May 5, 1959 J. M. ALEXANDER ET AL 2,884,859

ROCKET PROJECTILE

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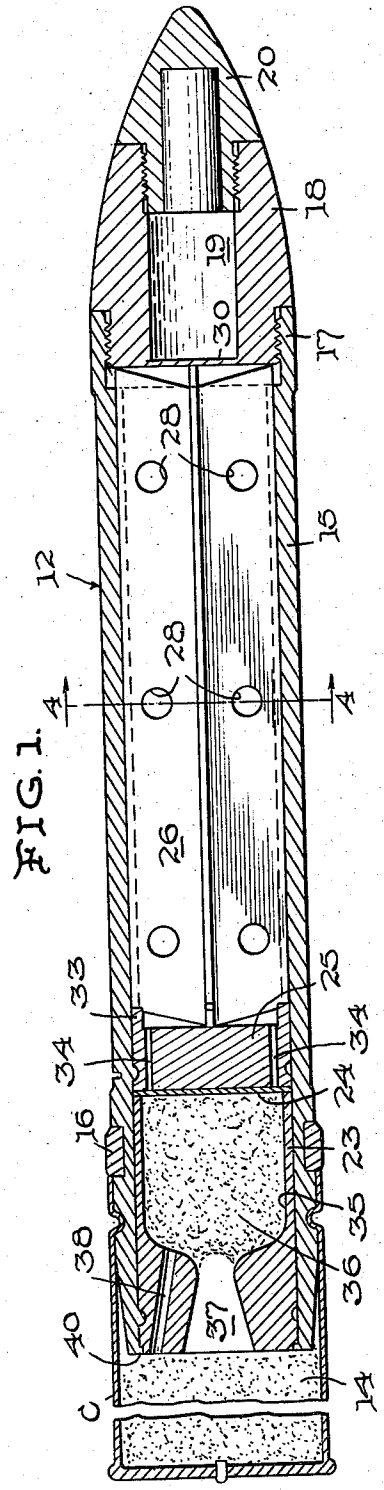

FIG. 1.

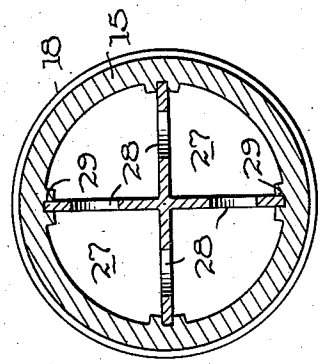

FIG. 4.

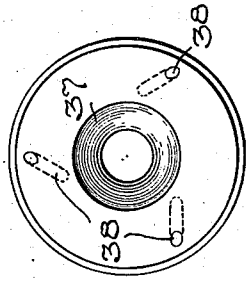

FIG. 3.

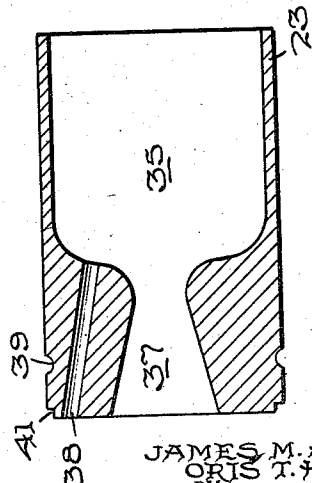

FIG. 2.

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ROCKET PROJECTILE

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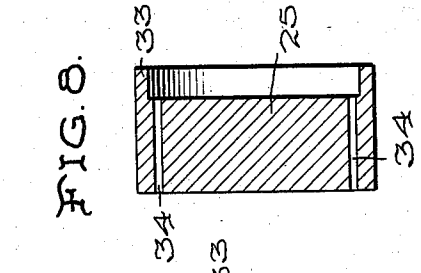

FIG. 8.

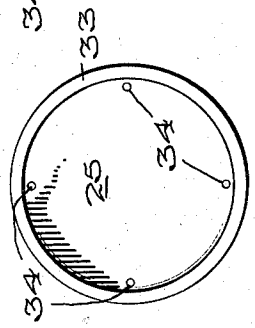

FIG. 7.

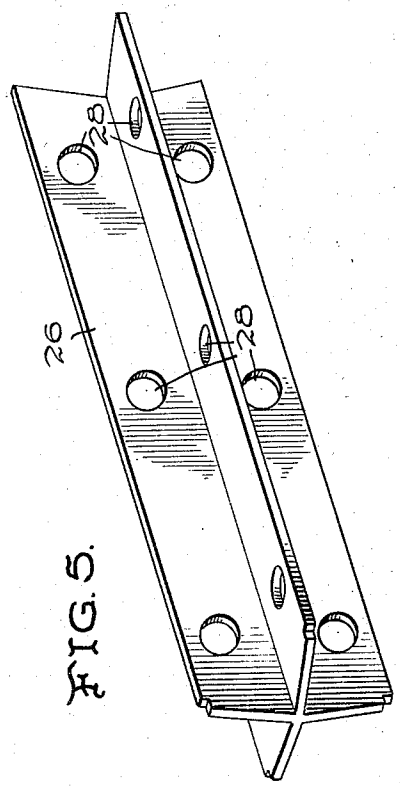

FIG. 5.

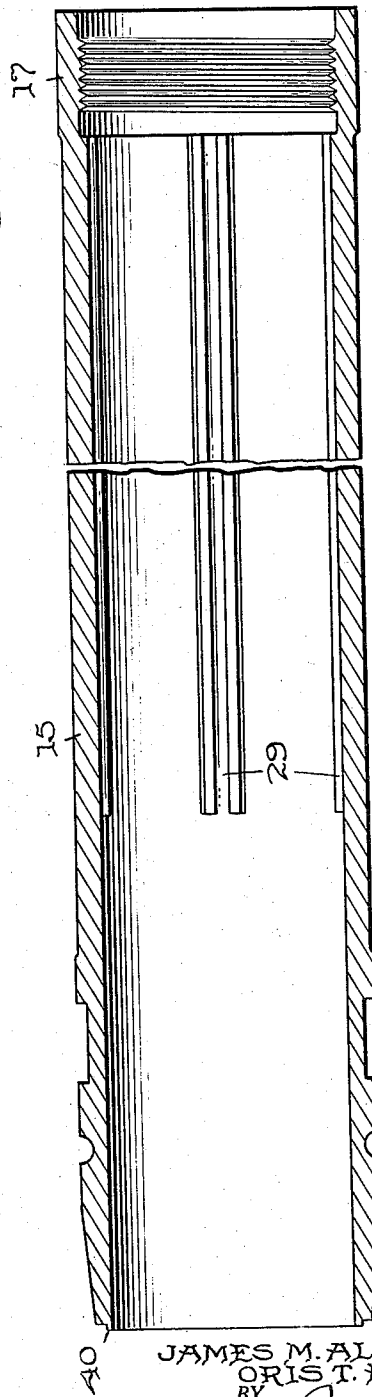

FIG. 6.

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ROCKET PROJECTILE

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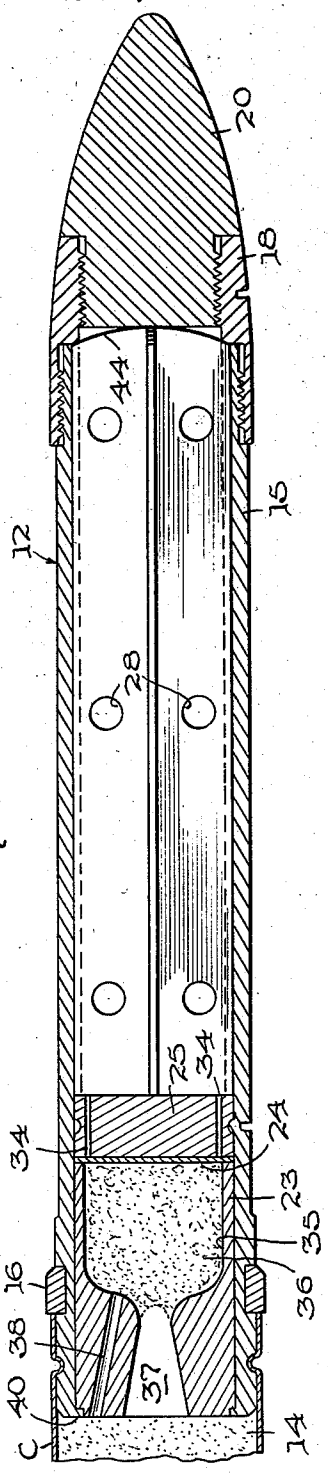

FIG. 9.

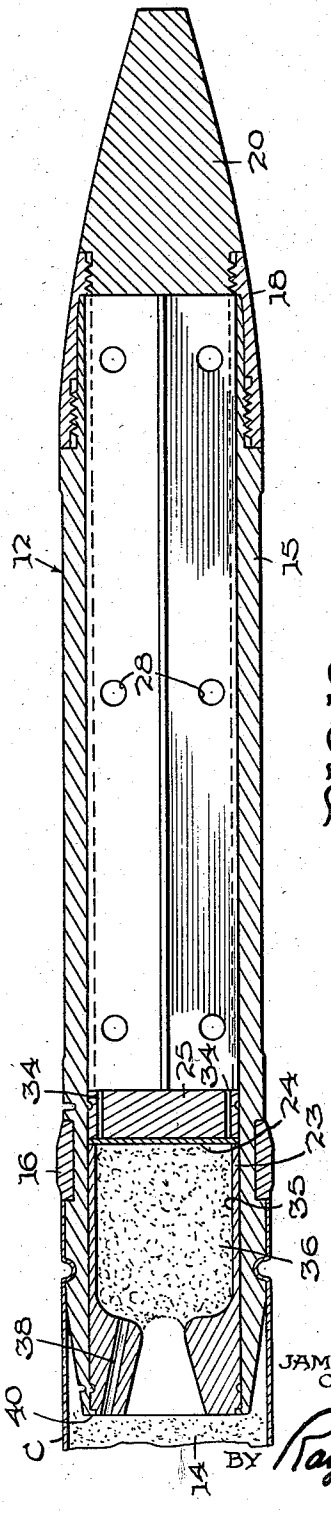

FIG. 10.

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ROCKET PROJECTILE

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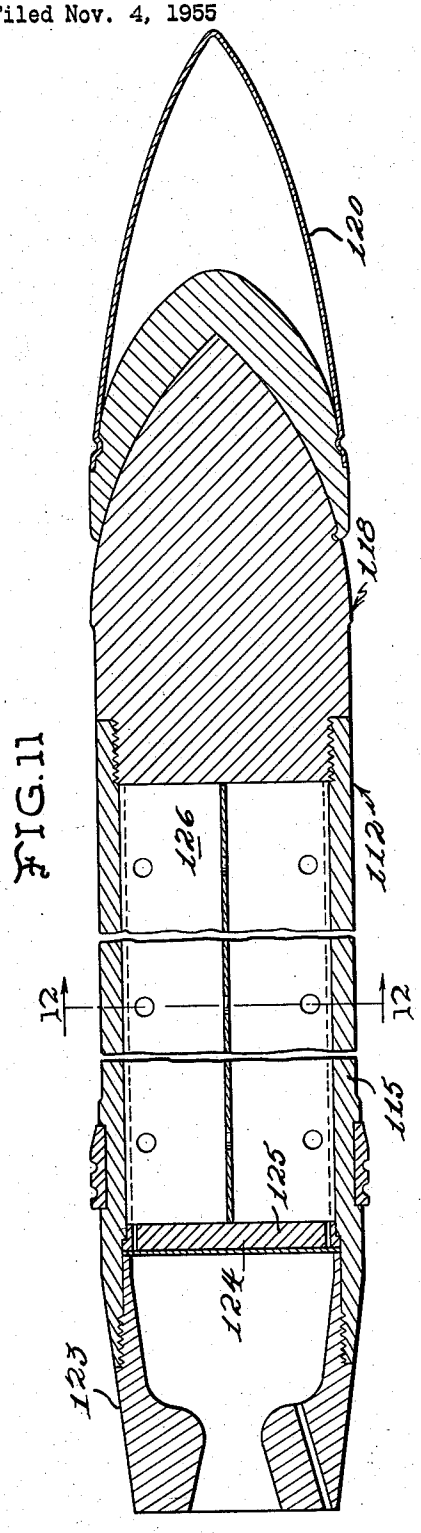

FIG. 11

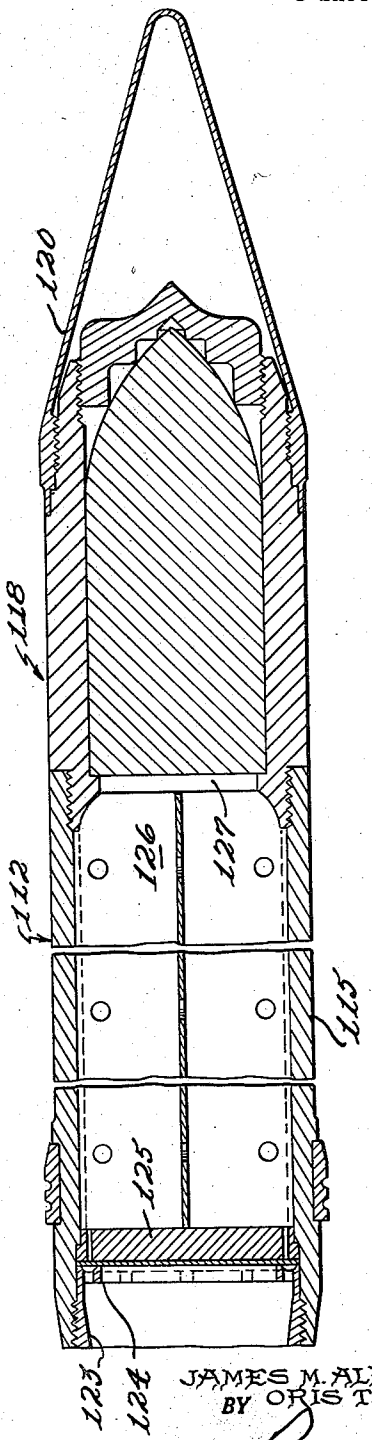

FIG. 12

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ROCKET PROJECTILE

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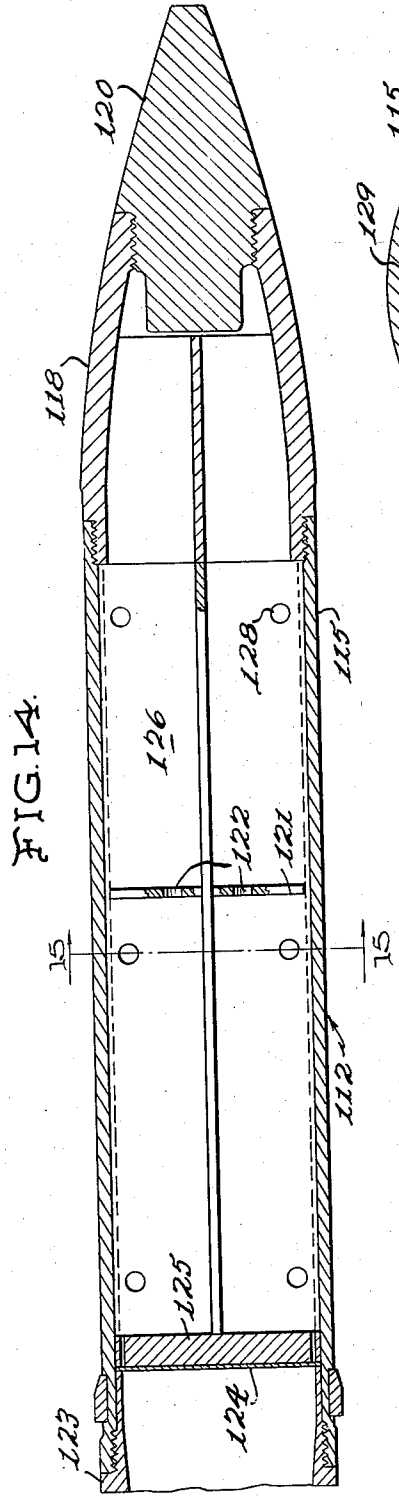

FIG. 14.

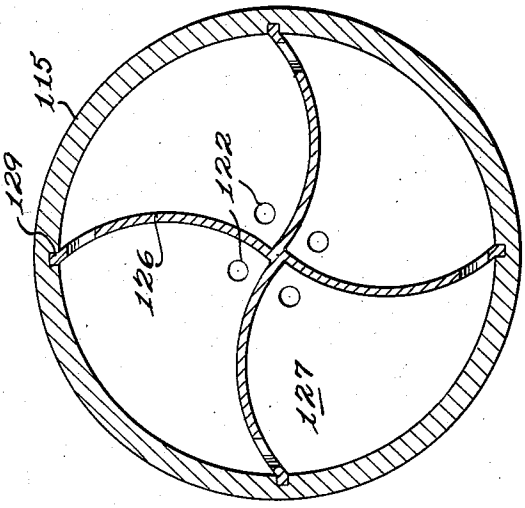

FIG. 17.

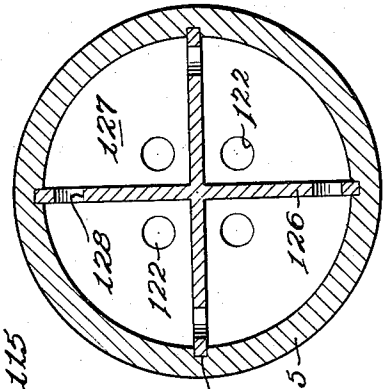

FIG. 15.

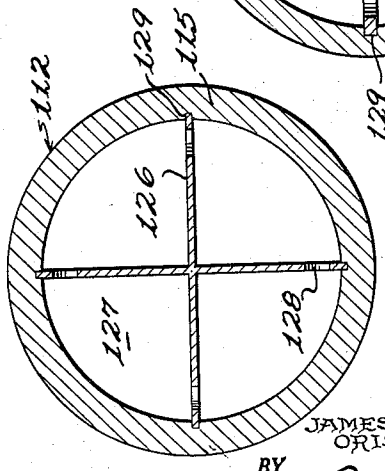

FIG. 12.

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ROCKET PROJECTILE

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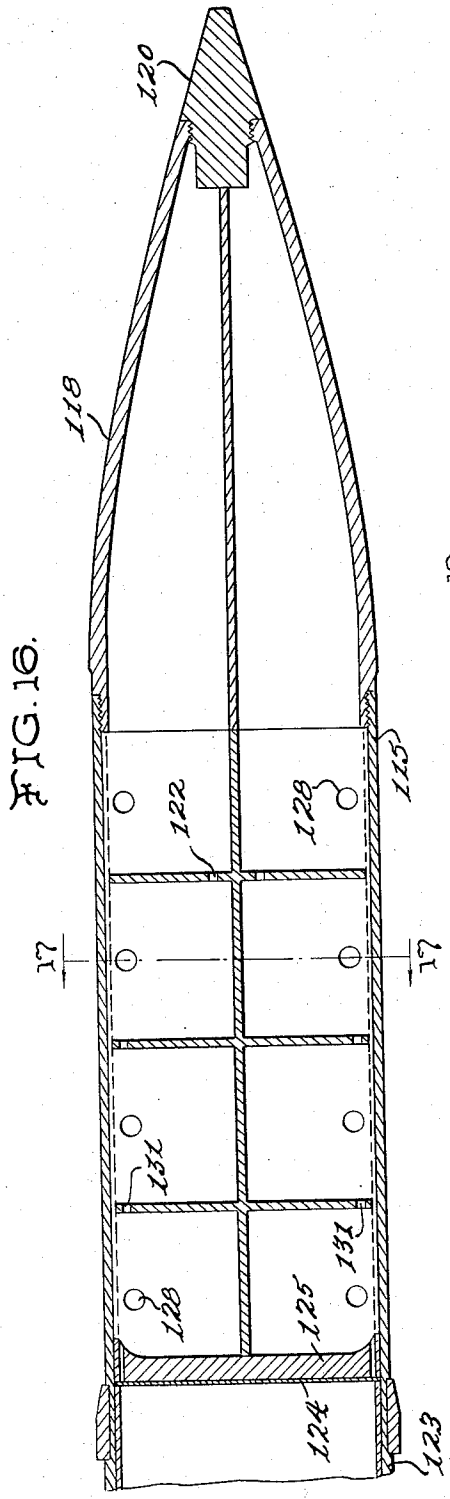

FIG. 16.

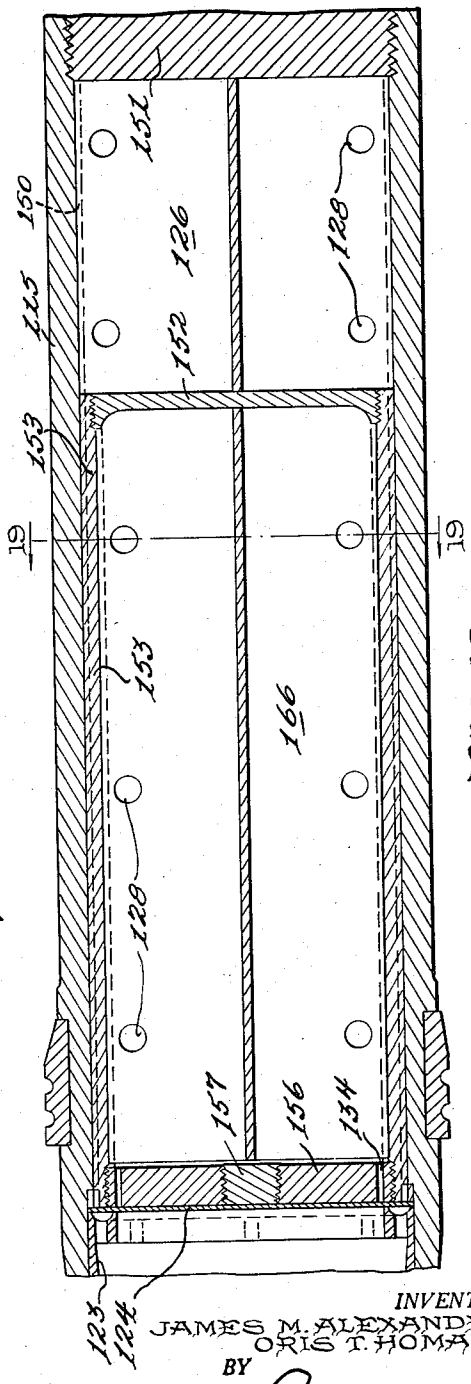

FIG. 18.

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ROCKET PROJECTILE

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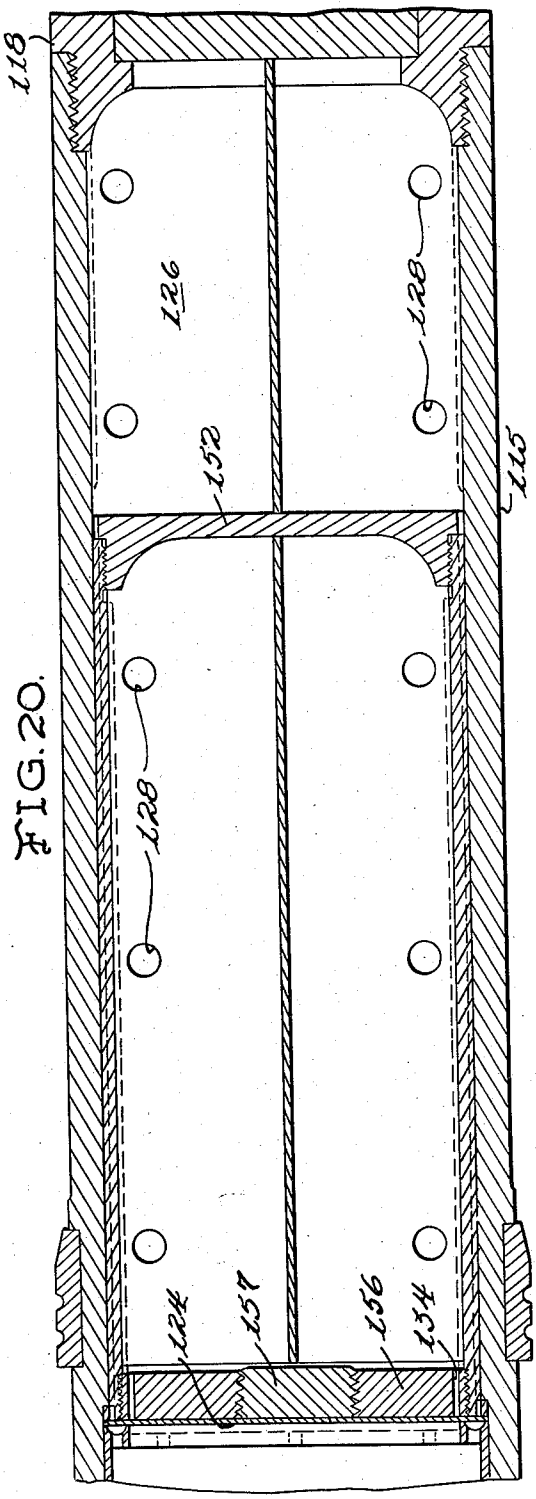

FIG. 20.

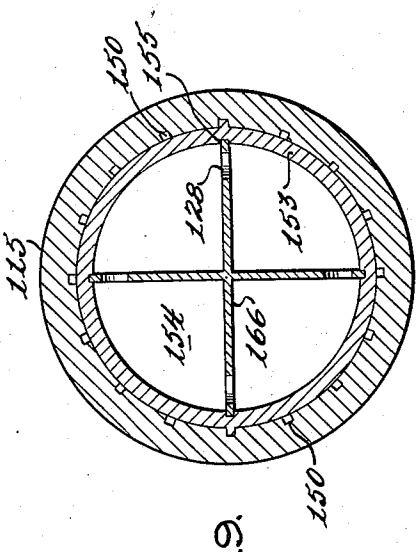

FIG. 19.

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ROCKET PROJECTILE

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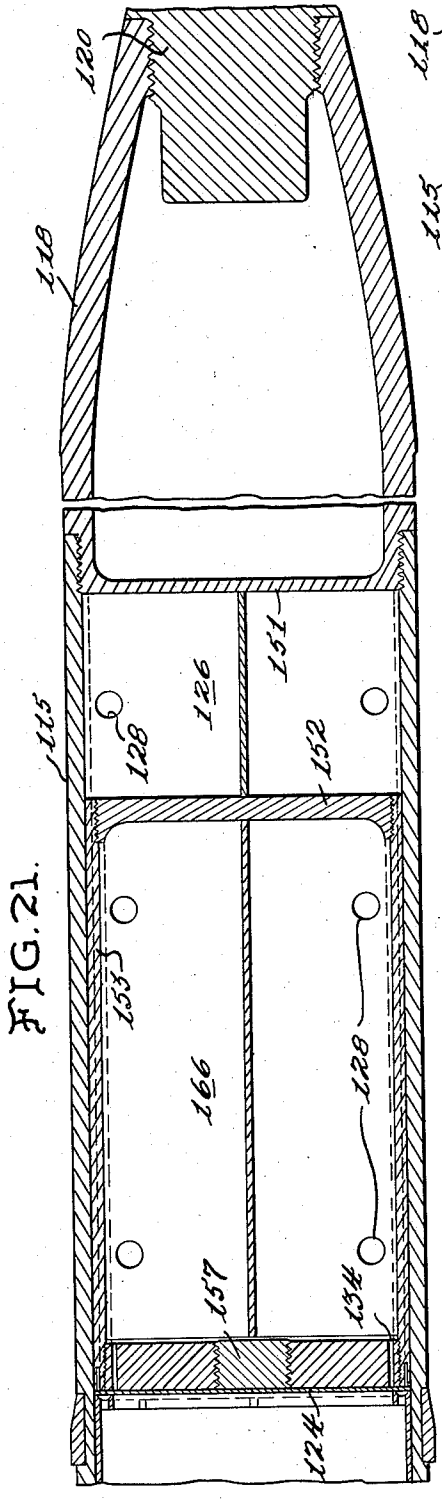

FIG. 21.

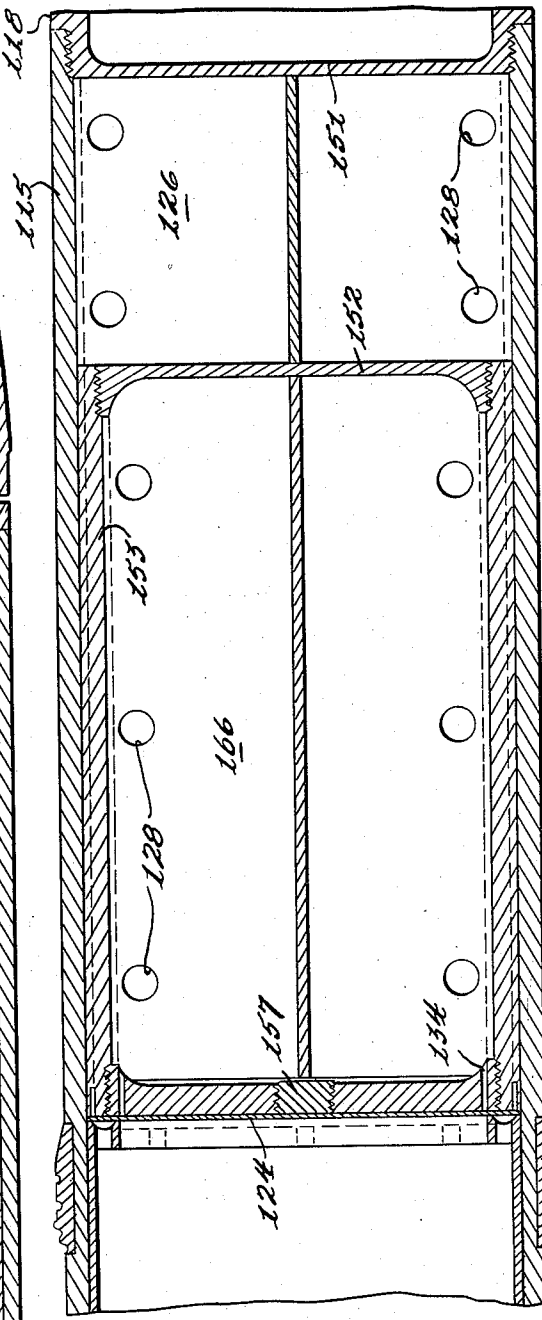

FIG. 22.

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United States Patent Office

2,884,859

Patented May 5, 1959

2,884,859

ROCKET PROJECTILE

James M. Alexander and Oris T. Homan, Parsons, Kans.

Application November 4, 1955, Serial No. 544,970

15 Claims. (Cl. 102—38)

This invention relates generally to artillery projectiles and more particularly to rocket assist types of projectiles of the major caliber fields such as the 57 mm. through the 280 mm. or any such other caliber as the Ordnance Corps of the U. S. Army and U. S. Navy would consider practicable and is a continuation-in-part of our application Serial Number 461,358, now abandoned, filed October 11, 1954.

In the manufacture of artillery ammunition, it is a recognized fact that the longer the ranges, the higher the terminal velocities, the greater the striking forces and detonating forces the more potent the weapon becomes. Present day ammunition has reached its current ranges and high muzzle velocities by increasing the breech or chamber pressures of the gun by utilizing a longer and larger cartridge case, so that more of a propellent charge can be used. These breech or chamber pressures have about reached their feasible limits as the increases in the pressure to reach these higher velocities, has reduced the barrel life of the gun to a minimum.

Moreover, in the design and manufacture of small caliber artillery ammunition, it has not been possible to develop a proximity or even a time delay fuse for the smaller sizes. It is definitely desirable to be able to fire the small caliber projectiles with contact fuses as anti-aircraft projectiles but this type of ammunition is very hazardous and hence, not desirable for use in or around crowded areas or under conditions in which these projectiles in their normal trajectory would fall within the limits of our own troop concentrations. Thus it would be extremely advantageous to be able to fire, as anti-aircraft defense weapons, a projectile of small caliber that would have an extremely high rate of climb and be safely armed with a contact fuse, yet armed so as to explode automatically at or near the top of its trajectory. Thus the present invention insures that any small caliber ammunition that fails to find a target in its trajectory, will disintegrate through self detonation to eliminate the hazard of falling high explosive missiles.

Accordingly, the chief object of the present invention is to provide an improved rocket type projectile having longer ranges, higher terminal velocities, more ballistic power and greater striking forces which will obviate the above and other disadvantages of known prior art structures.

Another important object of the present invention is to provide an improved rocket type projectile having a fuel which acts as both a fuel for the main propellent and the bursting charge.

Another objective of the present invention is to provide an improved rocket type projectile having a single or dual propellent in which the fuel or fuels are accurately metered by centrifugal force through a nozzle to a rocket combustion chamber to provide the main propulsive force for the projectile after it leaves the gun as well as rotational stabilizing forces therefor.

A further important of the invention is to provide an improved rocket type projectile in which the fuel or fuels

and explosive chamber is located on the central axis thereof so as not to upset the rotational balance of the projectile while in flight.

A still further important object of the invention is to provide an improved rocket type projectile which is susceptible of ready and economical manufacture while being of far superior performance characteristics.

Other objectives and advantages of this invention will become apparent during the course of the following description.

In its broadest aspects, the invention contemplates a rocket assist type projectile utilizing either a single or dual propellent that becomes operative only after the projectile has been fired from the gun, the propellents of which could be used either as a propelling charge or as a bursting charge or both so as to safely and economically obtain longer ranges, higher terminal velocities, greater striking and detonating forces.

In the drawings we have shown several modifications of the basic forms of the invention. In these showings:

Figure 1 is a central, longitudinal sectional view of one form of the invention;

Figure 2 is a central, longitudinal sectional view of the rocket motor showing its combustion chamber, its exhaust or jet nozzle and one of the directional acceleration holes or smaller jet nozzles;

Figure 3 is a rear elevational view thereof;

Figure 4 is a vertical transverse sectional view of the invention, taken on the line 4—4 of Figure 1, parts being shown in elevation;

Figure 5 is a perspective view of the agitator forming a part of the present invention;

Figure 6 is a central, longitudinal sectional view of the body of the projectile comprising the present invention;

Figure 7 is an end elevational view of the metering nozzle forming a part of the present invention, looking from the right in Figure 1;

Figure 8 is a central, vertical sectional view thereof;

Figure 9 is a central, longitudinal sectional view of a slightly modified form of the invention;

Figure 10 is a central longitudinal sectional view of another slightly modified form of the invention.

Figure 11 is a central, longitudinal sectional view of one form of the invention using a single mono liquid propellent with an armor piercing war head;

Figure 12 is a transverse, sectional view thereof taken on the line 12—12 of Figure 11 showing the agitator placed in the broached slots;

Figure 13 is a view similar to Figure 11 but showing a different type of armor piercing war head;

Figure 14 is a central, longitudinal sectional view of another form of the invention using a single liquid propellent as both a propellent and a bursting charge and utilizing either a timed, contact, or a proximity fuze;

Figure 15 is a transverse, sectional view thereof taken on the line 15—15 of Figure 14 and showing the agitator placed in the broached slots with the explosive limiting spacer in position;

Figure 16 is a central longitudinal sectional view of another form of this invention using a single liquid propellant as both a propellant and a bursting charge and utilizing either a timed, contact, or a proximity fuze;

Figure 17 is a transverse, sectional view thereof taken on the line 17—17 of Figure 16 and showing the explosive limiting spacer and the curved agitator in the broached slots;

Figure 18 is a central longitudinal, sectional view to an enlarged scale of the form of the invention shown in Figure 11 but modified for use with a dual propellant;

Figure 19 is a transverse, sectional view thereof taken on the line 19—19 of Figure 18 and showing the propel-

lant chamber locked in two of the broached slots of the projectile body;

Figure 20 is a central, longitudinal, sectional view of the form of the invention shown in Figure 13 but modified for use with a dual propellant;

Figure 21 is a central, longitudinal, sectional view of the form of the invention shown in Figure 14 but modified for use with a dual propellant; and

Figure 22 is a central, longitudinal, sectional view of the form of the invention shown in Figure 16 but modified for use with a dual propellant.

The present invention may be applied to projectiles of various kinds and types, including armor piercing, high explosive, shells, bombs, and torpedoes and the initial flight of such projectiles may be initiated in any suitable manner. In the case of light artillery ammunition, the projectile may be assembled in the usual way of crimping the cartridge case, carrying the usual powder charge, to the projectile. In heavy or major caliber ammunition the projectile may be separate from the powder charge or the cartridge case.

The invention utilizes the rocket principle incorporated into and becoming an integral part of an artillery projectile for the purpose of increasing the range, the terminal velocity, the striking and the detonating force of the projectile after it has been fired from the gun. The rocket motor utilizes liquid fuels which in some instances are liquid explosives that contain a flash back preventative so that it cannot become a self detonating projectile.

The use of the liquid fuels was dictated because of higher power, more thrust, better metering, better control on their burning, greater facility in loading, and availability of a wider variety. In the single mono-propellant tetranitromethane and nitromethane, toluene, octane, dodecane or CO_2 gas makes a very powerful explosive as well as an extremely powerful propellant.

The initial rotational velocity imparted to the projectile by the rifling grooves in the gun barrel to spin and stabilize the projectile while in free flight is also used to develop centrifugal pressure to feed and meter the fuels to the rocket motor from the projectile body. This centrifugal pressure furnishes the pressure differential necessary to feed and meter the fuel at controlled and predeterminable rates through the metering nozzle passages to the rocket combustion chamber.

In some instances where a dual-propellant is used, the centrifugal pressure is also used to mix as well as feed and meter the different fuels to the combustion chamber.

The controlled burning of the fuel in the combustion chamber delivers a predeterminable amount of thrust or force which will accelerate the projectile in ever increasing velocities until a predeterminable amount of fuel has been expended. As this amount is reached, the remaining fuel will uncover the metering passages and the burning or detonation wave will travel back up stream to detonate the balance of the fuel in the body of the projectile unless a flashback preventative is used in the mono propellant.

A time delay or proximity fuse used in the larger caliber ammunition will operate in the usual way except that this projectile will have a much higher terminal velocity. When used with an armor piercing head, the projectile, upon reaching the target will start penetrating, the rotation will slow down, and the detonation wave will travel upstream and cause the projectile to explode, driving the armor piercing head in further or, in the event that the armor piercing head has already penetrated, the exploding of the remainder of the charge may take place after the projectile has passed the armor barrier.

In all calibers, provision is made to accelerate the rotational velocity imparted by the rifling during firing by the use of auxiliary directional rotational holes or jet nozzles drilled concentrically about the main jet nozzle of the rocket motor. These auxiliary holes will not only maintain but will increase the rotational velocity of the projectile so that the longer and heavier projectile will be ballistically stable in flight.

When used in major caliber ammunition in conjunction with a time delay or proximity fuse a flash back preventative is used in the mono propellant so that the balance of the fuel remaining unburned will then become a liquid explosive that will be initiated by the different types of fuses.

The propellants used in the forms of the invention disclosed in Figures 11–17 inclusive are also of the mono propellent type as hereinbefore described but utilize a flash back preventative or inhibitor so that the projectile will not be self detonating.

The rocket fuels used in Figures 1–17 inclusive of this invention are of the mono propellent type which furnish and contain all of the elements necessary for combustion within the same molecule. These liquids are not only rocket fuels but are also liquid explosives. Examples of such liquids are tetranitromethane, toluene, trinitromethane, nitromethane, nitroethane, 1-nitropropane, 2-nitropropane, 1,1-dinitropropane, 2,2-dinitropropane, 1,2-dinitropropane, 1,3-dinitropropane, 1,1-dinitroethane, 1,1,1-trinitropropane, 1,2,3-trinitropropane. The fuel and explosive chamber is located on the central axis of the projectile body so that the burning of the rocket fuels will not upset the rotational balance of the projectile while in flight.

When the projectile comprising the present invention is fired, the propellant charge in the cartridge case or in the gun barrel breech will drive the projectile out of the gun barrel in the usual manner, its rotation being started by the rifling grooves in the barrel. A tracer mixture or powder which is compacted in the combustion chamber of the rocket motor is ignited to furnish an additional amount of thrust which may be timed to a predeterminable limit and the projectile clears the gun barrel during this interval.

In the invention, a fusible sealing disc is employed to seal the metering nozzle passages between the tracer mix and the fuel in the body of the projectile and upon melting of the disc by the burning of the tracer mixture, built-up centrifugal pressure of the rotation fuel forces it through the metering passages into the burning mixture in the rocket nozzle where it is also ignited. The gases from the burning fuel are expelled under high pressure through the main rocket nozzle and the obliquely arranged directional rotation acceleration holes to propel the projectile while imparting an added rotational velocity.

The burning of the fuel in the rocket motor continues until such time as the fuel is almost expended at which time the fuel passages will be uncovered and the burning of the fuel will thereupon travel back up stream through the fuel metering passages and cause the balance of the fuel in the fuel chamber to explode, except in the forms of the invention shown in Figures 11–17 inclusive wherein a flash back preventative is incorporated in the fuel which thus can explode only on contact.

Referring to the drawings, numeral **12** designates as a whole the projectile comprising the present invention which is adapted for use as artillery ammunition and is assembled with a cartridge case C having the usual initial propellent charge **14**.

The projectile **12** includes an elongated tubular body **15** of strong, heated-resistant steel alloy, a copper rifling band **16** which abuts the cartridge case C, an external shoulder **17** having interior threads for connection with an adapter **18** having a chamber **19** terminating at its right end in a threaded portion for connection with a head or fuse **20**.

The interior of the projectile body **15** includes a rocket motor **23**, a fusible sealing disc **24**, a metering nozzle **25** and an agitator **26** in the liquid fuel space or chamber **27** defined between the nozzle **25** and the adapter **18**.

The agitator **26** functions to impart the rotational velocity of the projectile while in flight to the liquid fuel

in the chamber 27 and it is important that the fuel be equally distributed throughout the chamber 27 at all times so as not to upset the rotational balance of the projectile. To this end the blades of the agitator (which may be greater or lesser in number as long as they are angularly displaced equally) are each provided with a plurality of longitudinally spaced ports 28. This arrangement ensures that no fluid fuel can be trapped on one side of the blades and not drain equally with the others.

The agitator 26 is fixed in position within the body 15 by sliding the edges of the blades into angularly spaced broached slots 29 formed in the body. The blades thus divide the chamber 27 into compartments having free communication by virtue of the ports 28. Additional communication between the compartments is had at the ends of the agitator 26 due to the slope of the blade and edges inwardly and toward the left as seen in Figures 1 and 5 to define, in effect, cones of revolution whose apices are to the left to space the blades from the passages 34 and the thin wall 30.

More important, the inclined blade edges described not only afford free access of fluid fuel from the compartments in the chamber 27 to the apertures in the nozzle 25 but also afford direct access at the right end of the chamber to a frangible wall 30 closing the left end of the adaptor chamber 19 which may contain a detonator such as tetryl.

The metering nozzle 25 (Figures 1, 7 and 8) comprises a thick disc having a forwardly directed annular flange 33 which bears against the end edges of the agitator 25 and clamps it against the rear face of the adaptor 18. The nozzle is provided with a plurality of angularly spaced, longitudinally extending fluid metering passageways 34 whose rear apertures are closed by the sealing disc 24 which is clamped between the nozzle 25 and the rocket motor 23.

The rocket motor 23 includes a combustion chamber 35 in which a powder charge or solid propellant 36 of the restricted burning type is compacted. The combustion chamber terminates in a main exhaust jet nozzle or opening 37 and a plurality of angularly spaced, canted, directional acceleration holes or jets 38. The motor 23 is provided with a peripheral groove 39 which cooperates with a rib on the projectile body 15 to hold the rocket motor in place. It is further secured therein by a roll crimp 40 of the end of the body 15 over the end shoulder 41 of the rocket motor 23.

It is believed to be readily apparent that in the firing of the projectile 12, the propellent charge 14 in the cartridge case C will ignite the compacted solid propellant 36 in the rocket combustion chamber 35. The burning propellant 36, however, will not melt the seal 24 until the projectile 12 has left the barrel of the gun and is in flight. When the seal 24 melts, the centrifugal pressure resulting from the rotational velocity of the projectile (due to the barrel rifling and the added rotational thrust obtained by the canted jets 38) will result in liquid fuel being metered through the passages 34 in the nozzle 25 to the combustion chamber 35 from the fuel chamber 27.

The burning of the liquid fuel in the combustion chamber 35 provides the main acceleration of the projectile after it leaves the gun barrel or tube and continues until the fuel in the chamber 27 is almost expended. As explained herein, the uncovering of the fuel passages by the lessened fuel in the chamber 27 permits the burning to back up through the fuel passages 34 and ignite the balance of the fuel in the chamber 27 to explode the projectile 15.

If the target is struck by the projectile before its self-explosion or detonation, the fuse 20 and the tetryl in the adaptor chamber 19 will effect detonation. As shown in Figures 9 and 10 where the adaptors clamp the head or fuse against the agitator 26, it is not essential that the adaptor 18 include a chamber 19 for a detonator such as tetryl.

In Figure 9, we have shown a smaller caliber projectile 15 wherein the position of the rifling band 16 is moved rearwardly on the projectile for longitudinal balance purposes whereas in Figure 10, the band 16 is moved forwardly along a larger projectile. As shown in Figure 9, the right ends of the agitator blades are curved forwardly as at 44 to allow the unexpended fuel free communication and access to the rear face of the fuse so as to effect proper detonation of the projectile upon its striking a target and to enable clamping contact of the agitator by the head, the curved plate ends being unnecessary in the larger projectile of Figure 10.

It will now be readily apparent that the forms of the artillery projectile comprising the present invention as shown in Figures 1–10 inclusive will automatically explode or explode on contact with a target, uses a single main propellant which is also the explosive charge, will not explode until after leaving the barrel of a gun, and will have a longer range, a higher terminal velocity and a greater striking force than other known projectiles, while also lengthening the life of a gun barrel tremendously.

The propellants used in the forms of the invention disclosed in Figures 11–17 inclusive are also of the monopropellant type as hereinbefore described but utilize a flashback preventative or inhibitor so that the projectile will not be self detonating. These forms of the invention are of the higher calibers, and in structure and operation are similar to the projectiles disclosed in Figures 1–10 inclusive.

These forms 112 of the invention also comprise a body portion 115, a rocket motor 123, a fusible sealing disc 124, a metering nozzle 125, and a fuel agitator 126 in the fuel chamber 127. The chamber terminates in an adaptor 118 for a war head 120. Figure 11 differs from Figure 13 only in the use of a different type of armor piercing war head and adaptor connecting it to the body 115 of the projectile 112.

It will be appreciated that if either of the disclosed projectiles contacts an armored barrier before all of the fuel in the chamber 127 is consumed as a rocket propellant, the unconsumed portion will become a liquid explosive detonating on impact.

The embodiment of the invention disclosed in Figures 14 and 15 is similar to that of Figures 11–13 but differs in the inclusion of a transversely extending, spacer disc 121 formed integrally with or fixed to the agitator 126. The disc 121 is provided with an aperture 122 positioned adjacent to but spaced from the axis of the projectile in each of the sections of the fuel chamber 127 formed by the agitator 126.

The apertured spacer disc 121 is an important feature of the invention in that it retains a predeterminable (by the spacing of the apertures 122 from the axis) amount of the liquid explosive or fuel in the forward part of the projectile to provide the bursting charge. The spacer disc also braces the agitator 126 and as shown in Figure 16, a plurality of spacer discs 121 are employed to brace the agitator as the weight of the liquids in the projectile runs about 78 lbs. The need for either such bracing or heavier agitators is appreciated when considering the stresses involved in accelerating 78 lbs. to 7,200 r.p.m. in $\frac{2}{1000}$ of a second.

In order that none of the propellant fuel be trapped between the discs, all but the one at the front are provided adjacent their peripheral edges with a plurality of angularly spaced drain apertures 131. The agitator blades of the embodiment shown in Figures 16 and 17 are curved for extra strength as this form is one of the larger calibers such as 120—155 and 240 mm. It will be noted (Figures 12, 15 and 17) that the broached slots 129 are formed directly in the projectile body 115 and not in raised ribs as in Figures 1–10 inclusive.

In all of the projectiles disclosed, the combustion

chamber of the rocket motor **123** contains a predetermined amount of a solid propellant which burns at a rate of from 2 to 10 inches per second. This propellant is one of the solid rocket propellants such as: NDRC National Defense Research Committee, Galcit Series; Guggenheim Aeronautical Laboratory, California Institute of Technology; ballistic, smokeless or black powder and due to its burning characteristics, acts as a delay element. The operation of the projectiles disclosed in Figures 11–17 is, of course, the same as set forth in connection with Figures 1 to 10.

In Figures 18–22 inclusive, the forms of projectiles shown are generally similar in construction and similar in operation to those hereinbefore described but differ in that dual propellants are used which may or may not be explosives. As seen in Figures 18 and 19, the inner surface of the projectile body **115** is broached to provide a multiplicity of slots **150** therein.

A short agitator **126** is mounted between a plug **151** separating the fuel chamber from the nose adaptor and a removable end wall **152** of an inner cylinder **153** which forms the oxidizer chamber **154**. The outer surface of the cylinder **153** is provided with a pair of diametrically opposed splines which seat in two of the broached slots **150** so as to rotate with the projectile.

The inner surface of the cylinder is provided with angularly spaced slots **155** in which the blade edges of an agitator **166** are seated. The left or rear end of the oxidizer chamber **154** is closed by a metering nozzle **156** having metering passageways **134** and a filler plug **157** for sealing the oxidizer which may be nitric acid in the chamber **154**. The fuel in the fuel chamber may be aniline oil-furfural alcohol, or ethyl alcohol which is delivered to the combustion chamber of the rocket motor **123** by the broached slots **150**. These and the metering passageways **134** are, of course, sealed by the fusible sealing disc **124**.

The projectiles disclosed in Figures 20, 21 and 22 are respectively the same as the mono-propellant projectiles of Figures 13, 14 and 16 modified for use with dual propellants. It will be apparent in the operation of the latter that as soon as the fusible sealing disc **124** has been melted, centrifugal pressure of the rotating projectile will cause oxidizer to be metered through the passageways **134** and fuel to be metered through the slots **150**. The two react simultaneously upon contact to burn at a predetermined pressure to furnish the rocket assist power.

Thus, whether a mono-propellant or a dual propellant is used, the terminal velocity, range and striking force of the projectile is tremendously increased with an attendant material reduction in gun barrel wear.

It is to be understood that the forms of the invention herewith shown and described are to be taken as a preferred example of the same and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

We claim:

1. A projectile adapted to be fired from a rifled gun barrel by a conventional propellent charge therein comprising a tubular casing including a fuel chamber having fuel therein and a rocket combustion chamber including and terminating in a jet nozzle, a powder charge in said combustion chamber adapted to be ignited by the firing of the gun, a metering nozzle including fuel passages separating said fuel chamber and said combustion chamber, and a fusible disc adjacent said powder charge and sealing said passages and adapted to melt upon burning of said powder charge to admit fuel under centrifugally developed pressure by projectile rotation to said combustion chamber to furnish thrust to the projectile.

2. A device as recited in claim 1 wherein the fuel is explosive upon high velocity impact of the projectile to form a war head of said fuel chamber.

3. A device as recited in claim 2 wherein said fuel passages permit burning fuel in said combustion chamber to pass through said passages to ignite unexpended fuel in said fuel chamber upon the uncovering of the fuel passages by the expending of fuel.

4. A device as recited in claim 2 wherein said combustion chamber also terminates in a plurality of jet nozzles smaller than and concentrically arranged with said first mentioned jet nozzle and obliquely thereto to furnish rotational velocity to said projectile.

5. A device as recited in claim 2 wherein said fuel chamber is closed at one end by a thin walled chamber having a detonator therein.

6. A device as recited in claim 5 wherein an agitator including blades is mounted in said fuel chamber to impart rotation to the fuel upon rotation of the projectile and said blades are spaced from said thin walled chamber to permit free contact of the explosive fuel therewith.

7. A device as recited in claim 1 wherein said fuel passages permit burning fuel in said combustion chamber to pass through said passages to ignite unexpended fuel in said fuel chamber upon the uncovering of the fuel passages by the expending of fuel.

8. A device as recited in claim 1 wherein said combustion chamber also terminates in a plurality of jet nozzles smaller than and concentrically arranged with said first mentioned jet nozzle and obliquely thereto to furnish rotational velocity to said projectile.

9. A device as recited in claim 1 wherein an agitator including blades is mounted in said fuel chamber to impart rotation to the fuel upon rotation of the projectile.

10. A device as recited in claim 9 wherein said blades include ports to permit free communication of the fuel within said fuel chamber.

11. A device as recited in claim 9 wherein the ends of said blades are spaced from said fuel passages to permit free access of the fuel thereto.

12. A device as recited in claim 1 wherein said rocket combustion chamber has a press fit with said tubular casing and includes a peripheral groove engageable by a multi-point stake on the inner surface of said casing.

13. A device as recited in claim 1 wherein said metering nozzle has a press fit with said tubular casing and includes a peripheral groove engageable by a multi-point stake on the inner surface of said casing.

14. A device as recited in claim 1 wherein said fusible disc is clamped against the face of said metering nozzle by the forward end of said combustion chamber.

15. A projectile adapted to be fired from a gun barrel by a conventional propellent charge therein comprising a tubular casing including a fuel chamber having fuel therein and a rocket combustion chamber including and terminating in a jet nozzle, a powder charge in said rocket chamber, and means comprising a metering nozzle and a fusible seal therefor adapted to melt upon firing of said powder charge to admit fuel to and ignite it in said combustion chamber to effect propulsion of the projectile.

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