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SOME NEW RESULTS ON THE DEVELOPMENT OF SUPPORT LINES FOR LARGE PROPORTIONAL WIRE CHAMBERS

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ABSTRACT

Several support lines were tested in a 200 cm long proportional wire chamber (PWC). Results for three basically different solutions are presented. The best values for the inefficient region along the different support lines range from 1.6 mm down to 0.05 mm.

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1. INTRODUCTION

In large proportional wire chambers (PWC) the signal wires have to be supported in order to prevent them from moving under the repulsive Coulomb force of the neighbouring wires[1]). So far each solution that compensates this force resulted in an inefficient region along the supports. In this report we want to give some results for three different approaches to the problem.

2. PROPERTIES OF THE PWCs USED

The width of the inefficient region for different support lines was measured in a 20 cm wide PWC (PWC1), with 200 cm long signal wires spaced 2 mm apart. We were using tungsten wires with a diameter of 20 μ stretched with a tension of 45 g. These wires were supported every 40 cm to prevent them from moving to the high-voltage electrodes which were 10 mm away. The high-voltage electrodes consisted of 50 μ Cu-Be wires, spaced 1 mm apart, running parallel to the signal wires and having a tension of 100 g. They were supported every 50 cm by a thick nylon wire to prevent them from moving more than 0.5 mm to the signal wires under the attractive Coulomb force.

A second PWC (PWC2) had the dimensions 10 × 10 cm^2. The spacing between the signal wires was 2 mm and the distance to the high-voltage electrodes 8 mm. The electrodes consisted of stainless-steel meshes.

3. SET-UP FOR MEASUREMENTS

Most of our results were measured in the b_{18} test beam of the CERN Proton Synchrotron at low intensity. The geometrical set-up is shown in Fig. 1, and the electronics layout in Fig. 2. A trigger was defined by the coincidence of the three scintillation counters C1, C2, and C3. The different supports were installed in PWC1. The wires of the PWC2 were aligned parallel to the support lines, and perpendicular to the signal wires of PWC1; we used 32 wires in each chamber. The measurements were analysed with a Hewlett Packard 2115A computer.

The inefficiency η of the PWC1 at the position (i) defined by wire No. i in PWC2 is given by the expression

$$\eta = 1 - \varepsilon = 1 - \frac{C1 \cdot C2 \cdot C3 \cdot PWC2(i) \cdot PWC1}{C1 \cdot C2 \cdot C3 \cdot PWC2(i)} .$$

A typical measurement of the inefficiency across a support line is shown in Fig. 3.

For a comparison of the different measurements, we related these curves to the effective width of a region with 100% inefficiency, by normalizing to the same area as indicated in Fig. 3.

4. RESULTS

We tried several support lines in order to reduce the width of the inefficient region. We found four basically different solutions:

4.1 PVC-insulated copper wires with voltage applied to them

One solution consisted of a PVC-insulated cable*) (0.9 cm thickness), stretched across all signal wires[2] (Fig. 7a). They were glued to the support line with a lacquer which is soluble in alcohol. This gluing was necessary to compensate the Coulomb forces of adjacent wires. Otherwise the forces of every other wire would add up and move the wires, including the support line.

We measured the inefficiency for different voltages applied to the support line cable. The results are shown in Fig. 5 and Table 1.

The resistivity against high voltage was examined by applying a test voltage to a cable which was pressed between two grounded copper plates. The cable was well insulated up to 5000 V with a leakage current of less than 1 μA/cm. At higher voltages the conductivity of the insulation increased, but no breakdown occurred.

A related property of this support line is a noise rate on the signal wires that increases with the voltage applied to the support line[3]. We found that this rate is only slightly above the background noise. The results of these measurements are shown in Fig. 6.

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*) Soflex 0.11 mm^2 from Schweizerische Isola-Werke, Breitenbach, Basel (CH).

4.2 Styrofoam spacer

Another solution to the problem is to use a spacer between the signal wires and the high-voltage electrodes, alternating every 20 cm on both sides of the signal wire plane (Fig. 7b).

We obtained the best results for this type of support line with a 2 mm wide strip of styrofoam containing 10% carbon powder; it resulted in an inefficient region of 1.6 mm. This and the results of other mixtures of styrofoam and carbon powder are shown in Table 1. The maximum percentage of carbon powder that could be produced without difficulty was 10%.

4.3 Thin nylon fibres

A third solution consisted of nylon fibres woven across the signal wires (Fig. 7c). We tried 100 μ, 20 μ and 10 μ diameter nylon fibres. The latter two fibres were thin enough and were stretched with such a low tension that the friction between the wires is sufficiently small to maintain a constant spacing between the signal wires.

The results presented in Table 1 and Fig. 4 are based on a fibre with a diameter of 20 μ. The inefficiency depends on the gate width. We measured approximately 0.2 mm effective inefficient region for 58 nsec gate width.

4.4 Slightly conducting spacer

A 0.5 mm thick spacer made of some fibre-epoxy material with a resistivity of presumably 10^{10} Ω • cm produced an inefficient region less than 0.1 mm wide. On the other hand we have some indication that the overall performance of the chamber was affected by this special support.

5. DISCUSSION

The results for the different support lines show that each has certain advantages suited to the handling of different problems:

a) the spacer supports (4.2 and 4.4) are qualified for PWCs where one has to support signal wires and high-voltage electrodes in order to guarantee a constant gap width;

b) the nylon fibre support line is the least complicated solution from the mechanical point of view, resulting in a reasonably small inefficient region;

c) the cable support line has the smallest inefficiency for gate width of 30 nsec, at the expense of additional noise and the risk of an unknown long term stability.

In our experiment we intend to use the 20 μ diameter nylon fibre support line, because it is the simplest mechanical solution. The inefficient region with a 38 nsec gate is about 0.5 mm. A single fibre is woven every 20 cm. The total efficiency of a chamber is then reduced by 0.25%.

Acknowledgements

We are indebted to Professor J. Steinberger for valuable suggestions and discussions. We thank P. Schilly for technical assistance.

REFERENCES

1) J.H. Dieperink, K. Kleinknecht, P. Steffen, J. Steinberger, T. Trippe and F. Vannucci, Construction problems with large proportional wire chambers, CERN NP Internal Report 69-28 (1969).
   T. Trippe, Minimum tension requirement for Charpak chamber wires, CERN NP Internal Report 69-18 (1969).

2) A similar method was used by G. Charpak's group. It consisted of a nylon wire with a metal wire attached to it. This support line gives results similar to those of PVC-insulated SL.
   R. Bouclier, G. Charpak, Z. Dimčovski and F. Sauli, CERN NP Internal Report 70-2 (1970).

3) F. Sauli, private communication.

Table 1

	Material	Width of inefficient region (mm)	Special conditions
1	Styrofoam on one side of signal wires (~ 2 mm wide)	3.7	40 nsec gate width
2	No. 1 with 2.5% carbon	2.0	40 nsec gate width
3	No. 1 with 10% carbon	1.65	40 nsec gate width
4	No. 3 on both sides of signal wires	5.2	40 nsec gate width
5	20 μ nylon fibre	0.5	38 nsec gate width
		0.16	58 nsec gate width
		0.03	128 nsec gate width
6	PVC-insulated copper wires glued to signal wires	8.2	31 nsec gate; 0 V on support line
		3.6	31 nsec gate; 1100 V on support line
		0.8	31 nsec gate; 1800 V on support line
		0.3	58 nsec gate, 1800 V on support line

Figure captions

Fig. 1 : Geometrical layout for the measurement of the inefficiency of the support lines.

Fig. 2 : Electronic layout for the measurement of the inefficiency of the support lines.

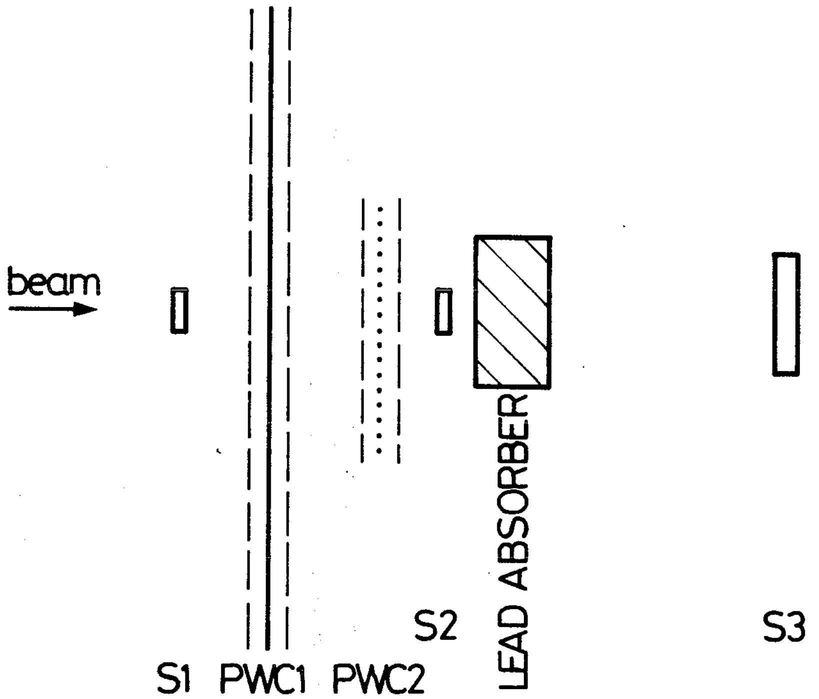
Fig. 3 : Inefficiency across a support line as a function of the position. The dashed region indicates the inefficient region calculated for this support line.

Fig. 4 : Inefficiency of 20 μ nylon fibre support line as a function of the gate width.

Fig. 5 : Inefficiency of the PVC insulated copper wire support line as a function of the applied support line voltage.

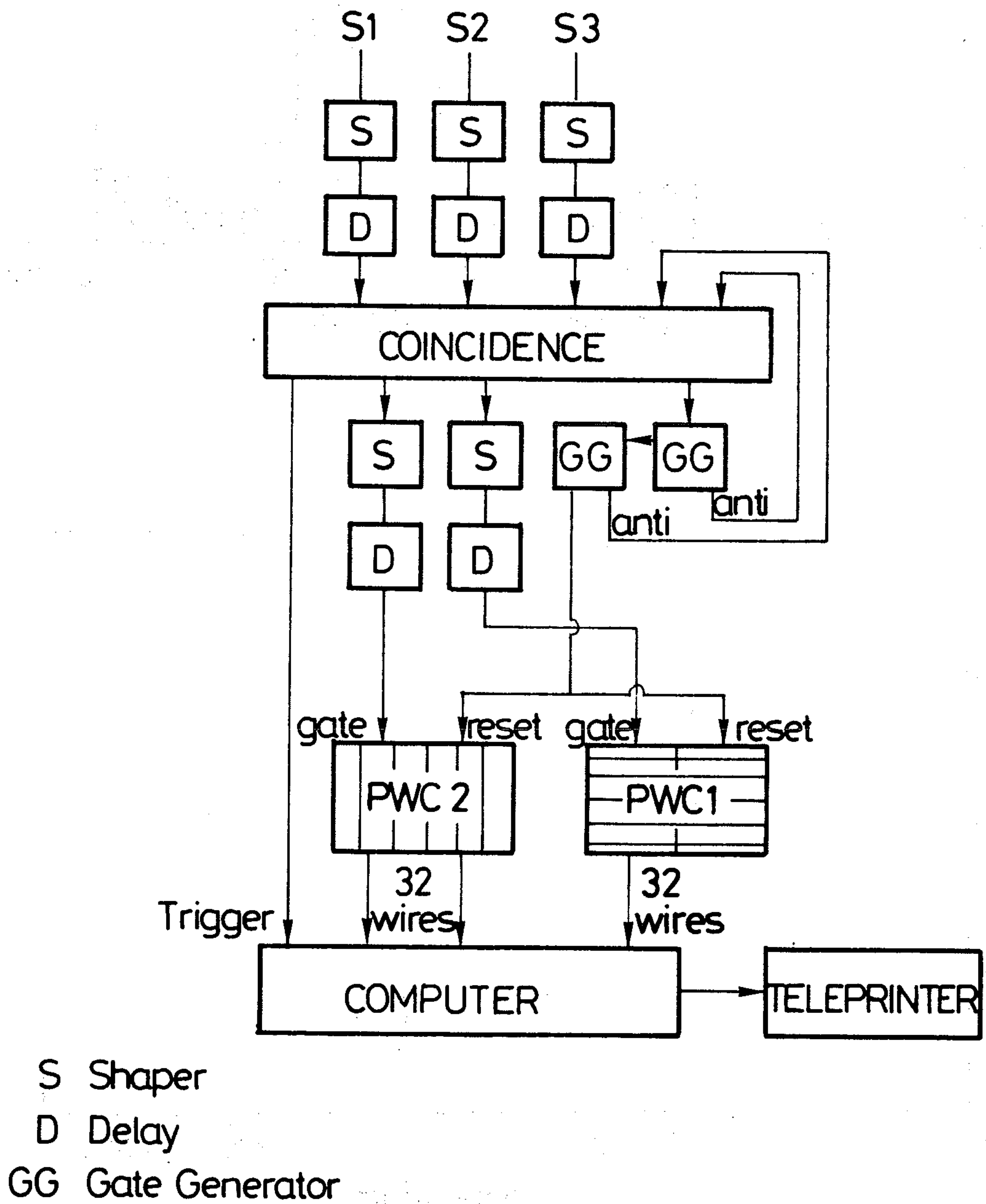
Fig. 6 : Noise rate of the insulated copper wire support line as a function of the applied support line voltage.

Fig. 7 : Mounting of the different supports.
(a) PVC insulated copper wire
(b) Spacer
(c) Thin nylon fibre



beam
S1
PWC1
PWC2
S2
LEAD ABSORBER
S3

FIG.1



S1
S2
S3
S
D
COINCIDENCE
GG
anti
gate
reset
PWC 2
PWC1
32 wires
Trigger
COMPUTER
TELEPRINTER
S Shaper
D Delay
GG Gate Generator

FIG. 2

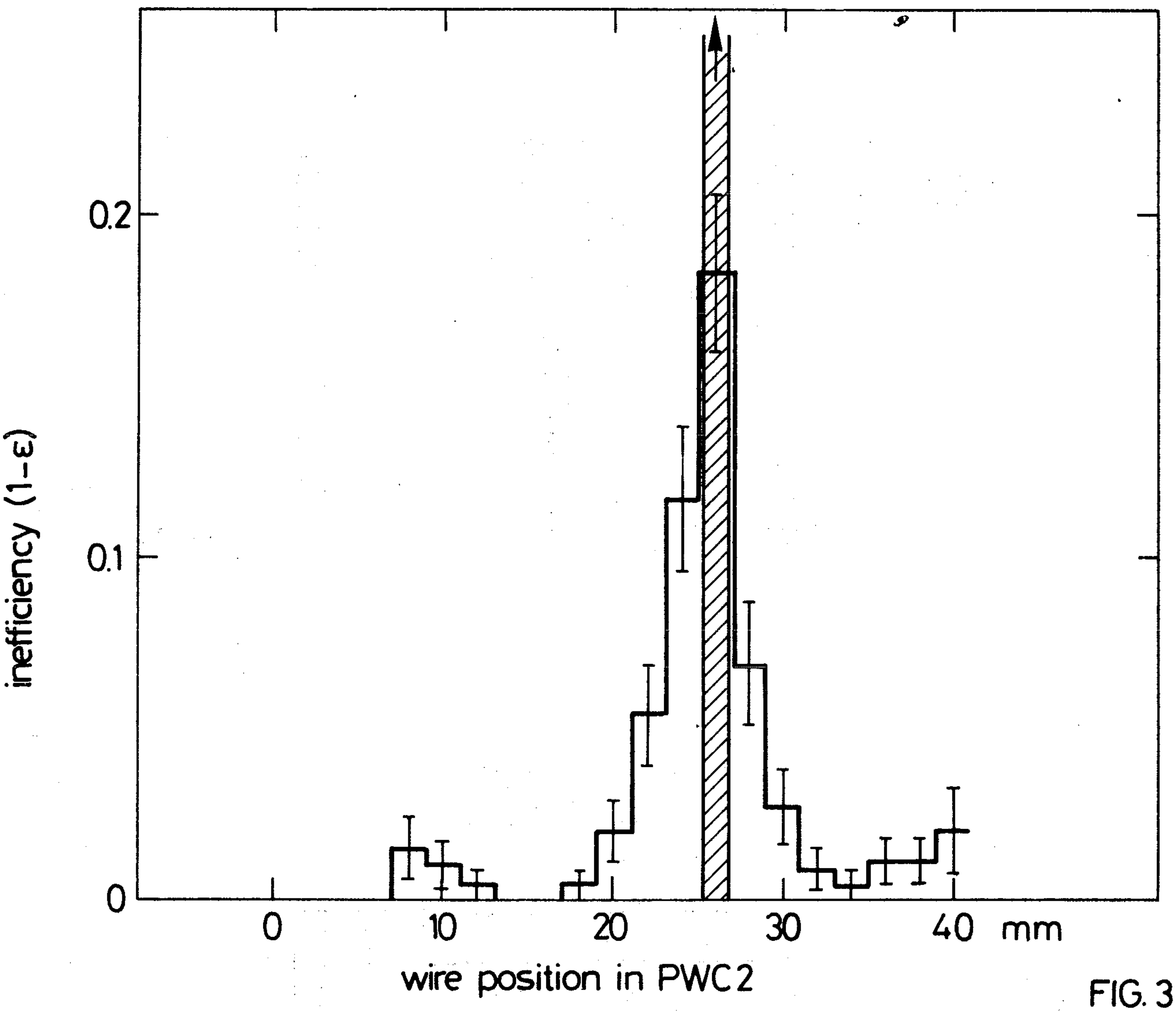

inefficiency (1-ε)
0.2
0.1
0
0
10
20
30
40 mm
wire position in PWC 2

FIG. 3

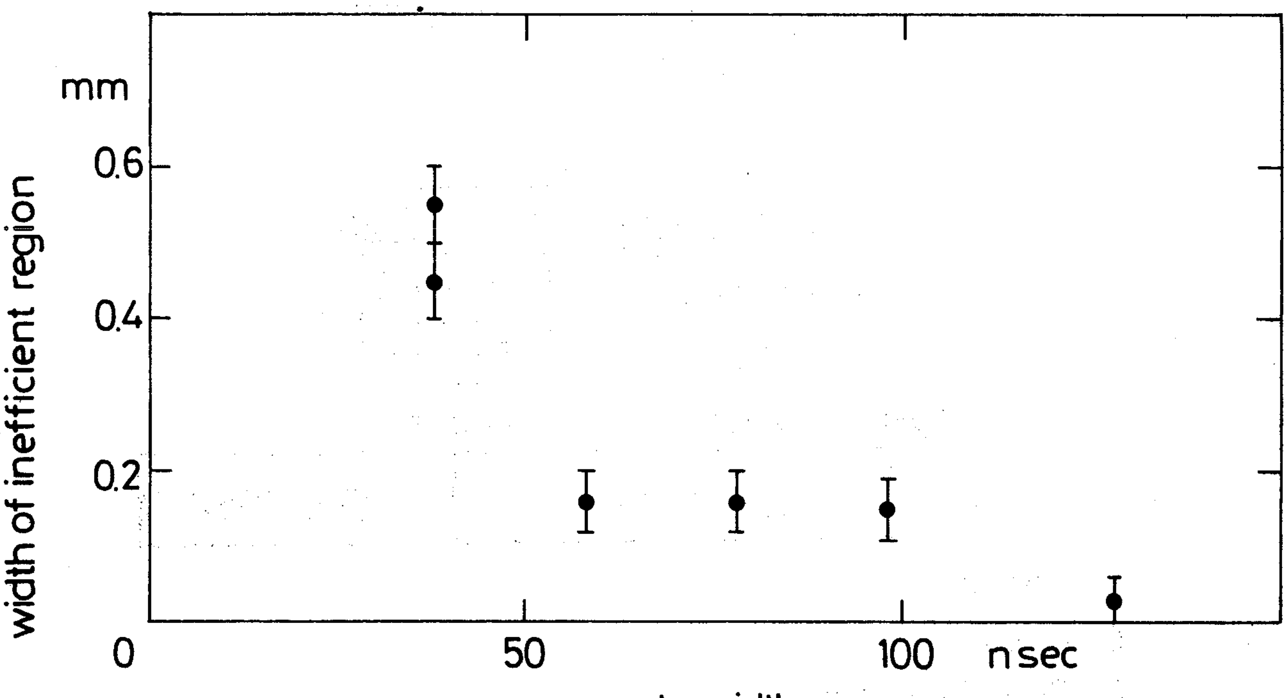

width of inefficient region
mm
0.6
0.4
0.2
0
50
100 nsec
gate width

FIG. 4

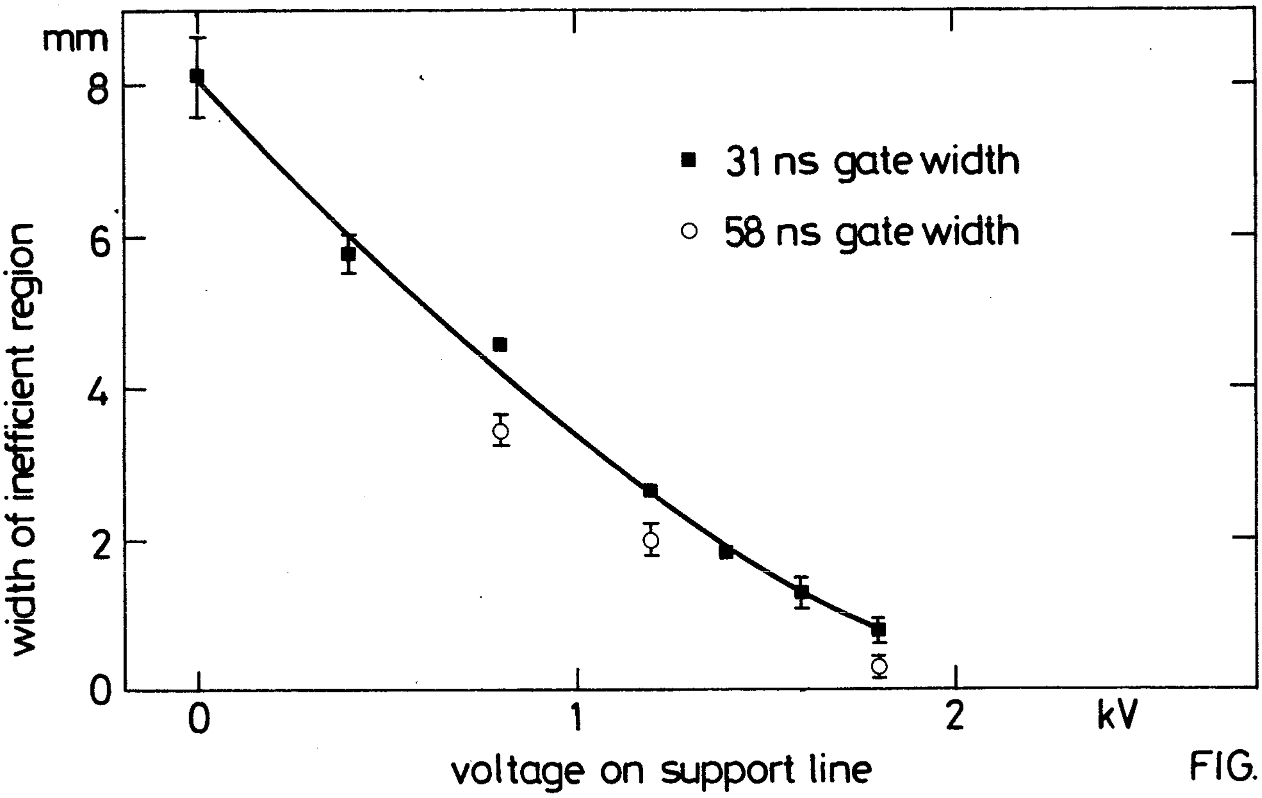

mm
8
6
4
2
0
31 ns gate width
58 ns gate width
width of inefficient region
0
1
2
kV
voltage on support line

FIG. 5

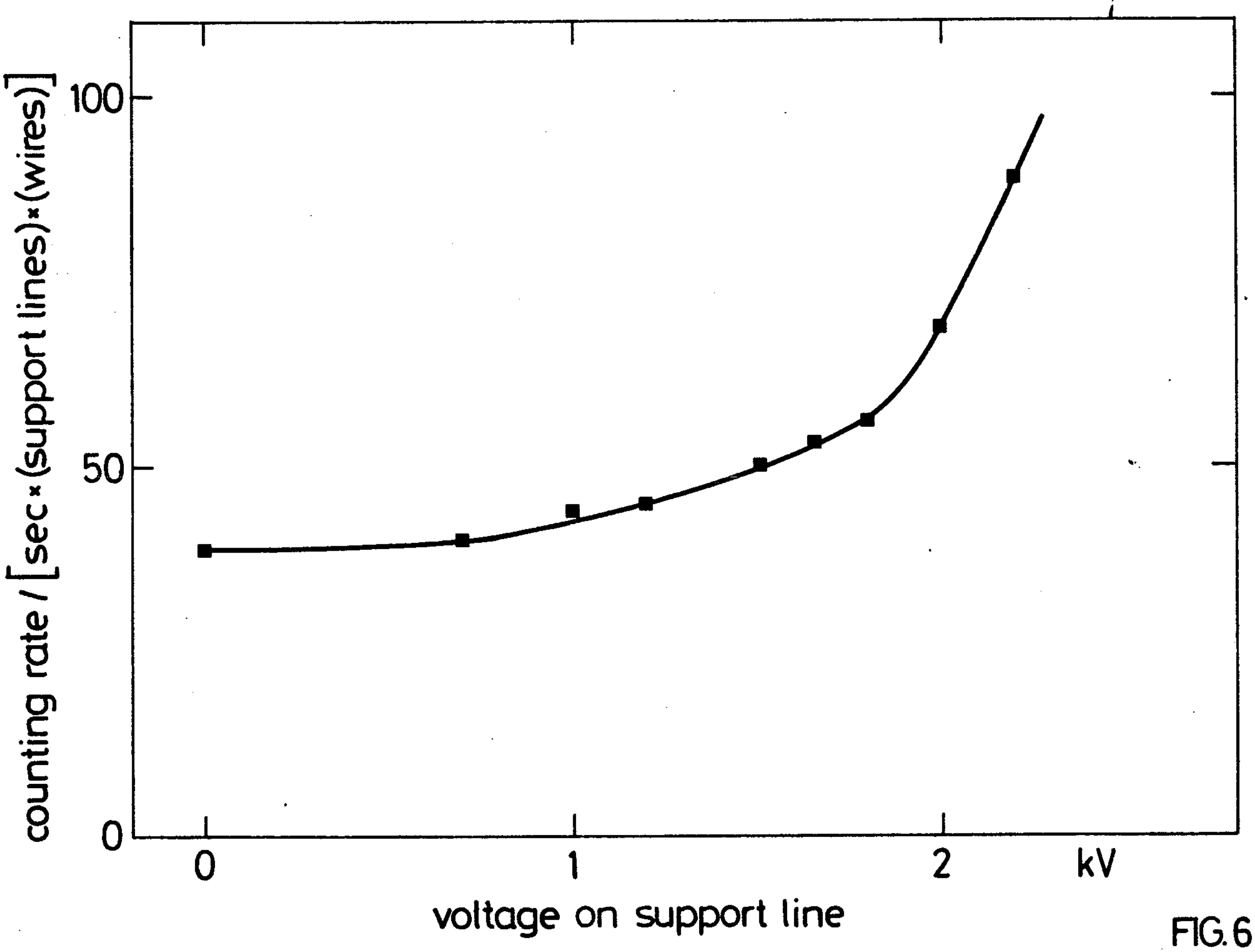

100
50
0
counting rate / [sec × (support lines) × (wires)]
0
1
2
kV
voltage on support line

FIG. 6

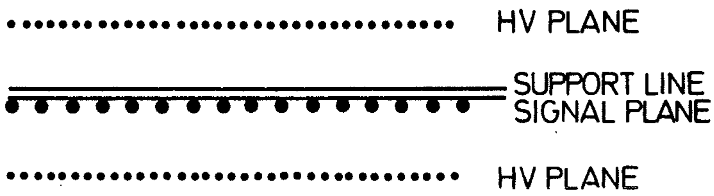


FIG. 7a

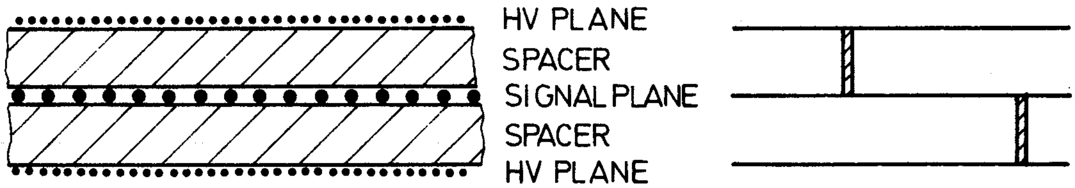


FIG. 7b

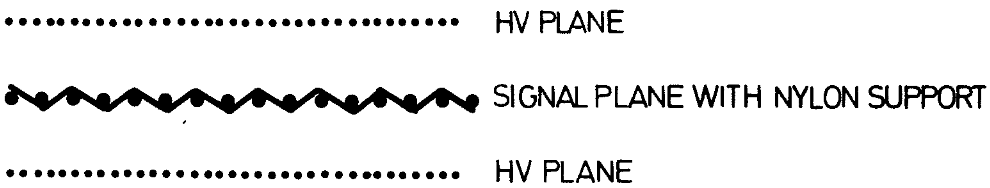


FIG. 7c