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J. W. TREAT, JR
PROJECTILE PROPELLING SYSTEM

2,922,341

Filed Nov. 7, 1955

4 Sheets-Sheet 1

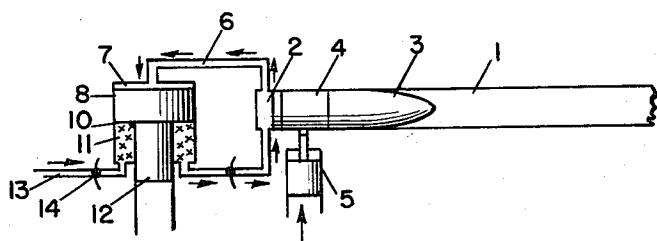


FIGURE 1

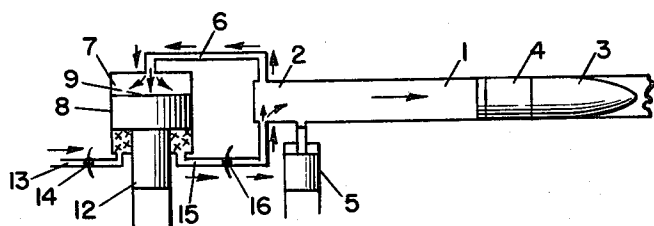


FIGURE 2

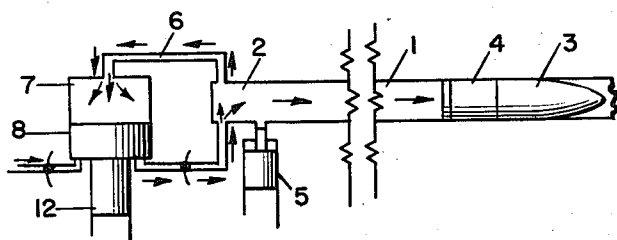


FIGURE 3

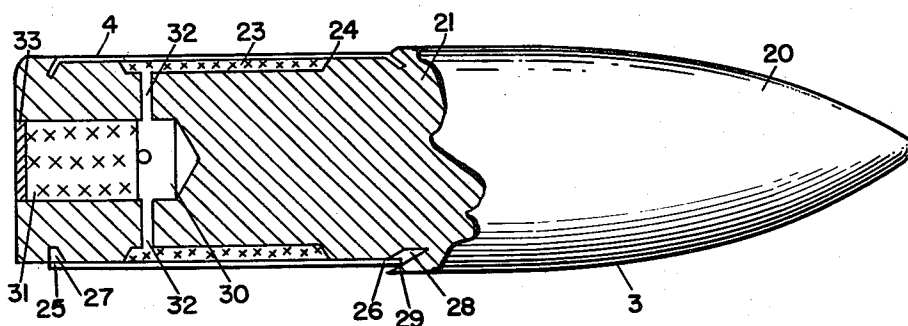


FIGURE 4

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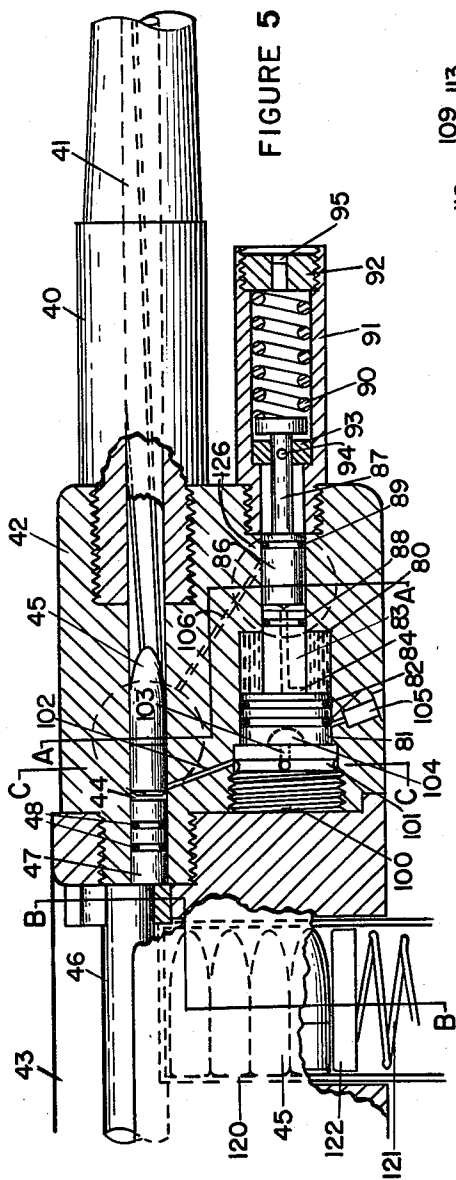
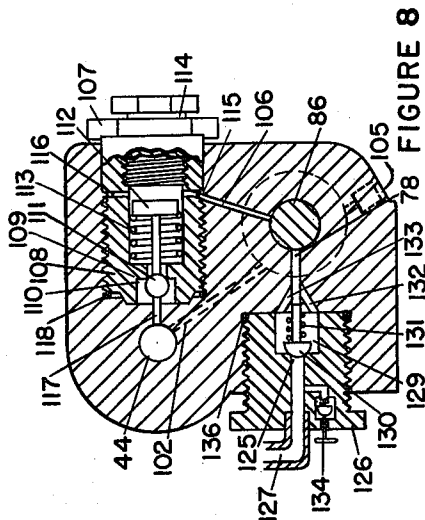
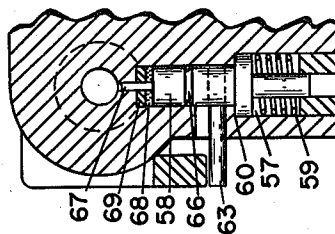
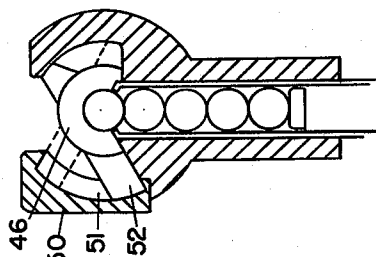
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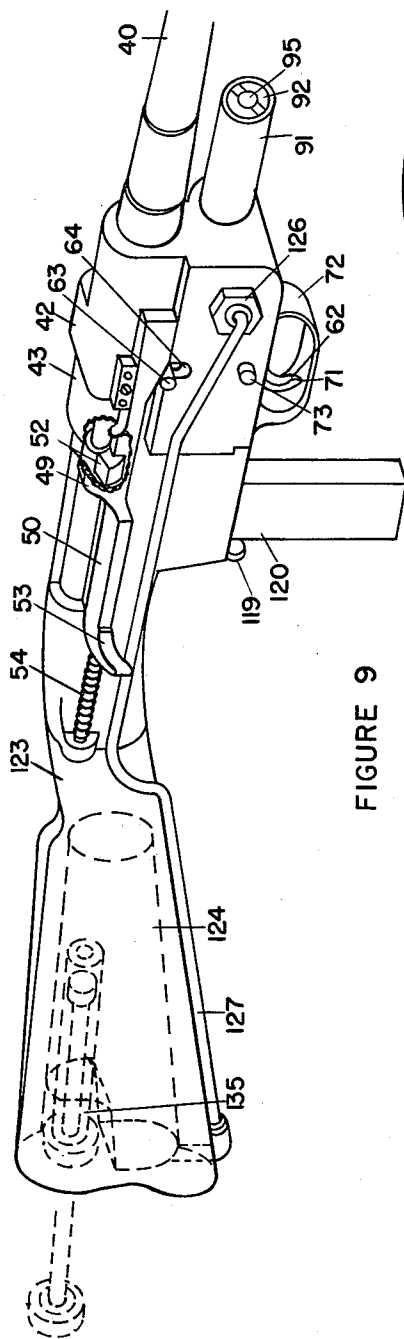


FIGURE 9

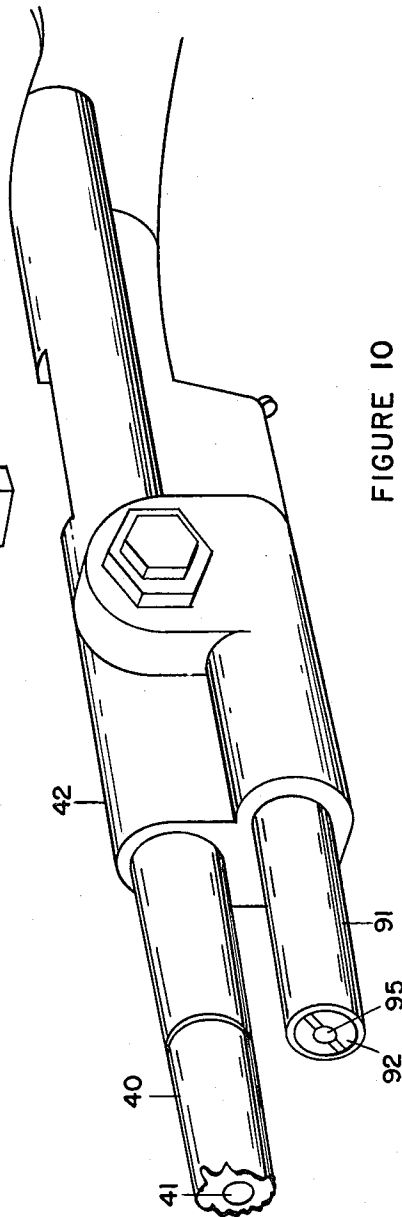


FIGURE 10

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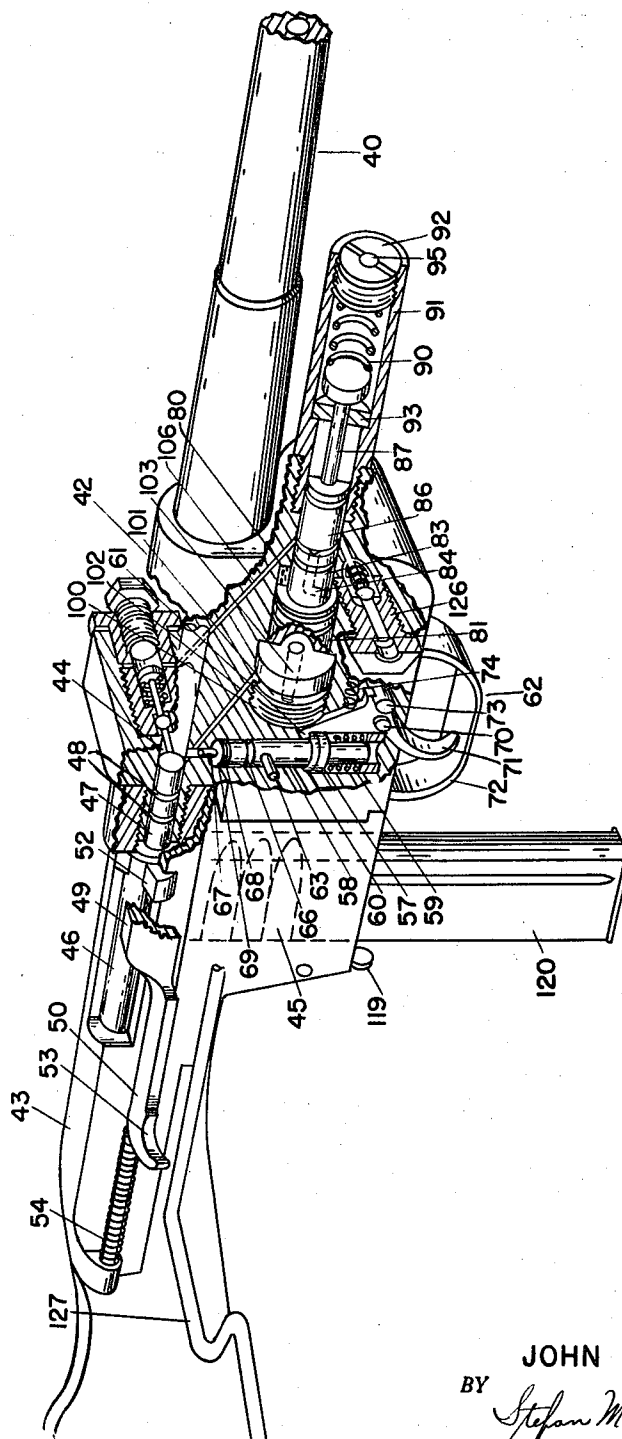
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PROJECTILE PROPELLING SYSTEM

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Application November 7, 1955, Serial No. 545,290

3 Claims. (Cl. 89—7)

This invention relates to an improved method and means for propelling a projectile with a liquid propellant and more particularly to a gun system capable of using liquid mono-propellant regeneratively injected into an initially dry chamber by pneumatic means initiated by a primer.

Heretofore, firearms employing liquid propellants generally were open-ended chambers, the open end being sealed by a caseless projectile. A liquid propellant having a high vapor pressure would be pumped into the chamber and then the mixture was ignited, generally with a spark plug to drive the projectile down the bore and out the muzzle of the gun. (See U.S. 1,343,456 and U.S. 1,359,295.) Due to difficulties in sealing the liquid propellant within the chamber and in ignition, these guns have never become popular. Solid propellant type guns employing cased ammunition, the case containing a percussion type primer were more popular because they were simpler and more convenient to use and required less complicated gun actions.

Several features possible with liquid propellants have, nevertheless, obviated complete abandonment of the production of liquid propellant type guns. The ease in storing and loading, the lack of a need for grain formation, the possibility of an easier means for effecting progressive burning or regenerative injection similar to that disclosed in U.S. 1,297,798 or U.S. 2,360,217 for solid propellants and other attractive features of a liquid propellant gun have always been the deterrent against its complete abandonment. But heretofore a successful gun system never proved feasible.

An object of this invention is to provide a novel method and means for propelling a projectile with a liquid propellant. Another object of this invention is to provide a propellant system for a firearm capable of using a mono-propellant as its main charge. Another object of this invention is to provide a propellant system embodying regenerative injection of the propellant so as to accomplish energy utilization of a high degree. A further object of this invention is to provide a propellant system having an adjustable regenerative injection rate. A further object of this invention is to provide a firearm using a liquid propellant with pyrotechnic ignition. Another object of this invention is to provide a firearm which commences operation from a dry chamber. Another object of this invention is to provide a firearm which, through its use of a dry chamber enables seals simpler than heretofore employed in liquid propellant type guns. Another object of this invention is to provide a liquid propellant system capable of adaptation upon all firearms regardless of type or size. A further object of this invention is to provide a gun embodying all the features in combination discussed above. And another object of this invention is to provide a liquid propellant type gun capable of being maintained in ready-fire condition for indefinite periods. Other objects will become apparent to those skilled in the art upon reading the following detailed disclosure and drawings in which:

Figure 1 discloses a schematic drawing of the system of this invention showing a cartridge in position to be fired, with the regenerative injection means ready to be activated.

Figure 2 is a schematic drawing showing the system just after the primer of the projectile has been ignited and the regenerative injection means beginning to operate.

Figure 3 is a schematic drawing showing the system as it appears at substantially the end of the metering stroke of the regenerative injection means.

Figure 4 is a broken perspective view of an embodiment of a projectile for use in the system disclosed in Figures 1 to 3.

Figure 5 is a partial side view of an embodiment of a gun utilizing the system disclosed in Figures 1 to 3 and the projectile disclosed in Figure 4.

Figure 6 is a cross sectional view of the gun shown in Figure 5 taken on line BB.

Figure 7 is a cross sectional view of the gun in Figure 5 taken on the line CC.

Figure 8 is a cross sectional view of the gun in Figure 5 taken on line AA.

Figure 9 is a right perspective view showing mostly the receiver and butt-stock structure of the gun of Figure 5.

Figure 10 is a left perspective view of the receiver and adjacent parts of the gun of Figure 5.

Figure 11 is a broken perspective view of the parts shown in Figure 9.

The objects of this invention are accomplished, broadly speaking, by a gun system using an initiating charge which upon being ignited, preliminarily acts upon a metering piston through the force of its gases to cause an injection of liquid propellant into the chamber of the gun. This liquid propellant then is ignited and the force of its gases drives a projectile out the bore of the gun. More particularly speaking, the objects of this invention are accomplished with the use of a gun which at the outset ignites an initiating charge to generate gas, the pressure of which is used to start the action of the gun. The force of the gases preliminarily drives a metering differential area piston which forces liquid propellant by an adjustable piston stroke into the dry chamber of the gun. The liquid propellant is ignited from the flame of the burning initiating charge and, therefore, generates additional gas pressure. This gas pressure not only drives a projectile out the bore of the gun but also drives the metering piston to the end of its stroke. Hence as the projectile travels down the bore of the gun, regenerative injection of the propellant occurs thereby enabling a desirable pressure-time relationship of the projectile travel in the gun. The employment of a dry chamber enables not only simpler seals but also the possibility of maintaining the gun in ready-fire position without fear of leakage or corrosion of the chamber by the liquid propellant. The desirable advantages of pyrotechnic ignition as well as the use of a monopropellant are other features of this invention.

Referring to Figures 1, 2 and 3 which disclose broadly the gun system of this invention, there is shown a bore 1 of a gun. Within the rear section of the bore is a chamber in which is shown a projectile 3 about to be fired. The projectile has a band 4 around its base which covers a primer shown in more detail in Figure 4. The projectile shown is fired by a firing pin 5, which hammers against band 4 of projectile 3 to cause ignition of a percussion sensitive primer, the flash of which ignites an initiating charge within the projectile. It should be noted that other ignition means such as electrical means, separate initiating means within the gun itself and the like may be employed and obviously under such conditions there will be modifications required in the manner of igniting the initiating charge. Leading from the chamber is a gas port 6 which communicates with

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one end of a metering chamber 7. Within the metering chamber is contained a differential area piston 8, the larger area 9 of the piston facing the inlet of the gas port 6. The smaller area 10 of the piston 8 is on the opposite side and contacts liquid propellant 11 contained within the metering chamber 7. The smaller area is effected by integrally attaching a guide rod 12 to the liquid propellant face 10 of the piston. This guide rod acts to guide the proper movement of the piston. The liquid propellant is passed into the metering chamber through inlet 13 containing check valve 14 which only permits flow into the chamber. The liquid propellant containing section of the metering chamber communicates with injection port 15. Port 15 communicates with the chamber 2 of the bore 1, and contains a check valve 16 which again only permits flow into the chamber of the bore.

The operation of the projectile propelling system shown in Figures 1, 2 and 3 begins with the loading of projectile 3 into the chamber 2 of the bore 1 and the filling of the metering chamber 7 with the liquid propellant 11. The projectile 3 contains a percussion type primer and an initiating charge. The firing pin 16 is activated to strike the band 4 of the projectile 3 thereby igniting the primer and the initiating charge of said projectile. Gases from the burning initiating charge travel into the chamber 2 and through gas port 6 into cylinder 7. In the cylinder they act upon the metering piston 8 and force the liquid propellant out through injection port 15 into the heretofore dry chamber 2. As the propellant enters into the chamber, it is ignited by the flame and heat of the burning initiating charge of projectile 3. Its ignition causes an increase in the gas pressure of the chamber as well as in the gas port 6 and metering chamber 7. This increase in gas pressure exerts a continuous increasing force against the piston 8 thereby metering the propellant 11 into the chamber 2. Also as the pressure increases and simultaneously with the propellant injection process, the projectile 3 is forced down the bore 1. This illustrates the regenerative injecting action of the system from an initially dry chamber state.

In Figure 4 there is shown an embodiment of a typical projectile for use in a gun such as seen in Figures 5 to 12 which uses the projectile propelling system of this invention. The projectile shown is of standard design having an ogival nose portion 20 and a cylindrical body portion 21. The rear portion of the projectile body has a narrower diameter in order to accommodate a ring or tubular band 4 which covers a percussion type primer 23 contained within a wide but shallow groove 24 encircling the periphery of the body portion 21. The band 4 is fastened to the projectile by crimping its end portions 25 and 26 inwardly into oblique channels 27 and 28 respectively upon the body of the projectile. Tab 29 of the projectile is then crimped inwardly upon the crimped end portion 26 of the band 4. The projectile has an axial cavity 30 in which is contained an initiating charge 31. Radially extending flash ports 32 communicate the axial cavity 30 with the primer groove 24. The rear end of the cavity 30 is sealed with rupturable and consumable disc 33.

The projectile of Figure 4 is fired by percussion of a firing pin against band 4. This ignites the primer 23 and its flash travels down flash ports 32 and contacts initiating charge 31. After ignition of the initiating charge by the primer flash disc 33 is ruptured and consumed. The gases from the burning initiating charge are used to initially operate the propelling system as described above and as will be described more fully below with reference to a gun employing the projectile shown.

With modifications the system of this invention could employ other type shells. For example, the caseless projectile disclosed in copending patent application entitled "Ignition System," Serial Number 415,537 filed March 11, 1954, now abandoned, could be used if the shell were

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adapted to hold an initiating charge for initially activating the metering piston of this system. If desired, one could use cased ammunition in which the case contains the primer and the initiating charge and the projectile is a standard solid slug of metal. Obviously, there are other useful projectiles that would be operative.

Figures 5 through 11 illustrate a particular embodiment of a rifle employing the projectile propelling system of this invention. Obviously, other rifles employing the system could be formulated.

The rifle shown in these figures has a barrel 40 with an axial rifled bore therein. The rear end of the barrel is threaded into a receiver extension 42 which in turn is threaded into a receiver 43. The receiver extension has a chamber 44 into which a projectile 45, similar to that shown in Figure 4, may be inserted. Chamber seal 47 of bolt 46 seals the rear end of the chamber. The chamber seal 47 has seal rings 48. Bolt 46 is capable of reciprocable movement within receiver 43. Bolt operating section 49 of operating rod 50 contains an angular cam slot 51, the surfaces of which act to operate the locking lug 52 of the bolt 46. Rearward movement of the operating rod 50 (see Figures 6 and 9) lifts the locking lug 52 to unlock the bolt. Complete forward movement swings the locking lug 52 down to lock the bolt (see Figures 5 and 11). The rod 50 has a finger piece 53 and is spring biased forwardly by an operating rod spring 54. The spring acts to keep the bolt 46 in battery position through the action of the operating rod 50.

Within a vertically disposed annular cavity 57 in the receiver extension 42 is a firing pin 58 spring loaded upward by a firing pin spring 59 when the pin is cocked. The pin is cocked when its cocking shoulder 60 is engaged by the sear shoulder 61 of trigger 62. A firing pin cocking cam pin 63 extends horizontally outward from firing pin 58. It is engaged by an oblique cam surface 64 on the undersurface of the forward section of the operating rod 50. The firing pin is depressed downward on the rear or cocking stroke of the operating rod. Around the forward surface of the firing pin body is an annular groove 66 which acts as a gas seal. The primer striking portion 67 of the pin 58 is of small diameter. Resting upon the shoulder between the body and the primer striking portion 67 of the firing pin 58 is a washer 68 of resilient material such as rubber, neoprene and the like and a metallic washer 69. (See Figure 6.) These act as the primary seal against leakage downward from the chamber into the firing pin cavity.

The trigger 62 is contained within the receiver extension 42 and is pivoted about trigger pin 70. The finger piece 71 of the trigger extends into a space enclosed by trigger guard 72. A trigger spring 74 normally spring biases the trigger in a counter-clockwise fashion about trigger pin 70. A conventional notched cross bar safety 73 can operate upon the trigger to prevent its movement.

In a forwardly extending horizontal cavity 80 forward of the trigger and firing pin assemblies is a gas metering and injection system. The system consists of the cavity 80 which is the cylinder. Within the cavity is a piston 81 having seal rings 82. Extending forwardly from the piston 81 is a hollow tubular guide rod 83 having propellant port 84. A needle valve 86 disposed between guide rod 83 and metering plunger 87 acts as a flame arrestor and closes off the forward end of the hollow opening of the guide rod until the needle valve is pushed forward past port 106 and the needle valve have seal rings 88 and 89 respectively at their front ends to prevent leakage. Seal ring 88 prevents forward leakage of the liquid propellant into the needle valve cavity. Seal ring 89 prevents forward leakage of the propellant gases that may travel down port 106 and of liquid propellant into the plunger and plunger spring cavity. The plunger 87 which bears against the needle valve member is spring biased rearwardly by a plunger spring 90. The spring and the plunger are normally housed within a plunger housing.

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91 which is threaded into the receiver extension 42 beneath the barrel 40. The forward end of the plunger housing is plugged by a threaded plunger housing plug 92. A bushing 93 around the neck of plunger 87 acts as a guide upon the stroke of the plunger. Vents 94 and 95 relieve any pressure built up within the plunger housing.

Cavity 80 within the receiver extension is sealed at its rearward opening by a threaded plug 100 (see Figures 5 and 12 especially). The plug has a peripheral groove 101 into which gas port 102 enters. The port directs propellant gases from the chamber 44 into groove 101. After entering into groove 101, the gases are directed against metering piston 81 by plug gas port 103. In order to increase the effectiveness of the gases in moving the piston 81 forward, a pocket 104 may be cupped into the head of the piston. Plug 105 seals the hole that was required to be made for drilling gas port 102.

Needle valve 86 acts as a flame arrestor preventing flame that may travel down port 106 from contacting the propellant charge in the compression chamber 80. Propellant port 106 leads from the needle valve cavity into valve assembly 107 (see Figures 8 and 11 especially). When the needle valve is pushed forward past the opening of the port, the liquid propellant flows upward into the port 106 and into the valve assembly. The valve assembly has a threaded tubular member 108. The tubular member has an annular shoulder 109 within its axially located cavity 110 which acts as a stop against ball 111. Ball 111 is detachably secured to a plunger 112 which is spring biased outwardly from the shoulder 109 of the annular cavity by valve spring 113. This spring biasing outwardly seats ball 111 upon the axial opening of the shoulder 109. Plug 114 is threaded into tubular member 108. A peripheral groove 115 around the tubular member 108 with radial ports 116 lead the propellant into the interior of the tubular member. Injection port 117 extends from the ball portion cavity of the tubular member 108 to the chamber 44 of the gun. A seal 118 prevents leakage around the threads.

The metering piston 81 is loaded with liquid propellant through an injection port 125. This port is within a threaded nipple 126. A propellant supply conduit 127 connects the tank 124 with the port 125. At the inner end of the nipple is a counterbored cavity 129 in which is contained a check valve 130 biased by spring 131. Ports 132 and 133 lead into the volume enclosed by the needle valve 86 and metering cavity 80. An air bleed valve 134 vents the volume of the propellant supply conduit 127 and part of the volume of the injection port 125 on the outer side of the check valve 130.

Within the receiver 43 and to the rear of the metering assembly in the receiver extension 42 is a magazine 120 in which caseless projectiles 45 are stored until use. A magazine spring 121 and a magazine follower 122 force the projectiles 121 upwardly in dispensing fashion to the bolt 46. The magazine is held in place by a magazine catch 119.

Within gun stock 123 is contained a tank 124 for storage of liquid propellant (see Figure 9). The propellant within the tank is transferred to the metering assembly of the gun by pressure induced within the tank through operation of a hand operated pressure pump 135. This pressure forces the liquid propellant out through supply conduit 127, into the injection port 125 of the gun and then into the propellant chamber 85 of the metering cavity 80.

To operate the gun of Figures 5 to 12, tank 124 within gun stock 123 is first loaded with liquid propellant. A magazine 120 containing caseless projectiles 118 of the design shown in Figure 4 is inserted into the magazine opening with the receiver 43. Magazine catch 119 holds the magazine in place. Trigger safety is placed in an "on" position. The liquid propellant in tank 124 is next pumped into metering cavity 80 by hand operation

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of pressure pump 135. The pump builds up pressure within the tank forcing the propellant out through supply conduit 127 through the injection port 125 and into metering cavity 80 shown in Figure 5. The pressure in the tank may be built up to the point that hand pumping will only be required after a series of rounds have been fired—the number of the series depending upon the pressure. Use of the reciprocating actions of the bolt could also be used to maintain the pressure between the injection port 125 and cavity 80, the propellant flows through check valve 130 (see Figure 8) through ports 132 and 133 (see Figure 8) and into the compression chamber of the metering assembly by feed port 78. Feed port 78 leads directly from ports 132 and 133 into the compression chamber. The propellant supply conduit is bled free of air when first firing by air bleed valve 134. Next operating rod 50 is pulled rearwardly. This movement cocks the firing pin 58 by action of cam surface 64 of the rod acting against cocking cam pin 63 to depress the firing pin against spring 59. The sear shoulder 61 of the trigger 62 engages the cocking shoulder 60 of the firing pin when the pin is sufficiently depressed downwardly. Movement of the operating rod also causes unlocking of the bolt 46 by swinging locking lug 52 upwardly through action of angular cam slot 51 of the rod 50, and rearward movement of the bolt. Upon release of the rod 50, operating rod spring 54 causes forward movement of the rod and bolt. A caseless projectile is swept off the top of the stock of caseless projectiles of the magazine and into the chamber 44 of the receiver extension 42. The bolt is locked at the completion of the reload stroke by action of cam slot 51 upon locking lug 52.

The gun is fired by placing the safety 73 in an "off" position and pulling the finger piece 71 of the trigger 62 rearwardly. This causes the sear shoulder 61 of the trigger to release the cocking shoulder 60 of the firing pin. The pin is driven by force of firing pin spring 59 into the band of projectile 45. The percussion type primer 23 under the band 22 is thereby ignited (see Figure 4). The flash from the ignited primer 23 travels through flash holes 32 and onto the initiating charge 31. The initiating charge becomes ignited and in burning generates gas pressure which travels through gas port 102, groove 101 of plug 100, plug gas port 103 and into pocket 104 of the metering piston 81. The metering piston is driven forwardly by these gases against the force of the plunger spring 90. As this occurs, liquid propellant contained in propellant chamber 85 is driven out of said chamber through port 84, through the cavity of guide rod 83, and into the volume rearward of the needle valve 86. When the needle valve 86 is driven forwardly past port 106, the propellant is driven upwardly through propellant port 106, through the valve assembly 107 and then into the chamber 44 of the gun. In the valve assembly 107, the propellant flows around tubular member 108, in groove 115, then into radial ports 116, around plunger 112, against ball 111 and through injection port 117. After entering into the chamber, the propellant burns generating additional gas pressure which is used to continue the injection system just described and to drive the projectile 45 out the bore 41 of the gun. This continuous injection of the propellant as it burns and as the projectile travels is known as regenerative injection. It should be noted that the chamber 44 was initially in a dry state until the burning initiating charge 31 caused injection of propellant into said chamber. By adjustment of the force of spring 90 through plug 92, the metering rate can be controlled for optimum energy usage of the propellant. In use, monopropellants are operable because burning is already present in the chamber when said propellant is used.

Obviously, the projectile propelling system is useful for all caliber weapons. Other designs for the gun and the projectile including the manner of ignition, type of projectile employed, the valve arrangement of the metering

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system, the liquid propellant storage system, adaptation to automatic operation and other features not recited are possible and can be made without departing from the spirit and scope of the invention as set forth in the appended claims.

The invention having thus been described what is desired to be secured by Letters Patent is as follows:

1. A liquid propellant gun comprising a receiver, a receiver extension fixed to said receiver and containing a chamber, ignition means, a liquid propellant metering assembly, a barrel fixed to the receiver extension, a reciprocating bolt operable to seal one end of the chamber, a projectile operable to seal the opposite end of the chamber and a liquid propellant supply, said metering assembly including a metering cylinder and a metering piston, one face of the piston cooperating with the cylinder to define a metering cavity, the opposite face of the piston cooperating with the cylinder to define a pressure pocket, conduit means connecting the metering cavity with the chamber and connecting the chamber with the pressure pocket, a one-way valve disposed in the metering cavity conduit means effective to permit fluid flow in circulatory fashion from the metering cavity to the chamber and thence to the pressure pocket whenever the piston is moved in a direction which tends to pressure fluid within the metering cavity.

2. A liquid propellant gun comprising a receiver, a receiver extension fixed to receiver, a projectile and a liquid propellant supply, a barrel fixed to the receiver extension, a bore extending through the barrel and the receiver extension, a bolt cavity formed in the receiver and inter-

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secting the bore, a reciprocating bolt disposed within the bolt cavity and operable to seal one end of the bore, said projectile being effective to seal the opposite end of the bore, said receiver extension containing an ignition means and a liquid propellant metering assembly, said assembly comprising a metering cylinder, a differential area piston disposed in the cylinder and carrying a tubular guide rod, a conduit leading from the bore to one side of the piston, a second conduit leading from the opposite side of the piston through said guide rod to the bore and means for introducing propellant to the opposite side of the piston, said second conduit containing a flow control means.

3. A liquid propellant gun as defined in claim 2 wherein the flow control means comprises an adjustable needle valve.

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