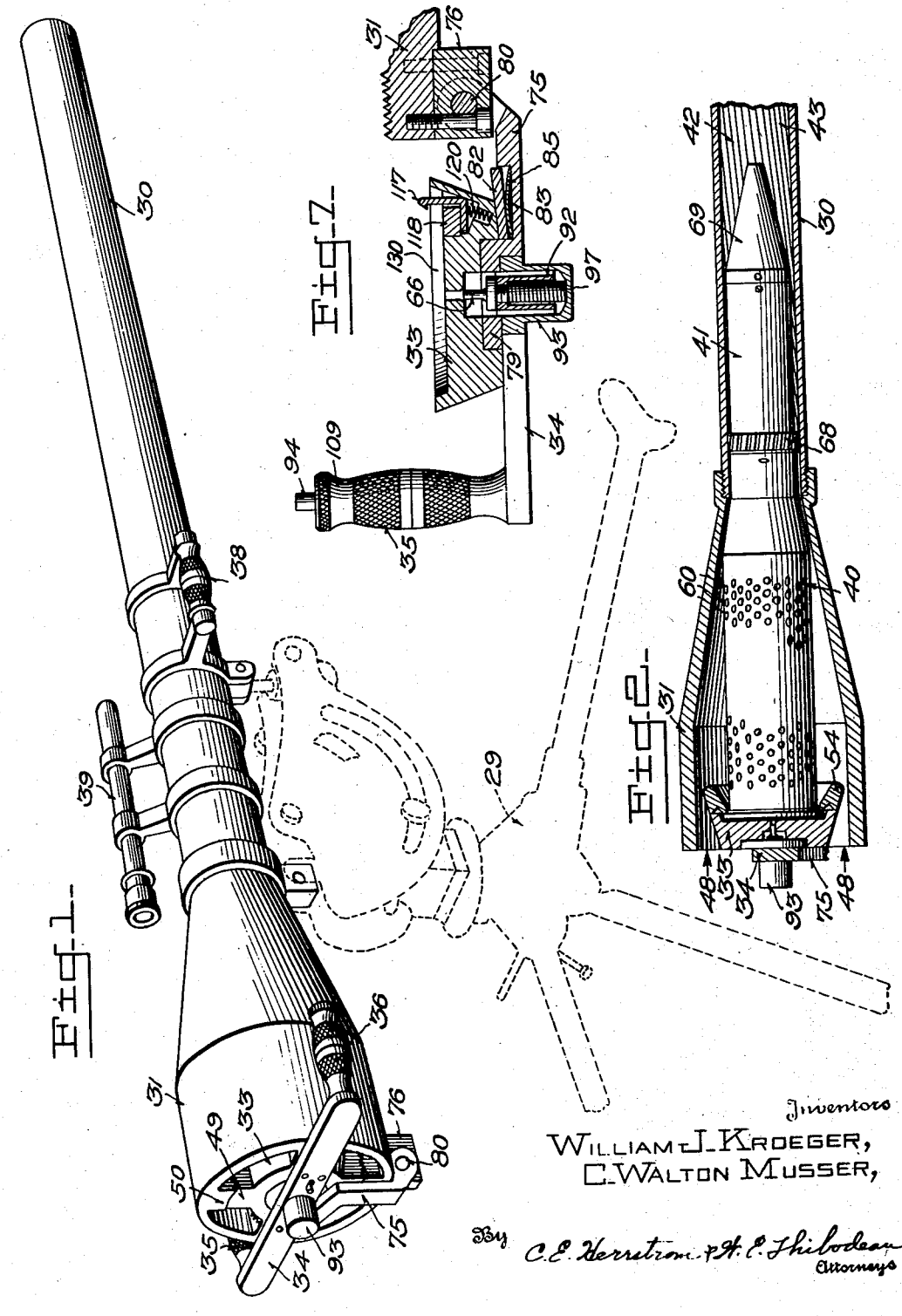
June 7, 1949. W. J. KROEGER ET AL 2,472,111

RECOILLESS FIREARM AND AMMUNITION THEREFOR

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RECOILLESS FIREARM AND AMMUNITION THEREFOR

Filed Feb. 14, 1945

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Fig 4.

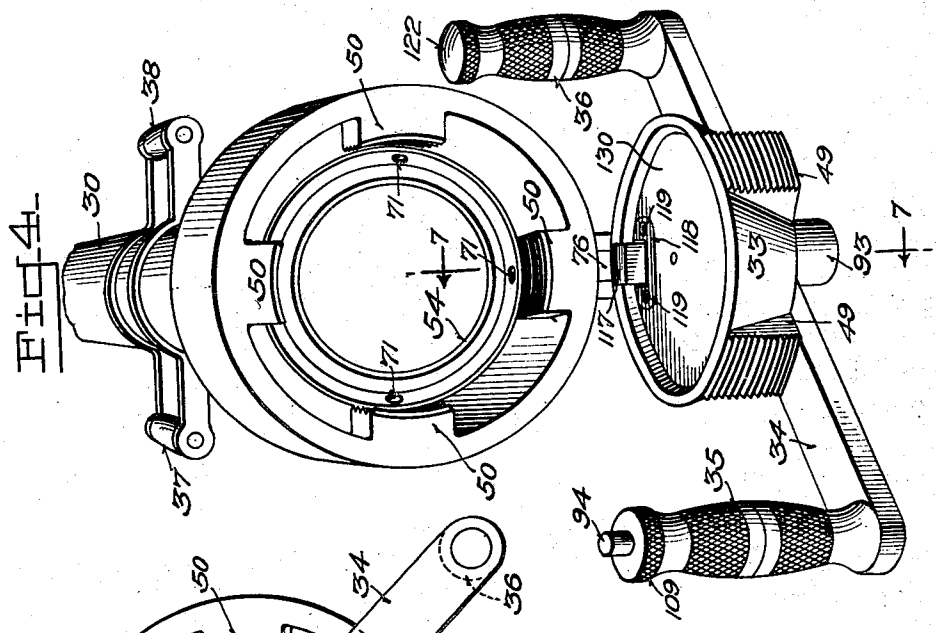


Fig 3.

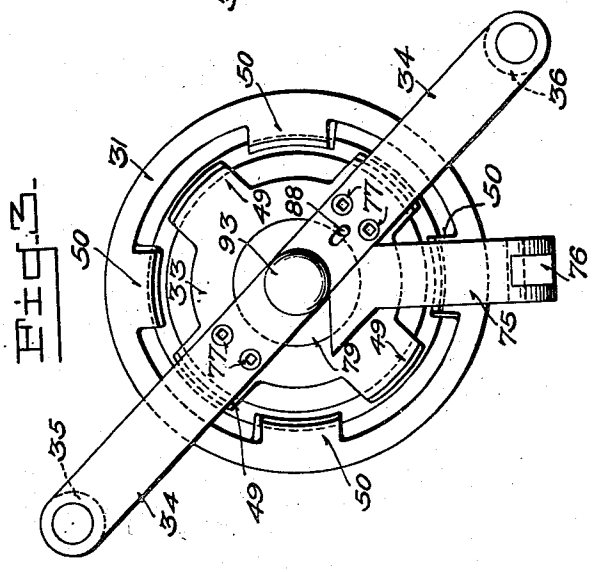


Fig 2.5.

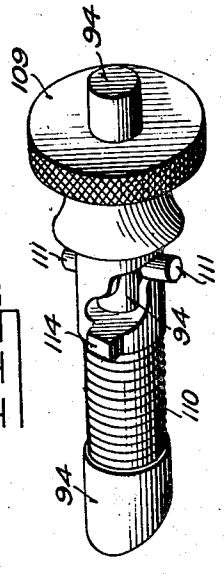
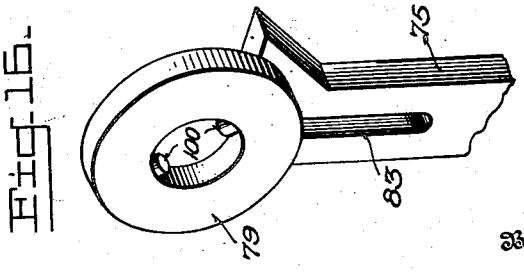


Fig 16.



Inventors

WILLIAM J. KROEGER,
C. WALTON MUSSER,

By C. E. Herrstrom & H. E. Thibodeau
Attorneys

June 7, 1949. W. J. KROEGER ET AL 2,472,111

RECOILLESS FIREARM AND AMMUNITION THEREFOR

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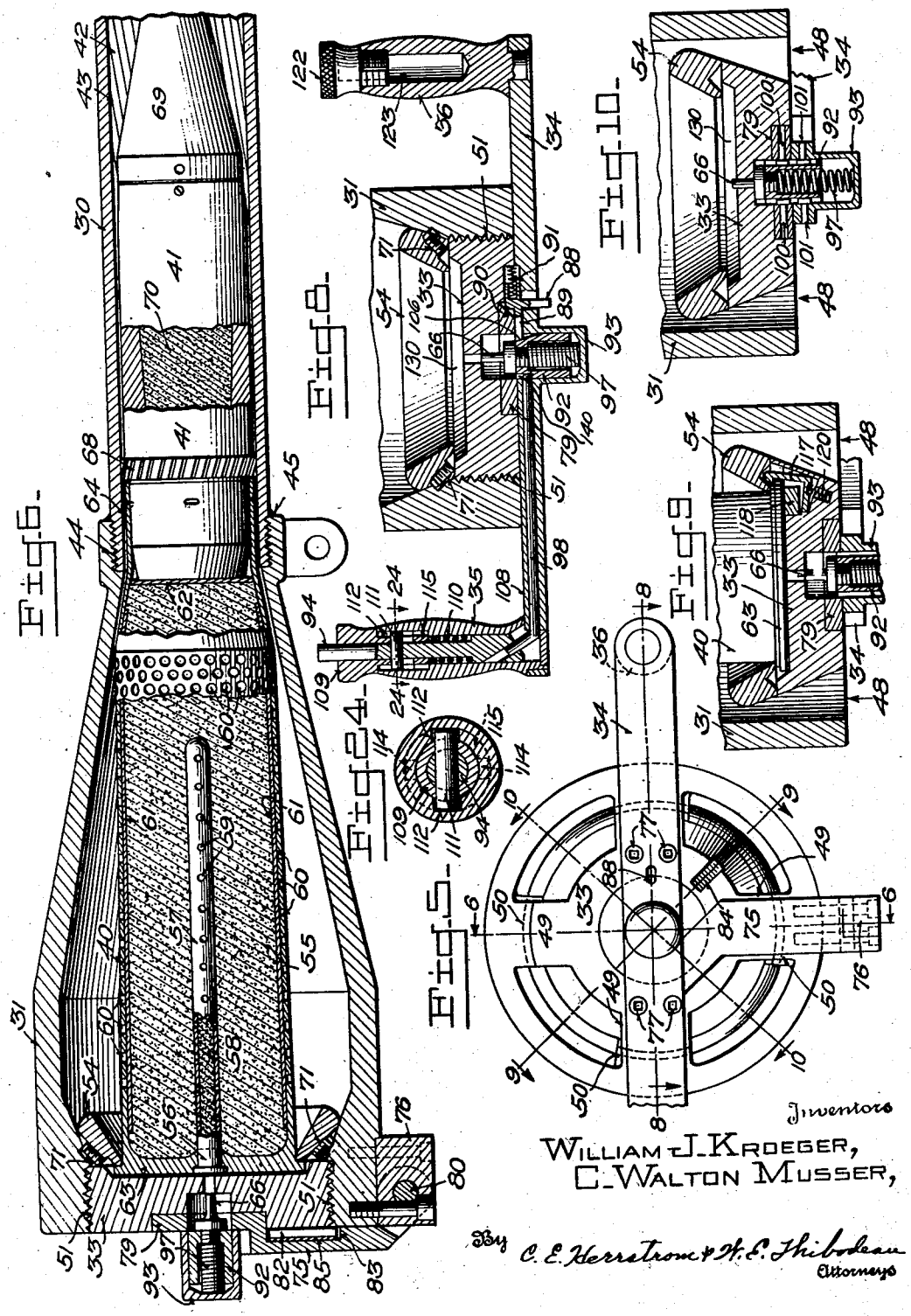


Fig. 6.

Fig. 8.

Fig. 10.

Fig. 9.

Fig. 4.

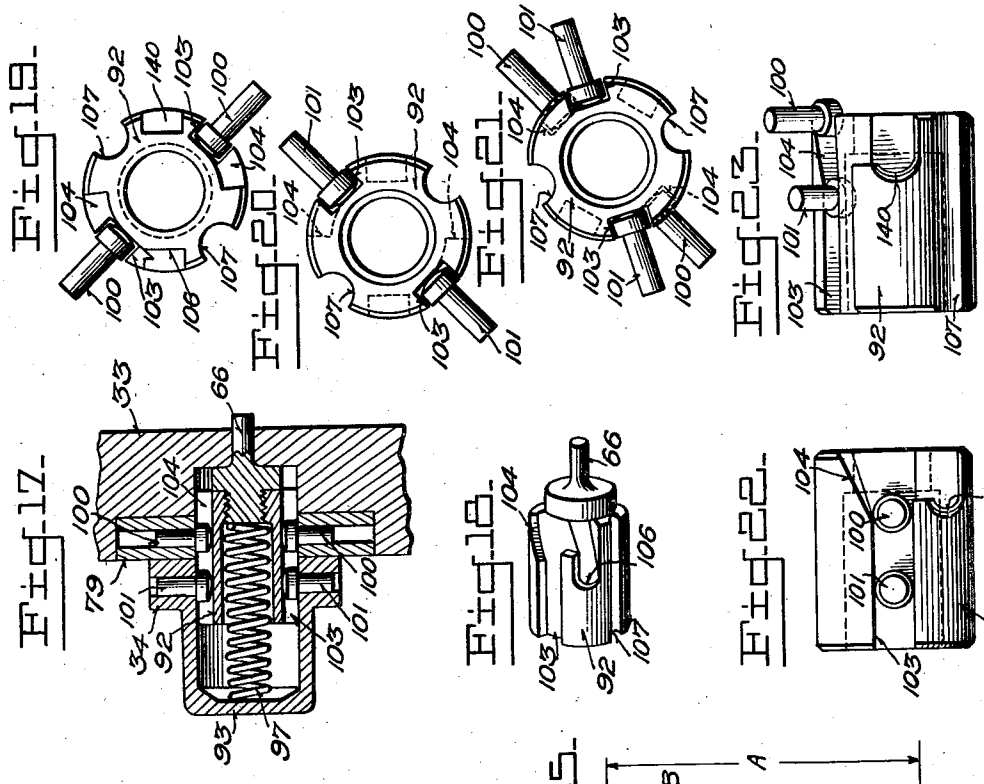
Fig. 5.

Inventors
WILLIAM J. KROEGER,
C. WALTON MUSSER,
By C. E. Herrstrom & H. E. Thibodeau
Attorneys

June 7, 1949. W. J. KROEGER ET AL 2,472,111

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Inventors

WILLIAM J. KROEGER,
C. WALTON MUSSER,

By C. E. Herrstrom & H. E. Thibodeau
Attorneys

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2,472,111

RECOILLESS FIREARM AND AMMUNITION THEREFOR

William J. Kroeger and Clarence Walton Musser, Philadelphia, Pa.

Application February 14, 1945, Serial No. 577,830

15 Claims. (Cl. 89—1.7)

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

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

Our 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 counterforces simultaneously set up by a rearward escape of propellent powder gas through openings or orifices in the gun's breach.

Broadly stated, the object of our invention is to improve the design and extend the usefulness of recoilless guns which incorporate principles of construction and operation first disclosed and claimed by our co-pending application Serial No. 536,590, filed May 20, 1944, and now abandoned, for "Recoilless firearms, ammunition therefor, and ballistic design thereof."

A more specific object is to provide for such "open breech" recoilless guns unique weapon designs and constructions which are peculiarly adapted to firearms of 75 millimeter and other high calibers.

Another object is to provide improved chamber and breech constructions for recoilless guns which utilize the "annular orifice" and the "perforated cartridge case" principles of our earlier application above identified.

A further object is to facilitate adjustment of breech orifice area and the securing of zero recoil at a desired performance level.

A still further object is to increase the simplicity, ruggedness and compactness of breech actions and of firing and safety mechanisms for recoilless firearm use.

An additional object is to make possible the practical construction and successful use of large caliber recoilless firearms which are capable of shooting projectiles carrying heavy quantities of explosive through long distances and yet which are so relatively light in weight and so compact in size as to be readily portable.

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

In constructing large caliber and other recoilless firearms pursuant to foregoing, we utilize the "annular breech orifice" and the "perforated cartridge case" principles which our co-pending application Serial No. 536,590 broadly covers. In supplement thereto we specially shape the gun's chamber gradually to taper outwardly from the barrel's end toward the chamber's breech; we adjust breech orifice area through the medium of a replaceable cone of unique design and mounting; and we provide improved breech extractor and firing and safety mechanisms which are simpler, more compact and rugged, and which are coordinated in a unique way that permits quicker and more convenient loading and firing.

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Our invention itself 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 perspective view of a recoilless gun of 75 mm. caliber which incorporates our inventive features and which is shown as being supported from a tripod for convenient aiming and firing;

Fig. 2 illustrates the recoilless gun's internal construction in simplified schematic form;

Fig. 3 shows our weapon in rear elevation with the breech bar and breech block thereof rotated to the unlatched position;

Fig. 4 illustrates the weapon of Figs. 1–2–3 with its breech block withdrawn from the chamber and swung downwardly on a supporting hinge;

Fig. 5 is a rear view of the weapon of Figs. 1 and 4 with the breech bar thereof horizontal and the breech block secured within the chamber where it constitutes the inner wall of an annular orifice;

Fig. 6 is a section on line 6—6 of Fig. 5 showing the internal construction of our improved weapon's barrel, chamber, breech, hinge mounting, ammunition, and firing mechanism;

Fig. 7 is a section on line 7—7 of Figure 4, Fig. 4 showing details of the breech block and trigger handle when in the open breech position;

Fig. 8 is a section on line 8—8 of Fig. 5 showing further details of the breech block, locking devices therefor, the firing mechanism, and trigger linkage;

Fig. 9 is a section on line 9—9 of Fig. 5 through the chamber, breech block, orifice cone, and cartridge case extractor;

Fig. 10 is a section on line 10—10 of Fig. 5 through hinge and breech bar rollers by which the firing mechanism's hammer is cocked upon each unlatching of the breech;

Fig. 11 shows further details of the breech block supporting hinge;

Figs. 12–13 are enlarged showings of "open" and "closed" breech locks with which the weapon is provided;

Fig. 14 shows the weapon's orifice adjusting cone in rear elevation;

Fig. 15 is a section on line 15—15 of Fig. 14 through that cone;

Fig. 16 shows the hinge fixture of Fig. 11 in front side perspective and with its hammer rollers in place;

Fig. 17 is an enlarged reproduction of the hammer and cocking roller mechanism first illustrated by Fig. 10;

Fig. 18 is a perspective showing of the hammer and attached firing pin as they appear when removed from the weapon;

Figs. 19—20—21—22—23 are views illustrative of how cocking of the hammer is effected by each unlatching rotation of the breech bar;

Fig. 24 is an enlarged section on line 24—24 of Fig. 8 through the gun's trigger handle with the trigger and associated safety mechanism in place therein; and

Fig. 25 is an enlarged perspective view of the trigger and cooperating safety mechanism as same appear when withdrawn from the trigger handle.

THE COMPLETE RECOILLESS GUN

Our inventive improvements are here illustratively disclosed as being incorporated in a military weapon of 75 millimeter caliber capable of a completely recoilless firing of projectiles weighing up to 15 pounds at muzzle velocities of 1000 feet per second. This gun's overall length is less than 82.0 inches and its total weight is but slightly more than 100 pounds. It is designed for convenient carrying by two or four men and when supported from a light tripod of the character shown in dotted outline at 29 in Fig. 1 may with complete safety to the user be fired with great accuracy and high military effectiveness.

As the description proceeds, it will become apparent that our improvements may also be applied to firearms of characters, sizes, and shapes other than the one here disclosed, and that the represented 75 mm. open breech weapon thus has been chosen only to illustrate and not to limit the inherently wide application and scope by which these improvements are characterized.

The illustrative recoilless firearm here shown consists of a barrel 30; an enlarged chamber 31 secured to the rear of this barrel and having the uniquely tapered shape represented; a breech block 33 partially closing (see Fig. 2) the rear of the chamber; a breech bar 34 secured to the block and carrying trigger and breech handles 35—36; a pair of carrying handles 37—38 (see Figs. 1 and 4); and a sight 39 for aiming the gun in conventional manner.

This sight 39 may be of a "direct" telescopic type (as shown) or an "indirect" or other type capable of providing for all firings within the gun's range. It may be mounted on the gun's barrel in any suitable manner, as sufficiently inclined to the left (see Fig. 1) to make aiming more convenient.

As here represented the carrying handles 37—38 are suitably clamped to the barrel 30 at the intermediate location best shown by Fig. 1. These handles, in conjunction with the trigger and breech handles 35—36 (see Fig. 4) enable two or four men readily to carry the weapon from location to location.

Once set up on its light tripod 29 (here indicated as being of standard design for caliber .30 machine guns of military type), firing of the weapon is controlled by trigger handle 35 conveniently grasped by the right hand of the user who places himself on the left side of the weapon ahead of the weapon's breech and in position to look through sight 39 in training the gun on its target.

Ammunition having our novel "perforated cartridge case" form shown at 40—41 in each of Figs. 2 and 6 is loaded into the weapon from the breech thereof in a manner presently to be explained. Such loading may be done either by the man who fires the weapon or by an assistant.

THE GUN'S RIFLED BARREL

As here shown the gun's barrel 30 has an inside diameter of 75 mm. (approximately 2.95 inches), a bore area of slightly less than 7.00 square inches, and a total length of 65 inches. It is constructed of steel of modified SAE 4340 grade having a minimum yield strength of 150,000 pounds per square inch. Its maximum wall ratio (outside to inside radius of the tube) is 1.17 and its maximum wall thickness thus is one fourth inch. A barrel of this material and design will withstand with a safety factor of over 2 the maximum internal pressure which a firing of the represented weapon sets up.

The bore of this barrel is rifled to secure the usual gains in accuracy and range which a spinning of the projectile in flight makes possible. The rifling represented has a right hand twist of one turn in 22 calibers (or approximately 65 inches of barrel 30) and utilizes the twenty-eight lands 42 with intervening grooves 43 which Figs. 2 and 6 show. Depending upon projectile stability needs other steepnesses of twist may obviously be chosen; and twists in the left hand direction may also be employed with equal effectiveness.

THE GUN'S TAPERED CHAMBER

As here shown the gun's chamber 31 takes the form of an enlarged cylinder uniquely tapered at its forward end and there affixed to the rear of barrel 30 in any integrally secure manner as by the aid of screw threads 44 (see Fig. 6).

In our improved 75 mm. weapon here shown this chamber 31 tapers from an internal diameter of about 3.00 inches at its forward junction with barrel 30 to about 6.50 inches within its enlarged and untapered rear portion. This latter diameter is considerably greater than the 75 mm, (approximately 2.95 inches) bore of the weapon's barrel. The chamber's total overall length is slightly over 16.0 inches; the enlarged rear walls thereof continue parallel for 5.35 inches of chamber length; these rear walls have a thickness of 0.62 inch; the forward walls of the chamber taper through a chamber length of 8.37 inches; and the inside surface of each of these forward walls has a "taper" angle (see Figs. 2 and 6) of 10° as measured from the weapon's center line.

This uniquely tapered chamber is constructed of steel of modified SAE 4340 grade having a minimum yield strength of 135,000 pounds per square inch. The chamber's internal volume between the breech block 33 and the barrel's end is of the order of 286 cubic inches. Like the barrel, this chamber will withstand with a safety factor of more than 2 any internal pressure likely to be generated during firing.

THE BREECH BLOCK AND CHAMBER ORIFICE

As here shown, the gun's breech block is removably secured within the rear of chamber 31, and constitutes only a partial closure therefor (see Figs. 2, 9—10). It takes the form of a cylindrical block 33 which is radially spaced from the chamber wall in a manner to form a substantially

annular orifice that leads from the chamber's interior to the rear exterior of the gun. A section of this annular orifice is shown at 48 in each of Figs. 2, 9—10. From those figures it will be seen that the breech block tapers inwardly from front to rear.

Four locking lugs shown at 49 in each of Figs. 3—4—5 extend radially from this central breech block 33 and interfit with mating protrusions 50 (again see Figs. 3—4—5) on the chamber wall interior. Each locking lug 49 carries threads on the periphery thereof as best shown in Fig. 4 and each mating protrusion 50 is provided with similar threads indicated at 51 in each of Figs. 6 and 8. When these two sets of threads are engaged as in Figs. 1, 5—6 and 8, they securely lock the breech block 33 within the rear of the chamber.

The chamber wall spaces which circumferentially separate the locking protrusions 50 have a diameter larger than the maximum for the breech lugs 49 and this relation enables free longitudinal movement by these lugs through the spaces named. This movement is utilized in inserting the breech block within the chamber and also in withdrawing the block therefrom, all in a manner presently to be described.

When inserted and locked within the chamber 31 as shown in Figs. 1, 5—6, and 8 this breech block 33 constitutes a firm support for the ammunition which it helps to position within the weapon. The steel of its central core structure is of sufficient thickness and strength to withstand with a factor of safety of well over 2 the maximum rearward thrust exerted thereon during firing.

THE COMPETE ROUND OF AMMUNITION

Cooperating with the barrel, chamber and breech structure just described in ammunition having the unique character shown in Figs. 2, 6 and 9. As here illustrated the complete round of this ammunition includes a projectile 41 inserted into the rear bore of the barrel 30; a cartridge case 40 communicating with the rear of projectile 41 and firmly supported within the enlarged chamber 31 by the barrel at the forward end and by the breech block 33 plus an orifice adjusting cone 54 at the rear; a quantity of propellent powder 55 within the cartridge case; and powder igniting means shown in the form of a primer 56 and a booster 57.

This illustrated complete round for the 75 mm. weapon now being described has an overall length of nearly 24 inches and a total weight of about 22 pounds. Of this total weight approximately fifteen pounds are in the projectile 41, about three pounds in the propellent powder 55, and about four pounds in the metal case 40.

CARTRIDGE CASE OF CONVENTIONAL SHAPE

The cartridge case 40 of this illustrated ammunition round has the same dimensions and contour as do cases that are used in one well known line of 3 inch weapons of conventional closed-breech design. This identity makes metal blanks for our cases readily procurable.

From Figs. 2 and 6 it will be seen that the diameter of the so conventionally shaped cartridge case 40 is substantially less than that (only about 56%) of the surrounding chamber 31's enlarged rear portion (6.50 inches) and only slightly larger (about 3.6 inches) than the barrel's 75 mm. bore (2.95 inches). This particular case tapers outwardly for a short distance from the rear of barrel 30 at the same 10° angle as does the gun's chamber 31; it then assumes the substantially constant diameter with the exceedingly slow taper shown in spaced relation to the walls of chamber 31 therearound. The case's total length is 16 inches and the interior thereof affords approximately 138 cubic inches of powder space. The case wall is of durable metal such as heat-treated steel of modified SAE 1030 grade which is of sufficient thickness to remain intact during firing. For the 75 mm. case shown a wall thickness of the order of 0.070 inch is found to be adequate for the purpose named.

CARTRIDGE CASE PERFORATIONS AND LINING

Perforating this wall metal in the manner tought by our earlier mentioned co-pending application Serial No. 536,590 are a large number of relatively small openings 60 distributed throughout substantially the entire length and circumference of the case in the uniform manner indicated by Figs. 2 and 6. In the illustrative case shown the number of these openings totals 992 and each has a diameter of one quarter inch. These case wall openings 60 constitute an aggregate area of approximately 48 square inches or nearly one third of the total surface area (about 135 square inches) of the represented cartridge case 40. This aggregate opening area is about seven times the gun's earlier stated bore area of approximately 7.00 square inches.

For preventing the propellent powder 55 from falling out of these openings during loading and for acting as a diaphragm capable of withstanding adequate pressures before rupturing, use is made of a thin layer of frangible material 61 placed inside the perforated case 40 between the case wall and the powder. In practice one thickness of 0.006 inch lacquered "kraft" paper constitutes a satisfactory inner wall lining for the case. Such a lining disintegrates early in the combustion cycle of the propellent powder and thus enables escape of combustion gases and burning powder radially through the openings and into the chamber space immediately surrounding the case.

Our unique case construction here shown permits the named radial expansion of powder gases into the surrounding chamber without rupture of the metal between wall openings 60 or other damage to the case. Such security against failure of this kind safeguards the breech orifice 48 against blocking by case metal or other obstructions which would violently upset recoil neutralization, and allow dangerously high pressures to build up.

THE AMMUNITION'S PROPELLENT POWDER

The propellent powder represented at 55 substantially fills the entire volume of the cartridge case interior that is behind a forward retaining disc shown at 62 in Fig. 6.

For the 75 mm. ammunition shown this powder 55 may satisfactorily be used in a quantity totalling approximately 3.00 pounds. Satisfactorily it may be either of a "double base" or a "single base" propellent type.

One satisfactory grade of "double base" composition is identified as "PL429" and includes nearly 79% of nitrocellulose, about 20% nitroglycerin, about 1% diphenylamine, plus small percentages of inorganic salts. That powder's grains may satisfactorily take the form of multi-perforated (single perforated are also useable)

cylinders about 0.5 inch long and about 0.2 inch in diameter and having an average web thickness of about 0.04 inch.

When placed in the quantity stated within the cartridge case **40** this double base powder has a loading density (ratio of powder weight to weight of volume of water sufficient to fill the case when empty) of the relatively high order of about 0.6. After ignition and expansion of the burning powder into the total chamber volume (about 286 cubic inches) the applicable density reduces to the much lower order of about 0.3. This change occurs early in the combustion cycle.

The named "PL429" powder is found to exhibit satisfactory burning characteristics at the relatively moderate pressures employed by recoilless guns of the illustrated 75 mm. type here disclosed. Typically, such pressures for the particular weapon shown may be of the order of 10,000 pounds per square inch or less.

POWDER IGNITING MEANS

For igniting the propellent charge **55** use may be made of any suitable primer such as shown at **56—57** in Fig. 6. The percussion element **56** of this primer may be of a standard type such as is used in artillery ammunition of conventional design. It serves to ignite a larger charge of booster explosive **58** in tube **57** which satisfactorily may take the form of black powder in a quantity of the order of 60 grams. This booster charge is distributed throughout the entire length of the elongated tube **57** and through the represented perforations **59** therein combustion of the charge imparts very quick and effective ignition to the larger amount of propellent powder **55**.

This primer structure **56—57** is carried by the cartridge case head **63** in the central position shown by Fig. 6 where the attachment is rendered mechanically secure by force fitting or other suitable expedient. In this position the percussion element **56** is engageable by a firing pin **66** protrudable through the center of the breech block **33** as shown in each of Figs. 2, 6—7—8—9—10, 17—18. This pin is actuated by firing mechanism later to be described.

CASE POSITIONING MEANS

In the loaded position shown by Figs. 2, 6, and 9 this cartridge case head **63** is positioned centrally with respect to the walls of chamber **31** therearound. Such central positioning is effected by the orifice cone **54** constituting the represented open ring through which the projectile **41** and cartridge case **40** are inserted in loading the weapon. The breech block **33**, moreover, has a mating recess **130** in the front thereof which further receives the cartridge case head **63** during loading, and upon locking of the breech in position (as shown in Figs. 6 and 9) abuts against the case head thereby restraining same against backward movement.

A similar central positioning of the forward end of the cartridge case is effected by protrusion of an extreme front section **64** thereof (see Fig. 6) into the bore of barrel **30**. Just back of this barrel's end the case **40** flares outwardly as shown in Figs. 2 and 6 at the same 10° "wall" angle as does the tapered wall of the weapon's chamber **31**.

The cartridge case is restrained against longitudinal movement in the forward direction by engagement of case head **63**'s rim with the rear inner edge of breech cone **54**. Such restraint assures that the primer **56** will at all times be held

in proper position for effective engagement by the gun's firing pin **66**.

In this position the tapered forward portion of the cartridge case is parallel and immediately adjacent to the tapered portion of the chamber **31**. This assists in supporting the forward portion of the cartridge case in resisting deformation from the force of the powder explosion by permitting a more rapid equalization of case and chamber pressures at the outset of the propellent combustion.

As here shown the ammunition's projectile **41** communicates with the front section **64** of the just described cartridge case and is suitably held therein by a conventional "crimped" connection which permits ready forward release of the projectile upon combustion of the propellent powder.

THE PRE-ENGRAVED PROJECTILE

The represented projectile **41** makes use of a rotating band shown at **68** in Figs. 2 and 6. This band is pre-engraved, in the manner shown by our earlier mentioned co-pending application Serial No. 536,590, to assure more ready passage of the projectile through the barrel **30**'s rifled bore.

For the 75 mm. ammunition here described, the band **68** may satisfactorily be made of brass or other metal (such as gilding) about one half inch wide and the pre-engraving thereof preferably is dimensioned to provide with the barrel's rifling a diametrical clearance of the close order of about 0.005 inch. Clearances of this order assure proper registration with the barrel's rifling; prevent objectionable yaw of the projectile while within the bore and at the instant of leaving the gun; and at the same time permit the desired free passage of the projectile through the rifled bore upon combustion of the propellent charge.

As our co-pending application Serial No. 536,590 more fully brings out, such free passage is exceedingly important for were the projectile to jam, the rearwardly emanating combustion gases then would exert their full forward force upon the weapon itself and bodily propel it forwardly as a rocket. Moreover, such pre-engraving is found to raise the weapon's overall efficiency by lowering the force needed to advance the projectile through the barrel; it makes complete recoil neutralization relatively more easy due to cancellation of relatively small forces from which the typically variable "cutting" component has been eliminated; and the resultant eliminations of engraving pressure behind the projectile and of attendant "swedging" erosion of the bore's lands makes possible reductions in barrel weight and increases in barrel operating life.

INTERNAL CONSTRUCTION OF PROJECTILE

This illustrative projectile **41** has been represented as including an internal recess for carrying a quantity of high explosive charge **70** which may be detonated by suitable means such as a time or other fuze (not shown) installed in the projectile's nose **69** (or base) in well known manner. Optionally, the projectile might also consist of a solid mass of metal and in that event the illustrated recess for high explosive would be dispensed with.

In either case, the axial and transverse moments of inertia and the distance from the nose to the projectile's center of gravity will be so coordinated with the firing velocity and barrel rifling as to assure stability during flight. Yaw observations made and other firing data obtained by us confirm that the 15 pound projectile here

shown at 41 is in fact stable when fired from the illustrated barrel 30 having the represented rifling twist of one turn in 22 calibers.

THE ANNULAR ORIFICE AND RECOIL NEUTRALIZATION

The 75 mm. recoilless firearm illustratively here shown effects recoil neutralization in the unique manner taught by our earlier mentioned co-pending application Serial No. 536,590; that is, the forces of rearward reaction are neutralized by forwardly acting counterforces. In our improved weapon, here shown and described, these counterforces are produced by acceleration of the rearwardly escaping generated powder gases with an accompanying pressure gradient within the chamber and venturi. Therefore, the pressure force rearwardly acting against the obstructions presented by the breech can be counteracted by the forwardly acting pressure forces acting on the small annular forward portion of the chamber 31, the forwardly acting drag forces of the projectile 41 in the rifled barrel 30 and by the forwardly acting force component produced by the pressure of expanding gases in the conical and divergent portions of the earlier indicated annular orifice 48 (see Figs. 2—9—10) between the gun's breech block 33 and the rear wall of chamber 31 wherein this block is secured.

As is most clearly illustrated by Figs. 1, 3—4—5 this annular orifice extends all of the way around that block's central core and is obstructed only by the four radial lugs 49 which engage with the four mating protrusions 50 of chamber 31. All circumferential space between these lugs thus constitutes the named annular orifice 48 which leads from the interior of chamber 31 rearwardly to the exterior of the gun.

Upon ignition of the propellant powder 55 and the resultant discharge of projectile 41 out of barrel 30 there is expelled through the perforations 60 of cartridge case 40 combustion gases which are projected radially against the surrounding chamber wall and thence rearwardly out of the chamber through the annular orifice now being described. By thus acquiring momentum opposite to that of the forwardly moving projectile the explosive gas thus expelled sets up the aforesaid counterforces which tend to neutralize recoil.

In our 75 mm. weapon here shown we supplement this momentum effect by making the gun's annular breech orifice 48 of the represented "nozzle" shape indicated by Figs. 2, 9 and 10. Starting with a relatively narrow radial width at its front or throat, the annular orifice flares inwardly toward the rear with an angle of spread of approximately 20 degrees. Such an angle yields a satisfactory forward force component due to an expansion of the powder gases in passing rearwardly through the orifice as earlier explained.

Acceptable performance is found to be achieved when the nozzle orifice has the relatively short length which Figs. 2, 9 and 10 indicate. This illustrative length gives a rear discharge or "mouth" area of about 12.6 square inches which is over two and one-half times the orifice's front or "throat" area illustratively shown as being of about 4.76 square inches. In the 75 mm. gun represented about 2.50 inches constitute such a length. Dimensions other than that shown may of course be utilized with varying degrees of relative effectiveness.

It will be noted that in our chamber and breech design all of the nozzle or "Venturi" angle is on the inward portions of the annular orifice 48. This serves two useful purposes: (*a*) the major portion of the forwardly acting forces from the expanding combustion gases are exerted on the breech block 33 itself, thereby permitting a lighter construction in the parts 49—50 which lock the block within chamber 31; and (*b*) the resultant inwardly directed Venturi 48 tends to concentrate the firing blast into a smaller area, thereby having a beneficial effect on "flash."

ADJUSTMENT FOR ZERO RECOIL

In our adjustment for complete neutralization of recoil we find that there exists an optimum ratio between the bore area of the gun's barrel 30 and the throat area of the breech orifice 48. The factors which determine the value of this optimum ratio are more completely appraised by our earlier mentioned co-pending application Serial No. 536,590 which indicates that the required bore-to-throat area ratio is dependent primarily upon the amount of expansion obtained in the nozzle 48 and to a lesser extent upon such factors as the relative weights of the powder and projectile.

In our improved firearm of the illustrative 75 mm, design here disclosed this ratio for zero recoil is found to lie within the range of from about 1.40 to about 160. Adjustment of this ratio to the optimum value which during actual firing does in fact produce zero recoil is provided by the earlier mentioned breech orifice cone 54.

ORIFICE ADJUSTING CONE

In addition to supporting the rear of cartridge case 40, as already described, this cone 54 determines the weapon's ratio of bore area to throat area. Such determination results from the cone's definition of the forward interior wall of the weapon's annular orifice shown at 48 by Figs. 2, 9 and 10. As those figures further indicate, the rear interior wall is defined by the breech block 33 when same is secured within the chamber as shown by Figs. 6, 8—9—10.

While occupying such a portion of the total orifice area as is needed to provide the necessary adjustment this cone 54 does not alter the basic nozzle shape thereof and hence it constitutes a particularly efficient means for effecting the required adjustment. The maximum throat area is of course realized when the outside diameter and axial length of cone 54 are relatively small; hence the smallest size of adjusting cone is selected to afford a throat area large enought to meet the maximum requirements.

Applying the figures earlier stated, use of such a minimum diameter cone might give a bore-area to throat-area ratio of the 1.40 lower limit. To change this ratio to its other extreme of the named 1.60 maximum it is merely necessary to install an adjusting cone 54 of sufficiently larger diameter and axial length as to cut down the total throat area by the requisite amount; and to obtain ratios of intermediate values there may be substituted adjusting cones 54 of varying intermediate sizes.

In practice we find it convenient to mark on each cone the particular value of bore-to-throat area ratio which its use in the weapon will give. Thus the smallest cone may be marked 1.40; the next larger 1.42; a further larger size 1.44; and so on in increasing increments to the maximum cone size of 1.60. The illustrative cone shown in Fig. 14 carries the "ratio" marking of 1.48.

The following table lists ratio values for the

entire range stated, together with dimensions "A" and "B" having the significance best shown by Fig. 15.

TABLE

Dimensions of adjusting cone 54

Ratio of Bore Area to Throat Area	Dimension "A"	Dimension "B"
	Inches	*Inches*
1.40	5.745	0.376
1.42	5.758	0.362
1.44	5.770	0.348
1.46	5.780	0.336
1.48	5.790	0.324
1.50	5.800	0.313
1.52	5.809	0.302
1.54	5.819	0.291
1.56	5.828	0.280
1.58	5.837	0.270
1.60	5.846	0.259

From Fig. 15 it will be seen that "A" designates the cone's outside diameter, while "B" designates the radius of the cone's rounded forward portion. This radius merges into the cone's inwardly tapering outer surface illustratively here shown as defining an angle of 20 degrees with respect to the gun's axis. Figs. 9 and 10 show that this 20° angle exactly matches the angle of taper by the outer surface of the breech block **33** immediately behind the cone.

The "ratio" values set forth by the table are, moreover, based on: (*a*) a bore area for barrel **30** of 7.00 square inches; (*b*) an internal diameter of 6.50 inches for the parallel walled rear portion of chamber **31**; (*c*) a width of 1.50 inches for each of the breech block **33**'s locking lugs **49** and the chamber's mating protrusions **50**; and (*d*) an inward taper by the cone **54** and the breech block **33** of 20 degrees with respect to the gun's axis.

Choice of the exact cone size is most effectively determined by trial firings in a pendulum or other gun suspension which is free to swing and thereby indicate the presence, direction and magnitude of recoil should same exist. In the illustrative 75 mm. weapon represented zero recoil is found to call for an adjusting cone which gives a bore-area to throat-area ratio of the order of 1.48. With such adjustment the nozzle throat has a total area of the order of 4.76 square inches. This is approximately one tenth of the cartridge case's earlier stated "perforation" area of about 48 square inches.

SECURING CONE IN CHAMBER

In securing the selected adjusting cone **54** in the chamber position shown by Figs. 3, 6 and 8, we find it highly satisfactory to utilize four screws of the type shown at **71** in each of Figs. 4, 6 and 8. Such screws extend into the four openings indicated at **72** in Figs. 14—15 and thereby hold the cone's tapered outer surface in firm abutment with similarly tapered extensions of chamber **31**'s four breech locking protrusions **50**. Details of this attachment are best shown by Figs. 4, 6 and 8. The screws **71** are of the headless variety having countersunk depressions engageable by a mating wrench (not shown) for transmission thereto of appropriate turning torque.

To interchange cones it is only necessary to remove all four of these screws **71**, tilt the thus freed cone **54** in a way permitting extracting withdrawal from the chamber **31**'s open end as shown in Fig. 4, reinsert the replacement cone **54** in position within the chamber and there secure it by putting screws **71** back in place.

NEUTRALIZATION OF ROTATIONAL REACTION

As pointed out by our co-pending application Serial No. 536,590, firearms with 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 **30**'s right-hand twist gives clockwise rotation (as viewed from the rear) to projectile **41** 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.

Our 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 **48** 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 chamber protrusions **50** that the gases passing through orifice **48** have angular momentum imparted thereto.

Each of these chamber protrusions **50** has side walls that are slightly out of parallel with the gun's axis. As Figs. 3—4—5 clearly show, this side wall arrangement is such that the powder gases flowing rearwardly through the orifice **48** 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 **31** a torque counteracting that applied by the projectile. Only the relatively small degree of angular twist shown is found sufficient to make the thus imparted torque of the same magnitude as the barrel **30** imparts to the projectile **41** in advancing it through the rifled bore.

All neutralizing torque thus set up by the escaping gases is exerted on the sides of the locking surfaces in the venturi **48** and through chamber **31** is transmitted to the barrel **30**, and in this way the forces of rotational reaction are neutralized in a very simple yet highly effective manner.

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 chamber protrusions **50** in the opposite sense.

BREECH BLOCK'S WITHDRAWAL FROM CHAMBER

Explanation has already been given of how the breech block **33** is secured in the rear of chamber **31** by the aid of that block's locking lugs **49** and the mating protrusions **50** on the chamber interior. In the "engaged" position represented by Figs. 1, 5—6, 8 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 propellent charge **55** sets up.

To facilitate loading and removal of the cartridge case **40** after firing, provision is made for releasing this breech block **33** from its chamber attachment, rearwardly withdrawing it from the chamber **31** and swinging it out of alignment with the chamber interior to the downward position shown by Figs. 4 and 7. The earlier mentioned breech bar **34** to which the forwardly extending

handles 35—36 are affixed comes into play during these actions.

Then also utilized is a hinge support fixture 75 having its upper end connected with breech block 33's center and its lower end connected through a hinge pin 80 and an attachment block 76 to chamber 31's lower side wall. Through these elements the breech block 33 continues to receive support from the gun after it has been withdrawn from the chamber.

The earlier mentioned breech bar 34 is secured to the breech block 33 by means of four bolts shown at 77 in Figs. 3 and 5. Intermediate this bar and the main body of the block is an offset ring-like extension 79 of the hinge fixture 75. Around this ring extension both the breech block 33 and the bar 34 may be turned between the "horizontal bar" position of Figs. 1 and 5 and the "inclined bar" position of Figs. 3—4. In the gun here shown the range of this angular movement is of the order of 45 degrees, as contrast of Figs. 3 and 5 will indicate.

Counterclockwise rotation of the weapon's breech bar 34 serves to engage the breech locking lugs 49 into the mating threads of chamber protrusions 50 and thereby secures the breech block 33 within the chamber 31 as earlier explained; clockwise rotation moves the locking lugs out of engagement with the chamber protrusions and into the circumferential regions between protrusions. In the latter position, the breech block 33 is free for rearward withdrawal from the chamber.

Appropriate limits of such angular travel are established by those portions of the hinge support 75 which respectively engage the lower sides of breech bar 34 as shown in Fig. 5 and in Fig. 3. The former figure shows the bar and breech block 33 at the limit of counterclockwise rotation wherein the breech block is securely locked within chamber 31; the latter figure shows the bar and block at the clockwise limit of rotational travel in which the block has been freed for withdrawal from the chamber.

Serving to support the breech block upon such withdrawal is the earlier mentioned hinge fixture 75 secured at its lower end to chamber wall 31 as already described. Once disengaged from chamber 31 as shown in Fig. 3, the breech block 33 plus bar 34 and handles 35—36 are free for rearward withdrawal and downward swinging around hinge pin 80 to the position represented by Figs. 4 and 7.

When the breech block 33 is so withdrawn from chamber 31, the entire interior area of that chamber is unobstructed in a way permitting ready insertion of a projectile 41 and cartridge case 40 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 block upwardly from the position shown in Fig. 4; move it forwardly into the chamber's open end as indicated by Fig. 3; and finally give handles 35—36 and bar 34 a turning movement which brings the block to its counterclockwise limit of rotation in which the locking lugs 49 thereof engage the chamber's mating protrusions 50 as shown in Fig. 5.

THE "OPEN" BREECH LOCK

Our improved weapon here illustrated utilizes two locking devices by which the breech block 33 is respectively secured in the "inclined bar" position of Figs. 3 and 4 and in the "horizontal bar" position of Figs. 1 and 5. The first of these devices will be spoken of as the "open" breech lock and the second as the "closed" breech lock.

Purpose of the "open" breech lock is to keep the breech block 33 and its attached bar 34 in the inclined position of Figs. 3—4 at all times except when the block is fully inserted into the gun's chamber 31. This lock thus serves to hold the bar 34 and the breech block 33 in the inclined position of Fig. 3 as long as the breech block remains withdrawn from the chamber, as in Fig. 4.

The mechanism utilized includes a locking bar 82 having the general shape which Fig. 12 shows; a slot 83 cut into the forward face of hinge fixture 75 as shown in Fig. 16 for accommodating bar 82 as shown in Figs. 6 and 7; a slot 84 cut into the rear face of breech block 33 as shown by Fig. 5 for at times receiving a portion of bar 82 as shown in Fig. 7; and a leaf spring 85 beneath the bar 82 in hinge slot 83 as shown in Figs. 6—7 which urges that bar towards the breech block.

As long as the breech block 33 is fully inserted into the chamber 31, the bar 82 is held completely within the hinge slot 83 (see Fig. 16) by contact of the forward face of the bar with the rear face of the chamber's lower protrusion 50 (see Fig. 4). This condition is shown by Fig. 6. Under it the bar 82 is completely withdrawn from engagement with the breech block slot 84 (see Fig. 5) and no rotative restraint is imparted thereby to the breech block. In so far as bar 82 is concerned, the breech block 33 may now be rotated throughout its complete range of travel.

Once, however, the breech block 33 is withdrawn from chamber 31, leaf spring 85 then pushes bar 82 into the breech block slot 84 as soon as that slot is brought into alignment with the bar. From Figs. 3 and 4 it will be seen that such alignment is effected when the breech block is rotated to the fully unlatched position which Fig. 3 shows. In that position the bar moves forwardly into the breech block slot as indicated by Fig. 7.

Such movement locks the breech block 33 against rotational movement with respect to hinge mounting 75, in the forward slot 83 (see Fig. 16) of which the bar 82 is carried. Such locking action continues as long as the breech is withdrawn from the chamber. It prevents, for example, the handles 35—36 and the breech bar 34 from being moved out of the inclined position which Figs. 3—4, and 7 represent. Such prevention is made especially desirable by certain operating characteristics of our unique firing mechanism later to be described.

Upon reinsertion of breech block 33 into the chamber 31, locking bar 82 is once again pressed completely into its hinge slot 83 (see Fig. 16) as shown in Fig. 6 by contact of its forward face with the rearward face of the chamber's lower protrusion 50. This breaks the lock between breech block 33 and hinge mounting 75 and allows the block to be turned by handles 35—36 and bar 34 from the disengaged position of Fig. 3 to the chamber-engaged position of Fig. 5.

THE "CLOSED" BREECH LOCK

The "closed" breech lock earlier mentioned now becomes effective to hold the breech block 33 in this horizontal bar position of Fig. 5 until after the weapon's firing pin 66 moves forward. Mechanism utilized includes a "closed" locking pin and bar combination 88—89 shaped as shown in Fig. 13 and assembled with the breech block 33 and breech bar 34 as shown by Fig. 8; a slot 90 cut into the right side of hinge ring 79 as shown in Figs. 8 and 11 to be engaged by locking bar 89 as indicated by Figs. 5 and 8; a spring 91 which

urges the rear of bar 89 into hinge slot 90 as indicated by Fig. 8; and a firing mechanism hammer 92 having on its side wall a groove 106 (Figs. 18—19) whose bottom is tapered so as conveniently to engage an end of bar 89 in the manner also shown by Fig. 8.

This hammer 92 is carried within a hollow case 93 which is integral with and extends back from the breech bar 34 in the manner indicated by Figs. 1 through 10 and 17. As will later be explained, this hammer is moved rearwardly to the "cocked" position shown by Figs. 6—7—8—9 upon each unlatching rotation of breech bar 34; and it is released for forward advancement to the "fired" position shown by Figs. 10 and 17 upon each depression of the gun's trigger 94 in handle 35.

As long as hammer 92 is cocked, the taper of groove 106 in the side wall thereof indicated by Fig. 8 allows spring 91 to force locking bar 89 inwardly into engagement with hinge ring slot 90 (see Figs. 8 and 11) and thereby restrain the breech block and its bar 34 from rotative movement with respect to the hinge. This assures that the breech bar must remain in its chamber-engaged position of Fig. 5 unless either the hammer 92 moves forwardly to the position of Fig. 9 or unless locking pin 88 (see Fig. 5) is manually moved to the right against spring 91 (see Fig. 8).

Upon release of hammer 92 to its forward or fired position of Fig. 10 the slow taper of groove 106 in that hammer's side wall wedges bar 89 outwardly against spring 91 and thereby moves that locking bar out of the hinge ring's slot 90 (see Fig. 11). This wedging action imposes such small restraint upon forward movement of the hammer that it in no way interferes with the desired operation of our weapon's firing mechanism.

Each firing of the weapon therefore automatically unlatches the breech block's "closed" locking bar 89 and frees the breech block 33 for clockwise rotation and subsequent withdrawal from chamber 31. This result occurs whether ammunition is or is not present in the weapon.

A similar release of the "closed" breech lock may be effected manually as earlier mentioned. Such manual actuation requires only that the locking pin shown at 88 in Figs. 3 and 5 be pushed to the right against spring 91 of Fig. 8. Such pushing releases the breech block for clockwise rotation and withdrawal out of the chamber even though the weapon's hammer 92 may be cocked as indicated by Figs. 6—7—8—9.

THE FIRING MECHANISM

For igniting the ammunition's propellent charge 55 at the will of an operator use may be made of any suitable firing mechanism. Here represented by way of illustration is a unique mechanical type of firing mechanism by the aid of which an operator may fire the weapon by a simple depressing of the earlier mentioned trigger 94 carried by handle 35.

In the disclosed arrangement the firing pin 66 carried by the gun's breech block 33 receives through direct attachment with the earlier mentioned hammer 92 a firing blow created by the forward movement of that hammer. The force incident to that forward movement originates in a compression spring 97 carried between the hammer 92 and case 93 as most clearly shown in Fig. 17. This force is made available for firing the gun when a sear shown at 98 in Fig. 8 is withdrawn from in front of the hammer.

The illustrated hammer 92 takes the form of a metal cylinder having the general appearance best indicated by Fig. 18. The firing pin 66 is screwed into the front of this cylinder and thus at all times moves in unison therewith. This movement is between the "cocked" position of Figs. 6—7—8—9 and the "fired" position of Figs. 10 and 17.

COCKING OF THE HAMMER

As earlier stated, cocking of the hammer from the forward position of Figs. 10 and 17 to the rearward position of the earlier named figures is effected by rotation of the breech block 33 and its bar 34 from the "horizontal bar" position of Fig. 5 to the "inclined bar" position of Fig. 3. Such rotation is translated into rearward movement of the hammer by means of two pairs of rollers shown at 100 and at 101 in each of Figs. 10, 16—17, 19—20—21—22—23.

Rollers 100 are carried by the hinge ring 79 (see Figs. 10, 16—17), while rollers 101 are carried by the breech bar 34. Both sets of the named rollers engage with longitudinal slots 103 in the outer surface of hammer 92. The forward portion of each of these slots is tapered as shown at 104 in Figs. 17—18—19—20, 22—23.

With the breech bar 34 in the horizontal position of Fig. 5 both sets of these rollers 100—101 lie along line 10—10 of Fig. 5, and sections therethrough appear as shown in Figs. 10 and 17. The hammer 92 is shown by Figs. 10 and 17 and 22 in its forward or fired position wherein firing pin 66 has by the hammer and compression spring 97 been moved to its forward limit of travel.

Upon rotation of the breech bar 34 from the horizontal position of Fig. 5 to the inclined bar position of Fig. 3 the forward or hinge rollers 100 remain stationary, while the rearward or bar rollers 101 rotate the hammer clockwise as viewed from the rear, from the position shown in Fig. 20 to that indicated by Fig. 21, an angular rotation of approximately 26.5 degrees. Fig. 20 will be seen to correspond to Fig. 19, except that Fig. 19 shows the hammer and its rollers as viewed from the front or right of Fig. 17.

The named rotative movement brings the tapered sides 104 of the hammer slots 103 against stationary rollers 100, and by a camming action best apparent from Figs. 18 and 22 forces the hammer 92 backward against compression spring 97 and into the cocked position shown by Figs. 21 and 23 as well as by Figs. 6—7—8—9. When the cocked position has been reached the sear shown at 98 in Fig. 8 is by spring action later to be described forced inwardly ahead of the rear face of a restraining slot shown at 140 in Figs. 8, 19, 22 and 23.

RELEASE OF THE HAMMER

In this position the sear 98 holds the hammer cocked until such time as trigger 94 may be depressed. Upon such depression of the trigger the sear is withdrawn from its engagement with the restraining slot 140, and hammer 92 plus firing pin 66 are allowed to move forward due to the expansive force of spring 97. This forward movement brings firing pin 66 against the ammunition's primer 56 (see Figs. 6 and 9) and thereby fires the weapon.

The named forward movement can, of course, take place only after the breech bar 34 has been returned to the horizontal position of Fig. 5. In that horizontal position bar rollers 101 are again realigned with hinge rollers 100 as shown in Figs. 10, 17, 19—20, 22. This realignment frees the

hammer for unrestrained forward movement as soon as sear 98 is withdrawn from the front of the latching slot 140 therein.

In the illustrative construction shown hammer 92 is fitted relatively close to the inner walls of hammer housing 93. In order that "air pumping" action resulting from the closeness of this fit will not restain longitudinal movement of the hammer with respect to the casing, there is provided in the hammer's sides a second pair of longitudinal slots indicated at 107 in Figs. 18—19—20—21, 23. These slots allow free passage of air into the space behind the hammer upon forward or firing movement thereof, and from that rearward space upon backward or cocking movement thereof.

COMPLETE HAMMER OPERATION

The just described hammer mechanism will thus be seen to operate as follows. Following each firing of the weapon the firing pin 66 and hammer 92 occupy their forward positions as shown by Figs. 10 and 17 while the breech block 33 is still locked in chamber 31 with the bar 34 horizontal as shown in Figs. 1 and 5.

Rotation of the breech bar 34 to the inclined position shown in Fig. 3 causes the bar rollers 101 to rotate the hammer 92 clockwise as viewed from the rear, and this action in turn causes hinge rollers 100 to cam the hammer 92 backwardly against compression spring 97 as already explained by reference to Figs. 17 through 23. The so-cocked hammer now occupies the position shown by Figs. 6—7—8—9 and 23. Retention in that position is effected by sear 98 blocking forward movement of the hammer as shown by Fig. 8.

This blocking continues during subsequent withdrawal of the breech block 33 from the chamber to the position shown by Figs. 4 and 7. It also remains effective during reinsertion of the breech block into the chamber and engagement therewith by restoration of breech bar 34 to the horizontal position of Fig. 4. Such restoration re-aligns rollers 100—101 from the condition shown by Fig. 21 to that indicated by Fig. 20.

This re-alignment conditions the hammer for subsequent forward movement upon withdrawal of the restraining sear 98. Upon such withdrawal spring 97 forces the hammer and its firing pin 66 rapidly forward into contact with the cartridge case's primer 56 and thereby detonates the primer and fires the weapon.

By this action the firing mechanism is returned to the original "after firing" condition with which this description started.

THE TRIGGER AND SAFETY MECHANISMS

Cooperating with the hammer 92 and its just described cocking mechanism are trigger and safety mechanisms which will now be explained. These utilize the earlier mentioned sear shown at 98 in Fig. 8; the earlier mentioned trigger shown at 94 in the same figure as protruding from the forward end of trigger handle 35; and a rotatable safety button 109 carried in the hollow end of that handle as also shown by Fig. 8.

The sear 98 takes the form of a round rod slidably housed in the left half of breech bar 34 between the rear wall of that bar and a front cover plate 108 and having an outer end which is inclined as shown by Fig. 8 into a mating opening in the inner end of the plunger-like trigger 94. This trigger is axially moveable within handle 35 and safety fixture 109 but is by a key 111 prevented from rotational movement with respect thereto. By a "double" action of a trigger spring 110 this trigger 94, when not compressed into firing position, is urged towards its outward limit of travel. This travel limit normally would be the safety button's opposed lower or inner projections 114; however, the intervening agency of the spring 110, being connected to the safety button below the projections 114 and also connected to trigger 94, limits such travel to the distance over which spring 110 may be compressed against projections 114. Such urging holds sear 98 against hammer 92 as shown by Fig. 8.

Reference to Fig. 25 shows that spring 110 not only exerts tension between parts 94 and 109 but that it also is arranged to impart turning effort on safety button 109 with respect to trigger 109, as will be more fully explained below. Incident to this turning effort use is made of the key 111 which passes through an opening in the trigger 94 and by engagement with longitudinal slots 112 inside the trigger handle 35 (see Fig. 24) prevents rotation of the trigger within that handle while at the same time permitting axial trigger movement with respect to the handle.

Safety button 109 is provided with side slots through which the ends of trigger key 111 protrude as shown by Fig. 25. The trigger spring 110 encircles the trigger rod 94 as that figure also shows. The two ends of this spring respectively are attached: (*a*) to an enlarged portion of that rod shown in Figs. 8 and 25 at the sear-engaging end thereof; and (*b*) to the inner end of the safety fixture 109 (again see Fig. 25).

During assembly of the parts shown in Fig. 25 this spring is so wound onto its two end attachments that upon insertion of the trigger key 111 through the safety slots and the trigger, the safety button 109 has exerted thereon a torque tending to rotate it clockwise with respect to the trigger. (In this and later references to rotative direction with respect to the trigger, the directions should be considered as they would appear when viewed from the trigger's outer end—i. e. where it protrudes from handle 35—toward the trigger's opposite or inner end.) This rotative urge positions the safety slots as shown in Fig. 25 and thereby safeguards the trigger 94 against accidental depression into the gun's handle 35.

To insert the safety mechanism of Fig. 25 into the trigger handle 35 the trigger 94 in relation to the safety 109 is depressed and rotated to its fullest extent so as to align key 111 with the projections 114. Following insertion of the parts of Fig. 25 into the trigger handle 35 the trigger's safety button's opposed lower projections 114 (see Figs. 24 and 25) fit into an annular groove 115 that extends completely around the trigger handle's interior as indicated by Figs. 8 and 24. Such fitting holds the assembly of Fig. 25 in place within the trigger handle. Under this condition the safety fixture 109 is free only for rotation with respect to that handle 35 while the trigger rod 94 is free only for axial movement through the handle and fixture.

CONDITIONING THE SAFETY FOR FIRING

It has now been seen that trigger spring 110 urges the sear-end of trigger 94 outwardly toward the safety 109 and at the same time urges button 109 clockwise (see Figs. 4 and 25) with respect to the trigger and pin 111 extending therethrough. These two actions respectively hold the sear 98 against the gun's hammer 92 and main-

tain the side slots of safety 109 in the position of Fig. 25 to restrain inward movement of the trigger.

The rotational force on the safety button 109 at all times assists the tension force of the trigger spring 110 in forcing the sear 98 inwardly towards the hammer 92. This is accomplished by the cam surfaces of the side slots in the safety button 109 (see Fig. 25) engaging with the trigger key 111. This essentially has the effect of retaining the sear in position by a wedge-like action to make its operation more positive.

In order to condition the weapon for firing it is only necessary to turn the safety button 109 counterclockwise as viewed in Fig. 25 through an angle of about 45°. Such turning removes the slot side walls of fixture 109 from the path of inward travel by trigger key 111. Depressing force now applied to trigger 94 results in inward movement thereof which pulls the sear 98 of Fig. 8 outwardly away from hammer 92 and thereby releases same for forward firing movement under the action of compression spring 97.

Such firing of the weapon, moreover, is possible only when safety 109 is held in the counterclockwise turned position against the clockwise restoring torque of spring 110. Under this condition the trigger 94 may be depressed as just described. Under all other conditions spring 110 holds safety 109 in the position of Fig. 25 wherein depression of the trigger and firing of the weapon are effectively prevented.

LOADING AND FIRING

From the foregoing it will be seen that we have provided an improved recoilless firearm which offers important advantages in connection with both loading and firing. To place the ammunition round within the weapon it is merely necessary to unlock the breech block 33, withdraw it from the chamber 31 and swing it downwardly to the position shown by Figs. 4 and 7 thus completely freeing the chamber opening.

The ammunition round 40—41 is now inserted into the opened chamber and the rear of the barrel's bore. As the projectile enters the barrel the lands on the pre-engraved band 68 are brought into alignment with the grooves of the barrel bore and forward thrust is then continued until the rim of the cartridge case head 63 abuts with the breech cone 54. In this position the forward end of the cartridge case is centered by the barrel and the case head 63 is similarly centered within the chamber 31 by the breech cone 54 thereabout.

The breech block 33 (together with bar 34 and handles 35—36) is now moved upwardly and forwardly into the chamber. In approaching and engaging with the cartridge case head 63 the flared recess 130 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 34 and handles 35—36 now locks that block into the chamber with the case head's rim in abutment with the breech cone 54 and the case head in abutment with the breech block, the primer 56 in alignment with the firing pin 66 and the entire cartridge case 40 centrally positioned within the surrounding chamber 31.

The hammer 92 now has the "cocked" condition shown by Figs. 6 and 8 and the weapon is accordingly ready for firing. Upon the earlier explained rotation of safety button 109 a backward pressure on handle 35's trigger 94 will release the hammer and firing pin 66 to cause detonation of percussion element 56 and ignition of primer and propellent charges 58 and 55.

The resultant combustion of propellent 55 discharges the projectile 41 and at the same time ruptures the perforated cartridge case's frangible lining 51 and produces radial expulsion of the explosive gases into the chamber 31. This expulsion starts early in the burning cycle and is accompanied by continued combustion of the powder.

The resultant pressure within the chamber produces escape of the explosive gases through the annular breech orifice 48 and thence to the rear of the weapon. As already explained in part, this escape of explosive gases sets up counter forces which completely neutralize recoil and thus permit the weapon to be fired from a light tripod as shown at 29 in Fig. 1 or other suitable support.

The perforated wall metal of cartridge case 40 remains intact during this firing and is not ruptured or otherwise damaged. Since expulsion of explosive gas from all of the case perforations 60 is simultaneous, the represented tapered design of chamber 31 is in practical use found to be fully effective for diversion of the gases to the rear. The flow from the forward portion of the case adds to that from openings farther back and thus builds up in a manner appearing generally to approximate the increasing area within the chamber as the case's rear is approached.

Subsequent withdrawal of the fired cartridge case from the chamber is preceded by first unlocking the breech block and then withdrawing that block rearwardly and downwardly out of register with the chamber and into the position on hinge support 75 which Fig. 4 shows. Extraction of the fired case now becomes possible.

EXTRACTION OF FIRED CASES

For facilitating such extraction we supplement our hinge-mounted breech block 33 by an extractor represented at 117 in each of Figs. 4, 7 and 9. This extractor takes the form of a right-angle piece of metal protruding as shown from the lower face of the breech block 33. The position of this protrusion is such that the extractor hooks under the rim of the cartridge case head 63 in the manner shown by Fig. 9 when the breech block is positioned within the chamber.

The interior portion of this extractor fits into a recess in the breech block metal and is there held by a retainer bar 118 fastened over the recess by screws indicated at 119 in Fig. 4. A compression spring 120 urges the extractor's lip inwardly toward the center of the breech block as shown in Fig. 7.

Upon insertion of the breech block into the chamber after the ammunition's cartridge case 40 has been placed therein, the exposed end of extractor 117 first contacts the case head and is by it pushed inwardly and at the same time outwardly beyond the edge of the case head's rim. Continued advancement of the breech block into abutment with the case head forces the extractor's hooked end into the position shown by Fig. 9. Under this condition the extractor hook is ahead of the case rim and is urged inwardly thereagainst by compression spring 120.

After firing of the weapon unlocking of the breech block 33 and subsequent withdrawal thereof from the chamber to the position shown in Fig. 7 causes the extractor 117 to pull the fired case from the chamber to a position where the head thereof substantially protrudes from the cham-

ber's open end. The limit of this withdrawing movement is determined by the point at which the extractor hook 116 is brought below the level of the case rim in turning with the breech block 33 around the hinge pin 88 (see Figs. 6—7).

In this position the case can readily be grasped by the user and withdrawn from the weapon thereby conditioning same for insertion and subsequent firing of another ammunition round.

OTHER MECHANICAL DETAILS

For facilitating assembly and disassembly of the various parts and mechanisms of our 75 mm. recoilless weapon we have provided for carriage within the weapon's breech handle 36 of special wrenches (not here shown) by the aid of which all removable parts of the weapon may be dismantled for cleaning, adjustment or replacement.

The wrenches mentioned may be of any suitable type useable to: (*a*) turn the screws 71 by which the orifice adjusting cone 54 is held within chamber 31; (*b*) turn the screws 77 by which the breech bar 34 is secured to the breech block 33; (*c*) turn the screws 119 by which the retainer 118 is held in place over the cartridge case extractor 117; and (*d*) perform other incidental functions.

These tools may be of such relatively small size as to be accommodated within the hollow interior 123 (see Fig. 8) of handle 36. For permitting access thereto this handle is provided with a removable head 122 which screws into the handle's threaded open end as shown in Fig. 8.

Carriage of the wrenches in this manner in no way interferes with the intended functioning of the firearm and allows these highly useful tools conveniently to be kept with the weapon for immediate availability at all times.

PERFORMANCE DATA

The firing of thousands of rounds of ammunition has confirmed beyond all doubt the successful and practical character of the improved recoilless firearm here disclosed. With the represented projectile 41 weighing 15 pounds, muzzle velocities of 1000 feet per second are consistently attained by use of propellant charges of the earlier described 3 pounds of "PL429" double-base powder or equivalent (single or double-base).

Complete neutralization of recoil is uniformly achieved, and when firing the weapon from a tripod or other convenient support users report a complete absence of weapon motion backward, rotative, sidewise, or forward.

Accuracies of a high order also are achieved. At 300 yards it is possible to hit a one-foot bull's eye with remarkable consistence; at 600 yards the shot pattern is well-defined by a three-foot circle; and at 1000 yards hits can be scored on a six-foot target. Accuracies of comparable order are realized at even greater ranges.

The relatively light weight and small dimensions of the weapon at once make it possible for infantry use, and place in the hands of individual soldiers an effective defense and offense against enemy tanks and other military objectives.

BALLISTIC DESIGN

Design of the 75 mm. recoilless firearm here shown is based upon principles of analysis and calculation more fully disclosed by our earlier mentioned co-pending application Serial No. 536,590. In view of the complete explanation presented by that earlier application no attempt at repetition will here be made.

It will suffice to say that the design formula, analytical procedure, dimension calculations and optimum design selection are made in a manner closely similar to that which our co-pending application fully sets forth. That is to say, the projectile mass, muzzle velocity, caliber, barrel length and gun weight requirements are first specified. Then there is: (*a*) chosen for the firearm a breech nozzle of size and expansion ratio calculated to effect recoil balance; (*b*) selected a propellent powder with composition, burninng constant and web thickness calculated to complete combustion about simultaneously with the projectile's leaving of the barrel; (*c*) assumed a series of flow factor values and calculated for each the powder charge, chamber volume, barrel length, internal pressure and gun weight; and (*d*) selected for the firearm the flow factor whose calculated design values most closely match the specified requirements to be met.

The design thus calculated is experimentally verified by exhaustive proof firings and such modifications as will improve the weapon's performance are then made. The resulting recoilless firearm is thoroughly practical and gives a firepower per unit weight which is far in excess of the best heretofore attainable.

SUMMARY

The earlier described qualities of superior recoilless gun performance are the direct result of our here disclosed improvements in the design and construction of open-breech firearms. The individual features of such improvements are numerous and in the complete weapon these features effect the named results through cooperations and interactions which are both unique and novel.

From the foregoing it will thus be seen that we have improved the design and extended the usefulness of recoilless guns which incorporate principles of construction and operation first disclosed and claimed by our co-pending application Serial No. 536,590 filed May 20, 1944, for "Recoilless firearms, ammunition therefore and ballistic design thereof"; that we have provided for such "open breech" recoilless guns unique weapon designs and constructions which are peculiarly adapted to firearms of 75 mm. and other high calibers; that we have provided improved chamber and breech constructions for recoilless guns which utilize the "annular orifice" and the "perforated cartridge case" principles of our earlier applications just mentioned; that we have facilitated adjustment of breech orifice area and the securing of zero recoil at a desired performance level; that we have increased the simplicity, ruggedness and compactness of breech actions and of firing and safety mechanisms for recoilless firearm use; and that we have made possible the practical construction and successful use of large caliber recoilless firearms which are capable of shooting projectiles carrying heavy quantities of explosive through long distances and yet which are so relatively light in weight and so compact in size as to be readily portable.

Our inventive improvements thus are capable of wide application and hence are not to be restricted to the specific form here shown and described by way of illustration.

We claim:

1. In a recoilless firearm, the combination of a barrel, a chamber extending rearwardly from said barrel and having walls which taper outwardly through at least half the chamber's length 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 positioned in the rear bore of said barrel and a cartridge case positioned within said chamber communicating with said projectile and containing propellent powder, 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 enlarged rear portion and being perforated by a relatively large number of openings distributed circumferentially and lengthwise thereof and through which powder combustion gases may expand radially into said tapered chamber thereabout, a breech block secured in the rear of said chamber and there providing an orifice which leads from the chamber's interior to the rear exterior thereof and which permits escape of powder gases in proper quantity and at proper rate to neutralize recoil, and means including said breech block for supporting said perforated cartridge case against rearward movement and in spaced relation to the surrounding walls of said tapered chamber.

2. In a recoilless firearm, the combination of a barrel, a chamber extending rearwardly from said barrel and having walls which taper outwardly through at least half the chamber's length 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 positioned in the rear of said barrel and a cartridge case positioned containing propellent 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 chambers's forward end but substantially less than that chamber's enlarged rear portion and being perforated by a relatively large number of openings distributed throughout the circumeference and length thereof, means including a breech block in the rear of said chamber for supporting said cartridge case against rearward movement and in spaced relation to the said chamber walls thereabout and for also providing a substantially annular orifice which leads from the chamber's interior to the rear exterior thereof, and means for igniting said powder whereby to form powder combustion gases that cause the discharge of said projectile forwardly out of said barrel and that at the same time cause neutralization of the forces of recoil by expulsion of said gases through said case wall openings radially into said tapered chamber and thence rearwardly out of said orifice.

3. In a non-recoil gun, the combination of a barrel, a chamber extending rearwardly from said barrel and having walls which taper outwardly through at least half the chamber's length 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 positioned in the rear bore of said barrel and a cartridge case positioned within said chamber communicating with said projectile and containing propellent powder, wall metal 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 enlarged rear portion and being perforated by a relatively large number of openings distributed throughout

the circumference and length thereof, a layer of frangible material separating said powder from and preventing its passage through the case wall perforations prior to firing but yielding to the gas pressure of powder combustion, a breech block secured in the rear of said chamber and there providing an orifice which leads from the chamber's interior to the rear exterior thereof and which permits escape of powder gases in proper quantity and a proper rate to neutralize recoil, and means including said breech block for supporting said cartridge case against rearward movement and in spaced relation to the surrounding walls of said tapered chamber.

4. In a non-recoil gun, the combination of a barrel, a chamber extending rearwardly from said barrel and having walls which taper outwardly through at least half the chamber's length 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 positioned in the rear bore of said barrel and a cylindrical cartridge case of perforated wall metal communicating with said projectile and having a diameter approximately the same as said surrounding chamber's forward end but substantially less than that chamber's enlarged rear portion, propellent powder within said perforated cartridge case, a breech block secured in the rear of said chamber in radially spaced relation to the enlarged diameter chamber wall therearound and there forming with that wall a substantially annular orifice which leads from the chamber's interior to the rear exterior thereof and which rearwardly diverges inwardly towards the gun's axis whereby to converge around that axis powder gases from said cartridge case expelled through the orifice, and means including said breech block for supporting said cartridge case against rearward movement and in spaced relation to the surrounding walls of said tapered chamber.

5. In an open-breech recoilless firearm, the combination of a barrel, a chamber extending rearwardly from said barrel and having walls which taper outwardly through at least half the chamber's length 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 positioned in the rear bore of said barrel and a perforated cartridge case within said chamber extending at its front into the rear bore of said barrel for communication with said projectile and having a body diameter larger than that of said bore but substantially less than that of said chamber's enlarged rear portion, means in the rear of said chamber for supporting said cartridge case against both rearward and forward movement and spacedly positioned with respect to the surrounding chamber walls so as to provide a connecting passageway between the space around the case and the chamber's rear exterior, and tapered walls at the front of said cartridge case's body which are angularly mated with the tapered walls of said forward chamber portion immediately thereahead and which by the aforesaid cartridge case supporting means are spacedly positioned a relatively short distance from those forward chamber walls.

6. In an open-breech recoilless firearm, the combination of a barrel, a chamber communicating with said barrel and having a rear diameter substantially larger than that of said barrel's bore, an ammunition round comprising a pro-

jectile positioned within the rear of said barrel and a perforated cartridge case within said chamber extending at its front into the rear bore of said barrel for communication with said projectile and having a body diameter substantially less than that of said chamber's enlarged rear portion, a rim extending radially from the rear portion of said cartridge case, a ring fixed within the chamber's rear portion and encircling 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 surrounding rear chamber walls, and a breech block movable into and out of the portion of said chamber that is behind said ring and having a forward face which abuts the rear portion of said cartridge case and thereby restrains same against rearward movement, said breech block further providing a connecting passageway between the space around said cartridge case and the chamber's rear exterior.

7. 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 bore and a cylindrical cartridge case of perforated wall metal situated within the chamber and 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 fixed within said chamber's rear portion in spaced relation to the chamber walls therearound and encircling 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 chamber's rear portion immediately behind said cartridge case rim and said ring and also in radially spaced relation to the chamber walls therearound whereby to restrain the cartridge case against rearward movement and to form with the chamber walls a substantially annular orifice leading from the chamber's interior past said ring and to the rear exterior of the chamber.

8. 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, a perforated cartridge case within said chamber having a cross sectional area substantially less than that of said chamber's rear portion and being supported at its front by said barrel, a ring fixed within the chamber's rear portion in encircling relation to said cartridge case whereby to support same against lateral movement and being radially spaced from the surrounding chamber wall whereby to form with that wall a substantially annular orifice which leads from the chamber interior to the rear exterior thereof, and a breech block secured in said chamber behind said ring likewise in spaced relation to the aforesaid chamber wall whereby to support said cartridge case against rearward movement while at the same time containing said annular orifice without obstruction.

9. In a recoilless firearm, the combination of a barrel having a bore rifled with twist in a given direction, a chamber secured to the rear of said barrel, a projectile inserted into said barrel's rear bore, a propellent charge supported within said chamber in spaced relation to the walls thereof for generating combustion gases by which said projectile is pushed forwardly through said barrel and rotated in said given direction by said bore's rifling, a breech block in the rearward portion of said chamber having its periphery cut away at spaced portions circumferentially of the block to provide a substantially annular orifice interrupted by lugs that extend substantially radially from the block's central portion, mating protrusions extending inwardly from said chamber's rear interior into engagement with said breech blocks lugs and serving to secure said block within the chamber, and side walls for said chamber protrusions and said breech block lugs so inclined axially as to receive from said combustion gases which pass rearwardly through said annular orifice given direction rotative forces substantially equal to the forces of twist which said projectile receives from said rifled barrel.

10. In a non-recoil gun, the combination of a barrel, a chamber communicating with said barrel, a breech block movable into and out of the rearward portion of said chamber and having its periphery cut away at spaced portions circumferentially of the block to provide a substantially annular orifice interrupted by locking lugs that extend substantially radially from the central portion of t he block, coacting protrusions from the chamber's inner wall engageable by said locking lugs to secure said block within the chamber, and an orifice area adjusting ring fixed within said chamber immediately ahead of and concentrically with respect to said breech block and having an external diameter sufficiently larger than that of the breech block at its said cut away portions as to reduce the total area of said annular orifice by a preselected amount.

11. In a non-recoil gun, the combination of a barrel, a chamber communicating with said barrel, a breech block movable into and out of the rearward portion of said chamber and having its periphery cut away at spaced portions circumferentially of the block to provide an annular and rearwardly diverging orifice that is interrupted by locking lugs extending radially from the central portion of the block, coacting protrusions from the chamber's inner wall engageable by said locking lugs to secure said block within the chamber, and an orifice area adjusting ring of rearwardly converging contour fixed within said chamber immediately ahead of and concentrically with respect to said breech block and in abutment therewith and having an external diameter which is larger than that of the breech block at its said cut away portions whereby said ring reduces the forward area of said annular orifice by a preselected amount without altering the orifice's rearwardly diverging shape.

12. In a recoilless firearm, the combination of a barrel, a chamber communicating with said barrel ,a breech block movable into and out of said chamber and having its periphery cut away at spaced portions circumferentially of the block to provide a substantially annular orifice interrupted by locking lugs that extend substantially radially from the central portion of the block, coacting protrusions from the chamber's inner wall engageable and disengageable by said locking lugs upon locking and unlocking rotations of the breech block within the chamber, a support for said breech block affixed to the rear exterior of said chamber in radial alignment with

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

13. In a recoilless firearm, the combination of a barrel, an enlarged chamber extending rearwardly therefrom, a projectile in the rear of said barrel, a cylindrical cartridge case of perforated wall metal within said chamber spaced from the rear walls thereof and communicating at its front with said projectile, a breech block movable into and out of the rearward portion of said chamber immediately behind said cartridge case and having its periphery cut away at spaced portions circumferentially of the block to provide a substantially annular orifice leading from the chamber's interior to the rear exterior thereof and interrupted by locking lugs that extend substantially radially from the central portion of the block, coacting protrusions from the chamber's inner wall engageable by said lugs when the breech block is in a first rotative position whereby to secure said block in the chamber and interspaced between said lugs when the breech block is in a second rotative position whereby then to free said block for withdrawal from the chamber, and a breech block support member spanning said annular orifice in line with one of said chamber's protrusions and pivotally joined with said breech block's center whereby to permit block rotation between said first and second positions and hingedly joined with said surrounding chamber's wall whereby supportingly to permit complete withdrawal of said block from the chamber as well as impart guiding action to the block upon reinsertion thereof into the chamber.

14. In a non-recoil gun, the combination of a barrel, a chamber communicating therewith, a breech block movable into and out of the rear portion of said chamber and having its periphery cut away at spaced portions circumferentially of the block to provide a substantially annular orifice interrupted by locking lugs that extend substantially radially from the central portion of the block, coacting protrusions from the chamber's inner wall engageable and disengageable by said locking lugs upon locking and unlocking rotations of the breech block within the chamber, a support for said breech block affixed to the rear exterior of said chamber, a hinge member extending radially and in line with one of said chamber's protrusions from said support to the

center of said breech block and permitting rotation of the block within the chamber plus supported withdrawal therefrom, a bar extending across and secured to the rear of said breech block in line with opposing of said locking lugs carried by the block, and operating handles extending forwardly from said bar's two protruding ends to facilitate turning of the breech block within the chamber and to aid withdrawal of the block from and reinsertion of the block into the chamber.

15. In an open breech 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, a perforated cartridge case within said chamber having a cross sectional area substantially less than that of said chamber's rear portion and being supported at its front by said barrel, a rim extending radially from the rear portion of said cartridge case, a ring fixed within 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 immediately behind said cartridge case and providing a connecting passageway between the space around the cartridge case and the chamber's rear exterior, and an extractor fixture protruding from the forward face of said breech block for latching engagement over the rear rim of said cartridge case whereby upon withdrawal of the block from the chamber the cartridge case is at the same time also partially withdrawn from the firearm.

WILLIAM J. KROEGER.
CLARENCE WALTON MUSSER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
533,837	Bott	Feb. 5, 1895
710,124	Tasker	Sept. 30, 1902
718,719	Meigs et al.	Jan. 20, 1903
1,434,044	Cooke	Oct. 31, 1922
2,165,263	Holm	July 11, 1939
2,405,414	Eksergian	Aug. 6, 1946
2,406,537	Goehmann	Aug. 27, 1946

FOREIGN PATENTS

Number	Country	Date
468,583	Great Britain	July 8, 1937