Feb. 23, 1960 A. W. O'BRIEN, JR 2,925,729

CONTINUOUS METHOD OF RECORDING THE PROGRESS OF THE REACTION ZONE IN DETONATING OR BURNING COLUMNS

Filed July 8, 1957 2 Sheets-Sheet 1

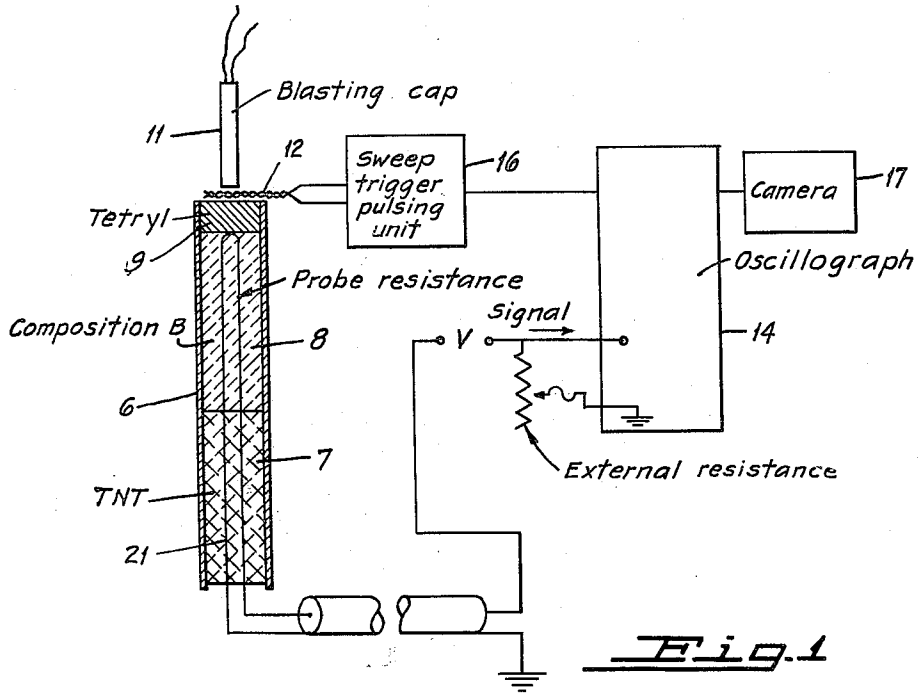


Fig. 1

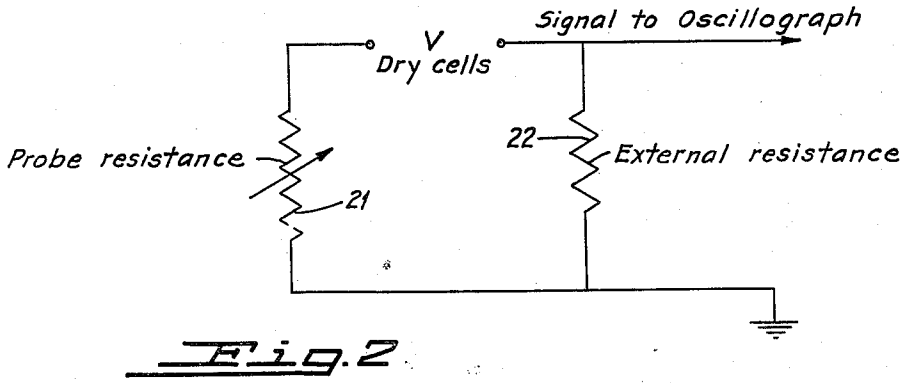


Fig. 2

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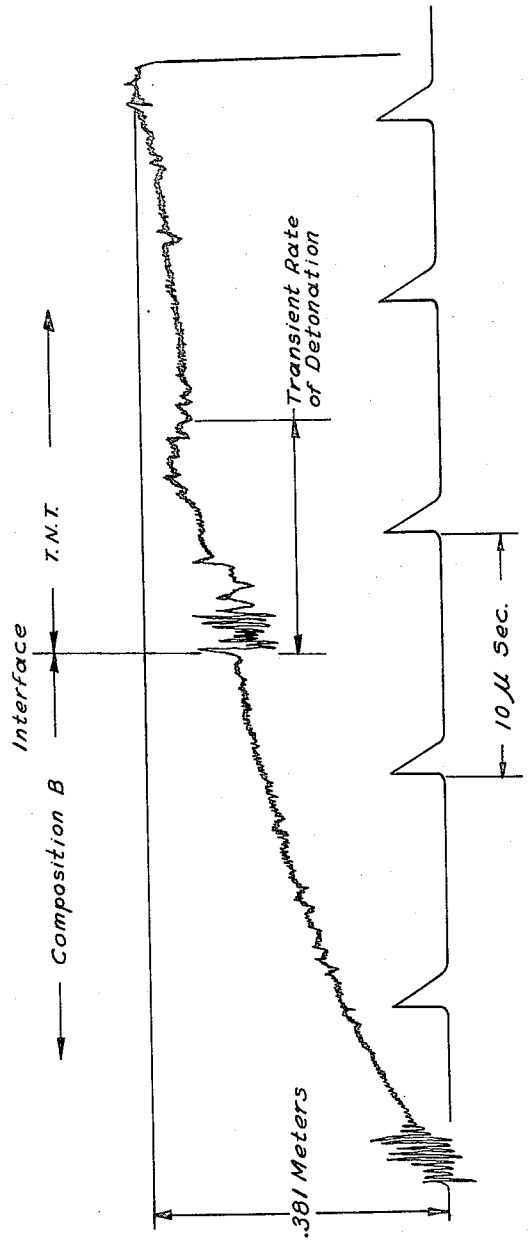
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Continuous Progress of the Detonation of a Composition B-T.N.T. Explosive Column

Fig. 3

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2,925,729

CONTINUOUS METHOD OF RECORDING THE PROGRESS OF THE REACTION ZONE IN DETONATING OR BURNING COLUMNS

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Application July 8, 1957, Serial No. 670,590

3 Claims. (Cl. 73—35)

This invention relates to the measurement of the rate of advance of a reaction through a column of an explosive or a propellant. More particularly, the invention is concerned with a method and apparatus enabling one to determine the velocity of movement of a reaction zone such as may be provided by a detonating explosive column or in a strand of a burning solid propellant.

Heretofore, the rate of linear movement of a reaction in a detonating or burning column has been determined by inserting probes into the column, a probe usually consisting of a pair of open-end conductors acting as a switch. The passage of the reaction across the conductors results in closing of the switch because of the high content of ions provided in the reaction zone. Closing of the switch, in turn, is ordinarily used to operate some type of pulsing and recording system, such as a counter-chronograph operated by a differentiating circuit. In this manner, the time taken by the reaction zone to traverse any measured linear segment of the zone is determined, and the average velocity of the reaction zone obtained. Any number of segments may be measured by the insertion of the necessary number of probes and provision of an adequate number of pulsing and recording devices.

The aforementioned method of measurement is discontinuous in the sense that only the average velocity between any two points can be determined. The method and apparatus of the present invention enables one to determine a continuous measurement in the sense that it employs only a single probe which is inserted at an infinite number of points along the path of the reaction zone. Ion concentration is utilized to effect switching, but the switch employed is not simply an on-and-off type of switch; instead, the probe consists of a closed loop of resistance wire and the effect of ion concentration in the reaction zone can be likened to that of a slide on a slide wire potentiometer, the reaction zone decreasing the resistance in the loop of resistance wire in advance of the reaction zone at a rate equal to the velocity of movement of the reaction zone. This effect can be readily measured and by relatively simple electrical circuitry.

It is in general the broad object of the present invention to provide a novel method and apparatus for the measurement of advance of a reaction zone through a column of explosive or propellant.

The invention includes other objects and features of advantage, some of which, together with the foregoing, will appear hereinafter wherein the preferred form of apparatus is represented schematically. In the drawing accompanying and forming a part hereof,

Figure 1 is schematic showing of apparatus and a circuit which can be employed to practice the present invention.

Figure 2 is a diagram illustrating the operation of the circuit.

Figure 3 is a reproduction of an oscillograph record by the method of this invention.

Referring to the drawing, I have indicated an explosive column as provided by a length of pipe 6 (1" diameter by 15" in length) filled with TNT at one end, this being indicated at 7, and with a composition B at the other end, it being desired to determine the relative rate of explosion or detonation of composition B as compared to TNT. A small tetryl booster 9 was placed at one end of the pipe. A No. 8 blasting cap, indicated at 11, was utilized to initiate the reaction; an off-on type of probe 12 was utilized to trigger the sweep on an oscillograph, generally indicated at 14, this circuit including a sweep trigger pulsing unit 16, and the variation in the oscillograph being recorded by a camera 17.

Located centrally of the pipe was a resistance loop 21 consisting of approximately three feet of Chromel wire, 0.15" in diameter. The resistance was measured at approximately 11 ohms; the resistance loop was connected in a series circuit with a three-volt dry cell and an external resistance 22. The voltage change across the external resistance during detonation was monitored by an oscillograph and the sweep recorded by a camera.

The electrical considerations in the preliminary circuit are simple and require only the application of the Ohm's law in its elemental form: $E=IR$. The circuit utilized consists essentially of two series resistors and a source of constant voltage, as is indicated in Figure 2. As the resistance of probe 21 decreases, the current in the whole series circuit increases. This current increase requires that the voltage across the external resistance also increase. The oscillograph records this voltage in relation to time.

In Figure 3, I have shown an oscillographic record utilizing the apparatus described, this being a graph of voltage against time. Indirectly, it represents the measure of the changing resistance of the probe loop in relation to time and, further, provides a measure of the position of the reaction zone in relation to time. Thus, the velocity of the zone becomes the slope of the curve, and changes in velocity, acceleration and deceleration, are indicated by positive and negative changes in the slope of the curve. Further, it enables the relative velocity of reaction of composition B and of TNT to be compared.

The invention is capable of broad application. For example, it can be applied successfully in explosives where the effect of boosters, the diameter effects on propagation of the detonation, indirect measurement of the power of the explosive, the effects of additives for desensitizing or catalysis, etc., can be determined. Also, the measurements made possible by this invention have value where the point-to-point changes in velocity are important in precise measurements on explosives or propellants.

Also, the introduction of additional probes, parallel to the one indicated, and with the addition of appropriate external electric circuitry can provide information determining the physical dimensions and configuration of the reaction zone itself.

I claim:

1. Apparatus for determining the velocity of advance of a linearly moving ionization front of the reaction zone in columns of explosive and propellant, comprising: an electrical resistance loop positioned internally of and extending longitudinally with respect to one of said columns; a source of direct current for said loop; an external resistance in said circuit in series with said resistance loop and said direct current source means for determining at successive intervals the voltage drop across said external resistance during the presence of an advancing ionization front as a measure of the voltage drop across said loop; and means for initiating an ionization reaction at one end of said reaction zone whereby said ionization front is caused to advance in a direction parallel to said resistance loop.

2. Apparatus for determining the velocity of advance

of a linearly moving ionization front of the reaction zone in explosive or propellant columns, comprising: an elongated reaction column; a U-shaped, electrical resistance loop positioned internally of said column and extending longitudinally thereof; a source of direct current for said loop; an external resistance in said circuit and in series with said resistance loop and said direct current source; means for continuously recording the voltage drop across said resistance during the presence of an advancing ionization front, as a measure of the voltage drop across said loop; and means for initiating an ionization reaction at one end of said reaction column whereby said

ionization front is caused to advance in a direction parallel to said resistance loop.

3. The apparatus of claim 2 wherein said means for recording said voltage drop across said external resistance is an oscillograph having means for amplifying a direct current signal.

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