Feb. 19, 1946. D. S. BELL ET AL 2,395,211

AUTOMATIC GUN

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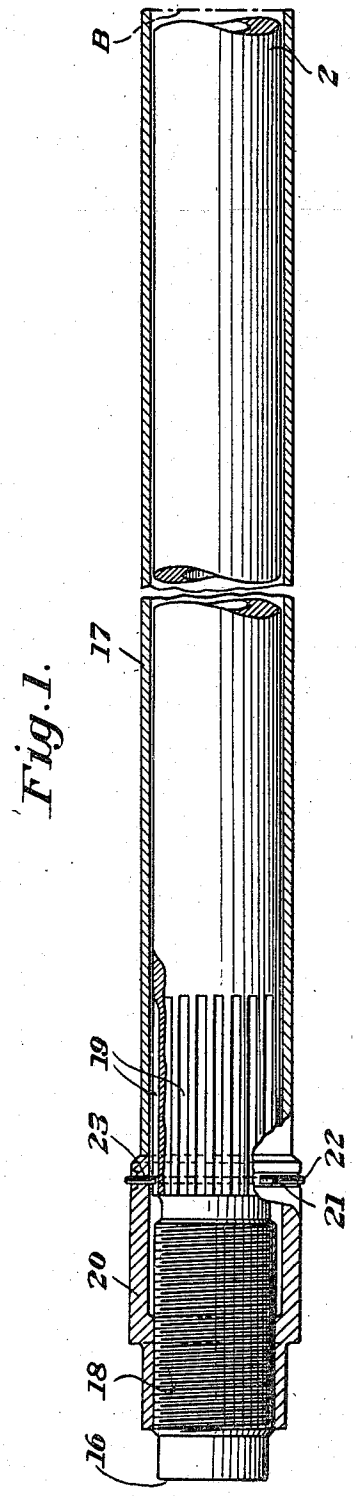


Fig. 1.

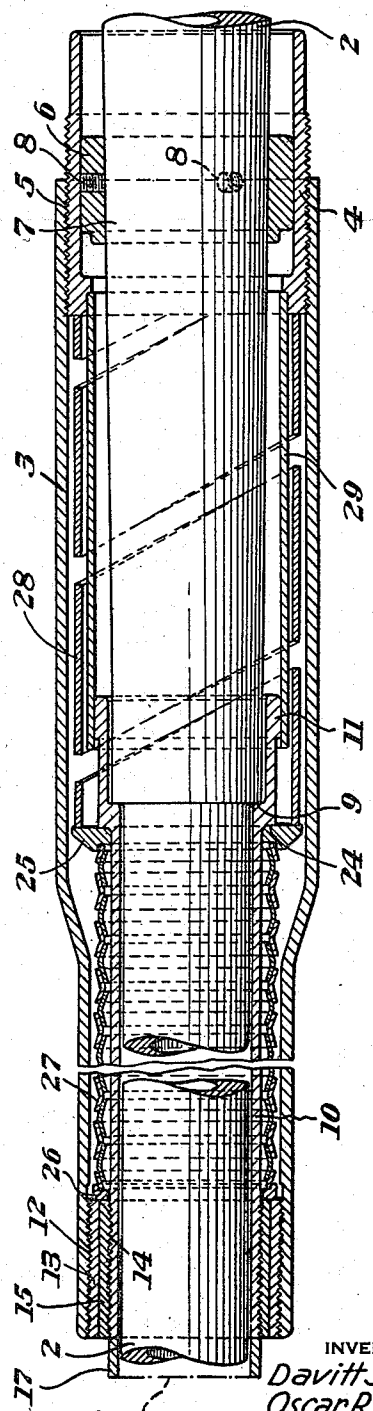


Fig. 2.

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Fig. 3.

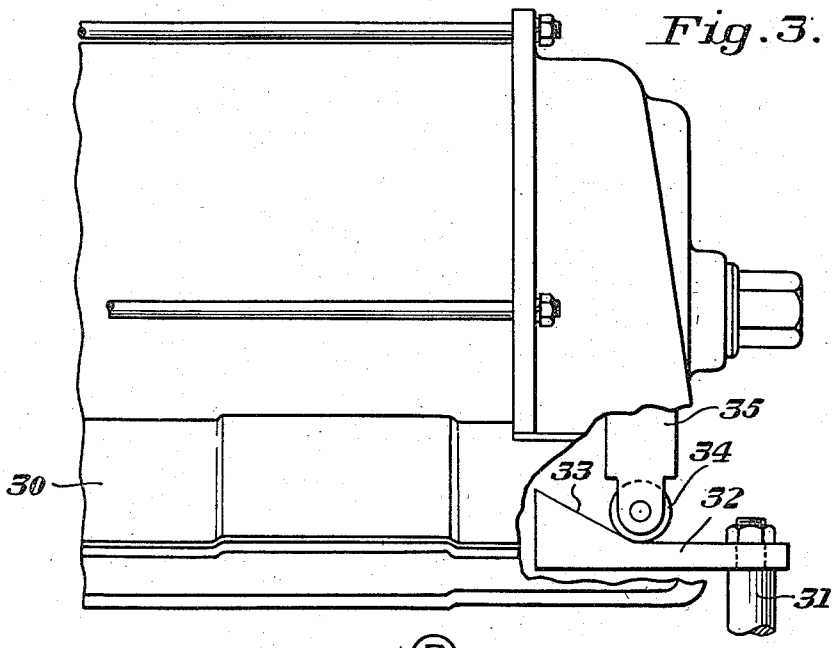
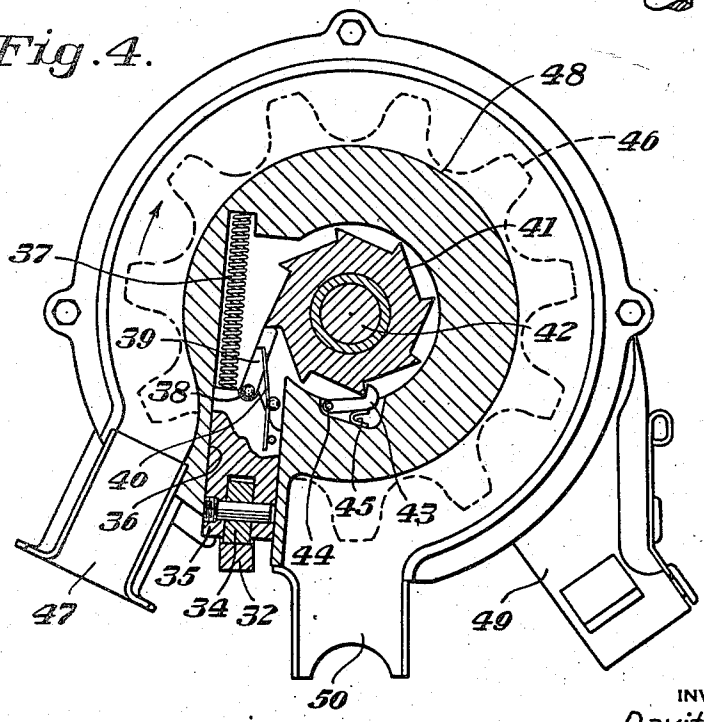


Fig. 4.



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AUTOMATIC GUN

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5 Claims. (Cl. 89—44)

This invention relates to automatic guns and particularly to the recoil mechanism thereof. It relates especially to that type of automatic guns in which the gun is movable on the mount and the mount is so constructed and arranged as to permit of recoil and return movement of the gun on firing thereof. The invention further relates to an adapter for automatic guns.

In our copending application Serial No. 383,538, now Patent 2,370,835, issued March 6, 1945, we have described and claimed an automatic gun of the type above mentioned employing an energy-absorbing spring having coacting friction surfaces for absorbing the recoil energy of the gun. A spring of the type mentioned has particular advantages when so employed as explained in said application. The present invention is in the nature of an improvement over the invention of said application.

Automatic guns of the type which are movable as a whole upon their mounts with the mount so constructed and arranged as to permit of recoil and return movement of the gun on firing thereof are frequently provided with ammunition feeding means adapted to be actuated by the recoil movement of the gun. At least a predetermined minimum amplitude of recoil movement is necessary upon each firing of the gun to insure proper operation of the ammunition feeding means. On the other hand, if the amplitude of recoil exceeds a predetermined maximum there is danger of damage to the gun or of faulty operation. In one well known type of gun this may occur through the gas cylinder striking the magazine slide.

Whatever the specific type of mounting or ammunition feeding means employed, it is important to insure that upon each firing of the gun the amplitude of recoil will always be between the limits above mentioned, that is, at least great enough to insure proper operation of the ammunition feeding means but not so great as to result in damage to the gun or faulty operation. This would not be a difficult problem to solve if the energy of recoil were the same upon each firing of the gun and the conditions of use were at all times uniform. In practice the opposite condition obtains. The recoil energy exerted upon firing of the gun varies widely depending upon the ammunition used and the conditions of operation. Ammunition of a given caliber contains different powder charges for different purposes. Considering for example a 20 mm. rapid firing cannon, the powder charge used with ordinary so-called "ball" ammunition is relatively light and exerts relatively less force upon firing of the gun than the powder charge employed with so-called "armor piercing" bullets. Moreover, powder charges of a given type are not always uniform and the force exerted upon firing may vary substantially.

Still further, the conditions of operation differ for gun mounts of different stiffness. A very elastic gun mount will permit the adapter support to recoil an appreciable amount, and thereby reduce the recoil energy taken up by the adapter spring. A more rigid gun mount, on the other hand, will not permit the adapter to recoil any appreciable amount, and the recoil energy of the gun relative to the adapter will be greater.

Therefore a problem exists of providing for at least a predetermined minimum and not more than a predetermined maximum recoil movement upon each firing of a rapid fire gun or cannon despite conditions which tend to make the amplitude of recoil vary quite substantially from time to time. In a particular type of rapid fire cannon, for example, a recoil of 22 mm. or .875" is required to operate the ammunition feeding means but the limit of recoil travel to avoid damage to the gun or faulty operation is 30.5 mm. or 1.213". Thus the amplitude of recoil must be controlled so as always to be between upper and lower limits which are only .338" or 8.5 mm. apart. The amplitude of recoil must lie between these relatively narrow limits whether the gun is firing ordinary ball ammunition or armor piercing ammunition and regardless of variations in the powder charges, the rigidity of the mount and other variables.

While the use of an energy-absorbing spring having coacting friction surfaces as disclosed in our said application is ordinarily satisfactory there are times when a spring of the type mentioned when used alone cannot be entirely relied upon. An ordinary substantially frictionless spring, such, for example, as a simple coil spring, when used alone has likewise been found not to be fully satisfactory under all conditions. We have discovered that satisfactory results can be relied upon under all conditions encountered in use of rapid fire guns if the recoil mechanism comprises a plurality of cooperatively acting springs including an energy-absorbing spring having coacting friction surfaces and a substantially frictionless spring. Preferably the substantially frictionless spring comes into operation predominantly in the first part of the recoil movement of the gun and is such as to insure that the recoil travel will always be at least the minimum required distance. The energy-absorb-

ing spring preferably is primarily active after the recoil has reached the predetermined minimum and insures stopping of the recoil movement before the predetermined maximum has been exceeded. Preferably the action of our recoil mechanism is made such that comparatively little resistance is offered to recoil until the predetermined minimum travel has been reached, thus insuring that even for relatively weak powder charges at least the predetermined minimum amount of recoil travel will occur, and that thereafter the recoil will be relatively quickly braked so that it will be stopped before the predetermined maximum is exceeded even when relatively powerful powder charges are employed.

We prefer to employ as our energy-absorbing spring a ring spring formed of interfitting elastic rings having coacting tapered friction surfaces, although other energy-absorbing springs may be used. We prefer to employ as our substantially frictionless spring an ordinary coil spring, although other equivalent springs may be used. The springs are preferably so arranged that the substantially frictionless spring first relatively weakly resists recoil and the energy-absorbing spring subsequently relatively powerfully resists recoil. Moreover, the energy-absorbing spring dissipates a substantial proportion of the energy of recoil as friction or heat, thereby tending to damp the counter-recoil movement, which is desirable. The energy-absorbing spring and the substantially frictionless spring may cooperate in various ways, as, for example, in series or in parallel. We find it satisfactory to arrange the springs in series, the substantially frictionless spring first being compressed and the energy-absorbing spring then rapidly bringing the recoil movement to a stop. We preferably provide means whereby compression of the substantially frictionless spring is limited so that after a predetermined point in the recoil travel the energy-absorbing spring only yieldingly resists recoil.

After the gun has returned to its original position in counter-recoil, it may still be moving forward, or "over travel," due to the kinetic energy imparted to it by the release forces of the springs. This forward movement might be stopped by making the entire spring mechanism double-acting, as is the ring spring in our said application. As a rule it is, however, desirable to make the over-travel as short as possible without producing excessive counter-recoil forces. We preferably arrange the springs so that only the more powerful energy-absorbing spring is double-acting and serves alone to resist the movement of the gun in over-travel.

The spring mechanism as herein disclosed is adapted for application to a previously existing gun.

Other details, objects and advantages of the invention will become apparent as the following description of a present preferred embodiment thereof proceeds.

In the accompanying drawings we have shown a present preferred embodiment of the invention, in which

Figures 1 and 2 taken together constitute a central longitudinal cross-sectional view of recoil mechanism for a rapid fire cannon, a portion of the barrel being also shown;

Figure 3 is an elevational view of a portion of the gun housing showing a part of the ammunition feeding means; and

Figure 4 is a vertical transverse cross-sectional view through the ammunition feeding means.

Referring now more particularly to the drawings, the gun barrel is shown at 2 in Figures 1 and 2. As will be apparent, Figure 2 shows the portion of the mechanism disposed to the right of the portion shown in Figure 1 so that Figures 1 and 2 should be considered as a single figure broken at the line B. There is provided a housing 3 threadedly connected to a collar 4 by threads 5, the housing and collar forming parts of the gun mount, which mount may also include a bracket connected with an airplane, tank or other vehicle or a tripod or other gun carrying device to which the housing and/or collar may be fastened. In any event, the housing 3 may be considered as stationary with the mount and forming a part thereof. The gun is carried by the mount and housing but is movable relatively thereto upon recoil, counter-recoil and over-travel.

A bushing 6 is driven onto the tapered portion 7 of the barrel 2 and held in place by set screws 8. The bushing 6 is externally cylindrical and is slidable within the collar 4. The barrel has a shoulder 9 and a sleeve 10 having an enlargement 11 at its inner end surrounds the portion of the barrel to the left of the shoulder 9 viewing Figure 2 and abuts against the shoulder as shown in that figure. Threaded to the housing 3 internally thereof at 12 is a collar 13 and threaded to the sleeve 10 externally thereof at 14 is a collar 15. The inner surface of the collar 13 and the outer surface of the collar 15 are smooth and these collars cooperate to form bearings which cooperate with other bearings to be described to maintain the parts in alignment during operation of the gun.

The sleeve 10 is connected with the gun barrel 2 so that when the gun is fired (the muzzle or discharge end 16 of the barrel being at the extreme left hand end of Figure 1) and the gun proper, including the barrel, recoils to the right viewing Figure 2 the sleeve 10 will move to the right with the barrel. Such connection may be accomplished in various ways, the structure shown in the drawings comprising an extension sleeve 17 (Figures 1 and 2) which is slipped over the end of the barrel and abuts the left hand end of the sleeve 10 as shown at the left hand end of Figure 2. The muzzle end of the barrel is externally threaded at 18 and the barrel is also splined at 19. A lock nut 20 is screwed onto the end of the barrel and tightened up firmly against the left hand end of the extension sleeve 17 (Figure 1). When the lock nut is thus tightened up its right hand end will overlie the splines 19 of the barrel. The lock nut has a groove 21 in which is adapted to be positioned a lock nut spring 22 having at one end a radial projection 23 adapted to enter a groove between two of the splines 19 to hold the lock nut against unscrewing. Thus when the barrel 2 recoils toward the right viewing Figures 1 and 2 upon firing the lock nut 20, extension sleeve 17 and sleeve 10 move with the barrel as a unit.

The sleeve 10 itself has an external shoulder 24 facing toward the left viewing Figure 2 and a follower collar 25 abuts against such shoulder. Another collar 26 abuts against the right hand ends of the sleeves 13 and 15. Between the collars 25 and 26 is disposed an energy-absorbing spring having coacting friction surfaces. In the structure shown in the drawings such spring is a ring spring 27 which per se may be of known construction. The ring spring 27 comprises interfitting elastic rings having coacting tapered fric-

tion surfaces. Upon being compressed it transforms a substantial part of the kinetic energy of compression into heat of friction and stores up part of such energy which is recoverable when the spring is released. The characteristics of such springs are known and need not here be detailed.

Between the follower collar 25 and the collar 4 is a substantially frictionless spring shown as in the form of a flat coil spring 28. Fastened to the collar 4 as by brazing or welding so as to be in effect integral therewith is a stop sleeve 29. Such sleeve extends towards the left from the collar 4 inside the coil spring 28 as shown in Figure 2 but terminates at a point substantially spaced from the follower collar 25 when the parts are at rest as shown in such figure. The enlargement 11 of the sleeve 10 has sliding engagement or bearing with the interior of the stop sleeve 29 whereby to cooperate with the collars 13 and 15 to maintain the parts in proper alignment during operation of the gun.

When the gun is fired the gun proper including the barrel 2 recoils towards the right viewing Figures 1 and 2. The barrel carries with it upon recoil the sleeves 10 and 17 as before described. The housing 3 and collar 4, however, remain stationary relatively to the mount or the vehicle upon which the gun is carried so that the sleeve 10 upon recoil moves toward the right viewing Figure 2 relatively to the housing 3. During the initial part of the recoil the coil spring 28 is compressed as its right hand end bears against the stationary collar 4 and its left hand end bears against the follower collar 25 which is held against the shoulder 24 of the sleeve 10 by the ring spring 27. The ring spring 27 is substantially stronger than the coil spring 28 so that the coil spring is compressed until the sleeve 10 and follower collar 25 have moved toward the right to the point at which such collar engages the left hand end of the stop sleeve 29. Since the stop sleeve 29 is in effect integral with the housing 3 which is stationary the follower collar 25 can move no farther and during the subsequent part of the recoil travel the ring spring 27 comes into play to rapidly brake and terminate the recoil movement.

Thus the coil spring 28 allows comparatively free recoil until the follower collar 25 strikes the stop sleeve 29, after which the ring spring 27 quickly brakes the recoil. The coil spring 28 is made light enough so that at least the predetermined minimum recoil travel will always occur with even the least powerful ammunition which may be used. On the other hand, the ring spring 27 is strong and effective enough to terminate the recoil movement before the predetermined maximum recoil travel has been exceeded.

In counter-recoil, the comparatively moderate release energy of the energy-absorbing spring added to that of the substantially frictionless spring will move the gun back toward and beyond its original position unless a new shot is fired before this movement is completed. This is usually not the case and, as a rule, after every shot the gun not only moves back into its original position but reaches the latter at a speed which will produce over-travel causing recompression of the double-acting energy-absorbing spring. After the last shot in a burst, such over-travel is bound to occur. When such over-travel occurs it will always be limited to a short distance, due to the cushioning action of the energy-absorbing spring.

The recoil mechanism described insures that the ammunition feeding mechanism, now to be described, will always function properly.

The ammunition feeding mechanism is illustrated more or less diagrammatically in Figures 3 and 4. A portion of the gun casing is shown at 30, a part of the casing being broken away to illustrate a portion of the ammunition feeding means. The gun fires toward the right viewing Figure 3 so that the gun including the casing 30 recoils toward the left viewing that figure.

Fixed to the stationary mount by a bolt 31 is an operating member for the ammunition feeding means, such operating member being designated generally by reference numeral 32 and comprising an inclined cam surface 33. A follower roller 34 lies above the operating member 32 in cooperative relationship therewith as shown in Figure 3. Upon firing of the gun the gun recoils toward the left viewing Figure 3 and the roller 34 rides up the inclined cam surface 33 to operate the ammunition feeding means as now to be described.

The roller 34 is rotatably carried by a slide 35 slidable in a guideway 36 in the gun mechanism, the slide 35 being urged downwardly viewing Figure 4 by a coil spring 37. This insures the roller 34 always being in contact with the operating member 32. Pivoted to the slide 35 at 38 is a pawl 39 biased to turn in the clockwise direction about the axis of the pivot 38 viewing Figure 4 by a spring 40. The pawl 39 cooperates with a ratchet 41 rotatably carried by a shaft 42. A hook shaped pawl 43 is pivoted to the gun mechanism at 44 and also cooperates with the ratchet 41 to prevent retrograde movement thereof, being biased toward the ratchet by a spring 45. Thus upon each recoil movement of the gun the slide 35 moves upwardly in the guideway 36 and the pawl 39 turns the ratchet 41 in the clockwise direction about the axis of the shaft 42 viewing Figure 4 through the space of one tooth and the pawl 43 holds the ratchet against turning back in the counterclockwise direction when the slide 35 returns to its lower or normal position as shown in Figure 3.

The ratchet 41 is effective for winding a spring (not shown) which in turn operates a sprocket wheel 46 in the clockwise direction viewing Figure 4. Since the operating mechanism for the sprocket wheel is known in the art and does not per se constitute the present invention and is not herein claimed it is not shown in detail. However upon each firing of the gun the mechanism above described operates through the spring wound by the ratchet 41 to advance the sprocket wheel 46 one step. The cartridge belt enters through the opening 47 and is trained about the sprocket 46 in the clockwise direction viewing Figure 4. The sprocket wheel moves the cartridge belt with the cartridges therein about the periphery of a cylinder 48. The belt may be made up of separable links. After each cartridge has passed around a part of the circumference of the cylinder 48 it is withdrawn from the belt by a portion of the gun mechanism (not shown) and the link connecting such cartridge to the belt is ejected through the chute 49. The cartridge passes on and enters the firing mechanism of the gun through the chute 50.

It will be appreciated that to insure operation of the ammunition feeding means upon the firing of each cartridge the slide 35 must partake of an amplitude of movement sufficient to advance the ratchet 41 through the space of one

complete tooth. Further movement of the slide 35 is not detrimental so far as the ammunition feeding means is concerned as there is no possibility of the slide turning the ratchet through the space of two teeth upon one operation of the slide. Thus it is essential in order to insure sufficient amplitude of movement of the slide 35 upon the firing of each cartridge or round of ammunition that the recoil movement of the gun be of sufficient amplitude longitudinally of the operating member 32 to cause the roller 34 to ride up the cam surface 33 far enough to cause the slide 35 to advance the ratchet 41 through the space of one complete tooth.

On the other hand excessive recoil of the gun may cause damage to other parts as above mentioned. The recoil mechanism above described and hereinafter claimed insures an amplitude of recoil upon each firing of the gun which lies between predetermined limits and results always in operation of the ammunition feeding means without damage to the gun.

In the form shown in Figures 1 and 2 the recoil mechanism is constructed as an adapter so that it is applicable to a previously existing gun. The previously existing gun would have the barrel 2 exposed. In applying the adapter thereto the bushing 6 is first applied as above explained, after which the mechanism shown in Figure 2 other than the barrel 2, bushing 6, set screws 8 and extension sleeve 17 is slid over the barrel, the component parts of such mechanism being temporarily maintained in assembled relationship with the springs 27 and 28 under light compression in any convenient manner. The extension sleeve 17 is then slid over the end of the barrel and the lock nut 20 and lock nut spring 22 are applied as above described. The housing 3 is, as above described, secured to the gun mount and an unrestricted rear slide support for the gun is provided.

While we have shown and described a present preferred embodiment of the invention it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied within the scope of the following claims.

We claim:

1. In combination, an automatic gun having a barrel, a mount therefor having a shoulder thereon, the gun being movable relative to said mount to permit recoil and return movement of the gun on firing thereof, spaced abutments carried by said barrel and movable therewith, a substantially frictionless spring between one of said abutments and the shoulder on the mount, and an energy absorbing spring extending between said one abutment and the other abutment, said frictionless spring permitting at least a predetermined minimum recoil of the gun and the energy absorbing spring so constructed and arranged so as to limit the total recoil to not over a predetermined amount.

2. In combination, an automatic gun having a barrel, a mount therefor having a shoulder thereon, the gun being movable relative to said mount to permit recoil and return movement of the gun on firing thereof, spaced abutments carried by said barrel and movable therewith, a substantially frictionless spring between one of said abutments and the shoulder on the mount, and an energy absorbing spring having coacting friction surfaces extending between said one abutment and the other abutment, said frictionless spring permitting at least a predetermined minimum recoil of the gun and the energy absorbing spring so constructed and arranged so as to limit the total recoil to not over a predetermined amount.

3. In combination, an automatic gun having a barrel, a mount therefor having a shoulder thereon, the gun being movable relative to said mount, the mount being so constructed and arranged as to permit recoil and return movement of the gun on firing thereof, a sleeve carried by the barrel and movable therewith and having spaced abutments thereon, a substantially frictionless spring between one of said abutments and the shoulder on the mount and an energy absorbing spring between said one abutment and the other abutment, said frictionless spring permitting at least a predetermined minimum recoil of the gun and the energy absorbing spring so constructed and arranged so as to operate primarily after said predetermined recoil to limit the total recoil to not over a predetermined amount.

4. In combination, an automatic gun having a barrel, a mount therefor having a shoulder at its outer end and a shoulder at its inner end, the gun being movable relative to the mount so as to permit recoil and return movement of the barrel on firing thereof, a sleeve carried by said barrel and movable therewith and having spaced abutments thereon, one of said abutments having a face thereon lying in the same plane as the face on the shoulder carried by the outer end of the mount, a substantially frictionless spring between one abutment and the inner shoulder on the mount and an energy absorbing spring between said last named abutment and the other abutment, said spring also engaging the face on the shoulder carried by the outer end of the mount to limit return movement of the barrel.

5. In combination, an automatic gun having a barrel, a mount therefor having a shoulder at its rear end and a ring removably secured at its forward end and having a radially extending face thereon, said barrel being carried in the mount so as to permit recoil and return movement of the barrel relative thereto, a sleeve surrounding said barrel and having a collar thereon at its rear end and a removable ring on its forward end having a radial face thereon lying in the plane of the radial face of the ring on the mount, said sleeve with its collar and ring being movable with the barrel, a substantially frictionless spring interposed between the shoulder on the mount and the collar on the sleeve, and an energy absorbing spring having one end in engagement with said collar and its other end in engagement with the radial faces of the rings carried by the sleeve and mount, when the gun is in normal position said rings being in sliding engagement and supporting and centering the barrel within the mount.

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