Effect of Wire Cross Section on the First Pulse of an Exploding Wire

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(Received 29 April 1965; and in final form, 28 May 1965)

The optimum discharge in an exploding wire circuit is described. In this type of discharge, the stored energy of the capacitor discharges completely during the first pulse of the exploding wire phenomenon. It was determined from the results of experiments conducted in air at atmospheric pressure with Cu, Ag, and Pt wires that for an optimum discharge the initial voltage of the capacitor is directly proportional to the wire cross sectional area, and it is independent of the wire length. Consequently, the ratio of the stored energy of an optimum discharge to the mass of the wire is proportional to the inverse of the resistance of the wire at room temperature. The wire length was varied from 2.5 to 17.8 cm and the wire cross sectional area was varied from 4.8×10^{-5} to 3.2×10^{-3} cm^2.

THE circuit for the exploding wire experiment is shown in Fig. 1. A 14.7 μF, 20 kV capacitor was used as the energy storage capacitor. The total inductance of the circuit was 0.5 μH, and the total resistance of the circuit without the exploding wire was 10.76 mΩ. The current $i(t)$ was measured with a 2.430 mΩ inductance-free T & M current viewing resistor, and the voltage across the wire $v(t)$ was measured with a Tektronix P-6015 high voltage probe. Both the current and the voltage traces were recorded with a dual-beam Tektronix 545-A oscilloscope.

The characteristic current and voltage traces for an exploding wire are shown in Fig. 2. The regions I, II, and III are known as the first pulse, dwell, and re-strike regions, respectively. The phenomena that take place during these regions have been discussed extensively by many authors.[1]

In an optimum discharge, the stored energy of the capacitor, E_0, discharges completely during the first pulse. The current and the voltage traces for an optimum discharge are shown in Fig. 3. Both the voltage and the current diminish to zero by the end of the first pulse indicating the total discharge of the capacitor. The re-strike phenomenon does not occur.

The experiments were conducted in air at atmospheric pressure, and Cu, Ag, and Pt wires were used. The wire cross section was varied from 4.8×10^{-5} to 3.2×10^{-3} cm^2, and the wire length was varied from 2.5 to 17.8 cm. It was determined from the results of these experiments that the initial voltage of the capacitor for the optimum discharge, V_0, is dependent only on the wire cross section, and independent of the wire length. The plots of V_0 versus the wire cross section A for Cu, Ag, and Pt wires are shown in Fig. 4. The slopes of these curves indicate that V_0 is directly proportional to A.

The plots of the stored energy to the wire mass ratio, E_0/m, versus the resistance of the wire at the room tem-

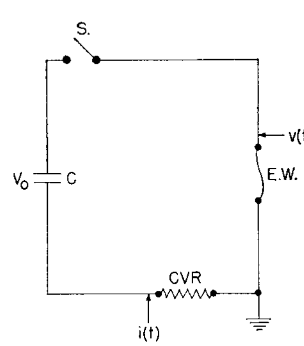

FIG. 1. The exploding wire circuit.

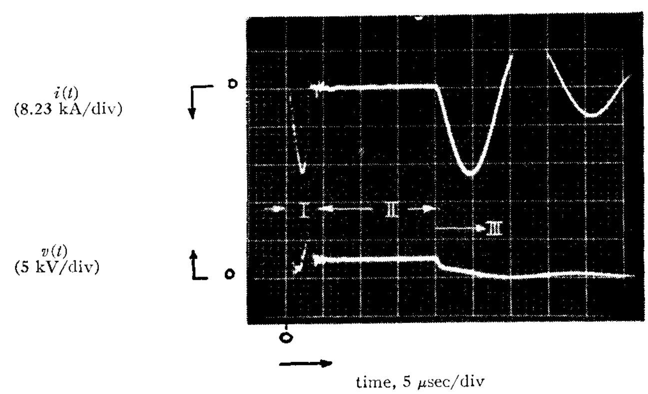

FIG. 2. Typical current and voltage traces for an exploding wire.

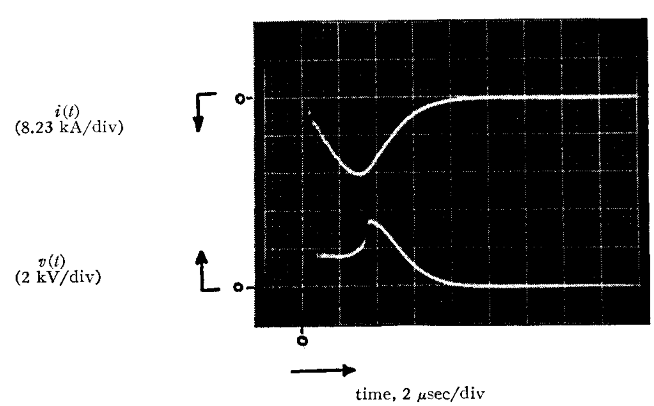

FIG. 3. The current and voltage traces for an optimum discharge.

[1] William G. Chase and Howard K. Moore, *Exploding Wires* (Plenum Press, Inc., New York, 1959, 1962, and 1964), Vols. 1, 2, and 3.

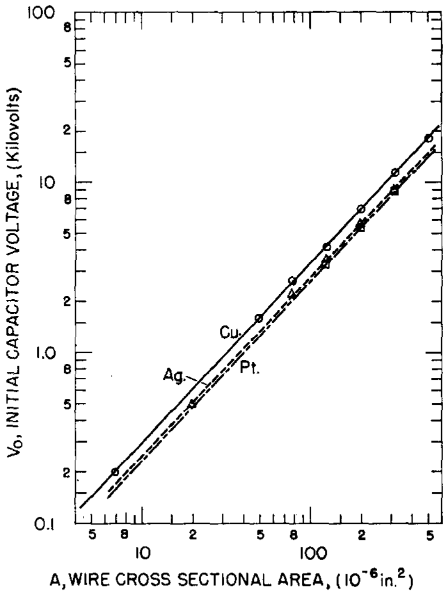

FIG. 4. The initial capacitor charging voltage versus the wire cross section area. (The wire lengths for most of the datum points were varied from 2.5 to 17.8 cm while keeping the wire cross section area constant.)

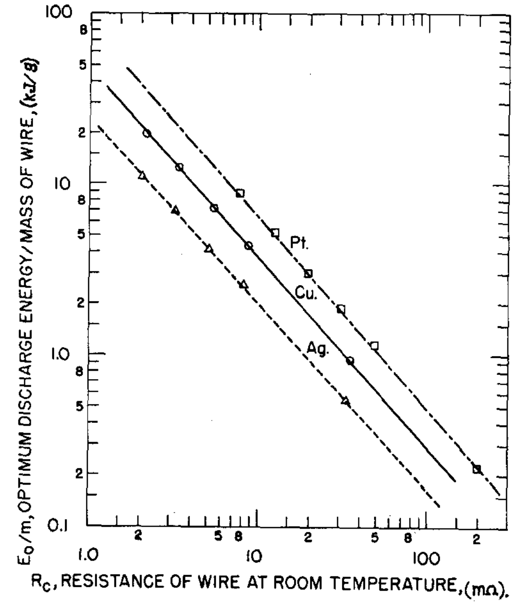

FIG. 5. The stored energy for an optimum discharge to the wire mass ratio versus the resistance of the wire at the room temperature.

perature, R_c, for the three metals are shown in Fig. 5. The slopes of these curves indicate that E_0/m is inversely proportional to R_c. The energy transferred to the wire was computed for several optimum discharges by integrating the power curve obtained from the current and voltage traces. This energy was more than 90% of E_0, the energy stored in the capacitor.

The $1/R_c$ variation of the E_0/m ratio is a consequence of the direct proportionality of V_0 to A. In the circuit used for these experiments, the E_0/m ratio was varied from 200 J/g to 20 000 J/g by decreasing R_c from 200 to 2 mΩ.

ACKNOWLEDGMENTS

The author wishes to thank Professor Pauline M. Sherman, Kenneth R. Sivier, Kenneth D. Ware, and Pai-Lien Lu for their suggestions and encouragements, and Leo J. Griffin for his invaluable assistance in conducting the experiments.