June 21, 1960 L. R. CRITTENDON ET AL 2,941,450

GAS OPERATING MECHANISM FOR AN AUTOLOADING FIREARM

Filed May 2, 1956 2 Sheets-Sheet 1

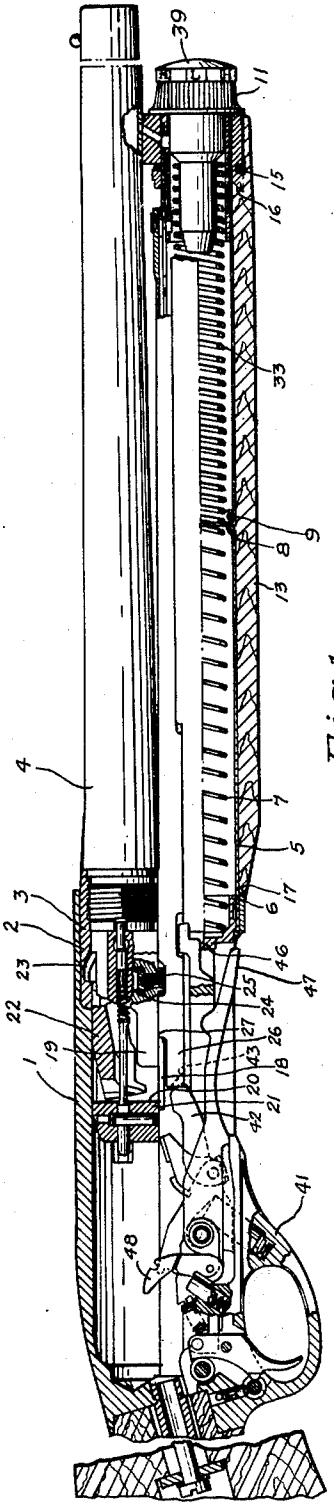


Fig. 1

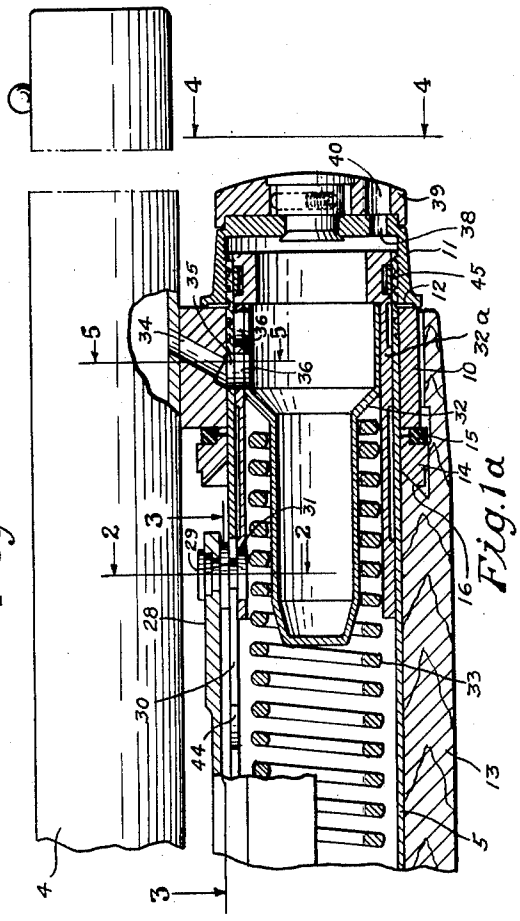


Fig. 1a

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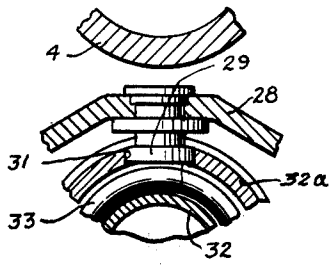


Fig. 2

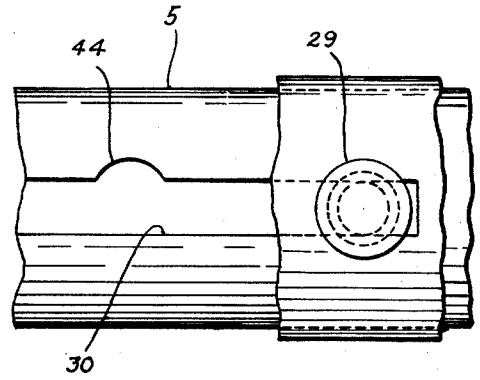


Fig. 3

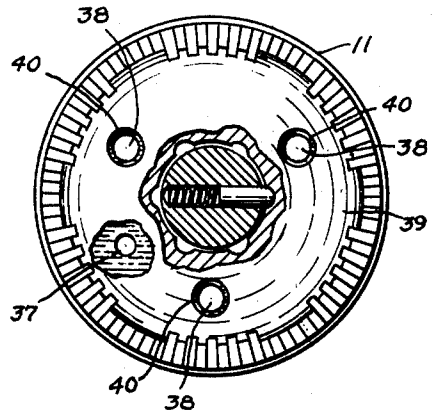


Fig. 4

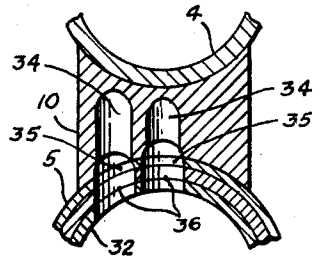


Fig. 5

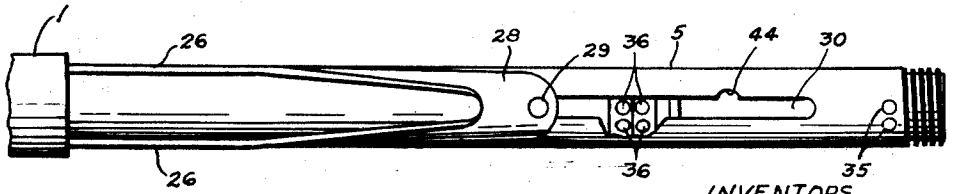


Fig. 6

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2,941,450

GAS OPERATING MECHANISM FOR AN AUTOLOADING FIREARM

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3 Claims. (Cl. 89—191)

This invention relates to an autoloading firearm and more particularly to an autoloading shotgun which may be produced in the various conventional shot shell gauges and which will be capable in any gauge of handling the diversity of various powered shot shells commerciallly available.

There have been available for many years autoloading shotguns which depend for their performance on utilization of the recoil motion imparted to a movably mounted barrel by the firing of the shot shell. While such shotguns have enjoyed wide acceptance, they are expensive to manufacture, for great care must be employed in their construction to insure that the recoil movement of the barrel is accurately guided and that the forces generated in stopping that recoil motion are adequately absorbed. Further, the motion of the barrel and the consequent redistribution of the recoil forces are disturbing to some shooters. There have been attempts, as exemplified by U.S. Patent No. 2,482,880, to operate an autoloading shot gun by means of gas pressure derived from the shot shell propellant. Insofar as we are aware, such designs have not been commercially acceptable and it is believed that difficulty may have been found in adapting this principle to successful operation with a range of high-powered and low-powered shot shells with which a commercial design must be capable of operating.

It is the principal object of this invention to produce a fixed barrel autoloading shotgun which may be manufactured with great economy and which is capable of functioning with the variety of high and low-powered shot shells commercially available.

In order to accomplish this result, we propose to utilize to the greatest possible extent complete assemblies and individual parts commercially available as parts of an existing fixed barrel manually operated repeating shotgun. Such a manually operated shotgun is illustrated in U.S. Patent No. 2,645,873 and the fire control assembly which is an important component thereof is illustrated in detail in U.S. Patent No. 2,675,638. We contemplate that this manually operated shotgun may be best converted to autoloading operation by the utilization of operating power derived from two sources. One of these sources of power is the excess energy contained in the charge of expanding gas which forces the shot pellets through the barrel of the shotgun. We propose to tap this source of power by providing a gas port communicating with the barrel in the manner of the conventional gas operated firearm and to apply the gas thus diverted from the barrel to provide part of the force needed to operate the autoloading mechanism. The other source of power is that found in the inertia effects resulting from the recoil of the gun as a whole and the stoppage of that recoil by the opposition provided by the shooter's shoulder. By the proper utilization and proportioning of these two sources of power, we have been able to produce an autoloading shotgun which, with a minimum of manual adjustment, functions adequately and dependably with the full range of various powered shot shells commercially available in the appropriate gauges, extending from the relatively low powered loads provided for trap shooting to the heaviest hunting loads. In 12 gauge, the range is from 2¾ to 4 dram equivalent powder charge with 1 to 1½ ounces of shot.

The exact nature of the invention, including several refinements in detail as well as other objects and advantages thereof, will become apparent from consideration of the following specification, referring to the attached drawings in which:

Fig. 1 is a longitudinal vertical sectional view through a shotgun produced in accordance with our invention.

Fig. 1*a* is an enlarged fragment of Fig. 1.

Fig. 2 is a vertical cross-sectional view on the line 2—2 of Fig. 1, illustrating the attachment of the action bars to the gas piston.

Fig. 3 is a horizontal sectional view illustrating the attachment of the action bars to the gas piston. It is taken on the line 3—3 of Fig. 1.

Fig. 4 is a vertical cross-sectional view taken on the line 4—4 of Fig 1, illustrating the adjustments possible with the magazine cap.

Fig. 5 is a vertical cross-sectional view through the gas port portion of the mechanism taken on the line 5—5 of Fig. 1.

Fig. 6 is a fragmentary top plan view with the barrel, fore-end, and magazine cap removed from the shutgun.

Referring to the drawings, it will be seen that the shotgun illustrated therein corresponds generally to that shown in U.S. Patent No. 2,645,873 above referred to. It will be noted that the shotgun comprises a receiver **1** having a counterbore **2** in which there is received a barrel extension **3** secured to or integral with a barrel **4**. A magazine tube **5**, which also functions at its forward end as a gas cylinder, extends into the receiver in axial parallelism with the barrel and is rigidly secured to the receiver as by a furnace or induction brazing operation. The magazine tube houses the usual magazine follower **6** and follower spring **7**, the latter abutting at its forward end against a magazine spring stop **8** secured in place by a crosspin **9** or a crimped impression in the magazine tube. A barrel guide ring **10** is secured to the barrel **4** in position to embrace the forward or gas cylinder end of the magazine tube when the barrel extension is seated in the receiver. Assembly of the barrel to the receiver is maintained by a magazine cap **11**, which threadably engages the magazine tube and bears against the forward face of the barrel guide ring **10**. The cap is releasably retained in position by a spring-urged detent plunger housed in the barrel guide ring and engageable with serrations **12** in the rear face of the magazine cap. As the description proceeds, it will become apparent that this construction permits taking down the gun or replacing barrels without disturbance or disassembly of the gas cylinder, piston or other internal working parts.

A wooden fore-end **13** substantially encloses the magazine tube and closes the gap between the magazine tube and the barrel **4**. This wooden fore-end is secured in place by a resilient rubber-like fore-end ring washer **15** engaged by the rear face of the barrel guide ring and urging a fore-end ring **14** having an undercut conical rear face into secure engagement with an undercut forwardly facing abutment **16** formed in the wood of the fore-end. At the rear end of the fore-end an angularly disposed tenon **17** is received in a matching cut in the forward face of the receiver. The inter-engagement of the tenon **17** with the receiver cut and the similar inter-engagement of the fore-end ring **14** with the undercut abutment **16** provides reinforcement to the wooden fore-end and prevents splitting thereof without requiring the usual provision of a metal liner cemented therein and thereby permits a substantial saving in weight.

Within the receiver 1 a breech bolt slide 18 is mounted for fore and aft reciprocation and guided by means which will later be described. This slide 18 is provided with a substantially rectangular lug 19 which is received within an aperture 20 formed in the body of a breech bolt 21. As in the patent previously referred to, a locking block 22 is also received in this aperture and has the function of interlocking the breech bolt 21 with the barrel extension 3 through the medium of a locking lug 23 engaged with a suitably shaped recess in the barrel extension. An operating handle 24 passes horizontally through a clearance aperture in the sidewall of the breech bolt into engagement with the breech bolt slide and is there releasably retained by means of a spring-urged detent plunger 25.

As in the case of the prior patent above referred to, a pair of action bars 26 are provided which are slidable in fore and aft grooves formed in the sidewalls of the receiver. The action bars are interlocked with the breech bolt slide by means of lugs 27 on the action bars engaged in cut-outs in the side flanges of the breech bolt slide. By this means the breech bolt slide and breech bolt are supported from the longiudinal guide grooves in the receiver walls and confined between the action bars and the top wall of the receiver. The action bars extend forwardly out of the receiver and continue in the space between the magazine tube and the barrel to a point where they are joined by a connecting bridge 28 formed integrally with the pair of action bars. A formed rivet 29 is secured to the connecting bridge 28 and passes through an elongated slot 30 in the magazine tube 5 into engagement with a hole 31 formed in the skirt 32*a* assembled in unitary fashion with a gas piston 32. The gas piston 32 is slidably received in the forward or gas cylinder end of the magazine tube 5 and is urged to a forward position therein by the force applied by a breech closing spring 33, also housed within the magazine tube and engaged at its rear end against the spring stop 8. The action bars are preferably slender, resilient members capable of flexing sufficiently to aid in smoothing out any peaks in the forces transmitted from the gas piston to the breech bolt slide.

Propellent powder gas is tapped from the barrel 4 through a pair of gas ports 34 drilled forwardly and upwardly through the barrel guide ring to intersect at an acute angle with the bore of the barrel. With the mechanism in the assembled position, the gas ports 34 communicate with matching gas ports 35 in the wall of the gas cylinder end of the magazine tube and, with the gas piston in its foremost position, these two previously mentioned gas ports communicate with gas ports 36 formed in the skirt 32*a* of the gas piston 32. The ports 36 are duplexed as best seen in Fig. 6 so that the ports 35 remain in communication with the interior of the gas piston after movement of the piston. By this means, propellent powder gases from the bore of the barrel are applied to the space within the gas piston end, expanding within the chamber provided between the gas piston and the magazine cap, act upon the piston to move the piston rearwardly to operate the breech bolt slide and mechanism associated therewith. As will be noted, a small gas vent 37 and threee larger gas vents 38 are provided in the magazine cap. Through manipulation of the selector dial 39 which is rotatably mounted on the magazine cap and provided with apertures 40, either the small vent 37 or all three of the larger vents 38 may be placed in communication with the atmosphere to provide a selected degree of gas escape from the magazine tube or gas cylinder. This arrangement permits a portion of the gas admitted to the magazine tube to be bled out to atmosphere with important advantages in maintaining the cleanliness of the system as well as in improved functioning. Since this escape of gas is through the magazine cap rather than inside the fore-end, it does not tend to split or otherwise weaken the fore-end which does not therefore require internal reinforcement with a steel sleeve.

Within the receiver 1 there is mounted a trigger plate 41 corresponding substantially to that shown in both of the Patents Nos. 2,645,873 and 2,675,638, previously referred to. This fire control assembly differs from that shown in the first-mentioned prior patents only in that the disconnector 42 is so formed at its forward end that it does not act as an action bar lock but is, instead, overridden by the angular rear end 43 on one of the action bars and downwardly displaced thereby whenever the action bar is rearwardly displaced by any substantial amount from its forward or breech locked position. The result of this overriding of the disconnector is to disable the fire control mechanism and make it impossible to release the hammer unless the breech is closed and securely locked to the barrel extension 3. By reference to either of the cited patents, it can be noted that the fire control mechanism is a disconnector type of fire control which does not permit the trigger to reassume control of the hammer after firing a shot unless or until the trigger finger is completely relaxed to allow the trigger to return to its forward position. In this way, it is possible to prevent full automatic fire, as in a machine gun.

As previously noted, the autoloading operation of this firearm is dependent on the use of power derived from two sources. Considering first, the power derived from the inertia effects, it will be noted that the system comprising the breech bolt 21, the locking block 22, the breech bolt slide 19, the dual action bars 26, and the gas piston 32, is one involving parts of substantial weight and inertia. In typical 12, 16, and 20 gauge embodiments of our invention the breech bolt slide 19, dual action bars 26 and gas piston 32, which is the portion of the system on which inertia forces are effective prior to unlocking of the breech bolt, have a weight of substantially 8 ounces and this may be as low as six ounces without substantial reduction in benefits received from inertia effects. The breech bolt 21 and locking block 22 have a weight which is determined by the gauge of the shotgun, typical values for a 12 gauge gun being 7.2 ounces. Once the locking block has been disengaged from the barrel extension, inertia effects come into play on the entire moving system which has a weight of about 15½ ounces in a 12 gauge gun.

When the shotgun is fired in normal operation, the entire gun has a tendency to recoil rearwardly as a result of the well-known law of motion that to every action there is an equal and opposite reaction. With any human shooter, there is an initial period of substantially free recoil consumed in the compression of the shooter's clothing and the softer layers of flesh overlying the bony structure of his shoulder. During this initial period of free recoil, the entire gun mechanism acquires a substantial rearward velocity. At the close of the initial period of free recoil, the shooter's shoulder begins to resist recoil movement with increasing force and the buttstock of the shotgun and those parts rigidly associated therewith are decelerated. As pointed out above, however, the breech bolt slide and parts rigidly associated therewith are held in their foremost position by the action spring 33 and when these parts have been moved rearwardly enough to unlock the locking block the masses of the bolt, locking block and of the fired shell are added to the relatively movable parts of the system. As a result, when the buttstock, receiver, and barrel are decelerated there is a tendency for the breech slide and those parts associated therewith to continue in rearward motion, such motion being opposed only by the forces of friction and by the force of the action spring 33. Although the force derived in this way is not sufficient to produce complete autoloading functioning of the firearm unless excessively heavy inertia weights are added to the system, it does provide a substantial operating force. The reality

of this force may be readily demonstrated by closing the gas ports 34 or by substituting a barrel which is not provided with a gas port. If, at the same time, the action spring 33 is entirely removed or replaced by a relatively light spring, the arm may be fired in the normal manner and visual observation will show that the inertia effects have causes the breech mechanism to be unlocked and partially opened. The effect of inertia on the functioning of the arm can be substantially removed by holding the weapon free at arm's length and firing it in such a way that there is no substantial opposition to free recoil of the entire system. When so fired, it will be noted that even in the complete absence of an action spring 33, the breech mechanism will not be unlocked or opened as a result of firing. It has been observed that the magnitude of this effect is not altogether dependent on the power of the shot shell load employed. In fact, the operating force derived from inertia is not much greater when the heavy hunting loads are fired than it is when light trap and skeet loads are fired. Actually, the variable resistance at a shooter's shoulder or shooting style causes a materially greater change in operating force derived from inertia than does a change in loading of the shot shell. In all cases of firing from the human shoulder, the force derived from inertia is, however, a substantial and essential contribution to the operation of the firearm.

As previously noted, the balance of the power necessary to effect autoloading operation of the firearm is obtained by tapping gas from the barrel through the gas ports 34. With a gas port area in the vicinity of .0250 square inch for a 12 gauge gun, the relationship between the exact gas port area and the operating power derived therefrom is fairly linear. If this area is obtained with a single port, however, there is an occasional tendency for performance to be somewhat erratic. We have found that it is desirable to apportion this gas port area among a plurality of ports of lesser diameter, which as noted from the drawing enter the barrel at an angle to the line of projection of the shot charge therein. Several advantages are derived from this division of gas port area, one being that the smaller diameter gas ports permitted thereby minimize the amount of lead, wad fragments, etc. associated with the shot charge, which to some extent tend to pass through or to momentarily lodge in the gas ports. It has also been established through considerations of the flow of gas through orifices that when the exit channel is narrowed the flow is slowed down over and above that which would be expected simply by the reduction in area. Thus, even though the total gas port area is the same, there will be less gas flowing through two or three small gas ports than through one port and the flow through the multiple ports is much more consistent from shot to shot.

We have found that for 12 gauge shotguns a total gas port area of 0.0257 square inch is near the optimum and that an area of 0.030 square inch is about the maximum permissible. We have also found that we get adequate uniformity and throttling of the gas flowing through the orifices if the total area is apportioned between two or more ports. For example, each of two gas ports having a diameter of 0.1285 inch has an area of substantially 0.01297 square inch, so that two such ports have a total area of substantially 0.02594 square inch and have proven to be entirely satisfactory. Further, ports of this diameter tend to be self-cleaning and are not likely to be partially closed with carbonaceous deposit as may be the case with substantially smaller ports. With the smaller gauges of shotguns where operating pressures are generally higher and the weight of reciprocating parts to be moved are somewhat less, a smaller gas port is desirable and this smaller area can be obtained by moderate reductions in the diameter of the gas ports.

It has also been noted that the magazine cap 11 is provided with one venting aperture 37 and with three venting apertures 38 selectively used and through which a portion of the gases admitted to the gas operating system are permitted to escape to atmosphere. The selection of whether the single aperture 37 or the multiple apertures 38 are in alignment with the holes 40 is, as noted, determined by the setting of the selector dial 39 in accordance with the power of the loads being used, multiple apertures being used for high-powered loads such as the 2¾" Magnum loads and the single small aperture being used with lower powered field and trap loads.

The venting of the gas system presents a number of significant advantages, one being related to the fact that moisture, debris and fouling of various sorts which might otherwise tend to condense on or accumulate within the gas operating system will be readily discharged through these apertures, and the forward return movement of the gas piston provides a scavenging action to clean out the system. This action prevents the accumulation of condensed moisture which could cause rusting, and the accumulation of other condensed gaseous products of combustion which could tend to deposit solid fouling of a carbonaceous nature.

Another extremely important advantage of the vented gas system becomes apparent from theoretical consideration of the flow of gas through throttling orifices which establishes that the rate of flow through such an orifice is not as dependent upon the differential pressure across the orifice as would ordinarily be expected. In fact, in a system of this kind it can be shown that less gas will flow through the orifice into a system having a low pressure on the downstream side of the orifice than would flow into a system having a higher downstream pressure which is exactly opposite to the expected effect. Venting of the gas system from the downstream side of the throttling orifice therefore permits:

(1) The use of orifices from the barrel of size sufficient to ensure that they will not become clogged, and

(2) Exerts a two-fold effect in reducing the forces acting on the piston by:

(*a*) Bleeding off gas which would exert pressure on the piston; and

(*b*) As a result of the decreased downstream pressure resulting from the vent, the rate of flow through the throttling orifice is also reduced.

The end result is increased reliability of performance and the decrease of shock loads upon the gas piston, the action bars and other movable elements of the system with increased service life for all.

With 12 gauge, Trap, Skeet, or low base field loads a single venting aperture .067 inch in diameter is adequate but with such high-powered loads as the 12 gauge, 2¾" Magnum, it is preferable, as pointed out before, to utilize three venting apertures each of which may be 0.128 inch in diameter. The selector dial permits the choice to be made by the shooter in accordance with the loads being used.

In order to successfully accommodate the diversity of loads with which the modern shotgun is faced, we have deliberately designed the gas ports and the gas vents in the magazine cap to provide so little power that the firearm will not operate as an autoloader with any but the very high-powered loads unless the gas operating force is augmented by the forces derived from inertia and previously discussed herein. Although the operating forces derived from the two sources are additive and both increase with the more powerful shot shells, the net result of this combination of two operating forces is to impose on the mechanism shock loadings of substantially smaller magnitude than would be applied if an attempt were made to operate solely by means of power derived from the gas, as has always been the case heretofore in weapons utilizing gas power.

As has been previously noted, the forces derived from inertia may be substantially eliminated by firing the arm

at arm's length and so supported as to minimize the opposition to free recoil. With the arm fired in this way and depending for operating power solely on gas passing through the gas ports, it may be demonstrated that with the low-powered loads there will be consistent failures to extract the fired shell or to eject it from the receiver after firing. When these same loads are fired from the shoulder in the normal manner, the forces derived from inertia will produce consistent functioning with any type of shooter, whether he be one who holds his firearm loosely and shoots with a slack shoulder or in such a way as to roll with the recoil, or whether he be a shooter who holds his arm rigidly and backs up the buttstock of the gun with a very firmly supported shoulder. With the higher powered loads enough additional force is derived from the gas that there will be only occasional failures to extract when the gun is fired in a free recoil condition, showing that with such loads our shotgun borders on being fully gas-operated. In normal operation, the gun will be fired with the relatively low-powered loads with a small venting aperture in the magazine cap and when a change is made to the relatively high-powered shot shells, the selector will be changed to expose the multiple vents of a larger diameter to minimize shock loads on the mechanism. No immediate harm, however, will result from firing the high-powered loads with the smaller vent aperture, since it requires an accumulation of excessive shock loadings to cause any appreciable damage to the working mechanism.

For details of the novel interconnection between the action bars and the gas piston, reference may be had particularly to Figs. 2 and 3. It will be noted that the rivet **29** is permanently attached to the action bar bridge **28** and that this rivet is provided with a necked-down portion which passes through and is guided by the slot **30** in the wall of the magazine tube. The head **29** on the inner end of the rivet has a greater diameter than the width of the slot, so that the action bars are snugly guided in parallelism with the magazine tube and the rivet is securely held in position to remain engaged within the hole **31** in the skirt **32***a* of the gas piston. Disassembly of the mechanism for inspection and cleaning is permitted by the provision at one point along the slot **30** of a disassembly notch **44** of large enough diameter to permit the passage of the rivet head **29**. With the action bars retracted to bring the rivet **29** into registry with the disassembly notch and with the barrel removed from the firearm, the action bars may be twisted to one side and upwardly to disengage the rivet from the gas piston skirt and permit the piston to be expelled by the action spring through the front of the magazine tube. Assembly is effected in reverse order by placing the gas piston in the magazine tube and compressing the action spring to bring the hole **31** into registry with the disassembly notch **44**, the rivet **29** being inserted therethrough and engaged within the hole **31**. It may also be noted that the skirt **32***a* of the gas piston **32** is provided with a piston ring **45**. The piston ring has a relatively loose fit in an annular groove in the piston and maintains an adequate gas seal with the wall of the magazine tube while permitting the piston itself to fit relatively loosely therein. The piston ring also acts as an effective scraper, tending to remove any carbonaceous or other deposits which may form on the inner wall of the magazine and tend to impede the operation of the gas piston. The piston skirt is relieved on its outer circumference except in spaced bands to minimize the area contacting the wall of the magazine tube. The combination of the scraping action of the piston ring and a looser piston fit permitted by this construction results in an arm which may be fired for several thousands of rounds without requiring any cleaning of the gas operating system. Factors contributing to cleanliness are, of course, the small gas ports from the barrel which reduce the amount of material permitted to enter the gas piston, and the gas venting apertures in the magazine tube cap which tend to render the system self-cleaning to a considerable extent.

The function of locking the gun open after the last shot has been removed from the magazine and fired is performed by a lug **46** on the end of the magazine follower **6** which, without a shell in the magazine, overlies the forward end of the carrier **47**. When the breech bolt slide reaches its rearward position, it engages in the usual manner with the carrier dog **48** and, with the carrier blocked by the lug **46** the breech bolt slide is locked in this rearward position. The slide may be released to permit the breech to close by manually engaging the follower **6** through the bottom loading port and urging it back into the magazine tube sufficiently to disengage the lug **46** from the carrier.

No attempt has been made herein to describe the details of those portions of the mechanism which are common to one or the other of the two previous patents referred to herein and, to the extent that the operation of such mechanism is not immediately obvious from an inspection of the drawings, reference may be made to those patents to complete the picture. Although we have shown and described herein only one specific embodiment of our invention, we do not consider that the invention is limited to the specific details of this disclosure. For an exact definition of the limits which we consider applicable to our invention, reference may be had to the appended claims.

We claim:

1. In an autoloading firearm having a barrel, a receiver to which said barrel is secured, a tubular magazine secured to said receiver and extending forward therefrom in parallelism with said barrel, a breech bolt within said receiver, and locking means to releasably secure the breech bolt as a closure for the breech end of the barrel; the improvement in autoloading operating mechanism comprising in combination a breech bolt slide longitudinally slidable in said receiver and coupled to said breech bolt with capacity for limited longitudinal movement with respect thereto, said slide being engageable with said locking means to unlock same during the rearward portion of said limited longitudinal movement and to lock the same during the forward portion of said limited longitudinal movement, said slide being arranged at the rearward extreme of said limited movement to cause the reciprocation of said breech bolt with the slide; a pair of laterally spaced action bars rigidly coupled to said slide and longitudinally slidable therewith; a gas cyinder formed by the forward portion of said magazine tube and a cap closing the forward end of the same; gas port means communicating between the bore of the barrel and the interior of said gas cylinder; and a gas piston reciprocable in the cylinder formed by the forward end of the magazine tube and rigidly coupled to the forward end of both of said action bars, said action bars being joined to each other at their forward end by an integral bridge shaped to partially embrace the outside of the portion of the magazine tube defining the gas cylinder, an elongated slot formed in the side wall of said gas cylinder portion of the magazine tube, a lug attached to said action bar bridge and extending through said slot, said lug being formed with a head engaging the inner wall of said cylinder at each edge of said slot, a skirt on said gas piston, and means defining a hole in said gas piston skirt embracing the head of said lug.

2. The combination described in claim 1, said slot being provided in a location remote from the ends thereof with a lateral enlargement great enough to pass the head of said lug to permit disengagement of said action bars from said cylinder and said piston.

3. The combination described in claim 2, said lateral enlargement being offset to one side of the line of said slot requiring said action bars to be twisted laterally to that side to permit disassembly.

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