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GAS-TRIGGERED PINCH DISCHARGE SWITCH

Princeton Technical Note 101

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GAS-TRIGGERED PINCH DISCHARGE SWITCH*

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The advantages of gas-triggered discharges confined by ablating insulator surfaces for low inductance switching of large current pulses have been discussed in a previous note.(1) This note also describes the design and performance of a particular inverse pinch switch which successfully incorporates these features. A similar switch has subsequently been constructed which discharges in a direct pinch mode and displays significantly better performance than its predecessor. The device is shown schematically in Fig. 1.

The electrodes are plane, circular discs of aluminum, 14 cm in diameter, separated 4 cm by two concentric plexiglas insulators which define an annular discharge gap 2.5 cm wide. A group of twelve ¼" radial holes are drilled through the inner insulator, via which the discharge gap is first evacuated, and then triggered by a pulse of gas. The concentric return conductor is separated from the electrode edges and outer plexiglas cylinder by a

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teflon sleeve which extends into the external coaxial leads to the load and to the source.

In its present application, this device switches a 15 μfd, 10 KV capacitor bank across another discharge chamber[2] which draws some 3×10^{5} amp peak current at about 500 KC. The operational sequence consists of the evacuation of the switch gap to a pressure considerably below the Paschen limit for argon ($\approx$ 0.5 mm Hg - mm), the subsequent charging of the capacitor bank to the desired voltage, and finally the symmetrical injection of a small amount of argon through the radial ports in the inner insulator into the discharge gap. As the gas density rises past the Paschen limit, a diffuse breakdown precipitates over the entire gap ring. In this type of operation the switch stabilizes at an inductance of about 3×10^{-9} H, and at a resistance of about $5\times10^{-3}\,\Omega$, and displays a minimum of initiation noise and electrode damage. It is found to sustain several hundred discharges before requiring dissembly for cleaning and buffing of the electrode surfaces.

The two critical dimensions in the device are the length and the annular width of the discharge gap. The former was established by empirical experiments as the minimum length which would permit sufficiently low gas density at breakdown to sustain the diffuse discharge mode.

Shorter gap lengths, which predicated higher gas densities at breakdown, displayed a tendency to concentrated arc filaments.

The width of the annular gap was determined as a compromise between minimizing the inward constriction or "pinching" of the discharge, which would tend to increase the inductance, and the necessity to provide adequate gap width for the discharge to develop the desired cylindrical symmetry. Magnetic probe experiments in similar discharge chambers without the inner insulator show that the breakdown current tends to assemble itself into a cylindrically symmetric pulse, about 2 cm in radial width, near the outer insulator[2] (Fig. 2). If too large a diameter inner insulator is inserted into such a chamber, thereby establishing an annular discharge gap smaller than this preferred initial current pulse width, the discharge is found to use only a small angular fraction of the gap, concentrating in a higher inductance, higher resistance configuration at some azimuthal position. The initial current pulse width, and hence the minimum gap width is presumably associated with the effective skin depth of the discharge plasma, and thus would be mildly frequency dependent. Although this frequency dependence has not yet been explored in detail, it is anticipated that the influence of the channel width on the azimuthal symmetry of the discharge will persist in other applications of this type of switch.

REFERENCES

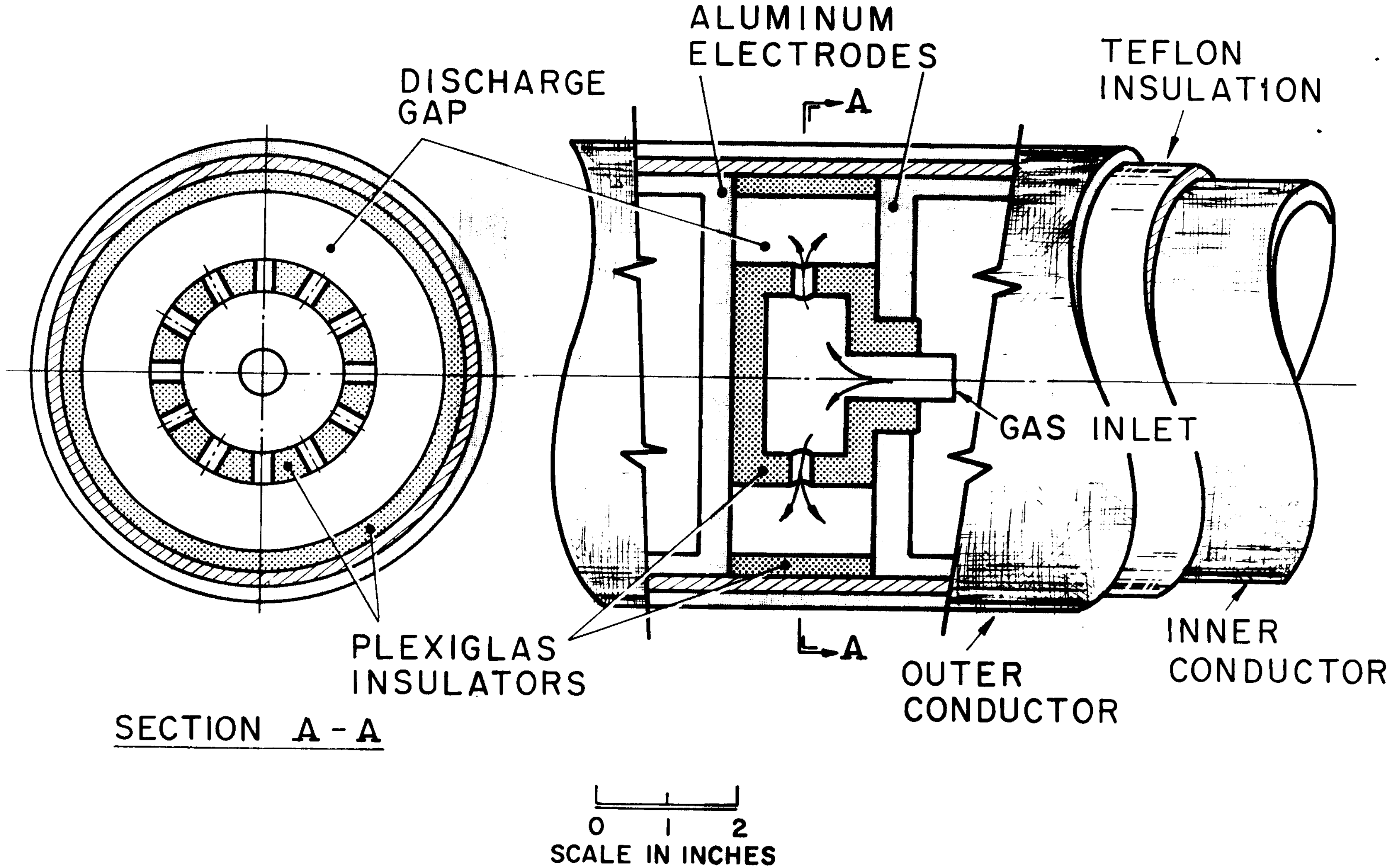
1. R. G. Jahn, W. von Jaskowsky, and A. J. Casini, Rev. Sci. Inst. 34, 1439 (1963).
2. R. G. Jahn and W. von Jaskowsky, AIAA Jour. 2, (1964).

FIGURE CAPTIONS

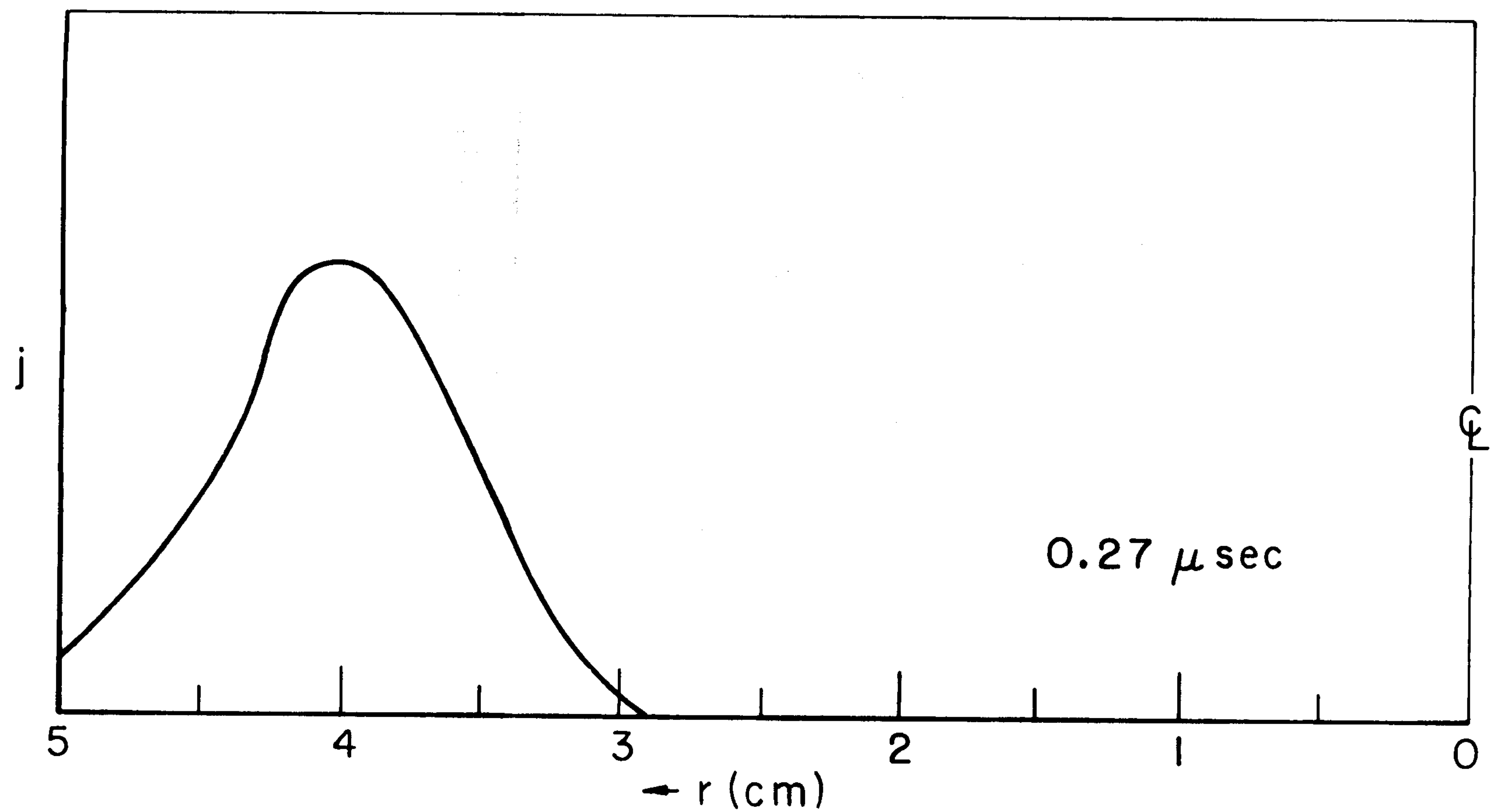
Figure

1 Schematic diagram of Pinch Discharge Switch

2 Current density distribution in 10 cm diameter pinch discharge in 20 μ argon



ALUMINUM ELECTRODES
DISCHARGE GAP
TEFLON INSULATION
A
A
GAS INLET
PLEXIGLAS INSULATORS
OUTER CONDUCTOR
INNER CONDUCTOR
SECTION A - A
0
1
2
SCALE IN INCHES



j
℄
0.27 μ sec
5
4
3
2
1
0
← r (cm)