FIRING MECHANISM FOR HIGH RATE OF FIRE MULTI-BARREL AUTOMATC WEAPON

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This invention relates to a automatic weapon of the Gatling-gun type, having a plurality of barrels mounted for rotation about a common axis and, more particularly, to improvements in the firing mechanism reducing the weight, size, complexity and driving power requirements to produce a very high rate of fire weapon.

The prolongation of the "cold war" period has seen an increase in guerrilla type warfare. With this has come a need for improvements in the rate of fire of weapons of the well-known Gatling-gun type, which currently are in the military arsenal for a variety of applications, e.g., mounting on aircraft for strafing missions. While the current guns are primarily of 7.62 mm. or 20 mm. size, there has been an increasing need for development of weapons similar in caliber and size to the current hand carried anti-personnel weapons, such as a rifle. Such a gun would fire a round of approximately .22 inch caliber, as is used, for example, in the current M 16 U.S. military rifle.

A typical Gatling-gun comprises a housing enclosing and supporting a rotor assembly, the rotor assembly, in turn, supporting a plurality of barrels. These weapons use percussion or electrically fired ammunition, having a mainspring usually supported in the cartridge-carrying bolt assembly for each firing pin. When the rotor is caused to revolve, either by means of an external electrical or hydraulic drive, or cartridge gas drive, interaction between the housing and the rotor by means ofcams and gearing causes the various weapon actions. In this way, ammunition is delivered to the gun bolts, the cartridges chambered, the bolts locked for firing, the cartridges fired, and the empty cartridge cases extracted and ejected.

With an increasing need for a smaller caliber, higher rate of fire, more reliable gun, means are needed to reduce the complexity and size of the firing mechanism. To date, Gatling-gun type weapons for percussion primed ammunition typically have required a separate mainspring for, or included in, each bolt assembly to move the striker or firing pin. It would be desirable to simplify the mechanism to eliminate one or more of the mainsprings. In particular, it should be pointed out that the firing pin mainspring required for the smaller caliber cartridges with heretofore known design techniques will be quite large in comparison with the cartridge itself, contrary to the situation which exists for weapons of the 7.62 mm. or 20 mm. size when the problem does not exist.

It is a general object of the present invention to provide an improved firing mechanism for an automatic weapon of the Gatling-gun type having a plurality of barrels attached to a rotor for rotation about a common axis.

Another object of the invention is to provide a smaller, lightweight automatic multi-barrel gun having an improved bore rate of fire, multi-barrel, automatic weapon of the Gatling-gun type, further enabling reduction in the gun driving power requirements.

Another object of the invention is the provision of an improved automatic weapon of the Gatling-gun type having a firing mechanism so arranged with respect to cooperating parts in the gun assembly that a larger, more reliable mainspring can be used, having lower operating stresses than would otherwise be possible using conventional design approaches, thus minimizing the probability of failure of the mainspring.

Briefly, the invention comprises improvements in the firing mechanism in a small caliber, high rate of fire, multi-barrel, automatic weapon of the Gatling-gun type having a housing including a quasi-elliptical main bolt driving cam and a rotor assembly coaxially located within the housing. The rotor assembly includes a plurality of guide ways equally spaced about the circumference thereof adapted to receive and retain a plurality of bolt assemblies for longitudinal reciprocating movement of the bolt assemblies therealong when driven by the cam and cam follower means on the housing and each bolt assembly, respectively. At the forward end of each rotor way is a locking well adapted to receive the bolt during the firing interval of the weapon action. The rotor assembly is driven by means of a suitable external mechanism operated by electrical or hydraulic power.

More specifically, one of the features of the invention is the substitution, for the conventional individual firing pin mainsprings, of a single mainspring mounted externally of the bolt assemblies. The single mainspring of the invention is preferably mounted on a cover or bolt access door pivotedally supported on the housing. The invention also incorporates an improved and simplified bolt assembly having in addition to the follower means a body portion with a hammer piece and striker slidably received in recesses in the body portion, guide means received in the rotor ways, bolt lock-unlock cam engaging means, as well as cartridge-handling means. Cooperating with our improved bolt assemblies and mainspring are a plurality of levers supported from the housing. The levers are operably connected to the single mainspring and to each other and sequentially contact the hammer piece as follows:

As the rotor revolves, the hammer piece engages a first one of the levers, which pivots, turning another lever which, in turn, pivots in one direction to depress the single mainspring. This continues until the bolt reaches the locked or battery position, at which point the round is chambered. At this time, a locking cam in the housing engages the bolt and locks it in the firing position. The first lever has an arm circumferentially displaced from an arm of the other lever so that, with continued rotation of the lever, the hammer slips off the first lever while still engaging the arm of the other lever. The latter, being engaged with the now compressed single external mainspring, pivots in the opposite direction to forcibly drive the hammer piece forward, in the absence of the retarding force provided by the first lever, to fire the round. Subsequently, on further rotation of the lever, the hammer piece rides over the rotor and housing, another cam on the housing unlocks the bolt assembly. A small retractor spring (or a further housing cam means), at the same time, operates to move the hammer back to its normal position. The first lever is then ready to engage the next bolt assembly hammer for a repetition of the cycle in the multi-barrel weapon. The bolt assembly, still gripping the now spent round, is longitudinally moved back along the quasi-elliptical cam path to the ejection position.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter of our invention, it is believed the invention will be better understood from the following detailed description of its structure and operation, taken in connection with the accompanying drawings in which:

FIG. 1 is an external view of an automatic weapon of
the Gatling-gun variety incorporating our improved firing mechanism;

FIG. 2 is an internal view, partially in cross-section, taken along line 2 of FIG. 1, with some of the gun parts being deleted for clarity, illustrating one bolt assembly in a position to accept a cartridge and another bolt assembly locked in the firing or battery position.

FIG. 3 is a perspective view of the gun of FIG. 1 with a bolt cover unatched to expose the rotor tracks, with the position of the actuating lever members being shown as on the hammer piece, just before release of the first lever member, for firing the weapon by movement of the second member;

FIGS. 4 and 4a are enlarged side and partial plan views, respectively, partially in cross-section, of one of the improved bolt assemblies of the invention, according to FIG. 1;

FIG. 5 is an end view, along the horizontal axis, of the bolt assembly of FIG. 4;

FIG. 6 is a partially expanded plan view of the bolt access cover and an alternate latching mechanism arrangement further illustrating the relative positions of the actuating members, as well as the location of the single mainspring and associated plunger, indicated partially by dotted lines;

FIG. 7 is an end view of the bolt access cover illustrating bearing surfaces of several cams contacted by actuating members and the bolt assembly (shown in dotted lines) during operation of the weapon;

FIG. 8 is a side view of the rotor illustrating the rotor ways and grooves;

FIGS. 9 and 10 are cross-sectional views of the rotor body taken along lines 9 and 10 of FIG. 8;

FIGS. 11a–11e are schematic diagrams of the operation of the improved firing mechanism of the invention with the rotor being seen in a constant position with respect to a relative stationary housing; and

FIG. 12 is a perspective view of a bolt access cover or cam member.

Description

Turning now to the drawings, in particular FIGS. 1 and 2, the major components of an automatic weapon of the Gatling-gun type incorporating our invention are:

(1) a rotor assembly, indicated generally at 10; (2) a housing, indicated generally at 20; (3) a housing bolt access cover or cam member, indicated generally at 30; (4) a guide bar assembly, indicated generally at 45; (5) front and rear gun supporting means 50 and 55, respectively; (6) a plurality of barrels, one of which is indicated at 60; and (7) barrel clamping means, indicated generally at 70 and 80. Also indicated in the drawings is an improved arrangement for actuating all of the firing pins by a single mainspring 142 mounted externally of the bolt assemblies, i.e., in the bolt access cover or cam member 30. Another feature of the gun shown are means incorporated in the bolt access cover member 30 whereby the firing pin actuating mechanism is automatically deactivated whenever the cover is opened, as when one of the six bolt assemblies is to be inspected. The device which also provides for manual safing of the weapon during loading without removal of any part of the gun, is indicated generally at 120.

Turning first to a detailed description of the rotor assembly 10, which is a main structural component, it will be noted that the rotor is supported in the housing 20 at either end by ball bearings 116–116 to permit relative rotation therebetween. The front part of the rotor body also supports the barrel cluster. To this end, there are provided a plurality of openings, in this instance six in number, one of which is indicated at 12. Each opening is threaded for engagement with a threaded end 14 of a barrel 60. Each barrel end has a shoulder portion adapted to seat in a counterbore 10a in the rotor body face 10b, whereby the extreme rearward end or chamber portion 60b of the barrel is aligned with the locking well portion 16 of the rotor. The barrels may also be fixed in place by other suitable locking means, such as cams, lugs, or pins. The rotor body, in this instance, is machined in one piece and has a plurality of bolt slots or grooves, indicated generally at 18, broached or otherwise cut axially of the body and spaced circumferentially thereabout. As seen in FIGS. 8, 9, and 10, the rotor slots 18 include a plurality of guide ways or tracks which cooperate with mating parts of our improved bolt assembly, hereinafter described in detail. To this end, each slot 18 includes an upper lateral support or anti-friction cam roller way 21, having a dimension W, in the forwardward 16c of the rotor. The bottom or radically inward boundary of the guide way 21 is formed by a pair of laterally-projecting walls 22–22. The space between the projecting walls, indicated by the dimension X in the drawings, forms a recess or guide-way 23 for the main body portion of the bolt assembly indicated at 100, FIG. 2.

The ways or grooves 18 in body portion 10c are further cut away beneath the projecting walls 22–22 to form a guide way 24 for the head portion of a roller shaft locking or guide pin as well as for the extractor lugs 132a, which are parts of the bolt assembly illustrated and described in detail in conjunction with FIGS. 4 and 4a.

The guide way 24 has the dimension Y, indicated in FIG. 9. Finally, the groove 18 has a bottom wall 26 providing clearance for the body portion of the bolt assembly. The guide portion immediately out wardly of wall 26 has the dimension Z, equal to dimension X. Obviously, the tracks or ways 18 could also be formed by fastening to the rotor body—at the diameter of wall 26—a plurality of machined pieces having the necessary laterally-projecting portions forming the dimensions W–Z, as described above. As shown in FIG. 2 at the rear of the rotor is a drive gear 25 held by a retainer plate 29 fastened to the rotor by a plurality of screws, one of which is indicated at 29a. It will be noted that the rearward portion 10e of the rotor body ends in a groove 32 which comprises one extremity of a middle portion 10d. The middle portion of the rotor continues the guide ways and walls 22, 23, and 24, indicated by the respective dimensions X, Y, and Z in FIG. 9. Groove 32, on the other hand, is provided for clearance of the rear end of the bolt assembly depicted in FIG. 4, in particular, the head end of the guide pin, to facilitate removal of the bolt assembly 100 from the rotor 10. As will be further noted from FIGS. 11a–11e, the cut-down portion 10d is provided with several clearance portions which are for the several housing, and a plurality of actuating levers, as hereinafter described in detail. Also shown are a pair of clearance slots 33–33 which permit passage of round delivery fingers 188–188 of the cartridge guide bar assembly, indicated generally at 45. At the forward end of middle portion 10d is a locking well 16. The locking well includes a chamfered breech lock surface 36 adapted to be engaged by a pair of locking lugs on our improved bolt assembly when the bolt is locked, as shown in FIG. 11c. Surface 37 on the forward maximum diameter portion 10e of the rotor body contains the barrel holes 12 and provides another boundary wall in the locking well 16. As seen in FIG. 2, at the extreme forward end of the rotor body is a recess or shoulder portion 38 adapted to receive the front bearing means 11a for rotationally supporting the rotor within housing 20, at pad 42.

The generally cylindrical housing 20, preferably a single casting, includes means now to be described in detail, for respectively supporting the rotor 10, longitudinally reciprocally camming the barrel assemblies 100, and supporting the several components of the firing mechanism and safing means 120, which are also described in detail, both as to structure and function, hereinafter. Thus, at the rear of the housing is a reduced diameter portion 41 having a pad 43 supporting rear bearing means 11b. As shown in FIG. 3, the outer surface of
portion 41 may be provided with lugs 41a or other means suitable for fastening the gun to the supporting members and/or to externally mounted or accessories (as shown), which may include an ammunition storage and feed system. The housing also includes a main cam or track 44 having a quasi-elliptical shape. It will be apparent, from FIG. 2 that on relative rotation of the housing and member 11, each bolt assembly 113 reciprocally moved longitudinally—axially—of the gun to pick up and deliver, the rounds to the chamber, and return the spent case for reformation, as hereinafter described in detail under the heading "Operation." A pad portion, indicated generally at 45c, is provided for support of the cartridge guide bar assembly 45. As shown in FIG. 3, a number of other support pads are cast or formed integrally with the housing, including pads 46a and 46b used to pivotally support a plurality of actuating members or levers. A pair of drilled bosses 48a and 48b aligned axially of the gun pivotally support the bolt access cover or cam member, indicated at 30. A further pad 242 also provides a latch for the cam member latching arm 120, and may contain a detent mechanism 243 used to retain the arm in the locked position, and at the front of the rotor is a bearing retainer plate 52 fastened by bolts 53 to the rotor face, as shown in FIGS. 1, 5 and 6.

An important feature of our invention, and a major component of the multi-barrel automatic weapon of FIG. 2, are the improved bolt assemblies, indicated generally at 110. As explained, the bolt assembly in the typical prior art weapons of the Gatling-type firing percussive ammunition contains generally an individual firing pin and mainspring assembly to initiate firing of the cartridge, together with guide means and extractor lugs for gripping the cartridge case. Turning specifically to FIGS. 4a and 5, indicated generally at 110 is an elongated generally rectangular body portion of the bolt assembly, one of which will be described in the various assemblies and identical. The body portion supports cam follower means comprising guide roller 112, an anti-friction roller 114, a roller shaft 116 and a guide pin indicated generally at 118. Extending axially of the body portion is a central passageway indicated generally at 119 having a forward and rearward recess 119a and 119b, respectively. Intersecting the passageway 119, approximately midway of the ends thereof, is a transverse slot 121 having an upper opening 121a and a bottom opening 121b. Positioned in the body portion is a portion of the firing mechanism comprising a hammer 135, a striker on a firing pin, indicated at 124, and a retractor spring 126. The hammer 122 includes a forward shank portion 122a, a laterally outwardly projecting blade or contact arm portion 122b, and a rearward shank portion 122c. The forward portion of the bolt body is provided with a seat 128 adapted to receive a closure wall member or recoil plate 129 force-fitted therein. The recoil plate 129 has an aperture 129a therethrough adapted to receive point 124a of the firing pin or striker, to permit the latter to contact the cartridge primer for initiation of the round. The striker head 124b, at the opposite end from the point 124a, captures one end of retractor spring 126, the other end of the spring seating on the rear face of the recoil plate at 129b. The striker 124 abuts the forward shank 122a of the hammer and is slideable in passage portion 119b. The hammer rearward shank 122c, on the other hand, holds portion 116 which is the fully retracted position. It will be noted that body portion 110, preferably a single cast or forged piece, also includes means cooperating with cam means mounted on the housing to lock and unlock the bolt assembly during operation of the weapon. To this end, a generally L-shaped lug 131 is provided, including an unlocking forward facing tang 131a and an outer locking surface 131b. Further, as perhaps best seen in FIG. 5, the forward end of the bolt body also includes integral cartridge carrying means 132a for gripping the extractor rim of a cartridge. In addition, projecting laterally on either side of the body 110 is a locking lug 134a adapted to seat against the bolt head lock or rearward surface 36 of locking well 16 in the bolt body description. Locking and extractor lugs 134a—134b and 132a—132b, respectively, are also adapted to ride on the guide ways walls 22—22 of rotor body 10 during operation of the weapon, with lugs 134a riding outwardly and on the walls and the extractor lugs riding inside guide way 24. Finally, it will be noted that the roller shaft locking and guide pin 119 includes an enlarged head portion 119b. The guide pin head also rides in slot 24 in the rotor body, provided by dimension Y, bearing on the inner and outer walls thereof, for controlled relative longitudinal movement of the bolt assembly 110 with respect to the rotor. It will be noted that shank portion 122c of hammer 122 has a flattened portion 122d. The flattened portion of the shank is adapted to slide into a reduced slot portion 121c and, thus, a feature of our improved bolt 110 is the entire assembly of the parts of the bolt mechanism, since, except for the press-fitted recoil plate, all parts may be easily assembled without the need for tools, as follows. The retractor spring and striker pin are passed through the upper opening 121a into a recess 119a of the central passageway 119. The hammer is slumped into the lower opening 121b—blade portion 122b first—with the flattened shank portion 122d passing through the transverse slot portion 121c. Pushing the hammer and striker forward compresses the retractor spring, allowing the roller shaft 116, on which rollers 112 and 114 have been assembled, to be dropped into the shaft opening 116a in the body. Guide pin 119 is then inserted in a cross-hole 118b, intersecting perpendicular opening 116a, the pin body fitting in a groove 116d for locking the roller shaft. The bolt assembly is then joined to the rotor body 10 by inserting the guide pin head 119c, tipping the opposite end of the bolt assembly into the clearance slot 32, and moving the bolt towards the rear. The bolt head or front portion is lowered part way into the locking well 16. During operation, the guide pin head 119c is always to the rear of the slot 32 and the forward end of the bolt is held in place by either (1) engagement of locking lugs 134a—134b with the outer surfaces of the laterally projecting guide wall 22—22 and extractor lugs 132a—132b with guide way 24 or (2) by engagement of a locking cam, hereinafter described in detail, with surface 131b of the lock/unlock lug 131. Advantages of this arrangement include that the bolt assemblies may be easily unlocked—manually—and slid to the rear for removal, and cleaning of the barrels, and that it is unnecessary to remove portions of the rotor guide ways to remove or assemble bolts with the rotor.

In place of the typical single bolt roller guide, it will be noted that our improved design features a double follower arrangement in the form of a cam roller 112 and anti-friction roller 114. This provides means, in combination with the described track or guideway arrangement of rotor 10, for accomplishing the reciprocating motion of the bolt assemblies with a low-friction bearing member at the point where the highest lateral loads occur between the bolt and rotor. It should also be pointed out that, contrary to the design of current Gatling-type weapon systems, our improved bolt assembly is particularly adapted for use with smaller caliber weapons. The construction described above enables the retention of a comparatively low weight and striking energy. That is, in one application it was found possible to have a hammer weight of 250 grains and a striking energy of about 7 inch-pounds, in no more the .22 caliber weapon. To obtain this size relationship with the typical conventional firing mechanism would mean a substantial increase in the size of the bolt assembly, thus increasing the loads and forces driving cams and making cartridge control within the weapon more difficult. In other words, the forces
needed to actuate the firing pin mechanism for a cartridge of approximately .22 inch calibre using known mainspring and plunger design would require a bolt assembly, including mainspring and plunger (hammer), almost as large as that required for the conventional 7.62 mm, round. Thus, to provide a small, lightweight and simplified bolt assembly, we have removed the mainspring from its customary location inside the bolt and mounted it in a unique manner, as now described in detail. Firing rates much higher than heretofore obtainable were achieved due to the minimized bolt size and reduced bolt-rotor friction forces, which further enabled a significant reduction in rotor or gun, driving power requirements with improved reliability.

Thus, another significant feature of the invention is the provision for a single mainspring and an external mounting arrangement therefore. In FIGURES 2, 3 and 6, in particular, it will be seen that secured to pad 48 and 480 of the housing 20 by a hinge pin 48c is a cam and mainspring mounting cover assembly, indicated generally at 30, which, when opened, provides access to the bolt assemblies. The cover or cam member 30, as will be seen, functions in the embodiment shown as a mounting platform for the single mainspring and plunger mechanism described herein, as well as support for a plurality of cam means operable to lock or unlock the bolt. Other means are provided to actuate the firing pin mechanism of the bolt assembly in response to relative rotation between the housing and rotor or gun. In addition, a relative linear motion between bolts and housing. In addition, the bolt access cover member 30 is so interlocked with the firing pin actuation mechanism that the mainspring is automatically deactivated and incapable of causing the gun to fire whenever the cover is opened for maintenance. This latter feature provides manual safety device for use during maintenance on any part of the gun or its associated equipment.

To explain the mounting function of the cover assembly 30 with respect to the cams and mainspring, as seen in FIGS. 3, 6, and 12 the cover opens by pivoting about pin 48c, the pin passing through hole 48c formed in a thickened edge portion 132 at one edge of the main curved body portion 30c of member 30. The curved portion 30a conforms the member to the circular shape of the generally cylindrical wall of the housing 20, of which the cam members or covers form a part when closed. As viewed in FIG. 12, the outer or upper surface includes a pair of ribs 133—133 extending from the hinge pin tunnel or boss portion 132 toward a similarly enlarged lateral edge portion 134 at the opposite side of the body portion 30a, which ribs act to strengthen and stiffen the cam member. Extending part way through edge portion 134 is a recess or hole 135, the forward or bottom wall of which opens to a smaller passage 136, in turn opening at the opposite edge of the body 30a. Intersecting passage 136 at right angles thereto is still another smaller passage in the form of a slot 137. Further, as seen in FIG. 12, the thickened portion 134 at the edge of the cover body is partially cut away to form a larger slot 139, intersecting slot 137. Slot 139 is adapted to receive a part of the latching mechanism, indicated generally at 120, including latching bar or handle 240 pivotally mounted in the cover body by means of a pin 241 inserted in a hole 241a in a boss formed on the exterior or upper surface of the cover body 30a. A portion of the arm 240 is received in a slot 242a in pad 242 on the housing. A bolt and plunger spring actuated detent for handle 240 may be provided, as indicated generally at 243, to maintain arm or handle 240 in slot 242a. The hole or passage 135 receives the single mainspring 142 and plunger 144, the mainspring resting between the bottom wall of passage 135 and the head end 144a of the plunger. In addition, at the opposite end of the plunger is a hole 146 containing a pin 147 projecting into slot 137 for relative sliding movement therein and in and out of contact with arm 240, as seen in FIG. 6.

Viewing the bolt access cover or cam member 30 from the underside, i.e., from the interior surface, as seen in FIG. 3, means are shown for locking and unlocking the bolt assemblies 190 and 190 in an open and closed position. To provide a locking cam, indicated generally at 164, a cocking lever stop lug indicated generally at 165, a retractor cam indicated generally at 166, and an unlocking cam indicated generally at 168. The unlocking cam, which may be integrally formed with body portion 30a, or attached thereto, is shown pinned to the housing by a bearing means 168a. The locking or retractor cams, or both, may also be separate of the cover and attached by suitable fastening means. In any event, the cocking lever stop lug 165 projects inwardly of the housing during operation of the weapon, and includes a pair of bearing surfaces 165a and 165b adapted to make contact with the cocking lever 160, as hereinafter described in detail, during one portion of the firing cycle. Note that lug 165 is located adjacent the lateral edge portion 134 of cover assembly 30, and near the rearwardmost edge of body portion 30a. Locking cam 164 includes an initial locking or contact ramp portion 164a, a holding ramp portion 164b and a clearance ramp portion 164c, serially arranged along its interior surface. Unlocking cam 168 is of generally L-shaped configuration, as seen in FIG. 6. The barrel assembly 190 is adapted to engage tang 131a of bolt assembly 100, as described hereinafter. Thus, tank 165b overlies clearance ramp 164c of locking cam means 164. Turning next to a description of the retractor cam means 166, as seen in FIG. 3, the retractor cam projects from the interior cover surface with its nominal longitudinal axis skewed from a plane parallel to the general direction of surface 165b of lug 165, the latter extending in a plane normal to the gun axis. The retractor cam includes an initial contact surface or ramp portion 166a, which proceeds at an angle back along the cam body to a small flat ramp portion 166b at the extreme end of the effective length of the cam body. As described hereinafter, the retractor cam 166 contacts the hammer 122 shortly after the hammer rides off both the cocking and firing levels 160 and 162, i.e., there is a segment of the circular path followed by the rearwardly rotating rotor and housing mounted part equivalent to about 30°—40° during which neither the cocking lever itself, stop lug means 165 acting thereon, nor the retractor cam is effective to maintain the hammer in the rearmost or "cocked" position. During the initial portion of this 30°—40° of rotation, the firing lever is free to drive the hammer forward to strike the cartridge primer. Thus, as will be seen in FIG. 3, actuating members in the form of a cocking lever 160 and firing lever 162 are pivotally mounted, e.g., by pins 170 and 172, respectively, to the housing 20, although they could be mounted on the bolt access cover 30. Turning first to the cocking lever, it is generally triangular member having a hammer contact arm indicated at 174, a stop contacting or bearing surface 175, and a cocking lever contact or driving arm 176. Conversely, the firing lever 162 has a driven arm 177, a power arm 178, and a hammer contact arm 179.

Operation

Turning now, specifically, to FIG. 11a—11c, operation of the improved firing mechanism of our invention for use in a very high rate of fire, small caliber, Gatling-gun type weapon will now be described in detail. For purposes of clarity of illustration, in FIG. 11a a hammer 10 is not moving and that housing 20 is rotating about the rotor, the opposite being true, of course, in actuality. Thus, as shown in FIG. 11a, bolt 100 is in its farthest aft position and a round or cartridge (comprising case C, extractor rim R, and bullet B) has just been delivered from the guide bar assembly 45. The rim or extractor
groove R is gripped by the bolt extractor lugs 132a—132a. At this point, retractor spring 126 is holding hammer 122 and striker 124 in the extreme rearward position. Rearward shank 122c is against the stop (shaft 116) and striker point 124a is withdrawn from aperture 129a. Bolt 120 is now driven forward in the housing by the cam follower 112 riding in the drive portion of the quasi-elliptical cam 44, the bolt being guided by rotor ways 21, 23 and 24 cooperating, respectively, with the bolt roller 114, lugs 134a—134a and 132a—132a, and with the guide pin head portion 118a. As shown in FIG. 11b, cocking lever 160 and firing lever 162 are starting to function. That is, initially cocking lever bearing surface or flat 175 is in contact with stop lug surface 165b which maintains the cocking lever in position to engage hammer 122, now moving linearly—from right to left in the illustration—as well as angularly with respect to the housing. As the hammer approaches arm 174 of cocking lever 160, the forward portion of the bolt is similarly approaching the locking well 16. Hammer blade point 121a just contacts arm 174 and, since the hammer is moving linearly with respect to the arm, the hammer causes clockwise pivoting of lever 160 about pin 170. Arm 176, in turn, drives arm 177 of firing lever 162, to begin pivoting the firing lever clockwise about pin 172. Power arm 178, in contact with head 144a of plunger 144, starts compressing the single, externally-mounted mainspring 142. At the same time, hammer contact arm 179 of firing lever 162 is being driven to the right, i.e., opposite to the direction of arm 174 of cocking lever 160, to be in position to subsequence accept the hammer as rotation continues and the hammer, levers and mainspring approach the fully cocked position of FIG. 11c, the rotor (or bolt) reaches the initial locking ram portion 164a of locking cam 164 the surface of which begins to bear on the outer locking surface 131b of L-shaped lug 131. At this point, cocking lever 160 has reached its full clockwise position and cannot rotate further, being held between hammer 112 and stop lug surface 165b. At this point hammer 122 has arrived in front of the leading edge of firing lever 162. To facilitate completion of the cocking action the leading edge of hammer blade 122b may be chamfered at 122c—122c. When fully cocked, levers 160 and 162 are both initially in contact with hammer blade 122b and they have both reached their limits of clockwise and counter-clockwise rotation, respectively. At this point, cam surface 164a is driving surface 131b of bolt 100 radially inward and cam follower 112 reaches the forward-most dwell or chamfering portion 44a of cam 44, bolt 100 rotates slightly counter-clockwise about guide pin 118, the guide pin head 118a being held in guide way 24, causing locking lugs 134a—134a to contact breech lock surface 36 of locking well 16, and the cartridge (already having entered the barrel 60) to be driven to the fully-chambered position of FIG. 11d. Striker tip 124a is now aligned with the cartridge primer through aperture 129a. While bolt 100 is being held in the locked position, by the holding portion 164b of cam 164 and by locking lugs 134a, which are abutting their respective bearing surfaces (i.e., lug surface 131b and rotor surface 36) hammer 122 is rotating past, and off, the end of cocking lever arm 174. The mainspring 142, being fully compressed, immediately drives the firing lever 162 clockwise as seen in FIG. 11d. Since the firing arm 179 of lever 162 is axially directed on arm 174, the former is free to drive hammer 122 and striker 124 forward in the bolt. Mainspring 142, being considerably stronger than the relatively small reactor spring 126, drives striker point 124a through aperture 129b and forcibly into the primer, firing the round. Cam 164b and contact surface 36 continue to bear against the external barrel portion, as described above, and during the initial dwell portion, roller 112 remains in housing cam portion 44a. Approximately 30° past initial contact between the lock/unlock lug 131 and cam 164, the trailing edge of hammer blade
hammer including a blade portion projecting laterally of the bolt assembly; a mainspring mounted externally of the rotor and bolt assemblies;

and a plurality of actuating members pivotally mounted in said housing and projecting radially inwardly thereof, said members being operably connected to said mainspring, said hammer blade portion sequentially engaging and disengaging respective ones of said actuating members during a predetermined period of said relative rotation for sequentially compressing and releasing said mainspring, whereby said hammer is driven forcibly into contact with a cartridge carried by said bolt assembly to fire said cartridge when said rotor assembly is in the locked position.

2. The apparatus of the invention according to claim 1, wherein a first one of said plurality of actuating members has a first arm slidingly engageable with said hammer blade portion at the beginning of said predetermined period of relative rotation and a second arm extending at an angle from said first arm, and a second one of said actuating members has a first arm driv ingly engaged with the second arm of said first member, said second arm being pivotally and angularly with respect to the first arm of said first member to initially pivot said first and second actuating members clockwise and counter-clockwise, respectively, said second member having a second arm operable to compress said mainspring during said pivotal movement, and a third arm circumferentially offset from said arm of said first actuating member with respect to the rotor axis and slidingly engageable with said hammer blade portion subsequent to the engagement of said first arm therewith, and wherein said cam means includes a hook portion projecting inwardly of said housing and cooperating with the means at the forward end of said bolt to drive said bolt assembly into a locking well in said rotor forward of said ways, wherein when said bolt assembly is in the locked position said first arm of said first actuating member disengages said hammer blade portion, said second arm of said second member is driven by said mainspring to cause said second actuating member to pivot in the clockwise direction, said third arm driving said hammer forcibly into contact with said cartridge, said third arm subsequently disengaging said hammer blade portion at the completion of said predetermined period of rotation, whereby said first arm of said first actuating member is returned to its initial position to await sliding engagement with a succeeding bolt assembly moving longitudinally in said ways.

3. In an automatic weapon having a plurality of barrels circumferentially arranged about a common axis, a rotor supporting said barrels, a housing circumferentially spaced about and rotatably supporting said rotor therewith, a plurality of cartridge-carrying bolt assemblies mounted in axial ways in said rotor, a cartridge firing mechanism in each bolt assembly, cooperating cam means on said bolt assemblies and said housing, respectively, for causing reciprocal longitudinal movement of said assemblies to and from a forward firing position responsive to relative rotation of said rotor and said housing, the improvement of means operating the cartridge firing mechanism of said bolt assemblies comprising:

a mainspring mounted on said housing;

lever means pivotally mounted on said housing adjacent to and operably connected with said mainspring, said lever means including a pair of arms projecting inwardly of said housing, the arms of said pair being circumferentially displaced from each other with respect to the rotor axis for respectively and sequentially slidably engaging and disengaging successive ones of the firing mechanisms of said bolt assemblies moving laterally and angularly with respect thereto responsive to predetermined period of said relative rotation, thereby to pivot said levers to successively compress said mainspring to store energy therein and then release said stored energy, whereby one of said arms successively drives each of said firing mechanisms forcibly into contact with a cartridge carried by the respective bolt assemblies to fire said cartridges.

4. The apparatus of the invention according to claim 3 wherein said lever means comprises:
a first actuating member, said first actuating member having:

(1) a first arm projecting radially inwardly of said housing, and

(2) a second arm substantially at right angles to said first arm; and

a second actuating member, said second actuating member having:

(1) a first arm extending oppositely of the second arm of said first member and in contact therewith,

(2) a second arm in contact with said mainspring, and

(3) a third arm projecting radially inwardly of said housing,

wherein said first arm of said first member initially slidingly engages said firing mechanism for pivoting movement of said first member in one direction, said second arm of said first member drives said first arm of said second member in response to said pivoting movement to pivot said second member in the opposite direction for subsequent sliding engagement of said third arm with said firing mechanism, the pivoting movement of said second member causing said second arm thereof to compress said mainspring for storing said energy, whereby upon further relative rotation of said rotor and said housing said mainspring is fully compressed, at which time said first arm of said first member disengages said firing mechanism, said mainspring drives said second arm of said second member to pivot said second member in a direction opposite to the initial pivotal movement thereof to fire the cartridge, whereby on still further relative rotation said third arm disengages said firing mechanism to permit extraction of the spent cartridge.

5. The apparatus of the invention according to claim 3 including means operable to lock and unlock said bolt assemblies in said forward position for respectively firing and extracting said cartridges comprising:

first cam means in said housing projecting inwardly thereof, said first cam means having contact ramp, holding ramp and clearing ramp portions, respectively, serially arranged along the working surface thereof;

a secondary cam means in said housing having a hook portion extending inwardly and rearwardly of the housing, said hook overlying said clearance ramp portion of said first cam means; and

means on the forward end of each of said bolt assemblies including a hook portion extending outwardly and forwardly of said housing, whereby said contact ramp portion slidingly contacts an outer surface of said hook portion during the initial portion of said predetermined period of relative rotation to force said forward end radially inwardly to lock said bolt assembly in a well in said rotor forward of said ways, said holding ramp portion thereafter maintaining said bolt assembly in said locked position while said cartridge is fired, and wherein upon further relative rotation during said predetermined period said second cam means hook portion is received in said oppositely opening bolt assembly hook portion and lifts said bolt assembly out of said well for extraction of the spent cartridge from the firing position, on still further relative rotation of said rotor and said housing.

6. The apparatus of the invention according to claim
5 wherein said housing includes a third cam means located to contact a flat on one of said lever means, whereby one of said lever arms is positioned to engage each of the firing mechanisms of bolt assemblies successively moving laterally and angularly with respect thereto during the initial portion of said predetermined period of relative rotation.

7. The apparatus of the invention according to claim 3 wherein each of said bolt assemblies includes:

an elongated body portion having a central passageway extending axially therethrough, said passageway having a closure wall at the forward end thereof including a centrally located aperture, and a transverse slot intersecting said passageway approximately midway of the body portion;

a hammer member, said hammer member having forwardly and rearwardly extending shank portions slidingly received in said passageway and an intermediate blade portion projecting laterally outwardly of said body portion for limited axial movement in said slot;

a firing pin slidingly received in the forward portion of said passageway between said forward shank portion and said closure wall, said firing pin having a reduced portion at said end thereof receivable in said aperture and projecting outwardly of said closure wall when said firing pin is in a forward position; and

resilient means normally urging said firing pin and said hammer member toward a rearward position, whereby said hammer blade portion is positioned to slidingly engage the other of said lever arms at the beginning of said period of relative rotation.

8. The apparatus of the invention according to claim 6 wherein said housing includes a forth cam means having a ramp portion lying in a plane skewed from a plane normal to the axis of rotation of said rotor, the ramp portion of said fourth cam means contacting said firing mechanism at the end of said predetermined period of relative rotation for withdrawal of said firing mechanism from contact with a fired cartridge to insure unlocking of said bolt assembly at extremely high rates of fire of said automatic weapon.

9. In an automatic weapon having a plurality of barrels circumferentially arranged about a common axis, a rotor supporting said barrels, a cylindrical housing surrounding said rotor, bearing means supporting said rotor within said housing for relative rotation with respect thereto, a plurality of cam means on said housing, a pair of actuating members pivotally mounted interiorly of said housing, and a mainspring operably connected to said actuating members, the improvement of a bolt mechanism comprising:

an elongated, generally rectangular body portion having a central passageway extending axially thereof; a transverse slot through said body portion midway thereof and intersecting said passageway;

a hammer member having forwardly and rearwardly extending shank portions slidingly received in said passageway and an intermediate blade portion, said blade portion projecting laterally of said shank portions outwardly of said body portion for limited axial movement in said slot;

a firing pin located in said central passageway, said firing pin having a reduced diameter portion at one end receivable in an aperture at the forward end of said body portion, the other end of said pin having an enlarged head portion abutting said forward shank portion;

a retractor spring captured between an internal shoulder in said passageway and said forward shank portion and normally urging said hammer member and said striking pin rearwardly in said body portion; and

cam follower means at the rearward end of said body portion for cooperating with one of said housing cam means to cause reciprocal longitudinal move-

ment of said bolt mechanism in ways in the rotor responsive to relative rotation of said rotor and said housing;

cartridge carrying means at the forward end of said body portion for handling cartridges during sequential delivery, firing and extraction thereof at a forward position on said rotor responsive to said relative rotation, said carrying means including forward guide means receivable in said rotor ways and laterally projecting means integral with said body portion at the forward end thereof for cooperating with another one of said plurality of housing cam means to lock said bolt mechanism in the forward position, wherein said hammer member sequentially engages and then the other of said actuating members for compressing said mainspring and thereafter disengaging said one of said members, and subsequently said other actuating member is operated by the mainspring to move said hammer member forward forcibly to drive said one end of said striker pin through said aperture in the rotor to fire the cartridge, said hammer member thereafter disengaging said other actuating member, said laterally-projecting means being operable by said one other of said housing cam means to unlock said bolt mechanism for extraction of the spent cartridge, on further relative rotation of the rotor and housing.

10. An automatic weapon having, in combination: a plurality of barrels circumferentially arranged about a common axis; rotor means supporting said barrels; a cylindrical housing surrounding said rotor means; bearing means rotatably supporting said rotor means within said housing; a plurality of cartridge-handling bolt assemblies, said bolt assemblies each having a firing mechanism, cam follower means, and guide means, said guide means being receivable in ways in said rotor means; a first cam means on said housing engaging said follower means for successive longitudinal reciprocal movement of said bolt assemblies in said rotor ways to and from a forward position for chambering of cartridges in a firing station and extraction of expended cartridges therefrom, in response to relative rotation of said housing and said rotor means; means on said bolt assemblies and said housing, respectively, cooperating to selectively lock and unlock said bolt assemblies in said forward position; and means operating said firing mechanism when cartridges are chambered by said bolt assemblies including, a mainspring mounted on said housing, a plurality of operably-connected levers pivotally mounted in said housing, said levers including a first arm initially slidingly contacting said firing mechanism in response to said relative rotation, said firing mechanism moving laterally and angularly with respect to said first arm and pivoting said actuating members in opposite directions, a second arm in contact with and compressing said mainspring during said pivoting movement to store energy therein, and a third arm likewise slidingly contacting said firing mechanism during a predetermined period of relative rotation of said rotor and said housing subsequent to said initial contact, said first and third arms of said levers being offset circumferentially of said rotor means, thereby to cause said relatively moving firing mechanism to disengage said first arm when the cartridge is fully chambered and said bolt assembly locked by said cooperating means, releasing the stored energy in said mainspring and driving said third arm in the opposite direction, to cause said firing mechanism to forcibly contact the cartridge to fire same, whereupon said cooperating means subsequently unlocks said bolt assembly for further longitudinal reciprocal movement of the bolt assem-
bly away from said forward position, responsive to further relative rotation of said rotor means and said housing, for extraction of the spent cartridge.

11. The apparatus of the invention according to claim 10 wherein said locking and unlocking means includes an L-shaped member at the forward end of the bolt assembly and projecting radially outwardly in said housing, and second and third cam means on said housing projecting radially inwardly thereof towards the bolt assembly, said second cam means initially contacting an outer surface of said L-shaped member and driving said forward end of said bolt assembly into a locking well in said rotor during said predetermined period of relative rotation of said rotor means and said housing, said third cam means subsequently engaging an arm of said L-shaped member and withdrawing said forward end from said locking well at the completion of said period of rotation, said forward end of said bolt assembly having tangs for gripping cartridges during the firing cycle, and wherein said guide means includes a pair of ears integral with said L-shaped member and projecting laterally of said bolt assembly at the forward end thereof and a locking pin for said follower means projecting laterally of said bolt assembly at the rearward end thereof.

12. An automatic weapon having, in combination: a plurality of barrels arranged about a common axis; externally powered rotor means supporting said barrels; a cylindrical housing surrounding said rotor means; bearing means rotatably supporting said rotor means within said housing; a plurality of bolt assemblies, said bolt assemblies each including a firing mechanism, cartridge-handling means, follower means, and guide means, said guide means being received in ways in said rotor means; quasi-elliptical cam means in an internal peripheral surface of said housing, said quasi-elliptical cam means having a driving portion and a dwell portion, respectively and sequentially engaging said follower means for successive longitudinal reciprocal movement of said bolt assemblies in said rotor ways to and from a forward position for successively chambering, firing, and extracting of cartridges when fired, in response to relative rotation of said housing and said rotor means, said dwell portion corresponding to said forward position; cooperating means on said bolt assemblies and said housing, respectively, including first cam means locking said assemblies in said forward position, and second cam means unlocking said bolt assemblies when the cartridges are fired, during a predetermined period of said relative rotation; and means actuating said firing mechanism when cartridges are chambered by said bolt assemblies, said actuating means including,

(1) a mainspring mounted on an external peripheral surface of said housing,
(2) a contact member reciprocally movable axially of said housing in response to the spring forces of said mainspring, and
(3) a pair of actuating members pivotally mounted in said housing and drivingly connected both to said contact member and to each other,

wherein during said predetermined period of relative rotation one of said actuating members is initially slidingly contacted by said firing mechanism moving laterally and angularly with respect to said mainspring thereby compressing said mainspring to store energy therein, said one of said actuating members subsequently disengaging said firing mechanism when the cartridge is fully chambered and said bolt assembly locked in said forward position, thereby to allow the stored energy in said mainspring to pivot said other of said actuating members in said one direction to forcibly drive said firing mechanism into contact with the cartridge to fire said same, whereupon said other of said actuating members subsequently likewise disengages said firing mechanism to permit extraction of the spent cartridge, on further relative rotation of said rotor and said housing.

No references cited.

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