June 18, 1968 H. A. KIRSHNER 3,388,633

MULTI-STAGED BALLISTIC DEVICE

Filed Feb. 1, 1967

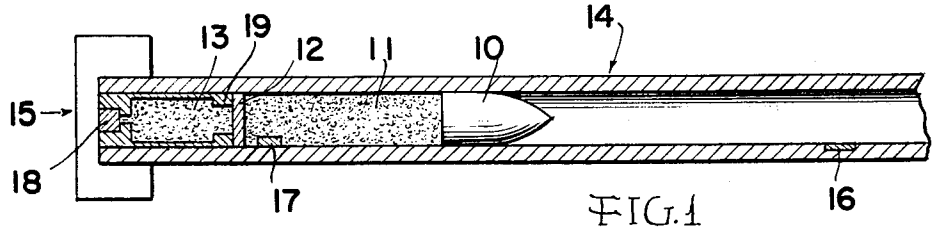


FIG. 1

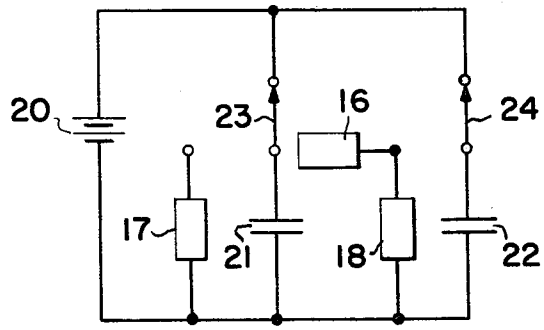


FIG. 2

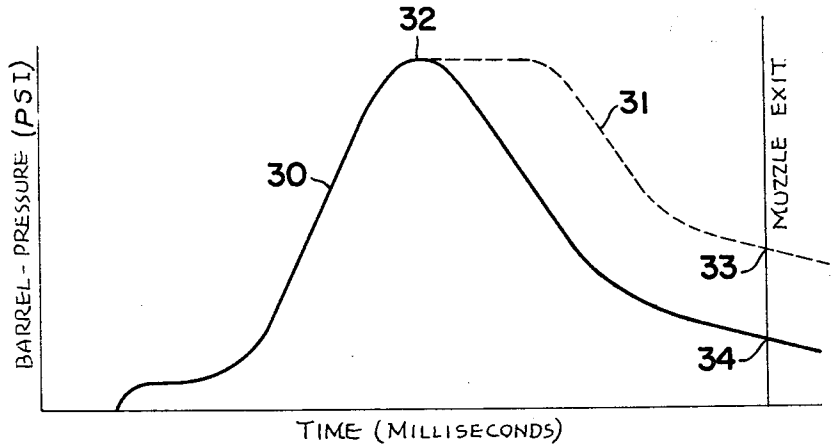


FIG. 3

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United States Patent Office 3,388,633 Patented June 18, 1968

3,388,633

MULTI-STAGED BALLISTIC DEVICE

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Filed Feb. 1, 1967, Ser. No. 613,978
6 Claims. (Cl. 89—8)

ABSTRACT OF THE DISCLOSURE

A ballistic device having a first stage containing a projectile and a second stage containing a piston element which is fired subsequent to the ignition of the first stage to compress and control the expanding gas accelerating and driving the projectile through the barrel of the projectile launcher.

This invention relates to ballistics and particularly, to a multi-staged ballistic device and a method and apparatus for firing the same which is capable of controlling the pressure produced by propellant combustion.

In ballistic devices, projectile velocity is limited by many factors. This limitation is encountered primarily in problems generally relating to weapons design. For practical purposes a weapon has weight and pressure limitations imposed upon it. One method used to increase projectile velocity is to increase the expansion ratio of the weapon; that is, the ratio of total gun volume to chamber volume. This can be accomplished by increasing the length of the barrel. But this increased length has its disadvantages since there is a corresponding increase in the weapon's weight, a decrease in portability, and a change in the weapon's profile. Therefore, the length of the barrel for a given weapon is limited, even though an increase in projectile velocity would be realized by an increase in barrel length.

The velocity of a projectile is governed by the pressure at its base during its travel through the barrel. As the projectile moves through the barrel, however, a pressure gradient develops. This pressure gradient is such that the pressure at the base of the projectile is less than the chamber pressure. This condition, which exists in all weapons, becomes increasingly apparent as higher and higher velocity projectiles are required. This problem has led to increased research in the area of new propellant formulations which affect the transfer of energy from the propellant to the projectile. Recent developments have led to improved propellant compositions and grain configurations, ratios of propellant charge to projectile mass, and improvements in igniter compositions, charges, and configurations. Propellants have been developed which produce lower molecular weight gases. These produce higher projectile velocities, since the lower the molecular weight, the higher the gas velocity and hence a decrease in the pressure gradient. However, in spite of this, the need still exists for greater control of the shape of the pressure-time curve produced by the propellant combustion.

Accordingly, a principal object of the present invention is to provide improved means for controlling the pressure-time curve in a combustion chamber for a propellant device.

Another object of the invention is to provide an improved method for effecting the transfer of energy from a propellant to a projectile.

A further object of the invention is to provide an improved projectile launching device for producing high velocity gases with a controlled pressure gradient and resultant high projectile velocity in weapons.

Although multi-staged ballistic devices are not new in the art, the prior art devices have failed to solve the problem of pressure control now met by the present invention. Prior art devices have been made to produce high velocity gases but without effectively attaining the desired or ultimate high projectile velocity in weapons through lack of means to control the pressure-time relationship in the combustion chamber. A better understanding of the invention may be had by recourse to the following description, which description should be considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a sectional side view of a multi-staged ballistic device of the projectile-firing gun type, embodying the invention;

FIG. 2 shows a schematic diagram of an electric firing circuit for the device of FIG. 1 in accordance with the invention; and

FIG. 3 is a graph showing curves indicating desired resultant pressure relationship attained in the effective operation of the device of FIG. 1.

Basically, the ballistic device or weapon of the present invention comprises two stages and preferably is of the type having a gun barrel. The first stage contains a projectile and a main propellant charge capable, upon firing, of providing an expanding gas for accelerating and driving the projectile through the barrel. The second stage in rear of the first, contains a piston element and a secondary propellant charge capable likewise upon firing of providing an expanding gas for driving and accelerating the piston element. A sensing device, positioned along the barrel, is adapted and connected to ignite the second stage after a predetermined time has elapsed from the initial ignition of the first stage. The acceleration of the piston towards the already accelerating projectile causes a compression in the expanding gas driving the projectile. By controlling the time delay between the ignition of the first and second stages, the shape of the pressure-time curve of the propellant gas can be controlled and the firing of the projectile can be adjusted for maximum velocity.

Referring particularly to FIG. 1 of the drawing, it will be seen that the first stage of the multi-staged ballistic device includes a projectile **10** and a main propellant chamber **11** rearward of and axially aligned to the projectile and containing a standard type propellant. The second stage of the device is in axial alignment with said first stage and contains a piston **12** and a secondary propellant chamber **13**, also containing a standard type propellant. The first stage of the device may be molded together and need not have a case, whereas the second stage propellant is preferably contained in a casing. The multi-staged device is contained in the rear of a gun barrel **14** which is a tubular guide element similar to a typical projectile launcher. The barrel **14** is open at one end and closed at its other extremity by a breech block **15**, and is arranged to maintain the integrity of the multi-staged device prior to the firing of the same. The barrel is aligned and communicating with the two stages for guiding the projectile in its forward movement therefrom after firing.

Referring to FIGS. 1 and 2, a sensing device **16** is positioned in the barrel forward of the initial position of the multi-staged device. The sensing device **16** may be of the position sensing type, a pressure or thermal sensor, or a controlled timing device and is adapted to control the instant for ignition of the secondary propellant charge after a predetermined time delay from the firing of the first stage or after one of the above mentioned conditions have been met. In the present apparatus an electrical firing circuit is preferably employed to fire the multi-staged device.

Ignition of the two propellant charges is accomplished by primers **17** and **18**. These primers are of the standard

type, preferably electric as indicated above, so that the separate firing of the individual stages can be more accurately controlled. Primer **18** communicates with sensing device **16** as seen in FIG. 2.

Upon ignition of the main propellant charge, projectile **10** is accelerated through barrel **14** toward sensing device **16** and the open end. The sensing device **16** may be placed, if a position sensing device is employed at a position where the pressure at the base of the projectile begins to decrease from that required for maximum velocity, or at any point within the barrel where control of the pressure is desired. As the projectile **10** reaches this position in the barrel, the sensing device will detect the projectile and initiate the relay of an ignition signal to primer **18** which will in turn initiate the firing of the second stage propellant charge.

The acceleration of the piston **12** towards the moving projectile compresses the main propellant gases being formed to impart motion to the projectile, and thereby increases the pressure at the base of the projectile so that an increased velocity is attained. By controlling the time delay between the firing of the two stages, the system can be adjusted for maximum velocity. This time delay can be controlled as shown here by the position of the projectile in the barrel. It is to be understood that the inventive device is not limited to this particular means of control, which is given merely for illustrative purposes, but that the time delay may also be controlled by the pressure or temperature in the barrel, or by an independently controlled timing device, as previously mentioned.

Among other features of the invention, a support ring **19** for the piston **12** is positioned between the two propellant charges to prevent any backward movement of the piston. The support ring **19** may be formed as an integral part of the secondary propellant charge casing, or it may be designed to be attached thereto. The support ring is rigid and preferably may be made of a steel or like metal, and is further rigidly affixed to the said casing between the piston and the rear end of the secondary propellant chamber so that the piston is well supported in effect by the breech block whereby the pressure produced by the ignition of the main propellant charge will not affect the secondary propellant charge. Because of this support, which prevents any backward movement of the piston, the grain configuration of both propellant charges can be utilized to assist in controlling the rate of gas production due to propellant burning, since the grain of the secondary propellant charge are not crushed upon the firing of the projectile.

Referring now more particularly to the electrical firing circuit, in accordance with the invention this includes a battery **20** or other electrical power source which creates a potential difference between the plates of capacitors **21** and **22**. The capacitor **21** is connected in the circuit to accumulate a sufficient charge to cause the main propellant charge primer **17** to ignite the propellant when the circuit between the capacitor and the primer is closed, as by throwing the switch **23**. Sensing device **16** operates to close the switch **24** upon detecting the projectile. This causes the discharge of the capacitor **22** through the primer **18** and thus initiates the firing of the secondary propellant charge.

The graph of FIG. 3 illustrates the increase in barrel pressure achieved by using the inventive device described. The solid line **30** represents the pressure developed in the barrel by the firing of a single stage device. The dotted line **31** represents the pressure developed by the firing of a two stage device, the second stage being fired immediately upon reaching the peak pressure indicator at **32**. The second stage may be fired at any time before or after the peak pressure is reached thereby obtaining a great latitude in the control of barrel pressure. The point **33** is the barrel pressure that may be achieved by a multi-staged ballistic device upon leaving the barrel. Point **24** in the exit pressure achieved by a single-staged device. This increased pressure of the multi-staged device will in turn cause a greater projectile velocity.

From the foregoing description, it will be apparent that various modifications may be made in the structure of the device shown and that this device is not limited to weapons, as it can have application in any system where propellant gases are used to do work.

It is also apparent that an improved multi-staged ballistic device as provided in accordance with the invention is effective to control the pressure-time relationship in a combustion chamber for a propellant device. Furthermore, said improved ballistic device aids in producing high-velocity gases with a controlled pressure gradient and a high projectile velocity in weapons.

I claim:

1. A multi-staged ballistic device for use as a projectile launcher comprising, a tubular barrel, projectile sensing switch means positioned at a point within and along the barrel at a predetermined location from its ends, means providing first and second propellant stages within said barrel, said first stage including a main propellant chamber with a projectile at its forward end, said second stage being rearward of and axially aligned with said first stage and including a secondary propellant chamber having an elongated casing, a movable piston at the forward end of said casing as a closure means therefor, said propellant chambers containing the separate propellant charges, separate electric ignition means in contact with each of said propellant charges, said second-stage ignition means being connected to operate with said projectile sensing means, and a support ring for the piston rigidly attached to said casing for the secondary propellant chamber, whereby any backward movement of said piston is prevented when said main propellant charge is ignited.

2. A multi-staged ballistic device according to claim **1**, wherein said support ring is elongated and metallic to provide a rigid support between the piston and the rearward end of the secondary propellant chamber.

3. A multi-staged ballistic device according to claim **2**, wherein said first and second stages are contained in the rearward end of said tubular barrel and provided with a supporting breech block for said rearward end of the secondary propellant chamber.

4. A combined projectile launcher and multi-stage ballistic device comprising, an elongated tubular gun barrel, first and second firing stages, said first stage containing a main propellant charge, a projectile in the barrel forward of said charge, said second stage being rearward of and axially aligned with said first stage and including a secondary propellant casing with a chamber therein, said chamber containing a secondary charge with electrical priming means therefor, a piston in said second stage forward of said casing and secondary charge, said tubular barrel being aligned and communicating with said first stage forwardly thereof for receiving and guiding the projectile in its forward movement therefrom, said piston being seated on a support ring attached to said secondary propellant casing and said casing being supported by a breech block at the rear end of said barrel to prevent backward movement of said piston when said main propellant charge is ignited, electrical projectile sensing means positioned at a forward point within the barrel at a predetermined distance from the forward end, electrical priming means and a firing switch connected therewith for initiating the main propellant charge, and means including a second firing switch connected between said sensing means and the priming means for said secondary charge whereby the ignition of said secondary charge is initiated upon passing of said projectile forwardly along the barrel.

5. A combined projectile launcher and multi-stage ballistic device comprising:

an elongated tubular gun barrel having an open forward end and a closed rear end with a removable breech block,

means providing a first stage for said device within

said gun barrel and including a forwardly positioned projectile and a main propellant chamber directly rearward of and axially aligned with the projectile,

a main propellant charge in said chamber,

main propellant ignition means including an electric primer in said chamber,

means providing a second stage for said device within the gun barrel in rear of and axially aligned with the first stage,

said second stage including a piston at the rear end of the main propellant chamber and a rigid metallic support ring therefor directly in rear thereof,

a secondary propellant casing in said second stage having a propellant chamber therein and extending between the supporting ring and the breech block,

a secondary propellant charge in said last-named chamber,

electric projectile sensing means positioned within the barrel at a point forward of the projectile, and

secondary propellant ignition means including a second electric primer carried by said casing at the rear end thereof in communication with said last-named chamber and connected with said sensing means for firing the charge in said chamber in response to operation of said sensing means by said projectile.

6. A combined projectile launcher and multi-stage ballistic device as defined in claim 5, wherein the electric primers in the propellant ignition means are each provided with a firing capacitor and a firing switch connected for selectively charging said firing capacitor and applying the charge to the primer to fire the respective charge thereof.

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