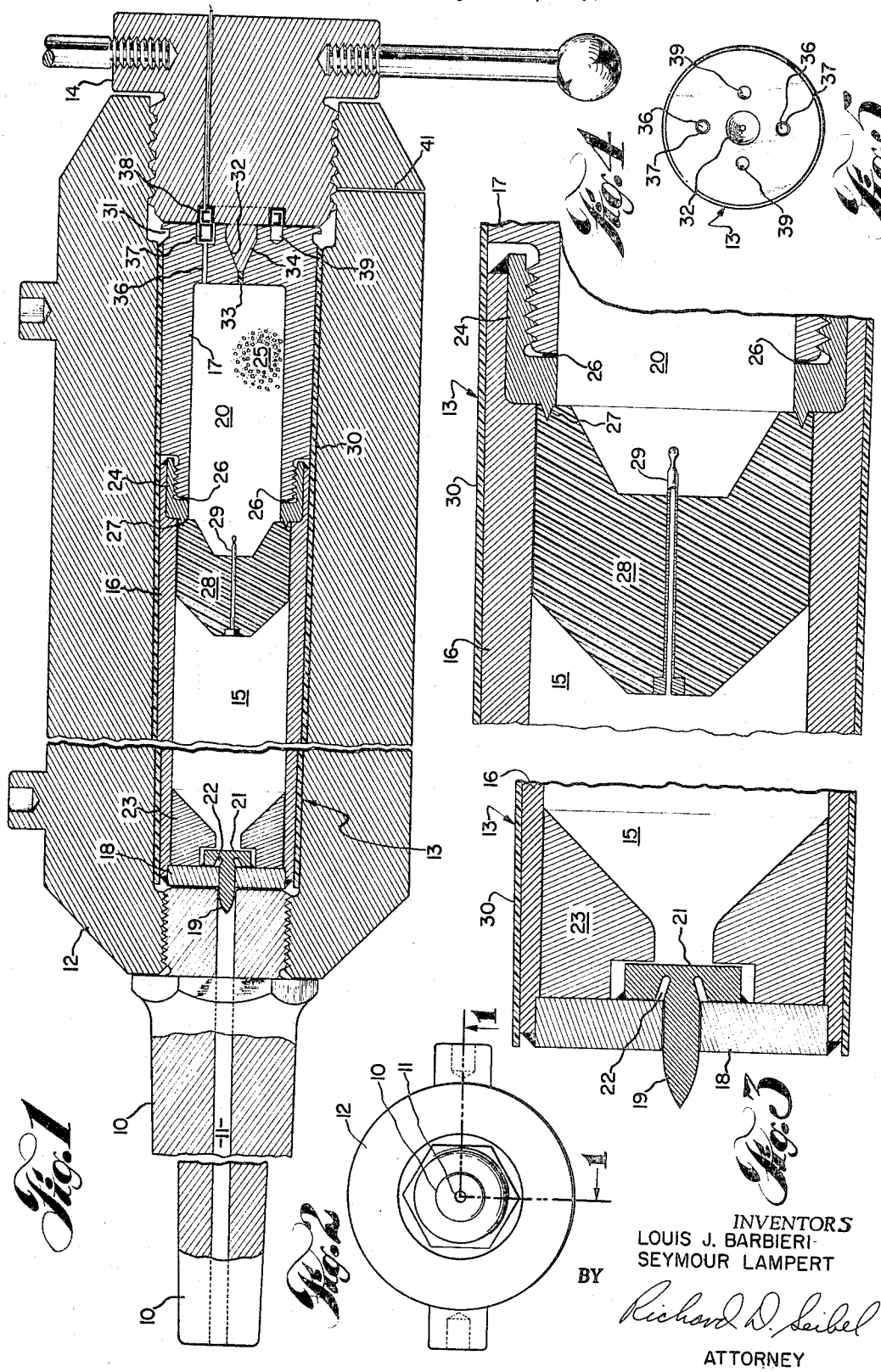
June 20, 1967

L. J. BARBIERI ET AL

3,326,084

LIGHT GAS CARTRIDGE

Filed April 23, 1965



INVENTORS
LOUIS J. BARBIERI
SEYMOUR LAMPERT

BY

Richard D. Seibel

ATTORNEY

United States Patent Office 3,326,084 Patented June 20, 1967

3,326,084

LIGHT GAS CARTRIDGE

Louis J. Barbieri, Tustin, and Seymour Lampert, Santa Ana, Calif., assignors to North American Aviation, Inc.

Filed Apr. 23, 1965, Ser. No. 450,398
10 Claims. (Cl. 89—7)

This invention relates to a gun system for launching projectiles at high velocity and more particularly relates to a cartridge employing a low molecular weight gas for propelling a projectile.

In order to obtain long range and high penetrating capability of projectiles, it is desirable to have a high muzzle velocity. Laboratory investigations have shown that high pressure low molecular weight gases can be employed to propel projectiles to higher muzzle velocities than obtainable with combuston gases from conventional explosives. Such a high velocity gun is illustrated in U.S. Patent 2,872,846. Devices previously available have been limited to laboratory investigations and have employed only very light projectiles. Additionally these laboratory instruments have required extensive preparation between each successive firing so that a very small number of projectiles can be fired in a given time period. Generally the entire gun is taken apart so that the damaged remains of a firing can be removed and a new test arrangement provided in the gun. In the previous laboratory devices the burning powder gases are in contact with the gun wall while the gun chamber is under high pressure, thereby causing severe damage to the walls and limiting the effective life of the gun. The flames on the pressurized chamber walls can initiate cracking in the walls and affect the safety of operation of the gun.

It is therefore a broad object of this invention to provide an improved means for propelling projectiles to very high velocities.

Thus in the practice of this invention according to a preferred embodiment there is provided a gun and a preloaded light gas cartridge therefor capable of indefinite storage before use. The light gas cartridge has a smooth continuous outer surface so that it is readily fitted closely in the breech of the gun. The light gas cartridge comprises a powder containing chamber having a conventional explosive gun powder and means for igniting the gun powder. A second adjoining gas sealed chamber contains pressurized gas of low molecular weight such as helium. A conduit is provided for charging the chamber with light gas and this conduit is arranged within the cartridge so that there is no impediment to use of the cartridge in a gun. A light weight piston separates the two chambers and upon combustion of the gun powder the piston is driven into the second chamber thereby further compressing the low molecular weight gas. A projectile assembly having a pressure rupture release structure is on the opposite end of the second chamber from the piston. When the low molecular weight or light gas is suitably compressed the resultant pressure ruptures the projectile support structure and propels the projectile along a gun barrel. The light gas flowing along the gun barrel driving the projectile provides a higher muzzle velocity than powder gases alone because of the higher acoustic velocity attainable in the lighter gas over the acoustic velocity in combustion products of a powder charge. After firing, another preloaded cartridge having a new powder charge and chamber of compressed low molecular weight gas can be rapidly reloaded in the gun for a repeated firing. Since the piston is contained in the cartridge and the combustion of powder is in the cartridge the gun is quickly readied for another firing and no damage occurs in the breech of the gun due to hot powder gases.

Thus it is a broad object of this invention to provide an improved light gas gun.

It is another object of this invention to provide a means for obtaining high muzzle velocity projectiles.

It is another object of this invention to provide a readily stored light gas cartridge.

Other objects and many attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a longitudinal cross section of a light gas gun employing a cartridge as provided in the practice of this invention;

FIG. 2 is an end view of the forward end of the gun of FIG. 1;

FIG. 3 comprises a cross section view of the forward end of the light gas cartridge of FIG. 1;

FIG. 4 comprises a cross section view of the center portion of the light gas cartridge of FIG. 1; and

FIG. 5 shows a rear view of the light gas cartridge of FIG. 1.

Throughout the drawings like reference numerals refer to like parts.

The advantage of using a light gas as a missile propellant rather than the combustion gas of a standard powder charge lies in the greater rate of expansion of a light gas at a given temperature and pressure than the rate of expansion of the combustion products of a conventiontal powder charge. If the energy contained in the standard powder charge is transferred to a monatomic, low molecular weight gas such as helium, then most of the energy in the gas is in the form of translational kinetic energy and none is present in the form of rotational or oscillatory modes as is the case with the higher molecular weight polyatomic gases which result when a powder is burned. In addition, because of the lower mass, a given energy produces a higher translational velocity of a helium atom than the velocity of a polyatomic molecule in a conventional gas. These factors combined result in a considerably higher expansion rate for helium gas at a given temperature and pressure and thus result in higher muzzle velocities in projectiles driven thereby than result from conventional powder gases.

FIG. 1 shows a longitudinal cross section view of a light gas gun incorporating the principles of this invention. The section is taken as shown in the end view of FIG. 2 so that the significant details of the cartridge can be illustrated. As illustrated in this embodiment there is provided a barrel portion 10 having a smooth or rifled bore 11 therethrough. The barrel 10 is threaded into a breece 12 which is preferably constructed of high strength steel to withstand the momentarily high pressures encountered in firing a light gas gun. A light gas cartridge 13 is illustrated loaded into the breech of the gun shown in FIG. 1. A breech block 14 is threaded into the breech 12 to properly position the cartridge 13 in the breech 12 and to contain the high pressures generated on firing the cartridge.

The light gas cartridge comprises two principal portions, a light gas chamber 15 and a gunpowder chamber 20 separated by a piston 28. The light gas chamber is forward of the gunpowder chamber in the cartridge, that is, toward the muzzle of the gun. The light gas chamber has its periphery defined by a light gas housing 16 that has an interior in the form of a smooth cylindrical surface and an exterior in the form of a conical surface to provide a draft of about 1° to permit ready extraction of a cartridge after firing. In a preferred embodiment a front end plate 18 is welded to the light gas housing 16 at the front end of the cartridge to provide a gas tight enclosure for the light gas chamber 15, as shown in FIG. 3. An axial hole in the front end plate 18 provides clearance for a projectile or missile 19. The projectile 19 is preferably

made integral with a rupture plate **21** which is in turn welded or brazed to the front end plate **18**. The rupture plate has a conical groove **22** which defines a tapered "boat tail" portion on the projectile **19**. The groove **22** provides an intentionally weakened area on the rupture plate **21** so that rupture thereof occurs at a controlled location and in a circular path having a diameter smaller than the caliber of the projectile. This specially arranged frangible region prevents rough portions of the ruptured end of the projectile from damaging the bore in the gun barrel during passage therethrough. The projectile and rupture plate assembly can be machined from a single piece of material such as steel or can be fabricated from two pieces secured together by a material such as solder or cement that will fail in shear under the high pressures generated by the compressed light gas.

Additionally there is provided insied the light gas housing **16** at the front end thereof a catcher plug 23 which serves to minimize impact loading on the front end plate **18** as hereinafter described. The catcher plug **23** is preferably press fitted into the light gas housing **16** and abuts the front end plate **18**.

As is most clearly shown in FIG. 4 at the rearward end of the light gas housing **16** there is provided a transition piece **24** which is preferably welded to the light gas housing to form a gas seal for the light gas chamber **15**. A powder housing **17** which is in the form of a closed cup is threaded into the transition piece **24** to provide a closed chamber **20** for containing conventional gun powder **25**. A resilient gasket **26** is conveniently provided between the powder housing **17** and the transition piece **24** to provide a gas seal for the powder containing chamber **20**.

The transition piece **24** includes a circularly extending knife edge **27** extending toward the light gas containing chamber. Impressed on the knife edge is a light weight piston **28** which is preferably constructed of polystyrene or aluminum coated with polytetrafluoroethylene or an aluminum outer structure having a honeycomb core. It is preferred to employ a polystyrene or similar plastic piston to provide a light weight for a given volume. In order to be stable in the cylinder, the piston must have a sufficient length to prevent cocking. The weight of the piston is kept low by employing a relatively low density material for the piston. The forward end of the piston, that is the end facing the muzzle of the gun, preferably has a tapered portion substantially matching the taper on the catcher block **23**. The rearward portion of the piston is seated on the knife edge **27** to provide a gas seal for containing the light gas. A tube **29**, preferably of metal molded in the plastic piston, is provided so as to extend axially through the piston **28**. This tube is crimped and soldered shut after the projectile is charged with a light gas as hereinafter described to provide a gas seal. By providing the filling tube through the piston, the exterior housing of the cartridge is left smooth and continuous so that there are no projecting impediments to use of the cartridge in a gun. By having the tube inside the cartridge, the completed cartridge is substantially axisymmetric and can be accommodated in the breech of a gun without any orientation problems.

The powder housing **17** has a substantially cylindrical interior surface and an exterior surface which is a continuation of the exterior of the light gas housing, that is the powder housing also has a 1° draft to facilitate extraction. A layer **30** of polytetrafluoroethylene about 0.010 to 0.020 inch thick is provided on the outer portion of the cartridge **13** over the light gas housing **16** and the powder housing **17** to accommodate manufacturing irregularities between the cartridge and the breech and also to facilitate extraction of the cartridge after firing the light gas gun. A conventional extractor groove **31** (FIG. 1) is provided on the rear of the powder housing for extraction of the cartridge from the breech.

A pressure relief port **32** about 0.05 inch diameter is provided in the rear of the cartridge and the port is sealed with a small plug of thermolabile material **33** such as a plastic that either melts or decomposes due to the heat of firing the cartridge. Polyethylene is a suitable material for the plug **33** and both melting and decomposition occur upon firing. The gas port **32** is substantially filled by a projecting portion **34** on the breech block **14** so that the plastic plug **33** is not driven from the cartridge by the high pressures therein.

Igniter ports **36** are provided in the rear of the cartridge and have conventional electrical igniters **37** therein for igniting the gunpowder **25** in the chamber **20** and firing the light gas gun. Two such igniters **37** are provided for increased reliability. An insulated electrical contact ring **38** extending in a circle around the face of the breech block **14** makes electrical contact to the igniters for firing the light gas gun. In addition, in the rear of the cartridge **13** there are provided two depressions **39** into which a spanner wrench can be inserted to assist in extraction of the cartridge as required. A gas vent **41** is provided in the breech block so that excess gas pressures in the cartridge can be vented after firing if necessary.

In order to obtain a muzzle velocity in the order of 10,000 feet per second or higher, it is desirable to employ a gun barrel **10** that is about 400 calibers long. Thus for a .30 caliber projectile the gun barrel is approximately ten feet long. For such a gun the inside diameter of the powder housing **17** is approximately 2½ inches and the overall length of the light gas chamber **15** is about 30 inches. It is preferred to employ from approximately 3 to 10 pounds of M–1 or M–2 type military gun powder in a cartridge of the type described. This produces a pressure of from 30,000 to 50,000 p.s.i. at the breech due to the powder explosion and the compression of light gas due to the piston reaches a pressure in the order of 100,000 p.s.i. at the failure of the rupture plate.

In assembling a cartridge of the type described, a projectile and rupture plate assembly are welded or brazed to a front end plate **18** which is in turn welded to the light gas housing **16**. A catcher block **23** is press fitted into the light gas housing and a piston **28** inserted. The piston has a diameter slightly smaller than the inside diameter of the housing to permit free movement of the piston under the pressure of the exploding gunpowder. A transition piece **24** having a knife edge **27** is then welded in place onto the light gas housing. A charge of helium is added in the light gas chamber **15** by means of a tube **29** passing through the center of the piston. It is preferred to charge the helium into the chamber at about 300 to 600 p.s.i. After the chamber is filled at such a pressure the tube **29** is crimped and sealed shut to form a gas seal. For this purpose it is convenient to plate the inside surfaces of the tube with solder and to heat the tube at the crimp to effect a gas seal. The pressurization of the forward chamber with helium causes the piston to be properly positioned in the housing and firmly seated on the knife edge **27** of the transition piece, thereby completely gas sealing the light gas chamber **15**. After filling and sealing the light gas chamber a powder housing **17** having a suitable charge of gun powder **25** is threaded into the transition piece to complete the cartridge assembly. A thin coat of polytetrafluoroethylene as described above is put on the exterior of the cartridge either before or after filling and the cartridge is stored until used for firing.

In order to fire the light gas gun described, a preloaded cartridge is inserted into the breech **12** and a breech block **14** firmly threaded against the base of the cartridge. Firing of the cartridge is by electrical contact with the igniters **37** as will be apparent to one skilled in the art. Upon firing the light gas cartridge the gun powder in the chamber **20** is burned thereby generating an elevated pressure which drives the piston **28** through the cylinder forming the light gas chamber **15**. The rapidly traveling piston aided by shock waves traveling along the light gas

chamber builds up a pressure in the order of 100,000 p.s.i. in the helium contained in the light gas chamber. This pressure ruptures the rupture plate 21 at the reduced section adjacent the groove 22 and acts upon the base of the projectile 19 to accelerate it to high velocity. The helium in the light gas chamber expands along the barrel to provide an accelerating force on the projectile throughout its travel in the gun barrel and because of the properties of helium as described above, the projectile is accelerated to a high muzzle velocity.

The piston traveling along the length of the light gas chamber is decelerated by the high pressure in the light gas chamber and in most instances is at relatively low velocity when it reaches the catcher block 23. The catcher block has a tapered face in order to obtain optimum gas flow characteristics in the light gas chamber and the forward face of the piston is preferably tapered to approximately the same slope to mate with the catcher block. The catcher block provides a relatively heavy mass which must be accelerated against friction forces and assists in minimizing the impact load on the front end plate 18 due to impact of the piston. A mismatch between the taper on the catcher block and the piston tends to cause plastic deformation of the piston in the cases where a high velocity remains therein and minimizes the maximum force applied to the catcher block and the end plate.

Since the projectile clears the end of the bore in the gun barrel, any gas in the light gas chamber 15 is exhausted through the muzzle of the gun. The combustion gases from the gun powder are not vented through the muzzle of the gun, however, except in situations where cracks or other leaks develop in the piston. In order to provide for safety in removal of the cartridge from the gun after firing, a thermolabile plug 33 is provided in the base of the cartridge. This plug is melted or decomposed by the elevated temperature due to the powder burning and any remaining pressurized gas in the cartridge after firing is readily forced past the plug and vented out through the gas vent 41 upon slight loosening of the breech block 14. Similarly it often occurs that one or both of the igniters are loosened in the firing and gas relief also occurs at that point so that the cartridge can be safely extracted from the breech. In order to extract the cartridge a conventional extractor is applied to the extractor ring 31 and if necessary a slight twist is put on the cartridge by way of spanner holes 39 in the base thereof. After a firing, another cartridge preloaded with helium and gun powder is readily inserted into the breech without additional preparation of the gun and another round can be fired in a short period of time.

It will be apparent that a cartridge incorporating the principles of this invention can readily be employed in other types of guns than the one specifically described herein. Thus for example, a quick locking breech block can be employed along with accessories such as automatic cartridge feeding and extraction and the like. A gun having percussion type of firing can be employed, in which case the cartridge is readily provided with conventional percussion primers rather than the electrical initiators illustrated in the preferred embodiment.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A self-contained light gas cartridge capable of indefinite storage for use in a light gas gun comprising:
- a hollow housing having a cylindrical interior portion and a slightly conical exterior portion;
- a projectile assembly in gas sealing relation to the forward end of said housing, said assembly including a frangible region for rupture at a predetermined high pressure in said housing;

- a piston in gas sealing relation in said hollow housing and cooperating therewith to define a forward chamber and an aft chamber therein;
- a charge of compressed light gas in the forward chamber;
- a charge of explosive in the aft chamber;
- means for igniting said explosive; and
- means for introducing the charge of light gas in the forward chamber comprising a filling conduit on the axis of said cartridge communicating with the forward chamber.

2. A self-contained light gas cartridge comprising:
- a substantially cylindrical housing sealed at its aft end and having a smooth, continuous outer surface for close fit within the breech of a gun;
- a projectile frangibly secured to the housing at its forward end in sealing relation thereto;
- a slidable piston in the housing cooperating therewith to define forward and aft chambers and having a sealed filling conduit extending through the piston and wholly contained within the housing whereby the housing presents a smooth exterior for reception by a gun breech;
- a pressurized light gas in the forward chamber;
- an explosive in the aft chamber; and
- means for igniting the explosive.

3. A light gas cartridge comprising:
- a hollow housing having a shallow draft along the length thereof and a coating of solid material of low coefficient of friction thereon;
- a missile secured to said housing at one end thereof by a connection that is rupturable at a preselected high pressure in said housing;
- a light weight piston in said housing dividing the interior into a forward chamber and an aft chamber, said piston gas sealing the forward chamber from the aft chamber and having a sealed conduit therethrough for fluid communication with the forward chamber before sealing;
- a compressed low molecular weight gas in the forward chamber;
- a charge of explosive in the aft chamber;
- means for igniting the explosive in the aft chamber.

4. A light gas cartridge comprising:
- a hollow housing having a shallow draft along the length thereof and an internal shoulder having a circular knife edge facing toward the forward end of said cartridge;
- a piston in said housing dividing said housing into a forward chamber and an aft chamber and seated on the knife edge to form a gas seal;
- a compressed low molecular weight gas sealed in the forward chamber;
- a charge of explosive in the aft chamber;
- means for igniting the explosive in the aft chamber; and
- a projectile assembly in the forward end of the forward chamber comprising a missile to be propelled and a rupture plate that is rupturable at a preselected high pressure in said housing;
- said piston including an axial conduit therethrough, said conduit being sealed shut for retaining the low molecular weight gas in the forward chamber.

5. A self-contained light gas cartridge capable of indefinite storage for use in a light gas gun comprising:
- a hollow housing having a shallow draft along substantially the full length thereof;
- a piston in said housing in gas sealing relation thereto separating said housing into a forward chamber and an aft chamber;
- a compressed low molecular weight gas sealed in the forward chamber;
- a charge of explosive in the aft chamber;
- means for igniting the explosive in the aft chamber; and

a projectile assembly in the forward end of said cartridge housing including a missile to be propelled and a rupture plate secured to said missile, said projectile assembly including a conical groove partially separating the missile and the rupture plate for providing a boattail on the missile and providing a deliberately weak portion of said rupture plate so that the locus of rupture is smaller than the caliber of the missile.

6. A light gas cartridge comprising:

a housing forming a chamber therein;

a piston in the chamber for dividing the chamber into a forward portion and an aft portion;

a missile at the forward end of said housing;

a rupture plate adjacent said missile for containing gas below a preselected pressure and releasing gas above the preselected pressure;

a compressed low molecular weight gas in the forward portion of the chamber;

a charge of gunpowder in the aft portion of the chamber;

a sealable conduit through said piston for admitting low molecular weight gas to the forward portion of the chamber;

a gas port in the aft portion of the chamber;

a thermolabile plug in said port; and

a layer of polytetrafluoroethylene on the exterior of said housing.

7. A light gas cartridge comprising:

a forward housing defining a forward chamber therein for containing a low molecular weight gas, said forward housing having a smooth cylindrical inner wall and an outer wall having a draft for facilitating cartridge extraction from a gun breech;

an aft housing defining an aft chamber for containing a charge of gunpowder;

a projectile assembly axially aligned in the forward end of said cartridge including a partially cylindrical missile to be propelled and a rupture plate secured to said missile, said rupture plate being gas sealed to said cartridge and including a deliberately weak portion for rupturing at a preselected gas pressure; said weak portion comprising a groove in the plate at its junction with the missile, said groove circumscribing the missile and having an inner diameter smaller than the diameter of the cylindrical part of said missile;

a catcher block in the forward end of the forward chamber having an aft facing conical surface, for minimizing shock loads on the end of said cartridge;

a light weight piston in the forward chamber, separating the forward chamber from the aft chamber and having a forward facing conical surface substantially similar to the catcher block surface;

a sealable conduit through said piston for filling the forward chamber with a low molecular weight gas;

a transition piece fixed to the aft end of the forward housing having an internally threaded portion and a forward facing knife edge gas seal for gas sealing with said piston;

a pressurized low molecular weight gas in said forward chamber;

a gas relief port in said aft housing communicating with the aft chamber and with the cartridge exterior;

a thermolabile plug in said gas relief port for providing temporary gas sealing of said port;

gunpowder in the aft chamber;

an igniter in the cartridge for igniting said gunpowder; and

a layer of polytetrafluoroethylene on the draft portion of the cartridge for facilitating extraction thereof.

8. A light gas gun system comprising:

a barrel portion having a bore therethrough;

a breech portion having a cartridge receiving chamber therein aligned with the bore, said chamber having a draft therein for facilitating cartridge extraction;

a breech block removably secured to said breech portion for closing the cartridge receiving chamber;

a removable cartridge in the cartridge receiving chamber; said cartridge having a draft thereon matching the draft of the chamber so as to fit snugly therein and further comprising:

a forward housing defining a forward chamber therein for containing a low molecular weight gas, said forward housing having a smooth cylindrical inner wall;

an aft housing defining an aft chamber for containing a charge of gunpowder;

a projectile assembly in the forward end of said cartridge and aligned with the bore in said barrel portion including a missile to be propelled and a rupture plate secured to said missile, said rupture plate being gas sealed to said cartridge and including a deliberately weak portion for rupturing at a preselected gas pressure;

a light weight piston in the forward chamber, separating the forward chamber from the aft chamber;

a sealable conduit through said piston for filling the forward chamber with a low molecular weight gas;

a knife edge gas seal on the forward housing for gas sealing with said piston;

a pressurized low molecular weight gas in said forward chamber;

gunpowder in the aft chamber;

an igniter in the cartridge for igniting said gunpowder; and

a layer of polytetrafluoroethylene on the draft portion of the cartridge for facilitating extraction thereof.

9. A light gas gun system comprising:

a barrel portion having a bore therethrough;

a breech portion having a cartridge receiving chamber therein aligned with the bore, said chamber having a draft therein for facilitating cartridge extraction;

a breech block removably secured to said breech portion for closing the cartridge receiving chamber;

a removable cartridge in the cartridge receiving chamber; said cartridge having a draft thereon matching the draft of the chamber so as to fit snugly therein and further comprising:

a forward housing defining a forward chamber therein for containing a low molecular weight gas, said forward housing having a smooth cylindrical inner wall;

an aft housing defining an aft chamber for containing a charge of gunpowder;

a projectile assembly in the forward end of said cartridge and aligned with the bore in said barrel portion including a missile to be propelled and a rupture plate secured to said missile, said rupture plate being gas sealed to said cartridge and including a deliberately weak portion for rupturing at a preselected gas pressure; said weak portion comprising a groove in the plate at its junction with the missile, said groove circumscribing the missile and having an inner diameter smaller than the bore of said barrel;

a catcher block in the forward end of the forward chamber having an aft facing conical surface, for minimizing shock loads on the end of said cartridge;

a light weight piston in the forward chamber, separating the forward chamber from the aft chamber and having a forward facing conical surface substantially similar to the catcher block surface;

a sealable conduit through said piston for filling the forward chamber with a low molecular weight gas;

a transition piece fixed to the aft end of the forward housing having an internally threaded portion and a forward facing knife edge gas seal for gas sealing with said piston;

a pressurized low molecular weight gas in said forward chamber;

a gas relief port in said aft housing communicating with the aft chamber and with the cartridge exterior;

a thermolabile plug in said gas relief port for providing temporary gas sealing of said port;
gunpowder in the aft chamber;
an igniter in the cartridge for igniting said gunpowder; and
a layer of polytetrafluoroethylene on the draft portion of the cartridge for facilitating extraction thereof. portion of the cartridge for facilitating extraction thereof.

10. A light gas gun system comprising:
a gun having a barrel and a breech; and
a self-contained cartridge having a projectile assembly sealing the forward end thereof fitting into the breech, said cartridge having a first closed chamber filled with pressurized light gas, a second closed chamber mounted rearwardly of said first chamber containing gun powder, a movable piston between said first chamber and said second chamber, an axially extending tube

through said piston communicating with said first chamber for injecting the pressurized light gas into the first chamber, and means for sealing the conduit subsequent to injection of the pressurized light gas.

References Cited

UNITED STATES PATENTS

1,416,827	5/1922	Holmes.	
2,872,846	2/1959	Crozier	89—7
2,882,796	4/1959	Clark et al.	89—7
2,972,947	2/1961	Fitzsimmons et al.	102—43

FOREIGN PATENTS

800,060	9/1894	Germany.

SAMUEL W. ENGLE, *Primary Examiner.*

BENJAMIN A. BORCHELT, *Assistant Examiner.*