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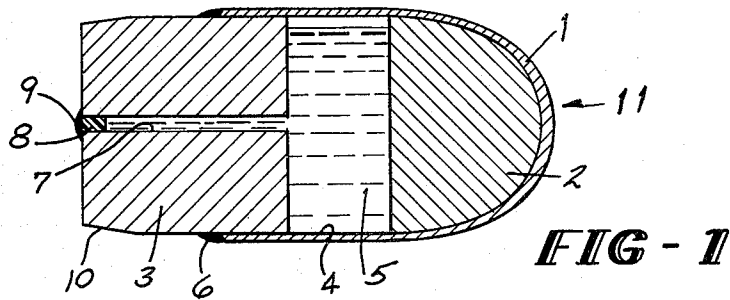
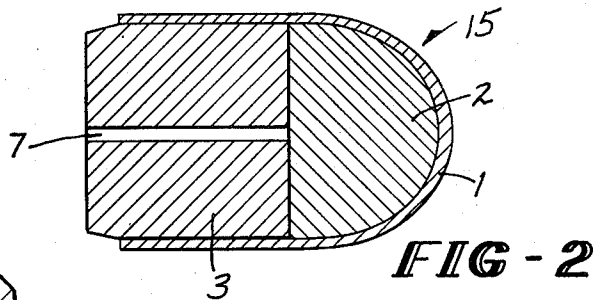
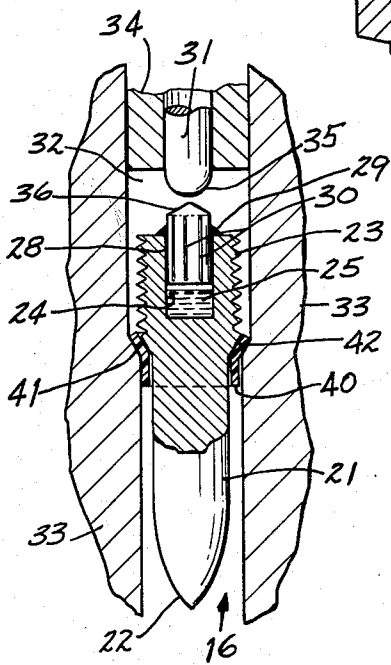
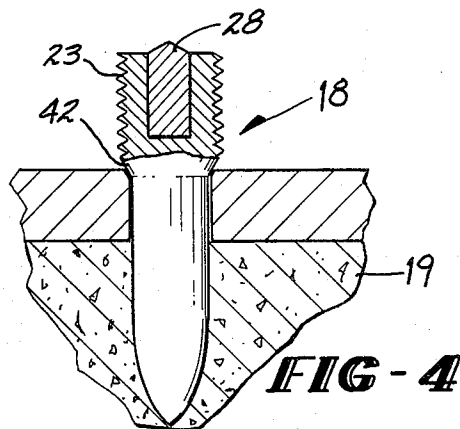
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LIQUID PROPELLANT PROJECTILE UNIT

Filed May 7, 1963

2 Sheets-Sheet 1



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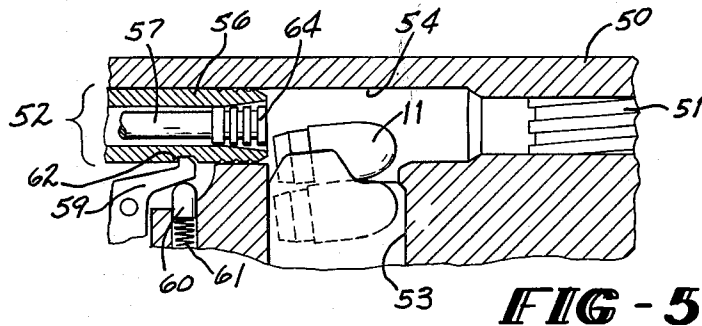
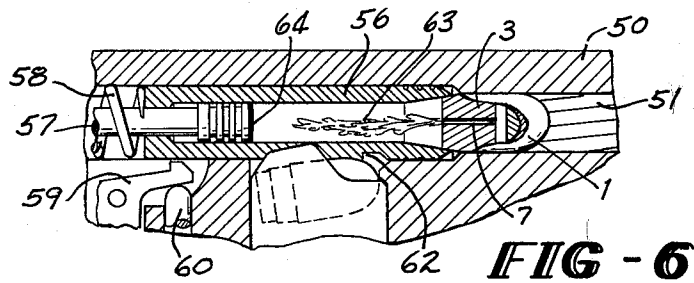
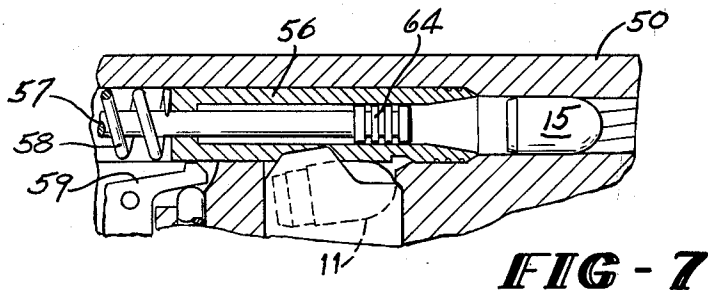
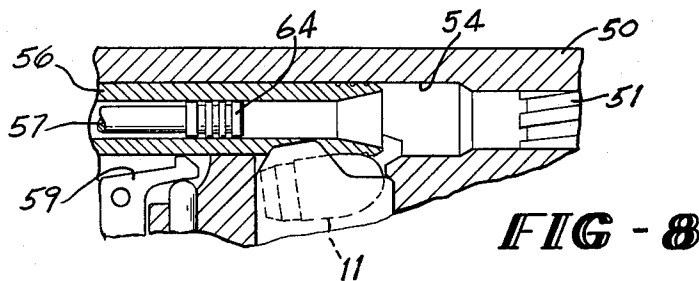
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2 Sheets-Sheet 2



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## LIQUID PROPELLANT PROJECTILE UNIT

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9 Claims. (Cl. 102—38)

This invention relates to an explosive driven unit and in particular to bullets and projectile-type fasteners each of which includes and uses a liquid propellant charge.

One object of this invention is to provide a relatively simple primerless type of bullet or projectile fastener which depends on adiabatic compression of gas in the compression chamber of a gun or tool barrel for ignition and explosive expansion of the propellant and thereby avoids need for carrying a propellant charge together with a priming mix separately from the bullet or other projectile unit.

Another object is to provide a simple projectile structure including a charge of mixed liquid alkyl nitrates, a pump piston, and a rupturable seal, all as an integral part of a projectile unit.

Another object is to provide a projectile structure having initially a cavity substantially filled with propellant, thereby avoiding need for additional cavity space for an adiabatically compressible gaseous phase for ignition of the propellant, but having finally a maximum projectable solid body of the desired caliber for projection through a barrel.

Another is a bullet or fastener with a liquid propellant charge, avoiding need for cartridge cases, their extraction or ejection, and also storage and metering devices.

Still another object is the provision of a bullet or fastener providing an accurate propellant charge together with a means for injecting that charge into the compression and firing chamber of a firearm or tool.

Still another object is the provision of a simple but rugged firing apparatus. The apparatus is capable of injecting the charge of liquid propellant in a compression chamber and of applying compression for ignition without the need for a propellant reservoir, for various fluid metering and valving parts, and for an apparatus pumper acting directly on the propellant with attendant deterioration.

Other objects and advantages will be evident from a description of various embodiments shown in the accompanying drawings in which:

FIG. 1 is a longitudinal view in cross section of a bullet according to this invention shown before firing;

FIG. 2 is a longitudinal view also in cross section of the same bullet shown after firing;

FIG. 3 is a longitudinal partly cross sectional view of a projectile type of fastener according to another embodiment of this invention shown before explosive driving in suitable driving apparatus only part of which is shown;

FIG. 4 is a view of the same fastener shown after it has been driven;

FIG. 5 is a fragmentary view of a suitable firing or driving apparatus according to this invention showing the parts and a bullet of the type shown in FIGURE 1 in the ready-to-fire position;

FIG. 6 shows the apparatus and bullet in chambering and pumping position;

FIG. 7 shows the apparatus and bullet during ignition; and

FIG. 8 shows the apparatus with certain of its parts being blown back by the burning propellant gases following ignition to put these parts into the ready-to-fire position again.

As shown in FIGURE 1 there is provided an embryonic

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bullet 11 consisting of the usual jacket 1 of a suitable copper base alloy, a solid front core section 2 usually of lead or an alloy of lead, and a rear core section 3 fitted snugly in the jacket and displaced rearwardly from the front section to provide a cavity 4 containing a charge 5 of a liquid monopropellant.

For example, in a typical 0.45 caliber bullet, a cavity volume and charge of about 0.5 of a cubic centimeter are contemplated; which is to say that the cavity is to be almost completely filled with an alkyl nitrate propellant, except for a few percent of volumetric capacity left to take up for thermal expansion and contraction of the liquid. A suitable liquid propellant is a mixture of ethyl nitrate and normal propyl nitrate. Specifically, 60 mole percent of ethyl nitrate admixed in normal propyl nitrate, and known as 60:40 EPN, was found to have the desired sensitivity and reliability from the standpoint of adiabatic compressive ignition and stability.

Projecting from the jacket and sealed in by the ring 6 of sealant such as solder or epoxy resin, the rear core section 3 has a central aperture 7 forming an ejection passage hermetically closed by a plug 8 of suitable consumable material such as polyethylene force-fitted into this tiny aperture to prevent loss of propellant before use. The closure 8, which may be further sealed and retained by the application of an epoxy adhesive 9 is adapted to rupture whenever the rear core section 3 is rammed forward by a thrust applied to the trailing end of the section at bevel 10 provided for the purpose.

After firing the projectile assumes the final form of the bullet 15 shown in FIGURE 2 where the sections 2 and 3 are put into abutment inside the jacket to provide a substantially solid bullet characterized by desirable external ballistic parameters.

Firing abolishes the cavity 3 and except for the presence of the remaining central aperture 7 the projected bullet 15 is quite conventional in appearance and behavior as compared to the embryonic forms 11.

The core sections may be of any suitable material such as steel, or a combination of materials to provide desired weight and/or hardness, balance, armour piercing properties, or mushrooming properties.

In FIGURE 3, the embryonic unit 16 is of a form suitable for assuming the final finished shape of the fastener 18 shown in FIGURE 4 driven into a supporting plate 19.

The unit has a main fastener section 21 of steel of suitable hardness and toughness having an ogivally tapered piercing point 22 and a threaded or otherwise formed and enlarged rear end 23, usually as shown to adapt section 21 for attachment of objects to the support. One end of the main section is recessed at the rear to form the propellant cavity 24 containing the EPN mixture 25 and partially containing the compression plug section 28 closing the cavity and retained in hollow section 21 frictionally and/or adhesively with the aid of a sealing ring of epoxy resin adhesive 29. In lieu of central passages, the plug section is provided with longitudinal serrations 30 forming passages around its cylindrical surface for ejection of the propellant when the seal 29 is ruptured as the plug section 28 is pushed in by ram 31 to fill the cavity 24 and drive the propellant out into the compression chamber 32 formed in tool barrel 33 around the ram between the fastener unit 16 and a compression plunger 34 coaxially mounted to slide forwardly with respect to ram 31 after the latter has completed its forward thrust against the fastener plug section.

Ram 31 and section 28 have convex faces 35 and 36, respectively, in juxtaposition to allow for application of the pressure of the ignited propellant against both sections of the fastener and avoid separation of them.

The serrations 30 take the form of preferably two or

three slots equally spaced about the circumference of section 28.

To chamber the projectile fastener unit 16 in the barrel 33 with a desired seal and a desired initial resistance and thereby provide confinement at the front end of the compression chamber, there is a tapered shot-start collar 40 forwardly converging to fit between the tapered tool shoulder 41 leading from the chamber to the barrel and the tapered fastener shoulder 42. The collar is made of a suitable plastically deformable metallic or plastic material such as soft aluminum, a 50:50 lead-tin alloy or a readily consumable polyolefin such as polyethylene. Alternately, the collar may be formed integrally as a thin readily deformable fin circumferentially extending out between the threads and the tapered shoulder. This, like the malleable metal and the combustible polyethylene, has the advantage of leaving no residual ring in the gun or tool barrel after firing.

In the gun device of FIGURES 5 to 8, shot start and sealing in barrel 50 is providing by ramming the projectile unit home to the beginning of the rifling 51 by means of the compound rifle bolt 52 part of which has a short stroke for picking the unit out of a magazine 53 and positioning it in gun chamber 54. The bolt, as in the driving device shown in FIGURE 3, has two coaxial parts, namely a bolt ram 56 sleeved about an inner propellant compression piston 57. These correspond, respectively, to ram 31 and plunger 34, FIGURE 3. The ram 56 is biased forwardly by the bolt coil spring 58 and is driven forwardly when the bolt sear 59, which is biased by sear follower 60 and its spring 61 into engagement with sear notch 62, is disengaged from the notch in response to the operation of the trigger (not shown). The driven ram then engages at bevel 10 with the piston section 3 of the bullet unit and rams the bullet jacket home while sealing off the gun chamber 54 from the magazine 53 by a sleeve valve action as shown in FIGURE 6. At this stage, there is formed a compression chamber 63 in the tubular ram between the bullet and the head 64 of the compression piston. Continued forward motion of the ram drives section 3 of the bullet forward to break seals at 6 and 9, and unseat plug 8 so that the rammed section 3 may act as a piston directly acting on the liquid propellant to get it through aperture 7 into chamber 63 as shown in FIGURE 6.

Further trigger action releases compression piston 57 to act on the mixture of liquid and gas for adiabatic compression of the latter and ignition of the former as shown in FIGURE 7.

This system allowing a closed breech is admirably suited to automatic recocking by "blow-back" action of the propelling gases acting on both the ram and the piston of the bolt after firing.

Entry of dirt is avoided since the system is closed and requires no outside ports continuously opening and closing with each shot for ejection such as occurs in systems using a cartridge case.

It will be understood that the bullet of FIGURES 1 and 2 need not be jacketed and that the front core section may be integral with the jacket shown. The bullet rear section may take either the centrally apertured form or the form of the uniformly serrated plug section of FIGURES 3 and 4. Likewise, these serrations providing passages at the outer surface of the plug may be replaced by a central passage for ejection of the propellant.

The means for sealing the ejection aperture is adherent to one of the unit sections and is rupturable at a predetermined ram force to release the propellant for adiabatic ignition.

In any event, the recess in the body section and also the plug section both are of complementary cylindrical configuration to adapt these for frictional retention yieldable under a forward thrust to allow telescoping action between the sections for decrease of the cavity volume and ejection of the propellant charge forcefully through the

ejection passage for relatively instantaneous fueling of the compression and combustion chamber.

As a safety feature, the cavities 4 and 24 are nearly completely filled with liquid, leaving insufficient volume unfilled for premature adiabatic ignition, in contrast with the compression chamber in the firing device where liquid propellant loading is from about 15 percent to about 45 percent of the initial volume. The liquid ejection ram of the bolt preferably has a somewhat slower stroke than the adiabatic firing compression piston.

What is claimed is:

1. An explosive projectile unit comprising a body section having a solid pointed front end and a hollow rear end having a cylindrical recess extending longitudinally from a body opening at the rear to a bottom surface in said body, a plug section of complementary cylindrical configuration slideably received in part and yieldably held in said recess and displaced rearwardly from said surface to define in said unit a longitudinal depth of cavity between said sections and an extension of said plug section protruding rearwardly from said opening, said extension being exposed rearwardly of said body section for impact with a plug section moving means, a charge of monopropellant substantially filling said cavity in the form of a flowable propellant, an aperture in at least one of said sections extending from said cavity to the rear of said unit for propellant ejection externally of the unit, and adherent means mounted on at least one of said sections for closing said cavity at said aperture rupturably at a predetermined pressure of said monopropellant developed as said plug section is moved against said bottom surface, whereby said unit is rendered substantially solid and projectable by subsequent ignition of the ejected charge of monopropellant.

2. The unit of claim 1 wherein the aperture is a central passage in the plug section and wherein the adherent means is in the form of a ring about said section and a closure member at said aperture.

3. The unit of claim 1 wherein the aperture consists of passageways uniformly distributed around the circumference of the plug section and wherein the adherent means is a ring around said section adjacent said passageways.

4. A bullet comprising a pointed body section having a jacket and a solid core portion filling the pointed front end of said jacket uniformly about a central axis, said jacket extending rearwardly of said front core portion to define a cylindrical recess extending centrally from a body opening at the rear to a surface of said front core portion, a rear core portion of complementary cylindrical configuration slideably received in part and yieldably held in said jacket centrally and displaced rearwardly from said surface to define in said bullet a depth of cavity between said portions and an extension of said rear portion protruding rearwardly from said opening by at least said depth adapting said extension for impact with a rear core portion moving means, a charge of alkyl nitrate mixture substantially filling said cavity in the form of a liquid propellant, at least one aperture in at least one of said jacket and rear portion disposed symmetrically with respect to said axis and extending axially from said cavity to the rear of said unit for propellant ejection externally of the unit, and means adherent to said jacket and rear portion symmetrically with respect to said axis for closing said cavity at said aperture rupturably at a predetermined pressure of said propellant developed as said rear portion is moved against said surface whereby said jacket and core portions are made a substantially solid bullet projectable by subsequent ignition of the ejected propellant.

5. The bullet of claim 4 wherein the charge of liquid propellant comprises about 60 mole percent ethyl nitrate and about 40 mole percent normal propyl nitrate.

6. The bullet of claim 4 wherein the aperture takes the form of a central passage in the rear core portion and

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wherein the means for closing said aperture rupturably includes an inserted consumable closure of combustible material.

7. The bullet of claim 6 wherein the closure is polyethylene and wherein the means adherent to the jacket and rear core portion is an epoxy resin.

8. An explosive projectable fastener comprising a body section having a solid pointed front end and adapted to penetrate a work surface, a hollow rear end having a cylindrical recess extending longitudinally from a body opening at the rear to a bottom surface in said body, said rear end including means for fastening an object to said surface, a plug section of complementary cylindrical configuration slideably received in part and yieldably held in said recess displaced rearwardly from said bottom to define in said fastener a depth of cavity between said sections and an extension of said plug section protruding rearwardly from said opening by at least said depth adapting said extension for impact with a plug section moving means, a charge of monopropellant substantially filling said cavity in the form of a flowable propellant, an aperture in at least one of said sections extending longitudinal-

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ly from said cavity to the rear of said unit for propellant ejection externally of the unit, and means adherent to said sections for closing said cavity and for closing said aperture rupturably at a predetermined pressure of said monopropellant developed as said plug section is moved against said bottom surface.

9. The fastener of claim 8 wherein the monopropellant is a liquid which comprises at least one alkyl nitrate such as ethyl nitrate, normal propyl nitrate, and the like.

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