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(54) **In-line annular piston fixed bolt regenerative variable charge liquid propellant gun with variable hydraulic control of piston.**

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Description

This invention relates to liquid propellant guns utilizing differential area pistons to provide continued or regenerative injection of a liquid propellant into the combustion chamber and, particularly, to such guns in which there are a plurality of coaxial elements, including at least one differential area piston, arranged so is to provide for relative action between elements as a means for controlling regenerative propellant injection.

An extensive summary of the prior art appears in the "Description of the Prior Art" of U.S -A-4,341,147 to R.E. Mayer. U.S.-A- 3,138,990, 4,023,463 and 4,050,349 cited in that document and U.S.-A- 4,241,147 itself are exemplary of that prior art. In general, the references cited show differential pressure pistons for forcing liquid propellant from a reservoir chamber into a combustion chamber responsive to combustion pressures. Also pertinent to the present invention are the descriptions of our copending European patent applications Nos. EP-A-140331 (84 112792.1) and EP-A-140332 (84112793.9) both of which were published on 8 May 1985, that is after the filing and priority dates of the present application. Both EP-A-140331 and 140332 disclose a moving differential area piston which cooperates with another member, i.e. the fixed bolt 5 in FIGURE 1 to control the flow rate or dispersion pattern or both of the propellant as it is pumped to the combustion chamber.

US-A-4 099 445 describes a gun structure in which the various propellant components are forced from fixed volume reservoir into the combustion chamber by means of a differential area piston to which an additional moving force is provided at the initial stage of it working stroke movement.

US-A-4 281 582 describes an injection piston of a regenerative liquid propellant gun which is attached to a second piston that has a programmed hydraulic resistance which controls its motion.

US-A-4 341 147 discloses a regenerative liquid propellant gun having a structure which reacts to combustion pressure to dispense and regulate the flow of liquid propellant from a reservoir within the breech structure of the gun. For this purpose, a combustion chamber is defined in the breech between a projectile in the barrel of the gun and the faces of first and second coaxial differential area, moveable, pistons. The pistons also define with the breech, on the side remote from the combustion chamber, propellant reservoirs. Combustion is initiated and both of the pistons move away from the barrel. The first piston, which is coaxial with the second, moves relative to the second piston opening ducts in the second piston to dispense propellant into the combustion chamber. The first piston engages and moves relative to a fixed support at the end of the breech remote from the combustion chamber.

EP-A-1 140 331 and EP-A-1 140 332 both disclose a regenerative liquid propellant gun structure in which the differential area piston is annular, having a peripheral cylindrical skirt extending away from the combustion chamber to define a propellant reservoir, and has an aperture permitting overrunning of a fixed bolt. The fixed bolt is shaped to define with the edge of the aperture a variable annular orifice for propellant injection as the piston moves. There is a second free piston overrunning the bolt and mating with the inside of the differential area piston to complete and provide for emptying of the reservoir. The structure also contains a spring to allow components to move responsive to increased combustion chamber pressure to provide for an initial movement of differential area piston relative to the bolt to start propellant injection and a fluid pressure means for movement of pistons after firings to facilitate reloading.

In EP-A-140331 and 140332 the fixed bolt is supported at its end remote from the barrel and is generally cylindrical apart from a zone of reduced diameter which cooperates with the aperture of the differential area piston. The aperture of the differential area piston is of uniform diameter in the axial direction whereas the diameter of the generally cylindrical fixed bolt is reduced by amounts varying in the axial direction to define the variable area orifice with the aperture of the differential area piston.

The present invention provides a direct injection regenerative liquid propellant gun structure having a breech casing defining a breech bore having a forward barrel end and an aft breech end comprising in combination:

a fixed member within said breech bore extending from, a supporting member near said barrel end aftwardly toward said breech end, said fixed member being generally cylindrical but having an enlarged portion near said supporting member;

a differential area piston having a head dividing the volume within said breech bore between a combustion chamber at said barrel end on the forward side of said piston head and a propellant reservoir on the aft side of said piston head, said differential area piston having a cut out portion for overrunning said fixed member as said piston moves along said fixed member from a gun charged position in which said cut out portion is in register with and forms a seal with said enlarged portion of said fixed member to a gun discharged position in response to pressure of combustion gas generated in said combustion chamber to inject

propellant from said reservoir to said combustion chamber;

said cut out portion and said enlarged portion being so sized and shaped to cooperate as said differential area piston moves with respect to said fixed member to define a variable area injection orifice between them for the flow of propellant from said reservoir to said combustion chamber.

FIGURE 1 is a longitudinal sectional view of a fully charged breech section of a variable charge regenerative liquid propellant gun in accordance with this invention.

FIGURE 2 is a longitudinal section view of the same gun structure having only half a charge as compared to that of FIGURE 1.

The implementation of the breech or chamber section of a liquid propellant gun according to the invention and as illustrated in FIGURES 1 and 2 of the drawings includes, as common to most fire arms and cannon, a gun barrel 1 attached to an enlarged breech mechanism section 2 which includes provisions for the introduction, ignition and burning of a propellant material to create a gas to drive a projectile through the barrel. The breech section 2 of this gun includes a casing 21 surrounding and defining a chamber 3, a breech plug structure 4 restraining two ,moveable pistons 6 and 7, and a fixed bolt structure 5. The moveable pistons cooperate with the bolt to accept, retain and dispense liquid propellant in a metered fashion in response to pressure created by combustion acting on differential area pressure piston 6.

Chamber 3 as defined by the interior wall 30 of the casing is cylindrical with one closed end wall 31 interrupted by the opening to the bore 11 of barrel 1 and two threaded portions 32 and 34 representing a facility for positioning and securing a breech closure mechanism, as for example, the breech plug structure 4, to provide reaction to propulsion pressures and a facility for securing the fixed bolt structure 5 in place. Casing 21 is illustrated as merely abutting the enlarged barrel base 13 to constitute end wall 31 of the chamber without defined restraining means. Any of the well known structures, e.g. drop block, pivoted block, etc., which are outside of the scope of this invention may be used to join this novel breech to the barrel while permitting loading of projectiles 12. Breech plug structure 4 is representative of a wide range of possible designs and is illustrated as having plug portion 42, interconnection means 43 constituting in this case a screw threads for securing the plug to the threaded portion 32 of breech casing 21, spring buffer assembly 44 and internal bore 46 supporting a block or fill piston block 7 by means of a cylindrical portion 72. There is no reason to preclude the use of interrupted screw threads at 32 to provide for quick removal and adjustment.

Bolt structure 5 is fixed in place in the breech structure axially of the gun by a web structure 50 which has a threaded portion for attaching it to the threaded portion 34 of casing 21 and a reduced cylindrical portion 53 providing support for the annular forward portion 70 of moveable block or fill piston 7 which slides between the reduced cylindrical portion 53 and the casing wall 30. An essential aspect of this invention is embodied in the shaped or contoured portion of the bolt which, as shown in FIGURE 1, has a cylindrical ledge portion 52 at the junction of the web structure 50, and the reduced radius shaft portion 51 of the bolt which is within the propellant reservoir 35. The cylindrical surface at 52 may carry a seal 54 and interfaces with the annular piston head 60 of the piston 6 in the position shown in FIGURE 1. The web portion 50 of bolt 5 also contains an axial cup-like combustion chamber 55 facing the opening to barrel bore 11 and multiple passages 56 between the rear shoulder 57 of portion 53 and the combustion chamber. As illustrated, passages 56 are merely holes drilled through the monolithic portion 53 of bolt 5.

The differential area annular piston 6 has a cylindrical skirt portion 63 which serves as a piston rod and primarily defines cylindro-annular reservoir 35 about the shaft portion 51 of bolt 5 which varies in capacity as pistons 6 and 7 are moved relative to each other within the operating cylinder portion of chamber 3. Piston head 60, which separates reservoir 35 from the entrances to passages 56 to combustion chamber 55 and acts as a valve to control flow of propellant from the reservoir, is dish-like and annular in that it has a central hole defined by the cylindrical surface 62 dimensioned to the diameter of bolt ledge 52 to permit seating a the ledge. The interior surface 64 of cylinder head 60 which may be shaped as illustrated to facilitate propellant flow and to provide appropriate strength has, because of the thickness of shirt wall 63, a lesser area than the exterior head surface and causes annular piston 6 to be a differential area piston acting between the combustion chamber and reservoir 35. Piston head 60 also has an exterior rim portion 61 journaled to the interior surface 71 of the cylindro-annular forward portion 70 of piston 7 which could be fitted with a piston ring. The exterior of piston 6 has a slightly reduced portion 66 which creates a narrow annular space 33 between the piston skirt 63 and the interior surface of the forward portion of piston 7.

The face of piston head 60 is shaped to provide a stop surface 65 which abuts the surface of shoulder 57 of bolt 5 when surface 62 is seated on bolt ledge 52. The central aperture of the piston head adjoining cylindrical surface 62 is also shaped

to provide a conical surface 67 flaring away from cylindrical surface 62 so that the annular gap between the piston head and ledge 52 which constitutes an injection annulus increases gradually in size as piston 6 moves rearwardly during firing. The maximum size of the injection annulus is the difference in radii of the cylindrical surface 62 and the bolt shaft 51 which is reached as soon as the flared conical surface of the piston head clears the ledge 52. Although both the ledge 52 and the piston head annulus surface 62 are defined here as cylindrical, it may be advantageous under certain conditions to have those surfaces made slightly conical, but less conical than surface 67, to facilitate seating and unseating.

The block or fill piston 7 of a liquid propellant gun according to this invention performs the same functions as that of Co-pending European Patent Application 84 112792.1 EP-A-0 140 331 but also includes structure which is specific to the present invention. The block or fill piston 7 is fitted in chamber 3 for reciprocal motion and, as already noted, has a cylindro-annular forward portion 70 projecting from its main body 73 which surrounds the annular differential area pressure piston 6 and overruns the reduced cylindrical portion 53 of the bolt structure. A rear cylindrical portion 72 is journaled in bore 46 in the breech plug 4, both supporting the piston and sealing the opening in the breech plug. The main body 73 of piston 7 includes an annular nose portion 74 surrounding and defining a partial axial bore 75 journaled on the stem portion 51 of bolt 5. The nose portion is recessed with respect to the forward portion 70, is defined by an annular recess 76 in the body 73 contoured to receive the annular skirt 63 of annular piston 6 to constitute an annular dashpot and is shaped to mate with the internal surface 64 of the pressure piston 6 so that the capacity of reservoir 35 can be reduced to zero on firing and prior to fill.

Piston 7 in the illustrated embodiment also has an internal accumulator cylinder 78 (which could be external if desired) interconnected with annular recess 76 by multiple conduits 77 and is provided with feed line conduits 17 and 27 for charging the cylinder 78. Free piston separator 79 with appropriate seals is located within cylinder 78 and serves to separate, and balance pressures between, the fluids in cylinder volumes 37 and 47 as they are charged through conduits 27 and 17 and respond to the results of relative movement between pistons 6 and 7. It is contemplated that cylinder portion 37, conduits 77 and annular recess 76 would be charged with water or a hydraulic fluid and cylinder portion 47 charged with air or gas pressure. The accumulator structure is an essential component of the invention and with the strategic locations of the interconnections between the multiple conduits 77 and annular recess 76 and with the optional valves 87 in conduits 77 constitutes a variable or programmed orifice hydraulic damper provides a shot-to-shot programmable mass flow rate capability which includes use of different charge quantities of propellant in reservoir 35.

The gun breech structure illustrated also contains features more fully disclosed and explained in co-pending European Patent Application 84 112792.1 EP-A-0 140 331 including, for example, the annular space 33 closed off by aligned seals carried by piston 7 as shown which also accommodate a variable capacity charge capability while retaining seal integrity. When charged with an appropriate fluid through conduit 36, annulus 33 can hydraulically support skirt 63 against firing pressures and can dispense lubricants, preservatives or combustion enhancements or combinations thereof past the piston head ring projection 61 into the combustion area. The breech structure 4 in this embodiment of gun is principally an annular breech block 42 which is adjustably retained in the casing by a threaded connection at 32 which as noted could be interrupted threads. It includes a spring buffer assembly 44 made up of Belleville washers 14, pressure ring 15 and pins 16 for positioning piston 7 and for allowing a set back movement of the combined structure of pistons 6 and 7 and the included reservoir 35 to unseat piston head 60 from ledge 52 to initiate feed of propellant from reservoir 35 to the combustion chamber. Other structure, e.g. a liquid spring, liquid damper, coil springs, etc., could be substituted for some of these elements. The structure also includes a drive cylinder 10 with conduit 28 for the insertion of fluid under pressure to drive piston 7 toward the barrel to reseat piston 6 onto the ledge 52 of bolt 5 in preparation for filling the reservoir. The structure also includes fill conduit 45 for the insertion of the liquid propellant and vent conduit 49 communicating with the enclosed cylindrical volume 78. In the embodiment illustrated, the flexible connections required to connect conduits 36, 45, 49, 17 and 27 to their proper supplies, valves, etc., are not shown because they are elements readily selected from available technology. The FIGURES include an igniter 26 communicating with combustion chamber 55 which can be of any convenient design but must have, or be accompanied by, a means for providing a sufficient charge to move pistons 6 and 7 to unseat piston head 60 from ledge 52 to open the annular injector.

The gun mechanism illustrated in FIGURE 2 is the same mechanism as that in FIGURE 1 but charged with only half of the amount of liquid propellant present in FIGURE 1. This shows the adaptability of the structure, a prime feature of the design, and the slightly changed positions of the

components with respect to one another to accommodate a half charge. Most noticeable are the smaller capacity of reservoir 35, the smaller volume of empty chamber at 3 between the forward end of piston 7 and chamber end wall 31, and the exposure of a length of screw threads 32 at 22 indicating that the adjustment of the mechanism to determine load charge is made by turning breech plug 4 farther into the chamber to reduce the distance between the nose portion 74 of piston 7 and piston head 60 in the loaded position. Less obvious is the volume reduction of annular recess 76 and a corresponding volume increase of the accumulator hydraulic cylinder 37. In addition in FIGURE 2, some of the conduits 77 are obstructed by the bottom of skirt 63 of the annular piston 6. The number and location of conduits 77, as already noted, must be determined to produce the desired throttling of flow of hydraulic fluid as it is forced from recess 76 to accumulator 78 to produce the desired hydraulic resistance. The amount of hydraulic resistance to be applied is determined by taking into account all factors including the design of piston head 60, the size of the injection annulus, the burning characteristics of the particular propellant etc., to produce the desired pressure/time curve on firing. The location of conduits 77 to cause some to be blocked off by piston skirt 63 prior to firing a partial charge is a part of this determination. Other mechanical means could be used as a substitute for valves 87 to change the flow capacity of conduits 77 as, for example, a rotating sleeve structure to move identically shaped and aligned apertures into and out of registry or to move skewed elongated apertures through a range of partially coincident positions.

OPERATION

Firing

The gun structure as illustrated in FIGURE 1 is fully charged and ready for firing with reservoir 35 filled with the liquid propellant to the maximum capacity and with annular ring 62 of the annular piston 6 seated on ledge surface 52 of the bolt so as to preclude leaking of the liquid propellant into the passages 56 leading to the combustion chamber 55. Space 33 is charged with an inert liquid to provide a hydraulic support for annular piston wall 63 during firing. The liquid in 33 as already noted may be very viscous, may have lubricant properties, or may contain materials chemically similar to those added to powders in conventional ammunitions for the treatment or preservation of barrels. The valve in conduit 45 is closed against backflow of the liquid propellant. Any existing pressure in space 10 and conduit 28 is relieved. Firing is initiated by means of activation of ignitor 26 which is provided with a charge or other means sufficient to create enough pressure in the combustion chamber 55 and communicating passages 56 to unseat piston head 60 from its mating position with the ledge on bolt 5 by driving the reservoir and fill piston 7 rearwardly against pins 16 partially collapsing belleville washers 14. The action of the igniter will both cause an initial injection of liquid propellant from reservoir 35 into combustion chamber 55 and ignite the injected liquid propellant. Ignition of the liquid propellant flowing from reservoir 35 will increase the pressure in the combustion chamber and passages 56 and produce a regenerative feeding of liquid propellant from reservoir 35 into the combustion chamber because of the differential area piston head 60 of the annular piston. As the pressure in combustion chamber 55 increases, it reaches the point of causing the obturation band portion of the projectile 12 to become deformed and permit the projectile to move.

The conical surface of the portion of the annular piston head 60 indicated at 67 causes the annular space between that surface and the edge of ledge 52 to increase during early movement of the piston 6 to produce an ever increasing thickness of the annular sheet of liquid propellant injected into the combustion chamber until all of the surface 67 clears ledge 52 after which the thickness of the annular sheet is a function of the difference in diameters of bolt shaft 51 and annular surface 62. The initial flow rate of liquid propellant produces an increased burn rate with an attendant pressure increase which is adequate to overcome the increased volume of the combustion chamber caused both by displacement of the annular piston and by the accompanying displacement of the projectile 12. The continued flow and burn rate after the injection annulus reaches full size, as already noted, is a function of the design of piston 6, the relative sizes and volumes of components and the characteristics of damping introduced by the variable orifice hydraulic damper which includes the dashpot recess 76, restrictive conduits 77, valves 87 and the accumlator structure 37, 47, 79. As piston head 60 approaches the nose portion 74 of fill piston 7, the injection piston 6 is brought to a halt hydraulically by the closing down of conduits 77 by piston skirt 63. The variable orifice hydraulic damper also provides tailored combustion chamber pressure rises to accommodate acceleration sensitive projectiles and projectiles of different weights.

Charging

At the completion of the firing, annular piston 6 is seated onto fill piston 7 with piston 7 being located against or near the stops 16, depending on

the relationship of the reaction of the buffer assembly and dissipation of the chamber pressures. After the insertion of a new projectile 12 by whatever breech action means has been incorporated into the specific gun using this invention, hydraulic or pneumatic pressure, whichever is used, may be inserted through conduit 28 to expand annular space 10 to drive both pistons, in register, toward the gun barrel until piston 6 seats onto the bolt ledge portion surface 52. The pressure on conduit 28 is then relieved and, if appropriate, breech plug 4 rotated, or reset if an interrupted screw is used, to obtain the proper position of stops 16 to provide for the proper capacity of reservoir 35 for the next firing. The valve in conduit 45 is then opened to admit liquid propellant under pressure into the collapsed reservoir at 35.

As liquid propellant is inserted into and expands reservoir 35 by forcing fill piston 7 away from piston 6, if necessary, against a residual pressure in cylinder 10, to prevent, or at least reduce, the amount of ullage in the liquid propellant in the reservoir. The fill process is continued until the fill piston seats onto pins 16. The gun mechanism is then charged for a subsequent firing and the annular space 33 can be filled if the charging system does not cause that to be effected as a result of the rearward movement of piston 7 which automatically expands space 33.

The foregoing describes the structure and operation of a regenerative monopropellant liquid propellant gun structure according to this invention employing the cooperation of a fixed axial bolt and an annular piston wherein the cylindro-annular piston rod cooperates with other members to define a reservoir for liquid propellant, wherein the annular planar piston head overruns part of bolt as it moves in response to combustion pressure, cooperates with a shaped portion of bolt and with variable orifice hydraulic means for applying a variable resistance back pressure to the piston to deliver a predetermined pattern and flow rate of propellant to the combustion chamber. An additional moveable piston member cooperates with the annular piston and with positioning means to limit travel of the additional moveable piston member to cause the propellant reservoir to have a variable capacity to provide a variable charge capability and shot-to-shot programmable mass flow rate of propellant and to facilitate charging of the gun by permitting the capacity of the reservoir to be increased from zero to a desire content as the liquid propellant is introduced to provide for aid free rapid propellant fill. Structural integrity is enhanced by use of a hydraulic pressure support of the annular piston rod which also facilitates lubrication and cooling of the structure.

Claims

1. A direct injection regenerative liquid propellant gun structure having a breech casing (21) defining a breech bore (30) having a forward barrel end (31) and an aft breech end (32) comprising in combination :

a fixed member (5) within said breech bore (30) extending from a supporting member (50, 34) near said barrel end (31) aftwardly toward said breech end (32), said fixed member (5) being generally cylindrical but having an enlarged portion (52) near said supporting member (34);

a differential area piston (6) having a head (60) dividing the volume within said breech bore (30) between a combustion chamber (55) at said barrel end (31) on the forward side or said piston head (60) and a propellant reservoir (35) on the aft side of said piston head (60), said differential area piston (6) having a cut out portion (64) for overrunning said fixed member (5) as said piston (6) moves along said fixed member (5) from a gun charged position in which said cut out portion (64) is in register with and forms a seal with said enlarged portion (52) of said fixed member (5) to a gun discharged position in response to pressure of combustion gas generated in said combustion chamber (55) to inject propellant from said reservoir (35) to said combustion chamber (55) ;

said cut out portion (64) and said enlarged portion (52) being so sized and shaped to cooperate as said differential area piston (6) moves with respect to said fixed member (5) to define a variable area injection orifice (52, 60) between them for the flow of propellant from said reservoir (35) to said combustion chamber (55).

2. The gun structure of Claim 1 wherein

said fixed member (5) is a bolt spaced from the wall (30) of said casing (21);

said differential area piston (6) has a substantially planar piston head (60);

said cut out portion (64) is an opening in said planar head (60) ;

said enlarged portion (52) is a band (52) protruding radially a discrete distance from said bolt;

the surfaces of said cut out portion (64) and said band (52) being configured both to mate to form a seal (64, 52) when said elements are in registry and to create a ringlike opening which expands at a predetermined rate with respect to movement of said piston (6) relative to said bolt (5) to a maximum

opening measured by said discrete distance when the distance of said planar head (60) from said band (52) exceeds said discrete distance,

whereby the rate of expansion of the ring-like opening and the maximum opening through which propellant flows from the reservoir (35) to combustion chamber (55) may be determined, at least in part, by the configurations of said cutout portion and said band.

3. The gun structure of Claim 2 wherein

said bolt (5) is fixed axially of said breech (2) by a web structure (50) removably secured in the barrel end (31) of said breech (2);

said differential area piston (6) is an annular hollow piston (6) having a cylindrical wall (62) extending from the periphery of said planar head (60) toward said breech end (32) of said casing, said periphery and said cylindrical wall being spaced from the interior wall (30) of said casing, and said cut out (64) being centered in said planar head (60);

there is a second piston (7) having a body portion (73) journaled in said breech casing for reciprocal movement and two concentric cylindrical wall projections (70, 74) extending from said body portion (73) toward the barrel and defining an annular slot (76) between them, the outer (70) of said two cylindrical walls fitting between said differential area piston (60) and said casing (21), and the inner (74) of said two cylindrical walls fitting between said bolt (5) and the cylindrical wall of said differential piston (6) to constitute a fill piston (7), and

said reservoir (35) is an annular volume of variable capacity defined by said bolt (5), the differential area piston (60) and the fill piston (7);

whereby the open end of said cylindrical wall of said differential area piston constitute said secondary piston portion (63) of said piston (6) and whereby the annular slot (76) between said concentric cylindrical wall projections (70, 74) of said second piston (7) constitutes an additional cylinder in which said secondary piston portion (63) operates.

4. The gun structure of Claim 3 wherein

there is an accumulator structure in said body portion (73) of said fill piston (7) comprising an accumulator cylinder (78), means (17) for charging said accumulator cylinder (78) with fluid pressure and fluid conduit means (77) interconnecting said accumulator cylinder and said additional cylinder ;

whereby, when said accumulator structure (78) is charged with a fluid, said additional cylinder (76) and said secondary piston portion (63) constitute a dashpot providing resistance to movement of said differential area piston (60) during firing.

5. The gun structure of Claim 4 wherein

said fluid conduit means (77) interconnecting said accumulator cylinder (78) and said additional cylinder include a plurality of ports into said additional cylinder which are located so as to be sequentially closed as said differential area piston (6) moves from its gun charged position to its gun discharged position during firing;

whereby said dashpot provides a variable hydraulic resistance to movement of said differential area piston (6).

6. The gun structure of Claim 5 further comprising:

adjustable valve means (87) in said fluid conduit means (77), interconnecting said accumulator cylinder (78) and said additional cylinder for regulating the flow capacity of said fluid conduit means (77):

whereby the movement of said differential area piston (6) can also be influenced by the adjustment of said valve (87) means to control hydraulic resistance behind the differential area piston (6).

Patentansprüche

1. Regenerativ-Flüssigtreibmittel-Geschützstruktur mit Direkteinspritzung, die ein Verschlußgehäuse (21) aufweist, das eine Verschlußbohrung (30) mit einem vorderen Laufende (31) und einem hinteren Verschlußende (32) bildet, enthaltend in Kombination:

ein feststehendes Teil (5) in der Verschlußbohrung (30), das sich von einem Halterungsteil (50, 34) nahe dem Laufende (31) nach hinten in Richtung auf das Verschlußende (32) erstreckt, wobei das feststehende Teil (5) im wesentlichen zylindrisch ist, aber einen vergrößerten Abschnitt (52) nahe dem Halterungsteil (34) aufweist;

einen Differentialflächenkolben (6) mit einem Kopf (60), der das Volumen in der Verschlußbohrung (30) zwischen einer Verbrennungskammer (55) an dem Laufende (31) auf der vorderen Seite des Kolbenkopfes (60) und einem Treibmittel-Reservoir (35) auf der Rückseite des Kolbenkopfes (60) teilt, wobei der Differentialflächenkolben (6) einen ausgeschnittenen Abschnitt (64) aufweist, um über das feststehende Teil (5) zu laufen, wenn der Kolben (6) sich entlang dem feststehenden Teil

(5) von einer Geschützgeladen-Position, in der der ausgeschnittene Abschnitt (64) mit dem vergrößerten Abschnitt (52) des feststehenden Teils (5) in Übereinstimmung ist und mit diesem eine Dichtung bildet, in eine Geschützentladen-Position bei einem Druck des Verbrennungsgases bewegt, das in der Verbrennungskammer (55) erzeugt wird, um Treibmittel von dem Reservoir (35) in die Verbrennungskammer (55) einzuspritzen;

wobei der ausgeschnittene Abschnitt (64) und der vergrößerte Abschnitt (52) so bemessen und geformt sind, daß sie zusammenarbeiten, wenn der Differentialflächenkolben (6) sich in Bezug auf das feststehende Teil (5) bewegt, um zwischen ihnen eine Injektionsöffnung (52, 60) mit variabler Fläche für die Treibmittelströmung von dem Reservoir (35) zu der Verbrennungskammer (55) zu bilden.

2. Geschützstruktur nach Anspruch 1, wobei

das feststehende Teil (5) ein Bolzen ist, der im Abstand von der Wand (30) des Gehäuses (21) angeordnet ist;

der Differentialflächenkolben (6) einen im wesentlichen planaren Kolbenkopf (60) aufweist;

der ausgeschnittene Abschnitt (64) eine Öffnung in dem planaren Kopf (60) ist;

der vergrößerte Abschnitt (52) ein Band (52) ist, das von dem Verschluß eine diskrete Strecke radial nach außen vorsteht;

die Oberflächen des ausgeschnittene Abschnitt (64) und des Bandes (52) beide so konfiguriert sind, daß sie zusammenpassen, um eine Dichtung (64, 52) zu bilden, wenn die Elemente in Übereinstimmung sind, und eine ringähnliche Öffnung hervorzurufen, die mit einer vorbestimmten Geschwindigkeit in Bezug auf die Bewegung des Kolbens (6) relativ zu dem Bolzen (5) zu einer maximalen Öffnung expandiert, die durch die diskrete Strecke gemessen ist, wenn der Abstand des planaren Kopfes (60) von dem Band (52) die diskrete Strecke überschreitet,

wobei die Expansionsgeschwindigkeit der ringähnlichen Öffnung und die maximale Öffnung, durch die Treibmittel von dem Reservoir (35) zur Verbrennungskammer (55) strömt, wenigstens teilweise durch die Konfigurationen des ausgeschnittenen Abschnittes und des Bandes bestimmt werden können.

3. Geschützstruktur nach Anspruch 2, wobei

der Bolzen (5) axial feststehend ist zu dem Verschluß (2) durch eine Stegstruktur (50), die in dem Laufende (31) des Verschlusses (2) lösbar befestigt ist;

der Differentialflächenkolben (6) ein ringförmiger Hohlkörper (6) mit einer zylindrischen Wand (62) ist, die sich von dem Umfang des planaren Kopfes (60) in Richtung auf das verschlußende (32) des Gehäuses erstreckt, wobei der Umfang und die zylindrische Wand im Abstand von der inneren Wand (30) des Gehäuses angeordnet sind und der ausgeschnittene Abschnitt (64) in dem planaren Kopf (60) zentriert ist;

wobei ein zweiter Kolben (7) vorgesehen ist, der einen Körperabschnitt (73), der in dem Verschlußgehäuse für eine Hin- und Herbewegung gelagert ist und zwei konzentrische, zylindrische Wandvorsprünge (70, 74) aufweist, die sich von dem Körperabschnitt (73) in Richtung auf den Lauf erstrecken und zwischen sich eine Ringnut (76) bilden, wobei die äußere (70) der zwei zylindrischen Wände zwischen den Differentialflächenkolben (60) und das Gehäuse (21) paßt und die innere (74) der zwei zylindrischen Wände zwischen den Bolzen (5) und die zylindrische Wand des Differentialflächenkolbens (6) paßt, um einen Füllkolben (7) zu bilden, und

das Reservoir (35) ein ringförmiges Volumen mit variabler Kapazität ist, das durch den Bolzen (5), den Differentialflächenkolben (60) und den Füllkolben (7) gebildet ist;

wobei das offene Ende der zylindrischen Wand des Differentialflächenkolbens den sekundären Kolbenabschnitt (63) des Kolbens (6) bildet und wobei die Ringnut (76) zwischen den konzentrischen, zylindrischen Wandvorsprüngen (70, 74) des zweiten Kolbens (7) einen zusätzlichen Zylinder bildet, in der der sekundäre Kolbenabschnitt (63) arbeitet.

4. Geschützstruktur nach Anspruch 3, wobei

eine Akkumulatorstruktur in dem Körperabschnitt (73) des Füllkolbens (7) vorgesehen ist, die einen Akkumulatorzylinder (78), eine Einrichtung (17) zum Beaufschlagen des Akkumulatorzylinders (78) mit Fluiddruck und eine Fluidleitungseinrichtung (77) aufweist, die den Akkumulatorzylinder (78) mit dem zusätzlichen Zylinder verbindet;

wobei, wenn die Akkumulatorstruktur (78) mit einem Strömungsmittel geladen wird, der zusätzliche Zylinder (76) und der sekundäre Kolbenabschnitt (63) einen Puffer bilden, der einen Widerstand für die Bewegung des Differentialflächenkolbens (60) während des Feuervorganges bildet.

5. Geschützstruktur nach Anspruch 4, wobei

die Fluidleitungseinrichtung (77), die den Akkumulatorzylinder (78) und den zusätzlichen

Zylinder miteinander verbindet, mehrere Öffnungen in den zusätzlichen Zylinder aufweist, die so angeordnet sind, daß sie der Reihe nach geschlossen werden, wenn sich der Differentialflächenkolben (6) von seiner Geschützgeladen-Position in seine Geschützentladen-Position während des Feuervorganges bewegt;

wobei der Puffer einen variablen hydraulischen Widerstand für die Bewegung des Differentialflächenkolbens (6) bildet.

6. Geschützstruktur nach Anspruch 5, wobei ferner eine einstellbare Ventileinrichtung (87) in der Fluidleitungseinrichtung (77) vorgesehen ist, die den Akkumulatorzylinder (78) und den zusätzlichen Zylinder miteinander verbindet zum Regeln der Strömungskapazität der Fluidleitungseinrichtung (77);

wobei die Bewegung des Differentialflächenkolbens (6) auch durch die Einstellung der Ventileinrichtung (87) beeinflußt werden kann, um den hydraulischen Widerstand hinter dem Differentialflächenkolben (6) zu steuern.

Revendications

1. Structure d'arme à feu à propulseur liquide du type régénératif à injection directe comportant une boîte (21) de culasse définissant un alésage (30) de culasse comportant une extrémité avant (31) côté canon et une extrémité arrière (32) côté culasse, comprenant, en combinaison :

- un élément fixe (5) se trouvant à l'intérieur dudit alésage (30) de culasse et s'étendant depuis un élément de support (50, 34) près de ladite extrémité canon (31) en arrière vers ladite extrémité culasse (32), ledit élément fixe (5) étant d'une façon générale cylindrique mais comportant une partie agrandie (52) près dudit élément de support (34) ;
- un piston différentiel (6) comportant une tête (60) divisant le volume à l'intérieur dudit alésage (30) de culasse entre une chambre de combustion (55) à ladite extrémité canon (31) sur le côté avant de ladite tête (60) de piston et un réservoir (35) de propergol sur le côté arrière de ladite tête (60) de piston, ledit piston différentiel (6) comportant une partie évidée (64) destinée à s'étendre au-delà dudit élément fixe (5) lorsque ledit piston (6) se déplace le long dudit élément fixe (5) depuis une position d'arme à feu chargée dans laquelle ladite partie évidée (64) coïncide avec ladite partie agrandie (52) dudit élément fixe (5) et forme un joint d'étanchéité avec cette partie jusqu'à une position d'arme à feu déchargée en réponse à la pression des gaz de combustion engendrés dans ladite chambre de combustion (55) pour injecter dans ladite chambre de combustion (55) le propergol provenant dudit réservoir (35) ;
- ladite partie évidée (64) et ladite partie agrandie (52) étant dimensionnées et configurées de manière à coopérer lorsque ledit piston différentiel (6) se déplace par rapport audit élément fixe (5) afin de définir un orifice d'injection (52, 60) de section variable entre ce piston et cet élément en vue de l'écoulement du propergol depuis ledit réservoir (35) jusqu'à ladite chambre de combustion (55).

2. Structure d'arme à feu selon la revendication 1, dans laquelle :

- ledit élément fixe (5) est une tiige d'obturation espacée de la paroi (30) de ladite boîte (21) ;
- ledit piston différentiel (6) comporte une tête (60) de piston, sensiblement plane ;
- ladite partie évidée (64) est une ouverture dans ladite tête plane (60) ;
- ladite partie agrandie (52) est une bande (52) faisant saillie radialement sur une distance discrète depuis ledit obturateur ;
- les surfaces de ladite partie évidée (64) et de ladite bande (52) étant configurées toutes deux de manière à s'accoupler de façon complémentaire pour former un joint d'étanchéité (64, 52) lorsque lesdits éléments coïncident l'un avec l'autre et à créer une ouverture annulaire qui se dilate à une vitesse prédéterminée en fonction du déplacement dudit piston (6) par rapport à ladite tige d'obturation (5) jusqu'à ce qu'elle forme une ouverture maximale dont la mesure est déterminée par ladite distance discrète lorsque la distance entre ladite tête plane (60) et ladite bande (52) dépasse ladite distance discrète,
- grâce à quoi on peut déterminer, au moins en partie, à l'aide des configurations de ladite partie évidée et de ladite bande, la vitesse de dilatation de l'ouverture annulaire ainsi que l'ouverture maximale à travers laquelle le propergol s'écoule depuis le réservoir (35) jusqu'à la chambre de combustion (55).

3. Structure d'arme à feu selon la revendication 2, dans laquelle :

- ladite tige d'obturation (5) est fixée, dans le sens axial de ladite culasse (2), par une structure formant voile (50) assujettie de façon amovible dans l'extrémité canon (31) de la culasse (2) ;
- ledit piston différentiel (6) est un piston creux annulaire (6) comportant une paroi cylindrique (62) s'étendant depuis la périphérie de ladite tête plane (60) en direction de ladite extrémité culasse (32) de ladite boîte, ladite périphérie et ladite paroi cylindrique étant espacées de la paroi intérieure (30) de ladite boîte, et ladite partie évidée (64) étant centrée dans ladite tête plane (60) ;
- un second piston (7) est présent, ce piston comportant une partie corps (73) supportée dans ladite boîte de culasse en vue d'un déplacement en va-et-vient et deux saillies concentriques (70, 74) formant parois cylindriques s'étendant depuis ladite partie corps (73) en direction du canon et définissant entre elles une fente annulaire (76), la paroi extérieure (70) des deux parois cylindriques précitées s'ajustant entre ledit piston différentiel (60) et ladite boîte (21), et la paroi intérieure (74) des deux parois cylindriques précitées s'ajustant entre ledit obturateur (5) et la paroi cylindrique dudit piston différentiel (6) pour constituer un piston de remplissage (7), et
- ledit réservoir (35) est un volume annulaire ayant une capacité variable définie par ladite tige d'obturation (5), le piston différentiel (60) et le piston de remplissage (7) ;
- grâce à quoi l'extrémité ouverte de ladite paroi cylindrique du piston différentiel constitue ladite partie secondaire (63) dudit piston (6) et la fente annulaire (76) entre les saillies concentriques (70, 74) de parois cylindriques dudit second piston (7) constitue un cylindre supplémentaire dans lequel ladite partie secondaire (63) de piston agit.

4. Structure d'arme à feu selon la revendication 3, dans laquelle :
- une structure d'accumulateur est présente dans ladite partie corps (73) dudit piston de remplissage (7) et comprend un cylindre accumulateur (78), un moyen (17) pour charger ledit cylindre accumulateur (78) avec un fluide sous pression et un moyen (77) formant conduit de fluide reliant entre eux ledit cylindre accumulateur et ledit cylindre supplémentaire ;
- grâce à quoi, quand ladite structure (78) d'accumulateur est chargée avec un fluide, ledit cylindre supplémentaire (76) et ladite partie secondaire (63) de piston constituent un amortisseur opposant une résistance au déplacement dudit piston différentiel (60) pendant le tir.

5. Structure d'arme à feu selon la revendication 4, dans laquelle :
- ledit moyen (77) formant conduit de fluide reliant entre eux ledit cylindre accumulateur (78) et ledit cylindre supplémentaire comprend, dans ledit cylindre supplémentaire, une pluralité d'orifices qui sont disposés de manière à être fermés successivement lorsque ledit piston différentiel (6) se déplace depuis sa position d'arme à feu chargée jusqu'à sa position d'arme à feu déchargée pendant le tir ;
- grâce à quoi ledit amortisseur oppose une résistance hydraulique variable au déplacement dudit piston différentiel (6).

6. Structure d'arme à feu selon la revendication 5, comprenant, en outre :
- dans ledit moyen (77) formant conduit de fluide un moyen formant valve réglable (87) reliant entre eux ledit cylindre accumulateur (78) et ledit cylindre supplémentaire pour régler la capacité d'écoulement dudit moyen (77) formant conduit de fluide ;
- grâce à quoi le déplacement dudit piston différentiel (6) peut aussi être influencé par le réglage dudit moyen formant valve (87) pour régler la résistance hydraulique derrière le piston différentiel (6).

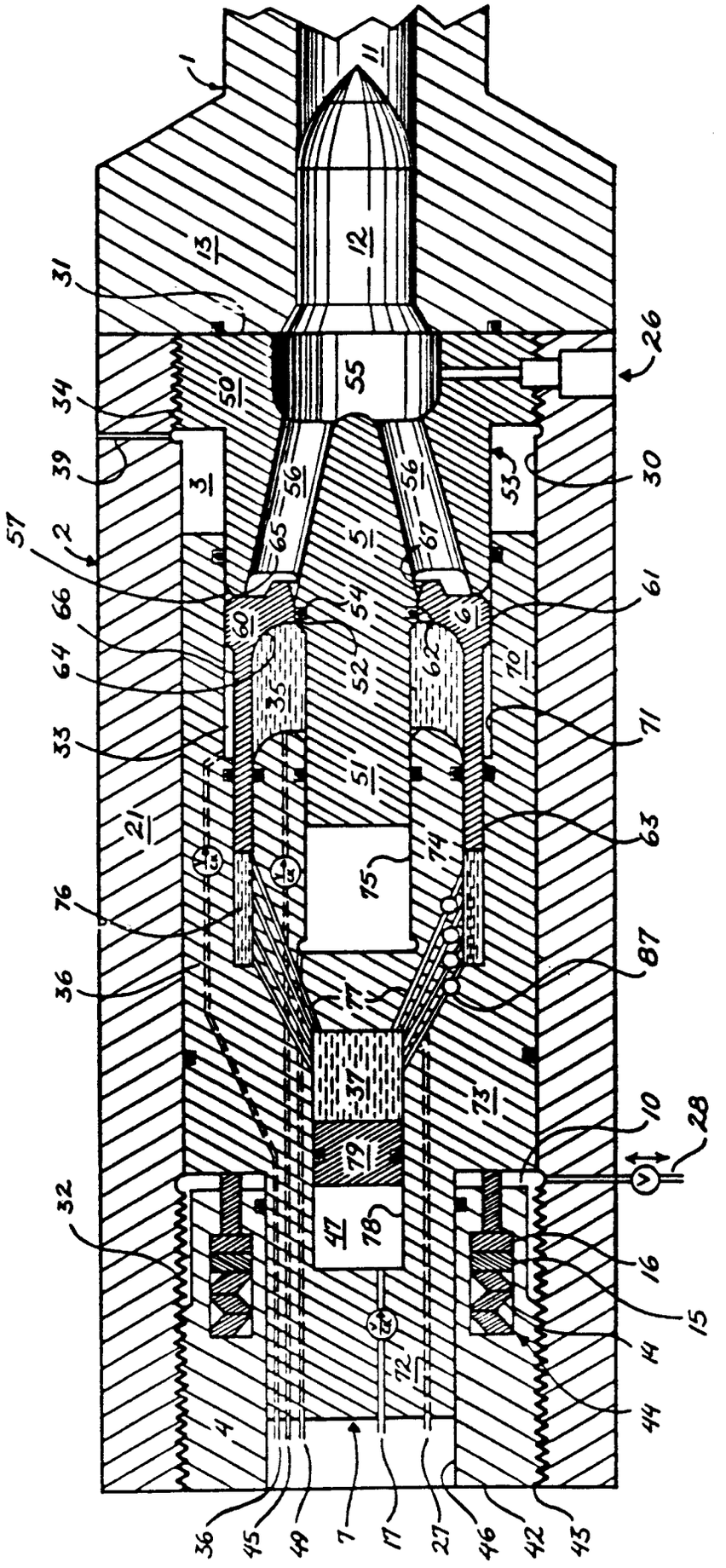

Fig 1

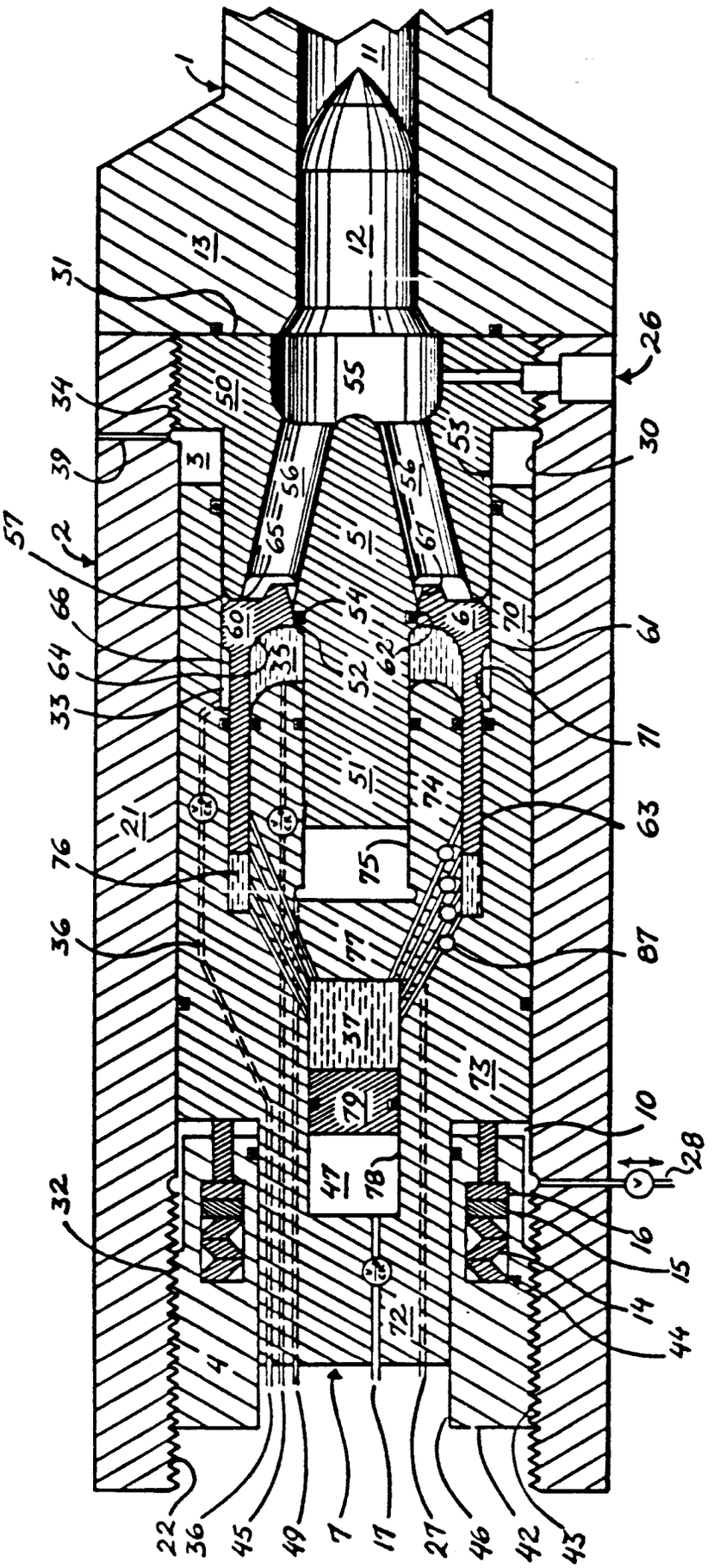
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Fig 2