March 13, 1962 R. W. KLUGE 3,024,729

RAM JET PROJECTILE

Filed April 24, 1948 2 Sheets-Sheet 1

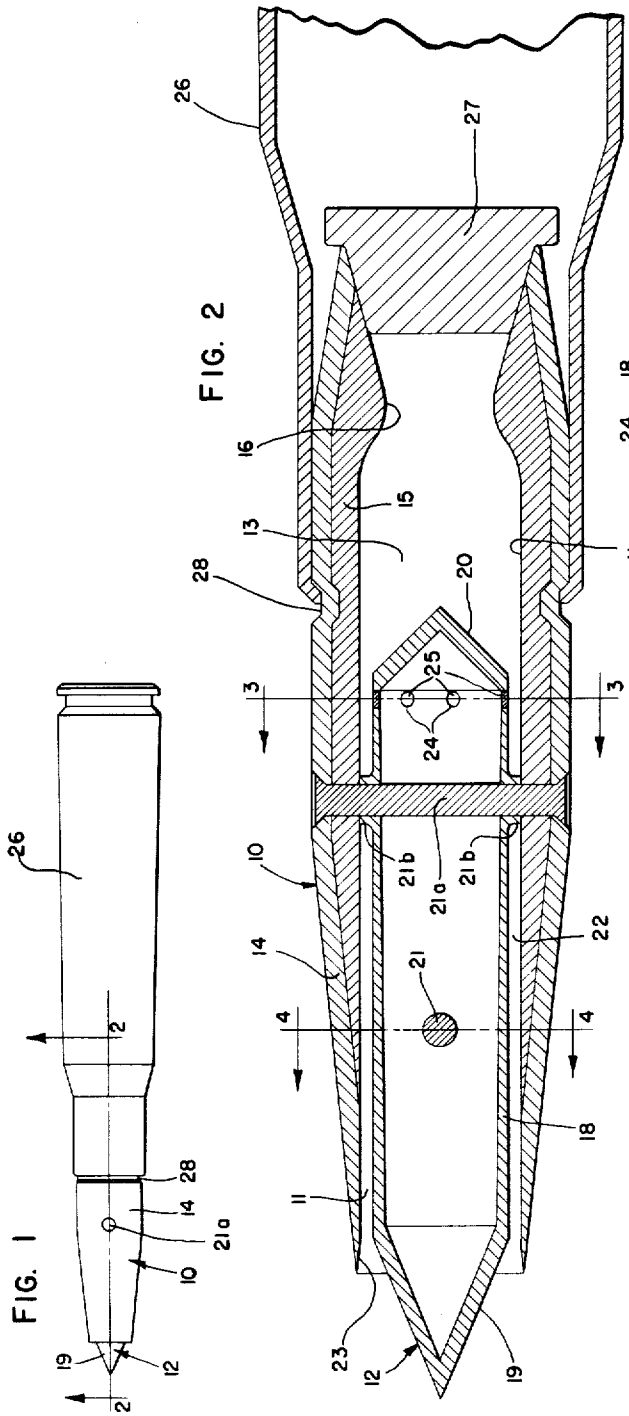


FIG. 2

FIG. 1

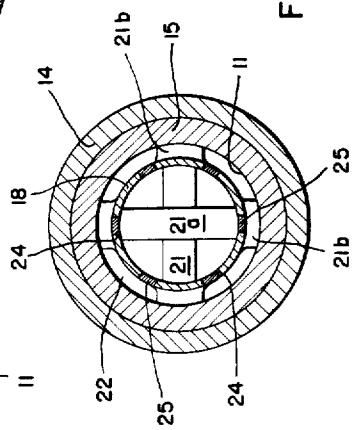


FIG. 3

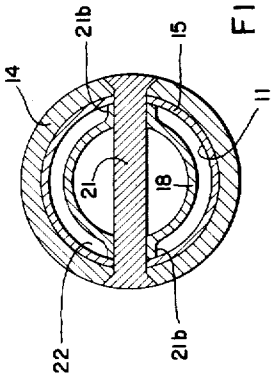


FIG. 4

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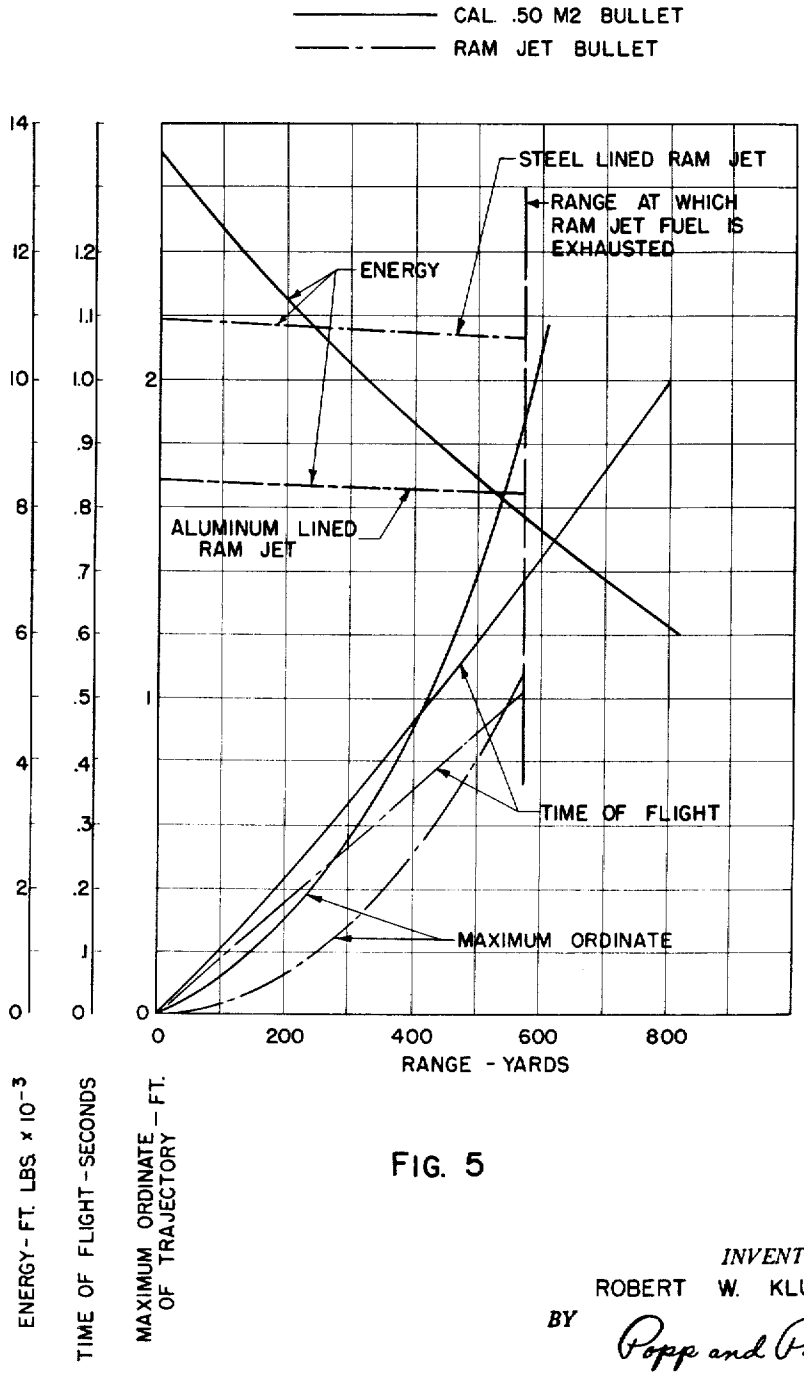


FIG. 5

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RAM JET PROJECTILE

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This invention relates to ammunition and more particularly to a ram jet projectile.

An important object of the invention is to provide projectiles which can be fired from small arms and artillery weapons of presently known types and which are self-propelled upon being discharged by the launching weapon.

Another object is to provide such a projectile which operates on a ram jet principle to propel itself in flight, that is, a projectile which in response to the movement of the projectile develops an air pressure in a combustion chamber provided within the projectile to combust a fuel also admitted to the combustion chamber.

Another object is to provide such a projectile which utilizes flight conditions to effect admission of the fuel to the combustion chamber.

Another object is to provide such a projectile which utilizes flight conditions to ignite the fuel admitted to the combustion chamber and therefore does not require an ignition mechanism.

Another object is to provide such a ram jet projectile which has a greater speed in flight than a conventional projectile of the same caliber, and therefore a flatter trajectory and shorter time of flight for a given range.

Another object is to provide a ram jet projectile which weighs less than a conventional projectile of the same caliber but which provides an equal or greater energy at any given range.

Another object is to provide such a light weight ram jet projectile, which requires less propelling charge for firing than a conventional projectile of the same caliber and therefore renders the total weight of a complete round of ammunition less than that of a corresponding conventional round of ammunition. In the case of providing the ram jet projectile in the form of fixed or semi-fixed rounds of ammunition, since less propelling charge is required, the propelling charge container can be made smaller and lighter and thus further reduce the total weight of the complete round.

A further object is to provide such complete round of ammunition which upon firing produces less recoil than a conventional round of ammunition for the same caliber of projectile and thereby permits larger caliber weapons to be used as hand weapons.

A further object is to provide such a ram jet projectile which develops practically constant impact energy over a relatively wide variety of ranges.

A further object is to provide a ram jet projectile which is simple in construction and inexpensive to manufacture.

A further aim is to provide a small ram jet missile which would make available a low cost means for testing various ram jet, shock diffuser and supersonic aerodynamic characteristics.

Other objects and advantages will be apparent from the following description and drawings wherein—

FIG. 1 is a side elevation of a fixed round of ammunition incorporating the ram jet projectile embodying the present invention.

FIG. 2 is an enlarged central longitudinal section through the projectile and a part of the cartridge case shown in FIG. 1, this view being taken on line 2—2, FIG. 1.

FIGS. 3 and 4 are transverse sectional views of the

projectile taken along the correspondingly numbered lines in FIG. 2.

FIG. 5 is a graph showing a comparison between the characteristics of a conventional caliber .50 M2 projectile and a caliber .50 ram jet projectile embodying the present invention.

While the ram jet projectile embodying the present invention may be of any desired caliber or diameter, the same is illustrated in the drawings and will be described as a caliber .50 projectile, that is, a projectile having an outside diameter of ½ inch.

The ram jet projectile comprises an elongated outer body **10** provided with a passage **11** extending axially therethrough and a fuel container **12** arranged within the body, a portion of the passage **11** providing a combustion chamber **13** to which pressurized air and fuel from the container **12** are admitted when the projectile is in flight and under conditions which will ignite the fuel and thereby power the projectile in flight.

The body **10** is shown as being annular in form and having concentric inner and outer surfaces throughout its entire length and including an outer shell or casing **14** and a liner **15** mounted therein. The liner **15** can be made of any suitable material such as steel or aluminum and the casing **14** is preferably made of a relatively soft material such as copper alloy to permit the periphery of this casing to be engraved by the lands and grooves of the rifling in the gun barrel and thereby impart rotation to the projectile in flight. It is only in the case of small caliber projectiles such as used in small arms weapons that a body clad with a relatively soft metal for rifling purposes need be used. In the case of larger calibers such as used in artillery weapons, the projectile body **10** may be provided with a rotating band (not shown) and thus permit the body **10** to be made in one piece.

Referring to FIG. 2, the outer peripheral surface of the body **10** is shown as having conical front and rear portions which join with the corresponding ends of a cylindrical intermediate portion, the conical portions tapering radially outwardly toward the intermediate cylindrical portion and the front conical portion being of greater axial length than the rear conical portion. The casing or shell **14** is shown as being of uniform thickness and surrounding the liner **15** whose outer peripheral surface is suitably formed to engage the inner peripheral surface of the casing or shell **14**. It will be noted that this construction interlocks the casing or shell **14** and liner **15** and prevents relative displacement therebetween axially of the projectile.

The passage **11** is shown as being cylindrical throughout substantially the full length of the projectile and has a restricted throat portion **16** at its rear which gradually enlarges toward the rear end of the body **10** and thereby provides an exhaust nozzle for the combustion chamber **13**.

The fuel container **12** is shown as being in the form of a cylindrical tank **18** having a conical, forwardly projecting front end head **19** and a conical, rearwardly projecting rear end head **20**. The fuel container **12** is shown as being arranged centrally within the front portion of the passage **11** in radially spaced relation to the interior of the body **10** and can be secured thereto in any suitable manner. For this purpose a pair of diametral pins **21** and **21***a* is shown as arranged in registered and tightly fitting holes provided in the body **10** and cylindrical tank **18**, the ends of these pins being upset so as to prevent axial displacement of the pins. The pin **21** is shown as being horizontally arranged adjacent the approximate center of the fuel container **12** and the pin **21***a* as being vertically arranged adjacent the rear of the fuel container. By this spacing the pins **21** and **21***a* axially

of the projectile and also by arranging their axes at right angles, it will be seen that the fuel container is securely mounted on the body **10** and held against axial and rotative movement relative thereto. In order to prevent radial displacement of the fuel container **12** relative to the body **10**, the cylindrical tank **18** is formed to provide a radially outwardly projecting boss or neck **21***b* surrounding each hole in the tank receiving the pins **21** and **21***a*, the outer ends of these necks **21***b* abutting the internal wall of the body **10**. The exposed ends of the pin **21** are shown as being flush with the outer peripheral surface of the body **10** and the exposed ends of the pin **21***a* are preferably slightly recessed from the outer peripheral surface of the body **10** so as not to possibly interfere with engraving of the outer shell or casing **14** when the projectile is fired from a rifled barrel.

The central or concentric location of the fuel container **12** within the front portion of the passage **11** in the body **10** provides an annular restricted air conduit **22** between the external and internal peripheral surfaces of the fuel container **12** and body **10**, respectively. This restricted air conduit **22** leads from the front of the projectile rearwardly to the combustion chamber **13** and is interrupted only by the radial necks **21***b*. It will be noted that the rear end head **20** of the container **12** provides the front wall of this combustion chamber **13**. The front end head **19** of this container **12** is shown as projecting forwardly of the outer body **10**. The forward extremity of the passage **11** is preferably flared outwardly as indicated at **23** to provide jointly with the conical front end head a slightly enlarged inlet for the air conduit **22**.

Fuel is arranged within the container **12** and to permit such fuel to be admitted to the combustion chamber **13**, an opening is provided in the container which provides communication between the interior of the container and the combustion chamber, this opening being normally closed by a closure which uncovers the opening when the projectile is in flight. Such opening is shown as being in the form of a series of circumferentially spaced holes or ports **24** provided in the fuel container **12** adjacent the combustion chamber **13** and preferably at the rear end of the side wall of the tank **18**. To insure the complete discharge of fuel from the container **12**, the internal chamber of the container **12** is shown as being frustoconical in the form with the larger end of the chamber adjacent the holes or ports **24** so that the fuel is ejected by centrifugal force derived from the rotation of the projectile. It will also be seen that the conical form of the interior of the end heads **19**, **20** for the container **12** also permits centrifugal force to act upon the fuel to move the fuel axially of the container toward the holes **24**.

Any suitable type of closure for uncovering the fuel outlet ports **24** when the projectile is launched can be employed. The operation of the closure to uncover these ports **24** can be induced by centrifugal force due to rotation of the projectile; by inertia upon launching the projectile; by temperature or pressure of the air or fuel developed by flight of the projectile; or by a combination of these factors. By rendering the closure operatively responsive to flight conditions, a closure operating mechanism is not required. The fuel discharge holes or ports **24** are shown as being closed by plugs **25** which are arranged to uncover these holes when the projectile is in flight. These plugs **25** are shown in the form of disks preferably made of metal which are releaseable from the ports **24** when acted upon by centrifugal force during flight of the projectile, thereby causing the metal plugs to uncover the holes or ports **24**. These plugs **25** are blown out of the rear of the projectile through the passage **11**.

The fuel employed in the fuel container **12** may be of any suitable type, either solid or liquid, but a liquid fuel such as kerosene or gasoline is preferred.

In FIG. 1, the ram jet projectile is shown as being mounted in the mouth of a propelling charge container or cartridge case **26** which is of conventional design although this cartridge case can be smaller and lighter than a conventional cartridge case for a conventional projectile of the same caliber as discussed hereinafter. The rim of the mouth of the cartridge case **26** is shown as being crimped into an annular groove **28** provided in the body **10**. This cartridge case contains a sufficient quantity of propellant which when ignited will force the projectile through the rifled barrel of the weapon and discharge the projectile at a high enough speed to permit the ram jet mechanism to operate and power the free projectile in flight. A closure **27** for the base or rear end of the projectile is provided so that satisfactory obturation is effected. This closure **27** is shown as being in the form of a tapered stopper fitted into the correspondingly tapered rear portion of the passage **11** and as having an enlarged head which abuts against the rear end of the body **10**, the diameter of this head being less than the diameter of the body **10**.

In traveling through the rifled barrel of the launching weapon, the projectile is caused to rotate about its longitudinal axis, this being effected by the exterior of the outer body **10** engaging the lands and grooves of the rifling and being engraved thereby. When free of the weapon, the closure **27** will be blown off the projectile by the air rushing through the passage **11** extending through the projectile.

It will thus be seen that the projectile is launched to rotate about its axis of flight and at a speed sufficient to set the ram jet mechanism into operation. The air conduit **22**, combustion chamber **13**, and throat portion **16** of the axial passage **11** in the projectile are of such form that air is compressed within the combustion chamber and a high static temperature is developed therein. Due to rotation of the projectile, centrifugal force acts upon the plugs **25** and removes these plugs from their fuel discharge holes or ports **24** and these plugs are blown out the rear of the passage **11**. The fuel discharge holes or ports **24** being so uncovered, centrifugal force causes fuel to flow from the container **12** into the air stream passing through the air conduit **22**. Thus a mixture of compressed air and fuel is admitted to the combustion chamber **13** where the static temperature is above the flash point of the fuel which causes the mixture to ignite. The products of combustion resulting from the ignition of the air and fuel mixture are exhausted from the combustion chamber **13** through the restricted throat opening **16** and in doing so exert a forward thrust on the projectile. This burning of the fuel continues until all the fuel in the fuel container **12** has been exhausted. Thus the projectile propels itself in flight at a speed equal to or greater than that which it had when it left the muzzle of the launching weapon.

It will be seen that by launching the ram jet projectile at an initial speed sufficient to develop a static temperature in the combustion chamber above the flash point of the particular fuel employed, no special ignition system is required to combust the fuel and air mixture.

Also it will be seen that flight conditions can be utilized to eject the fuel from the fuel container and therefore eliminate the need for any special fuel injection mechanism. This feature, plug self-ignition, is of particular importance in designing small caliber ram jet projectiles where space is limited.

A comparison of characteristics of a caliber .50 M2 projectile and a caliber .50 ram jet powered projectile designed as described above, is illustrated in the graph FIG. 5. This graph shows that the energy of the M2 projectile rapidly decreases whereas the energy of both the steel lined and aluminum lined ram jet projectiles embodying the present invention remains substantially constant until the fuel is exhausted, decreasing only slightly with increased range. Even with the aluminum lined ram jet projectile which is lighter in weight than the conventional M2 projectile, the terminal energy at 570 yards is greater with the former than with the latter. Further, the maxi-

mum ordinate of the ram jet projectile is less than that of the conventional M2 projectile and also the time of flight is less.

It will therefore be seen that a ram jet projectile, as compared to a conventional projectile of the same caliber, will deliver the same or greater impact energy; have a substantially constant and greater speed; deliver a substantially constant energy over a wide variety of ranges; have a shorter time of flight and a flatter trajectory; and requires a smaller propelling charge to achieve the above superior characteristics. Further, by reducing the recoil for launching ram jet projectiles, hand weapons of larger caliber than presently used can be designed.

The invention can be embodied in any form or size of projectile which is capable of being launched to develop flight conditions which will operate the ram jet mechanism. In this connection, it is not necessary that the projectile be launched to rotate about its axis of flight so as to employ centrifugal force to uncover the fuel discharge openings and eject the fuel therethrough, since other conditions developed by flight of the projectile can be employed to perform these functions.

I claim:

1. A ram jet projectile, comprising an elongated body adapted to rotate about its longitudinal axis in flight and having a passage extending axially therethrough, a fuel container arranged within said passage and secured to said body and forming a combustion chamber at the rear of said passage, said container being provided with an opening providing communication between said combustion chamber and the interior of said container, and a plug arranged in said opening and releasable therefrom into said passage when acted upon by centrifugal force during flight of said projectile thereby to uncover said opening and permit fuel to flow from said container.

2. In a ram jet projectile having an elongated body provided with a passage extending axially therethrough and a fuel container arranged within said passage, the combination therewith of means for mounting said container on said body, said means comprising pin members extending transversely through said container and each having its opposite ends anchored on said body to prevent longitudinal displacement of said pin members, said pin members being angularly arranged to each other and at longitudinally spaced locations along said container, and lugs projecting outwardly from said container at different circumferential and longitudinal locations and engaging the internal surface of said body to maintain an annular spacing between said container and body.

3. In a ram jet projectile having an elongated body provided with a passage extending axially therethrough and a fuel container arranged within said passage, the combination therewith of means for mounting said container on said body, said means comprising a pair of

pins extending transversely through said container and each having its opposite ends arranged in openings in the wall of said body, the outer extremity of each of said ends being upset to prevent axial displacement of said pins, said pins being arranged at substantially right angles to each other and at longitudinally spaced locations along said container, and outwardly projecting necks on said container and surrounding said pins at the places where said pins project from said container and abutting the internal surface of said body to maintain an annular spacing between said container and body.

4. In a round of ammunition including a propelling charge container having a mouth, the combination therewith of a ram jet projectile mounted in said mouth and adapted to be launched from a rifled barrel so as to rotate in flight and automatically feed and ignite fuel for ram jet propulsion of said projectile in flight, said projectile comprising an elongated body having a passage extending axially therethrough, a sleeve of relatively soft metal surrounding said body and engravable by the lands and grooves of said rifled barrel during launching to impart rotation to said projectile, a fuel container secured to said body and arranged within said passage in spaced relation to the interior of said body to provide an air conduit and forming a combustion chamber at the rear of said air conduit, said container being provided with an opening providing communication between said combustion chamber and the interior of said container, a closure for said opening and operatively arranged to be released into said passage in response to flight conditions obtaining when said projectile is in flight thereby to uncover said opening and permit fuel to flow from said container and be admitted into said combustion chamber, said air conduit and combustion chamber being formed to compress the air entering said combustion chamber through said air conduit and establish a temperature sufficient to ignite said admitted fuel, and a plug removably arranged in the rear of said passage and adapted to be blown out by the air rushing through said passage after said projectile is free of said rifled barrel.

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