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HIGH FIRING RATE, LIGHT GAS HYPERVELOCITY
GUN AND AMMUNITION THEREFOR
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3,496,827

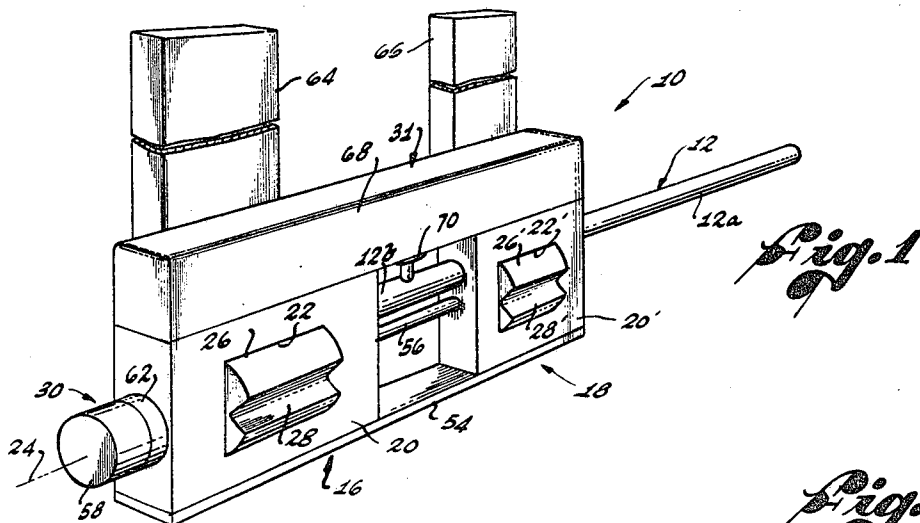


Fig. 2

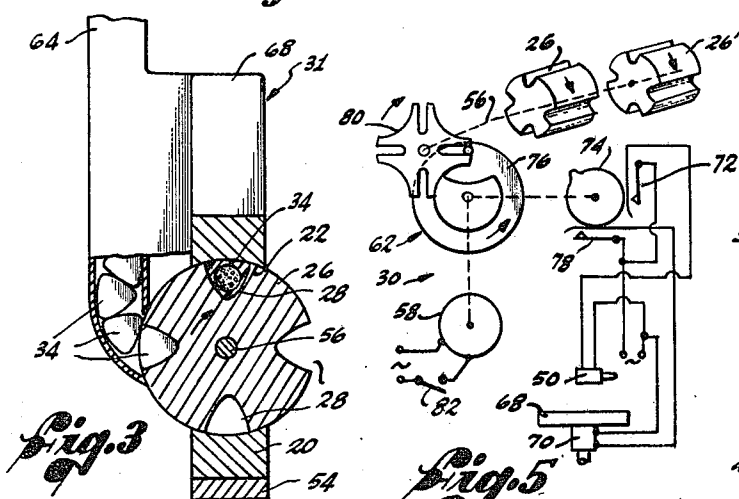
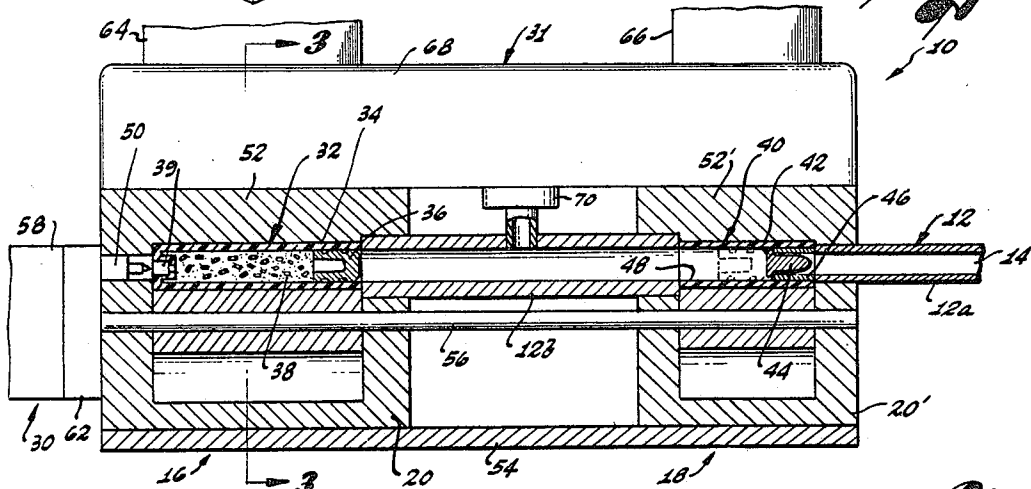


Fig. 3

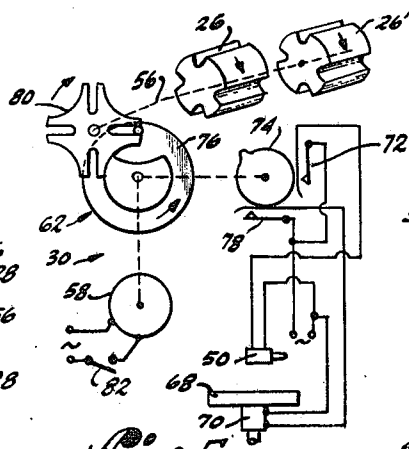
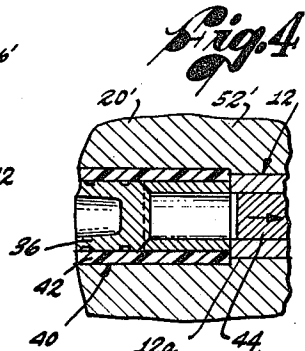


Fig. 4



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HIGH FIRING RATE, LIGHT GAS HYPERVELOCITY GUN AND AMMUNITION THEREFOR
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18 Claims

ABSTRACT OF THE DISCLOSURE

A high firing rate, light gas hypervelocity gun for use with primary ammunition containing a piston and a propellant charge and secondary ammunition containing a projectile, the gun having primary and secondary breech mechanisms spaced along a barrel containing a bore for successively transporting the primary and secondary ammunition rounds in unison to firing position, wherein each primary round is coaxially aligned with the breech end of the bore and the projectile of each secondary round is coaxially disposed within and releasably restrained against forward movement through the bore, and means for introducing a gas under pressure into the bore between the breech mechanisms, whereby when a primary round is fired in the primary breech mechanism with a secondary round in firing position within the secondary breech mechanism, the piston of the fired primary round is propelled forwardly through the bore to a terminal position within the secondary breech mechanism to compress the gas between the piston and the projectile of the secondary round currently in firing position and thereby effect expulsion of the projectile from the gun at a hypervelocity, and the piston of the fired primary round is ejected from the gun during subsequent operation of the breech mechanisms to transport the next primary and secondary rounds to firing position. Primary and secondary ammunitions for the gun.

REFERENCE TO COPENDING APPLICATIONS

Reference is made herein to copending applications Ser. No. 671,910, filed Sept. 1, 1967, and entitled, "Sealed Open Chamber Breech Mechanism and Caseless Ammunition Therefor" and Ser. No. 665,136, filed Sept. 1, 1967, now abandoned, and entitled, "Semi-Combustible Ammunition for Open Chamber Breech Mechanism."

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates generally to guns and more particularly to a high firing rate, light gas hypervelocity gun. The invention relates also to novel ammunition for use in the gun.

Prior art

Hypervelocity guns are known in the art and, as their name implies, are characterized by extremely high muzzle velocities, i.e., hypervelocities. Such hypermuzzle velocities are achieved in various ways. The present invention is concerned with the particular hypervelocity gun technique which involves compression of a gas to an extremely high pressure within a bore between a propellant driven piston and a releasably restrained projectile in the bore in such manner as to effect abrupt release of the projectile and expulsion of the projectile from the bore at a hypervelocity by the pressure of the compressed gas. The existing hypervelocity guns of this kind, while capable of achieving hypermuzzle velocities, are deficient

in that they are tedious and time consuming to reload. As a consequence, such hypervelocity guns have never been adopted as a practical weapon.

SUMMARY OF THE INVENTION

The present invention provides an improved light gas, hypervelocity gun which avoids the above-noted and other deficiencies of the existing guns of this type. The major advantage of the present gun, for example, resides in its rapid reloading and high firing rate capabilities. In this regard, it will become evident in the ensuing description that the present gun is uniquely adapted to automatic high rate firing. Generally speaking, the present gun is characterized by primary and secondary breech mechanisms spaced along a barrel containing a bore. The primary breech mechanism is arranged to receive and to successively transport to firing position in the breech mechanism primary ammunition rounds each containing a piston and a propellant charge. Each primary round, when in firing position, is coaxially aligned with the breech end of the bore. When a primary round is fired, its piston is propelled forwardly at high velocity through the bore by propellant gas pressure. The secondary breech mechanism is arranged to receive and to successively transport to firing position in the breech mechanism secondary ammunition rounds each containing a projectile. The projectile of each secondary round, when in firing position, is coaxially disposed within and is releasably restrained against forward movement through the bore. The gun is also equipped with means for introducing a gas under pressure into the bore between the breech mechanisms.

In firing operation of the gun, the breech mechanisms are operated in unison to simultaneously transport primary and secondary ammunition rounds to firing position. A charge of compressed gas is then introduced into the bore between the breech mechanism, after which the primary round is fired to effect forward propulsion of its piston through the bore to a terminal position in the secondary breech mechanism. As the piston travels through the bore, the gas in the bore is compressed to extremely high pressure between the piston and the releasably restrained projectile of the secondary ammunition round currently in firing position. As the piston approaches its terminal position within the secondary breech mechanism, the projectile is abruptly released and driven forwardly through the bore at a hypervelocity by the highly compressed gas between the projectile and the piston. The piston of the fired primary round lodges within the secondary breech mechanism and is ejected from the gun during subsequent operation of the breech mechanisms to transport the next primary and secondary rounds to firing position. In a typical hypervelocity gun according to the invention, the ammunition transport means of the breech mechanisms may be driven in unison at high speed to effect unified infeed movement of primary and secondary ammunition rounds to firing position and ejection of the spent pistons of the fired primary rounds, thereby to provide a gun with both a hypermuzzle velocity and a high firing rate. In this regard, it will become evident as the description proceeds that present gun is uniquely adapted to automatic high rate firing operation.

As will appear from the later description, the present hypervelocity gun may employ either closed chamber or open chamber breech mechanisms or both closed and open chamber breech mechanisms in various combinations. That is to say, both the primary and secondary breech mechanisms may embody a closed chamber breech actions or an open chamber breech action, or one mechanism may embody a closed chamber action and the other an open chamber action. In this regard, it should be noted

that a closed chamber breech action is one in which each ammunition round is inserted or rammed axially into a circumferentially closed firing chamber through one end of the chamber and the spent cartridge case of each fired round is extracted axially from the chamber. Examples of this type of breech mechanism are the conventional belt or clip fed mechanisms, the revolver mechanism, the Gatling mechanism, and the separate chamber mechanism. An open chamber breech action, on the other hand, is one in which each ammunition round is introduced laterally into a firing chamber through an open side of the chamber and the spent cartridge case of each fired round is ejected laterally through the open side of the chamber. Examples of such open chamber breech mechanisms are those disclosed in prior art Patents Nos. 2,983,223; 3,041,938; 2,831,140; 2,847,784; 3,044,890. Moreover, a hypervelocity gun according to the invention may have either a fixed barrel or a rotary barrel construction. A fixed barrel construction is one in which each gun barrel is stationary at all times and each firing chamber is stationarily aligned with the barrel, at least during firing of each ammunition round in the chamber. A rotary barrel gun, on the other hand, is one in which the gun barrel or barrels undergo continuous rotation about an axis parallel to and spaced laterally from the barrel or barrels and each firing chamber is coaxially aligned with and rotates about the axis with a barrel during firing of each round in the chamber, thus to achieve a very high firing rate. The aforementioned Patent No. 3,041,939, for example, describes a rotary barrel open chamber gun, and the remaining patents listed disclose fixed barrel open chamber guns.

According to a further aspect of the invention, the latter provides novel primary and secondary ammunition for the present hypervelocity gun. The primary ammunition comprises a unitized primary ammunition round including a piston and a propellant for driving the piston through the gun bore to compress the gas which is introduced into the bore between the primary and secondary breech mechanisms. The secondary ammunition comprises a unitized secondary round including a projectile to be propelled forwardly through the bore by the compressed gas and means for receiving the piston of the fired primary round to permit ejection of the piston from the secondary breech mechanism, in the manner explained earlier. As will be seen presently, the primary and secondary ammunition which is fired in an open chamber hypervelocity gun according to the invention may comprise fully cased open chamber ammunition having a cartridge case similar to that disclosed in the aforementioned prior art patents, semicom bustible ammunition having a skeletonized cartridge case similar to that disclosed in the copending application entitled, "Semi-Combustible Ammunition for Open Chamber Breech Mechanism," or caseless ammunition similar to that disclosed in copending application entitled, "Sealed Open Chamber Breech Mechanism and Caseless Ammunition Therefor."

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an open chamber hypervelocity gun according to the invention;

FIG. 2 is an enlarged fragmentary side elevation of the gun with parts sectioned for clarity of illustration;

FIG. 3 is a section taken on line 3—3 in FIG. 2;

FIG. 4 is an enlarged fragmentary section showing the piston of a fired primary ammunition round in its terminal position within the secondary breech mechanism of the gun; and

FIG. 5 diagrammatically illustrates the cylinder drive means, firing means, and pressurizing means of the gun.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In general terms, the invention provides a hypervelocity gun, represented in the drawings by the gun 10, having

a barrel 12 containing a bore 14. Spaced along the barrel are a pair of breech mechanisms 16 and 18. Breech mechanism 16 is located at the breech end of the barrel and is hereinafter referred to as a primary breech mechanism. Breech mechanism 18, hereinafter referred to as a secondary breech mechanism, is located forwardly along the barrel from the primary breech mechanism. It will be recalled that the present hypervelocity gun may employ various types of primary and secondary breech mechanisms. The illustrated primary breech mechanism 16 has a breech frame 20 supporting a movable ammunition carrier 26 containing at least one firing chamber 28. Carrier 26 is movable along a prescribed path of motion relative to its breech frame 20 to locate its firing chamber successively in an ammunition infeed position, a firing position, and an ejection position. When in infeed position, the carrier 26 is disposed to receive a primary ammunition round to be fired. When in firing position, the carrier firing chamber 28 is coaxially disposed relative to and opens forwardly to the breech end of the gun bore 14. Finally, when in ejection position, the carrier is disposed for ejection of the spent cartridge case of a cased primary round from the firing chamber after firing. The secondary breech mechanism 18 is essentially identical except for size to the primary breech mechanism 16. For this reason, the parts of the secondary breech mechanism are referred to by the same reference numerals, with a prime subscript, as the corresponding parts of the primary breech mechanism. For reasons which will appear as the description proceeds, the chamber 28' in the secondary breech carrier 26' is referred to as an ammunition chamber rather than a firing chamber, as is the chamber in the primary carrier. The secondary breech carrier 26', like the primary breech carrier 26, is movable along a prescribed path of motion relative to its breech frame 20' to locate its ammunition chamber 28' successively in an ammunition infeed position, a firing position, and an ejection position. When in infeed position, the carrier 26' is disposed to receive a secondary ammunition round to be fired. When in firing position, the carrier ammunition chamber 28' is coaxially disposed relative to and opens forwardly and rearwardly to the gun bore 14. Finally, when in ejection position, the secondary carrier is disposed for ejection of the cartridge case of a cased secondary ammunition from the ammunition chamber after firing. Drive means 30 are provided for driving the two breech carriers 26, 26' in unison to their infeed, firing, and ejection positions. Communicating with the gun bore 14, between the primary and secondary breech mechanisms 16, 18, are pressurizing means 31 for introducing a gas, such as hydrogen or helium, into the gun bore.

The primary breech mechanism 16 operates to transport primary ammunition rounds 32 in succession to firing position in the primary breech mechanism and to fire each primary round in this position. Each illustrated primary round comprises a yieldable, non-combustible cartridge case 34 containing a forward piston 36, a rear propellant charge 38, and a primer 39. The secondary breech mechanism 18 operates to transport secondary ammunition rounds 40 in succession to firing position within the secondary breech mechanism. Each illustrated secondary ammunition round comprises a yieldable, non-combustible cartridge case 42 containing a forward projectile 44, a projectile restraining sleeve 46, and a rearwardly opening piston-receiving cavity 48. It is significant to note here that while the illustrated primary and secondary ammunition is fully cased ammunition, the ammunition which is fired in the present hypervelocity gun may comprise semi-combustible or caseless ammunition similar to that disclosed in the aforementioned copending application.

Briefly, in operation of the present hypervelocity gun 10, the ammunition carriers 26, 26' of the primary and secondary breech mechanisms 16, 18 are first driven to

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infeed position. A primary ammunition round 32 is then introduced into the firing chamber 28 of the primary carrier and a secondary ammunition round 40 is introduced into the ammunition chamber 28' of the secondary carrier. Thereafter, the carriers are driven to firing position and the pressurizing means 31 are actuated to admit a charge of gas under pressure into the gun bore 14 between the breech mechanisms. At this point, the primary round 32 currently in firing position is fired by actuation of the primary breech firing means 50. The piston 36 of the fired primary round is then propelled forwardly at high velocity through the bore by the high pressure propellant gas generated by firing of the primary round. According to the present invention, the piston travels forwardly through the bore to a terminal position within the secondary breech mechanism 18, wherein the piston lodges within the secondary ammunition chamber 28' currently in firing position. In the particular embodiment of the invention illustrated, the piston of the fired primary round 32 enters and finally lodges within the rearwardly opening cavity 48 of the secondary ammunition round 40 currently in firing position in the secondary breech mechanism. As the piston of the fired primary round travels forwardly through the gun bore 14 to its terminal position in the secondary breech mechanism, the gas introduced into the bore prior to firing is compressed to an extremely high pressure between the piston and the projectile 44 of the secondary round 40 currently in firing position. According to the present invention, the projectile is restrained, by the projectile restraining sleeve 46 of the secondary round, against forward movement through the bore until the piston 36 of the fired primary round approaches its terminal position. The projectile is then abruptly released and propelled forwardly through the bore at hypervelocity by the pressure of the highly compressed gas between the piston and projectile. After firing, the ammunition carriers 26, 26' are driven to ejection position to eject the spent cartridge cases 34, 42 of the fired primary and secondary ammunition rounds 32, 40. The piston 36 of the fired primary round, which is then lodged within the spent cartridge case 42 of the fired secondary round, is ejected with the latter case.

In the particular hypervelocity gun 10 of the invention which has been selected for illustration in the drawings, the primary and secondary breech carriers 26, 26' are cylinders. These cylinders are rotatably mounted within chambers 22, 22' in the primary and secondary breech frames 20, 20', respectively, for turning on a common axis 24 parallel to and spaced laterally from the barrel 12. The carrier drive means 30 drives the cylinders in rotation in unison to locate the firing and ammunition chambers 28, 28' in their infeed, firing, and ejection positions.

The light gas hypervelocity gun 10 of the invention which has been selected for illustration in the drawings will now be described in greater detail. As noted earlier and will appear from this description, a hypervelocity gun according to the invention, may utilize either or both an open chamber breech action and a closed chamber breech action. The particular gun illustrated is an open chamber gun which employs an open chamber breech action in both of its primary and secondary breech mechanisms 16, 18. In this regard, it will be observed that each breech mechanism is essentially a convention open breech mechanism of the type disclosed in the aforementioned prior art patents. Thus, the breech frames 20, 20' of the breech mechanisms have the usual generally flat, rectangular shape and contain generally rectangular central openings which open laterally throughout the sides of the frame to form the breech chambers 22, 22'. As is well known to those versed in the open chamber gun art, the cylinder of an open chamber breech mechanism may contain one or more chambers and may be driven in unidirectional rotation or in oscil-

lation to locate each cylinder chamber in its infeed firing and ejection positions. The breech cylinders 26, 26' of the illustrated open chamber hypervelocity gun 10 of the invention contain the same number of uniformly spaced chambers 28, 28' and are driven in unidirectional rotation to locate each chamber in its infeed, firing and ejection positions. In accordance with a characteristic feature of open chamber mechanisms, each cylinder chamber opens laterally through the circumference and longitudinally through the front and rear ends of its respective cylinder. The open sides of the breech chambers 22, 22' define ammunition infeed and cartridge case ejection openings with which the chambers 28, 28' of the respective contained breech cylinders, 26, 26' register when in infeed and ejection positions, respectively. When in firing position, the open sides of the open cylinder chambers are closed by the firing straps 52, 52' of their breech frames 20, 20', respectively.

A further characteristic feature of an open chamber breech mechanism resides in the complementary, generally triangular shapes of the breech cylinder chambers and the open chamber ammunition rounds which are fired in the breech mechanism. In this regard, it will be observed that the breech cylinder chambers 28, 28' of the illustrated open chamber gun 10 and the ammunition rounds 32, 42 which are fired in the gun have the same generally triangular round shapes in transverse cross section as the firing chambers and ammunition disclosed in the aforementioned prior art patents. The sidewalls of each cylinder chamber and the sides of each ammunition round are cylindrically curved to the same radius of curvature as the respective breech cylinder, 26, 26', as the case may be. When an ammunition round is positioned in a cylinder chamber of either breech mechanism 16 or 18, two sides of the round seat flush against the sidewalls of the chamber and the third exposed side of the round is flush with the circumference of the corresponding breech cylinder, 26 or 26'. The inner surfaces of the firing straps 52, 52' of the breech frames 20, 20' are also cylindrically curved to the same radius as and slidably engage the circumferences of their respective breech cylinders 26, 26'. The primary and secondary breech mechanisms 16, 18 of the illustrated open chamber gun 10 are disposed in longitudinal alignment along and are rigidly secured to a base plate 54 in such a way the rotation axis 24 of the breech cylinders 26, 26' coincide. The barrel 12 of the gun comprises front and rear barrel sections 12a, 12b, respectively. The front barrel section 12a is secured at its rear end to and extends forwardly from the front end of the secondary breech frame 20'. The rear barrel section 12b extends between and is secured to the front end of the primary breech frame 20 and the rear end of the secondary breech frame 20'. These barrel sections are coaxially disposed in spaced parallel relation to the common axis 24 of the breech cylinders 26, 26'.

The cylinder drive means 30 of the illustrated gun 10 comprise a connecting drive shaft 56 which extends between the cylinders, along their common axis 24 of rotation. The rear end of this shaft extends rotatably through the forward end of the primary breech frame 20 and is coaxially secured to the forward end of the primary breech cylinder 26. The forward end of the shaft extends rotatably through the rear end of the secondary breech frame 20' and is coaxially secured to the rear end of the secondary breech cylinder 26'. Accordingly, the connecting shaft joins the breech cylinders 26, 26' for unified rotation thereof. It is significant to note here that the primary and secondary breech cylinders are relatively oriented in such a way that their chambers 28, 28' are axially aligned, whereby the corresponding chambers of the two cylinders rotate in unison to their infeed, firing and ejection positions. The illustrated drive means 30 further comprise a motor 58 mounted on the rear end of the primary breech frame 20. The shaft of this motor is

drivably coupled to the rear end of the cylinder shaft 56 through a rotary intermittent drive mechanism 62, such as a Geneva mechanism. During operation of the motor 58, this intermittent drive mechanism drives the primary breech cylinder 26, and hence the secondary breech cylinder 26', in intermittent rotation in such a way that the cylinder chambers 28, 28' are periodically arrested in their infeed, firing and ejection positions. Each firing chamber 28 of the primary breech mechanism 16, when in infeed position, registers with one open side of the primary breech chamber 22. When in firing position, each firing chamber is coaxially aligned with and opens forwardly to the rear portion of the gun bore 14 within the rear barrel section 12b. When in ejection position, each firing chamber registers with the opposite open side of the primary breech chamber. Each ammunition chamber 28' of the secondary breech mechanism 18 is similarly located when in its infeed firing and ejection positions, except that when in its firing position, the chamber opens forwardly to the portion of the gun bore within the front barrel section 12a and rearwardly to the portion of the gun bore within the rear barrel section 12b. It is evident at this point, therefore, that the primary firing chambers 28 and secondary ammunition chambers 28', when in infeed position, are disposed to receive primary and secondary ammunition rounds 32, 40, respectively. Insofar as the present invention is concerned, these ammunition rounds may be fed to their respective breech mechanisms in any convenient way. The illustrated hypervelocity gun 10 of the invention, for example, is equipped with primary and secondary ammunition hoppers 64, 66, respectively, for feeding the primary ammunition rounds 32 laterally in succession to the primary firing chambers 28 and the secondary ammunition rounds 40 laterally in succession to the secondary ammunition chambers 28', as these chambers rotate to infeed positions. The hoppers may be equipped with suitable spring loaded followers (not shown) for urging the ammunition rounds toward their respective breech cylinders 26, 26'.

As noted earlier, each primary ammunition round 32 has a cartridge case 34 containing a piston 36 which is sized to fit slidably in the rear portion of the gun bore 14, a propellant charge 38 for propelling the piston forwardly to the bore, and a primer 39 for igniting the propellant. Each secondary round 40 has a cartridge case 42 containing a projectile 44, a projectile restraining sleeve 46, and a rearwardly opening cavity 48, which is sized to receive the piston 36 of a primary round. The cartridge cases 34, 42 are sized and shaped to complement the primary and secondary cylinder chambers 28, 28' in the manner explained earlier.

The primary ammunition pistons 36 are preferably hollow as shown to maximize the propellant space in the primary rounds 32, and are provided with external sealing means for sealing the pistons to the wall of the gun bore 14. Each piston is frictionally retained in its cartridge case 34 to permit feeding of the primary ammunition rounds to the gun without separation of the pistons from their cartridge cases. The projectile restraining sleeve 46 of each secondary ammunition round 40 is frictionally fitted within the cartridge case 42 of the round and is constructed of a relatively hard metal. The external diameter of the sleeve is substantially greater than the diameter of the forward portion of the gun bore 14. Accordingly, when a secondary round is located in firing position within the secondary breech mechanism 18, the forward end of its restraining sleeve seats against the rear end of the front barrel section 12a. The central opening in the restraining sleeve has a uniform diameter at its forward end, which is the same as that of the forward portion of the gun bore 14. The rear end of the sleeve opening flares outwardly to a larger diameter, as shown. The projectile 44 of each secondary round has a forward end which fits closely within the uniform diameter portion of the central opening through its respec-

tive restraining sleeve 46. The rear end of the projectile flares outwardly to complement the flaring rear end of the sleeve opening. It is now evident, therefore, that when a secondary ammunition round 40 is located in firing position in the secondary breech mechanism 18, its projectile 44 is restrained against forward movement through the restraining sleeve 46 of the round. It is significant to note here that the rear ends of the projectile 44 and projectile restraining sleeve 46 of each secondary round 40 are spaced a distance from the rear end of the cartridge case 42 of the round to define within the case the rearwardly opening cavity 48. The length of this cavity is equal to or slightly greater than the length of each primary ammunition piston 36, whereby the cavity is sized to contain a piston.

Turning now to FIG. 2, it will be observed that the pressurizing means 31 for supplying gas under pressure to the rear portion of the gun bore 14 between the primary and secondary breech mechanisms 16, 18 comprise a pressure vessel or tank 68 for containing a supply of light gas, such as hydrogen or helium under pressure. In this instance, the tank 68 has a generally rectangular shape and is rigidly attached to the upper sides of the breech frames 20, 20'. Between the tank and the rear barrel section 12b is a valve 70. This valve has an inlet which communicates to the interior of the tank and an outlet which communicates to the rear portion of the gun bore 14 between the primary and secondary breech mechanisms 16, 18. Valve 70 is normally closed, and is periodically opened to admit a charge of gas under pressure into the gun bore 14 in timed relation to rotation of the breech cylinders 26, 26' from one firing position to the next.

This periodic operation of the valve 70 may be accomplished in various ways. The illustrated valve, for example, is a solenoid valve whose solenoid is energized through a switch 72 (FIG. 5) operated by a cam 74 driven from the rotary driving member 76 of the Geneva drive mechanism 62. Cam 74 also operates a second switch 78 for actuating the firing means 50 of the gun, which, in this instance, comprises a conventional electrical firing means. The cam 74 valve switch 72 and firing switch 78 are arranged in such a way that the switches remain open during rotation of the Geneva driving member 76 through that portion of each revolution in which the driving member drives the Geneva driven member 80 to rotate the breech cylinders 26, 26' from one firing position to the next. During the remainder of each revolution of the Geneva driving member 76, wherein the driven member 80 and hence the breech cylinders 26, 26' remain stationary, the cam 74 momentarily closes the valve switch 72 and then the firing switch 78. Each momentary closure of the valve switch 72 energizes and thereby opens the valve 70 to admit a charge of gas under pressure from the tank 68 into the gun bore 14. Each momentary closure of the firing switch 78 energizes the firing means 50 to fire the primary ammunition round 32 currently in firing position in the primary breech mechanism 16. The Geneva drive motor 58 is energized to condition the gun for firing by closure of a main switch 82.

It will now be understood that the illustrated hypervelocity gun 10 of the invention is fired by first loading the ammunition hoppers 64, 66 with primary and secondary ammunition rounds 32, 40, respectively, and then closing the main gun switch 82 to energize the Geneva drive motor 58. The primary and secondary breech cylinders 26, 26' are then driven in intermittent rotation through the Geneva drive 62 in such a way that the cylinder chambers 28, 28' are rotated in sequence to and momentarily arrested in their infeed firing and ejection positions. As each cylinder chamber rotates to infeed position, it receives an ammunition round from the corresponding ammunition hopper 64 or 66, as the case may be, after which the round rotates with its containing chamber to

firing position. Since the corresponding primary firing chambers 28 and secondary ammunition chambers 28' are aligned, intermittent rotation of the breech cylinders 26, 26' is effective to periodically transport a primary ammunition round 32 to firing position in the primary breech mechanism 16 and simultaneously transport a secondary ammunition round 40 to firing position in the secondary breech mechanism 18.

Immediately following arrival of each primary and secondary ammunition round in firing position, the valve switch 72 is momentarily closed to admit a charge of gas under pressure to the gun bore 14 between the breech mechanisms 16, 18. In a typical hypervelocity gun according to the invention, the gas is thus admitted to the gun bore under a pressure on the order of 1,000 p.s.i. to 3,000 p.s.i. The firing switch 78 is then closed to fire the primary ammunition round 32 currently in firing position. Firing of the primary round results in propulsion of its piston 36 forwardly at high velocity through the gun bore 14 to its terminal position within the secondary breech mechanism 18. In this terminal position, the piston is contained within the rear cavity 48 of the secondary ammunition round 40 currently in firing position. As the piston travels forwardly through the gun bore toward its terminal position, the initially pressurized gas in the bore is compressed between the piston and the restrained projectile 44 of the second ammunition round. In a typical gun according to the invention, the gas is thus compressed to a pressure on the order of 60,000 to 80,000 p.s.i. as the piston approaches its terminal position within the secondary breech mechanism.

According to the present invention, the projectile 44 of the secondary ammunition round 40 in firing position is restrained by its restraining sleeve 46 until the compressed gas in the gun bore 14 behind the projectile has attained the desired high pressure. This high pressure is then effective to force or extrude the projectile through its restraining sleeve and to thereafter propel the projectile forwardly through the forward barrel section 12a at hypervelocity.

The rate of intermittent rotation of the breech cylinders 26, 26' is such that the cylinders are driven from one firing position to the next after evacuation of the gun bore 14 has occurred following the previous firing. A new primary ammunition round 32 and secondary ammunition round 40 are thereby rotated to firing position, and the above described firing sequence is repeated. This rotation of the breech cylinders also transports the spent cartridge cases 34, 42, of the previously fired primary and secondary rounds from firing position to ejection position, wherein the cases are ejected from their respective cylinder chambers 28, 28'. The piston 36 of the previously fired primary round 32, which is now lodged within the spent cartridge case of the fired secondary round 40, is ejected with the latter case.

At this point, attention is again directed to the earlier discussion, wherein it was noted that while the invention is disclosed in connection with a hypervelocity gun utilizing an open chamber action in both of its primary and secondary breech mechanisms, either or both of the breech mechanisms may conceivably employ a closed chamber action. In this event, the primary and secondary rounds will be inserted axially into their respective cylinder chambers and the spent cartridge cases of the rounds will be extracted axially from the chambers. It is also important to note that while the invention has been disclosed in connection with a fixed barrel gun, the features of the invention may be embodied in a rotary barrel hypervelocity gun of the kind referred to earlier. Moreover, while the disclosed primary and secondary ammunition rounds 32, 40 are fully cased rounds, having cartridge cases of the type disclosed in the aforementioned prior art patents, either or both of the primary and secondary ammunition rounds may have skeletonized cartridge cases of the kind disclosed in the aforementioned copending application entitled "Semicombustible Ammu-

munition for Open Chamber Breech Mechanism." Also, the primary ammunition rounds may comprise uncased rounds which are totally devoid of a cartridge case like the rounds disclosed in the aforementioned copending application entitled, "Sealed Open Chamber Breech Mechanism and Caseless Ammunition Therefor." When firing uncased ammunition of this type, of course, the primary breech mechanism of the gun will be equipped with suitable obturator means, such as those disclosed in the application, for sealing the breech interfaces against propellant gas leakage.

It will be understood that the valve switch 72 and firing switch 78 are operated substantially simultaneously or in sufficiently rapid succession to effect firing of each primary round 32 while the gas pressure in the gun bore is at the proper initial elevated level, just mentioned. The rounds in firing position and the relatively close fit of the breech parts inhibit gas leakage from the bore, of course. If necessary, the breech mechanisms of the gun may be provided with additional sealing means for this purpose.

It will now be understood, therefore, that while the invention has been disclosed in connection with a particular physical embodiment thereof, various modifications of the invention are possible within the spirit and scope of the following claims.

What is claimed as new in support of Letters Patent is:

1. In a hypervelocity gun for firing primary ammunition rounds each containing a propellant and a piston and secondary ammunition rounds each containing a projectile, the combination comprising:

- a barrel containing a bore;
- a primary breech mechanism at the breech end of said barrel including means for transporting said primary ammunition rounds in succession to a primary firing position wherein each primary round is coaxially aligned with said bore;
- a secondary breech mechanism along said barrel forwardly of said primary breech mechanism including means for transporting said secondary ammunition rounds in succession to a secondary firing position wherein each secondary round is coaxially disposed within and releasably restrained against forward movement through said bore;
- pressurizing means for introducing a gas into said bore between said breech mechanisms, whereby when a primary round is fired in said primary firing position with a secondary round in said secondary firing position, the piston of the fired primary round is propelled forwardly through said bore to compress said gas between the fired piston and the projectile of the secondary round currently in said secondary firing position, and the latter projectile is released and propelled forwardly through said bore by said compressed gas;

firing means for firing each primary ammunition round in primary firing position; and

means for operating said primary and secondary ammunition transport means, said firing means, and said pressurizing means in timed relation in such manner as to locate a secondary ammunition round in secondary firing position simultaneously with location of each primary ammunition round in primary firing position, admit a charge of said gas into said bore approximately concurrently with arrival of each pair of primary and secondary ammunition rounds in firing position, and immediately thereafter fire the primary round in primary firing position.

2. A hypervelocity gun, according to claim 1, wherein: said secondary ammunition transport means comprises an ammunition carrier having a chamber for receiving said secondary ammunition round prior to firing and the piston of the fired primary ammunition round after firing, and means for driving said carrier between an infeed position wherein said chamber is disposed to receive from said secondary magazine a

secondary ammunition round to be fired, a firing position wherein said chamber locates the contained secondary ammunition round in said secondary firing position and the chamber is disposed to receive the piston of the fired primary ammunition round and an ejection position wherein the chamber is disposed for rejection from the chamber of the piston of the fired primary round.

3. A hypervelocity gun comprising:

a barrel containing a bore;
a primary breech mechanism at the breech end of said barrel;

a secondary breech mechanism along said barrel forwardly of said primary breech mechanism;
each of said breech mechanisms including an ammunition carrier;

the carrier of said primary breech mechanism containing a firing chamber and being movable to locate said primary chamber in an ammunition infeed position and a firing position;

the carrier of the said secondary breech mechanism containing an ammunition chamber and being movable to locate said ammunition chamber in an ammunition infeed position and a firing position;

pressurizing means for introducing a gas under pressure into said bore between said breech mechanism;
firing means on said primary breech mechanism disposed in ammunition firing relation to said firing chamber when said firing chamber occupies said primary firing position;

means for driving said carriers in timed relation to simultaneously locate said firing and ammunition chambers in their respective firing positions; and
means for operating said driving means, said firing means, and said pressurizing means in timed relation in such manner as to admit a charge of said gas into said bore approximately concurrently with arrival of said firing and ammunition chambers in firing position and to immediately thereafter actuate said firing means.

4. A hypervelocity gun according to claim 3 wherein: said carrier driving means comprise means for driving one of said carriers to locate its chamber in infeed and firing position, means drivably connecting said carriers for unified movement of their respective chambers to said infeed and firing positions.

5. A hypervelocity gun comprising:

a barrel containing a bore;
a primary breech mechanism at the breech end of said barrel;

a secondary breech mechanism along said barrel forwardly of said primary breech mechanism;

each of said breech mechanisms including a breech frame containing a chamber and an ammunition infeed opening to said chamber, and an ammunition carrier supported on said frame within said chamber for rotation on an axis parallel to and laterally spaced from said bore;

the carrier of said primary breech mechanism containing a firing chamber parallel to and spaced laterally from said rotation axis and being rotatable to locate said firing chamber in an ammunition infeed position wherein said firing chamber registers with the infeed opening in the primary breech frame, and a firing position wherein said firing chamber is coaxially aligned with and opens forwardly to the breech end of said bore;

the carrier of said secondary breech mechanism containing an ammunition chamber parallel to and spaced laterally from said rotation axis and being rotatable to locate said ammunition chamber in an ammunition infeed position wherein said ammunition chamber registers with the infeed opening in the secondary breech frame, and a firing position wherein said ammunition chamber is coaxially aligned with

and opens forwardly and rearwardly to said gun bore;

means for driving said carriers in rotation in timed relation to simultaneously locate said firing and ammunition chambers in their respective firing positions; and

pressurizing means for introducing a gas under pressure into said bore between said breech mechanisms.

6. A hypervelocity gun comprising:

a barrel containing a bore;
a primary breech mechanism at the breech end of said barrel;

a secondary breech mechanism along said barrel forwardly of said primary breech mechanism;

each of said breech mechanisms including a breech frame containing a chamber and an ammunition infeed opening to said chamber, and an ammunition carrier supported on said frame within said chamber for rotation on an axis parallel to and laterally spaced from said bore;

the carrier of said primary breech mechanism containing a firing chamber and being rotatable to locate said firing chamber in an ammunition infeed position wherein said firing chamber registers with the infeed opening in the primary breech frame, and a firing position wherein said firing chamber is coaxially aligned with and opens forwardly to the breech end of said bore;

the carrier of said secondary breech mechanism containing an ammunition chamber and being rotatable to locate said ammunition chamber in an ammunition infeed position wherein said ammunition chamber registers with the infeed opening in the secondary breech frame, and a firing position wherein said ammunition chamber is coaxially aligned with and opens forwardly and rearwardly to said gun bore;

means for driving said carriers in timed relation to simultaneously locate said firing and ammunition chambers in their respective firing positions;

pressurizing means for introducing a gas under pressure into said bore between said breech mechanisms;

firing means on said primary breech mechanism disposed in ammunition firing relation to said firing chamber when said primary firing chamber occupies said firing position thereof; and

means for operating said driving means, said firing means, and said pressurizing means in timed relation in such manner as to admit a charge of said gas into said bore approximately concurrently with arrival of said firing and ammunition chambers in firing position and immediately thereafter actuating said firing means.

7. An open chamber hypervelocity gun comprising:

a barrel containing a bore;
a primary open chamber breech mechanism at the breech end of said barrel;

a secondary open chamber breech mechanism along said barrel forwardly of said primary breech mechanisms;

each of said breech mechanisms including a breech frame containing a chamber and a lateral ammunition infeed opening to said chamber, and an open chamber cylinder supported on said frame within said chamber for rotation on an axis parallel to and laterally spaced from said bore;

the cylinder of said primary breech mechanism containing a firing chamber opening laterally through the circumference and longitudinally through the front end of the primary cylinder and being rotatable to locate said firing chamber in an ammunition infeed position wherein the open side of said firing chamber registers with the infeed opening in the primary breech frame, and a firing position wherein the open side of said firing chamber is closed by the primary breech frame and the firing chamber opens forwardly to the breech end of said bore;

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the cylinder of said secondary breech mechanism containing an ammunition chamber opening laterally through the circumference and longitudinally through the front and rear ends of the secondary cylinder and being rotatable to locate said ammunition chamber in an ammunition infeed position wherein the open side of said ammunition chamber registers with the infeed opening in the secondary breech frame, and a firing position wherein the open side of said ammunition chamber is closed by the secondary breech frame and said ammunition chamber is coaxially aligned with and opens forwardly and rearwardly to said gun bore;

means for driving one cylinder in rotation to locate the corresponding cylinder chamber in infeed and firing position;

means drivably coupling said primary and secondary cylinders for rotation of said cylinders in unison to simultaneously locate said firing and ammunition chambers in their respective infeed and firing positions; and

pressurizing means for introducing a gas under pressure into said bore between said breech mechanisms in timed relation to rotation of said cylinders.

8. A hypervelocity gun, according to claim 7, wherein: said bore is reduced in diameter forwardly of said secondary breech mechanism to provide a rearwardly presented annular shoulder about said bore at the front end of said ammunition chamber when said ammunition chamber occupies said secondary firing position.

9. A hypervelocity gun, comprising:

a barrel containing a bore;

a primary breech mechanism at the breech end of said barrel;

a secondary breech mechanism along side barrel forwardly of said primary breech mechanism;

each of said breech mechanisms including an ammunition carrier;

the carrier of said primary breech mechanism containing a number of uniformly spaced firing chambers and being movable to locate each chamber in a firing position wherein the respective firing chamber is coaxially aligned with and opens forwardly to the breech end of said bore;

the carrier of said secondary breech mechanism containing a number of uniformly spaced ammunition chambers and being movable to locate each ammunition chamber in a firing position wherein the respective ammunition chamber is coaxially aligned with and opens forwardly and rearwardly to said bore;

means for driving said carriers in unison to concurrently locate said firing and ammunition chambers in firing position in succession;

pressurizing means for introducing a gas into said bore between said breech mechanisms; and

means for operating said carrier driving means and pressurizing means in timed relation in such manner as to admit a charge of said gas into said bore approximately concurrently with arrival of each pair of corresponding firing and ammunition chambers in firing position.

10. A hypervelocity gun, according to claim 9, wherein: each of said breech mechanisms comprises a breech frame containing a carrier receiving chamber and an ammunition infeed opening to said receiving chamber;

said carrier of each breech mechanism comprises a cylinder supported on the respective breech frame within the corresponding receiving chamber for rotation on an axis parallel and laterally spaced from said bore; and

each cylinder is rotatable to locate each of its chambers in the corresponding firing position and an am-

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munition infeed position wherein the respective firing chamber registers with the infeed opening in the corresponding breech frame.

11. A hypervelocity gun, according to claim 10, wherein:

at least one of said breech mechanisms comprises an open chamber breech mechanism; and

the cylinder chambers of said open chamber breech mechanism open laterally through the circumference of the corresponding cylinder.

12. A hypervelocity gun, according to claim 9, wherein: said primary breech mechanism includes firing means disposed in ammunition firing relation to each firing chamber when the respective firing chamber occupies its firing position;

said gun further comprises means for actuating said firing means immediately after each operation of said pressurizing means to admit a charge of said gas into said bore; and

said bore is reduced in diameter forwardly of said secondary breech mechanism to provide a rearwardly presented annular shoulder about said bore at the forward end of each ammunition chamber when the respective ammunition chamber occupies its firing position.

13. A hypervelocity gun and ammunition combination comprising:

a barrel containing a bore;

a primary breech mechanism at the breech end of said barrel including a primary breech frame, a primary ammunition carrier having a primary firing chamber opening through the front end of said carrier for receiving said primary rounds in succession, means supporting said carrier on said frame for movement of said firing chamber with said carrier laterally of said bore along a prescribed path of motion and through an ammunition infeed position wherein said firing chamber is disposed to receive a primary ammunition round to be fired, a primary firing position wherein said firing chamber is coaxially aligned with and opens forwardly to the breech end of said bore to permit firing of the contained round in said firing chamber, and an ejection position;

a secondary breech mechanism along said barrel forwardly of said primary breech mechanism including a secondary breech frame, a secondary ammunition carrier containing a secondary ammunition receiving chamber opening through the front and rear ends of said secondary carrier for receiving said secondary ammunition rounds in succession, means supporting said secondary carrier on said secondary frame for movement of said secondary ammunition chamber with said secondary carrier laterally of said bore along a prescribed path of motion and through an ammunition infeed position wherein said secondary ammunition chamber is disposed to receive a secondary ammunition round to be fired, a secondary firing position wherein said secondary ammunition chamber is coaxially aligned with and opens forwardly and rearwardly to said bore, and an ejection position;

pressurizing means for introducing a gas into said bore between said breech mechanisms;

a primary ammunition round within said primary firing chamber including a piston and a propellant for propelling said piston forwardly through said bore;

a secondary ammunition round within said ammunition chamber including a projectile coaxially disposed within said bore;

means for releasably restraining said projectile against said forward movement through said bore, whereby when said primary round is fired, the piston of said primary round is propelled forwardly through said bore to compress said gas between said piston and the projectile of said secondary round, and said pro-

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jectile is released and propelled forwardly through said bore by said compressed gas; and said ammunition chamber being dimensioned to receive and contain said piston after firing, and said secondary carrier being movable to its ejection position after firing for ejection of said piston from said ammunition chamber.

14. The combination, according to claim 13, wherein: said secondary ammunition round comprises a cartridge case having a rearwardly opening cavity for receiving said piston after firing, and said secondary carrier is movable to ejection position after firing to eject both said cartridge case and said piston.

15. An open chamber hypervelocity gun and ammunition combination comprising:

a barrel containing a bore;
a primary open chamber breech mechanism at the breech end of said barrel including a primary breech frame containing a chamber, a rotary carrier supported on said frame within said chamber for turning on an axis parallel to and laterally spaced from said bore, said carrier containing a firing chamber opening laterally through the circumference and longitudinally through the front end of said carrier, said carrier being rotatable to locate said firing chamber in an ammunition infeed position wherein the open side of said firing chamber registers with a lateral ammunition infeed opening in said frame, a firing position wherein the open side of said firing chamber is closed by said frame and said firing chamber is coaxially aligned with and opens forwardly to said bore and an ejection position wherein the open side of said firing chamber registers with a lateral ejection opening in said frame;

a secondary open chamber breech mechanism along said barrel forwardly of said primary breech mechanism including a secondary firing breech frame containing a chamber, a secondary carrier rotatably supported on said secondary frame within said chamber thereof for turning on an axis parallel to and laterally spaced from said bore, said secondary carrier containing an ammunition chamber opening laterally through the circumference and longitudinally through the ends of said secondary carrier, and said secondary carrier being rotatable to locate said ammunition chamber in an ammunition infeed position wherein the open side of the ammunition chamber registers with a lateral ammunition infeed opening in said secondary frame, a firing position wherein the open side of said ammunition chamber is closed by said secondary frame and said ammunition chamber is coaxially aligned with and opens forwardly and rearwardly to said bore, and an ejection position wherein the open side of said ammunition chamber registers with an ejection opening in said secondary frame;

a primary ammunition round to be positioned within said firing chamber including a forward piston and a rear propellant charge;

a secondary ammunition round to be positioned within said secondary ammunition chamber including a cartridge case containing a forward projectile and a rearwardly opening cavity behind said projectile which is dimensioned to receive and contain said piston;

means for releasably restraining said projectile against forward movement through said bore; and

pressurizing means for introducing gas under pressure into said bore between said breech mechanisms, whereby when said primary round is fired within said primary breech mechanism with said secondary round in firing position within said secondary breech mechanism, the piston of the fired primary round is propelled forwardly through said bore to a terminal position within said cavity of the secondary round to compress said gas between the fired piston and

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the projectile of the secondary round, the projectile is released and propelled forwardly through said bore by said compressed gas, and the piston of the fired primary round is ejected with the spent cartridge case of the secondary round upon rotation of said secondary carrier to ejection position after firing.

16. A hypervelocity gun for firing primary ammunition rounds each containing a propellant charge and a piston and secondary ammunition rounds each containing a projectile comprising:

a barrel containing a bore;

a primary breech mechanism including a primary breech frame at the breech end of said barrel, a primary ammunition magazine for containing said primary ammunition rounds, and means for transporting said primary ammunition rounds in succession from said primary magazine to a primary firing position within said breech frame wherein each primary round is coaxially aligned with said bore, said ammunition transport means comprising a primary ammunition carrier having a primary firing chamber opening to the front end of said carrier for containing said primary ammunition rounds and means supporting said carrier on said frame for movement relative to said frame between a primary ammunition infeed position wherein said primary firing chamber is disposed to receive a primary round from said primary magazine and a primary firing position wherein said firing chamber is coaxially aligned with and opens forwardly to said bore;

a secondary breech mechanism including a secondary breech frame along said barrel forwardly of said primary breech mechanism, a secondary ammunition magazine for containing such secondary ammunition rounds, and means for transporting said secondary ammunition round in succession from said secondary magazine to a secondary firing position within said secondary breech frame wherein the projectile of each secondary round is coaxially disposed within said bore, said secondary ammunition transport means comprising a secondary ammunition carrier having a secondary ammunition receiving chamber opening to the front and rear ends of said secondary carrier for containing said secondary ammunition rounds and means supporting said secondary carrier on said secondary frame where movement between a secondary ammunition infeed position wherein said secondary ammunition receiving chamber is supposed to receive a secondary round from said secondary magazine and a secondary firing position wherein said secondary ammunition receiving chamber is coaxially aligned with and opens forwardly and rearwardly to said bore;

means for releasably restraining the projectile of each secondary round and secondary firing position against forward movement through said bore; and
pressurizing means for introducing gas into said bore between said breech mechanisms, whereby when a primary round is fired in said primary firing position with a secondary round in said secondary firing position, the piston of the fired primary round is propelled forwardly through said bore the compressed said gas between the fired piston and the projectile of the secondary round currently in secondary firing position, and the projectile of the secondary round and currently in said secondary firing position is released and propelled forwardly through said bore by said compressed gas.

17. A hypervelocity gun for firing primary ammunition rounds each containing a propellant charge and a piston and secondary ammunition rounds each containing a projectile, comprising:

a barrel containing a bore;

a primary breech mechanism at the breech end of said barrel including a primary ammunition magazine for

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means for transporting said primary ammunition rounds in succession from said primary magazine to a primary firing position wherein each primary round is coaxially aligned with said bore;

- a secondary breech mechanism along said barrel forwardly of said primary breech mechanism including a secondary ammunition magazine for containing said secondary ammunition rounds, and means for transporting said secondary ammunition rounds in succession from said secondary magazine to a secondary firing position wherein the projectile of each secondary round is coaxially disposed within said bore; means for releasably restraining the projectile of each secondary round in secondary firing position against forward movement through said bore; pressurizing means for introducing gas into said bore between said breech mechanisms, whereby when a primary round is fired in said primary firing position with a secondary round in said secondary firing position, the piston of the fired primary round is propelled forwardly through said bore to compress said gas between the fired piston and the projectile of the secondary round currently in secondary firing position, and the projectile of the secondary round currently in said secondary firing position is released and propelled forwardly to said bore by said compressed gas; firing means for firing each primary ammunition round in primary firing position; and means for operating said primary and secondary ammunition transport means, said firing means, and said pressurizing means in timed relation in such manner as to locate a secondary ammunition round in secondary firing position simultaneously with location of each primary ammunition round in primary firing position, admit a charge of said gas into said bore approximately concurrently with arrival of each pair of primary and secondary ammunition rounds and firing position, and immediately thereafter fire the primary round in primary firing position.

18. A hypervelocity gun for firing primary ammunition rounds each containing a propellant charge and a piston and secondary ammunition rounds each containing a projectile, comprising:

- a barrel containing a bore;
a primary breech mechanism at the breech end of said barrel including a primary ammunition magazine for containing said primary ammunition rounds, and means for transporting said primary ammunition rounds in succession from said primary magazine to a primary firing position wherein each primary round is coaxially aligned with said bore;

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a secondary breech mechanism along said barrel forwardly of said primary breech mechanism including a secondary ammunition magazine for containing said secondary ammunition rounds, and means for transporting said secondary ammunition rounds in succession from said secondary magazine to a secondary firing position wherein the projectile of each secondary round is coaxially disposed within said bore, said secondary ammunition transport means comprising an ammunition carrier having a chamber for receiving each secondary ammunition round prior to firing and the piston of the fired primary ammunition round after firing and means for driving said carrier between an infeed position wherein said chamber is disposed to receive from said secondary magazine a secondary ammunition round to be fired, a firing position when said chamber locates its contained secondary ammunition round in said secondary firing position and said chamber is disposed to receive the piston of the fired primary ammunition round, and an ejection position wherein said chamber is disposed for ejection from said chamber of the piston of the fired primary round;

means for releasably restraining the projectile of each secondary round in secondary firing position against forward movement through said bore; and

pressurizing means for introducing gas into said bore between said breech mechanisms, whereby when a primary round is fired in said primary firing position with a secondary round in said secondary firing position, the piston of the fired primary round is propelled forwardly through said bore to compress said gas between the fired piston and the projectile of the secondary round currently in secondary firing position, and the projectile of the secondary round currently in said secondary firing position is released and propelled forwardly to said bore by said compressed gas.

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SAMUEL W. ENGLE, Primary Examiner

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42—39.5; 89—33; 102—38

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,496,827 Dated February 24, 1970

Inventor(s) David Dardick

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 43 change "cerrier" to -- carrier --

Column 11, line 7 change "rejection" to -- ejection --

Column 17, before line 1 add the following:

-- containing said primary ammunition
rounds, and --

Signed and sealed this 16th day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents