national accelerator laboratory

FN-225
2110
2119

HIGH RESOLUTION LOW TEMPERATURE WIRE SPARK CHAMBERS

M. Atac
National Accelerator Laboratory

February 1971

ABSTRACT

Narrow gap spark chambers operating at low temperatures have been developed. Results show that spatial resolutions of 65-75μm can be obtained.

Operated by Universities Research Association Inc. Under Contract with the United States Atomic Energy Commission

It was reported earlier[1] that the spatial resolution of spark chambers may be improved at lower temperatures. Preliminary results were convincing enough to do further experiments with narrow gap high wire density (200 wires/inch) spark chambers at lower temperatures. Gas density increases with lower temperatures, enabling us to reduce the gap of the spark chamber. A consequence of this smaller gap is a reduction of the deviation of the spark column from the true particle trajectory. Electron diffusion and spark impedance are also reduced with higher gas densities. This means the high current density spark column looks like a thin filament.

W. J. Willis[2] reported that the spatial resolution is considerably improved with narrow gap spark chambers at high pressures. The present NAL results show that the effect of the low temperatures is similar to the effect of the high pressures in improving the spatial resolution.

The liquid nitrogen cryostat with the spark chamber inside is shown in Fig. 1. Figure 2 shows the cross section of the spark chamber and the cryostat. The cryostat is made of low density, 0.03 gm/cm^3, expandable styrofoam. The thickness of the styrofoam is about 4 mm on either side of the spark chamber within the sensitive area. Therefore, the multiple scattering of high energy particles from the 50 mg/cm^2 styrofoam window is quite negligible.

Spark chamber gas flows in the cryostat to the spark chamber volume and then exits the cryostat at a flow rate of about 10cc per minute. The gas is precooled in the plastic tube before entering the spark chamber. The printed circuit wire plane contains 200 wire strips per inch. The ground side of the spark chamber is 25μm thick aluminum foil. The total gap between the printed circuit wire plane and this foil is about 3mm. The sensitive area of the wire plane is about 4 x 5 cm^2. The width of the Cu strips is about 63μm, These 10μm thick wire strips are fanned out to 0.5mm spacing where the spark current is magnetostrictively picked up. This effective time scale expansion by a factor of four improves the pickup resolution of the magnetostrictive readout. A special pickup coil is made for this experiment with ten turns of wire directly wound on the magnetostrictive line. The width of the coil is 0.5mm. Thus a possible broadening of sonic pulses by the pickup coil is minimized.

The operation of narrow gap spark chambers requires fast rising high voltage pulses to prevent the capture of the electrons before the avalanches begin to form. The rise time of the high voltage pulses was between 12-15nsec with amplitudes reaching 10-12 kV. For the tests a Ru^{106} β-source (E_{max} = 3.56 MeV) was used and only the minimum ionizing electrons were selected with a plastic scintillator to trigger the spark chamber. Some of the typical magnetostrictive pickup pulses are shown in Fig. 3, and some of the conditions and the results are listed in the table.

TABLE

Picture 2	Gas Filling	Temperature (degrees C)	Applied H.V.Pulse (kV)	Average Number of Wires Having Spark	Pulse Width	Estimated spatial resolution (μm)
a	90% Ne 10% He	25	3.5	36	3μsec	Poor
b	90% Ne 10% He	-190	10	6	500 nsec	90-100
c	100% Ar	25	6.5	7	600 nsec	100-120
d	100% Ar	-180	12	4	370 nsec	65-75

In picture 2-a, we believe that the spark current is distributed over many wires. Thus many small magnetostrictive pulses overlap to give a complex looking pulse shape. When we analyze the pictures we see that pulses become tripolar and the pulse width decreases as the temperature decreases and the density of the spark chamber gas increases.

CONCLUSIONS

a) It is probable from the results that even higher resolutions may be obtained by using krypton and xenon gasses. I think, however, that it is more economical to use Ne-He or Ar at low temperatures since 60-85μm spatial resolution is comparable to the wire spacing.

b) To preserve the spatial resolution obtained from the spark chambers, scalers of at least a 40 MH_z rate are required.

c) Larger area printed circuits are technically quite feasible and to a first approximation the window thickness of the cryostat is not dependent on the area of the spark chamber.

d) The resistance of the Cu strips decreases by a factor of 6 in cooling from room temperature to -190°C. Therefore, the possibility of damaging wires is reduced due to the lower resistivity at lower temperatures.

The author expresses his appreciation to Drs. W. J. Willis and J. Lach for the useful discussions, and to C. Kerns for developing the hydrogen thyratron pulser.

References

[1] M. Ataç, NAL Summer Study Report SS-210 (1970) Pg. 109.

[2] W. J. Willis, et.al. High Resolution Optical Spark Chamber, Nucl. Inst. and Meth., Vol. 91, (1971) 29; W. J. Willis, High Resolution Wire Spark Chamber, Nucl. Inst. & Meth. 91(1971) 33.

Captions

Fig. 1. The spark chamber and cryostat assembly.

Fig. 2. Cross Sectional view of the spark chamber and cryostat assembly.

Fig. 3. Magnetostrictive pulses obtained from the spark chamber at various gas densities.

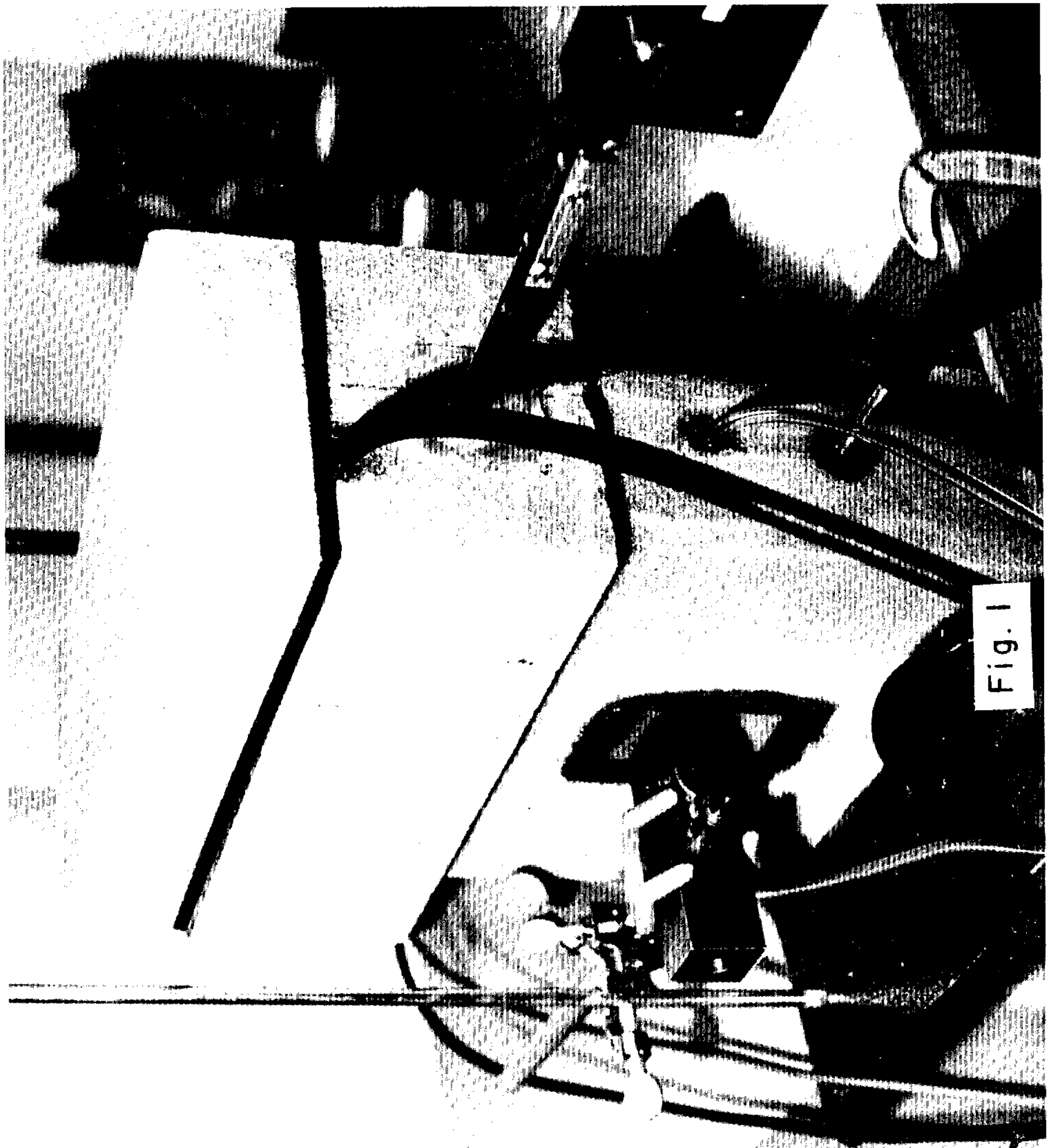

Fig. 1

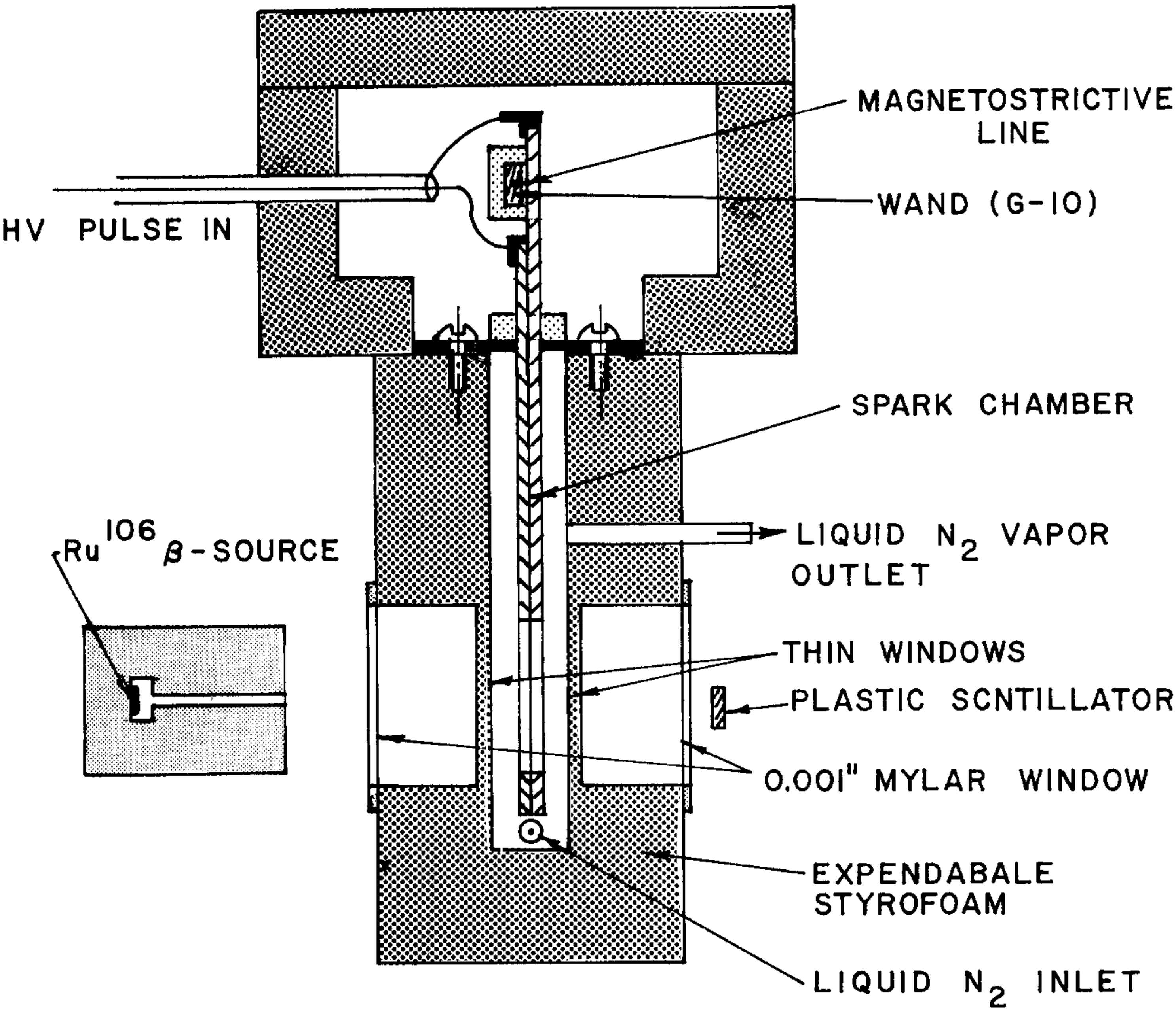
MAGNETOSTRICTIVE LINE
WAND (G-10)
HV PULSE IN
SPARK CHAMBER
LIQUID N2 VAPOR OUTLET
Ru106 β-SOURCE
THIN WINDOWS
PLASTIC SCNTILLATOR
0.001" MYLAR WINDOW
EXPENDABALE STYROFOAM
LIQUID N2 INLET

Fig. 2

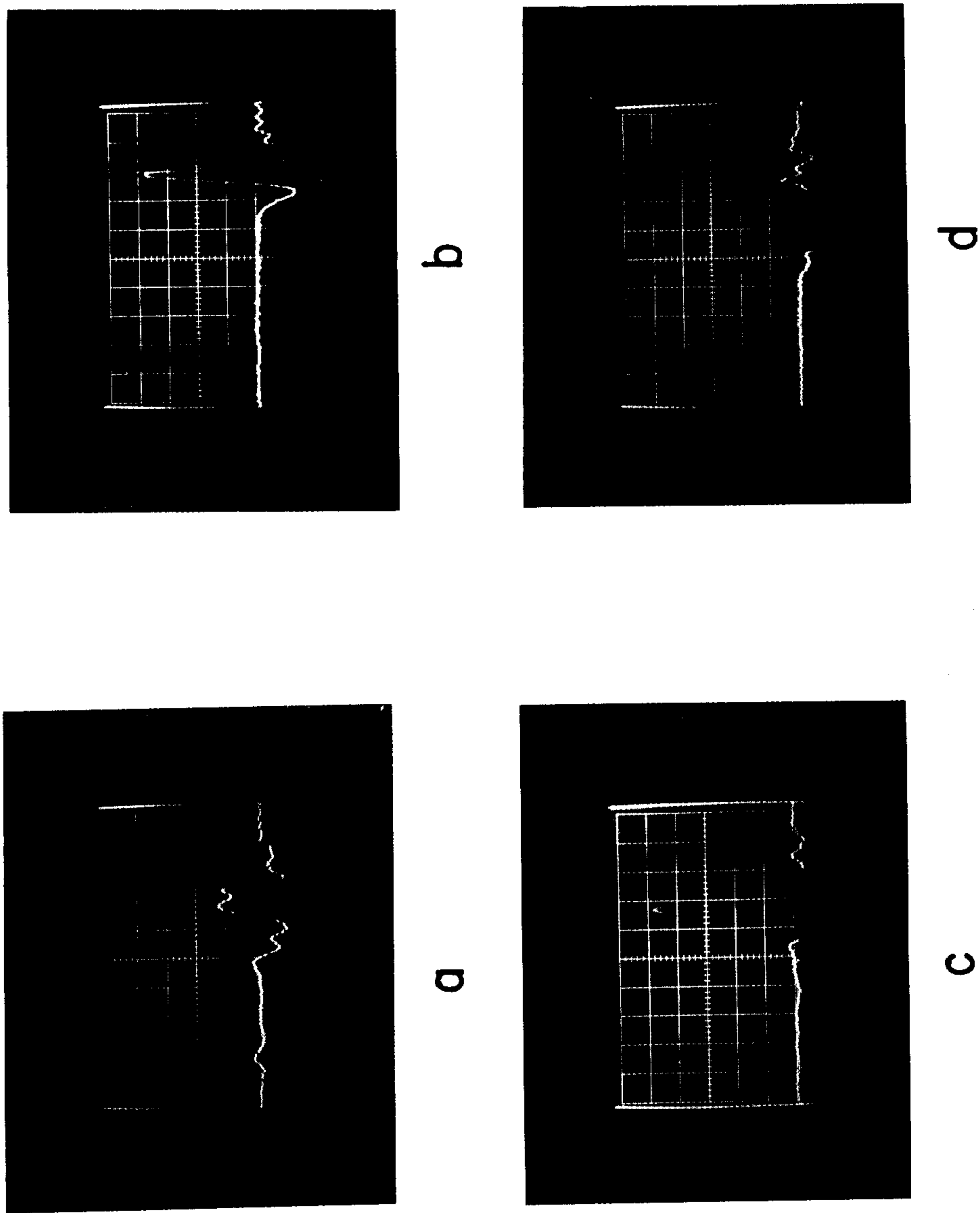

FIG-3