April 3, 1962 E. D. JONES 3,027,751

APPARATUS FOR DETERMINING DETONATION OR BURNING VELOCITIES OF MATERIALS

Filed Sept. 18, 1958 2 Sheets-Sheet 1

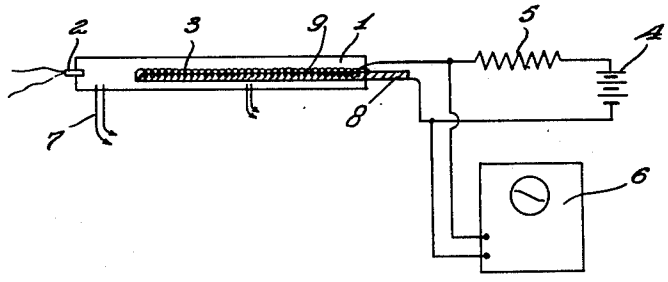


Fig. 1

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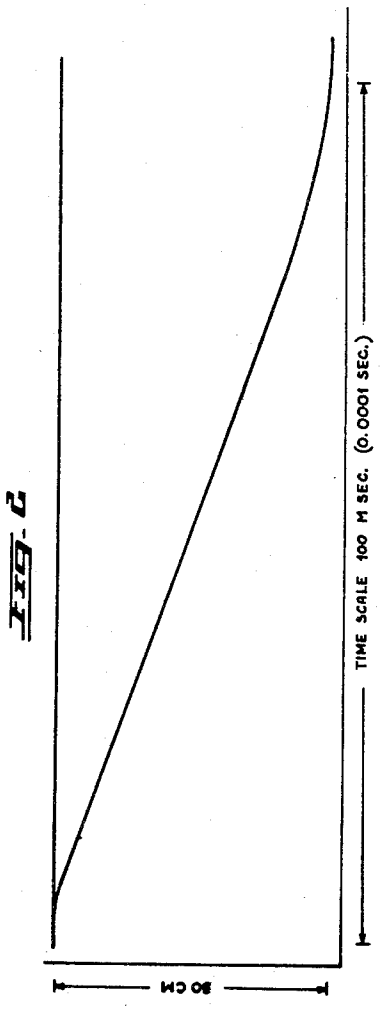


Fig. 2

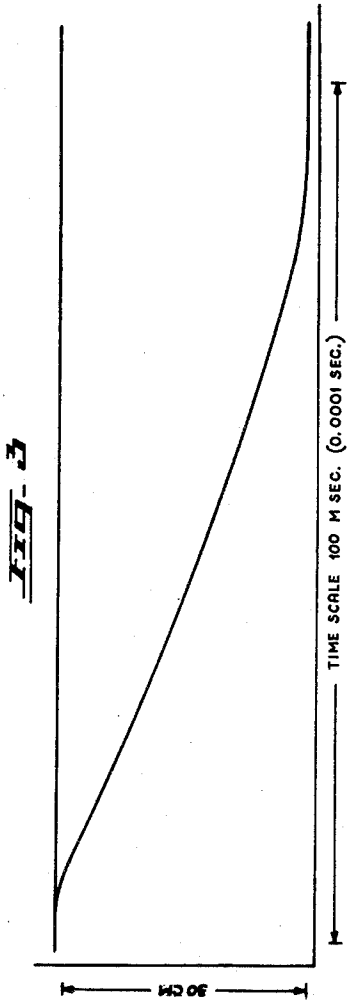


Fig. 3

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APPARATUS FOR DETERMINING DETONATION OR BURNING VELOCITIES OF MATERIALS

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1 Claim. (Cl. 73—35)

This invention relates to an apparatus for determining the velocities of detonation or burning of materials, such as the velocities of detonation of explosive charges or the burning rates of solid rocket fuels.

Information regarding continuous changes in the velocities of detonation of explosives is important since it enables blasters to determine the best ways of using them, particularly when the detonation is to be propagated across a gap of air, water, wood or other barrier to initiate detonation in a second column or charge. Information on detonation velocities can also be used to determine the manner in which explosives are to be employed when used in various locations such as in boreholes under hydrostatic pressure or in the open, in lead pipes, etc.

As regards the importance of knowing the burning rate of any fuel to be used in the manufacture of rocket missiles, it is self-evident and need not be discussed any further.

It is an object of this invention to provide an efficient, inexpensive and accurate device for determining the detonation rate of explosive charges or the burning rate of such materials as rocket fuels.

The apparatus of this invention comprises in combination an electrical resistance element consisting essentially of a central metallic mandrel and an insulated resistance wire wound thereon, said resistance element being adapted for location in contact with the material under study and said resistance wire being adapted for fusion to said mandrel in coincidence with the advance of a combustion front along said material; a source of direct current for said element; an external resistance in series with said element and said source; and a cathode ray oscilloscope in parallel with said element and adapted to display the voltage across said element as a function of time.

The invention may be better understood by reference to the accompanying drawings pertaining to the determination of the detonation velocity of an explosive charge, and wherein:

FIG. 1 shows a diagrammatic view of one type of apparatus of the invention set for operation; and

FIGS. 2 and 3 show oscillograms obtained by the method and the aforesaid type of apparatus of the invention.

Referring to FIG. 1, an explosive charge is shown as 1 with an electric blasting cap 2 and a resistance element 3 embedded therein. A voltage source consisting of a battery 4 supplies a voltage to the element 3 through a high resistance wire 5. The element is connected to the vertical deflection plates of a cathode ray oscilloscope 6. A pair of adjacent insulated wires 7, embedded in the charge 1 between the cap 2 and the element 3, form the trigger circuit of the oscilloscope 6. Photographic means, not shown, are used to record the oscillograms which are produced.

In operation, a light-tight camera (not shown) is attached to the oscilloscope 6 viewing its screen. The light beam is deflected off the screen and the camera then opened. The beam sweep is then set for a time interval of, say, 100 microseconds and the beam is swept across the screen at the starting voltage level and deflected off again. The charge 1 is then detonated by means of the cap 2 and

the detonation wave thus produced short-circuits the wires 7. The short-circuiting of the wires 7 brings the light beam back on the screen, the beam deflecting horizontally for a short interval before the detonation front reaches the element 3. As the detonation front progresses across the element 3, the voltage of the latter is reduced with a resultant inclined deflection of the beam on the screen, as shown in FIGS. 2 and 3.

The non-linearity of the inclined deflection of the beam is due to changes in the velocity of detonation as the latter progresses across the charge 1. The ability to detect local variations in detonation velocities is a major feature of this invention.

A suitable element for use in the apparatus of this invention comprises an insulated resistance wire wound on a metallic mandrel. This structure is shown in FIG. 1 wherein the element 3 is made up of the mandrel 8 with the resistance wire 9 wound spirally upon it. As the detonation front proceeds along element 3, the wire 9 is fused or impacted into the mandrel 8 and the electrical resistance of the element progressively decreases. A particularly suitable element consists of a cotton-covered copper/nickel wire wound around a tinned copper wire mandrel, the winding pitch being sufficiently great to ensure that heat, ionized gases, etc. are allowed to penetrate to the under surface. The pitch should not be less than about one diameter of the covered wire. Increased pitch is permissible as long as uniformity which governs the accuracy of the determinations is preserved. Furthermore, the mandrel may be grooved in order to receive the turns of wire but this is not necessary if uniform spacing can be achieved by other methods and if the means which secure the wire to the mandrel, such as varnish or other finishing coat, are strong enough to protect the windings from damage or displacement in ordinary handling.

Other forms of construction of the aforesaid type resistance unit are possible, the principle being simply to attach a resistance wire to a continuous metal support into which the wire is progressively impacted as the detonation or combustion front passes. Thus a base strip of metal along which a single length of insulated wire is attached, e.g. by varnish or lacquer, would be suitable.

Suitable resistance values can be more readily obtained, however, if the resistance element is one in which a reistance wire is wound around a central rod, and this form of element is therefore a preferred embodiment. It has been found convenient to wind the resistance elements to provide approximately 100 ohms resistance per foot of element. If the central rod is magnetic, the winding should be non-inductive whereas, if the rod is non-magnetic, the winding may be straight.

While the resistance element may be inserted through or cast in the center of the material under study, it has been found more practical to tape the resistance element to the outside of the material. With the latter method, it is necessary that the taping be performed so that longitudinal gas passages are not formed along the resistance element down which a flame could be driven ahead of the detonation or combustion front thereby causing premature destruction of the resistance element. It is preferable to lay a strip of plasticine or similar material over the element before taping in order to prevent this occurrence.

When the resistance element is strapped to the outside of the material, and the material is to be detonated or burned on the ground, it is good practice to lay the material on the ground with the element resting on the ground.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

An apparatus for obtaining a continuous measurement of the velocity of detonation or burning of a material, which comprises in combination an electrical resistance element consisting essentially of a central metallic mandrel and an insulated resistance wire wound thereon, said resistance element being adapted for location in contact with the material under study and said resistance wire being adapted for fusion to said mandrel in coincidence with the advance of a combustion front along said material; a source of direct current for said element; an external resistance in series with said element and said source; and a cathode ray oscilloscope in parallel with said element and adapted to display the voltage across said element as a function of time.

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