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ABSTRACT

A compact, simple, internally triggered spark gap for discharging spark chambers is described. The pulse on the spark chamber provides the trigger spark by charging a capacitor formed by the trigger electrode, one of the two main electrodes, and an alumina dielectric until a surface breakdown occurs across the dielectric. The unit provides delay times of 15 to 100 nsec. with jitter times of several nsec. and has a life of the order of a million pulses when discharging 20,000 pF from 10 kV.

This note describes a simple, internally triggered spark gap that can produce a controlled and rapid discharge of a spark chamber. This makes possible narrow pulses which are particularly important in preventing the development of spurious sparks in chamber gaps having no tracks[1]). Resistors can be used to discharge spark chambers, but they seriously decrease the peak voltage when the capacitance of the chamber and pulser is large. This is because a short RC discharge time then requires a small resistance across the chamber. If this resistance is comparable to that of the pulser spark, the fraction of the voltage across the chamber is reduced[2]).

The firing time of an untriggered gap that is placed across the chamber can be adjusted through a small range by varying the electrode separation. However, if it is to fire reliably, it must do so nearly as soon as the sparks form in the chamber, and may interfere with their development. This problem does not occur if the gap is triggered after a controllable delay.

The spark gap shown in Figs. 1 and 2 is triggered by an additional outer electrode that also receives its pulse from the chamber. The alumina dielectric, the trigger electrode, and the tungsten center electrode together form a capacitor of about 10 pF that is charged through the resistor after the chamber is pulsed. The dielectric intensifies the electric field at its surface near the electrodes; after a time delay (determined by the capacity, the resistance, the shape of the applied spark chamber pulse, and the spark development time) a trigger spark forms and fires the main gap[3]). If the separation between the outer case and the trigger electrode is less than several mm, charging through the stray capacity between them will also play a role in the trigger spark formation.

Variations in the overall delay times are most easily made by adjusting the main gap spacing which then changes the main spark development time. The fall time of the pulse (about 15 to 20 nsec for a 5000-pF chamber in parallel with a 15 000-pF pulser capacitor) is not changed when this adjustment is made. Typical pulses for such a case are shown in Fig. 3.

The overall delay time is shown in Fig. 4(a) for a test setup using a capacitor rather than a spark chamber. The setup eliminates the ringing which usually occurs when the chamber size divided by the velocity of light is comparable to the pulse rise time, since such ringing will alter the delay time and add to the usual confusion. The applied pulse has an essentially linear rise 20 nsec long followed by a constant amplitude of 8 kV. The delay time shown (Fig. 4) is the time between the start of the rise measured by extrapolating its linear part back to the baseline, and the start of the fall measured by extrapolating its linear part back to the applied pulse (that is, as it would be with no discharge gap).

The region of stable triggered operation lies between 1- and 3-mm gap spacing. The main gap fires spontaneously for spacings smaller than 1 mm and fails to fire at all for spacings when much larger than 3 mm.

Figure 4(b) shows delay times when a 50-pF capacitor is put in parallel with the capacity of the trigger. This causes a six-fold increase in the RC delay time. Because the spark formation time plays a major role, the overall delay time increases by a much smaller factor.

The delay times for actual chambers are comparable to those shown in Fig. 4(a). The much larger possible range of adjustment of gap spacing and delay time before excessive jitter sets in is apparent when the curves for triggered operation (R = 1.5 kΩ and 10 kΩ especially) are compared with the one for untriggered operation (R = ∞). A delay time of 20 nsec corresponds to a full pulse width of about 50 nsec at half maximum.

The pulse-to-pulse jitter times shown in Fig. 4 are for new gaps. In actual installations where large numbers of these are used to near the end of their lives, the jitter time will increase somewhat but will generally remain less than ±5 nsec. The life for gaps discharging 10-kV pulses on 5 000-pF chambers in parallel with 15 000-pF pulser capacitors is about a million pulses, and is limited by erosion of the alumina dielectric.

Figure 5 shows the circuit diagram of a unit which includes a triggered gap, a parallel, long-time-constant damping resistor (20Ω), a pulse monitor, and a clearing field supply. This entire unit measures 2.0 cm by 3.3 cm by 16 cm.

We would like to thank Neil Evans for developing the test setup and collecting the data for Fig. 4.

FOOTNOTES AND REFERENCES

*Work done under auspices of the U. S. Atomic Energy Commission.

1) The use of a spark gap for discharging chambers is described in B. A. Dolgoshein and B. I. Luchkov, Nucl. Instr. and Meth. 26 (1964) 345; G. E. Chikovani, V. N. Roinishvili, and V. A. Mikhailov, Nucl. Instr. and Meth. 29 (1964) 261; B. A. Dolgoshein, B. U. Rodionov and B. I. Luchkov, Nucl. Instr. and Meth. 29 (1966) 270.

2) Data on the time dependence of the pulser spark resistance is given in Sherwood Parker and Charles Rey, Nucl. Instr. and Meth. 43 (1966) 361.

3) The use of dielectrics in intensifying spark gap fields is described in J. Craggs and J. Meek, High Voltage Laboratory Technique (Butterworths Scientific Publications Ltd., London, 1954); Louis Lavoie, Sherwood Parker, Charles Rey and Daniel Schwartz, Rev. Sci. Instr. 35, (1964) 1567.

FIGURE CAPTIONS

Fig. 1(a). Schematic of spark gap.

(b). Cross section thru spark gap. Mylar insulation around the center and trigger electrodes is not shown. The alumina dielectric is cut from 3.1-mm i. d. by 4.7-mm o. d. tubing, the tungsten center electrode from 3-mm diameter rod, and the ground electrode from a 1/4 - 20 brass screw.

Fig. 2. Photograph of the spark gap with the cover removed. The rubber washer over the trigger electrode holds the resistor in place.

Fig. 3. Pulses on double gap 1 m by 2 m spark chamber module with 8-mm gap widths using two discharge gaps on the 1-m side opposite the pulser.

Fig. 4(a). Delay times for discharge gap as a function of gap spacing for three values of triggering resistance and for untriggered operation ($R = \infty$). Typical jitter times (in nsec) about the plotted values are indicated along each curve.

(b). Delay times for discharge gap with 10-pF trigger capacitance paralleled with 50-pF, primarily to show the effect (such as it is) of the RC component of the total delay.

Fig. 5. Schematic of discharge gap combined with parallel damping resistor ($10\Omega + 10\Omega$), clearing field supply, and pulse monitor.

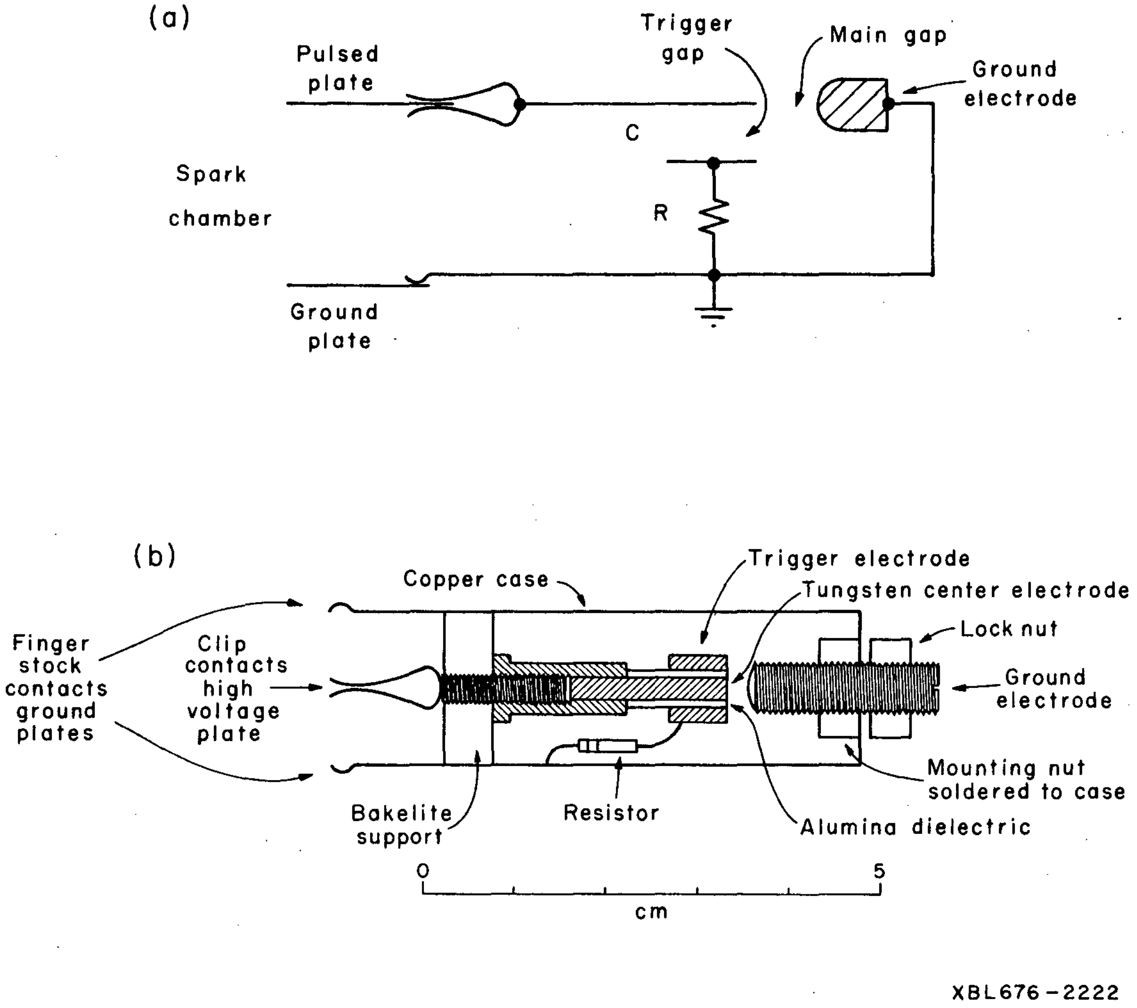
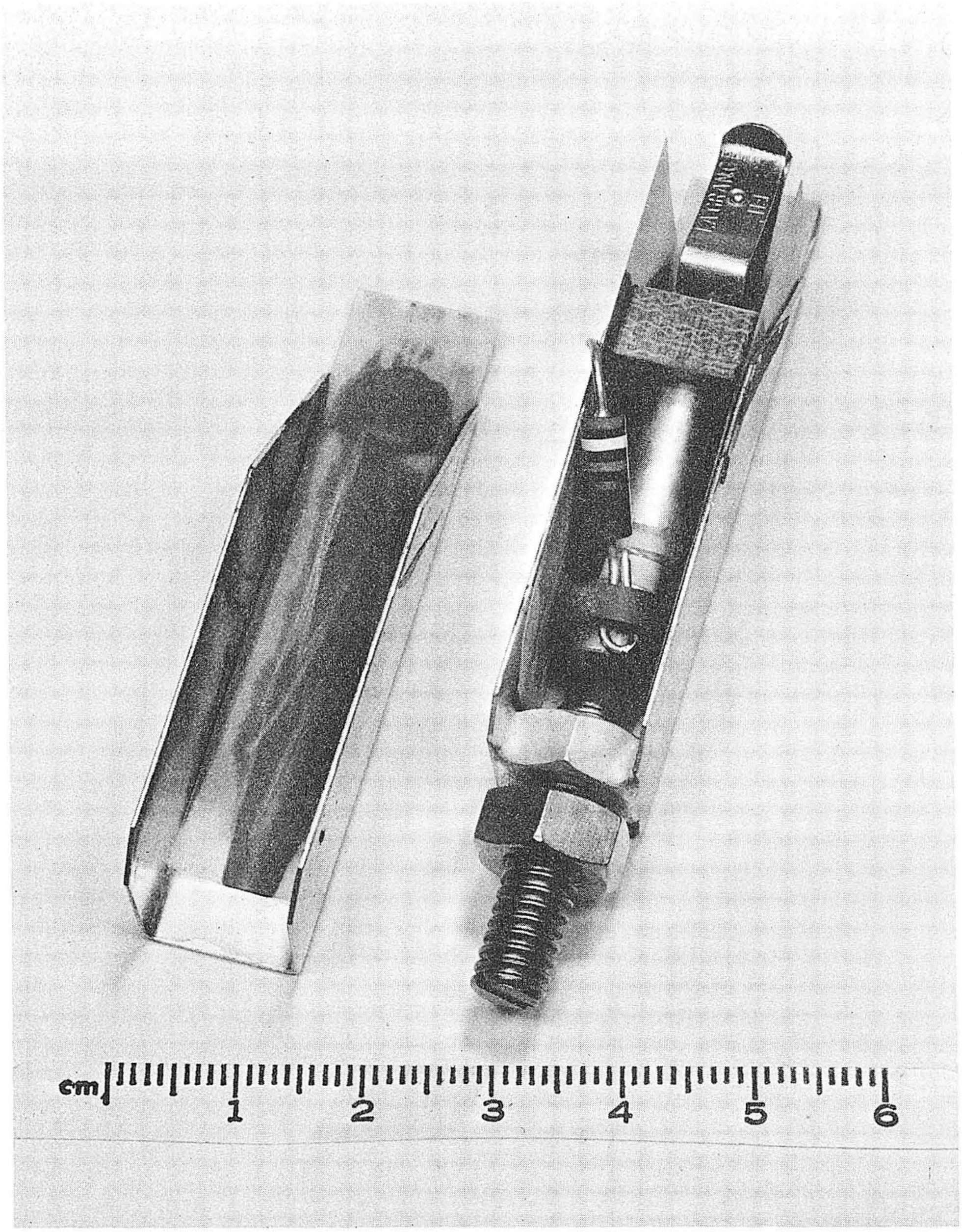
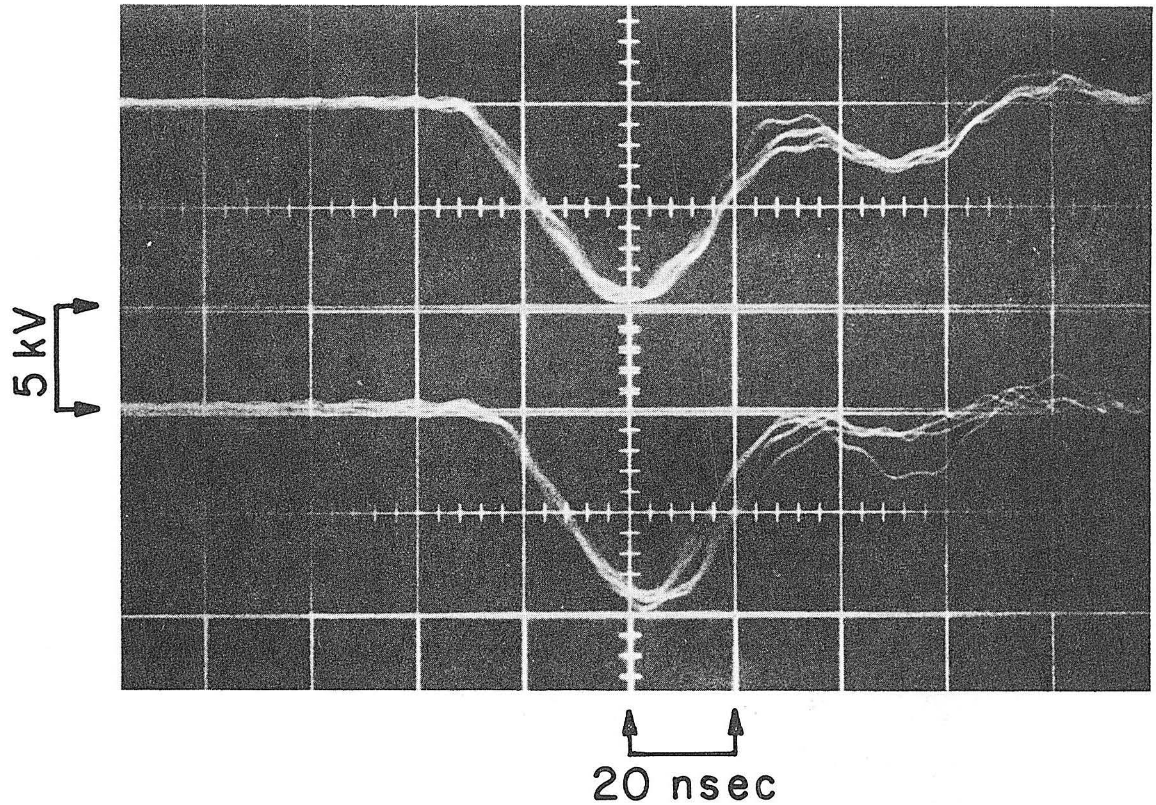

(a)
Pulsed plate
Trigger gap
Main gap
Ground electrode
C
Spark chamber
R
Ground plate
(b)
Copper case
Trigger electrode
Tungsten center electrode
Lock nut
Finger stock contacts ground plates
Clip contacts high voltage plate
Ground electrode
Mounting nut soldered to case
Bakelite support
Resistor
Alumina dielectric
0
5
cm
XBL676-2222

Fig. 1



XBB 676-3208

Fig. 2



XBB 676-3209

Fig. 3

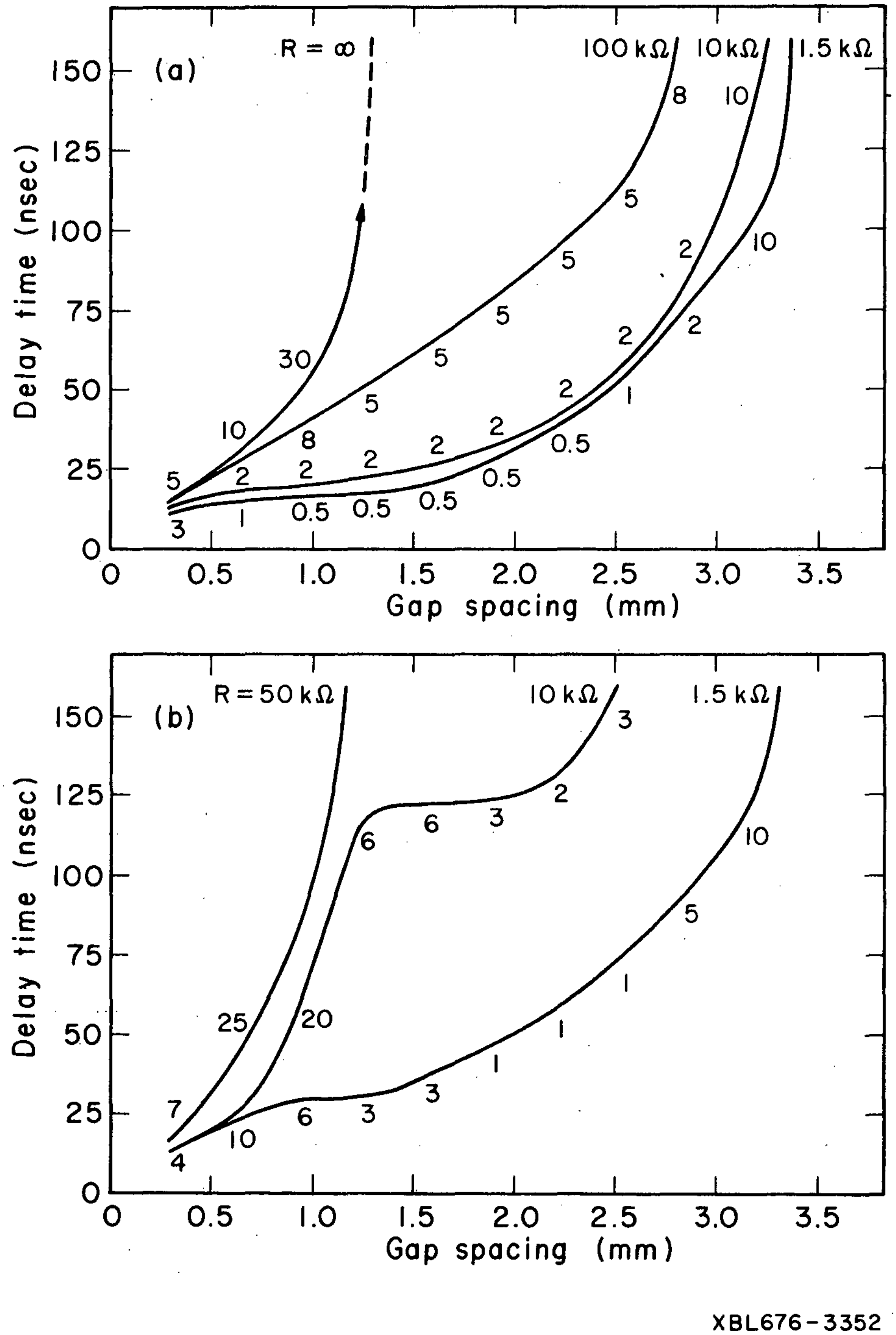

(a)
R = ∞
100 kΩ
10 kΩ
1.5 kΩ
Delay time (nsec)
Gap spacing (mm)
(b)
R = 50 kΩ
10 kΩ
1.5 kΩ
Delay time (nsec)
Gap spacing (mm)
XBL676-3352

Fig. 4

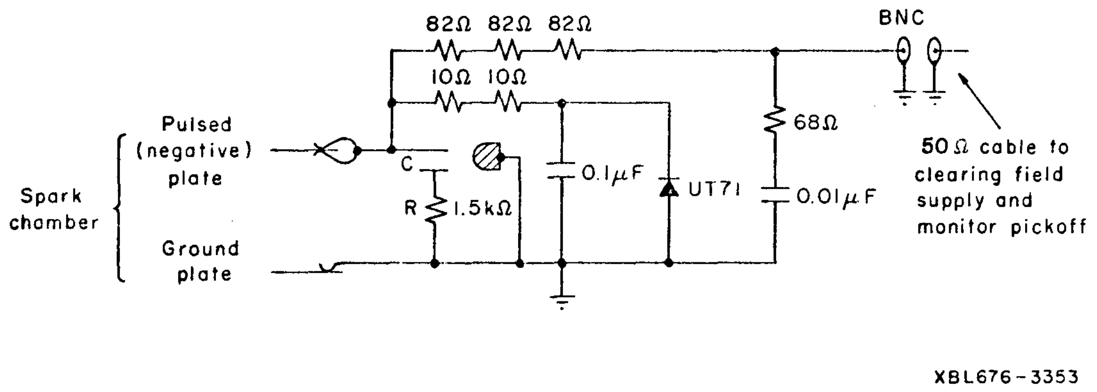

82Ω 82Ω 82Ω
10Ω 10Ω
BNC
68Ω
Pulsed
(negative)
plate
Spark
chamber
Ground
plate
C
R
1.5kΩ
0.1μF
UT71
0.01μF
50Ω cable to
clearing field
supply and
monitor pickoff
XBL676-3353

Fig. 5