ISTITUTO NAZIONALE DI FISICA NUCLEARE
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V. Bidoli, A. Di Biagio, E. Iarocci, G. Nicoletti and L. Tortora: DETECTION OF INDUCED PULSES IN PROPORTIONAL WIRE DEVICES WITH RESISTIVE CATHODES.

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V. Bidoli[(x)], A. Di Biagio[(x)], E. Iarocci, G. Nicoletti and L. Tortora[(o)]:

DETECTION OF INDUCED PULSES IN PROPORTIONAL WIRE DEVICES WITH RESISTIVE CATHODES.

ABSTRACT. - A method is described for detecting the pulses induced by the avalanche around the sense wire of any proportional wire device. The pick-up electrodes are placed outside the device itself. This is obtained by making the cathode electrode out of a suitably resistive material, so that it is transparent to the inducing field for a time long enough for induced pulses to be detected by a pick-up placed behind the cathode. Tests have been made on proportional tubes with a helix delay line as a pick-up electrode.

1. - INTRODUCTION. -

A widely used method to localize the position of the avalanche along a sense wire in a proportional wire device, is the detection of the pulse induced by the drifting ion cloud on suitably shaped cathode electrodes, like:

- strips making an angle with the wire, or
- delay lines parallel to the wire.

The requirement for an electrode to be both the cathode and the pick-up electrode may give rise in practice to some problems and limitations. For instance, by cutting the cathode into strips one introduces

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electric field inhomogeneities, which reduce the safe H.V. operating range. On the other hand if a delay line coaxial with the wire is used, and if the helix must be the cathode, same mechanical trickery must be adopted in order to get a helix wound on the inner wall of a tube(1).

2. - DETECTION OF THE INDUCED PULSE. -

In the detector under consideration the cathode should be made by a resistive material, with a resistivity

a) high enough, in order to be transparent to the inducing field, for a time long enough to allow full detection by a pick-up electrode placed behind the cathode ;
b) low enough to avoid that a voltage drop is produced by the current due to the detector during its operation, which would make it unstable.

Tests have been made on proportional tubes by detecting the induced pulses on a helix delay line placed outside the cathode (H.O.C. tubes). The longitudinal cross section of a H.O.C. tube is shown schematically in Fig. 1. The anode wire is on the axis of a tube of

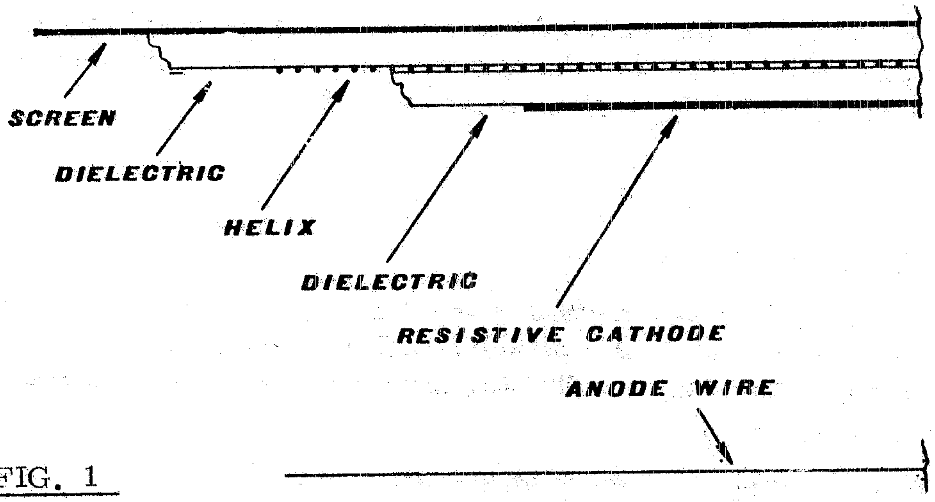


FIG. 1

insulating material, the inner surface of which is coated with a resistive layer (the cathode). A helix of a conductive wire is wound around the tube, in order to pick-up the induced pulse. Behind the helix there is an additional dielectric layer and a conductive foil, which acts both as the screen and as the second electrode of the delay line. In order to briefly describe its operation and to derive the useful range of resistivity for the cathode, the equivalent circuit of the device is shown in Fig. 2a in a lumped parameter representation. R, L, C_R, C_L are the relevant resistance, inductance and capacitance per unit tube length. The current generators i(z) (z being the longitudinal coordinate), simulate the current distribution of the induced pulse : i(z) has

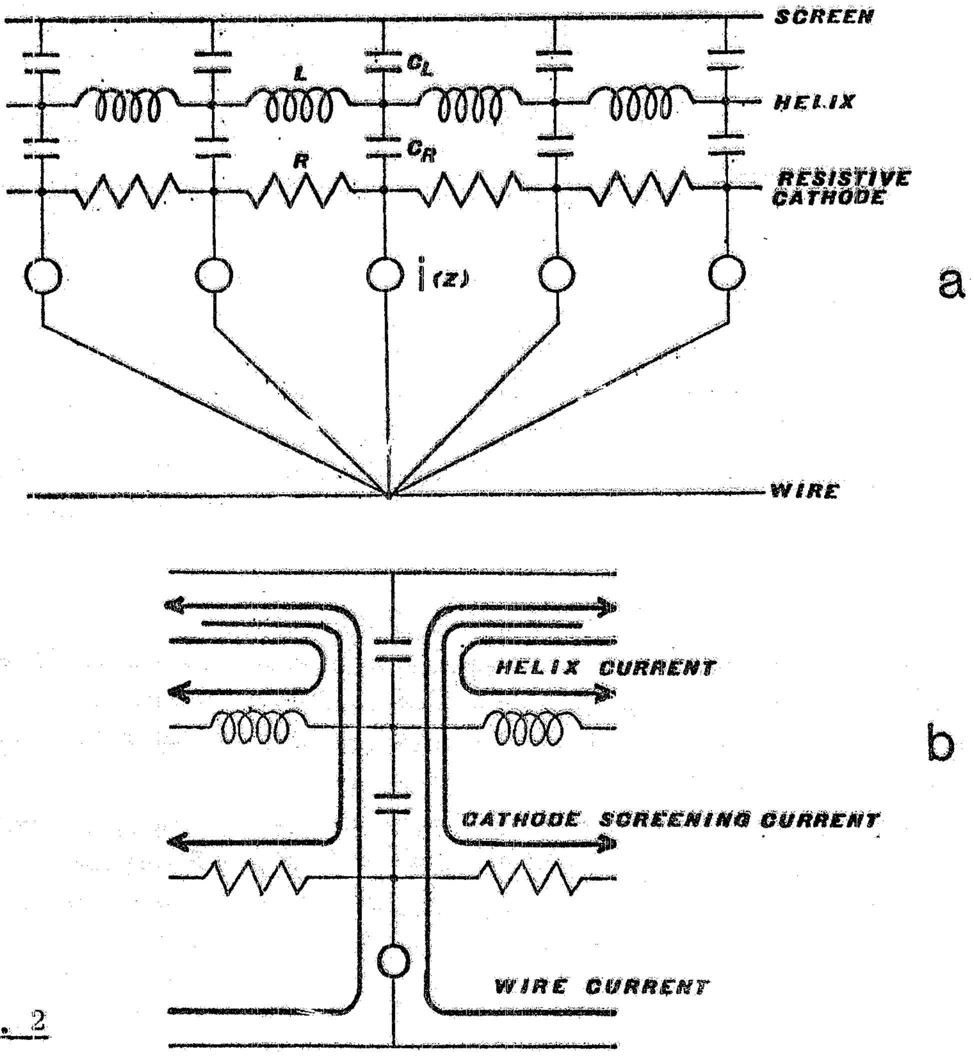


FIG. 2

a bell shaped distribution around the avalanche point, with a width of the order of the tube diameter.

At the start of the process, each current generator drives current into the lowest impedance loop (wire → C_R → C_L → screen), charging the series $C_R - C_L$ (called C in the following) and giving rise to the pulse on the wire (Fig. 2b). C_L starts discharging itself into the neighbouring elements of the LC_L transmission line, while C discharges itself into the neighbouring RC line elements. In this circuital scheme the resistive cathode is transparent to the induction (viz. a useful pulse is picked-up on the helix) if the C_L discharge is faster on the LC_L line than on the RC one.

Without going into the mathematical description of the RC line bahaviour, one can immediately estimate the order of magnitude of the minimum cathode specific resistance.

By taking into account that the width along z of the induced current is of the order of the tube diameter D, the transparency condition is

$$(R \cdot D)(C \cdot D) \gtrsim R_o (C_L \cdot D) \qquad (1)$$

where $R_o = \sqrt{L/C_L}$ is the characteristic impedance of the transmission line.

Since in practice

- R_o will never exceed $\sim 1\ K\Omega$,
- C will not be less than $0.5\ C_L$,
- D is not smaller than ~ 1 cm,

in the worst case R is required to be at least of the order of $2\ K\Omega/cm$, and this value is quite far from being disturbing for tube operation.

3. - OPERATION OF A H.O.C. TUBE.

Several prototype tubes have been built and operated to test the method, described above, using ready at hand materials. Work is in progress in order to achieve full optimization of both materials and parameters involved.

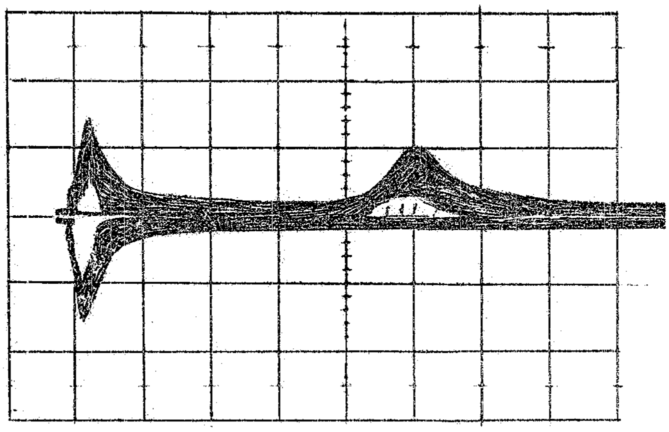
The resistive cathode is obtained by coating the inner wall of a plexiglass or PVC tube with a layer of graphite (Aquadag) or graphite-GR2$^{(2)}$ mixture. In this way any useful resistance value above $\sim 1\ K\Omega$/square may be produced. The above mixture can be easily used to make a smooth and uniform surface with good adhesion to the plastic and coating can be made in practice in a trivial way.

The characteristics of one of the tested tubes were the following:

- dimensions : 2 cm inner diameter, 1 m length ;
- cathode specific resistance : $R = 2\ K\Omega/cm$;
- inner dielectric : plexiglass tube, 1 mm thick ;
- helix : copper wire, 0.16 mm in diameter and with 0.5 mm spacing ;
- outer dielectrics : rolled mylar foil, 1 mm thick ;
- screen : rolled Al foil, 50 μm thick ;
- $\sqrt{L/C_L} = 800\ \Omega$, $\sqrt{LC_L} = 6$ ns/cm ;
- sense wire : 30 μm diameter .

The pulses generated by the electrons from a Sr^{80} collimated source have been observed loading the wire with a $400\ \Omega$ resistor which is one half the delay line characteristic impedance : if the cathode is fully transparent, both the induced and wire pulses are expec ted to be practically equal. At the read-out end the line is closed into its characteristic impedance, and the source is kept near this end in order to make negligible the delay line distortion, and thus put into evidence a possible screening effect of the resistive cathode. The other end of the delay line is kept open, so that the reflected pulses can be observed in order to see the pulse distortion due to the finite rise time and non-zero attenuation of the delay line.

The pulses observed on the wire (negative) and on the line (positive) followed by the reflected pulse are shown in Fig. 3 : the


50 mV/cm

200 nsec/cm

H.V. = 2300 V

Gas mixture =

= A_r 80% ,

Isobutane 20%

FIG. 3

induced pulse turns out to be practically equal to the wire pulse, showing that the screening effect of the interleaved resistive layer is negligible. In this prototype the time constants defined in (1) are 50 and 15 ns for the RC and LC_L lines respectively. The space resolution wich can be achieved is $\sim \pm 5$ mm. We have also tested other H.O.C. tubes, differing in diameter (2 or 3 cm), sense wire diameter (30 or 50 μm), cathode specific resistance (1-10 KΩ/cm), delay line characteristics ($\sqrt{L/C_L}$ = 500 - 1.2 KΩ , $\sqrt{LC_L}$ = 6 - 20 ns/cm). All of them have been found to work in a similarly satisfactory way. Work is in progress in order to decrease the tube wall thickness, test the long time behaviour of the resistive cathode and develope a fast and reproducible construction procedure.

REFERENCES. -

(1) - G. Flügge et al., DESY Int. Report F1/F33/F39 - 76/05 (1976).

(2) - GR2 is an offset glue which is used to make high resistivity layers in the chambers of DM1 detector at Orsay.