Oct. 28, 1947. C. E. BALLEISEN ET AL 2,429,598

RECOIL GEARING

Filed March 7, 1946 3 Sheets-Sheet 1

Fig. 1.

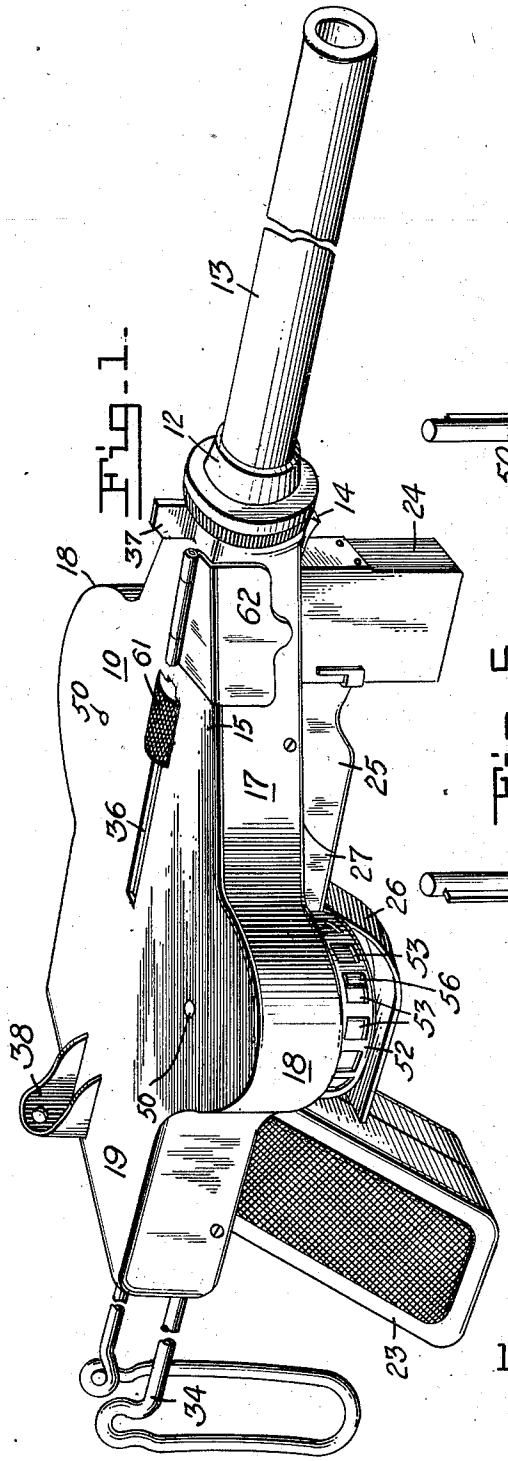
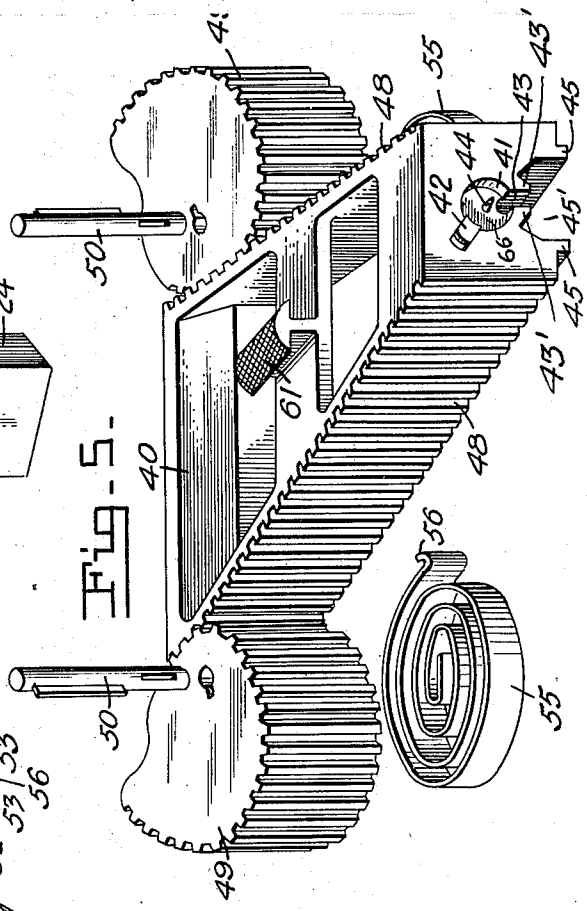


Fig. 5.



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Fig. 2.

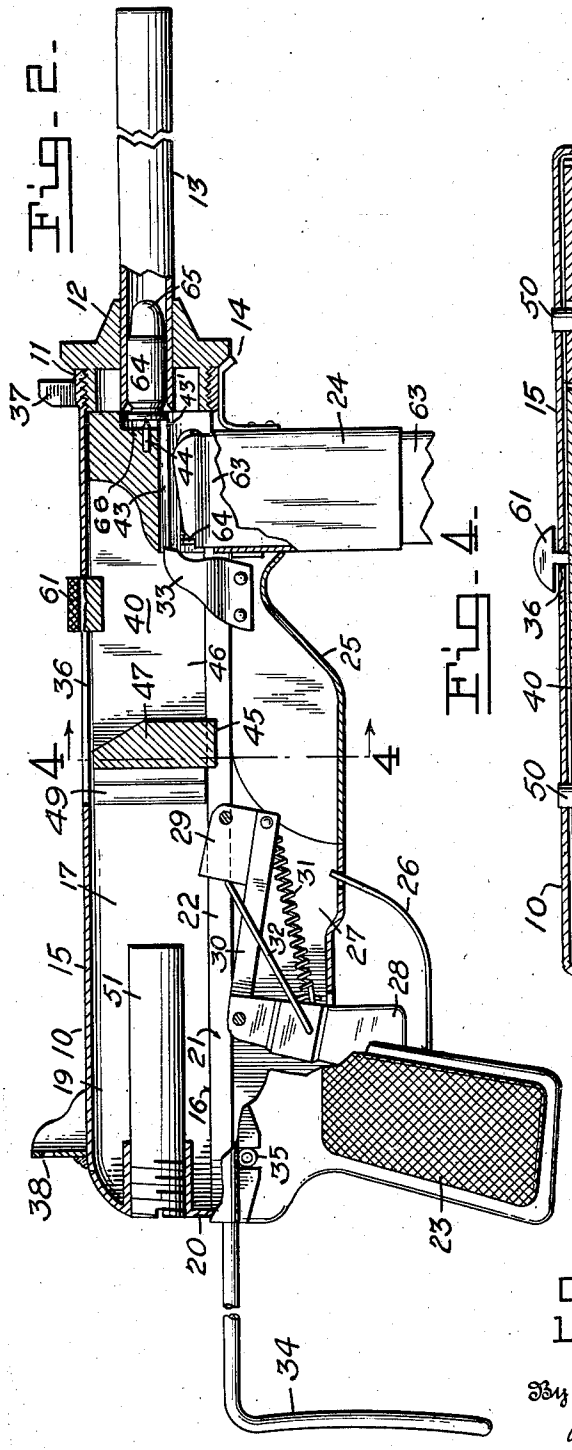
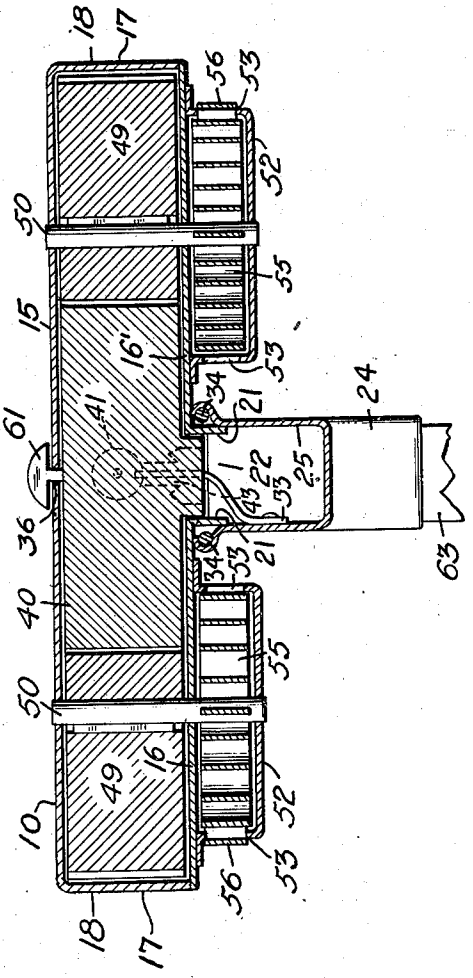


Fig. 4.



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Filed March 7, 1946 3 Sheets-Sheet 3

Fig. 5.

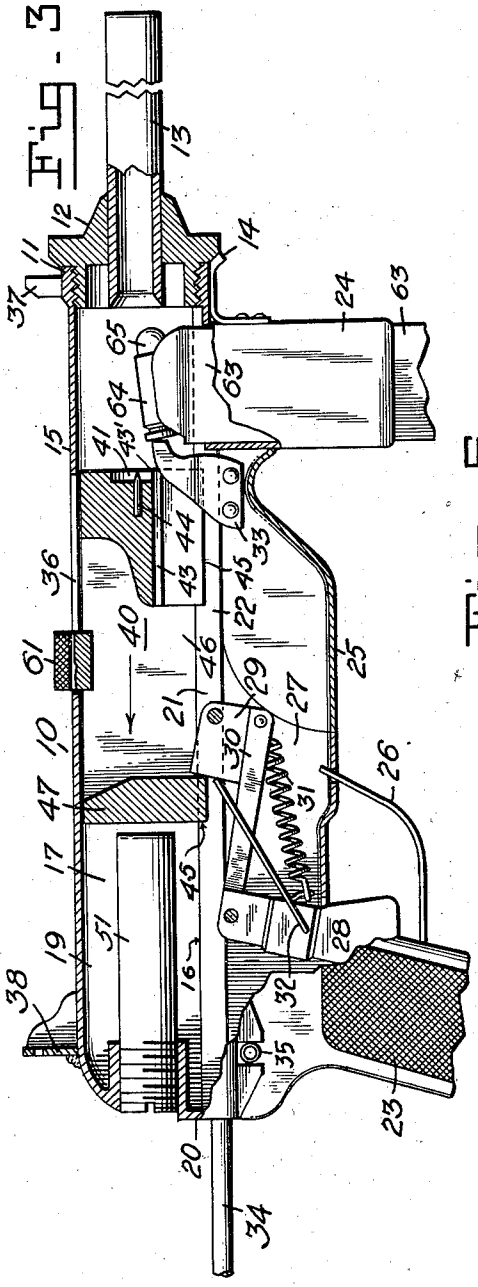
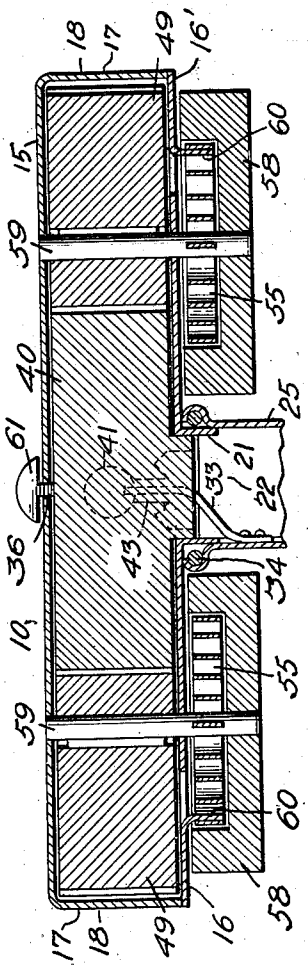


Fig. 6.



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Patented Oct. 28, 1947 2,429,598

UNITED STATES PATENT OFFICE

2,429,598

RECOIL GEARING

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Application March 7, 1946, Serial No. 652,753

3 Claims. (Cl. 89—194)

(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.

The invention relates to gun actions and has for an object to effect improvement in construction of the bolt and recoil spring devices to the end that a maximum inertia will be available for operation of the said loading and ejecting mechanism of the machine gun while at the same time the weight of material required will be greatly reduced, as compared to that required in prior arms.

A further aim is to simplify the action of the gun so that complexity in driving spring form and mounting will be minimized.

Additional objects include the embodiment of the invention so that it may be incorporated in small sub-machine guns as well as rifles and larger arms.

Additional objects, advantages and features of invention reside in the construction, arrangement and combination of parts involved in the embodiment of the invention, as will appear or be understood from the following description and accompanying drawings, wherein:

Figure 1 is a perspective view of a small arm in which our invention is embodied;

Figure 2 is a longitudinal vertical sectional view with certain parts thereof in plan view, of said weapon at the instant of impact of the firing pin upon a cartridge;

Figure 3 is a similar view showing the parts at cocked position;

Figure 4 is a cross-section on the line 4—4 of Figure 2;

Figure 5 is a perspective view of the bolt and gears with both of the springs displaced;

Figure 6 is a view similar to Figure 4 showing a modification in which a flywheel element is included.

Referring more particularly to the drawings, there is shown a machine gun which embodies features intended to function in a manner corresponding to that of the current caliber .45 submachine gun, M3, of the United States Army but using a new bolt action and a new construction of driving springs. This prior gun is shown in a copending application of Sampson and Hyde, Serial No. 533,569, filed May 1, 1944, for Automatic machine gun, and now Patent No. 2,403,306, issued July 2, 1946. The present weapon includes a case portion, or receiver 10, which is a specially stamped sheet metal assembly, the elements in

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which may be made in several parts of suitable number as expediency may dictate.

In the present instance the forward part of the receiver is provided with a forwardly projecting annular bushing 11 into which is screwed the barrel collar 12 of the M3 gun. As heretofore constructed, this collar carries a barrel 13 chambered as in the prior mentioned gun, the collar being held in assembled position by the usual ratchet 14. Immediately to the rear of the bushing the receiver is formed as a horizontal chamber bounded by parallel top and bottom plates 15 and 16—16' the forward parts of which are trapezoidal in plan with sides convergent toward the bushing. Vertical side walls 17 join the lateral edges of the plates. At the base of the trapezoid portion the receiver is slightly enlarged to provide semi-circular gear chambers 18 and at the rear the receiver is narrowed to approximate the width of the base of the trapezoid portion and extended in uniform width as at 19, closed by a transverse back plate 20. The receiver is of uniform height through the parts described, the top and bottom plates conforming to the plan shape indicated and the side walls being extended similarly, bounding the chambers 18 and the rear extension 19. The bottom of the receiver is formed in two parts 16—16' spaced apart at parallel inner edges and flanged downwardly at 21 at these edges so as to form a longitudinal slot 22 between them. A rear hollow grip part 23 is fixed on the lower part of the receiver rearwardly of the slot 22, and on the lower forward part of the receiver a magazine chute 24 is fixed extending into the receiver and having a passageway communicating with the space within the receiver immediately to the rear of the bushing 11. Between the grip and the chute 24 an intermediate housing 25 is set removably, held by a trigger guard 26 sprung thereinto and into the forward side of the grip as in the mentioned sub machine gun. The grip portion may include side plate parts 27 within the housing 25, in which a trigger 28, sear 29 and connecting link 30 with the conventional trigger spring 31 are mounted in the machine gun mentioned. The pivot for the trigger comprises one arm of a bail-like piece 32 one end of which is set through the plates 27 to form a pivot for the trigger while the other end is similarly set through the plates 27 to form a trigger stop pin. At its forward part the housing 25 has an ejector 33 fixed thereon similar in shape and function to the ejector in the prior sub machine gun referred to. The side

plates 27 may form continuations of the bottom plates 16 or may be attached, as found expedient. In the present instance a detachable and adjustable wire stock 34 is shown assembled on the gun in the same manner as heretofore familiar in the sub machine gun mentioned and using a similar releasable fastening 35.

The top plate of the receiver is formed with a longitudinal narrow central slot 36 having a length at least equal to the extent of reciprocation of the bolt as will be described. Conventional front and rear sights 37 and 38 are shown on the upper side of the receiver in proper locations.

A bolt 40 is provided, of an isosceles trapezoidal form corresponding to the shape of the forward part of the receiver. Its forward or apex portion is truncated sufficiently for the formation therein of a recess 41 which, when the bolt is in battery, will fit around the base of a cartridge chambered in the barrel; the rear end of the latter being projected a distance rearwardly of the bushing 11 as heretofore. An extractor 42, the same as that in the bolt of the prior mentioned gun, is mounted in the forward end of the bolt 40 at the upper right hand part. The bolt is slotted on the forward under side as at 43 to permit movement of the tip of the ejector 33 therethrough and beyond the forward end of the bolt when the latter moves rearwardly. The ejector is at a level above the lower side of an extracted cartridge so as to tilt the latter and cause its ejection as heretofore. Conventional firing pin and operating means may be mounted in the bolt if desired, but in the present instance a fixed firing pin 44 is shown set rigidly at the center of the recess 41 so that at the instant the bolt moves into battery the pin will also detonate the primer of a cartridge chambered in the gun. The bolt is formed with slight downward guide extensions 45 at its forward and base parts extending longitudinally and fitted slidably in the slot 22. The lower part of the bolt at its forward part is channelled as at 45' except adjacent the slot 43, where depending cartridge-pushing lugs 43' are provided, somewhat wider than the slot 43, so as to clear the top round 64 of a magazine clip in the chute 24. The central part of the bolt is recessed as at 46, this recess stopping short of the base 47 of the bolt so that the guide 45 thereon at the rear may engage rearwardly of the sear when the bolt is moved to cocked position.

The right and left sides of the bolt are vertical and are toothed to form respective racks 48 which extend divergently from the front end of the bolt to its base. While the racks are rectilinear as shown, they may be otherwise if desired. In the gear chambers 18 there are mounted eccentric—and in the present instance non-circular—gears 49, supported revolubly by pins 50 in the receiver at such distance laterally of the bolt that, when the latter is at battery position, the gear portions of minimum radius will be meshed with the respective rack faces immediately adjacent the base of the bolt, and the developed radii of the remainder of each gear are progressively greater, so that as the bolt moves rearwardly the gear will remain meshed with the convergent racks throughout movement of the bolt to full recoiled position. The bolt racks are prevented from running off the gears by any customary expedient, a buffer 51 being formally indicated in the rear portion of the receiver.

The bottom plates of the receiver are apertured to receive the pins 50 therethrough, and on the under side of the receiver respective circular

spring cups 52 are secured, these cups having flat bottoms spaced from the plates 16—16' of the receiver, the pins 50 being also revoluble in the cup bottoms. In the side of each cup a series of vertical slots 53 is formed spaced circumferentially as anchorages for the drive springs now to be described.

Respective spiral torsion band springs 55 are located in each of the cups 52, their inner ends being inserted through suitable slots in the pins 50, while the outer ends of the springs are formed with outwardly turned hooks 56, each set in one of the slots 53 of its respective cup 52. By adjusting the spring hooks circumferentially from one slot to another the driving force of the springs may be regulated in a simple manner.

The pins may be conventionally keyed in the gears 49, so that on recoil of the bolt rotation of the gear and pins will wind the springs 55 so as to place them under tension or increased tension, tending to reverse the motion of the gears and bolt.

It should be noted that the gears are heavy block bodies and are greater in dimension in the direction of their axes than would be necessary to afford the necessary gear faces to transmit and overcome the torque of the springs shown, the purpose being to gain mass in their operation, increasing the moment of inertia produced at the beginning of recoil of the bolt, and at the end of counterrecoil under the drive of the springs 55 as will be further explained.

In Figure 6 there is shown a modification of the invention, in which the construction is the same as that before described, excepting that the cups 52 are omitted (although corresponding cups may be included if desired), and the springs will be enclosed by recessed flywheels 58, the pins 59 corresponding to the pins 50 being fixed with respective gears and springs, but also extended into and keyed with the flywheels. The outer ends of the springs in the instant case may be hooked upon down turned tongues 60 struck from the bottom plates of the receiver cover, and extending into the recesses of the flywheels, one or more of those tongues being provided for each spring.

The bolt is provided with a cocking knob 61 at the topside, the stem of which is extended upwardly through the slot 36, and the knob portion of which lies close over the top plate of the receiver. By applying manual pressure to this knob when the bolt is at its forward limit of movement, the bolt may be moved rearwardly until its rear lower part wipes over the sear 29 allowing the latter to spring upwardly into the recess 46 and so hold the bolt in cocked position thereafter.

The forward part of the receiver may be provided with a discharge opening and hinge cover at 62, so that spent cartridges may be ejected from the receiver in operation of the gun as will be described.

In the ordnance art the terms semi-automatic, and automatic are technically applied respectively to: (*a*) an arm which in response to firing of a round will restore the gun to loaded cocked position ready to five another round at will by manual operation of the trigger: and (*b*) a weapon which will respond to firing of a round by reloading and repeating the firing operation continually while the trigger is depressed.

The use of the term "automatic" in the appended claims, however, is intended to include semi-automatic as well as full automatic mech-

anisms, and unless otherwise specifically stated the claims are also intended to include gas operated and strictly recoil-operated mechanisms such as the Browning devices, or the Garand, as well as primer-actuated devices, in which an operating slide or barrel or separately reciprocating bolt is employed, or both.

In operation, the gun being cocked as before indicated, a clip **63** containing a number of rounds **64** may be inserted in the chute **24** from below until stopped in the position shown in Figure 3. The head of the top cartridge then is positioned with its upper head part in the path of the depending lugs **43'** of the bolt when it next moves to battery under urging of the driving springs. The clip is also formed with its lips inclined upwardly toward the breech so that the nose of the bullet **65** is further elevated above the lower side of the chamber of the barrel this being the usual condition with the conventional clip for the mentioned sub machine gun. When the trigger is pulled, the bolt is released and is driven forwardly by the torque transmitted through the gears from the driving springs **55**. It engages the heel of the cartridge above and at each side of the primer and presses the round forwardly sliding between the lips of the clip, this being inclined upward toward the chamber and the bullet being supported against the lips of the magazine by the subjacent rounds and magazine spring as heretofore familiar in the current sub machine gun cal. .45 M3 of the United States Army. The round engaged by the bolt consequently moves in an upwardly inclined path, so as to enter the chamber of the gun, the rounded nose of the bullet facilitating this entry, and the flared breech opening of the chamber as well. Entry of the round into the chamber causes its head end to rise until the cartridge is coaxial with the barrel and recess **41** in the face of the bolt as the round nearly reaches full chambered position.

Movement of the bolt now continuing, with the head of the cartridge entering the recess **41**, and the bolt for the moment unimpeded, the recoil face **66** at the bottom of the recess approaches and engages the face of the head at the same time that the extractor **42** snaps past the rim of the head and into the groove of the cartridge head.

At the same time that the recoil face of the bolt recess approaches the cartridge head, the firing pin **44** engages the primer, initiating explosion of the propellant. Inertia of the bolt and gears will cause the recoil face to press the round home before propagation of the explosion has developed dangerous pressure in the cartridge, and to also adequately oppose reaction of the force exerted against the bullet, so that movement of the latter is initiated with an effectiveness approximating that of a locked bolt before the mass of the bolt and gears is overcome. The cartridge is finally pressed rearward, moving the bolt with high acceleration before the bullet leaves the barrel, overcoming the opposition of the driving springs. Further recoil of the bolt continues by the momentum thus imparted thereto, and also by the driving force of the gears resulting from their momentum. This winds the springs to their maximum loaded state as the rear side of the recess **46** passes and is engaged behind the sear.

It will be apparent that upon release of the bolt by the sear, the application of the torque of the springs is effective with maximum mechanical advantage, the teeth of long radius of the gears acting first against the racks, so that a very quick counterrecoil is initiated, and the progressive decrease of radius of the engaged gear parts thereafter enables the acceleration of the bolt to be sustained with an economical and highly effective expenditure of energy in accelerating the bolt and mass of the gears and moving them to battery positions. Likewise, upon firing, recoil may be initiated in the bolt and gears by utilizing the high impact value of the cartridge forces at the beginning of recoil so that these will be effective initially with the highest acceleration values, and as effective cartridge pressure on the bolt decreases and the moment of inertia of the gears is converted to compression of the springs, the resultant of the moment of the gears is magnified by the increasing radius of the gears. Also, as the resistance of the springs gradually overcomes the momentum of the bolt at the rear part of recoil movement, the greater radius of the gears increases the effectiveness of the springs exponentially as the springs overcome the gear moments around their axes.

It will be appreciated that the flywheel effect is inherent in the gears themselves and the system in either form disclosed has the advantage that a minimum mass is moved in a straight line, and the reactions due to movement of the gears oppose each other and so are neutralized. In consequence, actual recoil movement of the gun, "jump," and vibration, will be largely reduced in this action.

In the application of the invention to practical use, the value of the propellant and weight of the projectile being known, as well as the time during which the projectile is being accelerated in the barrel, a reasonable weight for the bolt is determined upon consistent with the forces to be transmitted, work to be done, and shocks of use. This may be less than required for a simple reciprocating bolt and longitudinally acting driving spring of the prior art, and a major part of the body of the bolt here shown between the racks may be removed. The mass required in the gears or the gears and flywheels, and the radii of the gears and load-depression curve of the springs may then be calculated, based on the required length of reciprocation of the bolt and the work involved in loading and ejecting, with suitable margins for casual impedances from various causes.

While we have illustrated our invention in detail in the best embodiment in which it has been completed, it should be understood that this is purely exemplary, and that its adaptation to other gun actions is contemplated as within the scope of the invention; and that changes in construction shapes and proportions of the parts illustrated, substitution of materials and equivalents, mechanical or otherwise, may be made without departing from the spirit of the invention set forth in the appended claims. In the claims, the term "fire actuated bolt" is intended to denote a bolt which moves reciprocally or otherwise in consequence of the firing of the piece in which it is incorporated.

We claim:

1. In an automatic firearm having a receiver, a barrel mounted thereon having a chamber open through the breech to the receiver, the combination therein of a bolt reciprocable in the receiver from a battery position at the breech to a recoiled position spaced rearwardly from the breech, said bolt having rearwardly divergent rack elements

fixed therewith at opposite sides, eccentric gears revolubly mounted in the receiver and meshing with correspondingly opposed portions of said racks, said gears being so constructed and arranged that their parts of minimum radii are adapted to mesh with the rear portions of the racks, the teeth of the gears being developed on a peripheral curve such that the gears remain meshed with the racks throughout movement of the bolt, and respective spring means for the gears, each said spring having one end anchored to the receiver and the other end fixed with one of said gears, whereby said gears and spring means are adapted to store the energy of the recoil movement of the bolt and to release said energy with progressively increased mechanical advantage to move said bolt in counter-recoil movement to battery position.

2. The structure of claim 1 in which the receiver has a bottom plate, the bolt racks being convergent longitudinally of the bolt in one direction, and the gears correspondingly eccentric, said gears having shafts fixed therewith extended through the bottom plate of the receiver, each said inclosure being a case concentric with the shaft having a plate parallel to the bottom plate and a circular wall normal thereto, said wall having a multiplicity of vertical circumferentially spaced slots therein and each spring having at

one end a hook end releasably engageable with one slot and its one end attached to one of said gear shafts.

3. The structure of claim 1 said receiver including a top plate and a bottom plate, the racks being convergent longitudinally of the bolt forwardly and the gears correspondingly accentric, said gears being above said bottom plate on shafts normal thereto, flywheels fixed with the gears concentric with the axes of rotation of the gears, said flywheels being next to one of said plates and recessed theretoward and a spiral spring in the recess of each flywheel, each spring having one end keyed to one of said gear shafts and the other end anchored to the receiver.

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