July 13, 1948. C. W. MUSSER 2,444,949

RECOILLESS FIREARM

Filed Nov. 14, 1945 3 Sheets-Sheet 1

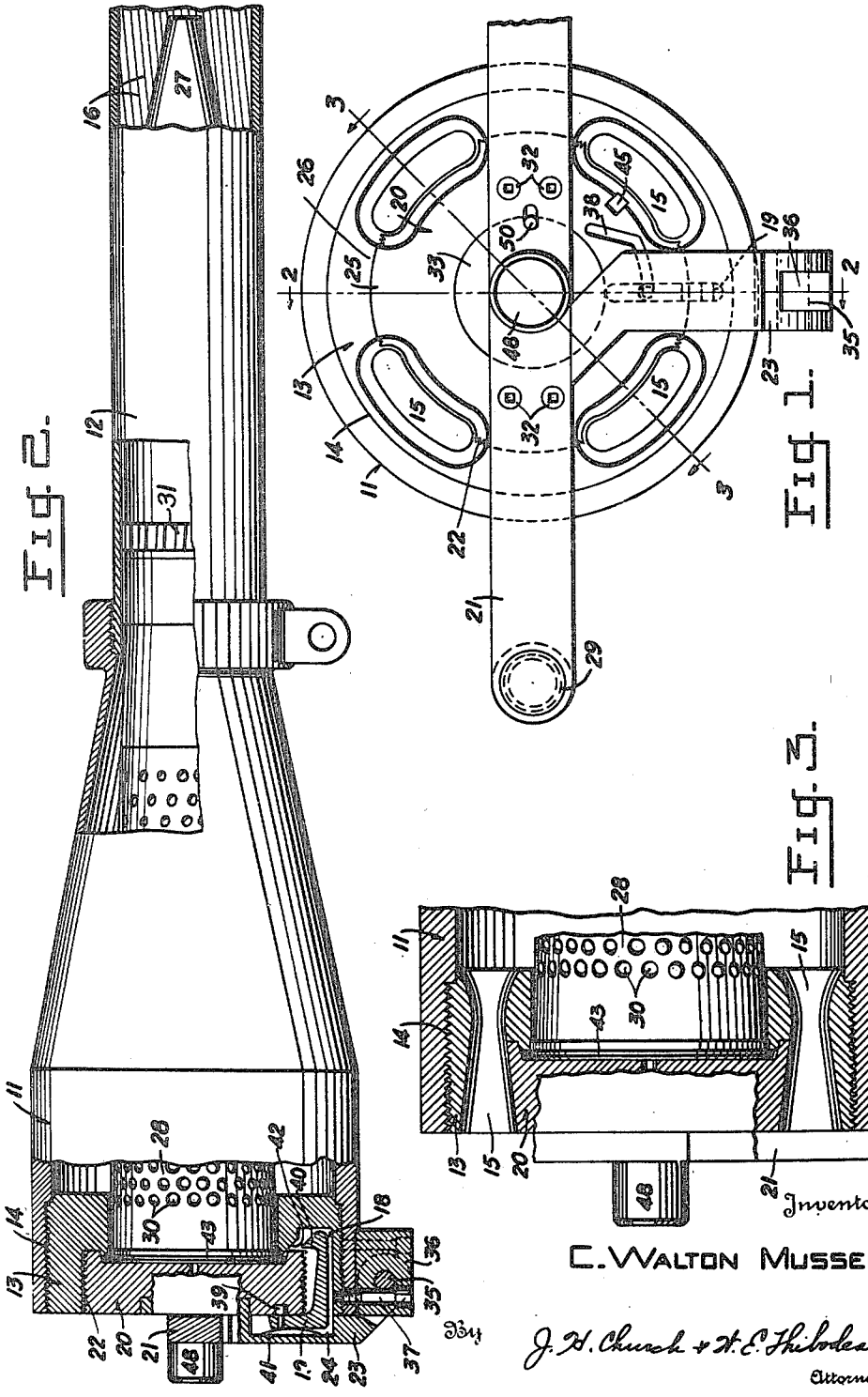

Fig. 2.

Fig. 1.

Fig. 3.

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RECOILLESS FIREARM

Filed Nov. 14, 1945 3 Sheets-Sheet 2

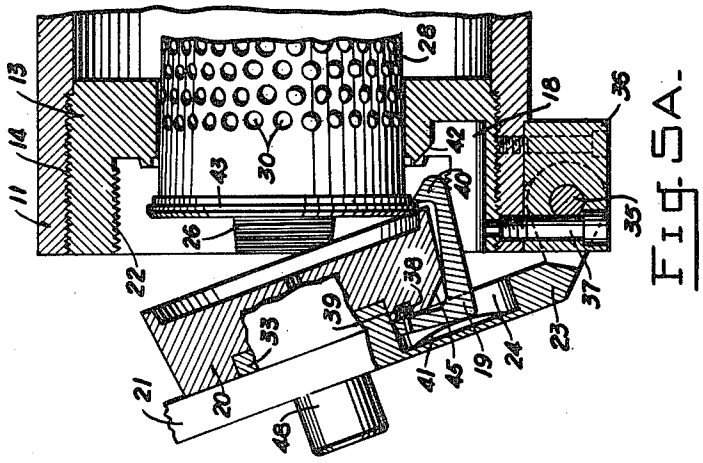

Fig. 5A.

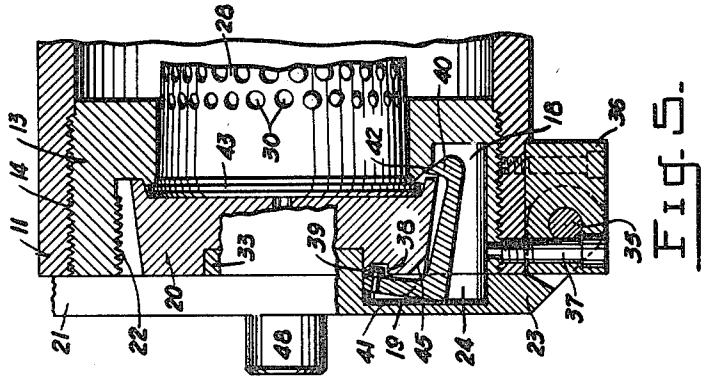

Fig. 5.

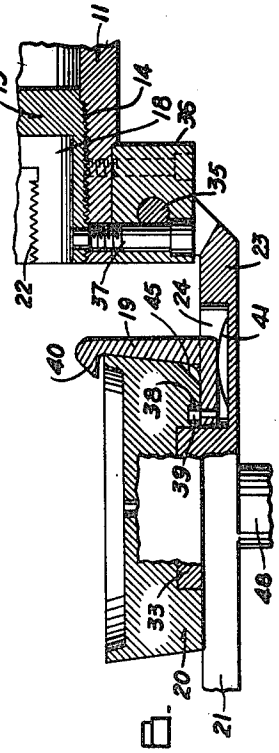

Fig. 5B.

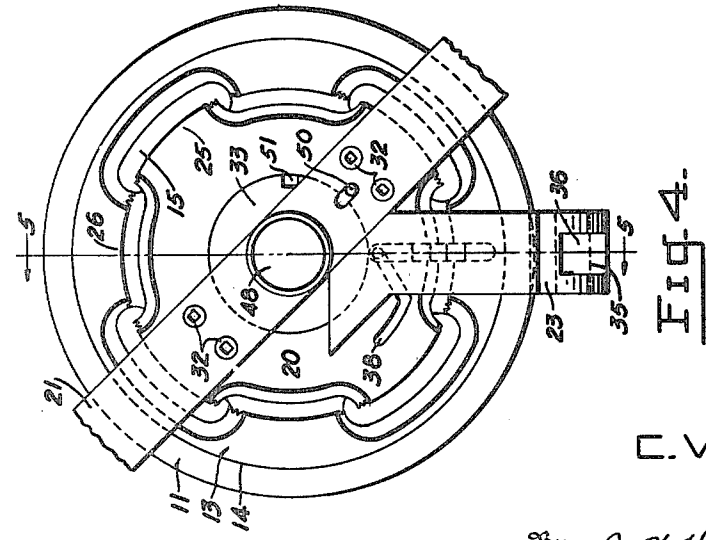

Fig. 4.

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RECOILLESS FIREARM

Filed Nov. 14, 1945 3 Sheets-Sheet 3

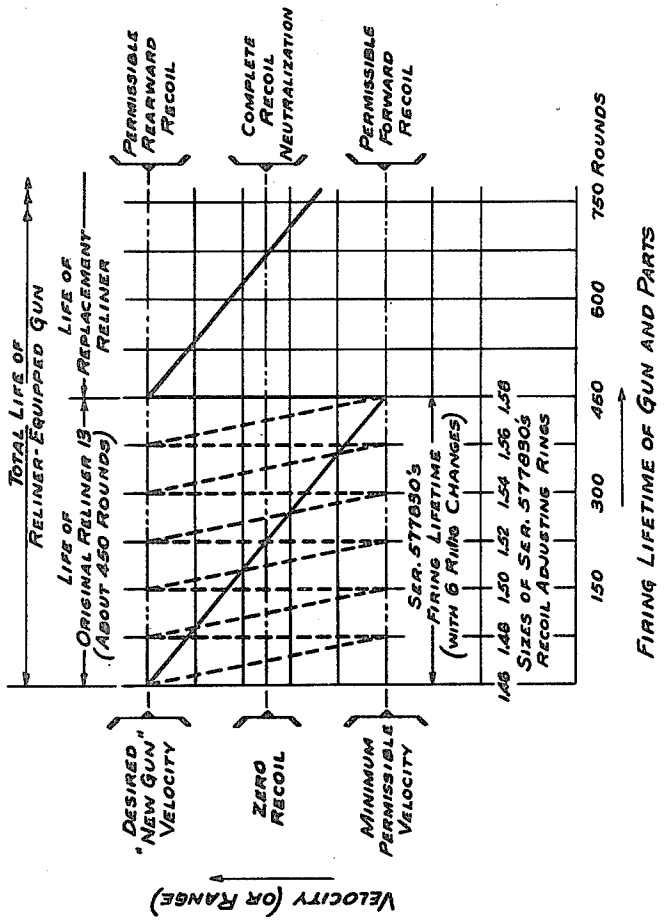

Fig. 6

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UNITED STATES PATENT OFFICE

2,444,949

RECOILLESS FIREARM

Clarence Walton Musser, Philadelphia, Pa., assignor to the United States of America as represented by the Secretary of War

Application November 14, 1945, Serial No. 628,647

7 Claims. (Cl. 89—1.7)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

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

My invention relates to firearms of the recoilless type and it has special reference to non-recoil guns wherein the forces of rearward reaction that result from projectile discharge are neutralized by forwardly acting counter forces simultaneously set up by a rearward escape of propellant powder gas through openings or orifices in the gun's breech.

Broadly stated, the object of my invention is to improve the design and extend the usefulness of recoilless guns which incorporate principles of construction and operation earlier disclosed and claimed by co-pending applications of Kroeger-Musser: (*a*) Serial No. 536,590, filed May 20, 1944, for "Recoilless firearms, ammunition therefor, and ballistic design thereof"; and (*b*) Serial No. 577,830, filed February 14, 1945, for "Recoilless firearm and ammunition therefor."

A more specific object is to substantially increase the effective life of such guns over that possessed by their forerunners in the recoilless gun field.

Another object is to provide non-recoil gun constructions which are peculiarly adapted to firearms of 75 millimeter and other high calibers and which eliminate the problem of recoil adjustment that characterizes prior art recoilless weapons.

A further object is to protect the gun's extractor mechanism from erosion by the blast of escaping gases.

A still further object is to attain the foregoing improvements without sacrificing the advantages of light weight, ruggedness and simplicity of action.

Other objects and advantages will become apparent as the disclosure and description hereof proceeds.

In practicing my invention I accomplish the foregoing aims by utilizing the "annular breech orifice," the "perforated cartridge case," and the "specially tapered gun chamber" principles which copending applications Ser. Nos. 536,590 and 577,830 broadly cover. In supplement thereto I have provided a unique gun chamber "reliner" which makes the replacement of gun parts subject to erosive wear caused by rearwardly expelled gases a comparatively simple and rapid operation.

As is later brought out this "reliner" may be of a uniform design for large and small weapons. Regardless of the weapon's caliber, only one size reliner is necessary throughout the life of the gun. Instead of adjusting differently dimensioned recoil adjusting devices when wear occurs, as in the prior art, a gun may be completely renewed by replacement of the worn reliner.

2

My new weapon design additionally shields the cartridge case extractor from corrosive powder gases and causes the extractor further to automatically lock the breech in the "open" position.

My invention together with illustrative embodiments thereof will best be understood from the following description when taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a rear view showing of my improvements applied to a recoilless gun of 75 mm. caliber;

Fig. 2 presents a showing, in partial section from line 2—2 of Fig. 1, of the chamber, breech, chamber reliner, extractor, hinge mounting and rifled barrel;

Fig. 3 is a section on line 3—3 of Fig. 1 through opposing Venturi-like openings that extend axially through the chamber reliner;

Fig. 4 shows my weapon in rear elevation with the breech bar and breech block thereof rotated to the unlatched position;

Fig. 5 is a section on line 5—5 of Fig. 4 showing how the extractor is released from rotational locking engagement with the breech block when the breech is closed;

Fig. 5A is a similar view showing the breech partially opened and illustrating the extractor partially entered under spring pressure into locking engagement with the breech block;

Fig. 5B indicates how the extractor positively locks the breech block against rotative movement when the block is further withdrawn from the chamber; and

Fig. 6 is a graph showing how the firing lifetime of my new gun has been extended far beyond that of its comparable prior art recoilless firearm.

Problem to be solved

My invention comprises improvements in recoilless firearms of the "open breech" type described and shown in the co-pending applications of Kroeger-Musser, Serial Nos. 536,590 and 577,830, earlier identified. The weapons of those earlier applications have already gained widespread acclaim due to their exceptional effectiveness and military value on battlefields around the world; they have, in fact, made each infantry-

man a potential artilleryman with concomitant accuracy approaching that of a "sharpshooter" rifleman.

When those earlier weapons were originally designed, the broad objects were to provide the first successful recoilless guns having the above-described effectiveness. Such aims were accomplished by those firearms. Since then, the principal objectives have been to increase the firing lifetime and reduce the time and effort necessary to maintain the gun in satisfactory firing condition.

Experience with the above-mentioned early recoilless firearm designs have shown that a maximum of about 450 rounds is the average lifetime of the 75 mm. construction shown by Ser. 577,830 depending on the type of propellant powder used. To attain even this figure it is necessary to utilize about six changes of a recoil adjusting ring or cone (54 of Ser. 577,830's drawings) which is subject to erosion from the blast of rearwardly escaping explosive gases. Moreover, the proper selection and replacement of this ring requires a certain amount of skill, time and training which are additional disadvantages when such changes have to be made under combat conditions.

Elimination of the foregoing problem has been accomplished by a unique shaping of the venturis through which the rearwardly moving gases escape, and a novel arrangement for renewing gaseously eroded gun parts with but a minimum of time and skill. In addition this new construction includes means for protecting the extractor mechanism from rapid gaseous erosion, thereby eliminating another part-renewal problem.

Advantages of new gun over prior art

The aforementioned handicaps in the prior art have been, for all practical purposes, overcome by my here disclosed improvements which have enabled such guns to far outlast their forerunners in the recoilless weapon field.

For example, it has been found that the same number of ammunition rounds (about 450, depending on the powder used) may be fired from my improved firearm before the novel reliner requires replacement as could be shot from the earlier type rifle during the latter's entire lifetime. Since many new reliners may be substituted before other parts of the gun are worn to the point where the entire weapon is unusable, it may readily be seen that the life span of the new recoilless gun has been tremendously expanded.

Reference to Fig. 6 will graphically illustrate these advantages. That drawing plots the total firing life of the gun against the attainable velocity (or range) of the projectiles fired therefrom, showing the rate of change in velocity (or range) which occurs when the gun's recoil adjusting ring (54 of Ser. No. 577,830's drawings) or unique chamber reliner 13 is worn by erosion from its "new gun" condition to a point where excessive correction factors must be used. The intermediate stages refer to proportionate levels of firing utility.

The abscissae are plotted along the firing lifetime of the illustrated 75 mm. gun and its earlier counterpart described in Ser. No. 577,830 showing clearly the relative life of the two weapons. The marked abscissa points 1.46 to 1.58 represent increasing sizes of recoil-adjusting replaceable rings or cones (54 of Ser. 577,830's drawings) which need to be installed in the earlier Kroeger-Musser weapon throughout its firing lifetime as erosion enlarges the gun's annular orifice or throat.

The represented "curves" in Fig. 6 compare the longevity and efficiency of my improved weapon described herein with the older type recoilless rifle. The dotted-line curve shows the lowering in velocity which results from enlargement of the prior art gun's annular orifice due to erosion of the aforementioned rings and the gun chamber wall. As more and more rounds are fired from a firearm whose original recoil adjusting ring is of the size exemplified by 1.46 in Fig. 6, velocity changes from the aforementioned "new gun" condition to the minimum permissible velocity necessary for useful operation.

This course is repeated through successive ring changes (first 1.48, then 1.50, etc.), each time replacing the worn adjusting member with one of next larger size. The larger rings each reduce the throat area therearound by an amount sufficient to restore the original bore-to-throat ratio, simultaneously reestablishing velocity at the maximum or "new gun" level. As shown, the described velocity or gun's range renewal can be effected by such ring changes about six times in the life of the prior art weapon before wear of its chamber requires that it be discarded.

With my improvement, changes in velocity are far more gradual, as the solid-line curve of Fig. 6 indicates. This accounts for the earlier mentioned fact that approximately the same number of projectiles (about 450 rounds) can be fired before the unique chamber reliner needs replacement, as formerly could be shot in the entire six-fold-renewed lifetime of the prior art recoilless firearm.

Replacement of the novel chamber reliner completely renews the gun for all practical purposes so that the just stated firing record may be duplicated. This renovation may be repeated over and over again, as all parts subject to any appreciable wear are thus supplanted by new ones. The Fig. 6 graph thus indicates an "unlimited" firing lifetime for my improved weapon. This is a theoretical possibility; and no attempt has thus far been made to determine the actual gun life because of the vast amount of ammunition round and chamber reliners which would have to be expended. Sufficient experimentation has, however, already been performed to prove that my hereinafter described improved recoilless firearm far outlasts its predecssors in the art.

The gun chamber "reliner" of my invention

The drawings hereof illustratively show a recoilless firearm having a chamber 11 whose rearward end is a cylidrical portion which is continuous with a forward tapered portion that is threadably joined with a rifled barrel 12. This firearm construction is similar to that of the 75 mm. weapon shown in co-pending application Serial No. 577,830. For convenience of reference, mention hereinafter will be made to the "tapered" chamber 11; it should be understood, however, that the chamber thus referred to is not entirely tapered, but preferably is constructed of a cylindrical portion and a tapered portion as just described and as shown by the drawings. In accordance with any invention, a removable ring-shaped "reliner" 13 is threadably attached at 14 within the rear or breech end of gun chamber 11, and there immovably secured by a stud 37 which is screwed through a block 36, the chamber 11 and into the reliner 13 as shown in Figs. 2—5—5A—5B. The axial length of threaded juncture 14 is great enough to provide a gas-tight seal without gasketing.

This new reliner 13 is provided with an essentially annular orifice 15 (see Figs. 1—3—4) whose purpose is to control the flow of rearwardly escaping powder gases so as to achieve zero recoil by utilizing the Venturi operative principles described in the co-pending application mentioned above. The shape of that orifice 15 has, however, been redesigned and improved as will be more fully brought out.

In addition, my new reliner is designed to accommodate and shield from gaseous erosion the gun's case extractor fixture 19. This extractor fixture takes the form of a right-angled piece of metal, one entire arm of which is anchored for limited movement within a slot 24 situated on the forwardly facing surface of the breech block's hinged supporting member 23 as shown in Figs. 2—5—5A—5B. (By "forwardly facing surface" is meant that face which looks to the muzzle of the gun when the breech block 20 is inserted into the closed-breech position of Fig. 2 or Fig. 5.) The other extractor arm, which terminates in a hook 40 (see Figs. 5—5A—5B), protrudes resiliently (by virtue of the supporting spring 41 therefor) from the forwardly facing surface of supporting member 23. When the breech block is in the closed breech position this protruding extractor arm matingly enters a recess 18 (see Figs. 2 and 5) provided therefor in reliner 13.

This extractor 19 facilitates case extraction and also serves to prevent rotation of the gun's breech block 20 when that block is in the "open breech" position of Figs. 5A—5B, as will later be explained.

The ring-shaped reliner 13 has a forward opening (fillable by the cartridge case 28 as shown) and an expanded rearward opening whose inner periphery is threaded for engaging the lugs of the gun's breech block 20.

Preservation of the size of the annular orifice (or "venturi") 15, is essential to the efficient operation of recoilless weapons of the open breech type. Even though my improved design provides a shape which minimizes erosion caused by the explosive gases, inevitable wear will require restoration of the original dimensions of those orifices in accordance with the gun's ballistic design. This may be readily achieved by replacement of the reliner 13.

Such replacement is readily accomplished by removing screw 37, then with the breech block 20 in the open position shown in Fig. 5B, turning the reliner 13 counterclockwise out of its threadable engagement 14 with the gun chamber 11; and reversing the procedure to insert the new reliner having properly sized and shaped annular orifices 15.

The breech block and reliner orifices

As here shown, the gun's breech block 20 is removably secured within the rear of chamber 11, and constitutes only a partial closure therefor (see Figs. 1—2—4—5). This breech block 20 is essentially cylindrical in shape. It is radially spaced from the inner wall of reliner 13 in a manner to form the substantially annular orifice or venturi 15 that leads from the interior of the gun chamber 11, axially through the rim-like walls of the ring-shaped reliner 13, and exits as four oblong openings in the rear of the gun, as shown in Figs. 1 and 4. A section of this annular orifice is shown at 15 in Fig. 3 wherein it may be seen that the breech block 20 tapers inwardly from front to rear.

Four locking lugs shown at 25 in each of Figs. 1, 2 to 5B extend radially from this central breech block 20 and threadably interfit, as indicated at 22 in Figs. 1-2, with the mating protrusions 26 (again see Figs. 1, 2 to 5B) on the reliner's interior wall. When the threads on the periphery of locking lugs 25 are thus engaged with the threads of the mating protrusions 26 as just described, they securely lock the breech block 20 within the rear of the reliner 13.

The chamber reliner's wall spaces which circumferentially separate the locking protrusions 26 have a diameter larger than the maximum for the breech lugs 25. This relationship enables free longitudinal movement by those lugs through the spaces named. Such movement is utilized in inserting the breech block 20 within the reliner 13 and also in withdrawing the breech block therefrom, all in a manner presently to be described.

As in the case of the pioneer Kroeger-Musser gun earlier identified, insertion and locking of the breech block 20 within the chamber reliner 13 as shown in Figs. 1—2—3 constitutes a firm support for the ammunition which it helps to position within the weapon. The steel present in the breech block's central core structure is of sufficient thickness and strength to withstand, with appropriate factor of safety, the rearward thrust exerted thereon during firing.

The annular orifice and recoil neutralization

The 75 mm. recoilless firearm illustratively here shown effects recoil neutralization in the unique manner taught by the earlier mentioned co-pending applications Serial Nos. 536,590 and 577,830. In essence, the forces of rearward reaction are neutralized by forwardly acting counter-forces produced by the rearward escape of gases generated by combustion of gunpowder through the earlier indicated annular orifice 15 (see Figs. 1—3—4) between the gun's breech block 20 and the rear internal wall of chamber reliner 13 wherein this breech block is secured.

It may appear from a first impression of the drawings that the aforesaid "annular orifice" 15 is a misnomer inasmuch as it incorporates a number of smaller orifices. However, there is a good reason for considering the firearm to have but one annular orifice, principally because the fire-arm's recoilless mechanism actually functions as if there were only one such orifice. To simplify understanding of the construction of this annular orifice 15, a detailed description thereof follows.

As most clearly illustrated by Figs. 1—3—4—5—5A, this annular orifice 15 is comprised of two distinct portions directly interconnected with each other, both portions being included within the confines of the reliner 13. The major portion of orifice 15 is distinctly annular, although irregular in form, and comprises the rearward dished-out portion of reliner 13 (see Fig. 5A). When the breech block 20 is in its closed but unlocked position, its central core fills the central area of this rearward portion of annular orifice 15, leaving a circumferential opening entirely surrounding the breech block (see Figs. 4–5). The continuity of this portion of annular orifice 15 is broken only by the rearward extensions of the reliner which terminate in the mating protrusions 26, and the four radial lugs 25 which engage with those protrusions.

The minor portion of the annular orifice is actually divided up by four, supporting, axial walls of the reliner into four distinct axial openings which lead from the interior of gun chamber

11 rearwardly to merge with the single annular opening above described.

When the breech block 20 is in its closed and locked position (see Figs. 1—2—3), the described rearward portion of orifice 15 loses its single annular form and also becomes subdivided into four separate orifices, axially continuous with the four openings just described above. In this condition, the gun is in its firing position and, technically speaking, there are then four separate axial openings leading from the interior of gun chamber 11 and exiting as four substantially oblong openings to the rear of the gun as shown in Fig. 1. However, I prefer to consider and will hereinafter make reference to these separate axial venturi openings as being all part of one annular orifice 15, for in actuality these substantially identical openings all are directed toward a common purpose of applying a torque to the rearwardly escaping powder gases at a desired rate so as to counterbalance and neutralize the gun's recoil effect.

Requirements of strength and other design principles necessitate the use of rearward reliner extensions which terminate in the mating protrusions 26, and the four radial lugs 25 which mate therewith, that have the substantial wall thicknesses illustrated by the drawings. Were it not for such requirements my conception of a single annular orifice 15 would be much more apparent. If it were possible sufficiently to narrow the wall thicknesses of protrusions 26 and lugs 25, say to a few thousandths of an inch, it would be considerably more apparent that annular orifice 15 may truly be considered to be of singular rather than of plural form. However, since that annular orifice or venturi, which in the drawings hereof is shown to be subdivided into a plurality of openings, actually functions as if it were one, I shall hereinafter make reference to it as if same were actually an uninterrupted whole.

Upon ignition of the propellant powder (not here shown) within cartridge case 28 and the resultant forwardly discharge of the projectile 27 out of barrel 12, there is expelled through the perforations 30 of case 28 combustion gases which are projected radially against the surrounding chamber wall, and thence rearwardly out of the chamber through the annular orifice 15 now being described. By this acquiring momentum opposite to that of the forwardly moving projectile the explosive gases thus expelled set up counterforces which neutralize recoil.

In my improved 75 mm. weapon here shown this momentum effect is supplemented by making the forward, subdivided portions of the gun's annular breech orifice 15 oblong in a plane perpendicular to the gun's axis and of the "hourglass" shape parallel to the gun's axis shown in Figs. 1—3—4 to obtain the well-known "Venturi action." Starting with a relatively broad radial width at its front or mouth end, the illustrated subdivisions of the annular orifice each gradually converges inwardly to form a somewhat constricted throat portion; these annular orifice subdivisions then taperingly flare out from this throat region to their rear exit as shown in Fig. 3. The well-curved entrance greatly facilitates funneling the rearward moving gases into the four annular orifice subdivision with a minimum of wear thereon, while the illustrated exit angle is responsible for a satisfactory forward force component due to rapid expansion of the powder gases in passing rearwardly therethrough.

Acceptable performance is found to be achieved when the dimensions of the "hourglass" orifice 15 have the relative proportions shown in Fig. 3. However, dimensions other than those shown may of course be utilized with varying degrees of relative effectiveness.

It will be noted that in my new design the major portion of the "venturi" which serves to converge escaping gases and thereby effect recoil neutralization is located within the replaceable reliner 13. This affords important advantages over the earlier mentioned Kroeger-Musser weapons which were found to have certain portions of their chambers and breech blocks highly eroded by action of the products of powder explosion. In the here disclosed improved construction those portions of the gun chamber 11 and the breech block 20 are not exposed to the highly erosive initial blasts of hot, high pressure gases.

My invention has overcome another trouble found with the earlier mentioned Kroeger-Musser weapons. In those prior art weapons the gases which emerge past the constricted throat portion of the annular orifice and which expand while being discharged to the rear would also cause erosion of the gun chamber's interior. Although less damaging than the above mentioned initial blasts of hot, high-pressure gases, the effect of these rearwardly expanding gases is definitely detrimental to the chamber. When my inventive reliner is employed, the chamber is entirely shielded from those expanding gases as the venturi or annular orifice 15 through which those gases pass is entirely situated within the replaceable reliner 13.

This elimination of such erosion as a factor detrimental to the chamber and breech is found to be substantially complete for all practical purposes, and consequently has increased the gun's firing life span. The unique "hourglass" Venturi design further extends this period of usefulness since the reduced wear which its internal wall undergoes minimizes the number of reliner replacements necessary to maintain the gun in good working order. This latter improvement was emphasized in the actual tests earlier mentioned wherein it was found that before one reliner wore out, an equivalent number of ammunition rounds could be fired from my improved gun as could be fired in the entire lifetime of the longest lived prior art recoilless rifles such as are well represented by the 75 mm. weapon described in copending application Serial No. 577,830.

Adjustment for zero recoil

As previously stated in the work which led to the first successful recoilless type weapons it was found that for complete neutralization of recoil there exists an optimum ration between the bore area of the gun's barrel 12 and the throat area of the breech orifice 15. The factors which determine the value of this optimum ratio have been more completely appraised in the earlier mentioned Kroeger-Musser application Serial No. 536,590. This analysis indicated that the required bore-to-throat area ratio is dependent primarily upon the amount of expansion obtained in the funnel 15, and to a lesser extent upon such factors as the relative weights of the powder and projectile.

In my improved firearm of the illustrative 75 mm. caliber here disclosed this ratio for zero recoil is found to lie within the range of about 1.40 to about 1.60. In the original Kroeger-Musser 75 mm. weapon design, adjustment of this ratio

to the optimum value which during actual firing does in fact produce zero recoil is provided by a special, adjustable breech orifice cone (54 of Ser. 577,830's drawings). This cone was intended to bear the brunt of attack by the powder gases, and to be replaced when it and the chamber were so worn as to alter the aforementioned ratio necessary for zero recoil.

Although effective in achieving its intended "adjusting" function, the time and skill required to replace and adjust worn cones under combat conditions are handicaps to the gun's usefulness. My reliner-equipped gun overcomes all these limitations as follows: On the average, one reliner with the illustrated improved venturi will last as long as six old type cones as earlier explained with reference to Fig. 6, the need for time-consuming replacements likewise being diminished; the reliner is manufactured to specifications which include the predetermined optimum ratio for practically zero recoil, and therefore needs no adjustments when installed in the gun; and proper installation of my reliner is a relatively simple process of screwing it into place, whereas the prior art cones required somewhat skillful adjustment by means of a number of positioning screws.

Experience, moreover, has shown that a reduction in annular orifice 15, which thereby increases the aforementioned bore-to-throat ration beyond the optimum value for zero recoil, will cause a rearward "kick" to develop. Likewise, enlargement of orifice 15 causes a decrease in the bore-to-throat ratio which, if diminished below the proper proportion required for zero recoil, will result in a forward "kick" of the weapon upon firing.

As the gun is used, the annular orifice 15 will gradually become enlarged due to erosion so that excessive forward recoil which eventually develops will require the reliner 13 to be discarded. Since a certain amount of recoil can be tolerated without disturbing the gunner, it is preferable at the outset to make the reliner's orifice 15 somewhat under the size required for zero recoil. Thus designed, the useful life of the reliner 13 may be further extended, for it may be used until such time as the described annular orifice enlargement causes excessive and intolerable forward recoil.

A clear understanding of this "life-extending" design and other features may be had by reference to the graph of Fig. 6. As there represented in dotted line the prior art's recoil adjusting ring (54 of Ser. 577,830's drawings) causes some rearward "kick" when new, but as erosion wears the ring the breech orifice is thereby enlarged causing the gun to approach a zero recoil condition. A forward "kick" then develops on further firing and increases toward the point where it would not be tolerable. Before this point is reached the worn ring must be replaced.

The solid line "curve" representing the "kick" imparted to my illustrative 75 mm. reliner-improved weapon shows the comparatively more gradual change from maximum backward to maximum forward recoil which enables one reliner 13 to last as long as six rings of the comparable prior art gun. This more gradual change, moreover, makes the variance in the small amount of recoil that is present to be scarcely noticeable by the user, thereby making the gun easier to handle and control in combat firing.

Neutralization of rotational reaction

The principles regarding neutralization of rotational reaction taught by co-pending applications Ser. Nos. 536,590 and 577,830 have again been adopted in my here disclosed gun. Firearms having rifled barrels experience a rotational reaction by virtue of the spinning motion that firing imparts to the projectile. In the particular gun here shown, barrel 12's right-hand twist gives clockwise rotation (as viewed from the rear) to projectile 27 upon forward movement thereof through the barrel, and this right-hand acceleration of the projectile's mass imparts counterclockwise torque of equal magnitude to the barrel and chamber.

My improved 75 mm. weapon here shown includes provision for neutralizing such reactive torque by causing the explosive gases which rearwardly discharge through the annular breech orifice 15 to impart to the weapon counterbalancing torque of the same magnitude as that which the rifled barrel imparts to the projectile. This provision is effected by so specially shaping the reliner protrusions 26 that the gases passing through orifice 15 have angular momentum imparted thereto.

Each of these reliner protrusions 26 has sidewalls that are slightly out of parallel with the gun's axis. This sidewall arrangement (see Figs. 1 and 4) is such that the powder gases flowing rearwardly through the orifice 15 have imparted thereto a counterclockwise rotation (as viewed from the rear); these rearwardly moving gases being deflected to the right at the lower portion of the breech and to the left at the breech's upper portion.

By reason of the counteracting spin about the gun's axis thus given to the gases there is imparted to the chamber 11 a torque counteracting that applied by the projectile. Only a relatively small degree of angular twist (scarcely discernible in the drawings) is found sufficient to make the thus imparted torque of the same magnitude as the barrel 12 imparts to the projectile 27 in advancing it through the rifled bore.

All neutralizing torque thus set up by the escaping gases is exerted on the sides of the orifice openings 15 and through chamber 11 is transmitted to the barrel 12. In this way the forces of rotational reactions are neutralized in a very simple yet highly effective manner.

Obviously, were the gun barrel to be rifled with a left-hand twist, rotational reaction could be neutralized in exactly the same way merely by shaping the reliner protrusions 26 in the opposite sense.

Breech block's withdrawal from chamber

Explanation has already been given of how the breech block 20 is secured to the reliner 13 in the rear of chamber 11 by the aid of the breech block's locking lugs 25. In the "engaged" position represented by Figs. 1—2—3 this support is all that is needed to hold the breech block in place, and it is fully adequate to restrain the maximum chamber pressures which combustion of the propellant charge (not shown) sets up.

To facilitate loading and removal of the cartridge case 28 after firing, there is provided mechanism (which is similar to that described in co-pending application Ser. No. 577,830) and which enables the breech block 20 to be released and withdrawn from its chamber reliner attachment and to be swung to the downward position shown by Fig. 5B. During these actions the earlier mentioned breech bar 21 comes into play. To the two ends of this bar are affixed forwardly extend-

ing handles, the base of one of which is here indicated in dotted outline at 29 in Fig. 1.

The breech bar 21 is secured to the breech block 20 by means of four bolts shown at 32 in Figs. 1 and 4. Intermediate this bar and the main body of the breech block is an offset ring-like extension 33 of the earlier mentioned hinged breech block support member 23. This support member is connected at its upper end with breech block 20's center and at its lower end is connected through a hinge pin 35 and an attachment block 36 to chamber 11's lower side wall. The hinge pin 35 has a concavity in one side of its long axis fillable by a portion of stud 37 which thereby holds the pin in proper position within block 36 (see Figs. 2—5—5A—5B).

Both the breech block 20 and breech bar 21 may be turned around the ring extension 33 between the "horizontal bar" position of Figs. 1—2—3 and the "inclined bar" position of Figs. 4—5—5A—5B. In the gun here shown the range of this angular movement is of the order of 45 degrees, as comparison of Figs. 1 and 4 will indicate.

Counterclockwise rotation of the weapon's breech bar 21 serves to engage the breech blocking lugs 25 into the mating threads of chamber reliner protrusions 26 and thereby secures the breech block 20 within the chamber reliner 13 as earlier explained (see Fig. 1); clockwise rotation moves the locking lugs out of engagement with the reliner protrusions and into the circumferential regions between protrusions. In the latter position (see Fig. 4), the breech block 20 is free for rearward withdrawal from the chamber.

Once disengaged from chamber reliner 13 as shown in Fig. 4, the breech block 20 plus bar 21 and handles 29 are free to rearward withdrawal and downward swinging around hinge pin 35 to the position represented by Fig. 5B. When the breech block 20 is so withdrawn from chamber 11, the entire interior area of that chamber is unobstructed and prepared for ready insertion of projectile 27 and cartridge case 28 into the gun, or ready withdrawal of a fired cartridge case from the weapon.

To reinsert the breech block into the chamber, it is merely necessary to swing the breech block upwardly from the position shown in Fig. 5B; move it forwardly into the chamber reliner 13's rearmost open end as indicated by Figs. 5A and 5; and finally give the handles 29 and bar 21 a turning movement which brings the breech block locking lugs 25 to engage the reliner's mating protrusions 26 as shown in Figs. 1–2.

The "open" breech lock and case extractor

My improved weapon here illustrated utilizes two locking devices by which the breech block 20 is respectively secured in the "horizontal bar" position of Figs. 1—2—3, and in the "inclined bar" position of Figs. 4—5—5A and 5B. One of these devices will be spoken of as the "open" breech lock and the other as the "closed" breech lock.

The "open" breech lock and the case extractor are cooperatively combined, for all practical purposes, in one mechanism. The object of the "open" breech lock, which will be discussed first, is to prevent the breech block 20 and its attached bar 21 from being turned out of the "inclined bar" position at all times except when the breech block is fully inserted into the gun's chamber reliner 13. This lock thus serves to prevent the mating protrusions 26 from accidently striking the locking lugs 25 when the breech block 20 is swung upward from the Figs. 5A—B to the Fig. 5 position. Once the breech block is in the Fig. 5 position, however, the "open" lock is released and the bar 21 and breech block 20 may be turned counterclockwise from the Fig. 4 position to effect the earlier described locking register of the breech block with the mating protrusions of the reliner as shown in Fig. 1.

The mechanisms utilized and their operation to effect the case extracting as well as the described locking actions will now be discussed. Upon release of the "closed" breech lock (later to be explained in detail) the breech bar 21 and breech block 20 are turned from the horizontal position of Fig. 1 to the inclined position of Fig. 4. In so doing, a groove 38, cut in the breech block 20 to have the contour shown, is also moved from the position of Fig. 1 to that of Fig. 4. A locking pin 39 projecting from the earlier mentioned extractor 19 (see Figs. 1, 2 to 5B) is held by spring 41 in constant register with groove 38. As the breech block 20 is rotated from Fig. 1 to Fig. 4 position, pin 39 is caused by groove 38 to move radially inward from its Figs. 1—2 position to the location shown by Figs. 4—5—5A—5B.

This radial movement of locking pin 39 is transmitted to the attached extractor 19. As a result, the extractor's sloping, pointed hook 40 is brought close to the inner margin of the breech block 20 (see Fig. 5) and, under pressure of the leaf (or a coil) spring 41 (see Figs. 2, 5—5A—5B), is caused to ride radially along a bevelled groove 42 in the reliner 13 to engage the rim 43 of cartridge case 28 and thereby extract same (see Fig. 5A) as the breech block 20 is withdrawn from the chamber to the position of Fig. 5B.

When the breech block has been withdrawn somewhat beyond the position of Fig. 5A, the extractor hook 40 disengages itself from the cartridge case rim 43. This disengagement is brought about due to the fact that while the cartridge case 28 is being withdrawn rearwardly on an axial plane, the extractor hook 40 (being an integral part of breech bar 21) is following a radial path away from the axial plane by pivoting anticlockwise about the hinge pin 35. Upon such disengagement, pressure by leaf spring 41 pushes the extractor 19 against the breech block 20 as shown in Fig. 5B, and in so doing acts to lock the breech block 20 against rotation around the ring-like extension 33.

This locking is effected at the block's edge which is in contact with the extractor's inner point of bend as shown by Figs. 5—5A—5B. In alignment with extractor 19 when breech block 20 occupies the "inclined bar" position of Figs. 4—5 is a slot 45 (see Figs. 5—5A—5B) in the named edge (outer corner) of breech block 20. Once the breech block has been sufficiently withdrawn from chamber 11 to free extractor 19 from cartridge case rim 43, spring 41 pushes the extractor's inner bend portion into this slot 45 to effect the engagement shown by Fig. 5B. The extractor being anchored in slot 24 within the hinge fixture 23, the named engagement locks breech block 20 against rotational movement with respect to fixture 23.

While in such "open" position, the breech block 20 is thus non-rotatively maintained at all times in readiness for reinsertion into the gun chamber (see Fig. 4) without interfering contact occurring between locking lugs 25 and mating protrusions 26. Unlocking takes place by a reversal of the foregoing procedure. When the hinge fixture 23, breech block 20 and bar 21 are swung

upwards from the Fig. 5B to the Fig. 5A and then to the Fig. 5 positions, the sloping edge of extractor hook 40 strikes and rides radially outward against reliner 13's bevelled groove 42 (see Fig. 5). This withdraws the extractor from engagement with the breech block 20's mating slot 45, thereby freeing the breech block 20 and its attachments. By counterclockwise rotation of the bar 21 and breech block 20 as aforesaid, the breech can now again be restored to the "horizontal bar" position of Figs. 1—2—3.

The "closed" breech lock

The "closed" breech lock earlier mentioned now becomes effective to hold the breech block 20 in the horizontal bar position of Fig. 1 until after the gun's firing action has taken place. This lock, along with the weapon's firing mechanism, may satisfactorily duplicate the construction shown and described by co-pending Kroeger-Musser application Ser. No. 577,830.

Of the closed breech lock and the gun's firing mechanism it need only here be observed that the turning of breech bar 21 to the horizontal position of Fig. 1 causes a spring loaded locking pin 50 which protrudes rearwardly from the breech block 20 to move from its Fig. 4 location to that of Fig. 1 thereby engaging a slot 51 (see Fig. 4) in the hinge ring 23. Such engagement locks the breech block 20 to the non-rotatable hinge-ring 23, thereby preventing rotation of the breech block.

When the firing mechanism (not here represented) is actuated (by means not here shown), the locking pin 50 is simultaneously moved radially outward from the Fig. 1 (locked) to the Fig. 4 (unlocked) position. Withdrawal of the breech block 20 from chamber 11 may then be accomplished by clockwise turning the handles 29 and breech block about hinge-ring 33, as previously explained, and then swinging the entire assemblage downwardly about hinge pin 35.

Loading and firing

From the foregoing it will be seen that I have provided important life-increasing and other improvements to prior art recoilless firearms without impairing the advantages in connection with loading and firing possessed by those earlier weapons. To place the ammunition round within my improved gun it is merely necessary to unlock breech block 20, withdraw it from the chamber reliner 13 and swing it downwardly to the position shown by Fig. 5B, thus completely freeing the rear opening into chamber 11.

The ammunition round 27—28 is now inserted into the opened chamber and the rear of barrel 12's bore, the pre-engraved rotating band 31 (see Fig. 2) of projectile 28 being placed into registry with the barrel's riflings 16 (see Fig. 2). Forward thrust of the round is continued until the head rim 43 of cartridge case 28 abuts with the reliner 13 as shown in Figs. 2—5. In this position, the forward end of the cartridge case is centered by the rifle barrel and the case's head is similarly centered within the chamber by the reliner 13 thereabout. When the complete round is in the rifle, the cartridge case 28 is indirectly supported by the barrel 12 by virtue of the projectile located in the barrel which communicates with the cartridge case. As the case is thus supported, there is a very slight annular space all around the forward end of the case separating the case from the surrounding barrel. However, the instant the projectile leaves the case the barrel then directly supports the forward end of the cartridge case so that this annular space is interrupted.

The breech block 20 (together with bar 21 and handles 29) is now moved upwardly and forwardly into the chamber. In approaching and engaging with the cartridge case head the flared recess in the breech block's front comes into abutment with the head and thereby restrains the case against rearward movement. Counterclockwise rotation of the breech block by bar 21 and handles 29 in the manner earlier described, places the gun in readiness for firing, with the hammer (concealed in housing 46 of Figs. 2—5—5A—5B) in the necessary "cocked" position.

By means of mechanisms similar to those utilized by the earlier mentioned Kroeger-Musser firearms, but not here shown nor described, the weapon's safety catch is first released. Then, by a pressure on a trigger button (not shown) situated in one of the two bar handles 29 the hammer and firing pin are caused to detonate a percussion element and ignite primer and propellant charges (also not shown) in the ammunition round.

The resultant combustion of a propellant charge, discharge of the projectile 27, effect and disposition of the cartridge case 28 and explosive gases are also all amply described by co-pending application Ser. No. 577,830; the operative principles there disclosed apply to my hereindisclosed weapon as well.

After firing, the subsequent withdrawal of the fired cartridge case from the chamber is preceded by first unlocking the breech block and then withdrawing that breech block rearwardly and downwardly out of register with the chamber reliner and into the position on hinge support 23 which Fig. 5B shows. Extraction of the fired case in the manner previously described now becomes possible.

Other advantages of new construction

From the foregoing description and accompanying illustrations, certain mechanical details of my weapon which make possible the attainment of a number of earlier enumerated objects will have become evident. For example, the extractor 19 always remains within the reliner 13's recess 18 (see Figs. 2, 5—5A) where it is completely removed from the path of rearwardly moving explosive gases. This feature corrects a condition which led to rapid extractor erosion in the earlier Kroeger-Musser recoilless rifles. Now shielded behind the protecting reliner 13, the extractor 19 in my improved gun survives many times longer than its counterpart in the earlier design.

As previously mentioned, too, the removable reliner 13 bearing the portions of the annular orifice 15 most subject to gaseous erosion may be readily replaced. Such reliner renewal may satisfactorily be facilitated by a special wrench (not shown). The procedure used is to clamp the gun chamber 11 securely in a vise (not shown), remove stud 37 out of contact with reliner 13, and then fasten the opposing jaws of this named wrench onto the reliner through opposite venturis 15 at the rear of the gun with the breech block 20 and bar 21 in the Fig. 5B position. A counterclockwise turning of this wrench removes the reliner 13 from its threaded attachments 14 (see Figs. 2—3—5—5A—5B) to chamber 11.

Thus, in only a few moments, the used reliner, having borne the brunt of attack by the powder gases, may be replaced by a new reliner 13. The

speed and ease with which this simple change can be made by the user at or near the field of combat is a further advantage to this gun life-extending feature.

Summary

The foregoing description has shown that my here disclosed improvements have greatly enhanced the military value and usefulness of the open breech recoilless firearms now so widely acclaimed by the United States armed forces.

It will now therefore be apparent that I have improved the design and extended the usefulness of recoilless firearms which incorporate principles of construction and operation first disclosed and claimed by earlier filed co-pending applications of Kroeger-Musser; that I have substantially increased the effective-life of such "open breech" recoilless guns; that I have provided for such firearms unique chamber and breech designs which are peculiarly adapted to 75 mm. and other high caliber weapons and which eliminate the problem of recoil adjustment; that I have protected the gun's extractor mechanism from erosion by the backward blast of escaping gases; and that I have attained the foregoing improvements without sacrificing the advantages of light weight, ruggedness and simplicity of action.

My inventive improvements, here exemplified as applied to a 75 mm. weapon, are capable of wide application and hence are not to be restricted to that specific form here used for purposes of illustration.

I claim:

1. In a recoilless firearm, the combination of a barrel, a chamber communicating with said barrel and having a rear diameter substantially larger than that of the barrel's bore, an ammunition round comprising a projectile positioned in the rear of said bore and a cylindrical cartridge case having a multi perforated metal wall in communication at its forward end with said projectile and being of substantially smaller diameter than the rear portion of said chamber, a rim extending radially from the rear portion of said cartridge case, a ring-like reliner removably fixed by its outer periphery within said chamber's rear portion and having spaced Venturi-like openings extending axially therethrough to form a substantially annular orifice leading from the chamber's interior through the reliner and to the rear exterior of the chamber and further having a concentric inner periphery whose rearward portion is threaded and whose forward portion is diametrally reduced to encircle said cartridge case immediately ahead of its said rear rim whereby to restrain the case against forward movement and to support same in radially spaced relation to the chamber walls, and a breech block secured in said reliner's rear threaded portion immediately behind said cartridge case rim and also in radially spaced relation to the reliner's walls therearound whereby to restrain the cartridge case against rearward movement and to form a continuation of the inner wall of the substantially annular orifice which leads to the rear exterior of the chamber.

2. In a non-recoil gun, the combination of a barrel, a chamber communicating with said barrel and having a rear diameter substantially larger than that of the barrel's bore, an ammunition round comprising a projectile positioned in the rear of said barrel and a perforated cartridge case within said chamber communicating

with said projectile and having a cross sectional area substantially less than that of said chamber's rear portion and being supportable at its front by said barrel, a ring-like reliner removably fixed within the chamber's rear portion so that its forward portion is in encircling relation to said cartridge case whereby to support same against lateral movement, said reliner being provided with a number of spaced Venturi-like openings which extend axially therethrough to form a substantially annular orifice leading from the chamber's interior to the rear exterior thereof, and a breech block secured in spaced relation to the rear interior of said reliner whereby to support said cartridge case against rearward movement while at the same time continuing said annular orifice without obstruction in conjunction with said reliner's rear interior.

3. In a recoilless firearm, the combination of a barrel, a chamber extending rearwardly from said barrel and having walls which taper outwardly from the diameter of said barrel's bore at the chamber's front to a substantially larger diameter at the chamber's rear, an ammunition round comprising a projectile in the rear of said barrel and a cartridge case containing propellant powder positioned within said chamber and communicating with said projectile, a metal wall for said case forming for said powder a cylindrical enclosure of diameter approximately the same as said surrounding chamber's forward end but substantially less than that chamber's rear portion and being perforated by a relatively large number of openings distributed throughout the circumference and length thereof, means including a removable ring structure lining the inside rear portion of said chamber for supporting said cartridge case against lateral and forward movement and having axially extending therethrough Venturi-like openings which provide a substantially annular orifice leading from the chamber's interior to the rear exterior thereof, and means including a breech block which continues said annular orifice without obstruction in the rear of said chamber and which supports said cartridge case against rearward movement and in spaced relation to said chamber walls therearound, all said elements in the aforesaid combination so cooperating that upon igniting said powder the said projectile is discharged forwardly out of said barrel and at the same time the powder combustion gases which result from such ignition are expelled through said case wall openings radially into said tapered chamber and thence rearwardly out of said annular orifice to neutralize the forces of recoil which tend to develop upon the forward firing of a projectile from said firearm.

4. In a recoilless firearm, the combination of a barrel, a chamber communicating with said barrel, a removable ring structure lining the inside rear portion of said chamber and having spaced Venturi-like openings extending axially therethrough to provide a substantially annular orifice leading from the chamber's interior to the rear exterior thereof, a breech block movable into and out of the rear interior of said ring and having its periphery cut away at spaced portions circumferentially of the block to provide interrupted locking lugs that extend substantially radially from the central portion of the block, coacting protrusions from said ring's inner wall engageable and disengageable by said locking lugs upon locking and unlocking rotation of the breech block within the ring, a support for said breech block affixed to the rear exterior of said chamber

in radial alignment with one of said ring's protrusions, and a hinge member extending radially from said support to the breech block in line with one of said lugs in the breech block's locked position and supporting the breech block for rotative movement within the ring-lined chamber and also for complete withdrawal therefrom as well as for imparting support to the breech block when so withdrawn and also for guiding action for reinsertion into the chamber.

5. In a firearm, the combination of a barrel, a chamber communicating said said barrel and having a rear diameter substantially larger than that of the barrel's bore, a cartridge case containing powder situated within said chamber supportable at its front by said barrel and having its wall so perforated that gases of powder combustion therefrom will expand radially and further having a cross sectional area substantially less than that of said chamber's rear portion so that the gases will have room to expand, a rim extending radially from the rear portion of said cartridge case, a removable ring structure lining the inside of said chamber's rear portion and encircling said cartridge case immediately ahead of its said rear rim whereby to support said case in radially spaced relation to the rear chamber walls, a breech block movable into and out of the rearward portion of said chamber-lining ring immediately behind said cartridge case and being secured therein when rotated to a locked position and freed for withdrawal therefrom when rotated to an unlocked position, a support member for said breech block hingedly attached to the rear exterior of said chamber and extending radially into pivotal juncture with the center of said breech block whereby the breech block is supported for rotative movement between said locked and unlocked positions and for withdrawal from and entry into the chamber, and an extractor fixture protruding from the forward face of said support member for latching engagement over the rear rim of said cartridge case upon withdrawal of the breech block from the chamber to thereby partially withdraw the cartridge case from the firearm at the same time.

6. In a firearm, the combination of a barrel, a chamber communicating with said barrel, a removable ring structure lining the inside rear portion of said chamber and having a recess axially extending into the rear thereof, a cartridge case having a rear rim and containing powder situated within said chamber supportable at its front by said barrel and at its rear by said ring structure and having its wall so perforated that gases of powder combustion will expand radially and further having a cross-sectional area substantially less than that of said chamber's rear portion so that the gases will have room to expand, a breech block movable into and out of the rearward portion of said ring and being secured therein when rotated to a locked position and freed for withdrawal therefrom when rotated to an unlocked position, a longitudinal support member for said breech block having two surfaces which respectively face forwardly and rearwardly when said support member supports the breech block within said ring and further having two extremities one of which is hingedly attached to the rear exterior of said chamber in alignment with said ring-structure recess and the other of which extends radially into pivotal juncture with the center of said breech block's rear surface whereby the breech block is supported for rotative movement between said locked and unlocked positions and for wthdrawal from and entry into the chamber, an operating member affixed to said breech block for transmitting turning and withdrawing and inserting movements thereto, and an extractor fixture having an arm terminating in a hook protruding resiliently from the forwardly facing surface of said support member into said ring-structure recess for latching engagement by the hook with said cartridge case's rear rim upon withdrawal of the breech block from the ring-lined chamber to simultaneously thereby partially withdraw the cartridge case from the firearm, said extractor arm then being projected into locking engagement with said breech block where it prevents rotation of the breech block out of unlocked position until such time as the breech block has again been fully reinserted into the chamber when said extractor arm is removed from said locking engagement in the breech block to said recess in the chamber-lining ring upon contacting said ring.

7. In a non-recoil gun, the combination of a barrel, a chamber communicating with said barrel, a ring-like reliner removably fixed within the chamber's rear portion and having spaced Venturi-like openings extending axially therethrough to form a substantially annular orifice leading from the chamber's interior to the rear exterior thereof, said reliner having between two of its Venturi openings a recess axially extending into the rear of the reliner, a breech block movable into and out of the rear interior of said reliner and being secured therein when rotated to a locked position and freed for withdrawal therefrom when rotated to an unlocked position, a longitudinal support member for said breech block having two surfaces which respectively face forwardly and rearwardly when said support member supports the breech block within said ringlike reliner and further having two extremities one of which is hingedly attached to the rear exterior of said chamber in alignment with said ring's recess and the other of which extends radially into pivotal juncture with the center of said breech block's rear surface whereby the breech block is supported for rotative movement between said locked and unlocked positions and for withdrawal from an entry into the chamber, an operating member affixed to said breech block for transmitting turning and withdrawing and inserting movements thereto, and an extractor fixture protruding resiliently from the forwardly facing surface of said support member and aligned to rest within said reliner's recess when the breech block is inserted into the chamber whereby to be shielded from gaseous erosion during firing.

CLARENCE WALTON MUSSER.