

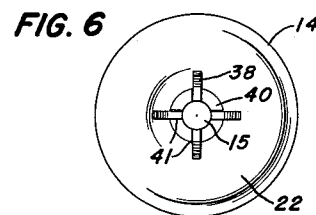
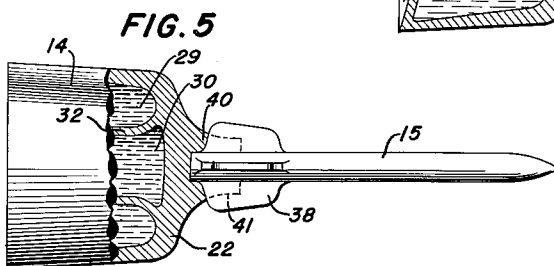
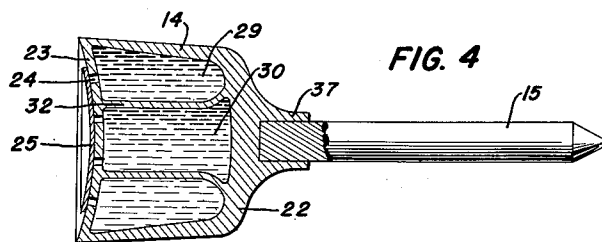
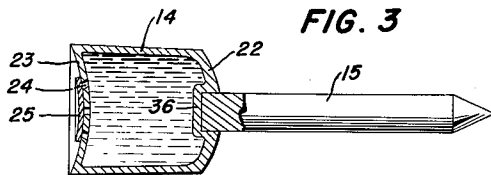
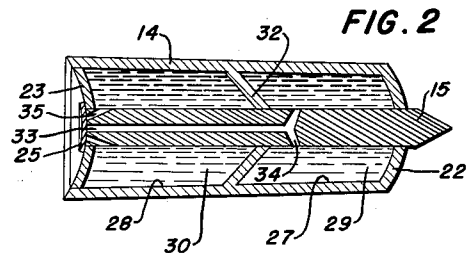
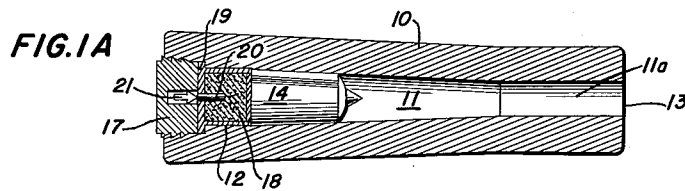
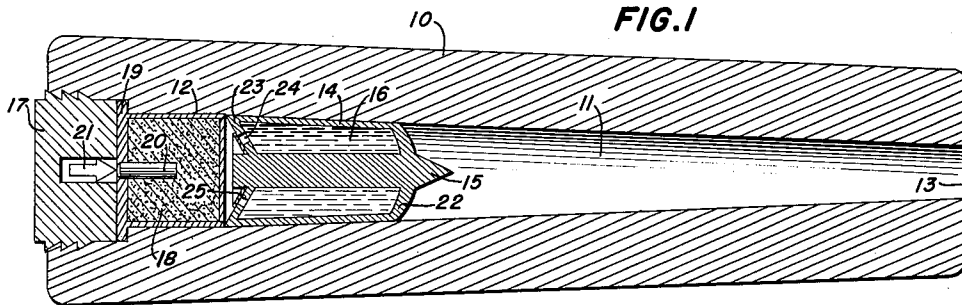
Dec. 5, 1961

C. R. RUSSELL
LIQUID PROPELLANT SQUEEZE-BORE GUN WITH
DEFORMABLE PROJECTILE SABOT

3,011,404

Filed Jan. 30, 1950

2 Sheets-Sheet 1



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FIG. 7

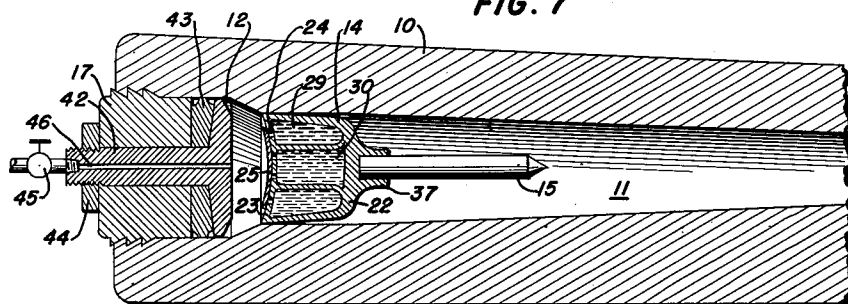


FIG. 8

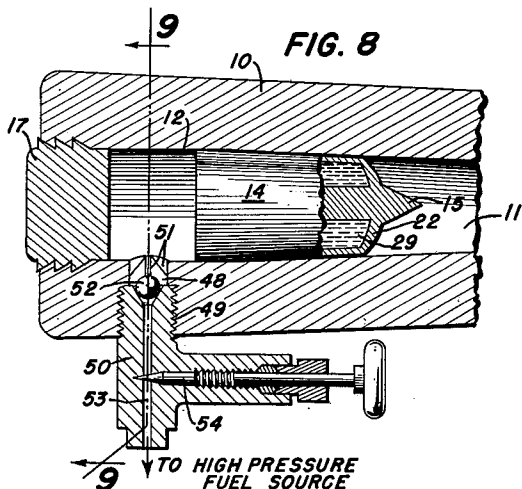


FIG. 9

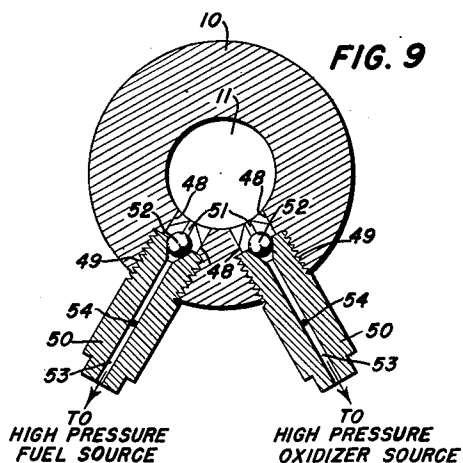


FIG. 10

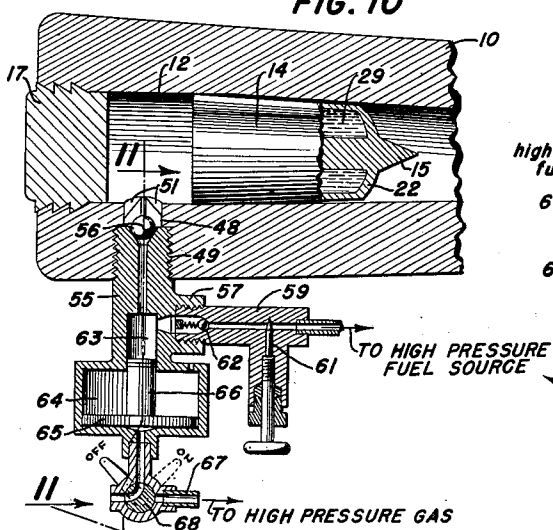
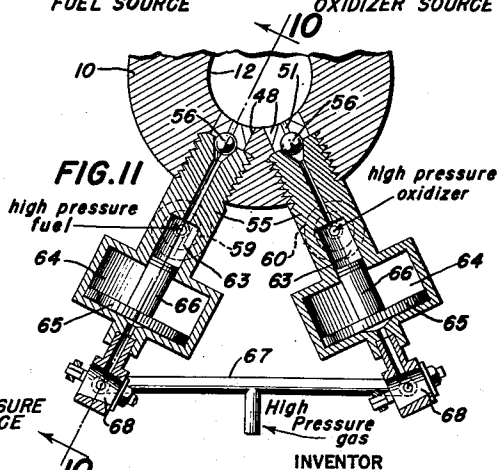


FIG. 11



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3,011,404

LIQUID PROPELLANT SQUEEZE-BORE GUN WITH DEFORMABLE PROJECTILE SABOT

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9 Claims. (Cl. 89—1)

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

This invention relates to improvements in ordnance, its chief purpose being to provide an improved gun or catapult system which will permit the attainment of hypervelocities. This broad aspect when translated into the specialized feature of the invention comprises a missile in the form of a liquid propellant-containing sabot and a gun barrel with a bore that tapers toward the muzzle to squeeze or extrude the propellant into the combustion zone behind the sabot and projectile as the two are shot out together.

The invention thus constitutes what could and herein is called a gun system since the barrel and projectile demand mutual cooperation for the implementation of the principle. That principle consists of the wedge action of the tapering bore on the deformable sabot of the sub-caliber projectile, the continuous deformation of the sabot, as the two travel from the breech to the muzzle, serving to continuously squeeze out the liquid contents of the sabot to generate pressure fluid which may remain either constant, or even may be made to slightly increase during acceleration of the projectile and does not drop progressively as is the case in conventional gun firings.

Such conventional firings comprise burning a powder charge at the breech end of the gun, thereby generating high pressure gas which flows down the bore after the projectile exerting pressure on the base of the projectile. This mode of propelling the projectile suffers the fundamental disadvantage for the attainment of hypervelocities that the generation of the gas is confined to the breech, whence it must accelerate and flow down the bore after the moving projectile. The pressure drop between the breech end of the gun and the base of the projectile increases rapidly as the projectile velocity increases, with the result that the force on the projectile for further acceleration decreases rapidly with velocity. Consequently, the ultimate attainable velocity is fundamentally limited for conventional gun systems.

Another disadvantage of conventional gun systems is that the gun must be sufficiently heavy to withstand pressures much in excess of the effective pressure on the projectile. The excess pressure at the breech results from the pressure drop required to accelerate the gas and cause it to flow down the bore and from peak pressures resulting from the rapid burning of the solid propellant charge.

To offset these disadvantages the invention is predicated on the generation of high pressure gas at the base of the projectile so that the force effective to accelerate the projectile is a maximum during its entire progress along the gun bore. In addition, the high pressure gas is generated at a rate which is determined by the projectile velocity and design of the gun so that peak pressures are avoided and most advantageous pressure-travel relation can be obtained.

Experimentation has shown that a liquid propellant system appears to offer the only solution to the problem of developing a gun having a hypermuzzle velocity. The liquid component of the projectile lends itself to extrusion during the progress of the projectile down the bore, and to that end the gun bore decreases in cross sectional area with distance from the breech so as to continuously collapse the liquid container.

With these premises in mind, it can be understood that one of the objects of the invention is to provide a gun

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system wherein the propellant is burned at the base of the projectile during part or even its entire progress through the gun bore, thereby to maintain maximum effective pressure upon its base without losses due to acceleration and flow of the gas from the breech of the gun.

Another object of the invention is to extrude or feed the propellant into the space behind the projectile at a rate which depends upon the velocity of the projectile, with the result that peak pressures can be avoided and the optimum pressure-travel relation can be obtained.

A further object of the invention is to achieve its purpose by the selection of a liquid propellant which has a flame temperature much lower than conventional gunpowder and/or does not produce corrosive combustion products, thereby reducing gun bore erosion.

A still further object of the invention which is derived from the first-stated object, is to provide a gun system wherein the propellant gas pressure is made to remain substantially constant during the acceleration of the projectile in the gun bore, in other words, from the time of ignition of the propellant while the projectile is stationed at the breech to the instant of its expulsion at the muzzle or for any desired portion of the gun bore such portion being determined by combining a selected length of tapered bore with a selected length of cylindrical bore.

Other objects and many of the 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 central, longitudinal section illustrating the gun system, the view being largely in diagrammatic form and showing one of a number of types of projectiles capable of use therein;

FIG. 1A is a central, longitudinal section illustrating a gun system on the order of FIG. 1, but wherein the tapering gun bore is modified by a cylindrical muzzle section;

FIG. 2 is a longitudinal section of the first modification of the projectile wherein provision is made for a bi-propellant instead of a mono-propellant as in FIG. 1;

FIG. 3 is a longitudinal section of the second modification wherein the projectile is partially socketed in an otherwise dissociated mono-propellant sabot;

FIG. 4 is a longitudinal section of the third modification wherein the projectile is partially socketed in an otherwise dissociated bi-propellant sabot;

FIG. 5 is a longitudinal section of the fourth modification wherein an arrow-like projectile is socketed in a sabot of the type in FIG. 4, provision being made for containing the fins;

FIG. 6 is a front elevation of the structure in FIG. 5;

FIG. 7 is a central longitudinal section of the second modification of the gun system, wherein the starting impulse is provided by a gas injection from an external high-pressure source;

FIG. 8 is a sectional view of a third modification of the gun system, wherein the constituents of a starting propellant which ignite upon contact are derived from separate external high-pressure sources;

FIG. 9 is a detail vertical section taken on the line 9—9 of FIG. 8;

FIG. 10 is a sectional view of a fourth modification of the gun system, taken on line 10—10 of FIG. 11, wherein the bi-component, self-igniting starting propellant has an auxiliary booster, and

FIG. 11 is a vertical section taken on the line 11—11 of FIG. 10.

In the drawings, in which corresponding numerals denote identical parts in each of the views where used, 10 indicates a gun, catapult or any mechanical equivalent of either. The gun, schematically illustrated, is of the heavy

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caliber type, but it is intended to extend the principle of the invention illustrated in that adaptation to smaller equipment such as shoulder arms and pistols. The gun has a bore 11 which tapers from the breech chamber 12 to the muzzle 13, excepting an instance presently noted. The bore may be rifled or not. As the sabot 14 of the projectile 15 proceeds along the bore the liquid propellant 16 is extruded at the rear. For that reason the bore is herein known as a squeeze bore. Since the burning of the extruded propellant keeps the expelling pressure at a substantially uniform level, and does not fall as in conventional guns, the barrel must be made of uniform strength from the breech to the muzzle to withstand the internal pressure all the way.

With the breech block 17 open, the missile is loaded into the bore, followed by a starting propellant charge 18. In FIG. 1 this charge consists of gunpowder, suitably packed in a case 19. Upon closing the breech block the primer 20 is exploded by releasing the firing pin 21. The gas generated by the starting propellant charge forces the sabot or propellant container 14 and its carried projectile 15 down the tapered bore. The powder case becomes a gas check for sealing the breech end of the bore.

At this point it is stated that the gunpowder charge 18 is mainly symbolic of a pressure source for initiating the flight of the sabot and projectile. A gunpowder cartridge is common to the point of being conventional for the purpose of driving a projectile out of a gunbarrel, and in most instances will be used for the purposes of the invention. But other modes of initiating the flight of the sabot and projectile can be employed, and these are illustrated in FIGS. 7 through 11.

Reverting to FIG. 1, the sabot 14 and projectile 15 are functionally a unit. The sabot is a modified can or annulus which axially carries the projectile. The front and back closures 22, 23 are welded or otherwise affixed to the projectile. They slant backwards so as to more readily yield to the collapsing moment of the tapering bore when the unit is driven out than if they stood normal to the axis. The wall of the sabot can be made relatively thin. The sabot contains the filling of propellant liquid 16; a monopropellant. This may consist of hydrazine, nitroparaffine, hydrogen peroxide or other suitable monopropellant.

The back closure 23 is perforated at 24 according to any desired pattern. These perforations are closed by a frangible patch 25 which provides a seal against leakage of the liquid at any time prior to its forcible extrusion under pressure. This occurs by the deformation of the sabot when driven out. The patch then opens under the force of the fluid pressure behind it, and the automatic augmentation of driving pressure will have begun.

The liquid propellant is ignited by the hot gas from the starting propellant and burns from the instant of its extrusion to the time when the totally collapsed sabot squeezes through the muzzle 13. In this as in each of the other forms of the invention, the progressive burning of the propellant during the entire driving out period of the projectile, maintains the maximum effective pressure on it and avoids the pressure loss as is conventionally the case where the gas accelerates from the breech of the gun. The foregoing desirable function results from the continuous and automatic feeding of the propellant into the bore space behind the projectile in an amount which depends upon the travel of the projectile. By this means peak pressures can be avoided, that is to say the achieving of a high pressure and then an abrupt drop from that level is avoided. To the contrary, the high pressure is achieved and is maintained at optimum pressure-travel relationship during the entire projecting period.

This result is largely a function of the tapering bore 11 because dependence is put on it for the wedge action that deforms the sabot and, in turn, extrudes the liquid propellant. But a portion of the bore can be made cylindrical as illustrated in the instance for FIG. 1A. Here

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the tapering bore 11 terminates in a cylindrical muzzle section 11a which is approximately one-third the length of the gun bore, but this ratio does not have to be adhered to precisely. The collapse of the sabot will have finished when the missile reaches the cylindrical muzzle section, and the latter has the advantage of forging the sabot into final cylindrical form thereby to contribute to the ballistic stability of the missile when in flight.

In FIG. 2 the propellant container or sabot 14 is divided into two compartments 27, 28 for the propellant liquids, the first containing a filling 29 of fuel the second a filling 30 of oxidizer. This showing of a bipropellant widens the possibilities of the missile wherein a third compartment contains a third liquid solely for the purpose of promoting ignition. The partition 32, slanted like 22 and 23, compels individual communication of the two compartments with the rear of the projectile 15. Port 34 provides access of the fuel to the rear of the projectile through the duct 33. The duct and ports compose a system of internal passage-ways, opening at various external surfaces of the projectile. The duct has its outlet at the rear as do the ports 35, and the exits sealed over by the patch as before.

FIG. 3 illustrates the virtual separation of the propellant container from the projectile. Here the container 14 has a very shallow socket 36 in its front closure 22. The base of the projectile is inserted in the socket and has a tight enough fit to hold the projectile centrally of the gunbarrel. In all forms disclosed herein the projectile is subcaliber and is carried by the sabot. It is conceivable, however, that the container-sabot could be made separate from the projectile, backing it up from the rear and pushing it down the bore in the manner already brought out. The projectile would still have to be subcaliber since its diameter may not be greater than the muzzle, but it could be materially larger than any of the projectiles illustrated.

FIG. 4 shows a bi-propellant sabot plus the socketing of the front closure at 37. Here the socket is deep, as distinguished from the shallow socket in FIG. 3 and in both cases the container can separate from the projectile. The bi-propellants, again designated 29, 30 are kept separate by the partition 32 which, in this case, can be made as a centered cylinder.

FIG. 5 is another illustration of a separable container-projectile combination. Here the projectile is equipped with fins 38 which virtually convert the long, slender body of the projectile into an arrow. The propellant container is socketed at 40, and has cross slots 41 into which the fins are inserted.

FIG. 7 is the second modification of the gun system wherein the pressure source for initiating the projection of the missile is located externally of the gun instead of in it as in FIG. 1. The latter form has the advantage of at once utilizing the cartridge case 19 as the gunpowder container and as a gas check between the breech chamber and breech block. In FIG. 7 the breech block 17 is made to carry a gas check device through which pressure gas is conducted. A tubular stem 42 has a head almost equal in diameter to that of the breech chamber 12. A pad 43 compressed between this head and the inner face of the breech block produces a seal.

This device is held in place by a nut 44 which is screwed onto the exposed threaded end of the stem. A valve 45 is attached to the stem in communication with the duct 46 in the stem, and it is intended to control the admission of gas from a suitably contrived external source. Upon opening the valve the pressure gas is admitted to initiate the flight of the missile. Pre-ignition, as by the hot gas of a gunpowder charge, is not required here. The liquid bipropellant can be of the hypergolic type (ignitable on mutual contact), promoting its own projecting force as soon as extrusion begins. The missile shown is the type in FIGS. 2, 4 and 5.

FIG. 8 is the third modification of the gun system, and

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here the missile starting pressure is also derived from an external source. The gun barrel 10 has a pair of radial passageways each comprising inner and outer openings 48, 49 of different diameters (FIG. 9). In the larger opening 49 of each passageway a valve fitting 50 is screwed. These fittings are identical, but one is to have any known and suitable type of piping leading to a high pressure fuel source, as labeled in FIG. 9, while the other will have piping leading to a high pressure oxidizer source. The fuel may consist of hydrazine and the oxidizer hydrogen peroxide. When these are injected they will ignite on mutual contact.

Several beveled fins 51 cage the ball check valve 52 in the smaller of the two openings, converting the latter into a check valve chamber. This is completed by the inner end of the fitting 50 which has its fluid passageway 53 recessed with a beveled seat for the ball. A valve 54 controls the passageway. The opening of the valves admits liquid fuel and liquid oxidizer from the respective high pressure sources which, then igniting, set up a gas pressure in the breech chamber 12 to project the missile. The latter, being subjected to the squeeze bore 11 extrudes its own liquid propellant behind it. Whether this is a monopropellant or a propellant of multiple constituents, it burns behind the missile, building up the projecting pressure as the bore distance increases.

FIG. 10 is the fourth modification of the gun system, differing from FIG. 8 in a detail that insures an ultra-high injecting pressure. Two identical fittings 55 (FIG. 11) are screwed into the side of the gun barrel so as to open into the breech chamber 12. Each fitting cages a ball check valve 56 the caging being done by a combination of fins, chamber and seat as in FIG. 8. A lateral enlargement 57 (FIG. 10) on each fitting has a nipple screwed into it, one being identified 59, the other 60 (FIG. 11). The nipple 59 has a pipe leading to a source of high pressure fuel; the nipple 60 a pipe leading to a source of high pressure oxidizer. Each nipple has a valve 61 for the manual control of the respective liquid, whether fuel or oxidizer. A ball check valve 62 of more or less common internal formation protects the manual valve against back pressure in each case.

Each of the fittings 55 has a high pressure chamber 63 and a force chamber 64. The latter contains a force piston 65 connected to a high pressure piston 66 which operates in the chamber 63. A pipe 67, common to each of the fittings, supplies high pressure gas from an appropriately maintained source, to each of the force chambers 64 at a place under the respective force piston. A manual valve 68 controls the admission and release of gas to and from these chambers, and on the premise that the valves 61 are turned on at about the same time that the valves 68 are turned the resulting starting charge is driven into the breech chamber at ultra-high pressure. The fuel and oxidizer components are ignitable on mutual contact, and the action upon and the interaction with the missile is the same as described in FIGS. 7 and 8.

Obviously many modifications and variations of the present invention are possible in the 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.

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. In a gun system of the character described, a sub-caliber projectile, a hollow, thin-walled sabot by which the projectile is coaxially carried, said sabot having at least one perforation at the rear end, covered by a frangible patch forming a total closure, and a filling of at least one propellant liquid extrusive at the perforation by the collapse of the sabot.

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2. In a gun system of the character described, a sub-caliber projectile having internal passageways having inlets and outlets at various parts of its exterior surface, a hollow sabot by which the projectile is axially carried, said sabot being partitioned to define plural compartments to each of which the respective inlets of the passageways have access, a frangible patch over the outlets which are the only otherwise exposed places of egress from the passageways, and volumes of liquid in each of the compartments, being kept separate by the partitioning and composing the constituents of a propellant which is combustible on mutual contact of said constituents.

3. In a gun system of the character described, a hollow sabot having a tapering external wall and an internal cylindrical partition, front and back closures connecting the wall and partition to form compartments, the back closure having perforations communicating with the compartments and the front closure having a socket, a subcaliber projectile fitted in the socket, a frangible patch attached to the back closure over the perforations so as to close the compartments, and volumes of liquid in each of the compartments, being kept separate by the partition and composing the constituents of a propellant which is combustible on mutual contact of said constituents.

4. In a gun system, the combination of a gun barrel having a bore tapered throughout at least a major portion of its length from its breech end to its muzzle end, means for opening and closing the breech end, means for applying pressure within the closed breech end for at least initiating movement of a projectile through said bore from the breech end toward the muzzle end; a projectile having an enlarged, hollow, deformable, closed sabot filled with an ignitable, extrudable propellant and fitting in the breech end of the bore, said sabot including means operable upon initial movement of the projectile to open a restricted aperture in the sabot whereupon the propellant will be extruded into the bore behind the projectile by deformation of the sabot by the tapered bore during movement therethrough, means for igniting the extruded propellant during initial movement of the projectile, the tapered bore cooperating with the apertured sabot so that the extruded, ignited propellant will maintain a substantially constant or increasing pressure in the bore behind the projectile as it moves through the bore.

5. The combination set forth in claim 4 wherein the means for applying pressure within the closed breech end for at least initiating movement of a projectile through said bore from the breech end toward the muzzle end includes a charge burnable behind the missile, producing a starting gas pressure to ignite said propellant and initiate the movement of the missile.

6. The combination set forth in claim 4 wherein the means for applying pressure within the closed breech end for at least initiating movement of a projectile through said bore from the breech end toward the muzzle end includes a breech lock operative to selectively close the breech chamber and having a head confronting the sabot, and a tubular stem mounted in the breech block and carrying the head, said stem being communicable with an external gas pressure source and communicating with the breech chamber to supply a starting pressure for the missile.

7. The combination recited in claim 4 wherein the means for applying pressure within the closed breech end for at least initiating movement of a projectile through said bore from the breech end toward the muzzle end includes a valve construction comprising two fittings connected to openings in the gun barrel and respectively leading to a high pressure fuel source and to a high pressure oxidizer source, and ball valves gaged in the openings, admitting the fuel and oxidized for generating a missile-starting pressure in the breech chamber and closing by the back pressure generated to insure the initiation of movement of the missile.

8. The combination set forth in claim 4 wherein the

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means for applying pressure within the closed breech end for at least initiating movement of the projectile through said bore from the breech end toward the muzzle end includes an injector valve construction comprising separate fittings connected to openings in the gun barrel, each fitting having a valved nipple controlling a respective high-pressure fuel and high-pressure oxidizer admissible from separate sources, a high-pressure chamber forming part of each fitting and into which the respective fuel and oxidizer are discharged, a force chamber and piston for each fitting having a pipe connection to a common source of high-pressure gas, a high-pressure piston carried by each forced piston, being operative in the respective high-pressure chamber to inject the respective fuel and oxidizer into the breech chamber, and ball valves caged in the openings, admitting the fuel and oxidizer for generating a missile-starting pressure in the breech chamber and closing by the back pressure generated to insure the initiation of movement of the missile.

9. The combination recited in claim 4 wherein the means operable to open a restricted aperture in the sabot includes at least one perforation in the rear wall of said

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sabot, a frangible patch over said perforation totally closing the sabot, said sabot having a filling of at least one liquid propellant displacing said patch when extruded at the perforation upon the collapse of the sabot by the wedge action of the bore taper on the sabot walls.

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