United States Patent

[11] 3,613,499

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[21] Appl. No. **860,677**
[22] Filed **Sept. 24, 1969**
[45] Patented **Oct. 19, 1971**
[73] Assignee **Her Majesty the Queen in right of Canada as represented by the Minister of National Defence**
[32] Priority **Sept. 25, 1968**
[33] **Canada**
[31] **030,894**

[54] **SWITCH FOR PROJECTILE-ACCELERATING SYSTEM**
5 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** ..... **89/8, 89/14 R**
[51] **Int. Cl.** **F41f 1/00**
[50] **Field of Search** 89/1, 7, 8, 14; 42/76

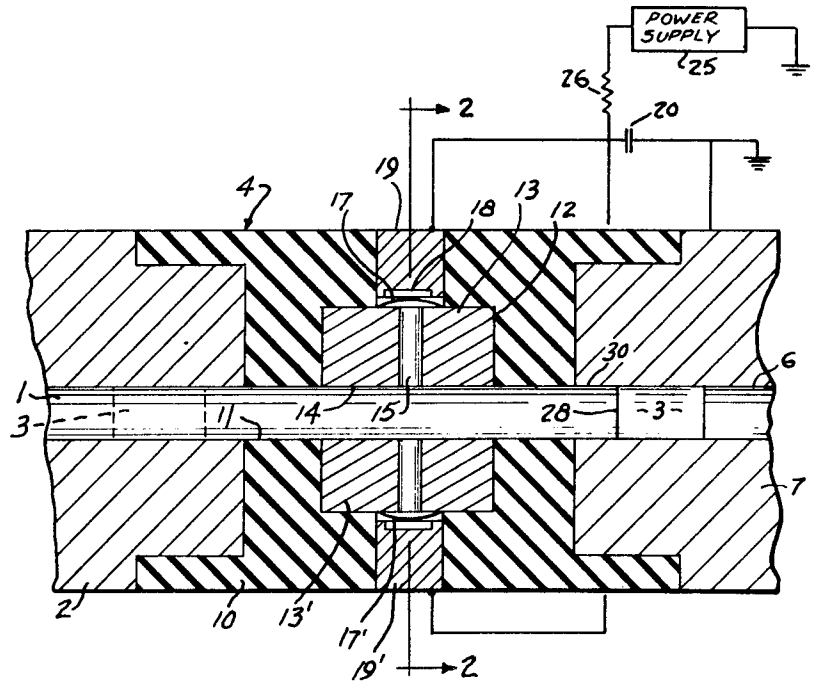
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ABSTRACT: An apparatus for accelerating a projectile through the barrel of a weapon is provided by a plurality of spaced-apart stations or sections along the barrel which are responsive to the passage of the projectile and cause an electrical discharge whereby enthalpy at each station is added to the expanding gas behind the projectile resulting in an increase in the projectile velocity.



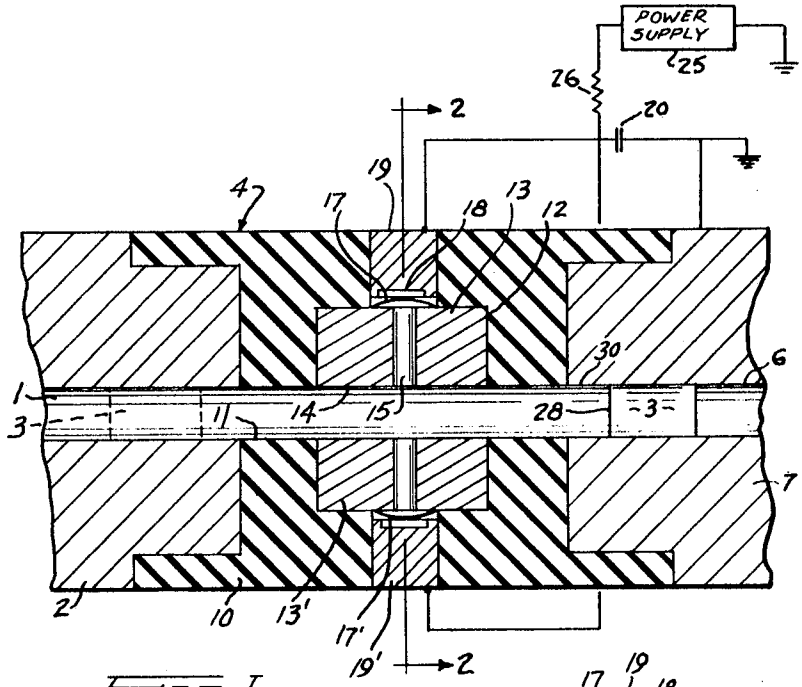


FIG. 1

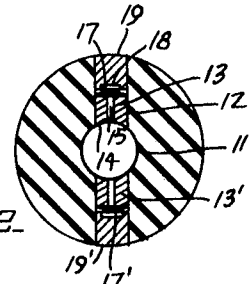


FIG. 2

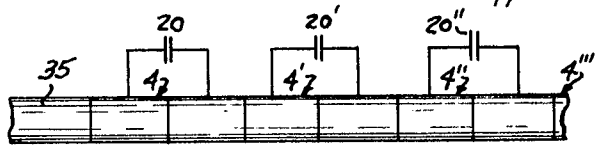


FIG. 3

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SWITCH FOR PROJECTILE-ACCELERATING SYSTEM

This invention relates to a method and apparatus for accelerating projectiles to hypersonic velocities and more particularly relates to a scheme involving the discharge of electrical energy into gas accelerating the projectile.

It is well known to achieve high projectile speeds by increasing the energy of the propelling gas with an arc discharge of electricity from a storage capacitor. It is also known to employ the magnetic field produced by current flowing through the arc to increase the force exerted on the projectile.

While these schemes are satisfactory in some respects one of the several problems associated with them is that of triggering the discharge at the correct time, so that its effect is most pronounced.

In the prior art, pressure sensors, ionization gauges, break wires and an initially created ionized gas mass have all been used with variable measures of success. In some cases the signal derived is directed to a switch consisting of a spark gap, or ignition, for triggering the discharge. In others the ionized gas mass itself permits an assisting discharge to occur between electrodes across which a potential has been applied, but between which the discharge is impossible in the absence of ionized gas.

All of these systems are costly and complex and it is with the desire to develop a simpler, but effective system, that the present inventors have directed their inquiries.

In following the teaching of the present invention a novel and simple switch is provided which presents the electric potential from a capacitor bank to electrodes bridging the area for an arc discharge. More particularly in accordance with the invention there is provided an apparatus for accelerating a projectile in which the projectile is caused to move down a barrel under the influence of a high pressure gas, the improvement which comprises, including an insulating section in said barrel, defining a preacceleration and a postacceleration section, an electrode in said insulating section contiguous with said barrel, a hole defined in said electrode extending away from the barrel, and a rupturable electrically insulating diaphragm covering said hole on the outward side of said electrode with respect to the barrel, a second electrode beyond said diaphragm, a space defined between said diaphragm and said second electrode, and means for connecting a high-potential electric source between said second electrode and an adjacent electrically conducting surface of said barrel gas in said preacceleration section behind said projectile escaping through said outwardly extending hole, upon passage of said projectile along said barrel and past said hole, rupturing said diaphragm and permitting electrical discharge between said second electrode, through said first electrode, and thence to said electrically conducting surface of said barrel.

Preferably the electrically conducting surface is the postacceleration section of the barrel, the diaphragm is a thin film of polytetrafluorethylene, and the high-potential source is a capacitor. Additional insulating sections and associated electrodes may be repeated along the barrel to allow a multiplicity of accelerating sections through which the projectile may pass in its travel through the barrel.

A description of the invention now follows in which reference will be made to the accompanying drawings and in which;

FIG. 1 shows a cross-sectional view through a projectile accelerating barrel,

FIG. 2 is a sectional view along line 2—2 of FIG. 1, and

FIG. 3 shows a side view of a development of an embodiment of the invention.

With reference now to FIGS. 1 and 2, a preacceleration breech chamber barrel 1 formed in a breech casing 2 allows the movement of a projectile 3 from a position shown typically in broken lines through the electrical energy section 4 and thence into the postacceleration barrel 6 formed in casing 7.

The electrical section 4 comprises an insulator block 10 having a bore through it at 11 which is contiguous with the barrels 1 and 6 in the casings 2 and 7. Section 10 is formed of a tough plastic material with good electrically insulating properties, and may for instance be an epoxy resin impregnated fiberglass, the plastic sold under the Trade Mark Araldite and other suitable materials.

As can also be seen with reference to FIG. 2 the plastic member 10 includes a cavity 12 within which is mounted an electrically conducting insert electrode 13 whose internal face 14 is also contiguous with the barrels 1 and 6. The electrode 13 is pierced by a bore 15 which will allow gas from the barrel section 11 to pass up to a diaphragm 17 which is separated by a small gas space 18 from an electrode 19. The electrode 19 is connected to one side of a capacitor 20, the other side of which is grounded and connected to electrically conducting casing 7. A suitable power supply 25 is connected to charge the capacitor 20 by well known means through resistor 26. As illustrated, but not essential to the performance of the invention, the electrode 13, the diaphragm 17 and the electrode 19 may be duplicated as shown at 13', 17' and 19' and then electrodes 19 and 19' are connected in parallel.

The diaphragms 17 and 17' are formed of a thin material which is a good insulator and can suitably be made of a polytetrafluorethylene tape. Particularly suitable is a film of Teflon FEP-fluorocarbon film by Dupont de Nemours and in the prototype Temp-R-Tape incorporating this substance manufactured by the Connecticut Hard Rubber Co. was found to be satisfactory.

In operation of the apparatus the projectile 3 is placed in the breech barrel 1 and the pressure is raised in the space to the left of it as shown in FIG. 1. Any known method may be used for achieving this as long as it is of the high-energy type, and may, for instance, be caused by detonation of an explosive charge, or by the rise in gas pressure caused by the rapid movement of a piston up the barrel 1 towards the block 4 from the left-hand side (not shown), such as illustrated, for example in U.S. Pat. No. 3,311,020. The precise method of raising the pressure in casing 2 is not critical to the performance of the invention. Under the influence of the pressure in barrel 1, projectile 3 accelerates to the right (in the drawing of FIG. 1) and enters the block 4. When the rear part 28 of the projectile starts to uncover the passage 15 some of the gas behind it is allowed to flow radially outwards and encounters the diaphragm 17 and 17'. These are distorted into the spaces 18 and 18' and become ruptured. As soon as the rupture occurs, the insulation resistance of the circuit between electrode 19 and 19' and the adjacent electrically conducting surface formed by casing 7 is reduced, and by suitable choice of potential across the capacitor 20, an arc discharge will occur, primarily between the inner faces of electrodes 13 and 13' and the left end 30 of the casing 7. This discharge immediately increases the enthalpy of the gas behind the projectile 3 producing a large pressure rise and further acceleration of the projectile. The presence of the second switch assembly of 13', 17' and 19' helps to ensure reliability and a symmetrical discharge through the gas behind the projectile.

In the prototype the diaphragm and 17 and 17' was secured in position on the electrode 13 and 13' with masking tape and was perforated by the mass of gas passing up bores 15 and 15'. The type of tape is not critical nor is its thickness, except that the breakdown field strength of the tape must not be exceeded by the applied voltage and it must be thin enough to rupture under the shock wave. In some instances it might be desirable to shape the edges of electrodes 13 and 13' adjacent the diaphragm 17 and 17' so that they assist in cutting the tape under the influence of the gas passing up bores 15 and 15'.

The delay between the opening of the passages 15 and 15' to the electrodes 19 and 19' should in general be less than 5 microseconds, although this time will vary with the application of the invention involved, and depends on the properties of the gas behind the piston and the depth of the passages 15 and 15'. The invention is particularly suitable to shock tube work and may be useful in certain types of magnetohydrodynamic work where the ionized gas itself is used for further applications.

It will be appreciated that the capacitor **20** may consist of a number of discrete capacitors connected in parallel, and in the prototype apparatus the potential across the capacitor was approximately 15 kv. the capacitance was 12.6 μf. and eight such capacitors were connected in parallel to provide the necessary energy into the arc discharge.

It will be appreciated that advantages of the invention will be achieved even if casing **7** is nonconductive as long as an adjacent electrically conducting surface for the arc discharge is provided (such as by an insert let into the casing **7** and contiguous with the barrel **6**). Alternatively the discharge might in some instances be made to casing **2** by connecting capacitor **20** to it rather than to casing **7**.

As a development of the invention if desired in any particular application, the electrical section **4** may be repeated down the length of a barrel **35** as shown in FIG. **3** at **4**, **4'**, **4''**, **4'''**, etc. Each unit can be constructed as described in FIGS. **1** and **2** so that, as the projectile passes through the sections **4**, **4'**, **4''**, **4'''** etc., progressively, the capacitor **20**, **20'**, **20''**, etc. associated with each section is discharged and further enthalpy at each stage is added to the expanding gas behind the projectile. This enables the invention to be applied so as to increase the projectile velocity to speeds limited essentially only by friction and the space available.

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

1. A apparatus for accelerating a projectile in which the projectile is caused to move down a barrel under the influence of a high pressure gas, the improvement which comprises, including an insulating section in said barrel, defining a preacceleration and a postacceleration section, an electrode in said

insulating section contiguous with said barrel, a hole defined in said electrode extending away from the barrel, and a rupturable electrically insulating diaphragm covering said hole on the outward side of said electrode with respect to the barrel, a second electrode beyond said diaphragm, a space defined between said diaphragm and said second electrode, and means for connecting a high potential electric source between said second electrode and an adjacent electrically conducting surface of said barrel; gas in said preacceleration section behind said projectile escaping through said outwardly extending hole, upon passage of said projectile along said barrel and past said hole, rupturing said diaphragm and permitting electrical discharge between said second electrode, through said first electrode, and thence to said electrically conducting surface of said barrel.

2. Apparatus as defined in claim **1**, wherein said electrically conducting surface comprises the postacceleration section of the barrel.

3. Apparatus as defined in claim **2**, wherein said rupturable diaphragm comprises a thin film of polytetrafluorethylene.

4. Apparatus as defined in claim **3** wherein said high-potential source comprises a capacitor.

5. Apparatus as defined in claim **1** wherein a plurality of said insulating sections are disposed along said barrel and interposed between sections defined by conductive casings, an individual high-potential electric source being connected between the second electrode of each insulating section and the associated conductive casing forming its postaccelerating section and the rupturable diaphragms each comprising a thin film of polytetrafluorethylene.