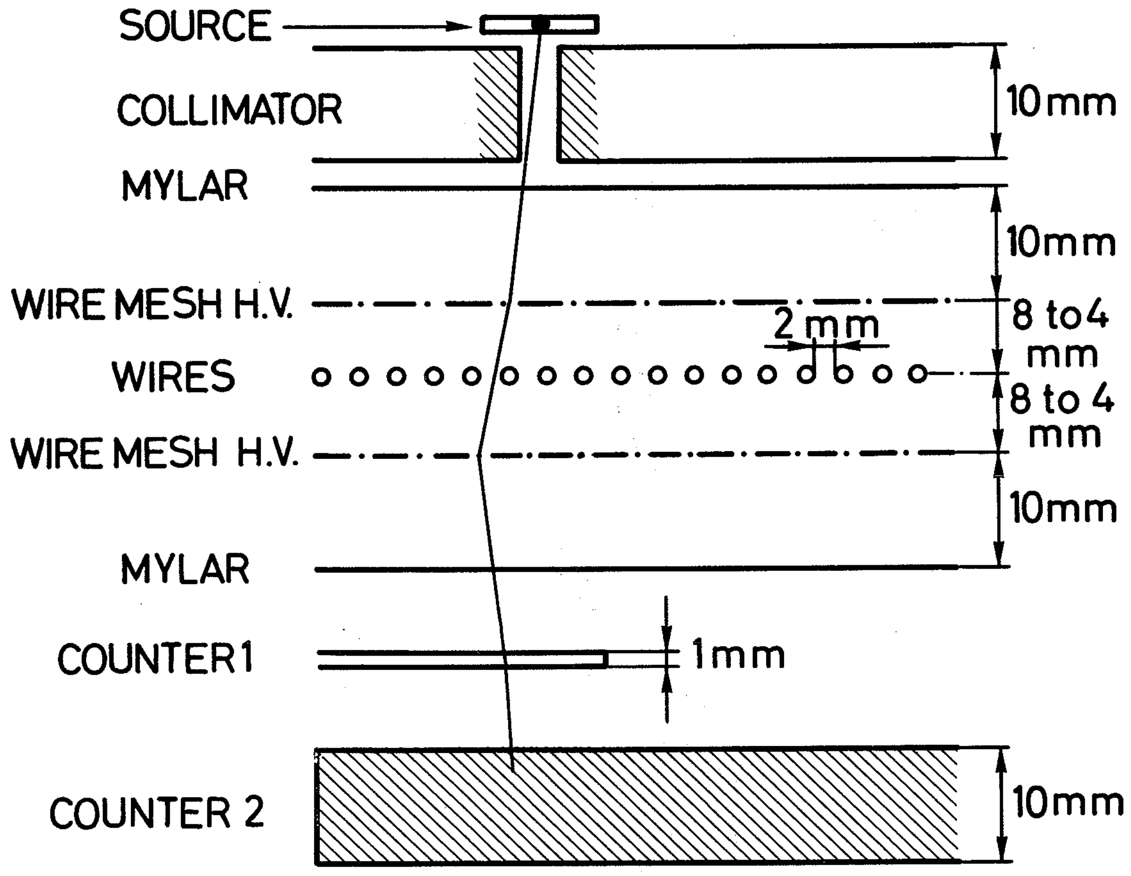

SOURCE
COLLIMATOR
MYLAR
WIRE MESH H.V.
WIRES
WIRE MESH H.V.
MYLAR
COUNTER1
COUNTER 2
10mm
10mm
8 to4 mm
2 mm
8 to 4 mm
10mm
1mm
10mm

FIG. 1

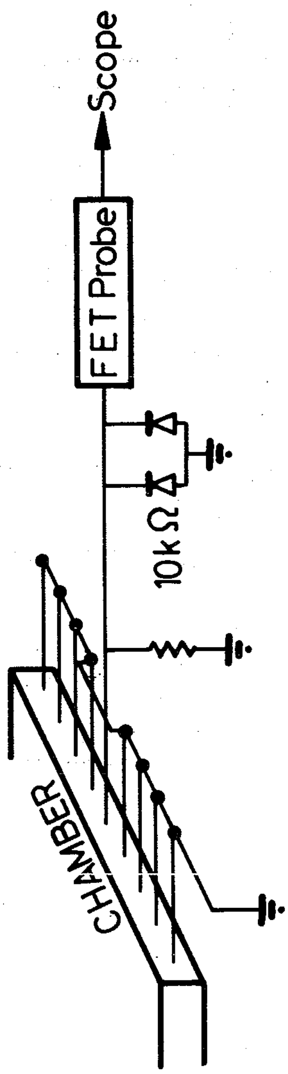
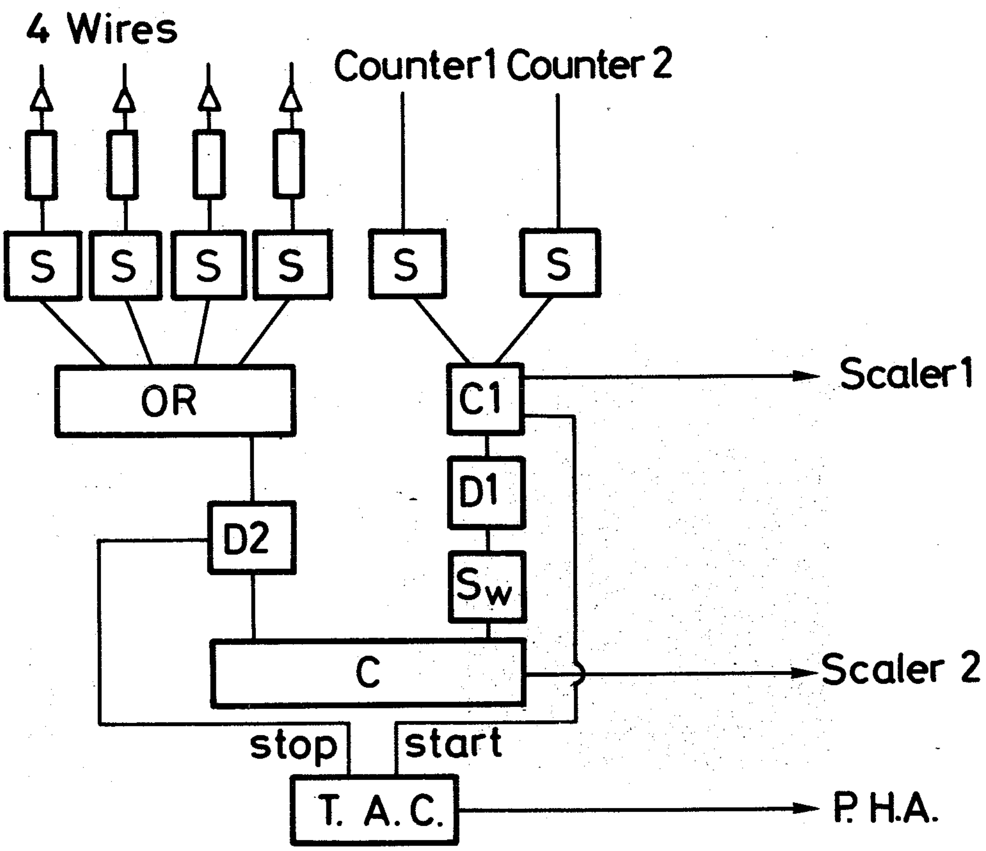


FIG. 2



A Amplifier

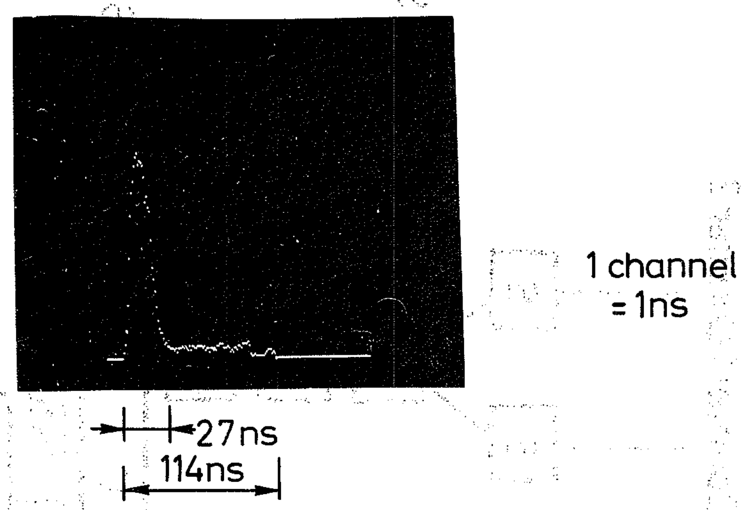
T Trigger

D Delay

C Coincidence

FIG.3

FIG.4a



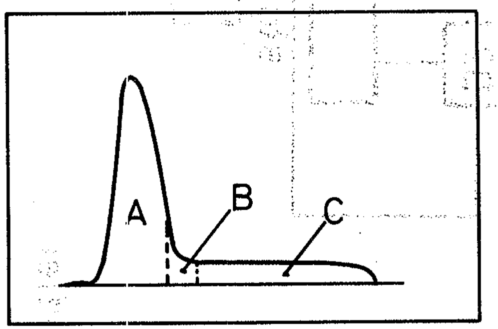


FIG.4b

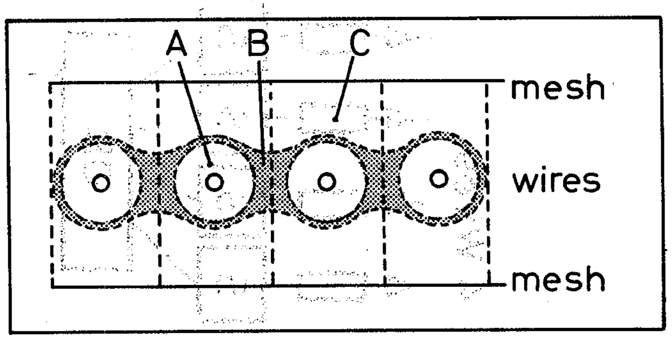


FIG. 4c

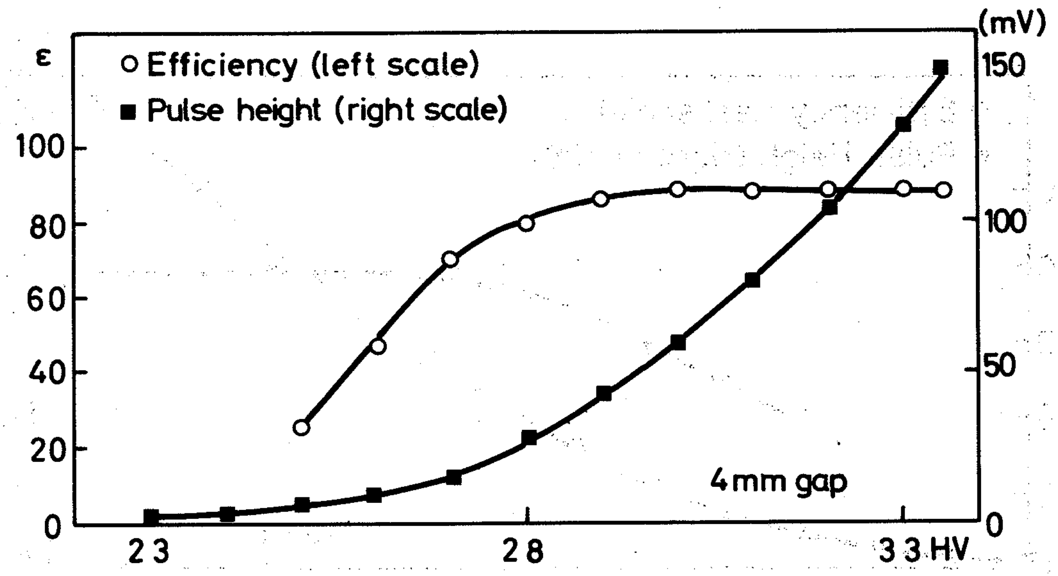

(mV)
ε
o Efficiency (left scale)
■ Pulse height (right scale)
100
80
60
40
20
0
150
100
50
0
4mm gap
2 3
2 8
3 3 HV

FIG. 5

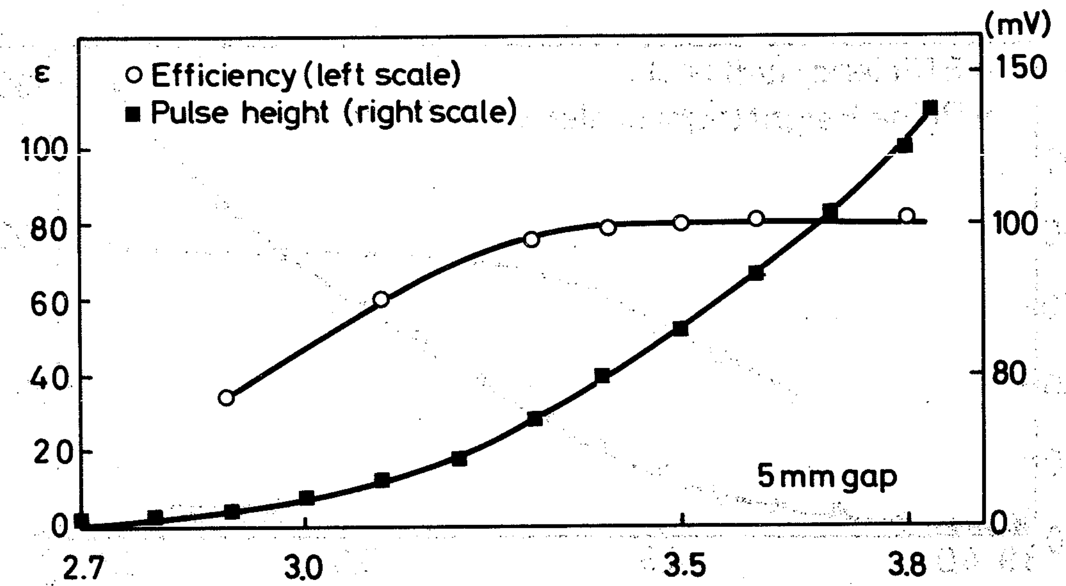

(mV)
ε
o Efficiency (left scale)
■ Pulse height (right scale)
100
80
60
40
20
0
150
100
80
0
5mm gap
2.7
3.0
3.5
3.8

FIG.6

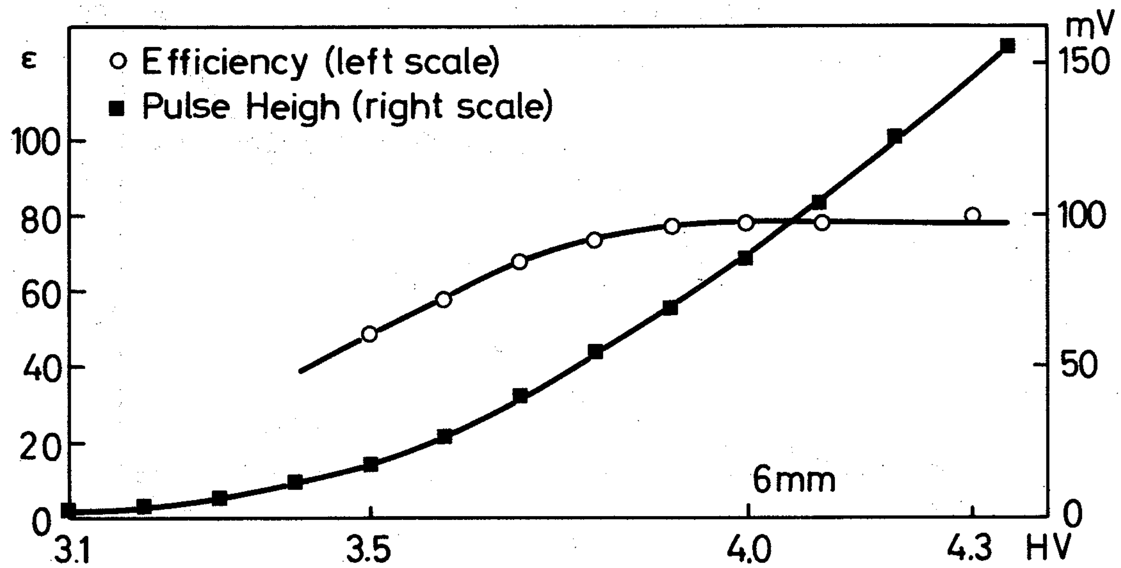

ε
o Efficiency (left scale)
■ Pulse Heigh (right scale)
100
80
60
40
20
0
mV
150
100
50
0
6mm
3.1
3.5
4.0
4.3
HV

FIG.7

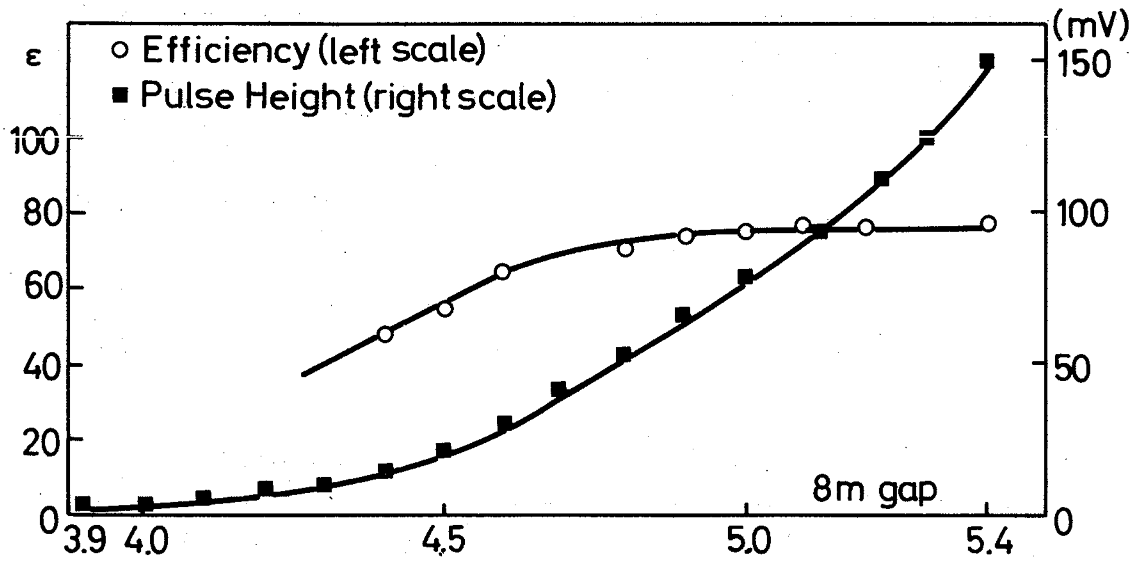

ε
o Efficiency (left scale)
■ Pulse Height (right scale)
100
80
60
40
20
0
(mV)
150
100
50
0
8m gap
3.9
4.0
4.5
5.0
5.4

FIG.8

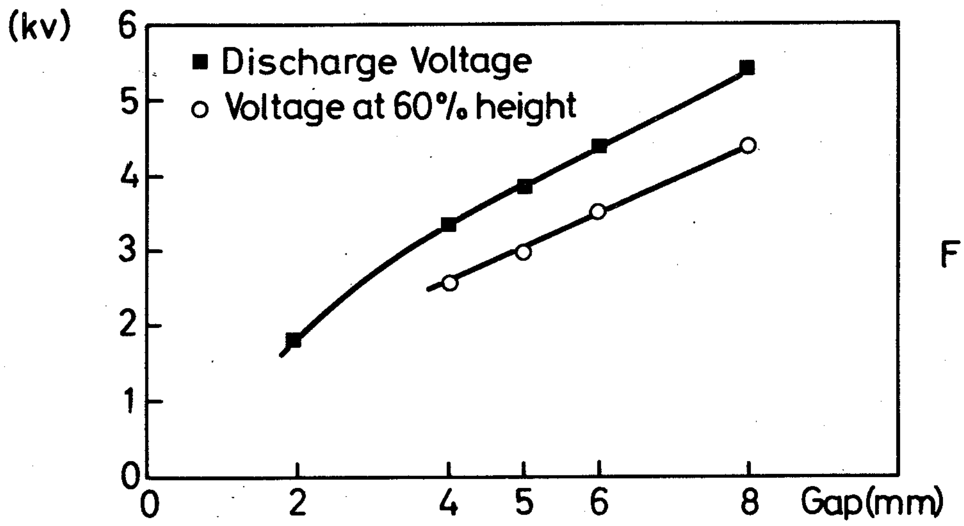


FIG. 9

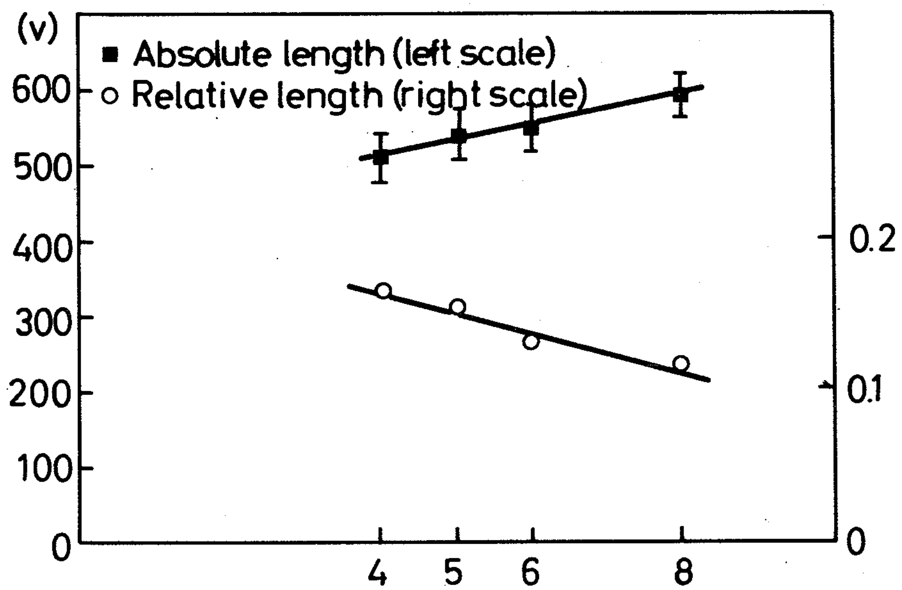


FIG. 10

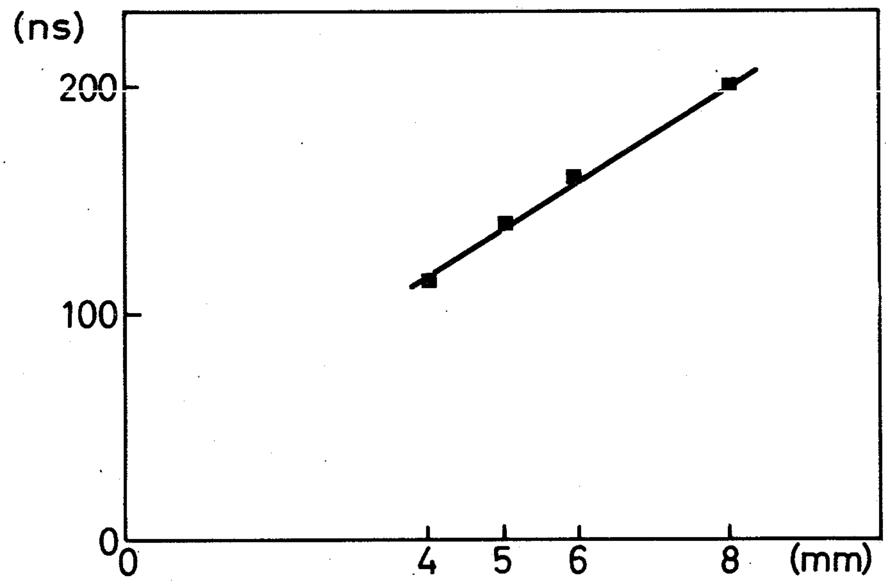


FIG. 11