Aug. 18, 1959 D. E. BLOXSOM, JR 2,899,864

HIGH VELOCITY GUN SYSTEM

Filed Dec. 26, 1956 2 Sheets-Sheet 1

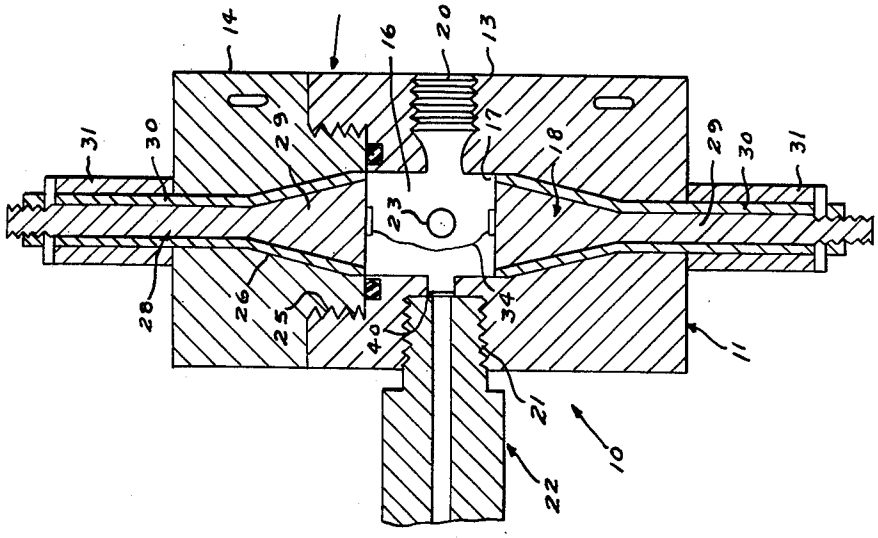


Fig-1

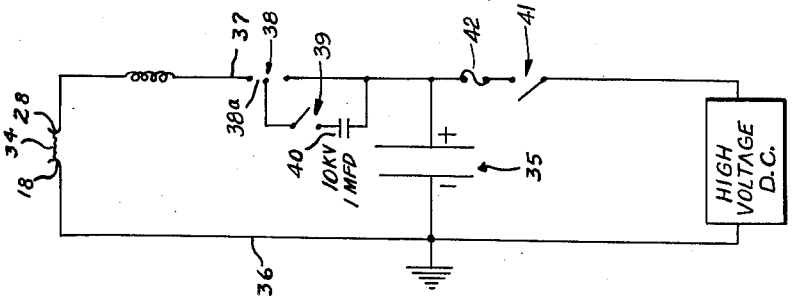


Fig-2

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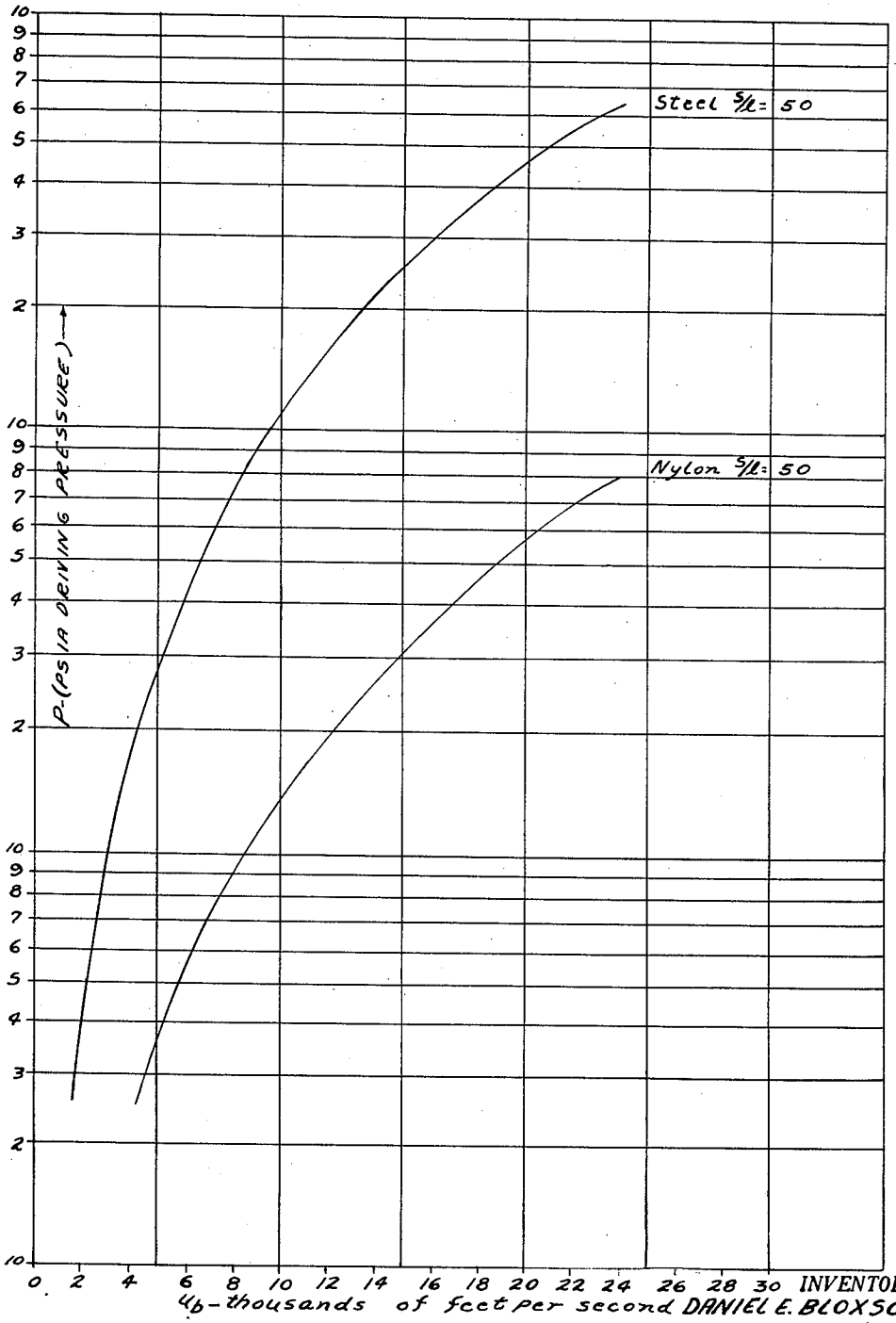


Fig. 3

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HIGH VELOCITY GUN SYSTEM

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3 Claims. (Cl. 89—7)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to me of any royalty thereon.

The present invention relates to a gas driven gun apparatus initiated by electrical discharge to fire a projectile at supersonic speeds; and, more particularly to a gun system in which a compressible fluid or gas is adiabatically heated for the release of a projectile at velocities approaching the speed of sound of the driving fluid or gas.

In present gun systems, conventional chemical explosives have a definite limit on the speed of sound available from the combustion mixture. For example, in an optimum hydrogen-oxygen explosion this limit is on the order of 7,000 feet per second. The process of adiabatically heating hydrogen with a piston arrangement results in a somewhat higher speed of sound than the chemical explosion, but requires the use of complex equipment. Furthermore, either process has a low heat transfer efficiency, requires a long time interval to heat the gas and to raise the temperature level.

It is a consequent and primary object of the present invention to provide spark heating by electrical discharge of a high energy source across a compressible fluid or gas at constant volume and to utilize the heated gas as a driving force to accelerate a projectile or bullet up to velocities approaching the speed of sound of the driving gas. Not only is high heat transfer efficiency achieved utilizing this combination, but the optimum temperature and pressure level can be reached within a minimum time, and in addition a highly elevated pressure state can be maintained over a long enough interval to provide continuous acceleration of the bullet during the time it is passing through the gun barrel.

It is another object to provide an electrical accelerator apparatus for a high velocity gun in which a starter or teaser wire is suspended within a gas filled chamber to initiate the transfer of heat energy from a high energy source into the gas when the source is charged to a predetermined level.

Another object is to provide a gas driven gun system wherein a thin wire is utilized to initiate the discharge of a capacitor bank within a gas filled gun chamber of the system to raise the temperature of the gas in the closed chamber from room temperature to the temperature desired.

It is another object to provide a high velocity gun system wherein a driving gas is adiabatically heated by electrical discharge of a capacitor bank across the gaseous medium within a minimum period of time with minimum heat transfer loss.

It is another object to provide a high velocity gun system in which the bullet is expelled by means of the electrical discharge of a high energy gap across a high density gas contained within a chamber so as to produce elevated temperatures and pressures of the gas within an optimum time interval in order to accelerate a bullet up

to velocity approaching the speed of sound of the driving gas during its travel through the gun barrel.

It is a further object to provide a gas driven gun system energized by an electrical discharge circuit to expel a bullet at supersonic speeds.

It is a still further object to provide an electrical accelerator which is capable of producing a high rate of energy transfer into a high density gas at constant volume so as to produce a high temperature gas capable of propagating a strong shock force for the acceleration of a projectile from a gun.

In accordance with the preceding objects and advantages as set forth, the present invention may be more fully understood from the following detailed description and explanation in connection with the accompanying drawings in which:

Fig. 1 is a longitudinal vertical sectional view of the chamber and barrel portion of the gun system;

Fig. 2 is a circuit diagram of the electrical discharge circuit which forms a part of the gun system; and

Figure 3 is a graph on which is plotted the bullet velocity as a function of the driving gas pressure.

In Fig. 1 there is shown a gun mechanism **10** forming a part of the present invention, and which is comprised broadly of a cylindrical gun chamber **11** and a gun barrel **22**. The chamber **11** is formed by an outer cylinder **12** comprised of a bottom electrode or cathode section **13** and a top electrode or anode section **14**. The bottom electrode section **13** consists of a central receptacle **16** and an electrode receiving opening **17** converging outwardly from one end of the receptacle through the wall of the chamber for placement of a cathode **18**. Extending outwardly from one side of the receptacle is a pressure measuring opening **20** for positioning of a suitable measuring device (not shown) and extending from the opposite side is a threaded opening **21** for insertion of the gun barrel **22**. Also, a pressure inlet **23** is provided in the chamber wall to supply gas into the receptacle.

Passing outwardly from the opposite end of the receptacle **16** is a cup-shaped aperture **25** for threaded connection of the top electrode section **14**. The top electrode section **14** also has an outwardly converging electrode receiving opening **26** for insertion of an anode **28**. In connected relation with the cathode section, the anode closes the opposite end of the receptacle **16** to form an inclosed chamber. In the preferred form, both the anode **28** and cathode **18** are made up of steel terminal plugs **29** positioned flush with the ends of the receptacle and projecting outwardly from the chamber walls. A glass insulating layer **30** is disposed about the plugs **29**, and an outer Micarta shielding layer **31** is disposed about the projecting ends of the electrodes to prevent additional gas from being produced during the energizing cycle.

For electrical interconnection of the electrodes **18** and **28**, a teaser or initiating wire **34** is fixed to the inner chamber or receptacle ends of the electrodes so as to extend across the gap within the receptacle. To prevent the teaser wire from touching the walls of the receptacle, it is made up and fixed to the anode, then let down and fixed to the cathode before assembly of the chamber. In the preferred embodiment the teaser wire **34** is composed of a length of No. 35 copper wire, which is both thin and flexible, the wire being bare and rewound along half its length before fixing it to the electrodes. This doubling of the wire was found to be necessary due to the sudden impedance change which occurs at the time the molten wire breaks, this change being caused by the initial arc gas impedance which is much lower than the molten wire impedance.

The gun barrel is, of course, sized to meet the dimensions of the bullet to be fired. For instance, where a

bullet is to be fired having a diameter of one-fourth inch and a length of one-fourth inch the gun barrel diameter approximates that of the bullet and can be of any desired length so long as optimum acceleration is obtained just prior to release of the bullet from the barrel. Also, the entrance or receptacle end of the gun barrel is sealed from the receptacle itself either by a diaphragm **40** which will rupture at elevated pressures or by other suitable means which will seal the chamber up to predetermined pressure levels at which level the driving gas will overcome the resistance of the sealing means to discharge the bullet.

The entire chamber, for testing purposes, was constructed to exceed 60,000 p.s.i. ultimate pressure for the spark heating of the gas. A purified gas or compressible fluid is pumped into the receptacle through the pressure inlet **23**, preferably in a high density state so as to increase the heat transfer throughout the gas from the electrical discharge. The gas itself is preferably helium or at least similar gas which has a high speed of sound, although it is possible to utilize any gas or liquid which exhibits favorable compression and expansion qualities and is capable of absorbing heat energy from an electrical source for acceleration of the bullet.

A primary feature of the invention is the electrical discharge apparatus which includes the electrodes **18** and **28** along with the teaser wire **34**, and which is shown in Fig. 2. The circuit is comprised essentially of a standard 1000 microfarad capacitor **35** producing 8000 joules energy at 4000 volts and which is connected in parallel by means of leads **36** and **37** to the electrodes and teaser wire. A second electrode gap or electrical switch **38** is provided in the lead **37** as shown in parallel connection with an electrical switch **39** and a second capacitor **40** in order to shield the teaser wire **34** from current flow when the capacitor **35** is being charged by suitable charging means provided in the circuit. Initially, the main switch indicated at **41** is closed to connect the power supply to the capacitor bank **35**. When said capacitor bank **35** reaches a predetermined energy level or, in other words, becomes fully charged, switch **41** is opened and control switch **39** is closed to allow capacitor bank **35** to discharge through the second capacitor **40** and switch **39** across the narrow portion **38***a* of the electrode gap or electrical switch **38**. Thus, when the gas in said electrical switch **38** ionizes, breakdown of the entire gap thereacross occurs to build up the charge on said second capacitor **40** and thereby block continuous flow of current therethrough. This break down of the entire gap across electrical switch **38** to permit the discharge of capacitor bank **35** and current flow through the teaser wire **34** within the main gun chamber results in a break down of the main gap between the electrodes **18** and **28**. For instance, when the teaser is sparked over with one microfarad at 10,000 volts, the gap will break down within two microseconds, the teaser wire being melted within approximately 20 microseconds, and the gas being completely heated within 50 microseconds. The breakdown voltage required to maintain the arc across the electrodes is considerably reduced by initiating the thin, bare wire **34** in a high density chamber thus eliminating the need for extremely high breakdown voltages on the order of 4,000,000 volts which would be necessary under normal conditions to break down the gap.

In a series of test runs cylindrical nylon and steel bullets were fired from a 50 calibre barrel having a length of 12 inches, the bullets being of a one-fourth inch diameter and length. The capacitor was energized to 4,000 joules energy input, and the helium was forced into a 5.42 cm.^{3} chamber to initial pressure of 2,300 p.s.i. at standard room temperature. Upon discharge of the capacitor across the chamber gap, the bullet velocities were measured by suitable means, the nylon bullet having a velocity of 7786±34 feet per second,

and the steel bullet having a velocity of 2768±26 feet per second upon release from the gun barrel. Computing back from the measured velocities, the chamber conditions in both tests were found to be: gas pressure, 26,300 p.s.i.a.; temperature 3410° K. to produce a speed of sound of 10,300 feet per second of the driving gas.

Theoretically the bullet velocities attained under the given starting conditions of the above test would be higher. Assuming that the volume change due to the addition of the gun barrel is negligible a velocity of 8480 feet per second could be expected for a steel bullet and 23,000 feet per second for the nylon bullet. In a theoretical determination of the expected velocities, two basic limitations appear which explain the novelty and advantages of the invention. As shown in Fig. 3, the velocity of the nylon and steel bullets can be plotted as a function of the driving pressure. This is in accordance with the basic equation of the velocity of a body starting from rest:

$u_b=\sqrt{2aS}$ where

a is the acceleration of the bullet; and

S is the distance through which acceleration is provided in the gun barrel.

Then, from Newton's second Law of Motion

$$a=\frac{F}{m_b}$$

where F is the unsealed force on the pellet, and m_b represents the mass of the pellet in pounds.

By definition, $F=pA$ where p is the pressure acting across an area (A) of the bullet.

Substitution into the base equation then gives

$$u_b=\sqrt{2\frac{pS}{\rho_b L}}$$

where ρ_b is the density of the bullet and L is its length. Thus the basic limit to the velocity which can be produced to accelerate the bullet during the time it is in the gun barrel will be a function of the final chamber pressure upon heating the gas.

Another basic limitation will appear as the bullet approaches the speed of sound of the driving gas. An unsteady flow expansion of the propelling gas can be attributed to the fact that energy is subtracted from the gas to propel the bullet. Thus, the pressure on the face of the bullet will drop as the pellet velocity is increased to introduce an additional velocity limit.

In addition to the above theoretical limitations, actual energy losses will occur to limit the resulting velocity attainable. The primary losses will occur due to the heat transfer by convection and radiation in the gun chamber and the gun barrel, and in the deceleration of the bullet due to drag.

The present invention overcomes the above limitations to a substantial degree by attaining extremely high driving gas pressures in a minimum time to thereby not only produce supersonic bullet velocities, but also reduce heat losses in the chamber and barrel by shortening the time duration for heating the gas to a substantially instantaneous reaction.

The high driving gas pressures are obtained not only by the use of the instantaneous discharge of electrical energy, but by releasing this energy across the novel teaser wire in an elevated density of gas. Under these conditions, the energy discharge apparatus produces extremely high temperatures while reaching pressures as high as 10^6 p.s.i.a., and enables the efficient transfer of heat to the gas at comparatively low energy levels. Also by the use of a thin, fragile teaser wire in a high density gas medium, efficient heat transfer by electrical discharge can be initiated and maintained at a 4,000 volt level in the capacitor in comparison with the necessity of a 4,000,000 volt charge for larger wires discharged across a gas at normal density. Of course, varying levels of energy

can be discharged across the wire, and at varying densities of the gas, if desired.

Summarizing, the present invention can be said to consist essentially in the use of an electrical discharge apparatus to heat a gas at constant volume to exceedingly high temperature and pressure levels for the acceleration of a bullet up to supersonic velocities approaching the speed of sound of the driving gas. These high temperatures and pressure states are attained by the use of a novel teaser wire and a capacitor bank initiated by the teaser wire to break down the gap between two electrodes stationed within a gas filled chamber at predetermined energy levels. It is to be understood that the present invention is not to be limited to a capacitor bank but could also utilize other electrical sources with the circuitry and gun construction described, such as an inductance bank or solenoid-type driven gun with a capacitor bank. Of course, the capacitor bank has been found to be especially unique in combination with the gun system in attaining extremely high energy levels for instantaneous discharge between the electrodes.

The embodiment of the present invention herein shown and described is to be regarded as illustrative only and it is to be understood that the invention is susceptible of variation, modifications and changes within the scope of the appended claims.

I claim:

1. An electrical accelerator to expel a projectile at a high velocity comprising: a closed chamber having a barrel projecting outwardly therefrom for release of the projectile; a high density gas contained within said chamber, an electrical discharge circuit to transfer heat energy to the gas consisting of two electrodes stationed at opposite ends of said chamber and a doubled teaser wire connected to said electrodes so as to extend across the gap therebetween, a high energy capacitor bank electrically connected in parallel to said electrodes and teaser wire by means of a pair of lead wires, means in said circuit to shield said teaser wire during the charging of said capacitor to a predetermined energy level whereupon the capacitor is discharged across said electrodes for the isovolumic heating of said gas comprising an electrical discharge gap in one of said pair of lead wires between said pair of electrodes and a source of power supply in parallel connection with a second capacitor and an electrical switch through which said first-named capacitor bank is discharged on reaching said predetermined energy level to discharge initially across part of said electrical discharge gap through said second capacitor and subsequently across the entire discharge gap, and diaphragm means between said closed chamber and the inlet end of said barrel rupturable under predetermined pressure of the gas in said chamber.

2. A gas driven gun apparatus to fire a projectile at supersonic speeds, comprising: a cylinder with a central gas receptacle located therein and having a gun barrel communicating with one side of the receptacle projecting outwardly from said cylinder for the predetermined firing of the projectile and rupture means to close the inner end of said barrel; an electrical discharge apparatus consisting of shielded electrodes closing the opposite ends of said receptacle so as to define a closed chamber, a thin, bare initiating wire fixed to said electrodes so as to extend across said chamber, a high energy capacitor bank electrically connected to said electrodes and initiating wire, first switch means to charge said capacitor bank to a predetermined energy level, and a second electrode gap and capacitor and switch means in parallel with said gap to shield said initiating wire from the current charging said first-named capacitor until the predetermined energy level is reached and second switch means to discharge said first named capacitor through said second named capacitor and said switch means initially across part of said second electrode gap and thereafter across the entire gap to effect current flow therethrough and across said initiating wire to release heat energy within said chamber; and a high density helium gas contained within said chamber at an elevated pressure level for instantaneous heating by the released energy, said rupture means normally retaining said gas in said chamber until a predetermined high pressure level is reached whereupon said gas is operative to accelerate a bullet from said gun barrel at a velocity approaching the speed of sound of the gas.

3. An electrically energized accelerator for the ejection of a projectile from a gun, comprising, a main housing having a central chamber and a pair of oppositely disposed, outwardly converging openings in communication with said central chamber, an anode positioned in spaced relation in one of said pair of openings having an inner end closing one side of said central chamber and projecting outside said housing at its other end, a cathode positioned in spaced relation in the other of said pair of openings having an inner end closing the opposite side of said chamber and projecting outside of said housing at its other end, a layer of insulating glass disposed about said anode and cathode and filling the space between said anode and cathode and the respective walls of said pair of openings, an outer layer of Micarta shielding disposed about the projecting ends of said anode and cathode, an initiating wire between the inner ends of said anode and cathode across the gap therebetween in said central chamber, inlet means in communication with said central chamber adapted to deliver gas under high pressure to said central chamber, a gun barrel attached to said housing in communication with said central chamber, chamber sealing means positioned intermediate said gun barrel and said chamber normally sealing said gas within said chamber and separable to release said gas into said gun barrel under a predetermined pressure, and electrical discharge means in circuit with said anode and cathode and said initiating wire, said electrical discharge means comprising a first capacitor connected in parallel to said anode and cathode and said initiating wire with an electrical discharge gap between said initiating wire and said first capacitor, and a normally open control switch and a second capacitor in circuit between said first capacitor and said electrical discharge gap and said anode and cathode and said initiating wire to shield said initiating wire until the charging of said capacitor attains a predetermined level and a main switch closed in one position to initially fully charge said first capacitor until said predetermined level is reached and opened in a second position to discharge said first named capacitor through said control switch and said second capacitor and said electrical discharge gap to ionize the gas therein and block subsequent current flow through said second capacitor.

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