Oct. 4, 1949. W. J. KROEGER ET AL 2,483,421

BREECH AND FIRING MECHANISM FOR RECOILLESS FIREARMS

Filed April 26, 1948

2 Sheets-Sheet 1

FIG. 1.

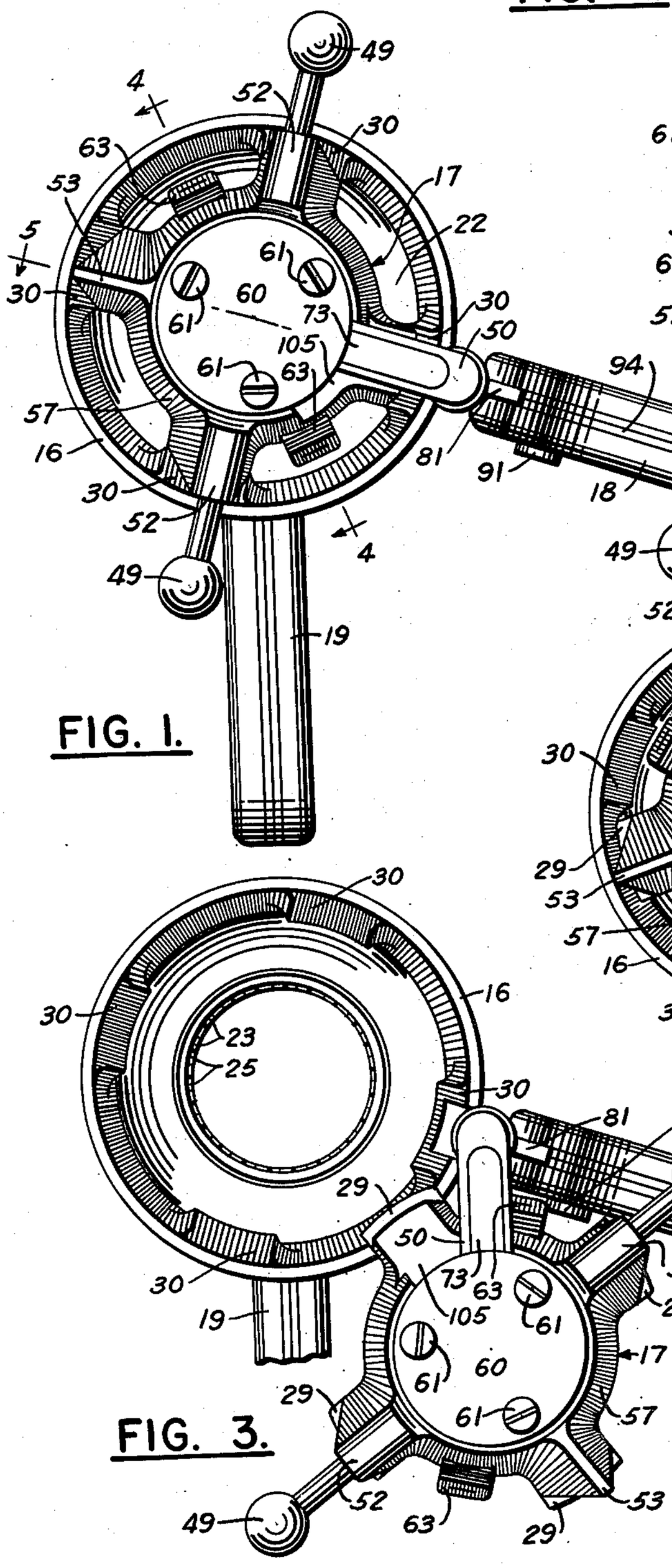

FIG. 4.

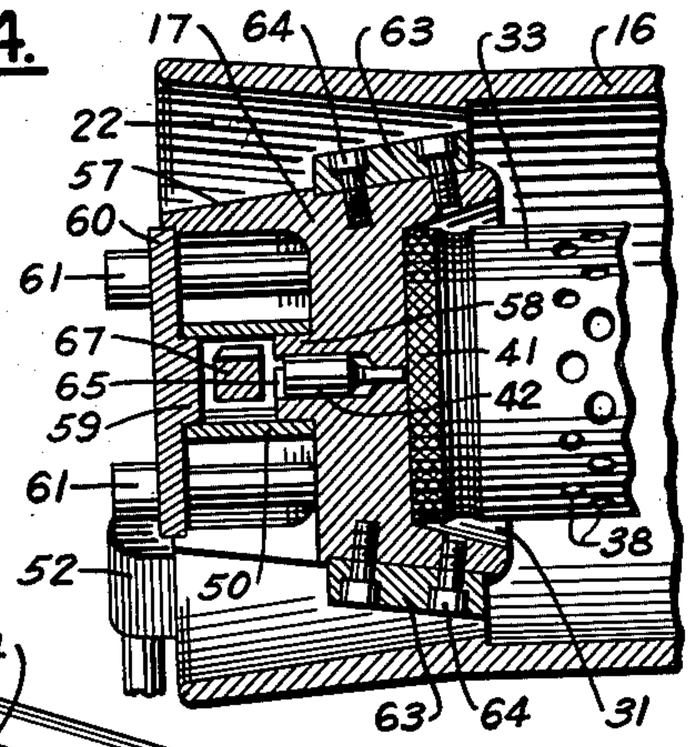

FIG. 2.

FIG. 3.

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Filed April 26, 1948 2 Sheets-Sheet 2

FIG. 5.

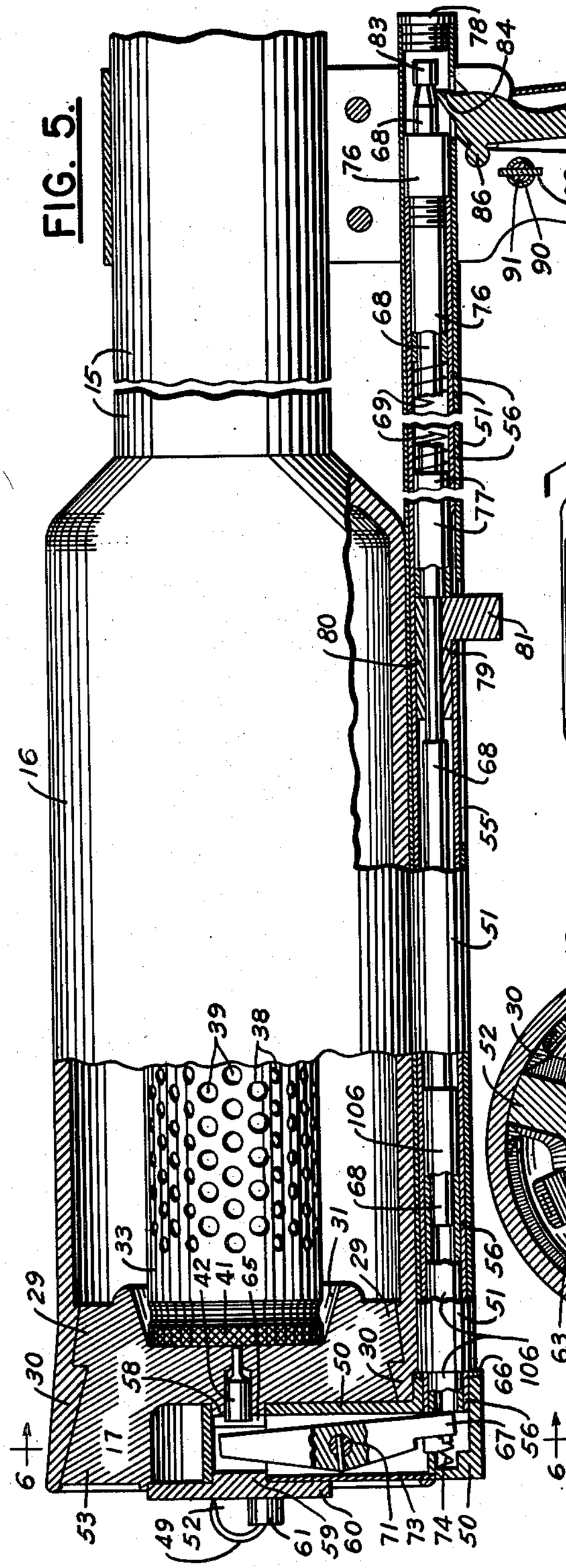

FIG. 7.

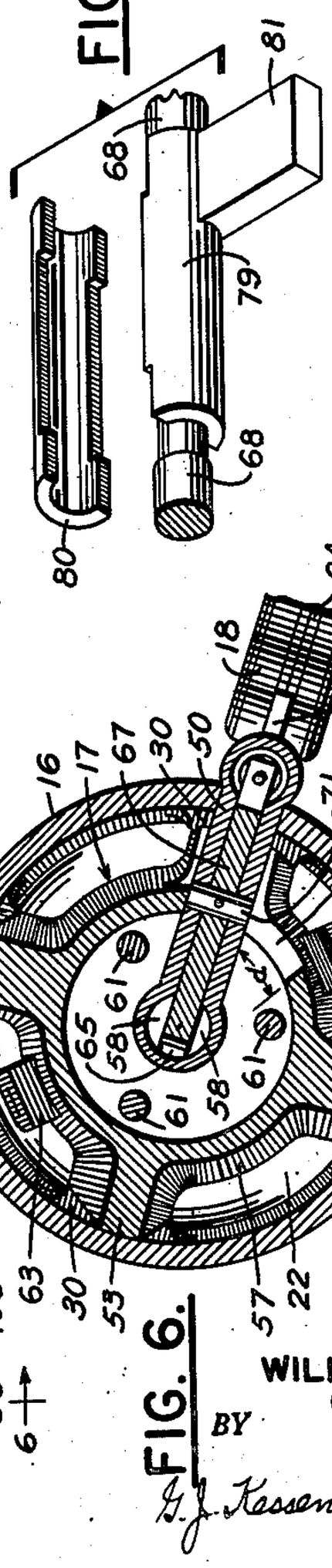

FIG. 9.

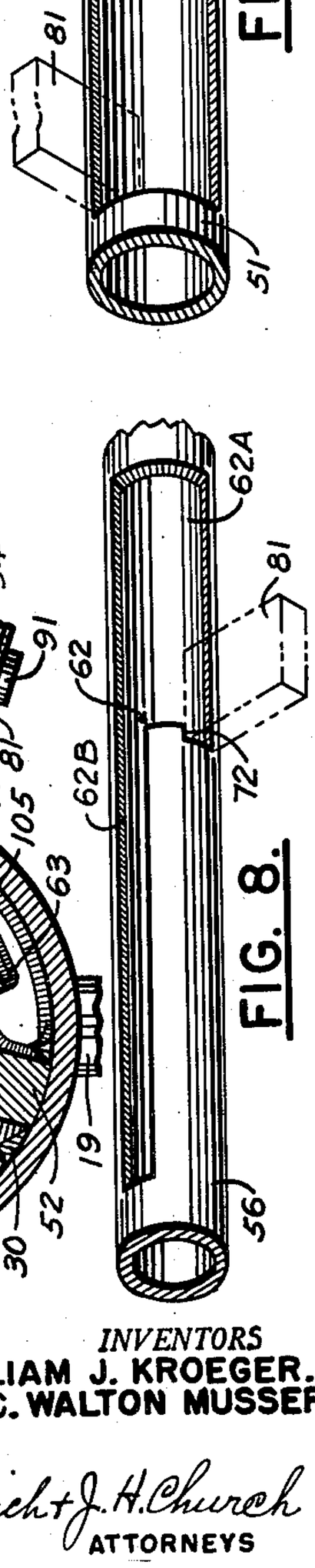

FIG. 8.

FIG. 6.

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Patented Oct. 4, 1949

2,483,421

UNITED STATES PATENT OFFICE

2,483,421

BREECH AND FIRING MECHANISM FOR RECOILLESS FIREARMS

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

Application April 26, 1948, Serial No. 23,186

7 Claims. (Cl. 89—1.7)

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

1

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

The present application is a contination-in-part of abandoned application Serial No. 536,590, filed on May 20, 1944, in the names of William J. Kroeger and C. Walton Musser for "Recoilless firearms, ammunition therefor, and ballistic design thereof."

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 the propellent charge's combustion.

Broadly stated, the object of our invention is to improve the design and extend the usefulness of recoilless guns wherein the named recoil neutralization is effected by a rearward escape of generated powder gas through openings or orifices in the gun's breech.

A more specific object is to provide improved chamber and breech constructions for such recoilless guns.

Another object is to provide improved designs for breech orifice nozzles to facilitate orifice area adjustment and the securing of zero recoil at a desired performance level, and to neutralize gun twist with rifled barrels.

A further object is to provide improved means for assuring substantially complete combustion of the powder within the gun's chamber, and for minimizing rearward discharge of unburned powder and fragments.

A still further object is to provide improved means for firing the gun and for preventing the gun from being accidentally fired.

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

In the aforementioned parent application we disclosed a number of factors to be necessary for satisfactory operation of our inventive recoilless firearm. In constructing one recoilless firearm pursuant to that disclosure we: (*a*) make the gun's chamber of substantially larger diameter than the ammunition cartridge case which fits therein; (*b*) support this cartridge case centrally

2

in this enlarged chamber solely from the two ends of the case; (*c*) provide in the gun's breech a rearwardly opening orifice of unique annular nozzle design and with ready adjustment for optimum area; (*d*) use a cartridge case having a metal wall which is perforated throughout the length and circumference of the case and which permits discharge of propellent combustion gases radially against the chamber's surrounding wall and thence rearwardly from the gun through the annular orifice of the gun's breech; (*e*) pre-engrave the projectiles for ready passage through the rifled bore of the gun's barrel; and (*f*) so coordinate the breech and firing mechanisms as to permit quick and convenient loading and firing.

The invention to which the present specification is essentially restricted is the specific breech closure structure used in the gun first disclosed by the aforementioned parent application. The present invention itself, together with illustrative embodiments thereof, will best be understood from the following description taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a view of the gun's rear end showing the breech block in its closed and locked position;

Fig. 2 is a similar view except that the breech block is shown in the closed, unlocked position;

Fig. 3 is also a rear view, but shows the breech block in the unlocked and open position, having been swung away clear of the chamber;

Fig. 4 is a view taken from line 4—4 of Fig. 1 to show details of the orifice throat adjusting blocks plus other parts of the gun's breech and firing mechanisms;

Fig. 5 is a view taken from line 5—5 of Fig. 1 to show the internal construction and other details of the gun's chamber and breech portions;

Fig. 6 is a section view taken from line 6—6 of Fig. 5 to show further details of the breech block and the tappet housing support therefor; and

Figs. 7–8–9 are enlarged showings of the hammer's split safety fixture plus the slotted hammer and hinge housing tubes therearound.

The complete recoilless gun

Our inventive improvements are here illustratively disclosed as being incorporated in a military weapon of 57 mm. caliber capable of a completely recoilless firing of projectiles. As the description proceeds, it will become apparent that

our improvements may also be applied to firearms of sizes, characters and shapes other than the ones here disclosed and that the represented 57 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 15; an enlarged chamber 16 secured to the rear of this barrel; a breech block 17 partially closing the rear of the chamber; a trigger handle 18 for the user's right hand by which firing of the weapon is controlled; a barrel handle 19 for the user's left hand by which training on the target is aided; and a sight (not shown) for aiming the gun in a conventional manner.

As here represented, the gun's trigger and barrel handles 18 and 19 are suitably clamped around the barrel 15 at the angularly spaced location shown by Figs. 1–2–3. Fig. 5 further shows trigger handle 18; barrel handle 19 is not there shown, but it is situated between the trigger handle and the muzzle (not shown) of the gun.

The chamber and breech

As here shown, the gun's chamber 16 takes the form of an enlarged cylinder which is affixed at its forward end to the rear of barrel 15 in any integrally secure manner, as by the aid of screw threads (not shown). If desired, this connection may be rendered more permanent by a brazing of metal (not shown) around the entire circumference of the juncture. Such brazing constitutes a gas-tight seal which prevents damage to the threads from powder leakage therethrough; it also prevents relative turning between the barrel and chamber.

As the drawings also show, the gun's breech block is a "spider-like" element removably secured within the rear end of chamber 16 and constitutes only a partial closure therefor. The breech block is actually an apertured supporting member on which are fixed certain vanes 52—53 whose form and function will later be described in detail. It takes the form of a cylindrical block 17 which is radially spaced from the chamber walls in a manner to form a substantially annular orifice or venturi that leads from the chamber's interior to the rear exterior of the gun. In Figs. 1 to 4 inclusive and 6 this annular orifice is shown at 22. As the drawings show, the annular orifice actually is interrupted by the four vanes 52—53; however, for all practical purposes the orifice acts as if it were a completely annular venturi as will later become evident, and therefore will herein be considered and referred to as such.

Four locking lugs 29 extend radially from this central breech block 17 and interfit with mating protrusions 30 on the chamber wall interior. These mating parts have the form best shown by Figs. 1 to 4 inclusive and 6, and when engaged as in Figs. 1, 5 and 6 they securely lock the breech block 17 within the rear of the chamber.

The chamber wall spaces which circumferentially separate the locking protrusions 30 have a diameter larger than the maximum for the breech block lugs 29, and this relation enables free longitudinal movement by those lugs through the spaces named. This movement is utilized in inserting the breech block into the chamber and also in withdrawing it therefrom, all in a manner to be described presently.

When inserted and locked within the chamber as shown in Figs. 1, 5 and 6 the breech block 17 constitutes a firm support for the ammunition (see Fig. 5) which it helps to position within the chamber. The steel of the block's central core structure is of sufficient thickness and strength to withstand, with a factor of safety of well over 3, the maximum rearward thrust exerted thereon during firing.

Cooperating with the gun's barrel and the just described chamber and breech structure is ammunition having the unique perforated case shown in Figs. 4–5. As explained in greater detail in the aforementioned parent application, the purpose of the perforations 38 in the cartridge case 33 is to permit the powder gases to issue therefrom in a radial manner, so as to expand within the enlarged chamber 16 and become exhausted through the annular orifice 22 to the rear exterior of the gun with a torque equal but opposite in direction to that caused by a projectile upon being fired through the gun's barrel.

In the loaded position represented by Figs. 4–5 the cartridge case head 41 is accordingly engaged by a mating recess 31 in the front of the breech block. This recess 31 flares outwardly toward the front so as more conveniently to receive the case head during loading. By its engagement with the head, the rear of cartridge case 33 is centrally positioned within chamber 16 and the entire case is restrained against backward movement. Thus positioned, the primer (not shown) carried by the cartridge case head 41 is engageable by a firing pin 42 protruding through the center of the breech block 17 and there actuated by firing mechanism later to be described.

The annular orifice and adjustable nozzle

Recoilless firearms of the open-breech type here considered neutralize the forces of rearward reaction by forwardly acting counterforces. In our improved weapon 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 forces 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 16, forwardly acting drag forces of the projectile (not shown) in the rifled (not shown) barrel 15 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 22 between the gun's breech block 17 and the rear wall of chamber 16 wherein this block is secured.

As illustrated in Figs. 1 to 4 inclusive and 6, this annular orifice extends all the way around that block's central core or hub and is obstructed only by the four radial vanes 52—53 which commence centrally from the common hub portion and terminate at their outward extremities in the breech locking lugs 29. All circumferential space separating lugs 29 thus constitute the named annular orifice 22 which leads from the interior of chamber 16 rearwardly to the exterior of the gun.

Upon ignition of the propellent powder (not shown) and the resultant discharge of the projectile (not shown) forwardly out of barrel 15, there is expelled through the perforations 38 of cartridge case 33 combustion gases which are projected radially against the surrounding cham-

ber 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 improved weapon we supplement this momentum effect by making the annular breech orifice of the represented "nozzle" shape. Starting with a relatively narrow radial width at its front or throat, the annular orifice flares outwardly toward the rear with a total angle spread of approximately 15 degrees. The exact value of this angle is chosen to yield the optimum of forward force component due to an expansion of the powder gases in passing rearwardly through the orifice as earlier explained. Too narrow an angle is found to cut down the magnitude of this forward force component, while if the angle is made too wide, the gases seem no longer to keep contact with the steepness of wall separation and much of the desired nozzle effect again is lost.

For maximum effectiveness it would be desirable to extend the annular orifice to a substantial axial dimension, but practical considerations show that acceptable performance is achieved when the nozzle orifice has the relatively short lengths which the drawings indicate (see Fig. 4 in particular). Thus, we prefer to select for the nozzle an axial length which gives a rear or discharge area of approximately four times the area of the orifice's front or throat area. Dimensions other than that shown may of course be utilized with varying degrees of relative effectiveness.

In our achievement of complete neutralization of recoil we find that there exists an optimum ratio between the bore area of the gun and the throat area of the breech orifice. This ratio is dependent primarily upon the amount of expansion obtained in the venturi **22** and to a lesser extent upon such factors as the relative weights of the powder and projectile. In a firearm of the annular orifice type here disclosed this ratio for zero recoil will lie within the range of about 1.35 to about 1.70.

Our improved weapon includes provision for adjusting this ratio to the optimum value which during actual firing does in fact produce zero recoil. In the illustrative arrangement disclosed, this provision takes the form of a pair of orifice blocks **63** affixed to flattened portions on opposing sides of the inner nozzle wall and there firmly held by any suitable means such as the represented bolts **64** (see Fig. 4) with countersunk heads. While occupying such a portion of the total orifice area as is needed to supply the necessary adjustment, these blocks **63** do not alter the basic nozzle shape thereof, and hence they constitute a particularly efficient means of effecting the required adjustment.

The maximum throat area is of course realized when both blocks **63** are removed; hence the annular orifice is designed to afford a throat area large enough to meet the maximum requirements under that condition. Applying the figures earlier stated, this might give a bore-area to throat-area ratio of the 1.35 lower limit. To change this ratio to its other extreme of the named 1.70 maximum, it is merely necessary to install at **63** orifice blocks of size sufficient to cut down the total throat area by the requisite amount; and to obtain ratios of intermediate values there may be substituted adjusting block **63** of varying intermediate size.

As pointed out in the aforementioned parent application, we find it convenient in practice to mark on each block the particular value of bore to throat area ratio which its use (along with a companion block of the same dimension) will give. Thus, one set of blocks will be marked 1.58; another 1.60; a third 1.62; and so on.

Choice of the exact block 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 57 mm. weapon represented, zero recoil has been found to require the use of a pair of blocks which give a bore-area to throat-area ratio of the order of 1.60. With such adjustment the nozzle throat has a total area which is approximately one-tenth of the cartridge "perforation" area.

Neutralization of rotational reaction

Firearms with rifled barrels experience a rotational reaction by virtue of the spinning motion that firing imparts to the projectile. In the particular gun shown the gun barrel **15** happens to have been rifled (not shown) with a right-hand twist, the result being to give clockwise rotation to projectiles fired therethrough, and this right-hand acceleration of the projectile's mass will impart counterclockwise torque of equal magnitude to the barrel. Our improved weapon includes provision for neutralizing such reactive torque by causing the explosive gases which rearwardly discharge through the annular breech orifice **22** to impart to the weapon counterbalancing torque of the same magnitude as that which the rifled barrel imparts to the projectile (not shown). This provision is effected by so specially shaping the rear tail pieces of the breech block vanes **52—53** that the gases passing through orifice **22** have angular momentum imparted thereto. (Of course, if the gun barrel happened to have been given a left-hand twist for its rifling, the same result could be achieved by directing or shaping the vanes **52—53** in a direction opposite to that shown, thereby imparting to the rearwardly escaping gases a clockwise torque which will counterbalance the counterclockwise rotation given by the gun to projectiles fired therethrough.)

As the drawings show, each of these breech block vane tailpieces tapers in the general manner shown from a maximum cross section beneath locking lugs **29** rearwardly toward a minimum and much narrower width at the rear extreme thereof. If this taper were the same on both sides of each tailpiece, the discharge of powder gases therepast would exert no rotative force in either direction, but instead the side force components set up by the expanding gases would be the same in both directions and hence completely counteract one another.

To obtain the desired torque neutralization we modify the tailpiece flaring to the extent indicated by the drawings. From those drawings it can be seen that the angle on the one side of each tailpiece differs from the angle on the other side in the proper amount and direction to give the gases a counteracting spin about the gun axis. The effect is to impart to the axes of breech orifice opening **22** small angular displacements (all in the same rotative sense) with respect to the main axis of the gun's barrel **15** and chamber **16**.

In consequence, the sides of these vanes having the smallest angle have imparted thereto a

stronger side or tangential thrust from the expanding gases than do the opposite vane sides, and there thus is imparted to the breech block a torque counteracting that applied by the projectile. Only the relatively small degre of angular unbalance indicated is found sufficient to make the thus imparted torque of the same magnitude as the barrel 15 imparts to the projectile (not shown) in advancing it through the rifled bore.

During firing the breech block 17 transmits this neutralizing torque to the chamber and thence to the barrel, and in this way all forces of rotational reaction are neutralized in a very simple, yet highly effective manner. In the illustrated weapon the combustion gases that flow rearwardly through the breech orifice openings 22 have imparted thereto a counterclockwise spin which is opposite to the clockwise spin given by the gun's right hand rifling (not shown) to the forwardly fired projectile (not shown). As the vane structure of the nozzle-forming portion of the breech block is asymmetric in relation to the gun's axis for each Venturi opening, a different amount of expansion tends to occur for opposite sides of each venturi for axial gas flow. Therefore, the center line of the gas flow through each nozzle is tangentially diverted in a circular pattern about the axis of the gun. The accompanying gas "reaction" torque exerted on the gun is clockwise and thus neutralizes the counterclockwise projectile "reaction" torque received by the barrel 15.

The breech block carrier and lock mechanism

Explanation has already been given of how the breech block 17 is secured in the rear of chamber 16 by the aid of that block's locking lugs 29 and the mating protrusions 30 on the chamber interior. In the locked position represented by Figs. 1, 5 and 6, 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 (not shown) sets up.

To facilitate loading, and removal of the cartridge case 33 after firing, provision is made for unlocking this breech block 17, rearwardly withdrawing it from the chamber 16 and swinging it out of alignment with the chamber interior to some downward position such as that shown in Fig. 3. Aiding these actions is an operating member which illustratively takes the form of a pair of handles 49 which protrude from the breech block, a radial support member shown in the form of a tappet housing 50 which extends into that block's center, and a lateral support member shown in the form of a hinge housing 51 (see Fig. 5) which interconnects the radial member 50 with the outside of the gun's chamber 16. These elements constitute mechanism by which the breech block continues to receive support from the gun after it has been withdrawn from the chamber.

The named operating member represented in the drawings by handle 49 protrudes in the manner shown from radial vanes 52 which extend rearwardly from the breech block 17 by a distance somewhat greater than do the remaining two breech block vanes 53. By these handles 49 an operator may rotate the breech block through the small angular distance indicated at *d* in Fig. 6. In the gun here shown this range of angular movement is of the order of 35 degrees.

Clockwise rotation serves to engage the breech block locking lugs 29 behind the mating protrusions 30 of the chamber and thereby secure the breech block therein as earlier explained; counterclockwise 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 17 is free for rearward withdrawal from the chamber.

Serving to support the breech block upon such withdrawal is the radially disposed tappet housing 50 earlier mentioned. This housing is attached at its outer end to a pivot tube or hammer housing sleeve 56 sliding and turning in the stationary hinge housing or support tube 51 earlier mentioned as being fixed to the outside of chamber 16; from this attachment the radial tappet housing extends through a cutaway portion in a rear rim 57 of the breech block to that block's center where the gun's firing pin 42 (see Fig. 5) is mounted.

There, circular openings in the front and rear of this radial member 50 accommodate opposing bosses 58 and 59 (see Fig. 5) projecting from the breech block and from a cover plate 60 therefor. This cover plate is secured to the block by the aid of three bolts 61 which pass through the plate and into tapped openings in the block metal thereby holding the plate firmly in a mating recess in the block's rear rim 57.

The rotatable connection thus established permits the earlier named angular movement of the breech block 17 with respect to the chamber 16, and also with respect to the tappet housing 50 which extends into the block's center from the chamber's outside. In this way application of clockwise turning force of handles 49 effects locking of breech lugs 29 behind the mating protrusions 30 of chamber 16; and application of counterclockwise turning force disengages those lugs from the chamber protrusions and thus frees the breech block for rearward withdrawal from the chamber. Both of these turning movements are limited in their extent by the sides of the represented opening 105 in the wall of the rear breech rim 57.

As aforesaid, the illustrated weapon is represented as having right-hand rifling (not shown). In such a weapon, the gas forces applied (as earlier explained) to neutralize torque reaction exert clockwise turning effort on the breech block and thereby maintain the locked position thereof during firing. Where the gun can be rifled with left-hand twist, then the locked position of the breech block should of course be at its counterclockwise limit of turning movement.

The earlier named hinge housing sleeve 51 is secured to the outer wall of chamber 16 by brazing or other permanent form of attachment. This hinge housing is continued forwardly to the trigger handle 18 and within it the smaller diameter hammer housing sleeve 56 is carried (see Figs. 5 and 8) in a manner permitting both radial and lengthwise movement. This form of carriage permits the affixed tappet housing 50 to be withdrawn rearwardly with respect to the hinge housing 51 and also to be rotated with respect thereto.

Once, therefore, breech block 17 has been disengaged from the chamber portrusions 30, application of rearward force to handles 49 causes the breech block 17, tappet housing 50 and hammer housing 56 all simultaneously to be moved back away from the rear of chamber 16. The range of this backward movement is sufficient to allow complete clearance of the breech block with respect to the chamber, and when this

condition is realized the breech block and tappet housing may both be swung downwardly to the position shown in Fig. 3. In such position the entire interior area of the chamber 16 is unobstructed in a way permitting ready insertion of the projectile (not shown) and cartridge case 33 into the gun, or ready withdrawal of a fired cartridge case from the gun's chamber.

To re-insert the breech block into the chamber it is merely necessary to swing the tappet housing 50 clockwise and upwardly about its hinge housing 51; position the breech block in its counterclockwise limit of travel with respect to housing 50; thrust the so positioned breech block forwardly into the open end of chamber 16 (in the Fig. 2 position); and finally turn the breech block to its clockwise limit of rotation in which the locking lugs 29 thereof engage with the chamber's mating protrusions (as best shown in Figs. 1 and 6).

Close fitting of the radial tappet housing 50 against the end of the hinge housing 51 when the breech block 17 is locked within the gun's chamber may be secured in any desired manner such as by the aid of shims of the type shown at 66 in Fig. 5.

The firing mechanism

For igniting the ammunition propellent charge (not shown) at the will of an operator, use may be made of any suitable firing mechanism, either electrical (not shown) or mechanical (here disclosed). 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 squeezing of the trigger handle 18. In the disclosed arrangement, the firing pin 42 carried by the gun's breech block 17 (see Fig. 5) receives through a tappet 67, a firing blow created by the rearward movement of a rod-shaped hammer 68. The force incident to this rearward movement originates in a compression spring 69 and is made available for firing the gun when a trigger 70 protruding from the front of trigger handle 18 is compressed into that handle.

The just named tappet 67 (see Figs. 4–5–6) is mounted on a rocker pin 71 within the radially disposed tappet housing 50. As earlier described this radial member 50 also constitutes the support for the breech block 17 when withdrawn from the weapon's chamber 16; serving to close the housing's back is a removable cover 73 held in place by an overlapping of the breech block cover plate 60. A tappet retractor spring 74 urges the outer end of this tappet to the forward travel limit shown in Fig. 5, and in that condition the inner end of the tappet is separated from the rear of firing pin 42 by the substantial clearance which Fig. 5 also shows.

The illustrated hammer 68 takes the form of a long, slender rod of steel or other suitable metal slidably contained (see Fig. 5) within the housing sleeve 56 earlier described as constituting a support for the outer end of the radial tappet housing 50. As earlier explained, this housing sleeve or pivot tube 56 is rotatably and slidably contained within the outer hinge housing tube 51 (see also Fig. 9) which hinge housing is fixed (as by brazing) to the outside of chamber 16 (see Fig. 5). That hinge housing, in turn, extends from the weapon's chamber to and slightly past the trigger handle 18 where the forward end thereof is closed by a plug 78.

It will be seen from the drawings that the

companion hammer housing 56 likewise extends within the stationary hinge housing 51 from the rear location of tappet housing 50 to the forward location of trigger handle 18. At the said forward location the housing or pivot tube 56 terminates in a spring retainer 76, taking the form of the represented sleeve attached to the tube end by a thread connection. At the rear end the hammer is slidably supported by a hammer bushing 106.

The inside diameter of the hammer housing 56 is somewhat larger than the outside diameter of the hammer rod 68 which it surrounds, and the earlier named hammer spring 69 is carried within the space thus made available. The forward end of this hammer spring abuts against the retainer 76, while the rear end of the spring exerts force against a spacer sleeve 77, also slidably carried between the central hammer 68 and the housing sleeve 56 which surrounds it.

Adjacent to this spacer 77 on the side opposite to the spring is a reduced diameter section of the hammer 68, and surrounding it is a split safety fixture made up of two parts 79—80 (see Figs. 5 and 7) having the mating character shown in the drawings. These two parts are housed within the hammer tube 56 for restricted slidable and rotative movement, and they also permit the hammer 68 to move axially therethrough along the hammer's reduced diameter portion.

Radially protruding from part 79 is a safety arm 81 which extends through registering slots 62 and 55 in the concentrically disposed hammer and hinge housings 56 and 51, respectively, to the outside for manipulation by the operator. The named slots 62 and 55 have the character illustratively shown in enlarged form by Figs. 8 and 9, and during cocking and firing of the hammer rod 68 these slots cooperate with the safety arm 81 in a manner to be explained presently.

The slot 55 in the outer or hinge housing 51 has the substantial width later named and is of length greater than the axial distance through which hammer 68 and safety arm 81 move during cocking and firing. The cooperating slot 62 in hammer housing 56 is comprised of two parts identified as 62A and 62B (see Figs. 8–9). This slot 62 is wide at its front (62A) and narrow at its rear (62B) and has on the narrow side thereof a total length somewhat greater than that of housing 51's slot 55; the wide region of this hammer housing slot is sufficiently long to enable the safety fixtures 79—80 to be inserted therethrough for assembly around the reduced diameter portion of hammer 68. This hinge housing slot 55 and the hammer housing slot 62 at its widest section (see Fig. 8) both have a total circumferential width of somewhat more than 90 degrees. In cooperation with safety arm 81 these two slots serve to restrain the downward swinging movement of the tappet housing 50 (see Fig. 3) to an angle of only slightly more than that 90-degree limit.

Under the "after loading" conditions represented in Fig. 5 the hammer 68 is cocked to the forward position where a latch head 83 thereof is advanced past trigger 70's sear 84; the hammer spring 69 is compressed between hammer housing 56's forward retainer 76 and the rearward spacer 77; that spacer abuts parts 79—80 and through them is held against rearward movement by engagement of safety arm 81 with the hammer housing 56's short lower recess 72 (see Fig. 8);

and in consequence the hammer 68 has none of the spring's compressive force exerted thereon.

To "arm" the hammer in readiness for firing, the safety arm 81 must be pushed forward against the compression of spring 69 to clear the recess 72 of the short slot 62A in tube 56 (see Fig. 8) and rotated upwardly into alignment with hammer housing 56's long slot 62B. This permits the spring 69 and spacer 77 to push the safety fixture 79—80 backwards to the point where the rear thereof abuts the larger diameter of the hammer 68. That hammer now receives the rearward force of the spring and pulls latch head 83 against the trigger sear 84 (see Fig. 5).

Under these conditions a compression of the trigger 70 into the housing 18 therefor will release the hammer allowing the compressed spring rapidly to move it backwardly along with spacer 77 and the safety fixture. By this movement the safety arm 81 moves in the narrow slot 62B of housing tube 56 to the rear limit thereof. This limit is reached just before the end of hammer 68 has contacted tappet 67, and at that point the spring's compressive force is removed from the hammer. The momentum of acquired motion causes the hammer to continue to move back through safety fixture 79—80 and by striking the outer end of tappet 67 to impart a blow to the firing pin 42 and thereby detonate the primer (not shown) in the cartridge case.

To re-cock the hammer in preparation for the firing of another round, the breech block 17 is by counterclockwise rotation disengaged from the chamber 16 and rearwardly withdrawn by handles 49. Tappet housing 50 transmits this rearward movement to the hammer housing 56 and pulls retainer 76 backwards in the stationary hinge housing 51. Safety arm 81, now abutting (see Fig. 9) the rear of hinge housing 51's slot 55, restrains the spacer 77 from rearward movement, and in consequence, the hammer spring 69 now becomes compressed.

By this rearward movement the narrow slot 62B in hammer housing 56 is drawn past the safety arm 81 into a position of housing 56 where that safety arm is in the area of housing 56's wide forward slot 62A. Incident thereto is a complete clearance of the breech block 17 from the end of chamber 16, and a resultant freedom of swinging movement of this block downwardly to the position shown in Fig. 3.

Such a swinging of tappet housing 50 rotates the hammer housing 56 counterclockwise in the stationary hinge housing 51. During this rotation of the hammer housing 56, the safety arm 81 continues to abut the rear of hinge housing 51, as shown dotted by Fig. 9, and thus the recess 72 in the short slot 62A of housing 56 (see Fig. 8) is brought into alignment with that arm. Release of breech block withdrawing force now allows the hammer spring 69 to pull the hammer housing 56 forward and thus re-engage this housing's short slot 62A recess 72 with arm 81, as shown by Fig. 8. Subsequent swinging of the breech block and the tappet housing 50 inwardly (clockwise) into alignment with the weapon's chamber rotates housing tube 56 and safety arm 81 clockwise in the stationary hinge housing 51. Here the breech block may be forwardly reinserted into the end of chamber 16 by movement which carries hammer housing 56, safety arm 81 and the compressed spring 69 all forward in the stationary hinge tube 51.

By this forward movement the firing mechanism is returned to the original or "after loading" condition of Fig. 5 with which this description started.

Firing pin, loader's and trigger safeties

The gun operator's or "loader's" safety has already been described in part. It utilizes the safety arm 81, which at the end of each cocking occupies the "after loading" position shown in Fig. 5. With the safety arm 81 in this position pulling of the trigger 70 is ineffective for releasing the hammer, and no firing of the weapon is possible.

Before the weapon can be fired it is necessary for the loader of the gun to push safety arm 81 forward out of housing tube 56's slot recess (see Figs. 8–9) and rotate it counterclockwise into alignment with that tube's long narrow slot 62B, thus effecting the "armed" position (not shown). When that has been done the compressive force of hammer spring 69 is transferred to the trigger sear 84, and withdrawal thereof from the latch head 83 allows the hammer to fly backwardly and cause tappet 67 to impart a percussive blow to the firing pin 42.

In addition to this loader's safety, our improved weapon here disclosed also includes: (*a*) a trigger safety; and (*b*) a firing pin safety.

The trigger safety utilizes mechanism associated with the trigger 70 within the trigger handle 18. This trigger is mounted for rotation about a support point 86 (see Fig. 5), and the lower portion of the trigger is held forwardly by a leaf spring 87. This spring urges sear 84 upwardly into engagement with the hammer's latch head 83.

The trigger handle 18 comprises two sections fastened to a carrier member 94 which is fixedly mounted on barrel 17. Also carried by the trigger handle 18 is a trigger guard 89, which completely surrounds the exposed portion of trigger 70 and requires that pulling movement be imparted to the trigger through application to this guard. A fastening ferrule 90 for this guard is borne by the carrier member 94 slightly below the corresponding support 86 for the trigger.

The trigger safety fixture is fully described in the aforementioned parent application and therefore needs no complete description here. It will suffice to mention that this safety fixture is dependent on guard 89 which has two sides that pivot around ferrule 90. This ferrule is hollow, and protruding from one end thereof is a safety button 91 which terminates in a locking key 92. The safety button is held in an extended position by a trigger safety spring (not shown). Key 92 fits into a mating slot (not shown) in one side of the trigger guard 89 and is prevented from rotational motion by fitting into the slots in the stationary central plate 94 of the trigger handle. As long as the safety button 91 protrudes from the side of handle 18, the just mentioned spring (not shown) holds half of this non-rotating locking key 92 in the slots (not shown) in the guard side 89. Under this condition the guard is locked against rearward movement into contact with trigger 70, and application of pressure to the guard 89 is prevented from effecting trigger operation.

When, however, the safety button 91 is depressed the locking key 92 is moved completely within the handle plate 94 and out of engagement with the trigger guard 89. Under this condition the guard is freed for backward movement and application of pressure thereto then becomes

effective for pulling the trigger and firing the weapon. In view of the fact that the safety spring (not shown) is continuously acting as aforesaid to move the safety button 91 into the "safe" position, the button must be kept depressed by the gunner during the entire time it is desired to keep the trigger guard 89 free for actuation of the trigger.

The third or "firing pin" form of safety involves the hammer tappet 67 and engagement of the inner end thereof with the firing pin 42 carried by the weapon's breech block 17. Surrounding the end of this firing pin is the rearward boss 58 (see Fig. 5), earlier described as fitting into a mating opening in the inner end of the tappet housing 50.

In order that the tappet 67 may strike the firing pin, this circular boss 58 is provided with the slots 65 represented in Figs. 4–5. When properly aligned with the tappet this slot permits such forward movement thereof as is necessary to impart a detonating blow to the firing pin.

This proper alignment (as shown in Fig. 4) exists only when the breech block 17 is locked within chamber 16 by clockwise rotation of lugs 29 behind the chamber's mating protrusions 30. When the breech block's lugs are disengaged from the chamber, this breech boss 58 is rotated to a position where the described slot therein no longer aligns with the tappet, and under this condition the boss wall mechanically blocks advancement of the tappet into contact with the firing pin.

Hence, even though the breech block 17 may be inserted into the chamber it is possible to fire the weapon only after there has been imparted to that block sufficient clockwise rotation to effect secure locking in the firing position.

Loading and firing

From the foregoing it will be seen that we have provided an improved recoilless firearm which offers special 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 17 by turning it counterclockwise from the Fig. 1 to the Fig. 2 position, withdraw it from chamber 16 and swing it downwardly to the position shown in Fig. 3, thus completely freeing the chamber opening.

The ammunition round is now inserted into the opened chamber and the rear of the barrel's bore. When the projectile (not shown) is positioned in the barrel bore (not shown) centering support is imparted to the entire cartridge case 33 and allows the rear head 41 thereof to droop only slightly from the rear chamber center. The breech block 17 is now moved forwardly into the chamber. In approaching and engaging with the cartridge case head 41, the flared recess 31 in the breech block's front serves to center the head thereby constituting a second support for the cartridge case. Clockwise rotation of the breech block by handles 49 now locks it into the chamber with the front shoulder (not shown) of the case in abutment with the barrel, and the case head 41 in abutment with the breech block, the primer (not shown) in alignment with the firing pin 42 and the entire cartridge case 33 centrally positioned within the surrounding chamber 16.

The weapon is now ready for firing, and upon the earlier explained pre-setting of safety arm 81 and compression of trigger button 91, a backward pressure on trigger guard 89 will cause

detonation of the primer and ignition of the charges contained within the cartridge case.

The resultant combustion of the propellent charge (not shown) discharges the projectile (not shown) and at the same time ruptures a frangible lining 39 (see Figs. 4–5) which lines the interior of the cartridge case to prevent the charge therein contained from falling out of the perforations 38. When the frangible lining 39 is ruptured the explosive gases within the cartridge case are radially expelled through perforations 38 into the chamber 16. This expulsion starts early in the burning cycle and is accompanied by continued combustion of the powder (not shown).

The resultant pressure within the chamber produces escape of explosive gas through the annular breech venturi and thence to the rear of the weapon. In a manner already explained in part, this escape of explosive gas sets up counterforces which neutralize recoil and thus permit the weapon to be fired either from the shoulder or from a light tripod or other mounting.

The perforated wall metal of the cartridge case 33 remains intact during this firing and is not ruptured or otherwise damaged. Indications are that the pressure within the chamber 16 on the inside and outside of the cartridge case wall equalizes itself early during the burning cycle. Thus, after the case has been fired, some of the openings 38 may be found to have thin films of ash either partially or completely covering their area.

Subsequent withdrawal of the fired cartridge case from the chamber is effected by unlocking the breech block, withdrawing it rearwardly, and swinging it downwardly out of register with the chamber. This frees the fired case for ready withdrawal from the chamber and conditions the weapon for insertion and subsequent firing of another ammunition round.

Summary

From the foregoing it will thus be seen that we have so designed and extended the usefulness of non-recoil guns wherein the forces of rearward reaction that result from projectile discharge are neutralized by forwardly acting counterforces simultaneously set up by release of powder gases through an orifice in the gun's breech; that we have provided improved chamber and breech constructions for such recoilless guns; that we have facilitated the construction and adjustment of the breech orifice nozzles and have more efficiently secured zero recoil at a desired performance level; that we have assured substantially complete combustion of the powder within the gun's chamber and have minimized the rearward discharge of unburned powder and fragments; and that we have provided improved means for firing the gun and for preventing the gun from accidentally being fired.

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 firearm, the combination of a barrel, a chamber communicating therewith, a breech block movable into and out of the rearward portion of said chamber and rotatable for locking engagement therewith, coacting interlocking members formed on peripheral portions of said breech block and the inner wall of said chamber and being engageable and disengageable upon locking and unlocking rotations of the breech

block within the chamber, a support for said breech block secured to the outside of said chamber, a companion member rotatively and slidably engaging said support for movement lengthwise of said chamber and barrel, and means extending radially from said breech block to said companion member and constituting a connection which permits rotative movement of the breech block within the chamber and which supports that block when same is withdrawn from the chamber.

2. In a firearm, the combination of a barrel, a chamber communicating therewith, a breech block movable into and out of the rearward portion of said chamber and rotatable for locking engagement therewith, coacting interlocking members formed on peripheral portions of said breech block and the inner wall of said chamber and being engageable and disengageable upon locking and unlocking rotations of the breech block within the chamber, a support for said breech block secured to the outside of said chamber, a companion member rotatively and slidably engaging said support for movement lengthwise of said chamber and barrel, a radial member extending from said breech block to said companion member and constituting a connection which supports the breech block when same is withdrawn from the chamber and which also permits the block to be rotated when within the chamber, a firing pin disposed in said breech block, a tappet arm carried by said radial member and spanning the space between the axis of the firing pin and the axis of the support's said companion member, and a hammer element movable axially of said companion member to strike said tappet arm and operate said firing pin.

3. In a firearm, the combination of a barrel, a chamber communicating therewith, a breech block movable into and out of said chamber, a support tube for said breech block secured to the outside of said chamber and extending lengthwise thereof, a pivot tube within said support tube carried thereby and free to slide and turn with respect thereto, means operatively connecting said pivot tube to said breech block whereby movement imparted to the block is transmitted to said pivot tube, a firing pin in said breech block, a tappet arm carried by said connecting means and extending between the axis of said firing pin and the axis of said pivot tube, and a hammer disposed within the pivot tube and movable axially thereof to engage said tappet arm and operate the firing pin.

4. In a firearm, the combination of a barrel, a chamber communicating therewith, a breech block movable into and out of said chamber, a support tube for said breech block secured to the outside of said chamber and extending lengthwise thereof, a pivot tube within said support tube carried thereby and free to slide and turn with respect thereto, means operatively connecting said pivot tube to said breech block whereby movement imparted to the block is transmitted to said pivot tube, a firing pin in said breech block, a tappet arm carried by said connecting means and extending between the axis of said firing pin and the axis of said pivot tube, a hammer disposed within said pivot tube and movable axially thereof between a forward cocked position and a rearward released position where the hammer engages said tappet and thereby operates the firing pin, a spring also within said pivot tube for urging said hammer from said cocked to said released position, and trigger means effective to engage said hammer and latch it in its said cocked position against the force of said spring.

5. In a firearm, the combination of a barrel, a chamber communicating therewith, a breech block movable into and out of said chamber, a firing pin in said breech block, a support tube secured to the outside of said chamber and extending lengthwise thereof, a pivot tube within said support tube carried thereby and free to slide and turn with respect thereto, a radial member connecting said breech block and pivot tube whereby movement imparted to said block is transmitted to said pivot tube, a tappet arm carried by said radial member and extending between the axis of said firing pin and that of said pivot tube, a hammer within said pivot tube movable lengthwise between a forward cocked position and a rearward released position where the hammer engages said tappet and thereby operates the firing pin, a safety fixture carried by said hammer and protruding through registering slots in said pivot and support tubes, a hammer spring within said pivot tube compressible between a forward extension of the pivot tube and said safety fixture, means including said fixture and the said tube slots through which the fixture protrudes for causing rearward movement of said breech block and pivot tube to compress said hammer spring, and a trigger effective upon forward return movement of said breech block and pivot tube to engage said hammer and latch it in its said cocked position against the compression of said spring.

6. In a firearm, the combination of a barrel, a chamber communicating therewith, a breech block movable into and out of said chamber, a firing pin in said breech block, a support tube secured to the outside of said chamber and extending lengthwise thereof, a pivot tube within said support tube carried thereby and free to slide and turn with respect thereto, a radial member connecting said breech block with said pivot tube and allowing said block and pivot tube to be moved axially with respect to said chamber and the block to be swung transversely away from the chamber's end, a tappet arm carried by said radial member and extending between the axis of said firing pin and that of said pivot tube, a hammer within said pivot tube movable lengthwise between a forward cocked position and a rearward released position where the hammer engages said tappet and thereby operates the firing pin, a fixture carried by said hammer and including a safety arm which protrudes through registering slots in said pivot and support tubes, a hammer spring within said pivot tube compressible between a forward extension of the pivot tube and said hammer fixture, means including said fixture's safety arm and the said tube slots through which that arm protrudes for causing rearward and swinging movement of said tube-supported breech block to compress said hammer spring and for causing forward return movement of the block to engage said arm in a safety notch in one side of said pivot tube slot, and a trigger effective upon manual movement of said safety arm out of said notch to engage said hammer and latch it in its said cocked position against the compression of said spring.

7. In a firearm, the combination of a barrel, a chamber communicating therewith, a breech block movable into and out of said chamber and engageable therewith and disengageable therefrom upon locking and unlocking rotations with

respect thereto, a support for said breech block secured to the outside of said chamber, a companion member engaging said support, a radial member supportedly connecting said breech block with said companion member and permitting rotative movement of the block within the chamber, a firing pin protruding from the rear face of said breech block, a tappet arm carried by said radial member and engageable with the firing pin, a hammer movable to strike the tappet and operate said pin, resilient means normally

urging the tappet arm away from the firing pin, and means mechanically positioned beside said protruding pin to permit contact thereof by said tappet when and only when said breech block occupies its locked rotative position within the chamber.

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No references cited.