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E. F. CHANDLER

2,391,865

SELF-PROPELLED PROJECTILE

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Fig. 1

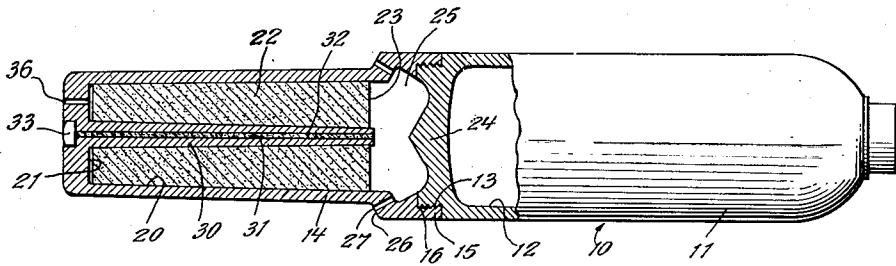


Fig. 2

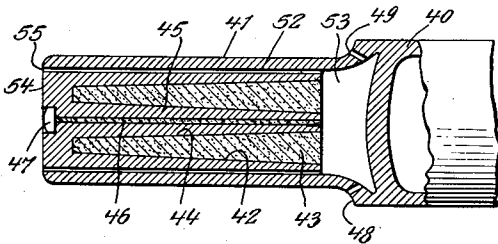


Fig. 3

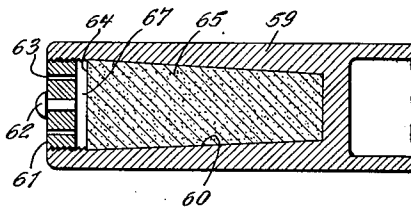


Fig. 4

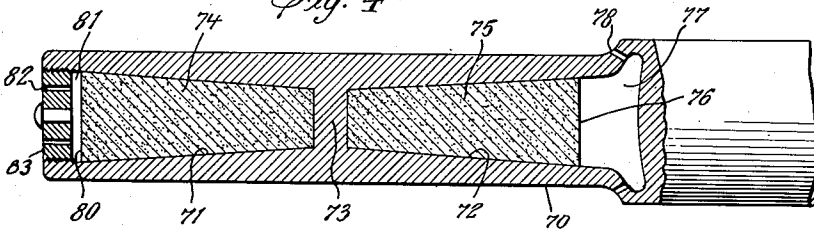
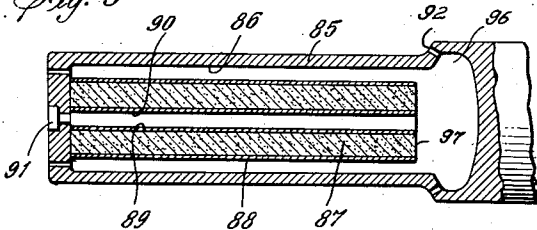


Fig. 5



UNITED STATES PATENT OFFICE

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SELF-PROPELLED PROJECTILE

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5 Claims. (Cl. 102—49)

This invention relates to projectiles, and relates more particularly to self-propelled projectiles of the reaction type and to a manner of improving their ballistic efficiency, and more especially to means of increasing the range and precision of fire of self-propelled projectiles. The present application constitutes a continuation-in-part of my co-pending application Ser. No. 416,442, filed October 25, 1941, which application, in turn, constituted a continuation-in-part of my co-pending applications Ser. Nos. 406,944 and 408,284, filed August 15, 1941 and August 26, 1941, respectively.

Projectiles of the self-propelled or reaction type may be given some initial impetus, as by an explosive charge contained in the barrel of the gun dispatching the same, but the principal source of energy for driving the projectile is contained in the projectile itself and is generated by burning a combustible substance in a closed chamber, the highly compressed gases evolved by the combustion of the material passing outwardly through suitable nozzles in the form of reaction jets.

In self-propelled projectiles intended for relatively short range firing, it is frequently desirable to so form the propellant charge as to present a relatively large surface of the combustible material to the burning action. To this end, the charge of the combustible material, which is generally cylindrical in shape, may be provided with one or more longitudinal bores therein or therethrough to increase this surface area of combustion. For long range work, however, it is important that the burning or gas-generating surface of the substance remain relatively uniform during substantially the entire burning period so as to maintain a substantially constant quantity of the gases available for ejection through the reaction jets. In this way, a relatively even jet velocity may be maintained at the nozzle or nozzles as a result of the relatively constant pressures developed in the combustion chamber.

Experimentation in the rocket art has shown that certain substances, while well suited for use as fuel for rockets and other forms of self-propelled projectiles, so far as combustion, gas generation and thermal characteristics are concerned, have otherwise given rise to serious difficulties, particularly in that soon after combustion commences, the charge of combustible material develops fissures which present increased combustion surfaces, thus varying the combustion rate and rate of evolution of gas. Another serious difficulty encountered in work of this character results from the expansion of the combustion cham-

ber due to the intense heat generated by the combustion, and in many instances the combustible charge has a tendency to contract even before the charge is ignited, thus producing an annular space between the outer periphery of the combustible charge and its enclosing chamber. In this fashion the burning of the combustible starting at the outer face thereof proceeds to work its way rearwardly or forwardly, as the case may be, between the charge of combustible and the chamber, and this, together with the fissures and cracks developed in the combustible itself, sometimes tends to ignite the entire combustible charge in a relatively short time, thus generating such extraordinary pressures as to burst the chamber before the projectile has traversed even a fraction of its desired journey.

These combustible fuels may be in a solid, semi-solid or gelatinous-like state. They may be composed, for instance, of a suitable mixture of nitroglycerine, nitrocellulose, and a solvent such as acetone, the several materials being mixed and kneaded to provide a homogeneous mass which is substantially self-combustible, even-burning and capable of producing the requisite amount of heat and pressure desired. This, however, is only one example of the many self-combustible, relatively non-explosive mixtures which may serve as fuel for rocket motors, self-propelled projectiles, and the like. When the projectile is finally fired, however, the combustible has usually become either a solid or a semi-solid, and experience has shown that fuels or powder compounds of this general character may prove to be hygroscopic and in some cases may dry out due to the loss of the solvent. More important still, the combustible material may, at the time that it is fired, have dried out so completely as to cause its surface to become cracked, and fissures may also form within the body, or the charge may shrink within its container, as previously mentioned. Any or all of these conditions tend unduly to increase the surface exposed to combustion, which tends to accelerate the gas generation, causing an excessive rise in the gas pressure.

Contraction of the combustible charge as well as the formation of fissures and cracks therein is to a very considerable extent eliminated by coating the charge with a film of cellulosic or other suitable moisture-resistant material, as described in my co-pending application Ser. No. 416,442. This moisture-proof covering preserves to a very considerable extent the character of the compound up to the time of actual firing, although the aforesaid difficulties may not be com-

pletely eliminated, even by this method. I am aware that various methods have been proposed to prevent the combustion from spreading from the face of the charge to its side walls in the event that the charge has previously shrunk within its housing, or in the event that the container has become enlarged due to the generation of heat and the intense pressures developed within the chamber. For instance, the charge has been cemented within the bore of the chamber by the use of a non-combustible cement, or other material, or the charge may be forced into the chamber under heavy pressure, all of which have met with only limited success.

I have found that propellants suitable for the purpose herein contemplated should be high in nitro-glycerine, and that the nitro-cellulose employed should contain over 12½% nitrogen. A mixture of this order evolves a greater volume of gas at higher temperatures than do those having lower concentrations of nitrogen. Moreover, these smokeless powder compositions burn more cleanly and completely, and at a lower initial pressure. They are readily worked and molded, retain their solvents, and therefore form films over their outer surface relatively slowly when exposed to the atmosphere, and generally reduce the danger of the formation of fissures. The exposed combustion area of the charge is thus insured of a relatively smooth face.

One of the particular improvements in the present invention consists in the formation of a tapered bore in the chamber carrying the explosive charge, the bore having its largest area at the exposed face so that as the charge continues to burn, a progressively smaller face is provided. The substantially cylindrical explosive charge is similarly tapered, and when such charge is inserted within the tapered bore there is established a snug fit between the wall of the chamber and the surface of the charge. More important still, as the burning is initiated at the end of the charge having the largest diameter, the enormous pressures developed in the explosion chamber reacting in all directions exert a tremendous force against this burning face, thus tending to move the cylindrical charge more firmly into its tapered seat.

In devices of this general character it has been found that better results are obtained by positioning the reaction jets substantially midway between the front and rear terminal portions of the projectile. In order to direct the propulsive gases in a line substantially parallel with the direction of movement of the projectile, this rear portion or afterbody containing the propulsive charge is desirably of reduced diameter, thus providing a shoulder having a plurality of spaced nozzles extending rearwardly from the combustion chamber to the outer surface. For the purpose of imparting gyratory motion to the projectile, these nozzles may be formed at an oblique angle to a line running longitudinally of the projectile.

In projectiles of this type, the combustion charge-receiving bore has its largest diameter at its forward end which is adjacent to the mid-section of the projectile, and tapers to a slightly smaller diameter as it approaches its rear terminal at the butt of the projectile. Suitable means are provided for initiating the burning at the forward face of the charge so that as the pressure develops within the combustion chamber, just in advance of this face, the enormous gas pressures press the charge rearwardly into exceedingly firm engagement with its tapered

seat. The rear terminal of the tapered seat is preferably closed, and as the pressure is exerted against the burning face of the charge, the outer periphery of the charge is moved into very tight engagement with the side walls of the bore, and thus positively prevents any rearward passage of the hot gases between the charge and the wall. This result is assured by providing a suitable vent in the wall of the propellant container at a point remote from the zone of combustion so as to unbalance the pressure therein, causing the pressure of the evolved gas to act upon the burning face of the charge and thereby press the charge into firm engagement with the surrounding walls of said container.

In order to ignite the charge at its face, a tube, preferably also tapered, extends from the butt of the shell through the center of the charge, the tube having its largest diameter adjacent to the butt and its smallest diameter at or near the combustion chamber. A suitable primer or booster charge may be positioned within the tube for initially providing the heat and pressure desired for dispatching the projectile. Being tapered, it is also hugged by the charge as the same tends to be moved rearwardly by the gas pressure evolved.

Whether the combustion charge for any given type of work is a substantially solid mass, or is of a gelatinous consistency, the provision of the tapered bore in the charge-carrying element with the burning face of the charge positioned at the larger end of the bore, effectively enables the charge to seat itself with its side walls pressed so tightly against the walls of the bore, to completely eliminate the possibility of the charge becoming ignited at any point to the rear of this progressively burning face. In the event, however, that the charge has a gelatinous consistency, the tapered bore may be eliminated and a substantially straight bore substituted, since the pressures developed in the combustion chamber cause the gelatinous material to flow sufficiently to press against the side walls of the bore as well as its rear wall.

In the drawing:

Fig. 1 is a partial longitudinal section taken through one of the embodiments of the present invention.

Figs. 2, 3, 4 and 5 are broken longitudinal sections taken through other forms of the invention.

Fig. 6 is a broken side elevation of a projectile afterbody of modified shape, the view showing in dotted lines a modified form of charge.

The projectile 10 illustrated in Fig. 1 comprises a forward section 11 which is preferably hollow, as shown at 12, and which may carry an explosive charge or any other type of charge. In the embodiment shown, the forward section is formed with a reduced threaded portion 13 at its rear terminal, such portion supporting the afterbody 14 which is formed with an enlarged portion 15 at its forward end having an internally threaded recess 16 which receives portion 13 in threaded engagement. Afterbody 14 is formed with a longitudinal bore 20 extending from the rear wall or butt portion 21 to the forward end of the afterbody. This bore is of tapered formation and is larger at its forward end than at its rearward end. The exterior of the afterbody may also be tapered, as shown, or it may be of uniform diameter if desired.

The propellant charge 22 is receivable in the bore, the forward face 23 of such propellant charge being spaced from the wall portion 24 at

the rear of the forward section. There is thus formed between face 23 and wall 24 a combustion chamber 25. A shoulder portion 26 between the afterbody 14 and its forward enlarged portion 15 is provided with a plurality of apertures 27 forming suitably shaped reaction jets or nozzle openings. A tapered tubular member 30 may be formed integrally with, or be secured to, butt portion 21 of the afterbody, such tube having a central bore 31 therethrough and carries therein a powder train 32 which is ignited by means of a percussion cap 33 centrally disposed in the butt section. The butt may include one or more apertures 36 forming vents for unbalancing the pressure acting upon the exposed burning face of the propellant.

When the charge is ignited, the combustion commences over the forward face 23 of such charge, and the combustion gases develop such enormous pressures as to act against such face, forcing the entire mass rearwardly and outwardly against the side walls of the bore, thus effectively preventing any portion of the mass, other than the exposed face, from being ignited. It will be noted that there is a slight space shown between the rear face of the charge and the surface of butt section 21, which space provides a cushion for the hard, solid charge. Such space may not be necessary if the mass is of semi-solid consistency.

In Fig. 2, forward section 40 is similar to that shown in Fig. 1, and in this instance the afterbody 41 is provided with a tapered longitudinal bore 42 receiving combustion charge 43, which likewise has a central tapered aperture 44 which receives powder tube 45, the powder 46 therein being adapted to be ignited by means of percussion cap 47. In this instance, also, shoulder portion 48 is provided with suitably shaped, spaced nozzle opening 49. The afterbody further includes a plurality of spaced nozzle openings 52 extending from combustion chamber 53 rearwardly to the butt section 54, thus forming reaction jets 55 in the rear wall of such butt section.

In Fig. 3, afterbody 59 is formed with a tapered aperture 60 which is smaller at its forward end and larger at its rear end. A closure cap 61 in the butt section is provided with a centrally disposed percussion cap 62 and a plurality of suitably spaced and formed nozzle openings or reaction jets 63. The exposed face 64 of the powder charge 65 is spaced from the inner surface of closure cap 61, thus forming a combustion chamber 67.

In Fig. 4, afterbody 70 is formed with two oppositely facing tapered bores 71 and 72, which may, if desired, be separated by means of a wall portion 73, and powder charges 74 and 75, respectively, are placed in bores 71 and 72. Forward face 76 of combustion charge 75 is thus positioned in combustion chamber 77 formed with reaction jets 78, and exposed face 80 of charge 75 is positioned in combustion chamber 81 and is spaced from closure cap 83 at the butt section, such cap having nozzle openings 82.

In Fig. 5, afterbody 85 is formed with a substantially straight bore 86, and the propellant charge 87 is encased in a cylinder 88, the outer periphery of which is spaced from bore 86. The charge further has a central bore 89 which receives an inner cylindrical member 90 containing the powder train which is ignited by means of percussion cap 91. The afterbody also includes reaction jets 92 at the forward end and jets 93 at the butt section. The charge 87 in this instance

may be of gelatinous consistency and pressures developed in combustion chamber 96 working against forward face 97 of the charge rams the charge into its confined chamber, packing the same tightly against its side walls.

Fig. 6 shows an afterbody 94 having a fully streamlined rear portion 95. There is also shown in dotted lines a modified form of charge which is positioned within a tapered bore 98. The main propellant charge 99 may be a substantially hard or solid mass, and this, in turn, is provided with a covering 100 of a gelatinous combustible, preferably having a slower combustion rate. It will be noted that covering 100 extends over the rear end wall of charge 99 as well. Bore 98 has, in this case, a greater taper than does the external periphery of main charge 99, and accordingly when the combustion gases react against the forward face 101 of the charge, a wedging action takes place. If desired, of course, this covering 100 of gelatinous or other semi-solid or plastic material may be of even thickness.

The several embodiments of the invention shown in the drawing are only a few of the many possible forms that the invention may take without departing from the spirit of such invention, as defined by the appended claims. In other words, such embodiments as are shown are for the purpose of illustration only and are not to be taken in any limiting sense. Also, it will be appreciated that many structural changes are within the scope of the invention. For example, the taper of the bore supporting the charge may be ever so slight, since the internal pressures are enormous, and in the case of a substantially solid charge even a small taper will give good results. In the case of the gelatinous or plastic charge, the taper may be eliminated entirely, as was pointed out at length. Any suitable means may be employed for unbalancing the pressure within the combustion chamber so as to insure the action described.

What I claim is:

1. A projectile of the reaction type comprising an elongated, substantially cylindrical body having a tapered, internal bore in the after section thereof, said bore having its smallest diameter adjacent to the butt section of the body, a gas-generating reaction charge positioned within said bore and closely fitting the same, such charge extending from the smaller end of the bore the major portion of its length, the area between the exposed face of the charge and the adjacent end of the bore forming a combustion chamber, a plurality of reaction jets extending rearwardly from the combustion chamber, means for igniting the exposed face of the charge, said means comprising a tapered tube, having its smallest diameter at its forward end, extending through the charge from the butt section of the projectile, and detonating means associated with the tube, the gases generated by the charge issuing through the reaction jets to propel the projectile and also reacting against the exposed face of the charge, forcing the same into firm engagement with the tapered walls of the bore and preventing the spread of combustion beyond such exposed face.

2. A rocket projectile comprising a body having a longitudinally disposed bore therein providing a tapered combustion chamber, a tapered propellant rocket charge within the tapered combustion chamber, a combustion space within the combustion chamber adjacent the larger end of the tapered rocket charge, a plurality of nozzles carried by the body and in discharge communication with

the combustion space, and a vent in the combustion chamber adjacent the smaller end of said charge, said vent allowing said charge to fit snugly into said tapered combustion chamber under the pressure developed by the combustion of the rocket charge within said space.

3. A projectile of the reaction type comprising a body having an internal bore in said body, a gas-generating charge positioned within said bore and closely fitting the same, the body having a space between an exposed end of the charge and the adjacent end of the bore forming a combustion chamber, a nozzle in discharge communication with the combustion chamber, a pressure relief vent in said body communicating with the opposite end of the bore, and means for igniting the exposed end of the charge, the gas generated by the charge driving the projectile and acting against the exposed end of the charge, forcing the same into firm engagement with the walls of the bore, sealing said vent and preventing the spread of combustion beyond such exposed end.

4. A rocket projectile comprising a body, a substantially cylindrical propellant rocket charge formed with a relatively flat face, the body having a chamber which envelops the charge, a combustion space within the chamber adjacent the face

of the charge, a nozzle carried by the body and in discharge communication with said space, means within the combustion space for igniting said face of the charge, means whereby the pressure evolved by the combustion for driving the projectile reacts against said face to urge the body of the propellant charge into firm engagement with the enveloping pressure chamber, and a vent in said chamber for relieving back pressure between said charge and the enveloping chamber.

5. A rocket projectile comprising a body having a substantially cylindrical bore therein forming a combustion chamber, a relatively cylindrical, propellant rocket charge fitted within said bore, a combustion space adjacent an end of said charge within the chamber, means for igniting the charge at said end to evolve propellant gas within the combustion space, a nozzle carried by the body and in discharge communication with said gas, means whereby pressure developed within the combustion space reacts against the burning end of said charge to compress the charge into said bore to prevent the combustion from spreading beyond the end portion of the charge, and a vent in said chamber to relieve pressure opposing the compression of said charge into said bore.

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