Dec. 20, 1960 L. A. SKINNER 2,965,000

LIQUID PROPELLANT, REGENERATIVE FEED AND RECOILLESS GUN

Filed Nov. 7, 1951 2 Sheets-Sheet 1

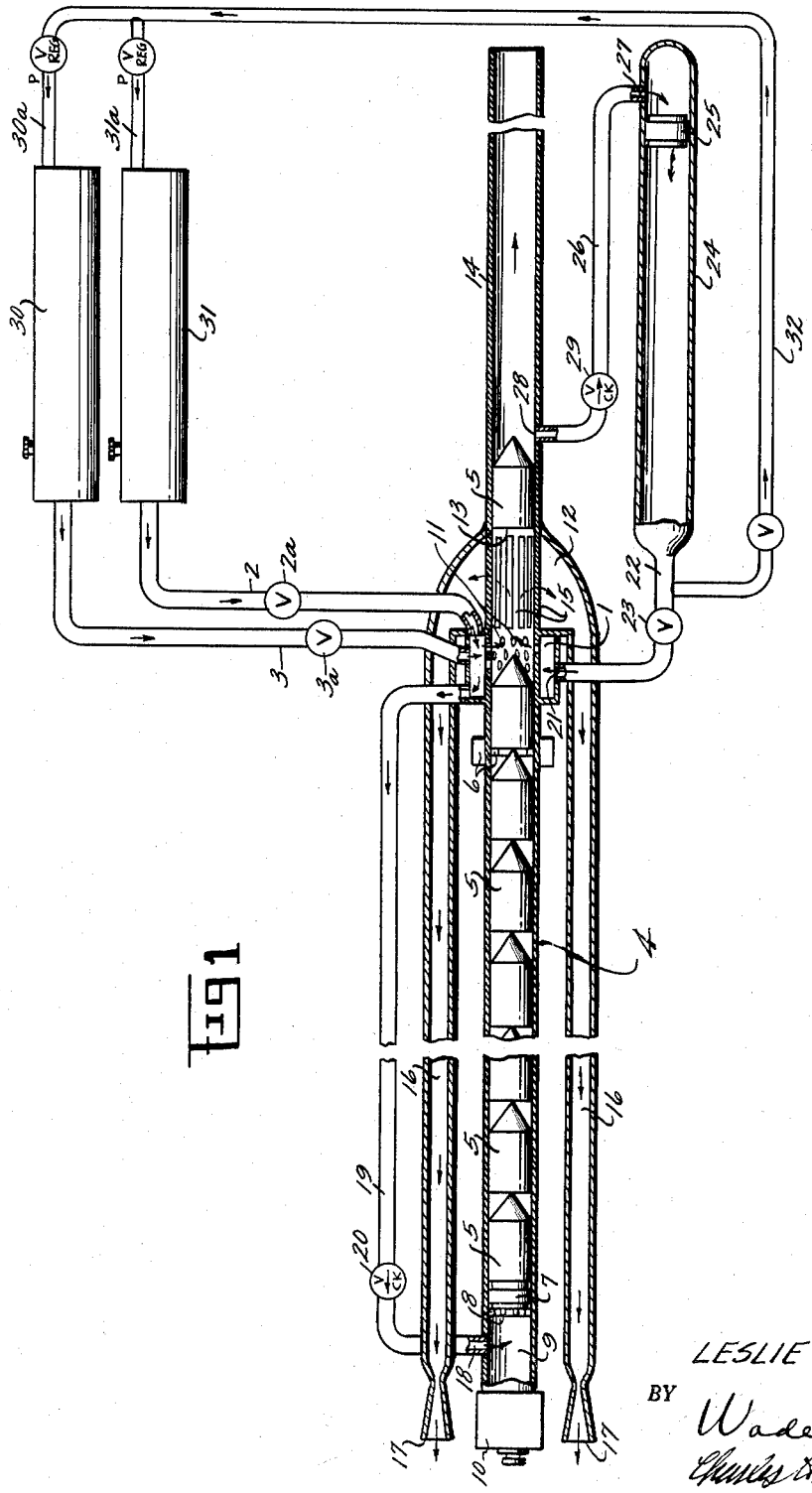


Fig. 1

INVENTOR.
LESLIE A. SKINNER

BY Wade Koontz and Charles H. Wagner
ATTORNEYS

Dec. 20, 1960 L. A. SKINNER 2,965,000

LIQUID PROPELLANT, REGENERATIVE FEED AND RECOILLESS GUN

Filed Nov. 7, 1951 2 Sheets-Sheet 2

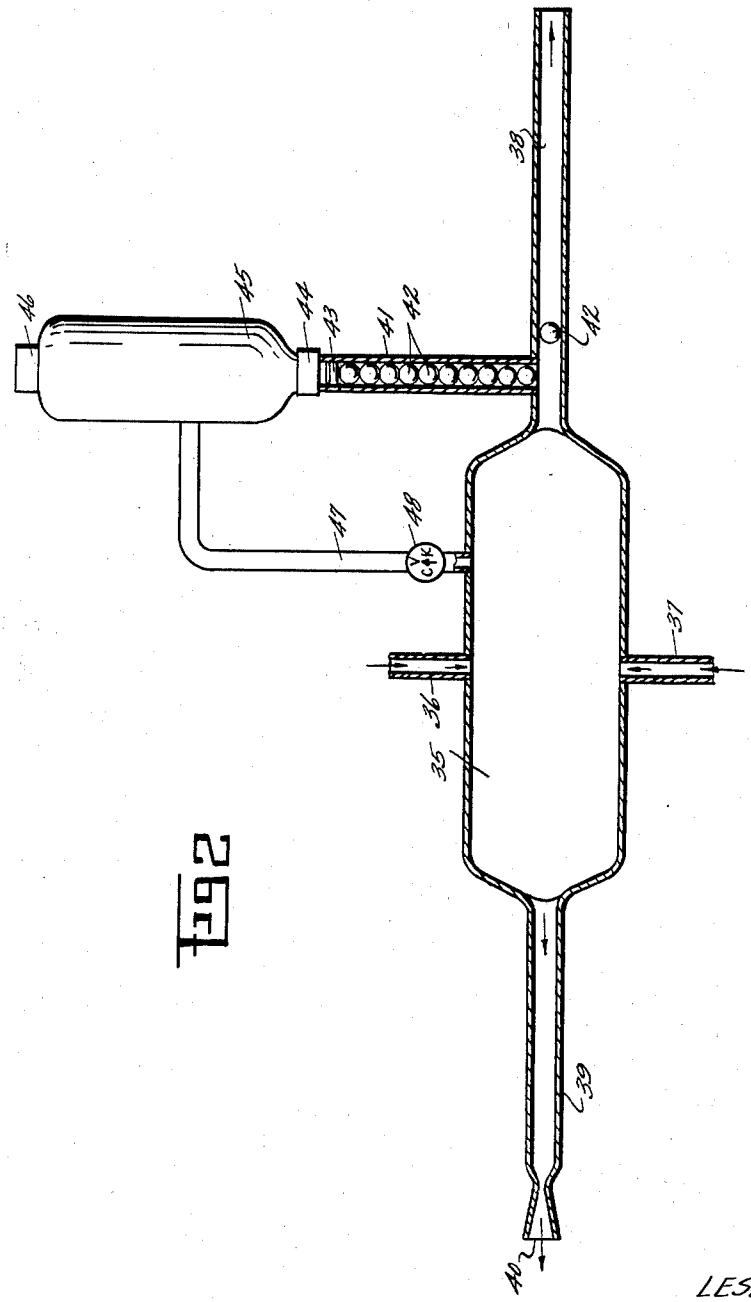



Fig 2

INVENTOR.
LESLIE A. SKINNER

BY

Wade Kooney
Charles H. Wagner Jr.
ATTORNEYS

United States Patent Office 2,965,000
Patented Dec. 20, 1960



2,965,000

# LIQUID PROPELLANT, REGENERATIVE FEED AND RECOILLESS GUN

Leslie A. Skinner, 5024 Nebraska Ave. NW., Washington, D.C.

Filed Nov. 7, 1951, Ser. No. 255,294

8 Claims. (Cl. 89—1.7)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention herein described may be manufactured and used by or for the Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to recoilless guns, intended primarily for use in military aircraft, employing liquid propellants and has for an object the provision of a gun having simplicity of design, light-weight, high cyclic rate of fire, employing large caliber shells and having a form suited especially to fixed mounting in aircraft, having conventional gun accuracy of fire with very low or complete lack of recoil.

The invention utilizes a thin walled gun tube or barrel and employs liquid propellants of the hypergolic types for creating the operating pressures for discharging the projectiles from the gun barrel or tube and actuating the repeated firing or automatic operational cycles of the gun. The gun includes enlarged gas or combustion and pressure chambers at the inner end of the gun tube with gas exhaust conduits or tubes extending rearwardly from the pressure chamber having restricted gas discharge nozzles at their rear ends for counteracting recoil.

A projectile feeding magazine is connected at its rear end to the combustion chamber by a pressure supply conduit for introducing pressure chamber pressure into the projectile feeding tube behind the projectiles so as to feed them into the gun tube one at a time, a check valve being interposed in the connection, a pressure regulator being provided to control the maximum projectile feeding pressure. Holding means is provided in the feeding tube for retaining the projectiles in the feeding tube against rearward movement while projectiles are being discharged from the gun barrel or tube, also while pressure is built up in the gun tube for subsequent discharge of a projectile therefrom.

The maximum regulated pressure in the rear end of the projectile or shell feeding magazine tube is employed, following a discharge of a projectile or shell from the gun tube, so that when a reduction of the pressure in the combustion chamber below the pressure in the tube occurs the differential pressure projects a fresh shell from the feeding tube into the gun tube.

Means are provided for introducing hypergolic liquid propellants, such as aniline and an oxidizer such as nitric acid, or $H_2O_2$ and alcohol and water, or $NO_2$ plus alcohol or $NO_2$, or Hydrazine ($N_2H_4$), or $H_2O$ and $NH_3$, or many others of adequate energy and logistic properties, into the combustion chamber to build up and maintain the projectile discharging pressure within the gun tube and pressure chamber and to maintain a predetermined pressure differential between the combustion chamber and the shell feeding magazine for feeding a projectile from the magazine tube into the gun tube each time a projectile is discharged from the gun tube or barrel, means being also provided for storing up an initial gas pressure for initiating the firing cycle of the gun.

The principle of operation of my automatic gun device



is to maintain a predetermined minimum working pressure in the combustion and pressure chambers at all times during the operation of the gun by feeding hypergolic liquid propellants into the combustion chamber at predetermined rates to produce this pressure and conveying this pressure into a pressure chamber at the rear end of the shell feeding magazine tube behind a piston therein for feeding or advancing the projectiles forwardly toward the gun barrel or tube, a pressure regulator being provided in the magazine tube for maintaining the projectile feeding tube pressure at a predetermined value which is slightly higher than the minimum combustion chamber pressure, whereby when a projectile is fed forwardly by the above differential minimum pressures into the gun tube the projectile will temporarily block the gun barrel to permit the combustion chamber pressure to build up to a predetermined maximum working pressure for driving the projectile through the gun barrel. The exhaust nozzles at the rear ends of the rearwardly extending exhaust tubes from the combustion chamber are so proportioned relative to the area of the gun barrel to minimize the recoil caused by gases being discharged forwardly through the gun barrel following each discharge of a projectile or shell.

Other objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawings in which like reference characters refer to like parts in the several figures.

*Drawings*

Figure 1 is a somewhat schematic longitudinal sectional view through an improved gun construction incorporating my invention.

Figure 2 is a schematic longitudinal sectional view through a slightly modified form of liquid hypergolic propellant actuated gun, incorporating my invention.

Referring to Figure 1, the reference number **1** denotes a combustion or fuel mixing and burning chamber having liquid propellant supply conduits **2** and **3** connected thereto for supplying hypergolic propellants into the combustion chamber **1** in desired quantities or at desired rates. Suitable control valves **2a** and **3a** may be provided for controlling the rates of delivery of the propellants into the combustion chamber **1**. These valves may be of the conventional pressure controlled or regulated types.

The combustion chamber **1** surrounds the forward end of a projectile or shell feeding tube or magazine **4** which is adapted to receive a plurality of projectiles or explosive shells **5**, the length of the tube **4** being determined by the number of projectiles to be handled therein. Latch or holding means **6** is provided for engagement with the first of the shells **5** in the magazine tube **4**, preferably at its rear end, to prevent rearward movement of that shell once it has been advanced into the forward end of the magazine tube **4**. A piston or follower member **7** is disposed in the rear end of the magazine tube **4**, stop means **8** being disposed in the magazine in the rear of the piston **7** to prevent rearward travel of the piston beyond the position shown in Figure 1 leaving a gas pressure chamber **9** between the piston **7** and the rear end of the magazine tube **4**. A maximum pressure regulating valve **10** is disposed in the closure for the rear end of the tube **4**, this valve is adjusted to limit the maximum pressure in the chamber **9** operable against the piston follower **7**.

Ports or apertures **11** are formed in the front end of the magazine tube **4** and lead from the combustion chamber **1** through the front end of the magazine tube **4** into the gun pressure chamber **12**, the front end of the pressure chamber **12** having an opening **13** in communication with a gun tube or barrel **14** disposed in axial

alignment with the magazine tube 4 with its rear end spaced from the forward end of the magazine tube 4. Projectile or shell guide bars 15 may be provided to bridge the gap between the adjacent spaced ends of the magazine feeding and gun tubes 4 and 14 for guiding the shells into the breech end of the gun barrel.

Extending rearwardly at opposite sides of the magazine tube 4, from the gun pressure chamber 12, is a pair of recoil absorbing exhaust tubes 16, each tube having a restricted discharge nozzle 17 facing rearwardly. The exhaust tubes 16 function to reduce the recoil by opposing the recoil thrust pressure of the gases from the combustion and pressure chambers 1 and 12 leaving the gun tube 14, the nozzles 17 constituting jet means facing rearwards for producing forward thrust on the gun unit as a whole in proportion to the pressure within the gun pressure chamber 12.

The magazine or shell feeding tube 4 has a gas inlet port 18 located adjacent the rear end thereof between the piston member 7 and the pressure regulating valve 10. A gas supply or pressure conduit 19 is connected to this gas inlet port 18 at one end and at its other end to the combustion chamber 1 and contains a check valve 20 opening toward the magazine tube, permitting gas and pressure to pass from the combustion chamber 1 through the conduit 19 into the magazine tube 4 behind the follower piston member 7 but preventing leakage of gas or pressure in the opposite direction through the port 18. The combustion chamber 1 also has a gas or pressure discharge port 21 in communication with a gas delivery conduit 22 having a control valve 23 therein, the conduit 22 being connected to an enlarged pressure storage chamber 24 disposed in parallel relation at one side of the gun barrel 14. The pressure storage chamber 24 comprises a cylinder having a piston member 25 arranged to travel therein intermediate its ends. A conduit 26 is connected at one end to a port 27 formed in the forward closed end of the storage chamber 24, the other end of this conduit 26 being connected to a port 28 in the wall of the gun barrel or shell 14, slightly forward of the position occupied by a shell or projectile when it is first introduced into the gun barrel. Check valve 29 is located in the conduit 26 to permit gas and pressure flow from the pressure chamber 12 into the pressure storage chamber 24 after the projectile or shell 5 in the gun barrel moves forwardly and uncovers the port 28. With the control valve 23 closed, each time a projectile 5 is discharged from the gun barrel 14 and the port 28 is uncovered the combustion chamber pressure becomes effective in the storage tube or chamber 24 to move the piston 25 to the left as shown in Figure 1 to increase the pressure in the pressure storage tube 24. This stored pressure in chamber 24 provides means for discharging the initial projectile or round 5 from the magazine tube 4 into the breach of the gun barrel 14, when the control valve 23 is initially opened. Pressure from the pressure storage chamber 24 can also be used to pressurize the hypergolic liquid propellant supply tanks, shown diagrammatically at 30 and 31 by connecting the tanks 30 and 31 to the storage chamber 24 by conduits $30^a$ and $31^a$ each having a control valve $30^c$ and $31^c$ therein connected to a common supply conduit 32.

In the operation of the gun shown in Figure 1 it will be assumed that the magazine barrel or tube 4 has been loaded, either through its rear end by removal of the pressured regulator device or through a loading port in its side. Opening of the valve 23 admits pressure to the combustion chamber 1. This pressure, through the conduit 19, creates pressure in the chamber 9 at the rear end of the magazine tube 4, causing the piston number 7 to advance the first projectile or shell 5 into the rear end or breach portion of the gun barrel 14. When the hypergolic liquid propellants from the tanks 30 and 31 are admitted into the combustion chamber 1 in suitably regulated ratios these burn, causing the pressure to rise quickly in the gun pressure chamber 12, for instance to perhaps 10,000 pounds per square inch. This pressure becomes effective to drive the first projectile 5 out of the gun tube at high velocity and due to the continued inflow of the propellant components this pressure remains at near that constant value throughout the passage of the shell 5 through the barrel 14. This pressure also becomes effective, due to the rearward jet discharge of the pressure through the exhaust tubes and nozzles 17, to exert forward thrust on the gun unit to reduce or eliminate the recoil thrust caused by the gases leaving the gun tube 14, the exhaust tubes 16 having substantially the same cross sectional area as that of the gun barrel 14. After the shell leaves the barrel 14 the pressure in the barrel and combustion chamber 1 drops, but the rate or quantity of propellant flow is substantially constant and is such as to still maintain a considerable pressure in the pressure chamber 12 of say about 5,000 pounds per square inch.

Gas under pressure in the meantime is being bled through the conduit 19 and check valve 20 into the gas chamber 9 and its pressure is immediately released down to the slightly above the minimum gun pressure chamber pressure, say about 5,200 pounds per square inch, thereby rebuilding the pressure chamber in 9 to its original 5200 pound value following the increase in volume of this chamber by one shell, due to the expenditure of one shell. When the first shell 5 leaves the muzzle and the gases are exhausted both fore and aft from tubes 14 and 16 the pressure in the combustion chamber 1 and in the gun pressure chamber 12 drops to the predetermined minimum say about 5000 pounds per square inch, permitting the higher regulated pressure of 5200 pounds per square inch in gas chamber 9 to force the next shell or projectile 5 forwardly into the breach of the gun barrel 14 and again close the gun tube 14, causing the pressure in chamber 12 to again increase to the maximum, or about 10,000 pounds as the second shell 5 is discharged through the tube 14.

Cylinders or tanks 30 and 31 containing the components of the propellant and pressurized and replenished as to pressure in the same manner as is the ammunition feed or magazine tube 4. As the shell 5 leaves its initial seating position in the breach of the barrel 14 the port 28 in gun tube 14 is uncovered, and the higher pressure of say 10,000 pounds becomes effective to pressurize the tanks 30 and 31 to a substantially similar amount of pressure. Fuel flow, once started is governed entirely by transient pressure ratios in the storage chamber 24 and in the gas chamber 12.

The gun tube 14 is preferably relatively long so that high velocities result from the use of low gun barrel pressures. This also permits the use of a gun tube having a relatively thin wall. Since hypergolic fuels are proposed no separate ignition system is required. The gun barrel may be rifled, also conical or cylindrical projectiles or shells may be employed.

Referring to the slightly modified form of the invention, as illustrated in Figure 2, the reference number 35 denotes a combustion or pressure chamber having hypergolic liquid repellant supply conduits 36 and 37 connected thereto, one of the conduits, for instance 36, supplying fuel into the combustion chamber under pressure from a supply tank not shown while the other conduit supplies the liquid oxidizer component into the combustion chamber under pressure from a suitable oxidizer tank (not shown). The hypergolic fuel and oxidizer liquid components are supplied at predetermined rates under the control of suitable valves and pressure regulators to maintain a predetermined minimum working pressure in the combustion, for example of 3,000 pounds per square inch.

Extending forwardly from the front end wall of the combustion chamber 35 is the gun tube or barrel 38

while a recoil absorbing exhaust tube 39, having a similar cross section to that of the barrel 38, extends from the combustion chamber in the opposite direction, a restricted exhaust nozzle being formed on the rear end of the exhaust tube 39.

Hypergolic liquid propellants are fed into the combustion chamber at predetermined uniform rates or ratios to maintain the minimum predetermined pressure in the combustion chamber of, for instance 3,000 pounds when there is no projectile or obstruction in the gun barrel 38. Under these conditions the gases from the combustion chamber discharge forwardly and at the same time rearwardly through the gun barrel and exhaust tubes respectively, the rearwardly extending exhaust tube discharge or thrust opposing the rearward thrust caused by the gas discharge forwardly through the gun barrel 38. In other words, the exhaust tube discharge eliminates or counteracts the recoil action of the gun tube discharge. Located in front of the combustion chamber 35, and extending upwardly from the gun tube, is a projectile supply and feeding tube or magazine 41. This tube 41 opens at its lower end into the upper half of the gun barrel 38 at a slight distance forwardly of the front end of the combustion or pressure chamber 35. The magazine 41 is sufficiently long to contain a desired number of projectiles or balls 42, and is preferably cylindrical to receive a piston member and gas seal 43, means also being provided in the form of a ratchet member or reverse motion check device 44 permitting movement of the piston 43 downwardly but resisting movement of the piston and gas seal or the projectiles in the opposite or upward direction. The upper portion of the magazine tube 41 is enlarged as shown in the drawings to provide an elongated pressure chamber 45 having a pressure regulator 46 in the upper end thereof for controlling the maximum pressure in the chamber 45 so as to maintain the same at a slightly greater pressure than the minimum controlled pressure in the combustion chamber 35, for instance, to maintain pressure in the chamber 45 at 3,100 pounds per square inch. The chamber 45 is connected to the combustion chamber 35 by a pressure supply conduit 47 having a check valve 48 therein, permitting gas flow from the combustion chamber 35 into the pressure chamber 45.

Operation of the apparatus shown in Figure 2 is as follows: Assuming that the magazine tube 41 is loaded with balls of projectile 42 and the chamber 45 is pressurized initially by some outside means, feeding for the first round into barrel 38, to some pressure which is higher than the minimum pressure in the combustion chamber 35 with both of the orifices or tubes 38 and 39 open, say a pressure of 3,100 pounds as is present in chamber 45 as determined by the regulating pressure valve 46, and that the hypergolic propellants are introduced into the combustion chamber at rates to maintain a slightly lower predetermined minimum pressure in the combustion chamber of say 3,000 pounds while both of the tubes 38 and 39 are open. The first ball 42 when released is forced downwardly into the gun barrel 38 by the 3,100 pounds pressure behind it, acting on the one way piston 43 and the column of balls 41—41. The gun barrel 38 up to now being under 3,000 per square inch minimum pressure. As soon as the lower ball 42 is forced into the gun barrel 38 by the excess 100 pound pressure the flow of gas out of the gun barrel 38 is interrupted and pressure in the combustion chamber 35 now raises to a much greater amount say about 6,000 pounds per square inch. This is because the propellant feed is constant and the orifice discharge area is reduced one-half by the blocking of the gun barrel by the ball 41. As soon as the ball is driven out of the gun barrel 38 by the maximum 6,000 per square inch built up pressure, gas can again flow out of both orifices or tubes 38 and 39 and the pressure in the combustion chamber 35 drops again to the original minimum value of about 3,000 pounds. This permits the feeding of the next ball into the gun tube 38 from the magazine 41 under the excess 100 pound pressure in the pressure chamber 35 and the firing operation of the gun is repeated until the ball magazine is empty.



Although two specific embodiments of the invention have been described above and shown in the accompanying drawings, it will be understood that other embodiments and modifications will become apparent to those skilled in the art. Accordingly, the foregoing disclosure is intended to be illustrative and is not to be construed in a limiting sense as various modifications may be made without departing from the spirit of the invention as defined in the accompanying claims.

I claim:

1. In a hypergolic liquid propellant gun, an elongated combustion chamber having front and rear ends, a gun barrel projecting forwardly from the front end of the combustion chamber in communication therewith, a shell feeding magazine tube projecting rearwardly from the rear end of the combustion chamber in axial alignment with the gun barrel, in communication at its front end with the rear end of the combustion chamber, hypergolic propellant supply means including conduit means for supplying at least two hypergolic propellants separately into the combustion chambers at a predetermined rate to be burned therein to pressurize the combustion chamber, pressure operated means in said magazine tube for feeding shells from said magazine to be into the rear end of said gun barrel comprising a pressure conduit connected between the combustion chamber and the rear end portion of the magazine tube to pressurize the tube, a check valve in said pressure conduit, and a pressure regulator in communication with the rear end portion of the magazine tube to maintain the shell feeding pressure therein at a predetermined value during operation of the gun which is greater than the minimum pressure within the combustion chamber when the gun barrel is empty and less than the maximum pressure in the combustion chamber after the shell is introduced into the barrel and before the same is discharged therefrom.

2. In a hypergolic liquid propellant operated gun, a combustion chamber, a gun barrel projecting forwardly from the combustion chamber in communication therewith a projectile feeding magazine tube projecting rearwardly from the combustion chamber in axial alignment with the gun barrel and in communication with the combustion chamber for receiving a plurality of projectiles and feeding the same into the rear end gun barrel one at a time, an exhaust tube in communication with the combustion chamber intermediate the gun barrel and magazine tube and discharging in diametrically opposite directions to the gun barrel for absorbing recoil during discharge of projectiles from the gun barrel, a restricted discharge nozzle at the rear end of said exhaust tube plural hypergolic liquid propellant supply means including plural conduit means therefrom connected to the combustion chamber for continuously feeding hypergolic propellants separately into the combustion chamber at pressures in excess of the maximum combustion chamber pressure during operation of the gun, means for regulating the relative rates of feed of the hypergolic propellants into the combustion chamber to predetermine the maximum build up pressure therein when a projectile is introduced into the gun barrel to obstruct the combustion chamber discharge therefrom through the gun barrel and determine minimum pressure in the combustion chamber, gun barrel, and exhaust tube, after the projectile has been discharged from the gun tube and before another projectile is introduced into the gun barrel, pressure operated piston means in said magazine tube for progressively feeding projectiles from the magazine tube into the rear end of the gun barrel including a pressure chamber and piston member in the rear end of the magazine tube in communication with the combustion chamber and a pressure regulator in the magazine tube pressure chamber for maintaining pressure in the magazine tube behind said piston means above said mini-

mum combustion chamber pressure and below said maximum combustion chamber pressure, and means in said magazine tube for holding the projectiles therein against rearward movement during the time pressure in the combustion chamber exceeds pressure in the pressure chamber.

3. In a liquid propellant operated repeating gun, a gun barrel, a combustion and pressure chamber connected to the rear of the gun barrel in communication therewith, a projectile feeding magazine tube extending rearwardly in spaced axial alignment to the rear end of the gun barrel with its front end opening into said combustion and pressure chamber, said magazine tube being adapted to receive a plurality of projectiles therein, means in the magazine tube for preventing rearward movement of the projectiles therein, a closure at the rear end of the magazine tube, pressure regulating means in communication with the rear end of the magazine tube, a piston member disposed in the magazine tube for projectile feeding engagement with the rearmost projectile in the magazine tube, stop means in the magazine tube limiting rearward movement of the piston member, a pressure supply conduit connected between the combustion and pressure chamber and the rear portion of the magazine tube intermediate said piston and the rear end closure, check valve means in said pressure conduit to permit pressure flow from the combustion chamber into the magazine tube rear portion, a pair of counter-recoil exhaust tubes connected to the (opposite sides of) combustion and pressure chamber and extending rearwardly at opposite sides of the magazine tube in parallel spaced relation thereto, restricted exhaust nozzle means at the rear ends of the exhaust tubes facing rearwardly, a pair of liquid propellant supply conduits connected to the interior of the combustion chamber in spaced relation to each other for supplying liquid hypergolic propellants separated into the combustion chamber, means for regulating the relative rates of flow of the propellants into the combustion chamber to determine the maximum pressure therein when the gun barrel is closed by the introduction of a projectile into the gun barrel from the magazine tube, and to determine the minimum pressure in the combustion chamber when the gun barrel is empty, a pressure delivery conduit connected at one end in communication with the interior of the gun barrel adjacent its rear end, just forwardly of the position occupied by a projectile when introduced in the rear end of the gun barrel, a pressure cylinder having a piston therein, said pressure delivery conduit being connected to the pressure cylinder at one side of the piston, check valve means in the pressure delivery conduit for admitting pressure from the gun barrel into the pressure cylinder when the pressure delivery conduit is uncovered by the passage of a projectile forwardly from the rear end of the gun barrel, a pressure supply conduit connected at one end to the combustion chamber and at its other end to the pressure cylinder at the other side of the piston therein, and control valve means in the pressure delivery conduit for controlling the pressure from the pressure cylinder into said combustion and pressure chamber.

4. In a liquid propellant operated repeating gun, a gun barrel having a breach end for receiving projectiles to be discharged through the barrel, a projectile supply magazine tube for the gun barrel disposed in rearwardly spaced relation to the breach end of the gun barrel in axial alignment with the gun barrel, and adapted to contain a supply of projectiles, an enlarged pressure chamber connected to the breach end of the gun barrel and the front end of the magazine tube in communication respectively with the barrel and tube, a plurality of exhaust recoil tubes in communication with the pressure chamber and extending rearwardly therefrom in parallel relation to the magazine tube, the combined cross sectional exhaust area of said exhaust tubes being substantially equal to the cross sectional area of the interior of the gun barrel, exhaust nozzles at the rear ends of the exhaust tubes discharging rearwardly, a combustion chamber surrounding the inner end of the magazine tube, the forward end of said magazine tube having pressure discharge ports formed therethrough to establish communication between the combustion chamber and the pressure chamber through the forward end of the magazine tube, projectile holding means disposed in the magazine tube adjacent its forward end for engaging and holding a projectile in the magazine tube against rearward movement when the projectile is moved to a position adjacent the forward end of the tube, rearwardly of the ports in the tube, a piston member movable in the tube for advancing the projectiles toward the front end of the tube, stop means in the tube for engagement with the piston to prevent rearward movement thereof, pressure regulator means forming a closure for the rear end of the tube, a pressure supply conduit connected in communication with the combustion chamber at one end and connected at its other end in communication with the interior of the magazine tube intermediate the piston and the pressure regulator, check valve means in the pressure supply conduit opening toward the magazine tube connected end of the conduit, separate hypergolic liquid supply conduits disposed in communication with the interior of the combustion chamber for feedng hypergolic liquid propellants separately into the combustion chamber and regulating means in said separate conduits for regulating relative the rates of introduction of the hypergolic liquid propellants into the combustion chamber.

5. Apparatus as claimed in claim 4 including a pressure cylinder having a piston therein, a pressure supply conduit connected at one end to the pressure cylinder at one side of the piston, and connected at its other end in communication with the interior of the gun barrel through a port in the gun barrel located in advance of the position of a projectile when introduced into the projectile receiving end, said port being uncovered by the forward movement of the projectile from the projectile receiving end to establish communication between the last mentioned pressure supply conduit and the pressure chamber, a check valve in said last mentioned pressure supply conduit opening toward the pressure cylinder, a pressure supply conduit connected between the pressure cylinder at the other side of the piston and the interior of the combustion chamber, and valve control means in the last mentioned conduit for controlling pressure from the pressure chamber to the combustion chamber.

6. Apparatus as claimed in claim 5 in which the pressure regulator means for the pressure in the rear of the magazine tube in back of the piston therein comprises means for maintaining a differential pressure on the piston just mentioned exceeding the pressure in the pressure chamber when the gun barrel is empty and less than the pressure in the pressure chamber when the gun barrel receives a projectile in its receiving end.

7. In a liquid propellant gun of the hypergolic type, a combustion chamber, a gun barrel extending forwardly therefrom with its rear end in communication with said combustion chamber, recoil absorbing exhaust tube means extending rearwardly from the combustion chamber in diametrically opposite direction from the gun barrel and in communication with the interior of the combustion chamber, exhaust nozzle means at the rear ends of the exhaust tube means discharging rearwardly, the cross sectional exhaust area of said recoil absorbing tube means and said gun barrel being substantially equal, hypergolic fuel and oxidizer liquid propellant means for introducing liquid hypergolic fuel and oxidizer propellants into the combustion chamber to be burned therein to create a predetermined minimum combustion chamber pressure when the gun barrel is empty of projectiles and causing a predetermined maximum combustion chamber pressure where the gun barrel is blocked by a projectile therein, a projectile feeding magazine tube connected to

the gun barrel through a projectile introducing port in the gun barrel adjacent the rear end of the gun barrel, a piston in said magazine tube for feeding projectiles from the magazine tube into the gun barrel one at a time, projectile holding means in said magazine tube disposed rearwardly of projectiles introduced therein for preventing rearward projectile movement of projectiles in the magazine tube, an enlarged pressure chamber connected to the magazine tube in rear of the piston therein, a pressure regulator valve connected to the enlarged pressure chamber maintaining a maximum operating pressure in said enlarged pressure chamber greater than the minimum combustion chamber when the gun barrel is empty and less than the combustion chamber pressure when the gun barrel is blocked by a projectile from the magazine tube, a pressure supply conduit connected at one end with the interior of the combustion chamber and at its opposite end to the interior of the pressure chamber, and check valve means in said pressure supply conduit, opening toward said pressure chamber.

8. In a hypergolic liquid propellant gun, a gun barrel, a combustion chamber in communication with the rear end of the gun barrel, recoil absorbing means comprising an exhaust tube in communication with said combustion chamber and extending therefrom in a direction rearwardly of the direction of the gun barrel having a restricted exhaust passage, a projectile magazine tube having a projectile delivery end in communication with the combustion chamber and the rear end portion of the gun barrel at its projectile delivery end for guiding projectiles from the magazine tube into the said rear end portion of the gun barrel, piston means in the magazine tube in rear of the projectiles when introduced in the magazine tube for advancing the projectiles toward the delivery end, a pressure chamber in communication with the interior of the magazine tube rearwardly of the piston member therein for supplying pressure to advance the projectiles therein into the gun barrel, maximum pressure regulating means for said pressure chamber, means to supply hypergolic liquids separately into said combustion chamber to be mixed and spontaneously burned therein to pressurize the combustion chamber, a pressure supply conduit connected from the combustion chamber to the pressure chamber to pressurize the pressure chamber from the combustion chamber and check valve means in said pressure supply conduit opening toward the said pressure chamber, whereby when the pressure in the combustion chamber increases during the discharge of a projectile through the barrel and exceeds the pressure in the pressure chamber, combustion chamber pressure is admitted to the pressure chamber to increase the pressure chamber pressure; and upon discharge of the projectile from the barrel, the barrel is vented and thereby reduces the combustion chamber pressure below the regulated pressure chamber pressure, and the higher pressure in the pressure chamber at that time is operative on the piston means to advance the projectiles in the magazine tube to feed a fresh projectile into the barrel to charge the gun barrel and interrupt the vented discharge of the hypergolic combustion gases from the barrel and combustion chamber to build up pressure in the combustion chamber in excess of the pressure chamber pressure for projecting the fresh introduced projectile from the barrel and recharging the pressure chamber.




**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 1,214,984 | Apps et al. | Feb. 6, 1917 |
| 1,343,456 | Jones | June 15, 1920 |
| 1,620,994 | Bustamente | Mar. 15, 1927 |
| 2,088,503 | Broussard | July 27, 1937 |
| 2,129,875 | Rost | Sept. 13, 1938 |
| 2,445,326 | Janney | July 20, 1948 |
| 2,474,183 | King | June 21, 1949 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 585,851 | Germany | Oct. 11, 1933 |
| 405,645 | Great Britain | Jan. 29, 1934 |
| 594,577 | Great Britain | Nov. 14, 1947 |
| 631,498 | Great Britain | Nov. 3, 1949 |