Dec. 24, 1946. G. W. PONTIUS, 3D., ET AL 2,413,113

AUTOMATIC GUN CHARGER

Filed Nov. 5, 1942 3 Sheets-Sheet 1

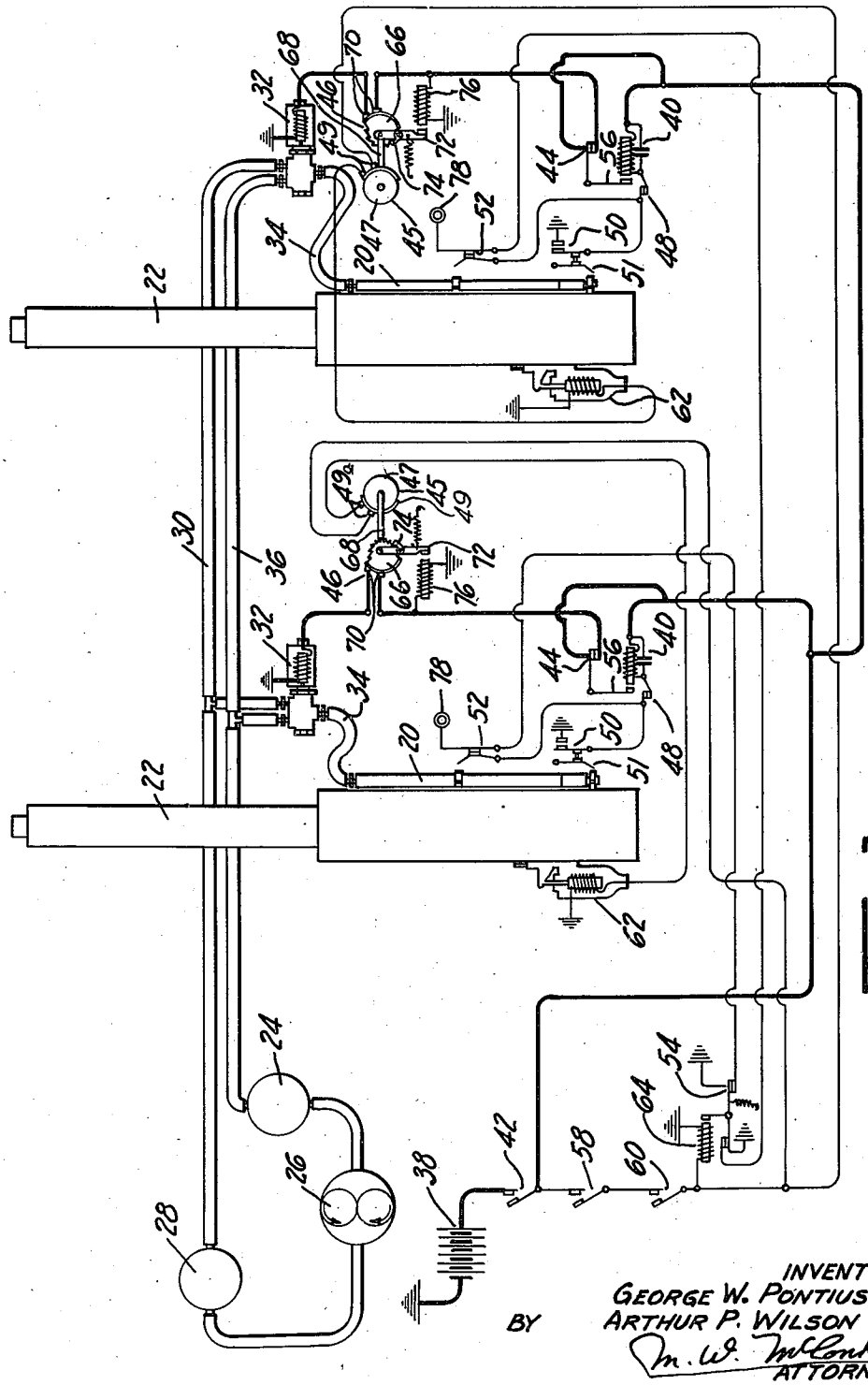


FIG. 1

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AUTOMATIC GUN CHARGER

Filed Nov. 5, 1942 3 Sheets-Sheet 2

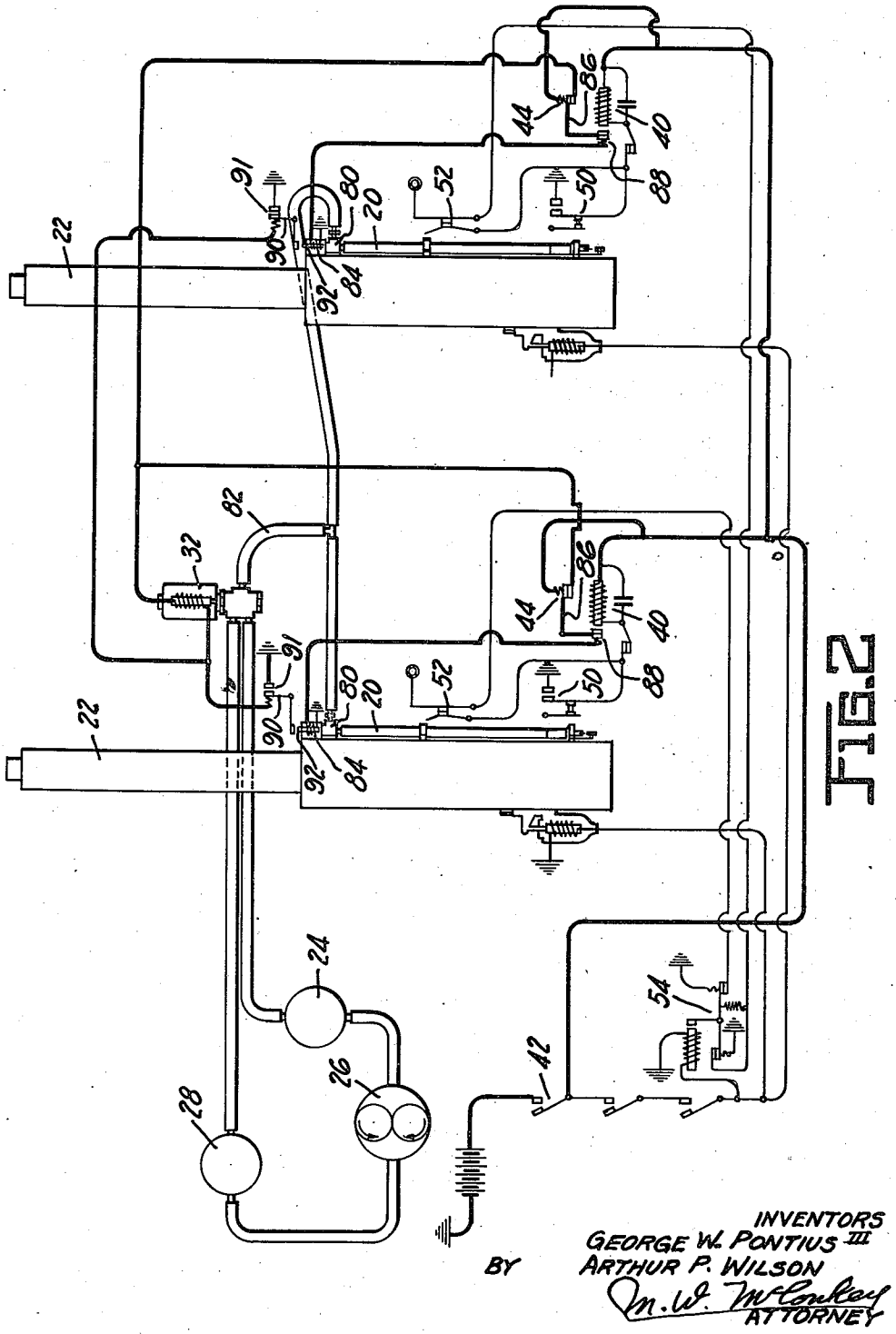


FIG. 2

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AUTOMATIC GUN CHARGER

Filed Nov. 5, 1942 3 Sheets-Sheet 3

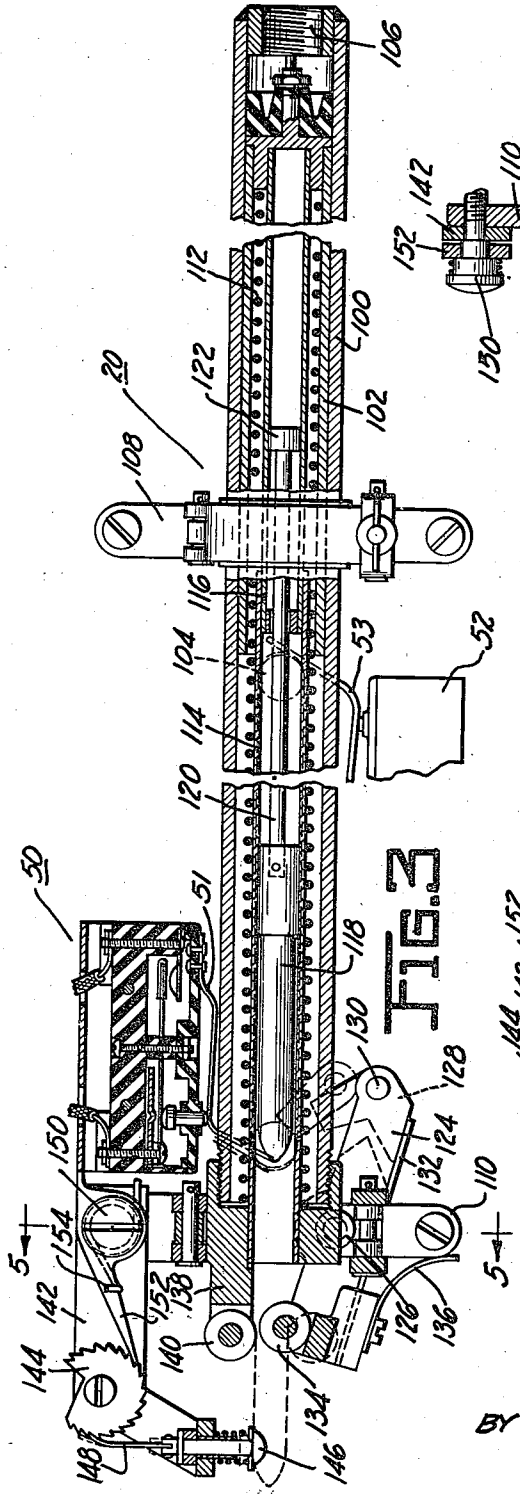


FIG. 3

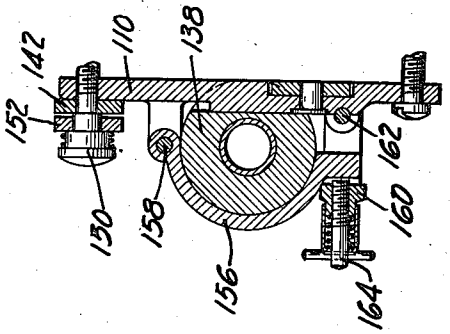


FIG. 5

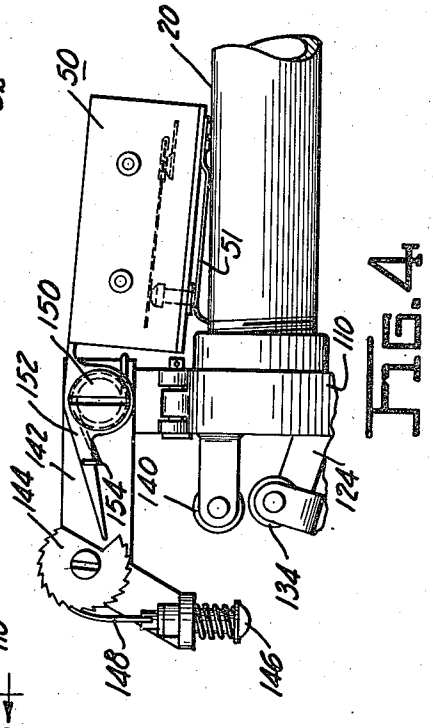


FIG. 4

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Patented Dec. 24, 1946

2,413,113

UNITED STATES PATENT OFFICE

2,413,113

AUTOMATIC GUN CHARGER

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Application November 5, 1942, Serial No. 464,609

4 Claims. (Cl. 89—1)

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This invention relates to charging systems for automatic guns and particularly to automatic charging systems therefor.

In many types of guns the loading operation is performed by the reciprocation of a breech block such as in machine guns and automatic cannon employed in military aircraft. In most of the automatic guns now employed, the reciprocation of the breech block and its attendant breech bolt is actuated by the power developed by the firing of a cartridge, which ejects the empty shell and places a succeeding cartridge in the gun breech ready for firing. If, however, one of these cartridges fails to fire there is no reciprocation of the breech block to eject the faulty cartridge and to insert a fresh cartridge. It may also happen that the moving parts of an automatic gun may become stuck or pinched so that it is unable to operate automatically. In either event, such a gun is termed a jammed gun, and the only way to restore it to automatic operation is to retract the breech bolt by means external to the gun.

In the past it has been customary to retract the breech bolt of a jammed gun by hand. Such an operation is ordinarily not possible in modern military vehicles since the guns may be located remotely from the operator, as, for example, in the wings of a military aircraft. In such a case, to free guns in the manner described, it is known to provide cables running from the wings to the cockpit, which cables can be actuated by the pilot or gunner. Obviously, such an expedient requires an elaborate system of pulleys and long cables, particularly in the case of the larger aircraft now employed, and with the larger caliber guns and cannon now in use it is very difficult to reciprocate the moving parts manually. Further, if the gunner or pilot has other duties, he cannot take the time and effort necessary manually to free and recharge the guns. These and other considerations make it desirable to have a power mechanism for recharging guns in the event of misfire and it is desirable to have this mechanism operate automatically.

Attempts have been made to provide power means to recharge guns, as for example by use of pneumatic power systems. Some of the pneumatic systems are automatic, using electrical controls to create an automatic action. Invariably, however, in these systems there is a mechanical time lag mechanism such as a dashpot which is reset each time a round is fired. If the gun should fail to fire in a time period longer than the normal time of bolt travel between successive firing of each round the dashpot will travel through its entire stroke and set the charging system in action. Obviously, the firing of each round places an abusive force on the dashpot, and its life as a result thereof is extremely limited.

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Another expedient has been proposed to effect the automatic recharging of guns, which expedient has been the use of automatic electric recharging mechanism. These devices have been open to the objection that oftentimes they are as large as the gun upon which they are used for recharging. Where space and weight are matters of prime importance such an expedient is hardly a desirable one.

This invention improves upon the prior art in that hydraulic fluid is used for effecting a recharging operation, and that electric power is used merely as a controlling means and not as the power means as is the case in an electro-mechanical charger. Hydraulic fluid has been found to be most reliable and positive in action and therefore is preferred over pneumatic systems. Too, since hydraulic fluid is available under pressure in most military vehicles, particularly aircraft, little additional burden is placed upon the power plant as would be the case where an electro-mechanical charging system is employed. Whereas with a pneumatic system the motivating fluid is exhausted to atmosphere at the conclusion of a charging operation, the fluid used in a hydraulic system is exhausted to a reservoir and may be used over and over again.

This invention is a further improvement over the prior art in that an electrical time lag mechanism is employed, thereby saving weight, and also not being open to the criticisms and objections inherent in a dashpot used to accomplish the same purpose. The improved charging system comprising this invention is also an improvement over the prior art in that hydraulic fluid under high pressure may be employed, thereby requiring only the use of a small motor having a high power-to-weight ratio thereby adding but little weight to the aircraft. A feature of the invention lies in the use of a single valve to control the flow of a fluid to a charging motor, small intermediate selector valves being employed to pass fluid only to the charging center of the gun requiring recharging.

Other important features of the invention include a specially designed charging motor using hydraulic fluid, spaced brackets for holding the charging cylinder to its gun and permitting easy removal of the charging motor without disman-

tling the gun, and a charge counting device to limit the number of charging operations to be applied to a single gun. This last is an important feature, since a gun requiring a large number of charging operations has probably expended its ammunition or is in some way defective. The invention also includes means whereby an armorer may reload the gun with a fresh belt of ammunition or test the operation of the gun when it is equipped with the improved charging system. There is also provided a cut-out means for stopping a "run away" gun, which otherwise might be injured by a long burst of fire.

With the foregoing problems in mind, it is an object of this invention to provide an electro-hydraulic charging system which is fully automatic, the charging system being applicable to a single gun or to a plurality of guns.

A further object of the invention is to provide an automatic charging system for either a single gun or a plurality of guns which will add but little to the weight of a military vehicle.

The still further object is to provide an automatic charging system which is operable by pressure from a fluid pressure system normally included in a military aircraft.

Yet another object is to provide a charging system for several guns wherein selector valves draw fluid from a single master valve to the particular gun or guns requiring charging.

Still another object is to provide an improved charging motor for use with hydraulic fluid.

A still further object is to provide a charging motor which is operable to retract the bolt of a misfiring gun and to hold it in retracted position before freeing it for unimpeded counter movement to the firing position.

A still further object contemplates the provision of means whereby the armorer of a gun equipped with this invention may reload a gun with a fresh belt of ammunition or test the operation of the gun.

Another object is to provide a charge counter for each gun which cuts out the operation of the charging system associated with each gun to stop a gun which fires regardless of whether the sear is actuated or not.

Another object is to provide a cut-out mechanism for the firing motor of an improperly operating gun.

These and other objects and features of the invention are pointed out in the following description in terms of the importance thereof which are shown in the accompanying drawings. It is to be understood, however, that the drawings are for the purpose of illustration only and are not designed as a definition of the limits of the invention, reference being had to the appended claims for this purpose.

In the drawings illustrating a preferred embodiment of this invention:

Figure 1 is a diagrammatic plan view of the entire charging system as applied to a plurality of machine guns;

Figure 2 is a diagrammatic view of a modified form of an automatic charging system employing selector valves for each charging motor;

Figure 3 is a longitudinal vertical segment of a charging motor and a cooperating switch therefor including a mechanical charge counter;

Figure 4 is a fragmentary elevational view of our improved charging cylinder showing its attendant switch in outline form, parts of the switch being shown in dotted outline; and

Figure 5 is a section taken along the lines 5—5 of Figure 3.

With reference to Figure 1 of the drawings there is shown, the invention having incorporated therewith a fluid pressure system normally forming a part of the equipment of an aircraft for supplying fluid under pressure to charging motor 20 attendant upon each gun 22 and operative to retract the bolt of a misfiring gun under conditions later to be described. The fluid pressure system comprises a reservoir 24 which supplies fluid to a pump 26 and places the fluid under pressure in an accumulator 28. The accumulator 28 is connected by a conduit 30 to each solenoid-operated valve 32. Valve 32 is connected by a conduit 34 to each charging motor 20, at times supplying fluid at high pressure from the conduit 30, and at times exhausting the fluid from the charging motor 20 through a return line 36 to the reservoir 24. The conditions under which the solenoid operated valves 32 operate will be later described.

The electric circuits shown in Figure 1 will now be described, and for purposes of simplification will be described with relation to one gun. However, like parts shown in Figure 1 bear corresponding ordinals and the circuit which will be described as applied to one gun is equally applicable to the other gun 22. Electrical energy may be supplied as from a battery 38, which battery passes current to a slow release relay 40 through an ignition switch 42. A branch of this circuit passes current to a switch 44 which is held open during the proper operation of its associated gun. The circuit which includes the switch 44 has also therein an electrical charging counter mechanism 46 which is placed intermediate the switch 44 and the solenoid operated valve 32.

The control of the charging mechanism 20 and its attendant solenoid operated valve 32 is effected by making and breaking the switch 44. The circuit effecting the operation of the switch 44 comprises the slow release relay 40 which has two branches leading to ground. Interposed between the relay 40 and ground is a manually operated switch 48 and a rear gun switch 50, which is closed and opened by the reciprocation of the breech pin which strikes a switch actuator 51 at the rearward end of its path of reciprocation. A second ground circuit for the slow release relay 40 includes the manually operated switch 48, a forward gun switch 52 and a double pole switch 54 which is closed.

Switch 50 is open at times when the breech bolt is in its forward position, but is closed by the breech bolt of the gun 22 when the bolt reciprocates during the firing of the gun. The switch is also closed at the completion of a charging cycle. Switch 52, which is at the forward end of the path of reciprocation of the breech bolt is normally closed by said breech bolt. The breech bolt will keep the switch 52 closed whenever the breech is closed, but when not closed by the breech bolt it tends to open, thus when the breech bolt is closed there will be a ground circuit for relay 40 through the switch 52 and the switch 54. Grounding relay 40 energizes it, actuating bell crank 56 thereby opening the switch 44, and thus cutting off the flow of current to the solenoid operated valve 32. Thus when switch 42 is closed, and the breech block of the gun 22 is closed the relay 40 will be grounded, and the only effect, then, closing the switch 42 will be to open switch 44 when the breech bolt is in a closed or forward position.

Closing switch 42 also passes current to one contact of a safety switch 58 which when closed passes current to one contact of the trigger switch 60. Closing trigger switch 60 passes current to a firing motor 62 mounted on each gun 22. The firing motor 62 when energized will actuate a sear, not shown, of the gun 22 and will cause the gun to fire provided there is a live cartridge in the firing chamber. Intermediate the switch 60 and the firing motor 62 is a cut-out mechanism 45 which operates as a unit with an electric counter unit 46. These will be described later in this description. Simultaneous with the closing of the trigger switch 60 is the energization of the relay 64, which opens the switch 54, thus breaking the ground circuit of the relay 40, which thereupon loses its energy. However, relay 40 is of the slow release type and will hold the switch 44 in open position during the particular time period for which the relay is constructed. This period can be any period longer than the time between the firing of each round of gun 22 when firing automatically. When the breech bolt upon firing reaches the rearward end of its travel, the breech bolt closes the switch 50 thereby grounding relay 40 thereby reenergizing it. This intermittent energization of relay 40 through switch 50 maintains the switch 44 in an open position so that the valve 32 will not be operated.

If the gun should jam, however, relay 40 would not be intermittently energized through switch 50 and at the expiration of the time period of the relay 40 the switch 44 would close, thereby passing current through the counter 46 and to the solenoid operated valve 32. Upon energization of the solenoid operated valve 32 fluid is passed from accumulator 28 to the charging motor 20 to retract the breech bolt thereof and recharge or recock the gun 22. When the breech bolt has been retracted by the charging motor 20 the rearward gun switch 50 will close thereby once more energizing the relay 40, and opening switch 44. With the trigger motor in energized condition, and after the breech bolt has returned to the forward position the gun will continue to fire automatically, thereby periodically closing switch 50 and periodically energizing relay 40 to keep the switch 44 open.

If a charging cycle as described above should be started and the firing period then terminated by opening the trigger switch 60 the gun 22 will nevertheless continue to charge. When the firing period ceases as by opening trigger switch 60 the relay 64 will be deenergized, allowing switch 54 to close, thus closing one of the two branch ground circuits for the relay 40. However, after the charging cycle has started switch 52 opens, thus opening the only possible ground circuit for the relay 40, since the other ground circuit to switch 50 is already broken. Thus with both ground circuits open, the relay 40 will continue to be deenergized effecting a charging cycle as previously described, as the switch 44 is already closed.

The electric counter unit 46 is provided to limit the number of charges for any one gun, as a gun which requires a large number of charges has expended its ammunition or is probably defective. This counter 46 comprises a plate member 66 having a conductor sector and notches along the edge of another sector. The member 66 rotates about a shaft 68, and brushes 70 contact the conductor sector. A ratchet arm 72 is also pivoted at the end of the shaft 68 and has a pawl 74 pivoted thereto, which contacts the

notches of the member 66. The arm 72 is actuated upon the energization of a solenoid 76, which solenoid is energized whenever the switch 44 is closed. That is, each time switch 44 is closed, solenoid 76 receives an impulse of current from the source to actuate the mechanism 45. Each movement of the arm 72 contacts a succeeding notch on the member 66 and after a predetermined number of current impulses through the solenoid operated valve 32 one of the brush segments 70 will move out of engagement with the conductor sector of member 66 to thereby cut off the flow of current to the solenoid operated valve 32. In this way a gun which has expended its ammunition and which repeatedly jams will not be charged after a predetermined number of charges have been made.

Since a useless expenditure of power would be attendant upon the continued energization of the firing motor 62 of a gun which has been cut out from the system by the counter mechanism 46, a firing motor cut out is incorporated into the system for deenergizing the firing motor of such a gun. This cut-out mechanism consists of a unit 45 connected to the charge counter by the shaft 68. The unit comprises a circular disk 47 of the same dimensions as the member 66 and having a conductor sector 49 like that of member 66. Two brushes 49*a* contact the conductor sector 49 and pass current to the trigger motor 62 when both are in contact with the conductor sector 49. When the counter mechanism 46 cuts out its attendant gun, the firing motor cut-out likewise cuts out the firing motor 62 of the same gun.

The switch 48 is manually operable, and by holding switch 48 open current cannot pass through the relay 40 as both its ground circuits will be broken, thereby dissipating its energy, thus closing switch 44 effecting a charging operation as described above. By means of switch 48 the gunner may charge any gun if he has reason to doubt that it is not in an operative condition, or if there is a "runaway" gun. This gun may be effectively stopped by opening switch 48, which also causes any gun to be charged. By holding switch 48 open the associated gun will charge and the breech bolt will be held in a retracted position, and if the object in so doing is to cool off a "runaway" gun, this switch can be kept open until such a gun is cooled to the point where another burst of firing will not injure it.

A ring 78 is provided to actuate one member of switch 52. This ring is used by the armorer when reloading the gun with a new belt of ammunition. By pulling on ring 78 the ground of relay 40 will be broken and if the pull is of a duration long enough to allow relay 40 to deenergize before releasing ring 78 current will thereby pass to the solenoid of valve 32 to effect a charge. If a live cartridge remains in the firing chamber, it will, of course, be ejected by the charging operation. The first link of a new belt is then inserted in the feedway of gun 22 and ring 78 is again pulled as before, allowing the gun pawl to engage the first live round. Following these operations, one more charging cycle must be performed before the gun will fire. This charge is usually performed by the gunner, just prior to combat by manually opening switch 48. This charging sequence is followed to provide an additional safety feature and makes possible the reloading of the gun while performing a minimum of manual operations upon it.

The details of construction of the charging cyl-

inder will be later described as well as the construction of the brackets which hold the charging motor 20 to the gun 22.

With reference to Figure 2 of the drawings there is shown an automatic machine gun charger employing a selector valve system. The selector valve system differs from the system shown in Figure 1 in that each charging motor 20 has a selector valve 80 for controlling the flow of fluid from the single master valve 32. The selector valves are connected to a common hydraulic fluid line 82 to the master valve 18 and are selectively opened to charge the proper gun. The selector valve 80 is open only when there is no fluid pressure in the line to the charging motor 20 and therefore needs to employ only a small and light weight solenoid 84. In most installations there is a saving in weight by the use of selector valves making the system very desirable for aircraft.

The electrical circuit for the selector valve system of Figure 2 is basically the same as for the system shown in Figure 1. Closing switch 42 passes current to relay 46, which as in Figure 1 has two ground circuits one through switch 50 and the other through switches 52 and 54. Relay 40, when energized, acts through a bell crank 86 to open switch 44 to master valve 32 in much the same way as in Figure 1. Bell crank 86 differs from bell crank 56 of Figure 1, however, in that it is a conductor of current, passing current through its length when switch 44 closes, the other end of bell crank 86 forming also a part of switch 88 at the same time it operates switch 44. When relay 40 is deenergized and the bell crank 86 is released, current flows from switch 44 to master valve 32 and in addition through bell crank 86 to switch point 89 and through a conductor to the solenoid 84 of selector valve 80, thus when the relay 40 is deenergized current is passed to the selector valve 80 associated with a misfiring gun and to the master valve 32.

The selector valve 80 is a simple solenoid operated or poppet valve of any suitable construction. The solenoid 84 employed may be made very small, and it is therefore desirable that means be provided to insure that there will be no pressure on the line 82 when it is operated. The means provided includes a bell crank 90 for grounding the master valve 32, which switch is operated by the opening movement of selector valve 80. A movable core 92 of the solenoid valve 80 actuates the bell crank 90, which closes a switch 91 thereby grounding the circuit to master valve 32. This construction insures that the selector valve 80 will always be open before fluid under pressure is passed to the charger motor 20.

The selector valve system employs mechanical charge counters, and these will be next described along with the charging cylinder 20. The electrical counters 46 of Figure 1 could also be applied and could be in the selector valve circuit with equal effect, and the mechanical charge counters associated with the charging motors 20 could also be applied to the system of Figure 1 with equal effect.

Referring now to Figures 3, 4 and 5 there is shown the charging motor 20 of Figures 1 and 2. Although this charging unit is well suited for the automatic systems here described, it is applicable also to any type of gun charging system. The unit may be used on a manually controlled system, and for such use none of the electrical features of the present systems would be used. A manually controlled system in which this unit could be used is described in the copending application of White and Pontius, Ser. No. 311,978, filed January 2, 1940, now Patent No. 2,332,419. The charging motors can also be used in a semi-automatic system such as described in the application of Pontius, Ser. No. 319,925, filed February 20, 1940, now Patent No. 2,355,179. Other uses and applications of the charging unit can be made and it is not intended to limit its use to the present systems.

The charging motor 20 comprises a cylindrical casing 100 within which a cylindrical piston 102 reciprocates. The right-hand end of the unit is toward the front of the gun on which it is mounted, and the left-hand end of the unit is secured to the rear of the gun. The piston 102 contacts a breech pin 104 (shown in dotted outline) and moves the breech block of the gun 22 rearwardly by acting on breech pin 104 during a charging operation. Fluid under pressure is directed into the cylinder 100 at the fitting 106, which may be connected to either the selector valve 80 of Figure 2 or directly to the solenoid operated valve 32 of Figure 1. The cylinder 100 is held to the gun by a forward bracket 108 and by a rear bracket 110.

The piston 102 is held in a forward position by a spring 112 which fits inside cylinder 100 and extends into piston 102. Spring 112 is mounted on a two-part tubular telescoping spring guide, one part of which comprises an outer member 114, the other part being an inner tubular member 116 secured to the piston 102. As the piston 102 reciprocates within cylinder 100 under the influence of fluid pressure and the spring 112, the inner member 116 telescopes in the stationary outer member 114.

A pointed pin 118 slides in guide member 114 and has an extended shank 120 which passes through a construction in the inner end of guide member 116, and has a head 122 attached to the end of the shank 120. The relationship of parts is such that the last portion of the rearward movement of piston 102 causes the inner telescoping member 116 to contact the pin 118 and move it rearwardly. The last part of the forward movement of piston 102 causes the constricted end of guide tube 116 to act on the head 122 of shank 120 to pull the pin 118 forward.

These movements of pin 118 cooperate with a breech bolt latch to hold the breech bolt in a retracted position after the charging stroke until the piston 102 has returned nearly to its starting position, permitting the unimpeded movement of the breech pin upon its return to the forward position. The breech pin latch includes a rocker arm 124 pivoted at 126 to the rear support bracket 110. Pivoted at the forward end of the rocker arm 124 is a catch finger 128 pivoted at 130 and urged by a leaf spring 132 to a "catch" position. At the rear end of the rocker arm 124 is a roller 134 designed to reduce friction when the rocker arm is contacted by the pin 118. Also secured to the rear end of the rocker arm 134 is a leaf spring 136 which contacts the bracket 110, and normally maintains the arm 124 in a disengaged position. A fitting 138 on the rear end of cylinder 100 has secured thereto a roller 140 to provide a thrust bearing when the pin 118 strikes the rocker arm roller 134.

The operation of the charging motor as thus far described is as follows. Charging fluid from any suitable control device, manual or automatic, enters the cylinder 100 at the fitting 106 and forces the piston 102 to the left, and in so doing

the breech bolt of the gun is retracted through the contact of the skirt of piston 102 with the breech pin 104, shown in dotted outline. As the piston 102 nears the end of its stroke, the guide tube 116 strikes the end of pin 118 forcing it between the rollers 140 and 134. This movement of the pin 118 forces the rocker arm 124 to pivot about 126 against the load in spring 136 so that the rocker arm 124 assumes a nearly horizontal position. In that position the latch 128 is in the path of the breech pin 104, as shown by the dotted outline of the latch 128. As the breech pin 104 nears the end of its permissive travel, it strikes the latch 128 and causes it to rotate about its pivot against leaf spring 132, allowing the breech pin 104 to pass. Once the breech pin 104 is past the latch 128 the spring 132 causes the latch to snap back to its normal position, locking the breech pin in its retracted position.

When the piston of the charging cylinder 20 reaches the end of its stroke the charging fluid is cut off from the pressure source and ported to atmosphere either automatically or manually. Spring 112 now forces the piston 102 to its starting position forcing out the fluid to atmosphere. The latch 128 on the rocker arm 124 holds the breech pin 104 and its breech bolt in a retracted position until the piston 102 is out of the path of travel of the breech pin 104 to allow the breech bolt to have unimpeded action on the closing stroke. The release of the breech pin 104 is accomplished by pulling the pin 118 from between the rollers 140 and 134, which removal allows the rocker arm 124 to rotate about its pivot to render the latch 128 inoperative. The pin 118 is pulled from between the rollers by the restriction in the inner tubular member 116 striking the head 122 on the shank 120 of the pin 118 as the piston 102 is moved to its starting position. The arrangement of the parts is such that the pin 118 is pulled out from between rollers only when the piston 102 has reached its starting position and out of the path of travel of the breech pin 104. As described, the device is a charging unit which will hold the breech bolt in a retracted position until the charging piston has withdrawn from the path of travel from the breech pin.

The charging unit as applied to the systems herein described incorporates further features. The actuator switch 50 is also shown in detail in Figure 3. The switch 50 is operated by a switch actuator 51 which is secured to the bottom of the switch 50. At every reciprocation of the breech bolt, whether during automatic firing or during a charging cycle, the breech pin 104 strikes the switch actuator 51 which in turn closes the switch 50. It will be noted that the switch 50 is of the snap spring type wherein a small movement of the actuator in one direction causes a relatively large movement in the opposite direction.

The charging unit as shown in Figure 3 incorporates a mechanical charge counter. Mounted on the rear bracket 110 is an arm 142 supporting a rotatable ratchet wheel 144 which has a removed segment as shown, and a reciprocable spring pressed push button 146. A strip of spring metal 148 is attached to the upper end of the push button 146 and contacts the ratchet wheel 144. The push button 146 extends into the path of travel of the pin 118, and at every charge stroke of the motor 20 the pin 118 strikes the push button 146 causing it to move upwardly against the compression of its spring, and causing the member 148 to move the ratchet wheel 144 one notch in a clockwise direction.

The actuator switch 50 is rotatably secured to the bracket 142 by means of a pivot pin 150. Protruding from the rearward side of the pivot pin 150 is a finger 152 which contacts the ratchet wheel 144 and which is urged rotatably in a clockwise direction by spring 154 coiled about the pivot pin 150, one end of spring 154 engaging the rear bracket, the other end of which contacts the finger 152. However, the switch 50 is held in a substantially horizontal position by the contact of the finger 152 with the ratchet wheel 144. The purpose of the ratchet wheel 144 and the push button 146 is to cut out the charging unit 20 from the hydraulic system when a predetermined number of charging operations have been made. As has been explained before, an excessive number of charging operations generally indicates that a gun has expended its ammunition or is in some way defective. It is therefore best to cut such a gun out from the hydraulic system so as not to reduce the hydraulic pressure excessively or unnecessarily.

The operation of the mechanical charge counter just described is as follows. At every charging stroke the ratchet wheel 144 will be rotated one notch by the spring metal strip 148 attached to the push button 146 whenever it is contacted by the pin 118. After a given number of movements, the ratchet wheel 144 will be rotated so that the relieved portion or segment is adjacent the finger 152, which, through the pressure of spring 154 causes the end switch unit 50 to rotate in a clockwise direction to the position shown in Figure 4. When in this position the switch 50 remains continuously in a closed position. This closed position is maintained by the torsional effect of spring 154 in rotating the switch 50 clockwise against the cylinder 100. Rotation of switch 50 against cylinder 100 actuates the operator 51 which closes the circuit. As has been described previously when the switch 50 remains in closed position a ground is made for the relay 40 thereby energizing it and keeping the switch 44 open to prevent the flow of fluid from the fluid pressure system through the valve 32 and the selector valves 80. To return the gun to normal operation, the ratchet wheel 144 is manually rotated to its starting position, causing switch 50 to once more assume an operative position as shown in Figure 3.

The switch 52 is also shown in Figure 3 and is operated by a switch operator 53, similar to the operator 51 for switch 50. This operator is contacted by the breech pin 104 whenever the breech is closed on the firing chamber.

Another part of the invention relates to brackets 108 and 110 for holding the charging unit to the guns. As shown in Figure 5, which is a section through the rear bracket 110, the bracket is of a type which may be opened to remove the charging cylinder 100 from the gun 22. A semi-circular locking member 156 is pivoted to the bracket 110 at 158. A clamp member 160 is hinged to the bracket 110 at 162 and acts through a screw 164 to clamp the locking member 156 around the fitting 138 of the charging cylinder 100. When it is desired to dismount the charging cylinder 100 the screw 146 is loosened, the clamp swung downwardly and the locking member swung upwardly. In this way the charging cylinder 150 may be removed from the gun and the gun removed without disconnecting the hydraulic circuit. This type of bracket is desirable for removing a gun from its emplacement for repairs, cleaning or replacement, which operations may be performed without disconnecting any hydraulic circuits.

The operation of the system shown in Figure 1 is as follows. The pump 26 is operated by any suitable source of power, and pumps hydraulic fluid from reservoir 24 to accumulator 28. Solenoid valves 32 are now ready to direct hydraulic fluid to conduits 34 when operated by the electrical circuit. Conduits 34 direct the fluid from valve 32 to the charging motors 20 to charge guns 22.

The electrical system may be conveniently divided into first and second circuits, and a firing circuit. The first circuit comprises a battery 38, switch 42, openable connection 44, counter-unit or current impulse responsive means 46—76, and electrically operated valve 32. The second circuit comprises the source or battery 38, switch 42, time-delay relay 40, normally open switch 50, switch 52, which is normally closed when the breech bolt is in its forward position of the gun, and normally closed means 54. The firing circuit comprises the battery 38, switch 42, trigger switch 60, relay 64, cut out member 45, and firing motor 62.

The operation of the electrical circuit will now be described with relation to one gun 22, as the operation is identical for the other gun. Ignition switch 42 is first closed, passing current to slow release relay 40 which is normally connected through manual switch 48, which is normally closed, and through switch 52, which is normally closed by the breech bolt when the breech of the gun 22 is closed and from there through switch 54 which is normally closed when the gun is not firing and is there grounded. Grounding this circuit energizes the relay 40, which acts through bell crank 56 to open switch 44, thus cutting off current to solenoid valve 32. When it is desired to fire the gun, safety switch 58 is first closed, and then trigger switch 60 is closed. The firing motor 62 is operated by the current from switch 60 and the gun begins to fire. At the same time relay 64 is energized, which breaks the ground of relay 40 at switch 54.

When the ground of relay 40 is broken at switch 54, there is a tendency for the relay 40 to release the bell crank 56, closing switch 44. However, relay 40 is a slow release relay having a release period greater than the interval between shots of the gun to which the charging mechanism is affixed. Since the same switch operation that breaks the ground of relay 40 at switch 54 also energizes the firing motor 62, the gun 22 will fire at the same time switch 54 is broken, and the breech bolt reciprocates, alternately closing and opening switch 50. Closing switch 50 grounds relay 40, energizing relay 40 so that it will continue to maintain switch 44 in an open position.

If the gun jams during a firing period actuator switch 50 remains continuously open because the breech bolt will not reciprocate, and the relay 40 becomes deenergized at the end of its time period causing switch 44 to close. Solenoid valve 32 then opens, passing fluid to the fluid motor 20 which charges the gun by retracting the breech bolt of the gun, ejecting the dud shell and inserting a fresh one. When the breech bolt reaches its most retracted position it acts on operator 51 to close switch 50, thereby grounding relay 40 and breaking the connection to solenoid valve 32. If the trigger system is still in a firing condition the gun will once more fire upon the breech bolt closing and contacting the cartridge chamber.

If the firing control is cut off during the charging stroke it is desirable to continue the charging operation so that a fresh cartridge will be in the firing chamber for the next firing period and this operation is as follows. Upon cessation of firing, relay 64 is deenergized and switch 54 is thereby closed. Relay 40 is not grounded, however, as the first movement in the charging cycle forces the breech bolt backwardly opening switch 52. Because switch 52 is open the ground of relay 40 is broken during the charging cycle until the breech bolt reaches the end of its reciprocatory movement, at which time relay 40 is grounded through switch 50, and valve 32 is thereby closed. The charging operation inserts a fresh shell in the firing chamber and the gun is once more ready for firing when the trigger is actuated.

Often when a period of fire is over it is desirable to reload the machine gun 22 by inserting a fresh belt of ammunition into the mechanism of the gun. The old belt is removed from the gun and a new belt inserted into the gun. The charging operations necessary to place a cartridge of the new belt into the gun can be performed by the charging system. The armorer pulls on ring 78, opening switch 52, breaking the connection to ground for relay 40. If ring 78 is pulled to keep switch 52 open for a period longer than the time interval of relay 40, the deenergization of relay 40 will release bell crank 56 closing switch 44, which actuates valve 32, charging the system. This first charging stroke ejects the live shell in the firing chamber. The first link in a new belt is then inserted in the feedway of gun 22, and ring 78 is again pulled, allowing the gun pawl to engage the first live round. Following these operations, one more charging cycle must be performed before the gun will fire. This charge is usually performed by the gunner, just prior to combat by manually opening switch 48. This charging sequence is followed to provide an added safety feature inasmuch as the gun cannot be fired until this final charge is made.

The electrical charge counter 46 cuts out a gun which requires an excessive number of charges, as such a gun is probably defective, and the operation is as follows. At every charge, solenoid 76 is energized, pulling on ratchet arm 72 which in turn rotates conductor member 66 about its pivot 68. The current meantime flows from brushes 70 through the conductor to operate valve 32. After a predetermined number of charges have been made, the ratchet will have rotated conductor member 66 out of contact with one of the brushes. In this position of member 66, current can no longer pass to valve 32, and thereafter when gun 22 jams it will not be charged, but will remain in a jammed condition.

As has been explained before when the charge counter 46 cuts out a misfiring gun the firing motor cut-out 45 likewise cuts out the firing motor 62 of the same gun.

In firing a gun it sometimes happens that a part will become stuck or injured so that a gun will continue to fire regardless of trigger actuation. Such a gun is known as a "runaway" gun. Our invention provides means to control such guns to keep them from becoming injured by long continued fire. This means is the manually operated switch 48 illustrated as near relay 40. By manually opening switch 48 the ground connections of relay 40 are all disconnected and switch 44 closes passing current to solenoid valve 32 causing it to charge the gun 22. Often a single charge is enough to restore a runaway gun to normal operation, but where this is not sufficient the breech bolt of the gun can be held in a retracted position by keeping switch 48 open until the gun

is cooled to a point where further "runaway" firing will not injure it. The switch 48 is shown adjacent to the gun, but by using longer conductors it may be placed near the other manually operated switches 42, 58 and 60.

The operation of the selector valve system shown in Figure 2 is as follows. Ignition switch 42 is first closed passing current to slow release relay 40 which is grounded through switch 50, which is normally closed by the bolt of gun 22 and from there through switch 54, which is closed when the gun is not firing. Grounding this current energizes the relay 40, which acts through a bell crank 86 to open switch 44 and switch 88, thus cutting off current to master valve 32 and selector valve 80. When it is desired to fire the gun, safety switch 58 is first closed, and then trigger switch 60 is closed. The firing motor 62 is operated by current from switch 60 and the gun begins to fire. At the same time relay 64 is energized, breaking the ground of relay 40 at switch 54.

When the ground of relay 40 is broken at switch 54, there is a tendency for relay 40 to release the bell crank 86, close switches 44 and 88. Relay 40 is, however, a slow release relay of any suitable time period greater than the period of automatic fire of the gun 22. Due to this characteristic, relay 40 will hold the bell crank 86 until its time period has elapsed, in the absence of an intervening charging current. Relay 40 is intermittently grounded, however, through actuator switch 50, and the bell crank 86 is thereby held to keep switches 44 and 88 in an open condition, preventing the operation of master valve 32 and selector valve 80. Actuator switch 50 is intermittently closed by the reciprocating breech bolt of gun 22 striking switch operator 51. At every shot of the gun 22, the breech bolt reciprocates and as the time between shots is less than the period of the slow release relay 40, it will be reenergized before its release period has expired.

If one of the guns should jam during a firing period, the relay 40 of the jammed gun becomes deenergized at the expiration of its release period, and the bell crank 86 moves to close switches 44 and 88. Selector valve 80 now opens, and the movement of its core 84 acts through bell crank 90 to close switch 91, grounding the current through the solenoid of master valve 32 which then opens to fluid pressure from the accumulator 28. When master valve 32 is operated, high pressure fluid flows into line 82, and through the open selector valve 80 and into the charging motor 20 of the jammed gun, charging that gun by retracting its breech bolt for counter-movement, which action ejects the dud shell and inserts a fresh one. During this charging operation, the selector valve of the other gun remains closed; no fluid can enter its charging mechanism, and the gun continues to fire uninterruptedly. When the breech bolt reaches its most retracted position during the charging stroke, it acts on operator 51 to close the switch 50, thereby grounding relay 40 and breaking the connection to selector valve 80 and master valve 32. The charging mechanism exhausts its charging fluid and the gun is again ready for firing. If the trigger system is still in a firing position, the gun will once more fire upon the breech bolt contacting the cartridge chamber.

Upon cessation of firing, relay 64 is deenergized, allowing switch 54 to close and establishing a ground for relay 40 through switches 48 and 52. This energizes the relay 40 which acts on bell crank 86 to render master valve 32 and solenoid valve 80 inoperative.

If the firing control is cut off during the charging stroke, it is desirable to continue the charging operation so that a fresh cartridge will be in the firing chamber for the next firing period and this operation is as follows. When the charging cycle is started just prior to the cessation of firing, switch 52 is opened, thereby breaking the ground circuit for relay 40 that is normally established upon cessation of firing. Relay 40 therefore remains deenergized, and switches 88 and 44 remain closed. When the breech bolt reaches the end of its charging stroke, it causes switch 50 to close thus grounding relay 40, and causing switches 88 and 44 to open, allowing the charging fluid to return to exhaust. By this operation a fresh cartridge is placed in the firing chamber, and the gun is again ready for automatic fire when the trigger is actuated.

The armorer's charging operation by pulling on ring 78 is similar to that of Figure 1 which has already been described. Also the operation for stopping a "runaway" gun in the system of Figure 2 is similar to that of Figure 1, which operation has also been described.

Having described our invention it is not intended to be limited by the specific embodiment herein disclosed. The hydraulic and electrical systems may be changed in many ways and yet fall within our invention. Any fluid could be used in place of a hydraulic fluid in the system disclosed. The devices included in the system may have various different applications and still come within the scope of the invention. Nor is the invention limited in any way other than by the terms of the following claims.

This application is a continuation in part of our copending application Ser. No. 371,742, filed December 26, 1940.

We claim:

1. A gun charging apparatus for use with a gun having a reciprocable breech bolt movable from a normal forward position of the gun to a retracted position thereof and then released for counter movement when charging of the gun is desired, comprising a fluid pressure motor adapted to be mounted on the gun and constructed and arranged to engage the bolt to retract the same, an electrical system including a source of current and first and second circuits, an electrically operated valve in the first circuit for controlling the flow of fluid to said motor and connected in the first circuit through an openable connection, a time delay relay in the second circuit constructed and arranged to be energized in response to normal reciprocation of the breech bolt to open said openable connection and to be deenergized in response to abnormal reciprocation of the breech bolt to permit closing of said openable connection, a switch in the second circuit normally open and constructed and arranged to be closed by the breech bolt when in a retracted position only, to connect the time delay relay in the second circuit to energize said relay, means in the second circuit normally closed to energize the time delay relay at times when the switch is open, a firing circuit including a firing motor mounted on the gun and a trigger switch interposed between the firing circuit and the source of current, and a relay in the firing circuit constructed and arranged to open said normally closed means when the trigger switch is closed so that energization of the time delay relay must depend upon normal breech bolt reciprocation.

2. A gun charging apparatus for use with a gun having a reciprocable breech bolt movable from

a normal forward position of the gun to a retracted position thereof and then released for countermovement when charging of the gun is desired, comprising a fluid pressure motor adapted to be mounted on the gun and constructed and arranged to engage the bolt to retract the same, an electrical system including a source of current and first and second circuits, an electrically operated valve in the first circuit for controlling the flow of fluid to said motor and connected in the first circuit through an openable connection, a time delay relay in the second circuit constructed and arranged to be energized in response to normal reciprocation of the breech bolt to open said openable connection and to be deenergized in response to abnormal reciprocation of the breech bolt to permit closing of said openable connection, a switch in the second circuit normally open and constructed and arranged to be closed by the breech bolt when in a retracted position only, to connect the time delay relay in the second circuit to energize said relay, means in the second circuit normally closed to energize the time delay relay at times when the switch is open, a manually operated switch in the second circuit normally closed and constructed and arranged to be opened to deenergize the time delay relay to manually initiate charging, a firing circuit including a firing motor mounted on the gun and a trigger switch interposed between the firing circuit and the source of current, and a relay in the firing circuit constructed and arranged to open said normally closed means when the trigger switch is closed so that energization of the time delay relay must depend upon normal breech bolt reciprocation.

3. A gun charging apparatus for use with a gun having a reciprocable breech bolt movable from a normal forward position of the gun to a retracted position thereof and then released for countermovement when charging of the gun is desired, comprising a fluid pressure motor adapted to be mounted on the gun and constructed and arranged to engage the bolt to retract the same, an electrical system including a source of current and first and second circuits, an electrically operated valve in the first circuit for controlling the flow of fluid to said motor and connected in the first circuit through an openable connection, a time delay relay in the second circuit constructed and arranged to be energized in response to normal reciprocation of the breech bolt to open said openable connection and to be deenergized in response to abnormal reciprocation of the breech bolt to permit closing of said openable connection, a switch in the second circuit normally open and constructed and arranged to be closed by the breech bolt when in a retracted position only, to connect the time delay relay in the second circuit to energize said relay, means in the second circuit

normally closed to energize the time delay relay at times when the switch is open, a switch in the second circuit constructed and arranged to close when the breech bolt is in its forward position of the gun and to open when the breech bolt is moved toward its retracted position to thereby complete a charging cycle once initiated, a firing circuit including a firing motor mounted on the gun and a trigger switch interposed between the firing circuit and the source of current, and a relay in the firing circuit constructed and arranged to open said normally closed means and when the trigger switch is closed so that energization of the time delay relay must depend upon normal breech bolt reciprocation.

4. A gun charging apparatus for use with a gun having a reciprocable breech bolt movable from a normal forward position of the gun to a retracted position thereof and then released for countermovement when charging of the gun is desired, comprising a fluid pressure motor adapted to be mounted on the gun and constructed and arranged to engage the bolt to retract the same, an electrical system including a source of current and first and second circuits, an electrically operated valve in the first circuit for controlling the flow of fluid to said motor and connected in the first circuit through an openable connection, a time delay relay in the second circuit constructed and arranged to be energized in response to normal reciprocation of the breech bolt to open said openable connection and to be deenergized in response to abnormal reciprocation of the breech bolt to permit closing of said openable connection, a switch in the second circuit normally open and constructed and arranged to be closed by the breech bolt when in a retracted position only, to connect the time delay relay in the second circuit to energize said relay, means in the second circuit normally closed to energize the time delay relay at times when the switch is open, a switch in the second circuit constructed and arranged to close when the breech bolt is in its forward position of the gun and to open when the breech bolt is moved toward its retracted position to thereby complete a charging cycle once initiated, a firing circuit including a firing motor mounted on the gun and a trigger switch interposed between the firing circuit and the source of current, means in the first circuit responsive to impulses of current to the electrically operated valve, a mechanism in the firing circuit having a member connected to said current impulse responsive means and operated thereby to cut-out the firing motor after a predetermined number of current impulses to said current impulse responsive means, and a relay in the firing circuit constructed and arranged to open said normally closed means when the trigger switch is closed so that energization of the time delay relay must depend upon normal breech bolt reciprocation.

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