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A WIRE EXPLODER FOR GENERATING CYLINDRICAL SHOCK WAVES IN A CONTROLLED ATMOSPHERE

BY D. L. JONES AND K. B. EARNSHAW

U. S. DEPARTMENT OF COMMERCE
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ABSTRACT

A design for a rugged exploding wire device is given. This device permits the study of strong cylindrical shock waves in controlled atmospheres using optical and microwave techniques. Adequate detail and pictures are given to allow construction of the device.

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Very little information on exploding wire devices is reported in the literature. Normally, exploding wire studies are made in air and it is the exploding wire itself that is of interest.[1, 2] For these studies, the device for exploding the wire may easily be made to have the necessary low inductance-electrical connections. In the few instances where the shock waves from the explosion have been investigated[3, 4] relatively low energy capacitor banks (~ 150 joules) were used. However, in order to study strong shock waves in a controlled atmosphere using a capacitor bank of 1500 joules or more a rugged blast chamber is required. For optical or microwave observations, the chamber must also be made of a transparent material.

The purpose of this paper is to report a ruggedly designed exploding wire device which can be used for optical and microwave investigations of strong cylindrical shock waves. The particular advantages of this device are: 1) the electrical connections are designed to have a minimum inductance; 2) the pressure and type of gas are controllable; 3) the device is simple to assemble, and cleaning of the chamber is quite easy; 4) the wire is held in place by gravity; and 5) the electrodes for the current return path are removed far enough from the wire axis to minimize mechanical interference with the expanding shock wave.

The assembled wire exploder is shown in Figure 1. The dark vertical line in the center is the wire which passes through the lid and the cross arm and makes contact with the bottom electrode. An exploded view of the device is shown in Fig. 2. Lids A and D are made of plexiglass one inch thick with a diameter of $12\frac{1}{4}$ inches. Plexiglass cylinder C is 3 inches long, $\frac{1}{4}$ inch thick, and has an $11\frac{1}{2}$ inch I.D. Vacuum joints between the lids and the cylinder are obtained by the rubber "O" rings which are visible in Fig. 2.

The current return path (cross arm B) is made from brass bar stock which is covered with a sheath of rubber insulation to avoid arcing. The cross arm is bolted to plate E through the bottom lid D, securing lid D to the plate. An "O" ring seal between cross arm B and lid D provides a vacuum seal. Plate E is fastened to the bottom member G which is attached to ground. Both plate E and member G are made of $\frac{1}{2}$-inch brass.

The cylindrical insulator J, which encloses a spark gap switch, is made of teflon with an outer diameter 2.88 inches and inner diameter of 2.41 inches. This insulator fits into the machined groove in lid D, through the holes in parts G and E. The top spark gap electrode I is of brass with an outer diameter of 2.40 inches. It fits into insulator J with the top part (H) fitting into lid D. The upper 3/8 inch of electrode I (part H) consists of a $\frac{1}{4}$-inch diameter rod covered with a one inch diameter teflon cylinder. The "O" ring in the teflon cylinder provides a vacuum seal for the electrode. The bottom spark gap (electrode K) which is normally attached directly to the capacitor, is made of 2.40 inch outer diameter aluminum. It belongs inside insulator J near the bottom.

Triggering is obtained by means of a high voltage pulse brought to the top spark gap electrode through a $\frac{1}{2}$-inch hole in cylinder F. A length of $\frac{1}{4}$-inch I.D. vacuum tubing outside the trigger cable insulates the cable from cylinder F. The trigger cable comes out flush with the center of the top electrode of the spark gap.

Fittings for gas inlet and vacuum taps may be placed at any convenient point in either lids A and D or cylinder C.

Tests with this device show it to be capable of maintaining a vacuum of 50 microns with a standard fore pump. Mass spectrometer analyses of argon gas samples taken under normal operating conditions at 10 cm. Hg. indicate that the gas purity is maintained to better than one part in 10^4, or about the standard guaranteed for bottled gases. System inductance depends on the wire size, the pressure and the voltage, but a typical value (without capacitors) is 48×10^{-9} Henry, including switch inductance. Working voltages have ranged 3 KV to 20 KV while maximum current at 20 KV is about 150,000 amperes.

This exploding wire device has been used to generate type III blasts[5] at pressures ranging from atmospheric to five centimeters of mercury. Shock front velocity and distance measurements obtained by the microwave Doppler Method[6] show that detectable shocks travel out as far as seven or eight centimeters from the wire axis. In fact, measurements of the velocity are made until the electron density in the front falls below the 10^{13} cm^{-3} which is required to reflect the microwaves. Using the measurements the similarity theory for strong cylindrical blast waves[7] has been verified to velocities as low as Mach number 3 in air.

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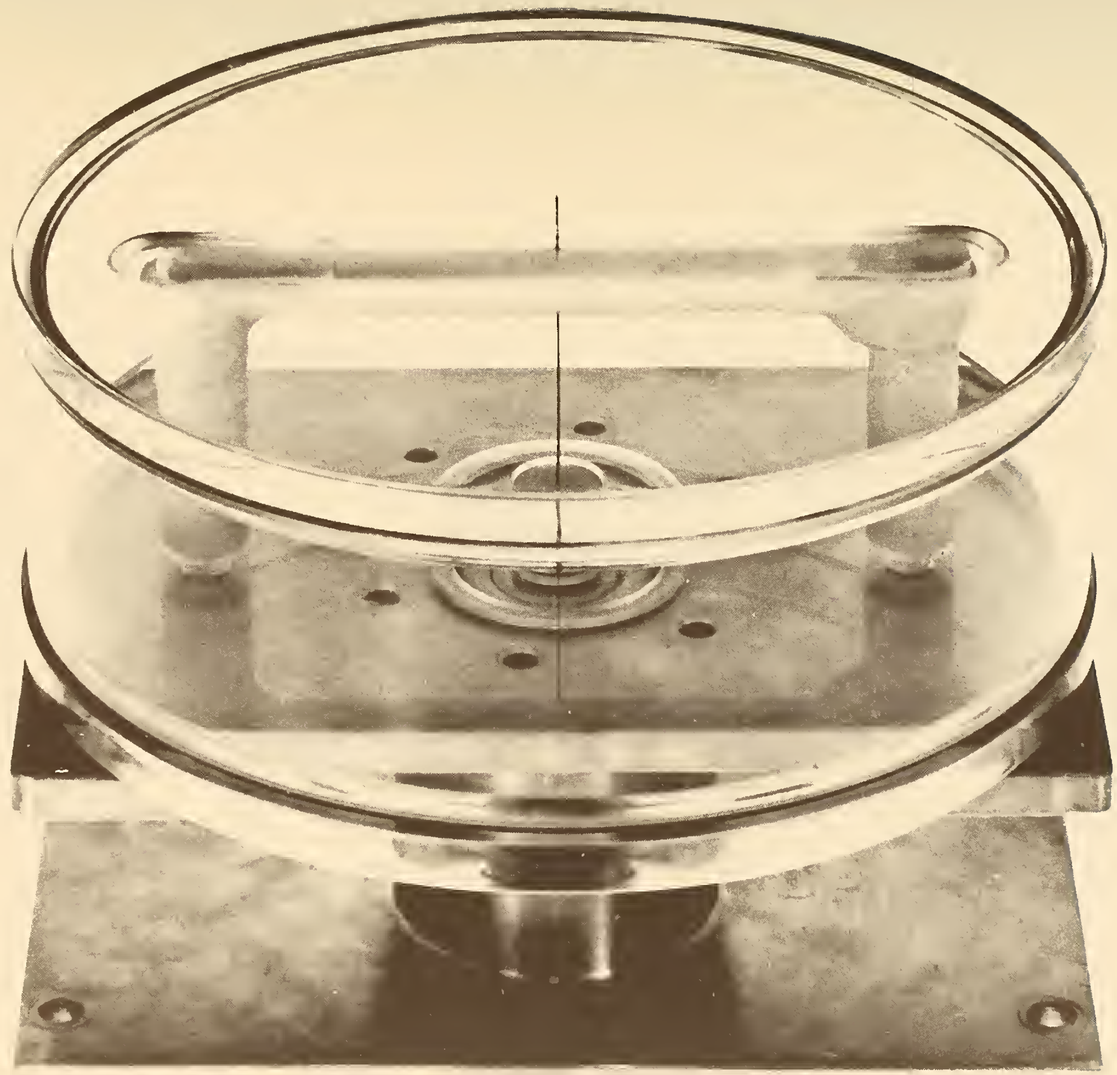

FIGURE 1 ASSEMBLED VIEW OF CYLINDRICAL SHOCKDRIVER

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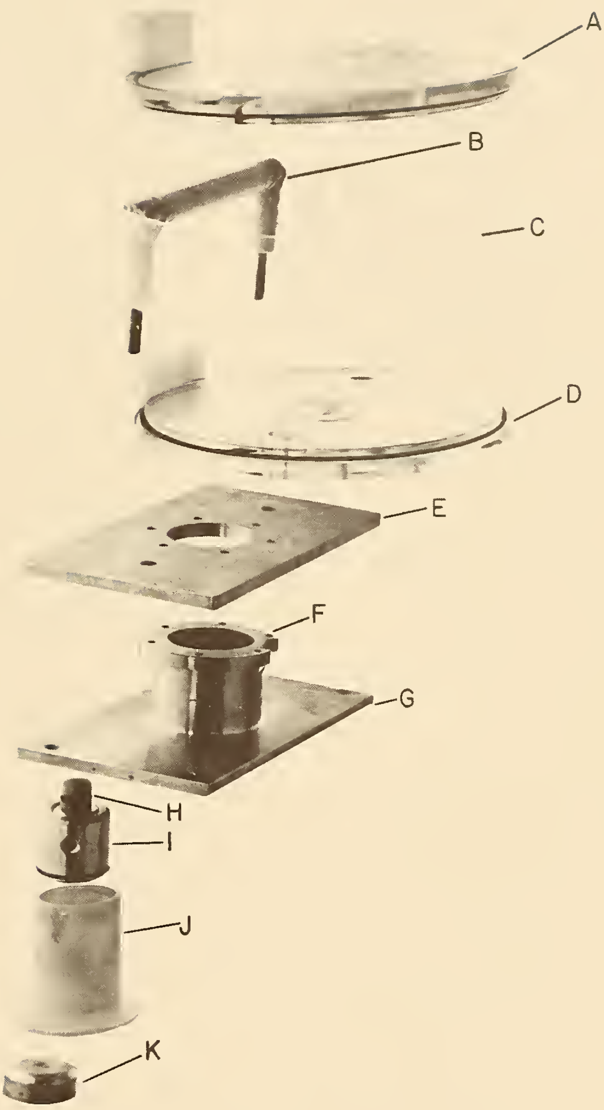

FIGURE 2. EXPLODED VIEW OF CYLINDRICAL SHOCKDRIVER

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