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(54) Electronically actuated trigger mechanism for compressed gas powered weapons or the like

(57) A compressed gas powered gun (10) includes an electronic actuator (114, 116, 118, 156) to achieve greater efficiency in the operation of the gun. The electronic actuator is operative to control movement of a bolt assembly (88) between a sealing position in which it seals a firing chamber (36) for compressed gas, and an unsealing position in which the gas in the firing chamber (36) is released to launch a projectile from the gun. The electronic actuator may also move a flow valve (74) controlling communication between the firing chamber (36) and a source of compressed gas. The gun is operable in either a manually operating mode or an electronically operating mode.

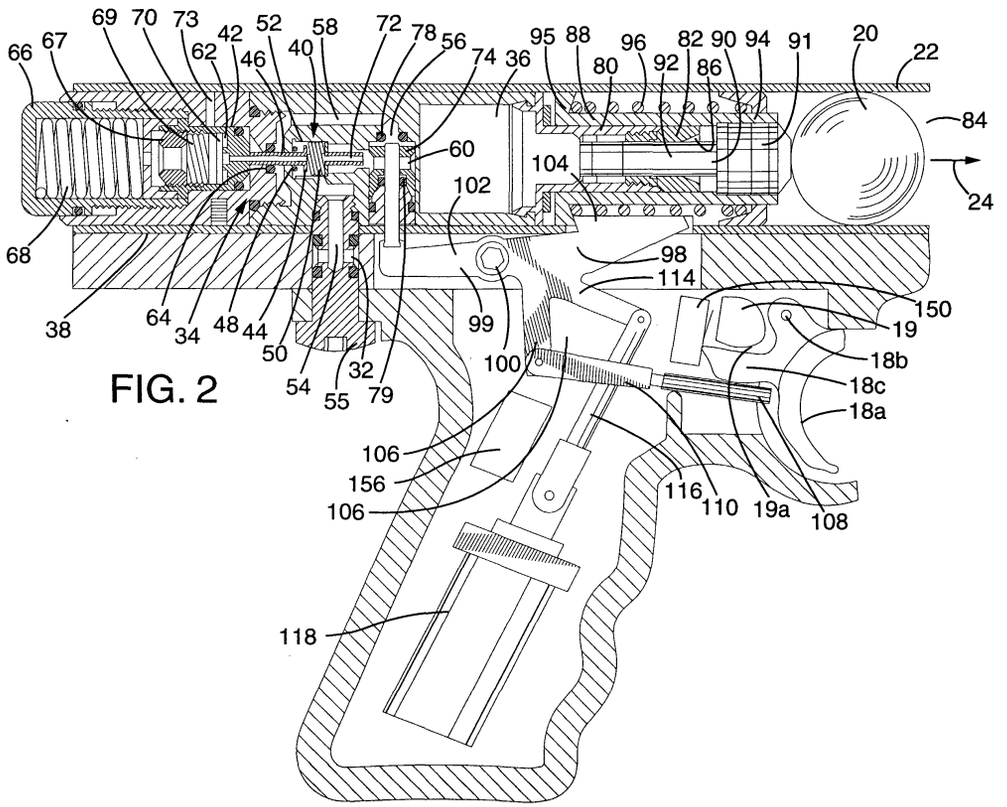

FIG. 2

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This is a continuation-in-part of U.S. application Serial No. 09/413,320, filed October 6, 1999, which claims priority to U.S. provisional application Serial No. 60/103,171, filed October 6, 1998. This application is also related to patent application Serial No. 08/955,047, filed October 21, 1997, now U.S. Patent No. 5,913,303, issued June 22, 1999, and patent application Serial No. 08/955,187, filed October 21, 1997, now U.S. Patent No. 6,024,077, issued February 15, 2000. Each of the above-identified applications and patents is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] This invention generally relates to an electronic actuator coupled with a trigger mechanism for use in compressed gas powered weaponry or the like.

BACKGROUND OF THE INVENTION

[0003] A variety of different types of weaponry which utilize discharged compressed gas to fire projectiles are known. These compressed gas powered weapons have particular use as tranquilizer guns and pellet marking guns which are sometimes referred to as "paintball guns." Generally marking guns use compressed gas to fire a relatively fragile projectile which comprises a frangible shell which is filled with a marking composition. The capsules are designed to break upon impact with a target and thereby discharge the marking material onto the target.

[0004] Such marking guns have a variety of different uses. For example, they may be employed to segregate livestock within a herd, assist in the counting of wild animals or for training of military or law enforcement personnel through simulation exercises. Likewise, they may be used by military and law enforcement personnel for crowd control. Another very popular use for such marking guns is for recreation. In particular, paintball marking guns are used for "war games" in which participants attempt to hit other combatants with paintballs thereby marking them and eliminating them from the game.

[0005] One attribute which is extremely important to users of paintball marking guns which are intended for such recreational war games, as well as those used for other purposes, is the manner in which the gun is fired. Obviously, paintball marking guns which are capable of increased firing rates offer the user a significant competitive advantage over his/her fellow combatants. One significant factor which influences the firing rate of any weapon is the type of firing arrangement that is employed. Paintball marking guns typically may employ manual, semi-automatic and fully automatic firing arrangements. A manual firing arrangement requires appropriate manipulation of the gun before successive projectiles are fired. In contrast, a semi-automatic firing arrangement enables a projectile to fired each time the trigger is depressed, while an automatic firing arrangement will fire multiple projectiles each time the trigger is pulled. In any event, it would be desirable to achieve greater monitoring and control of, among other things, the firing sequence employed by such weapons.

OBJECTS AND SUMMARY OF THE INVENTION

[0006] Accordingly, in view of the foregoing, it is a general object of the present invention to provide a electronic control mechanism for a weapon which overcomes the deficiencies of the prior art.

[0007] Another object of the present invention is to provide a trigger mechanism for compressed gas powered weapons which provides excellent performance and is very easy to maintain.

[0008] It is a more particular object of the present invention to provide a compressed gas powered weapon that utilizes an electronically actuated firing mechanism.

[0009] These and other features and advantages of the invention will be more readily apparent upon reading the following description of a preferred exemplified embodiment of the invention and upon reference to the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIGURE 1 is a side view of a compressed gas powered gun that utilizes the teachings of the present invention;
FIG. 2 is a partial side sectional view of the compressed gas powered gun of FIG. 1, taken axially through the gun,

showing the firing system in a ready-to-fire mode;
FIG. 3 is a partial side sectional view of the compressed gas powered gun showing the firing system in a firing mode after release of an actuating bolt assembly;
FIG. 4 is an electrical block diagram illustrating control circuitry used in the electronic actuating system according to a first embodiment of the present invention;
FIG. 5 is an electrical block diagram illustrating control circuitry according to a second embodiment of the present invention;
FIGS. 6a and 6b are electrical block diagrams illustrating control circuitry according to a third embodiment of the present invention;
FIG. 6c is an electrical block diagram illustrating an optional feature of the control circuitry of FIGS. 6a and 6b;
FIG. 7 is a flowchart showing a procedure followed by the control circuitry according to an embodiment of the present invention;
FIG. 8 is a side view of a novel trigger mechanism in accordance with an embodiment of the present invention; and
FIG. 9 is a side view of another novel trigger mechanism in accordance with an embodiment of the invention.

[0011] While the invention will be described and disclosed in connection with certain preferred embodiments and procedures, it is not intended to limit the invention to those specific embodiments. Rather it is intended to cover all such alternative embodiments and modifications as fall within the spirit and scope of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] Generally, the present invention relates to an electronic actuating system for a compressed gas powered weapon or the like which is capable of being operated with greater efficiency as compared to known firing systems. Such efficiency is achieved through a novel trigger mechanism and control and actuating circuitry which is incorporated into the firing system of the present invention. In one embodiment, the trigger mechanism is operable in either a mechanical mode or an electronically actuating mode to assist the user in successively actuating the trigger.

[0013] While the present invention is described in connection with a compressed gas powered gun, which has particular use a paintball marking gun, it will be readily appreciated that the teachings of the present invention can also be applied in other contexts. These include, for example, other types of compressed gas powered weapons. However, it should be understood that the actuating and switch-over mechanism of the present invention may be utilized in many applications other than compressed gas powered weapons.

[0014] FIGS. 1-3 illustrate one preferred embodiment of a compressed gas powered gun which incorporates the firing system of the present invention. Certain details of the gun are also disclosed in U.S. Patent 5,280,778, which is incorporated herein by reference in its entirety. As best shown in FIG. 1, the gun 10 comprises a longitudinally extending frame support or rail 12 with a trigger-guard 14 and handle 16 depending therefrom. A pivotally mounted trigger 18, the operation of which is described in more detail below, is disposed within the trigger-guard 14. The handle 16 may include an optional display unit 432 and buttons B1 and B2, whose operation will be described below.

[0015] The firing system is operable in a firing mode wherein a projectile is expelled from the gun and a ready-to-fire or reloading mode which places the gun in condition for firing. As seen in FIG. 2, a projectile 20, such as a marking pellet or paintball, exits an elongate, generally cylindrical barrel 22 in the direction of arrow 24 during the firing mode. An ammunition feeding tube 26 (FIG. 1) is disposed to supply a plurality of projectiles to the gun, one at a time, as will be understood by those skilled in the art.

[0016] For providing connection of the gun to a source of compressed gas, the gun includes an inlet port 30 which in the preferred embodiment comprises a conventional adapter which allows an air line or hose (not shown) to be quickly and easily connected and disconnected from the gun. The source of the compressed gas preferably comprises a tank of compressed air (not shown) as will be understood by those skilled in the art. In order to provide for ease of movement, the compressed air tank may be strapped to the back of the user or carried on a belt. The compressed gas source preferably is supplied at a pressure of approximately 700 pounds per square inch (psi). Of course, it should be appreciated that different types of sources of compressed gas could be used with the present invention. In addition, while compressed air is preferred, other compressed gases such as nitrogen may be used.

[0017] The compressed gas or air passes from the inlet port 30 via an annular inlet passageway which, in the illustrated embodiment, extends along the rail of the frame 12. This inlet passageway provides a passageway to a compressed gas delivery system which operates to control and meter the compressed gas received from the compressed gas source in both the firing and ready-to-fire modes of the firing system. Specifically, the compressed gas delivery system includes a pressure regulating system or assembly 34 and a fluid pathway which interconnects the compressed gas inlet port with an air or firing chamber 36.

[0018] In accordance with one preferred embodiment of the present invention, a pressure regulating assembly is adapted to rapidly recharge the firing chamber after it is expelled by filling at an increased pressure until a pre-selected

pressure is attained. In the illustrated embodiment, the pressure regulating assembly 34 is adapted to operate at a very high speed and provide for full pressure recharge of the firing chamber 36. This results in the firing chamber 36 being charged with compressed gas to the pre-selected pressure very rapidly thereby increasing the potential firing rate of the gun 10.

[0019] The pressure regulating assembly 34 and the fluid pathway are disposed in a cylindrical terminal housing or valve body section 38 of the gun. The regulating assembly 34 generally comprises a screw-type control and valve arrangement including a valve 40 disposed in the fluid pathway interconnecting the inlet port 30 and the firing chamber 36 and a regulator piston subassembly 42. The main structural details of the valve 40 include a head portion 44, a valve stem 46, a seat 48 and a biasing spring 50. A generally cylindrical regulator valve chamber 52 is formed in the valve body section 38 of the gun which is in fluid communication with the inlet passageway 32 via a fluid passageway 54 provided in the field strip screw 55. The valve head 44 is contained within the regulator valve chamber 52 while one end of the stem portion 46 extends outwardly to the regulator piston subassembly 42.

[0020] The valve 40 is operable to move between an open position, wherein compressed gas flows from the inlet port 30 to the firing chamber 36 via the fluid pathway and a closed position, wherein the inlet port 30 is isolated from the firing chamber 36. Specifically, when the valve 40 is in the closed position, the valve head 44 engages the valve seat 48 to thereby close off the flow of compressed gas to the firing chamber 36 as shown in FIG. 3. When the valve 40 is in the open position, compressed gas flows between the outer periphery of the valve head 44 and the walls of the regulator valve chamber 52 as shown in FIG. 2. The flow of compressed gas past the valve 40 continues to an on/off flow valve chamber 56 via a fluid passageway 58. In turn, the flow valve chamber 56 is interconnected with the firing chamber 36 by way of a second fluid passageway 60 which completes the fluid pathway between the inlet port 30 and the firing chamber 36.

[0021] In order to control the pressure in the firing chamber 36, the regulator piston subassembly 42 is adapted to move the valve 40 to a closed position when a predetermined pressure of compressed gas is sensed and to urge the valve 40 to an open position when a pressure less than the pre-selected pressure is sensed. The regulator piston subassembly 42 is arranged in a regulator piston bore 62 which is sealed from the flow of gas from the regulator valve chamber 52. In order to prevent gas from leaking into the regulator piston bore, around the valve stem an o-ring seal 64 is provided. The main structural components of the regulator piston subassembly include a threaded adjusting nut 66, a biasing spring 68 and a regulator piston 70.

[0022] In the preferred embodiment, a blow off valve arrangement valve is provided which includes a head 67 and biasing spring 69. When an over-pressure condition is sensed, the valve permits the compressed to vent to atmosphere via an overflow port 73.

[0023] In order to sense the pressure of the gas in the firing chamber 36, the regulating assembly 34 further includes a sensing line 72. The sensing line 72 is in fluid communication with the regulator piston bore 62 and is adapted to apply the pressure of the gas in the firing chamber 36 to the regulator piston subassembly 42. In a preferred embodiment, the forward end of the valve stem 46 extends to a location adjacent the firing chamber 36 and the sensing line 72 comprises a bore in the valve stem 46 which extends from adjacent the firing chamber 36 to the regulator piston bore 62 as shown in FIGS. 2-3.

[0024] When the firing chamber 36 is being filled or charged with compressed gas during the ready-to-fire mode of the firing system, the regulating springs 68, 69 bias the regulator piston 70 toward a forward position in the piston bore 62, which in turn, acts to move the valve head 44 away from the valve seat 48 as best shown in FIG. 2. The regulator piston 70 remains in this forward position and thereby prevents the valve 40 from closing until a predetermined pressure is supplied to the firing chamber 36 and to the piston bore 62 via the sensing line 72. When the pressure in the firing chamber 36 and the piston bore 62 reach the predetermined pressure, as shown in FIG. 3, the regulator piston 70 is moved counter to the force of the regulator springs 68, 69 to a rearward position which causes the valve 40 to engage the valve seat 48 and seal the regulator valve chamber 52. The compressed gas in the portion of the fluid pathway upstream from the valve head 44 and the biasing spring 50 coact to maintain a closure tension on the valve 40.

[0025] When the pressure in the air chamber 36 and, in turn, in the regulator piston bore once again falls below the predetermined pressure such as after a firing sequence, the regulating piston subassembly 42 urges the valve 40 to an open position. Compressed gas supplied to the regulator piston bore 62 via the sensing line 72 thereafter acts against the tension of the regulating springs 68, 69 to move the piston 70 rearward. Thus, compressed gas is again discharged until the pressure in the air chamber 36 reaches the predetermined level sufficient to urge the valve 40 closed.

[0026] In contrast to conventional arrangements in which the compressed gas is regulated to a lower pressure as soon as it enters the gun or the compressed gas delivery system, the described embodiment "regulates" the pressure in the firing chamber 36 itself by shutting of the supply of compressed gas when the firing chamber 36 reaches the desired pressure. Thus, the regulating system allows the firing chamber 36 to charge at very nearly the full line pressure of the compressed gas source. As can be appreciated, this allows the firing chamber to fill with compressed gas to the desired pressure much more rapidly than conventional designs.

[0027] This arrangement also ensures precise operation of the gun 10 for successive firings over a wide range of ambient temperatures. For example, when the ambient temperature increases, thereby increasing the gas pressure in firing chamber 36 and the piston bore 62, the regulator piston 70 is urged rearward to close the valve 40. If the ambient temperature increases to a level where the pressure in the piston bore 62 exceeds the desired firing chamber pressure and the gas supply pressure by a sufficient amount, i.e., 650 psi, the overflow valve will move sufficiently rearwardly to permit venting through the port 73. Conversely, when the ambient temperature decreases, thereby decreasing the pressure in the firing chamber 36 and the piston bore 62, the gas supply pressure decreases, urging the valve 40 to an open position. In this way, the pressure regulating assembly 34 operates to maintain a desired pressure supplied to the air chamber 36 for each firing of the gun.

[0028] In order to allow for the adjustment of the pressure to which the firing chamber 36 is charged, and thereby the velocity of the projectile 20, means are provided for adjusting the pressure at which the regulator valve 40 closes. Specifically, in the illustrated embodiment, the amount of force exerted by the first regulating spring 68 on the regulating piston 70 can be controlled through manual adjustment of a threaded velocity nut 66 provided on the end of the valve body 38. For example, in order to increase the pressure to which the firing chamber 36 is charged, the velocity nut 66 is turned so as to increase the force that the first regulating spring 68 applies to the regulating piston 70. A relatively higher pressure will then be required to urge the regulating piston 70 rearward and thereby close the valve 40. In a preferred embodiment, the pressure regulating assembly 34 should be set to shut off the flow of compressed gas from the inlet port 30 when the pressure in the air chamber 36 reaches approximately 450 psi.

[0029] In order to protect against an over pressure condition in the compressed gas delivery system resulting from a seal failure or the disassembly of the gun when the firing system is under pressure, the blow off valve and over pressure vent 73, discussed above, may also be provided.

[0030] In order to ensure that the pre-selected pressure is maintained in the firing chamber 36 for the firing mode, the firing system further includes a on/off valve 74 which seals off the firing chamber 36 from the compressed gas source when the firing system is operating in the firing mode. The on/off flow valve 74 is movable between open and closed positions and, in particular, is operable to open and thereby permit fluid communication between the firing chamber 36 and the inlet port 30 in the ready-to-fire mode of operation, as shown in FIG. 2. This enables the firing chamber 36 to be charged with compressed gas to the predetermined pressure via the compressed gas delivery system during the ready-to-fire mode. In the firing mode of operation, the on/off flow valve 74 closes thereby isolating the firing chamber 36 from the inlet port 30 and the compressed gas source. This isolation of the firing chamber 36 from the compressed gas source prevents compressed gas from flowing into the firing chamber to replace the air which has been discharged from the firing chamber in order to expel the projectile. This is of particular importance because the pressure in the regulator piston bore 62 has dropped resulting in the opening of the regulator valve 40. The on/off flow valve 74 is movable transversely relative to the longitudinal axis of the gun between the open and closed positions. In order to prevent compressed gas from leaking past the on/off flow valve when it is in the closed position, an o-ring seal 78 is provided adjacent the upper end of the flow valve chamber 56. In addition, a second o-ring seal 79 is provided adjacent the lower end of the flow valve chamber to prevent compressed gas from leaking out of the compressed gas delivery system.

[0031] The air or firing chamber 36 supplies the compressed gas that expels the projectile through the barrel 22 when the firing system is in the firing mode. The air chamber 36 is defined by a bore formed in the main body portion of the gun 10 terminating at one end with an intermediate firing tube or power tube 80. An annular sleeve 82 interfits within the power tube 80 and, along with the power tube 80, defines a discharge path for compressed air contained in the firing chamber 36 to blast into a breech 84 of the gun 10. The annular sleeve 82 includes a tapered portion 86 that further defines a passage for the blast of compressed gas. This tapered portion 86 on the power tube 80 is configured such that the air flows out of the air chamber 36 and the power tube at a controlled rate which prevents relatively fragile projectiles such as paintballs from breaking as a result of too much pressure building up behind the paintball. Inasmuch as the pressure supplied to the firing chamber 36 has been substantially reduced from the maximum available pressure from the compressed gas source, the volume defined by the firing chamber 36 is substantially larger than found in many known arrangements.

[0032] The blast of compressed gas exits the air chamber 52 upon actuation of a bolt assembly 88 which includes a power piston 90. The power piston 90 comprises head and body sections 91 and 92, respectively, with the body section 92 being sized to fit within the annular sleeve 82 and power tube 80. FIG.2 also illustrates the remaining structural features of the bolt assembly 88, including a cylindrical actuating bolt 94 disposed in surrounding relation to the annular sleeve 82 and power tube 80. The actuating bolt 94 includes a protruding dog portion 95 disposed at one of its ends. A recoil spring 96 retracts the actuating bolt 94 against a bumper 97 when the actuating bolt 94 is returned to a ready-to-fire position.

[0033] In accordance with the invention, an electronic actuating assembly is provided to permit precise operation of the gun. In addition, control circuitry is provided which generates appropriate signals to control the rate of fire, the number of shots fired per trigger pull, and present a fully automatic mode of operation to the user.

[0034] In keeping with the invention, the bolt assembly 88 is maintained in a ready-to-fire position with the use of a trigger mechanism which includes a sear 98 having an arm 99 that is rotatable about a pivot 100, which in a preferred embodiment comprises a threaded roller bearing axle. The arm 99 has a transversely extending actuating member 102 at one end, located on one side of a pivot 100, and an interlocking element 104 at the other end, located on the other side of the pivot 100. The actuating member 102 is generally aligned with the on/off flow valve 74. The interlocking element 104 includes a notched portion that engages the dog portion 95 of the actuating bolt 94 in the ready-to-fire position. The interlocking element 104 preferably also includes an elongated section extending substantially along the path of travel of the actuating bolt assembly 88 to provide a stop surface that prevents the actuating bolt assembly from engaging the interlocking element 104 during recoil of the actuating bolt assembly.

[0035] A first manual actuating lever 106 projects transversely on the side of the latch arm 99 opposite the actuating member 102 and the interlocking element 104. A sliding trigger arm 108 disposed within the handle 16 operates to transmit force from the trigger 18 to the actuating lever 106. As explained in detail in said U.S. Patent 5,280,778, this provides for semi-automatic firing of the gun 10 in operation. In the illustrated embodiment, the trigger arm 108 comprises a first link 110 which is pivotally connected to the manual actuating lever 106 and a second link 112 which is threaded into the first link. With this arrangement, any play in the trigger mechanism can be selectively adjusted merely by turning the second link 112 relative to the first link 110 and thereby thread the second link further out of or in to the first link.

[0036] For permitting electronic actuation of the gun, the sear 98 comprises a second electronic actuating lever 114 which expends outwardly from the pivot 100. The second actuating lever 114 is angularly offset from the first actuating lever 106. A push rod 116 is operably connected with a solenoid 118 disposed in the handle of the gun. The push rod 116 operates to transmit force to the second actuating lever 114 when the solenoid is energized. This action rotates the sear 98 to release the bolt assembly.

[0037] In accordance with one aspect of the invention, a switch-over mechanism is provided for permitting selection between a manually operable mode and an electronically actuating mode. As shown in FIGS. 2 and 3, the trigger 18 comprises a finger-engageable portion 18a, disposed on one side of a trigger axis of rotation 18b. The trigger further includes an outwardly protruding arm 18c, disposed opposite the finger-engageable portion 18a and the trigger axis 18b. The switch-over mechanism in this embodiment is a movable selector lever 19 that coacts with the trigger arm 18c. The lever 19 includes a camming surface 19a disposed to selectively couple the trigger arm with the electrical contacts of a trigger switch 150. When oriented in the position shown in FIGS. 2 and 3, the switch-over mechanism permits the trigger arm 18c to close the contacts of the electronic trigger switch 150. On the other hand, when rotated such that the camming surface 19a is disposed in contacting relation with the trigger arm 18c, the travel of arm 18c is restricted to effectively prevent the arm from urging the trigger switch contacts in closed relation. Optionally, the selector lever 19 is movable to a safe position to effectively prevent the trigger from being pulled.

[0038] The switch-over mechanism thus permits a user to readily manually select either a manual operating mode or an electronic operating mode. This feature is particularly advantageous when, for example, the user encounters a malfunction in one operating mode, such as would be the case with electronic circuit malfunction or power supply failure.

[0039] FIG. 4 illustrates a block circuit diagram for control circuitry that may be utilized in conjunction with the electronic mode of operation. Generally, the control circuitry is operable to provide a single pulse of a particular duration, or alternatively, a series or "burst" of pulses, each having a selected duration to a solenoid 118. In this fashion, the control circuitry provides various modes of operation, while at the same time, a precise degree of control of movement of the sear 98. In the illustrated embodiment, the control circuitry is operable to provide single shot pulses between approximately 10 milliseconds and 70 milliseconds. These pulses, in turn, energize the solenoid coil L1. The solenoid coil L1 operates in conjunction with an armature winding as would be understood by those skilled in the art to actuate the arm 114. This action, in turn, rotates, the sear 98 in order to release the bolt assembly and fire the gun.

[0040] As shown in FIG. 4, a voltage source, which in this case is 18 volts, is coupled through a main power switch 200, which is manually operable by the user to permit use of the electronic circuitry (see FIG. 1). The power supply may be located in the trigger guard, as shown by the battery-receiving portions 152 and 154 in FIG. 3. Similarly, the control circuitry may be located on a circuit board 156, disposed in the handle 16 of the gun.

[0041] The voltage supplied by the power source is sufficient to energize the solenoid coil L1. However, this voltage is reduced through a zener diode D1 to approximately 14.4 volts so that it may be used to provide power to the control circuitry of the system. A resistor R1 is coupled between the zener diode D1 and ground.

[0042] When the gun is operable in the electronic actuating mode as described above, depression of the trigger closes the trigger switch contacts 150. Closure of the trigger switch 150 causes a capacitor C1 to begin charging through a resistor R3. The increased voltage is applied to the input of a Schmidt trigger implemented as a nand gate 204. Based on the time constant of the RC network of C1 and R3, the output of Schmidt trigger 204 is a negative pulse having a duration of approximately one millisecond. Eventually, the capacitor C1 becomes fully charged such that the current through R3, and resultant voltage applied to gate 204 is zero.

[0043] The output of the gate 204 is applied to the trigger input of a timer integrated circuit IC1 in order to provide a

control signal at the output (pin 3 of IC1). The duration of the output control pulse determined by an RC time constant applied to the threshold input of the timer circuit IC1, in this case a potentiometer R5 and a capacitor C4. In the preferred embodiment, the threshold of timer circuit IC1 is adjustable between 10 milliseconds and 70 milliseconds based on the adjustment of potentiometer R5. The resultant output control signal is provided at the output terminal of timer circuit IC1. This output pulse is passed through a limiting resistor R5 to the gate of a switching transistor, denoted as MOSFET Q1. When the output signal is applied to the gate of Q1, current is drawn through the solenoid coil, denoted as inductor L1. As described above, this causes the arm 116 to move and release the bolt assembly.

[0044] When the trigger is released, the trigger switch contacts 150 are opened. This causes the capacitor C1 to discharge through a resistor R2 to reset the timer circuit IC1. Similarly, capacitor C4 discharges through the discharge input of the timer circuit.

[0045] The following Table 1 provides a summary of the components utilized in one preferred implementation of the control circuit shown in FIG. 4:

TABLE 1

Component	Type, Value or Rating
R1	65k ohms
R2	100k ohms
R3	10k ohms
R4	82k ohms
R5	500k ohms
C1, C2, C4	.1 μF
C3	.01 μF
Q1	BU2 71 MOSFET
D1	IN 5227
D2	IN 4007
IC1	LMC 555
204	CD 4095

[0046] FIG. 5 illustrates an alternative embodiment for controlling the electronic actuator. In this alternative embodiment, the power source is supplied to a voltage regulator integrated circuit IC1. The output of voltage regulator circuit IC1 provides a reduced voltage signal at a node 204. The circuit further includes a two-position DIP switch matrix 206. Based on the settings of the dip switches of switch matrix 206, various functionality may be achieved, as described below. The output of switch matrix 206 is provided to inputs of a micro controller IC2. For example, the following dip switch settings may correspond with the described functionality:

DIP SWITCH SETTINGS		
Switch 1	**Switch 2**	**Function**
0	0	Single shot
0	1	Fully automatic
1	1	3-shot burst
1	0	6-shot burst

The microcontroller operates in a logical fashion based on the switch settings to provide an output control signal or signals, having a desired duration. This output control signal is provided through resistor R4 to the gate terminal of a MOSFET transistor Q1. The drain terminal of transistor Q1 is connected to one of the terminals of the solenoid coil. In this manner, a control signal is applied to precisely switch the solenoid on and off at the desired times.

[0047] The following Table 2 provides a summary of the components used in the implementation shown in FIG. 5:

TABLE 2

Component	Type, Value or Rating
R1, R2, R3, R5	10k ohms
R4	10 ohms
C1	.33 μF
C2	.1 μF
IC1	NJM 78L05
IC2	Aftiny 12 microcontroller
Q1	NDT 45JAN MOSFET

Of course, the microcontroller may be programmed to provide additional functionality as well.

[0048] FIGS. 6A and 6B illustrate yet another embodiment of circuitry that may be used for controlling the electronic activator and for providing visual feedback to the user. The control circuitry includes a microcontroller 434 having an inverting oscillator amplifier 332, a display unit 432, the trigger switch contact 150 (from FIGS. 2 and 3), spring loaded buttons B1 and B2, a battery unit 412 having one or more batteries (not shown), and the solenoid coil L1.

[0049] In the illustrated embodiment, the buttons B1 and B2 are located on an outer surface of the gun and, when actuated, allow a signal to flow to the microcontroller pins 350 and 360 respectively. These buttons may be manipulated by a user to perform such functions as changing the rate of fire of the gun or resetting a game clock. The display unit 432 is also located on an outer surface of the gun in the illustrated embodiment, and may provide visual indication to the user of the status of the gun. For example, the display unit may indicate the firing mode of the gun. The display unit may also display such information as the current time remaining on the game clock, the number of shots fired, the status of the battery unit 412, and any error conditions.

[0050] The microcontroller 434 performs operations according to a series of executable instructions stored in an on-board memory (not shown). It may be implemented in any of a number of ways, and may also be a microprocessor coupled with a separate memory. In the illustrated embodiment, however, the microcontroller 434 is an ATMEL 8-bit microcontroller model AT90S2313 having a 2.048 ms interrupt timer for driving the execution of the program loop. As shown in FIG. 6a, the microcontroller 434 includes pins PBO through PB7 (Port B, bits 0-7), which are numbered 384, 382, 380, 378, 376, 374, 372, and 370 respectively; and pins PD0-PD6 (Port D, bits 0-6), which are numbered 336, 338, 344, 346, 350, 360, and 386 respectively. In the illustrated embodiment, pins 370, 372, 374 and 334 are used to load a program from an external source such as a personal computer. Of course, it is understood that data may be downloaded from the microcontroller using these pins as well.

[0051] The pin 344 is communicatively linked to a trigger switch 355. The trigger switch 355, which is implemented as a Hall switch in the illustrated embodiment, transmits a signal pulse to the pin 344 of the microcontroller 434 when the trigger of the gun is pulled in the electronic firing mode. The microcontroller 434 further includes a reset pin 334, pins 340 and 342 for providing output from and input to the inverting oscillator amplifier 332, a ground pin 362, and a power input pin 368.

[0052] The display unit 432 may be implemented as a variety of devices, including a liquid crystal display, or the like. In the illustrated embodiment, the display unit 432 is a HEWLETT PACKARD HCMS-2912, 5x7 pixel, 8-character LED, and includes power input pins 440 and 444, a ground pin 442, a reset pin 430, a logic pin 428, a select pin 426, a ground logic pin 424, a blank pin 422, a chip enable pin 420, a clock pin 418, a register select pin 416, and a data input pin 414. A pair of lines 398 and 404 connect the battery unit 412 to the pins 380 and 384 for the purpose of allowing the microcontroller 434 to detect the remaining battery charge.

[0053] In the illustrated embodiment, the microcontroller 434 is communicatively linked to the display unit 432. Specifically, the pins 376, 378, 380, and 386 of the microcontroller 434 are communicatively linked to the register select pin 416, the data input pin 414, the clock pin 418, and the chip enable pin 420 respectively. To display information on the display unit 432, the microcontroller selects the position in which a character is to be displayed by transmitting a selector signal to the register select pin 416, and indicates the content to be displayed in that character position by transmitting a bit map of the character to the data in pin 414.

[0054] The control circuitry shown in FIGS. 6a and 6b may optionally be provided with a programming unit, as illustrated in FIG. 6c. This permits a user of the weapon to add additional functionality to the control circuit, and, if desired, to override the program stored in the microcontroller 434. The programming unit, generally labeled 300, includes a memory (not shown) for storing program instructions and data, a VSS (ground) pin 304 , a VDD (positive voltage) pin 314, pins and 308 and 310 for providing output and receiving input to and from a computer (PCO and PCI respectively),

and input-output pins P1-P4, numbered 316, 320, 324, 326 and 328 respectively. In the illustrated embodiment, it is assumed that the programming unit 300 is a PARALLAX BS1-IC BASIC STAMP. Any suitable programming unit may be used, however, and it is understood that the connections and pin assignments may vary from model to model.

[0055] Referring again to FIG. 6c, the programming unit 300 is communicatively linked to the microcontroller 434 for sending and receiving instructions and data. In the illustrated embodiment, pins 316, 320, 324, 326, and 328 of the programming unit 300 are communicatively linked with pins 336, 338, 344, 350, and 360 respectively of the microcontroller 434.

[0056] According to an embodiment of the invention, a computer may be connected to the programming unit 300. In the embodiment of FIG. 6c, a computer (not shown) is communicatively linked to the programming unit 300 via a parallel port 322. The pins 308 and 310 are communicatively linked to the "BUSY" and "D0" pins respectively of the parallel port 322.

[0057] A variety of types of data may be exchanged between the programming unit 300 and the computer. As previously mentioned, a user may load a program from the computer into the programming unit. The user may also download stored data from the programming unit into the computer. For example, the programming unit may keep track of the number of shots fired during a game. This information could then be downloaded to the computer via the parallel port 322 upon completion of the game. The information could then be posted on a web site maintained by a paintball game vendor. The name of the user may also be stored in the programming unit.

[0058] The following Table 3 provides a summary of the components used in the implementations shown in FIGS. 6a-6c:

TABLE 3

Component	Type, Value or Rating
R1	10 ohms
R2, R3, R4, R5, R6, R7, R8	10k ohms
C1, C2	13.5 pF
Q1	BU2 71 MOSFET
D1	IN 5227

[0059] FIG. 7 illustrates the program steps generally followed by the microcontroller 434 in accordance with an embodiment of the invention. At step 500 the microcontroller 434 determines whether the solencid assembly 320 is currently activated. If it is, then the flow proceed to step 502 at which the microcontroller 434 determines whether the on-time for the solenoid has elapsed. On the other hand, if the on-time for the solenoid has not elapsed then the flow proceeds to step 520. If the on-time has elapsed then the process moves to steps 504 and 506 at which the power to the solenoid is cut-off and the shot count on the LED is incremented.

[0060] If the solenoid is determined not to be activated at step 500, then the flow proceeds to step 508. At step 508, the microcontroller 434 determines whether a shot burst (including full automatic fire) is in progress. If a shot burst is currently in progress then the microcontroller determines whether the off-time for the solenoid has elapsed at step 510. If the off-time has elapsed then the flow proceeds to step 512 at which the microcontroller activates the solenoid. The flow then proceeds to step 520. If, at step 510 the off-time for the solenoid has elapsed the flow proceeds to step 514. The flow also proceeds to 514 if has been determined that no burst is currently in progress at step 508.

[0061] At step 514 the microcontroller determines whether the trigger is currently being pulled. If the trigger is being pulled then the flow proceeds to step 516, at which the microcontroller determines whether the solenoid off-time has elapsed. If the off-time has elapsed then the flow proceed to step 518 at which the microcontroller switches on the power to the solenoid. The flow then proceeds to step 520. The flow also proceeds directly to step 520 if the "NO" branch at step 514 or 516 is taken. At step 520 the microcontroller 434 determines whether either of the buttons B1 or B2 are being pressed. If so, then the flow proceeds to step 522 at which the action indicated by the state of the buttons is carried out and at which the display is updated as appropriate. The flow then proceeds to step 524. The flow also proceeds directly to step 524 if the "NO" branch of step 520 is taken.

[0062] At step 524, the microcontroller determines whether a one second count has expired. If the one second count has expired then the flow proceeds to steps 526 and 528 at which the game clock on the display is updated and the one second counter is reset. The flow then returns to step 500. The flow also returns directly to step 500 if the "NO" branch is taken from step 524.

[0063] In an embodiment of the invention, the buttons B1 and B2 may be used to scroll through menu items on the display 432. Such menu items may include a game timer, firing rate, firing mode, and display brightness. The other button may change the setting for the displayed menu item. For example, the user might press B1 once to cause a

game clock to appear. Then, by pressing B2, the user may start and stop the clock.

[0064] Returning to FIG. 1, the trigger mechanism may optionally be configured such that a user's finger is "pushed back" after the gun 10 is fired through the execution of a pull stroke of the trigger 18. This provides the sensation of a "reactive trigger." The pushing back of the finger after the trigger 18 is actuated or pulled to fire the gun 10 helps the user pull the trigger in more rapid succession, thereby helping the user to achieve an increased firing rate. The trigger mechanism is operable to actuate the firing system from the ready-to-fire mode to the firing mode to fire the gun upon the execution of a pull stroke of the trigger 18 and from the firing mode back to the ready-to-fire mode to place the gun back in condition for firing upon the execution of a return stroke of the trigger 18. The pushing back of the user's finger after the gun is fired is accomplished by increasing the force applied through the trigger mechanism on the trigger 18, and counter to which the trigger must be pulled to fire the gun, immediately after the gun is fired. Since a lesser force is necessary to pull the trigger 18, this increase in the force opposing the trigger pull has a tendency to force the trigger 18 through the return stroke even if the user has not sufficiently released the trigger. Once the gun 10 is urged back in condition for another firing sequence, the force applied on the trigger 18 through the trigger mechanism is reduced in order to enable the trigger to be manually pulled with greater ease.

[0065] In the illustrated embodiment of the invention, an increased force applied on the trigger after the gun is fired is accomplished by configuring the on/off flow valve 74 with a differential piston head 120. The differential head 120 of the flow valve comprises a first portion 122 with a relatively larger effective surface area and a second portion 124 with a relatively smaller surface area. Thus, when the flow valve 74 is open, the system relies on the second portion 124 of the differential piston since as the effective area to which the pressure is applied. This results in a relatively smaller force being applied to the on/off flow valve 74 by the compressed gas in the system when the flow valve is moving to the closed position as compared to the force applied on the on/off flow valve 74 as it moves to the open position. As the differential piston head 114 is moved toward the O-ring seal 78, the system relies on the force applied to the lesser diameter portion 118 to provide resistance to the trigger pull.

[0066] On the other hand, when the air chamber has expelled and the differential piston head 120 is in engagement with the upper O-ring seal 78, the force applied to the system is transferred to the larger first portion 122 of the piston head 120. At this point, the gas from flow chamber beneath the head 120 has expelled. Likewise, the regulator valve 40 opens and the system upstream from the on-off valve goes to the full line pressure of the compressed gas source. This slams the on-off valve back to the open position with greater force than applied to the valve when moved from the open position to the closed position. Once returned to the open position, i.e., when the larger diameter head 114 is disengaged from the O-ring seal 78, the effective area of the on-off valve upon which the pressure acts is once again the smaller diameter piston head 122.

[0067] Specifically, as the first step of the firing sequence, the trigger 18 is pulled and the resultant longitudinal movement of the trigger arm 108 acts to rotate the actuating lever element 106 of the sear in a clockwise direction (relative to FIGS. 2-6) which in turn rotates the sear arm 99 in the clockwise direction. As shown in FIG. 4, the rotation of the sear arm 99 forces the on/off flow valve 74 into the closed position in response to the movement of the actuating member 102. This movement of the flow valve 74 into the closed position is resisted by the downward force (relative to FIGS. 2-6) exerted on smaller second portion 118 of the differential piston head on the flow valve 74 by the compressed gas in the system.

[0068] As shown in FIG. 3, once the on/off flow valve 74 has closed, the interlocking element 104 on the sear 98 releases the dog portion 95 of the actuating bolt and the compressed gas in the firing chamber 36 moves the power piston 90 rapidly forward and is released from the power tube 80 resulting in the discharge of the projectile 20 from the barrel 22. Upon the release of the compressed gas in the firing chamber 36, the compressed gas in the regulator piston bore 62 is also released via the sensing line 72 resulting in movement of the regulator valve 40 back into the open position. After the gun 10 has been fired, the gas pressure maintained in the system upstream from the on/off flow valve 74 continues to exert a downward force on the on/off flow valve. However, since all of the compressed gas downstream from the on/off flow valve 74 has been discharged, the effective area on which it acts is the larger first portion of the differential piston head. Thus, the force acting on the flow valve 74, and in turn on the trigger 18 through the sear 98, is increased immediately after the compressed gas is discharged from the firing chamber 36. Since the force now applied on the trigger 18 is greater than the force that had to be overcome to pull the trigger (or to overcome the force applied by the actuator), this force tends to force a user to release the trigger 18 and allow the firing system to return to the ready-to-fire mode. In one preferred embodiment, it takes approximately 4 lbs. to pull the trigger and as soon as the gun is fired the force increases to 8 lbs. It has been found that this "reactive trigger" can enable a user to increase his or her firing rate by approximately thirty-three percent over conventional trigger arrangements.

[0069] In addition, upon the release of the compressed gas in the firing chamber 36, the recoil spring 96 drives the actuating bolt 94 rearwardly against the bumper 97 where it is held in place by the force of the recoil spring. The increased downward force exerted on the on/off flow valve 74 will force the trigger 18 through the return stroke. In particular, the force on the on/off flow valve 74 moves the actuating member 102 of the sear to effect slight counter-clockwise rotation of the sear 98 to both open the on/off flow valve 74 and to latch the actuating bolt 94 with the

interlocking element 104. The firing chamber is then recharged to the desired pressure via the compressed gas delivery system as described above.

[0070] The differential between the force applied on the trigger 18 during the pull stoke and the force applied during the return stroke is further accentuated by the regulating system of the present invention. Particularly, as soon as the regulator valve 40 reopens because of the discharge of gas from the firing chamber 36, the pressure in the portion of the compressed gas delivery system upstream from the on/off flow valve 74 increases from the regulated pressure to the full line pressure of the compressed gas source. This increase in the pressure results in a greater downward force being applied to the on/off flow valve 74.

[0071] According to another embodiment of the invention, the functions of the sear 98 may be performed by two separate pieces: one piece actuated by the solenoid 118 to hold or release the interlocking element 104, and another piece actuated by a second solenoid to open or close the on/off valve 74. The activation of the second solenoid may be controlled by the control circuitry illustrated in FIGS. 4, 5, 6a-6c so that the on/off valve 74 is opened or closed at predetermined times. This would allow a high level of control over the pressurization of the firing chamber 36, leading to significant advantages. For example, the firing chamber 36 may be filled with compressed gas immediately after the user pulls the trigger to negate the effects of rapid temperature changes on the pressure in the chamber 36.

[0072] The control circuitry may also receive input from various sensors, such as a projectile velocity sensor, and adjust the gas pressure based on the input. For example, the pressure in the firing chamber may be increased if the velocity is detected as being too low, or decreased if the velocity is detected as being too high. The control circuitry may also receive input from a humidity sensor mounted on the weapon, and increase or decrease the pressure in the firing chamber 36 based on changes in humidity. For example, if the ammunition is gelatin based, as in the case of paintballs, the control circuitry could increase the pressure in the firing chamber if the humidity was high enough to cause the ammunition to absorb excessive amounts of moisture.

[0073] Additional solenoids may be employed with the invention to control other aspect of its operation as well. For example, a separate solenoid could be used to actuate a leading mechanism for the weapon.

[0074] Various other modifications may be implemented as well. For example, the electronic actuator may be replaced by an electro-pneumatic actuator, such as a solenoid valve and a ram push arm arrangement. In this case, the solenoid valve is operable to open a pneumatic chamber to thereby permit a quantity of compressed gas to enter the pneumatic ram. Those skilled in the art will appreciate that the movement of the ram may be operable to either extend or retract to actuate the sear.

[0075] In accordance with yet another optional feature of the invention, the trigger mechanism includes a magnetic repulsion system. When activated, the magnetic repulsion system operates to return the trigger of the gun back to its original position after a shot has been fired. As with the embodiment described above, the magnetic repulsion system also provides the feel of a "reactive trigger" based on the manner in which the trigger is moved to the ready-to-fire position. In its preferred implementation, the trigger mechanism includes a frame 565, and a finger engageable trigger 564 pivotably mounted in the frame 565, as shown in FIG. 8. The trigger 564 is pivotally attached by a pin 566.

[0076] The magnetic repulsion system comprises a magnet 560 disposed in the trigger 564, a generally circular piece 574 rotatably mounted in the frame and having a generally rectangular cavity 576, and an adjustable magnet 562 disposed within the cavity 576 so as to be slidable along the arrow 572. The magnets 562 and 560 may be made of variety of materials, including Neodymium Iron Boron.

[0077] The magnets 562 and 560 are oriented so that like poles of the magnets are closest to one another thereby creating a repulsive force between them. For example, the north pole of the magnet 562 may face the north pole of the magnet 560. The repulsive force between the magnets 562 and 560 pre-loads the trigger 564 so that it is biased into a ready position. At the relative positions depicted in FIG. 10, the force between the magnets 562 and 560 is at its maximum. To decrease the amount of repulsive force between the two magnets, the circular piece 574 may be rotated in either the clockwise or the counter clockwise direction indicated by the arrow 570. The force may also be decreased by moving the magnet 562 away from the magnet 560 along the arrow 572.

[0078] One variation of this embodiment of the invention is the use of electro-magnets in place of, or in addition to, one or more of the magnets shown in FIG. 8. This implementation is particularly advantageous in the embodiments described herein since they may be actuated and deactuated in a controlled fashion based on program instructions executed by the microcontroller.

[0079] In another variation of this embodiment of the invention the trigger mechanism includes a magnetic attractive system instead of a magnetic repulsion system. The magnetic attractive system is similar to the system shown in FIG. 8, except that the generally circular piece 574, along with the magnet 562, is rotatably mounted in the trigger frame 565, with opposing poles of the magnets 560 and 562 facing one another. Operation of the magnetic attractive system, including the adjustment of the magnet 562, is similar to that of the magnetic repulsion system described above, except that opposite poles of magnets 560 and 562 face one another. Of course, the distance between the frame 565 and the trigger 564 will be smaller in the attractive system than in the repulsion system depicted in FIG. 8.

[0080] As discussed previously, trigger switch 355 shown FIGS. 6a and 6c is preferably implemented as a Hall trigger.

A MICRONAS Hall Sensor #HAL508 is known to be suitable. Referring to FIG. 9, placement of the switch 355 in the gun according to an embodiment of the invention is shown. The switch 355 is located in the handle 16, adjacent to the magnet 560. As the trigger is pulled, the increasing magnetic field from the magnet 560 causes the switch 355 to be activated.

[0081] There are several advantages to using a Hall trigger for the switch 355. One is the lack of moving parts, which gives the switch a potentially unlimited cycle life. Another is that there is no line of sight needed between the switch and the trigger. Yet another advantage is that the package is smaller and more robust than a contact switch. Finally, by adjusting the Hall switch and/or the magnet 560, the range and hysteresis of the switch can be changed without affecting the package size.

[0082] In accordance with yet another optional feature of the invention, the electronics and other appropriate components may be provided as a kit that is used to "retro-fit" existing paintball guns configured to operate in a manual mode alone. That is, one or more of the described components, i.e., the modified sear 98, solenoid and actuating arm subassembly, circuit board 156 and/or modified trigger guard 14, may be utilized to retro-fit such existing weapons.

[0083] While this invention has been described with an emphasis upon preferred embodiments, it will be obvious to those of ordinary skill in the art that variations of the preferred embodiments may be used and that it is intended that the invention may be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications encompassed within the spirit and the scope of the invention as defined by the following claims.

Claims

1. An electronically actuating compressed gas firing system operable to discharge a projectile from a barrel of a gun or the like, the firing system being powered by a compressed gas source which provides compressed gas at an inlet, the firing system comprising:

   a firing chamber disposed to receive compressed gas from the compressed gas source for supplying compressed gas to expel the projectile through the barrel;
   a flow valve disposed between the inlet and the firing chamber, the flow valve being movable between an open position, wherein compressed gas is permitted to flow from the compressed gas source to the firing chamber, and a closed position, wherein the firing chamber is isolated from the gas source so as to maintain a preselected pressure in the firing chamber;
   a bolt assembly movable between a sealing position, in which it seals the firing chamber, and an unsealing position, in which it directs compressed gas from the firing chamber toward the projectile, thereby launching it from the barrel;
   an electronic actuator coupled to the bolt assembly, the actuator being operable to release the bolt assembly from the sealing position to allow the bolt assembly to move to the unsealing position, the actuator being further operable to move the flow valve between the open and closed positions; and
   a microcontroller operable to execute program instructions for providing control signals to activate and deactivate the electronic actuator.

2. The firing system of claim 1, wherein the firing system has a multi-shot mode, and wherein the microcontroller is further operable to execute program instructions for repeatedly activating and deactivating the electronic actuator when the firing system is in the multi-shot mode.

3. The firing system of claim 2, further comprising:

   a display unit communicatively linked to the microcontroller for indicating whether the firing system is in the multi-shot mode.

4. The firing system of claim 1, wherein the firing system has a burst mode, and wherein the microcontroller is further operable to execute program instructions for repeatedly activating and deactivating the electronic actuator for each shot in a burst when the firing system is in the burst mode.

5. The firing system of claim 4, further comprising:

   a display unit communicatively linked to the microcontroller for indicating whether the firing system is in the burst mode.

6. The firing system of claim 1, further comprising:

a display unit communicatively linked to the microcontroller for indicating the time remaining in a competition in which the firing system is used.

7. The firing system of claim 1, wherein the microcontroller is further operable to execute program instructions for recording a value representing the number of times the electronic actuator has been activated, the system further comprising:

a display unit communicatively linked to the microcontroller for displaying the value.

8. The firing system of claim 1, wherein the microcontroller is further operable to download data to a computer.

9. The firing system of claim 8, wherein the data includes the number of shots fired in a game.

10. The firing system of claim 8, wherein the data includes an identification of the user of the firing system.

11. The firing system of claim 1, further comprising a programming unit communicatively linked to the microcontroller for providing computer executable instructions thereto, wherein the programming unit is adapted to be connected to a computer that is external to the firing system and to receive computer executable instructions from the computer.

12. The firing system of claim 11, wherein the programming unit is further adapted to download data to the computer.

13. The firing system of claim 12, wherein the data includes the number of shots fired in a game.

14. The firing system of claim 12, wherein the data includes an identification of the user of the firing system.

15. A trigger mechanism for a weapon, the mechanism comprising:

a frame;
a finger engageable trigger attached to the frame, wherein the trigger is pivotable between a firing position and a non-firing position;
a first magnet disposed on the trigger; and
a second magnet disposed on the frame such that a force exists between the first and second magnets to bias the trigger to pivot into the non-firing position, wherein the second magnet is adjustable to vary the strength of the force.

16. The trigger mechanism of claim 15, wherein the second magnet is laterally adjustable to vary the strength of the force.

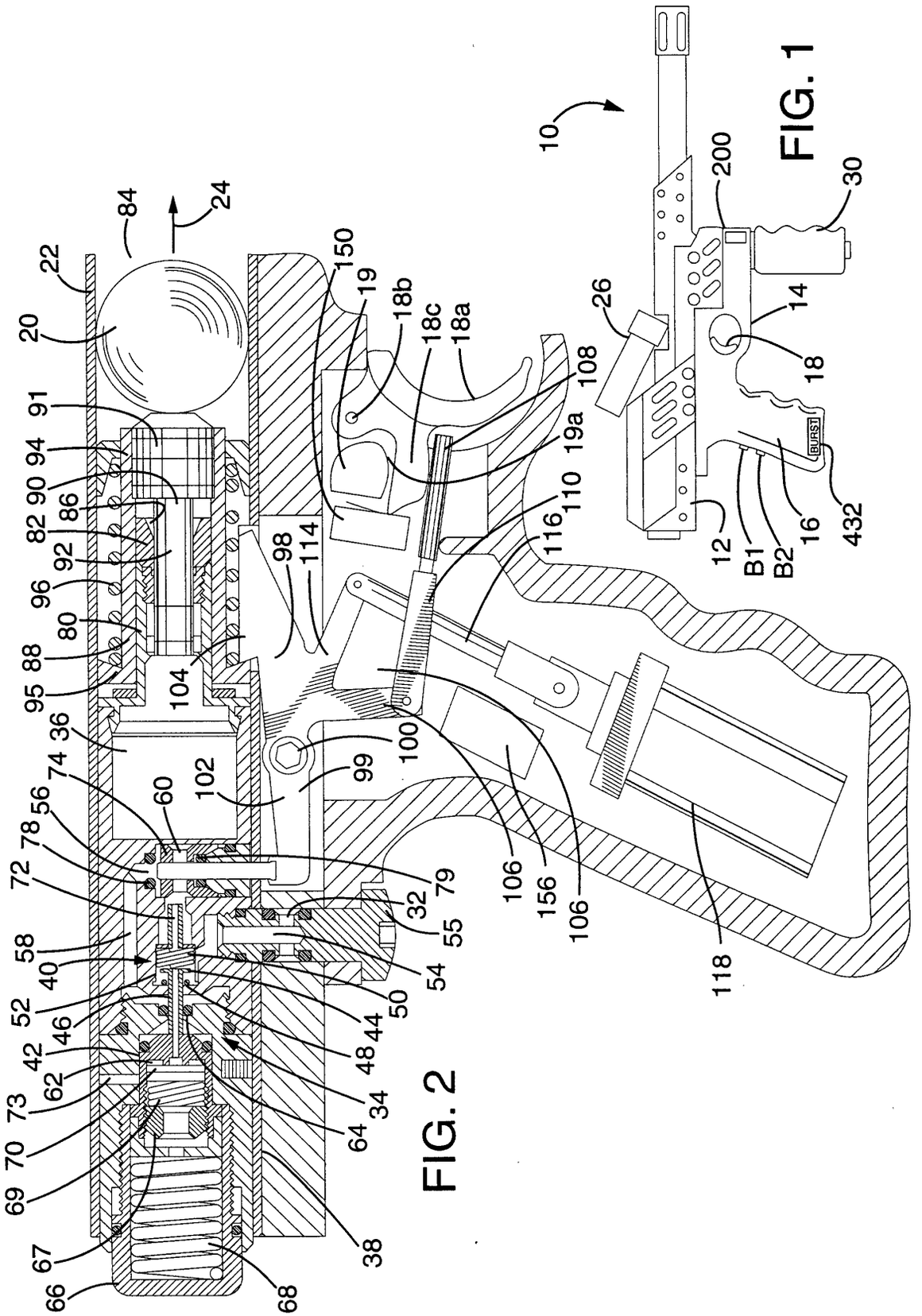
17. The trigger mechanism of claim 15, wherein the second magnet is rotatable to vary the strength of the force.

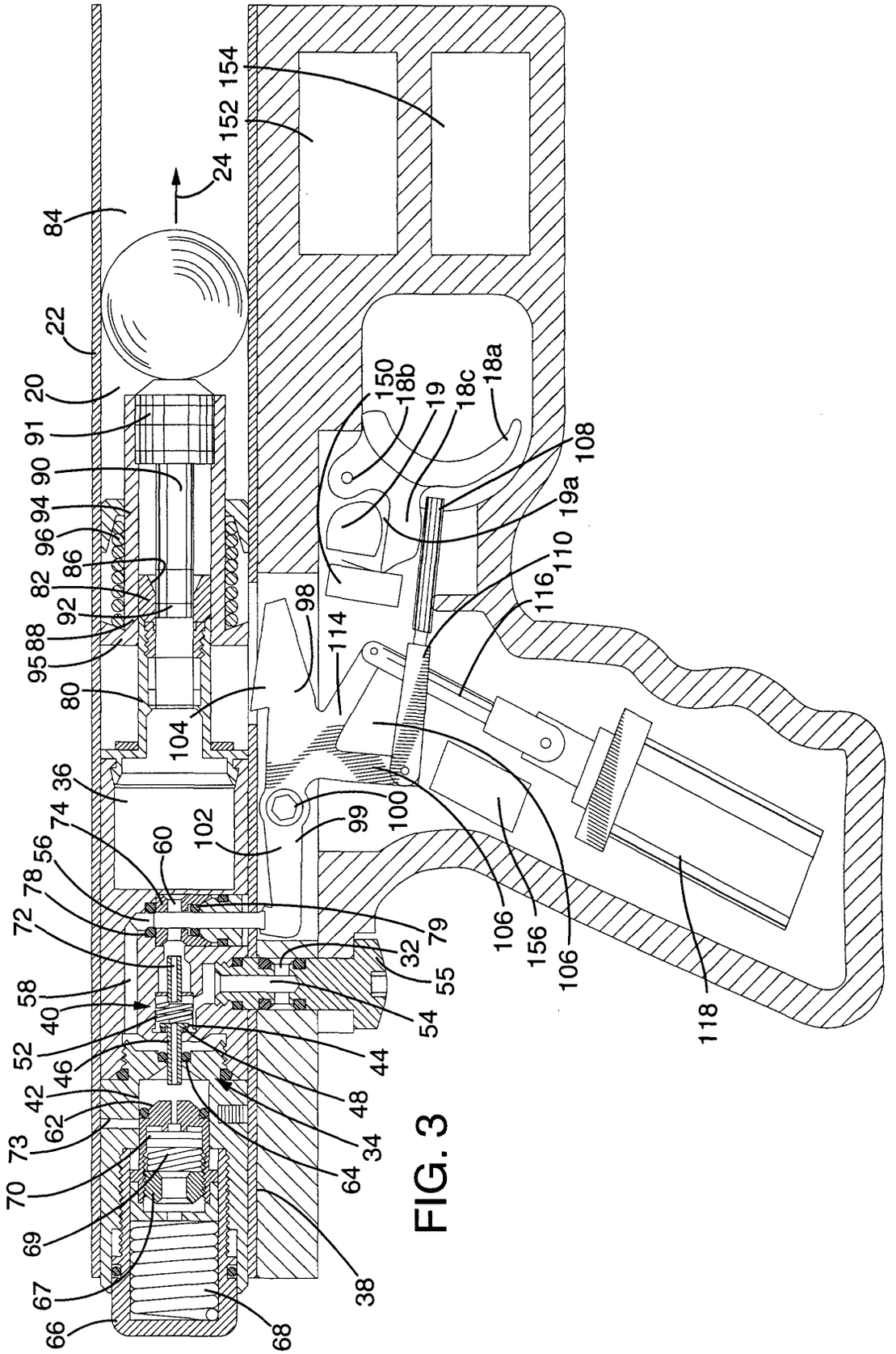
18. The trigger mechanism of claim 15, wherein the force is a repulsion force.

19. The trigger mechanism of claim 15, wherein the force is an attractive force.

20. A trigger mechanism for a weapon, the mechanism comprising:

a frame;
a finger engageable trigger attached to the frame, wherein the trigger is pivotable between a firing positions and a non-firing position; and
a Hall switch disposed adjacent to the magnet such that when the trigger moves from the non-firing position to the firing position, the Hall switch is activated to fire the weapon.


10
200
30
14
18
26
BURST
12
B1
B2
16
432
FIG. 1
84
24
22
20
150
19
18b
18c
18a
108
19a
91
94
90
86
82
92
96
80
88
95
36
74
56
78
72
58
40
52
46
42
62
73
70
69
67
66
68
38
64
34
48
44
50
54
55
32
79
60
102
104
98
114
99
100
110
116
106
156
106
118
FIG. 2


84
24
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154
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20
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90
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82
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58
40
52
46
42
62
73
70
69
67
66
68
38
64
34
48
44
54
55
79
32
60
102
99
100
98
114
150
18b
19
18c
18a
108
19a
110
116
106
156
106
118

FIG. 3

Fig. 4

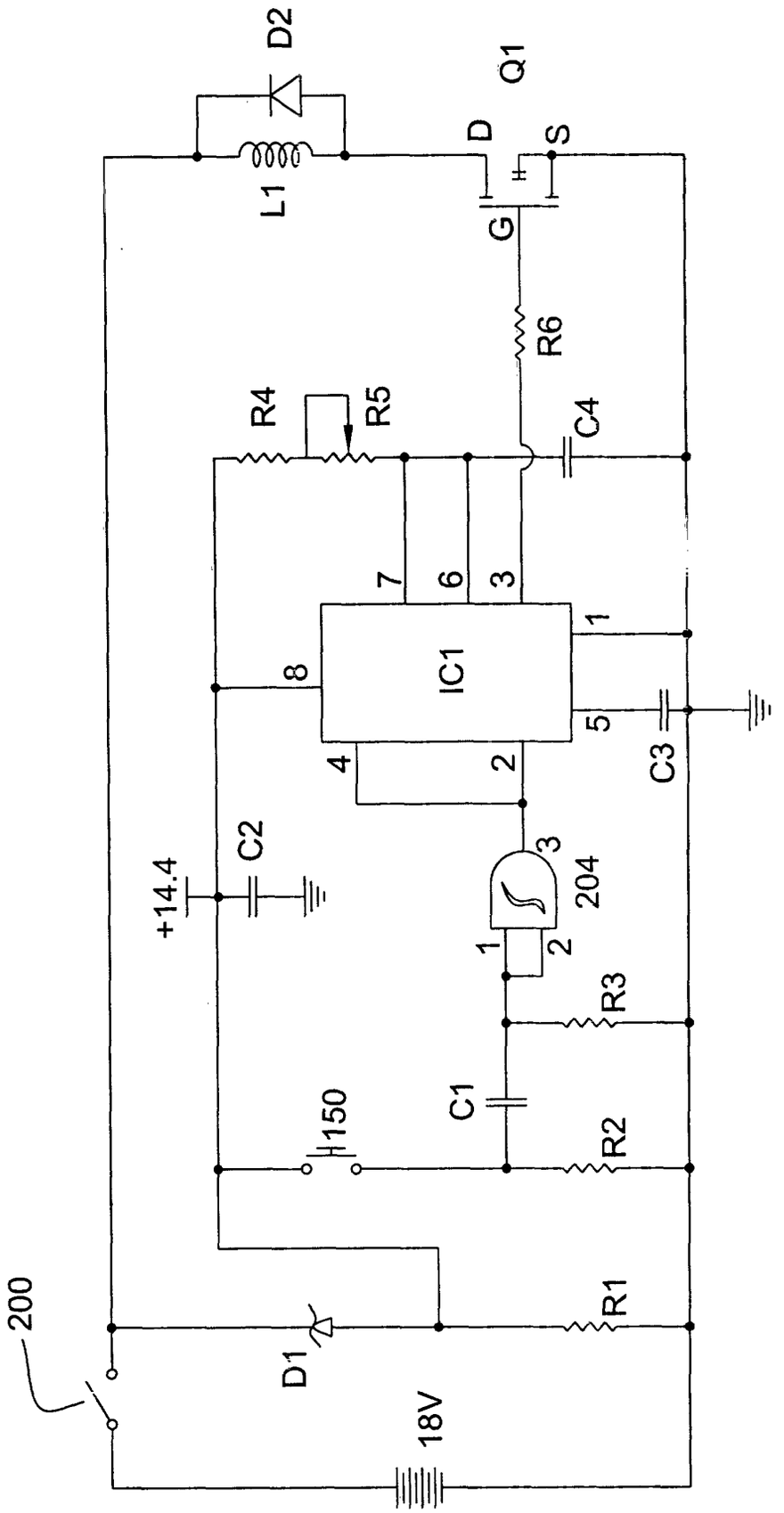
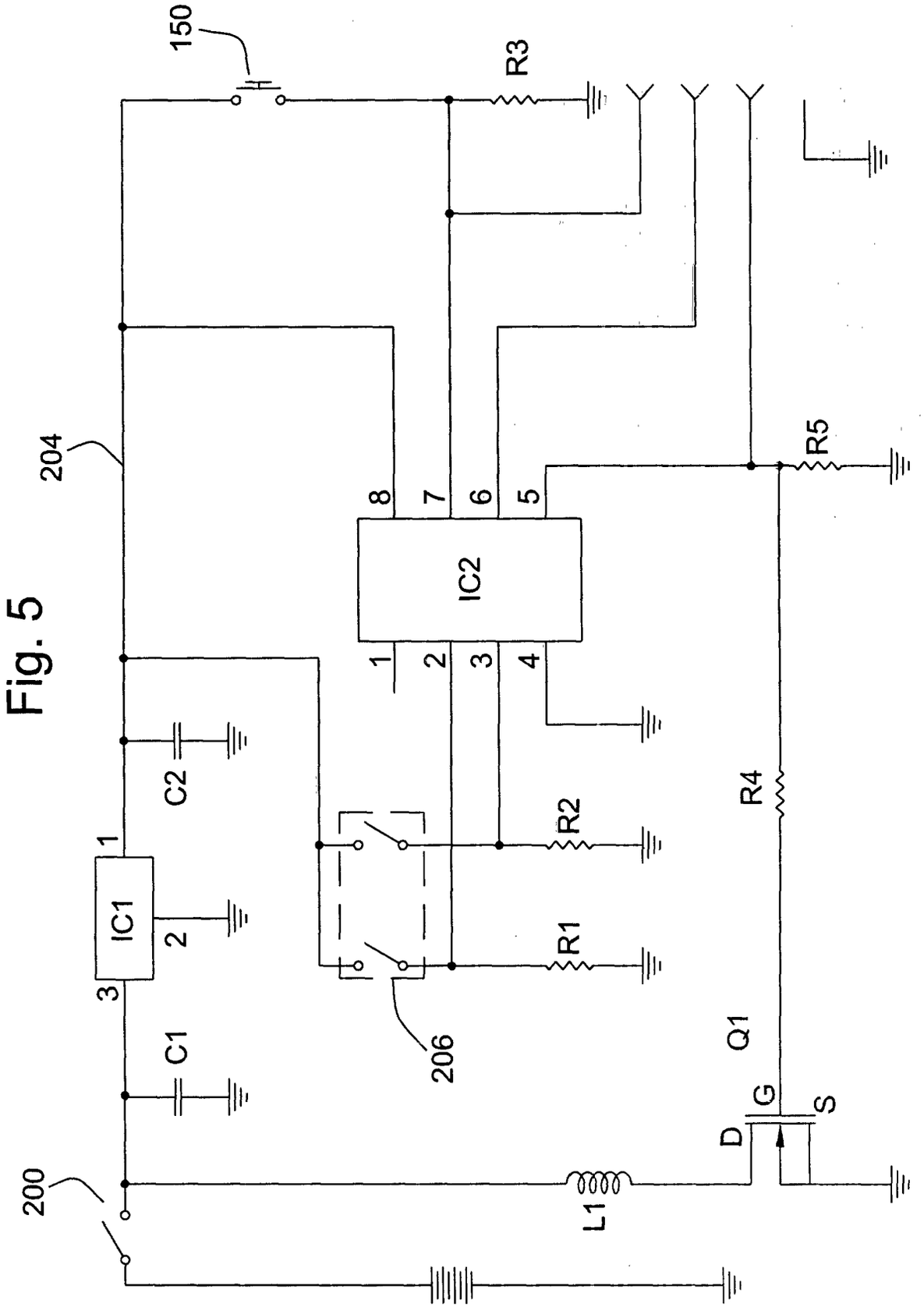

D2
Q1
D
S
L1
G
R6
R4
R5
C4
7
6
3
1
IC1
8
5
C3
4
2
C2
+14.4
3
204
1
2
R3
C1
150
R2
200
R1
D1
18V

Fig. 5


150
R3
204
R5
8
7
6
5
IC2
1
2
3
4
C2
R4
R2
1
IC1
2
3
R1
206
C1
Q1
G
S
D
200
L1

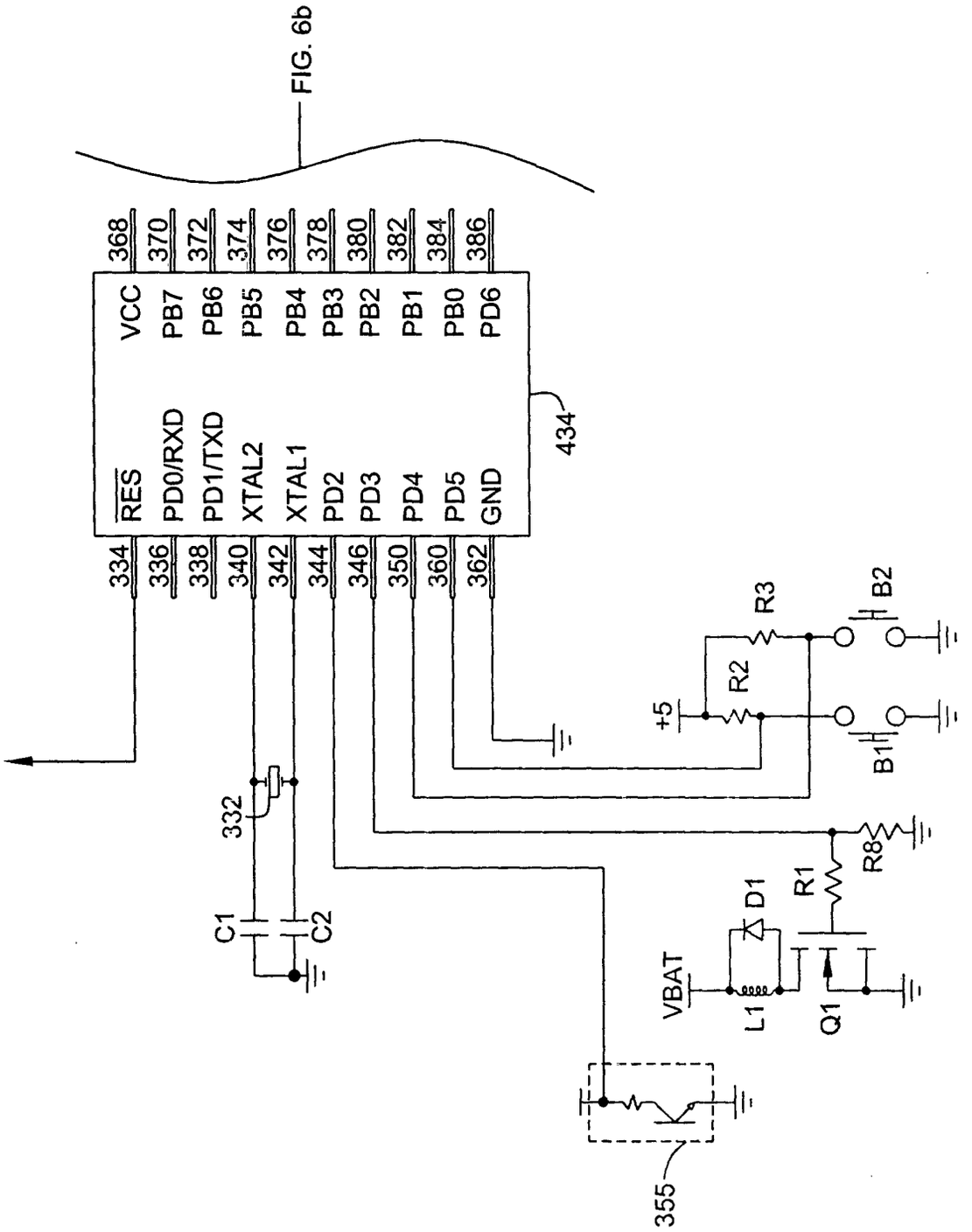


FIG. 6b
368
370
372
374
376
378
380
382
384
386
VCC
PB7
PB6
PB5
PB4
PB3
PB2
PB1
PB0
PD6
RES
PD0/RXD
PD1/TXD
XTAL2
XTAL1
PD2
PD3
PD4
PD5
GND
434
334
336
338
340
342
344
346
350
360
362
R3
B2
R2
+5
B1
332
R8
C1
C2
D1
R1
VBAT
L1
Q1
355

FIG. 6a

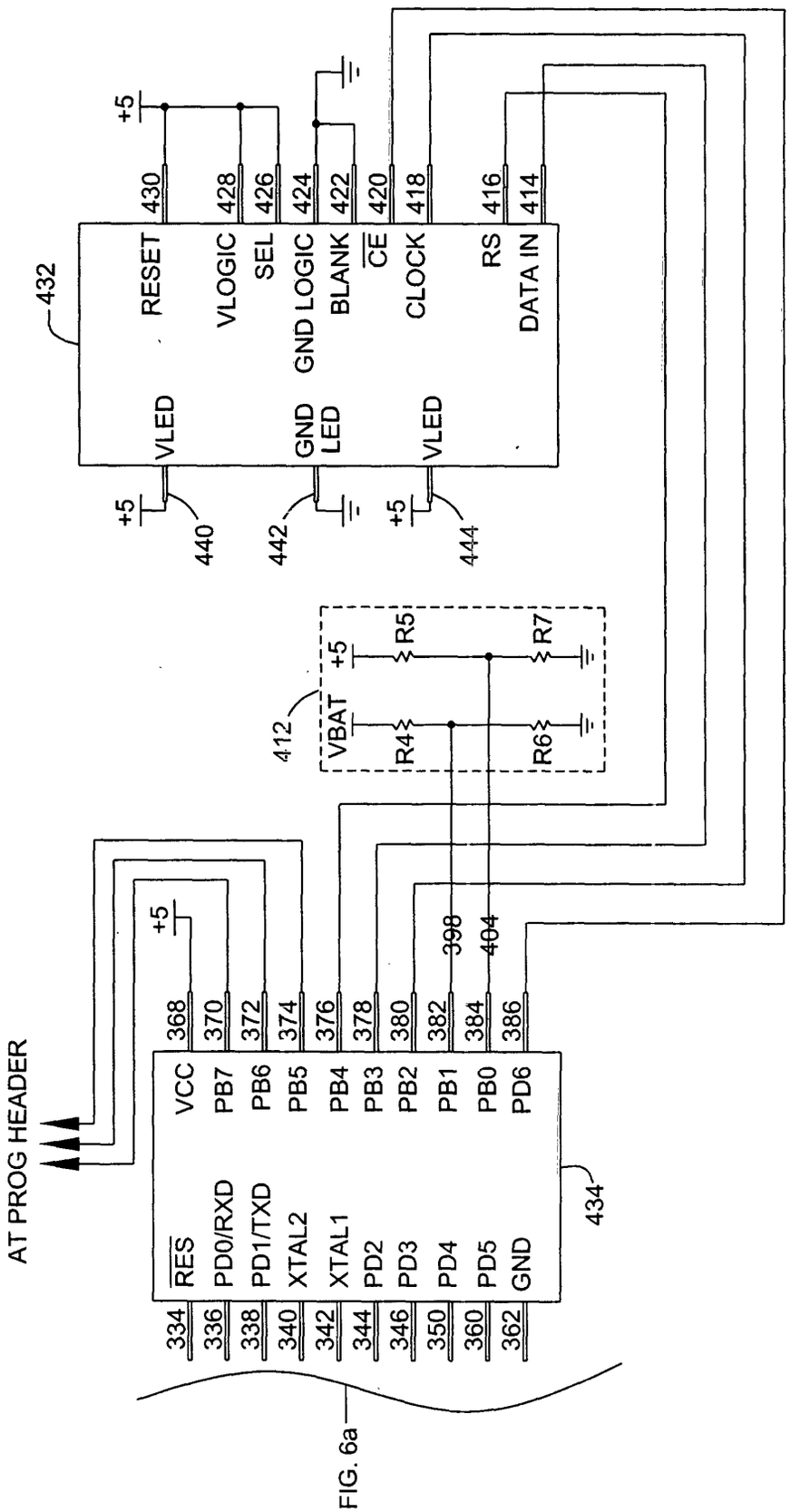

AT PROG HEADER
RES
PD0/RXD
PD1/TXD
XTAL2
XTAL1
PD2
PD3
PD4
PD5
GND
VCC
PB7
PB6
PB5
PB4
PB3
PB2
PB1
PB0
PD6
+5
334
336
338
340
342
344
346
350
360
362
368
370
372
374
376
378
380
382
384
386
390
404
434
412
VBAT
R4
R5
R6
R7
432
RESET
VLOGIC
SEL
GND LOGIC
BLANK
CE
CLOCK
RS
DATA IN
VLED
GND LED
VLED
430
428
426
424
422
420
418
416
414
440
442
444

FIG. 6a

FIG. 6b

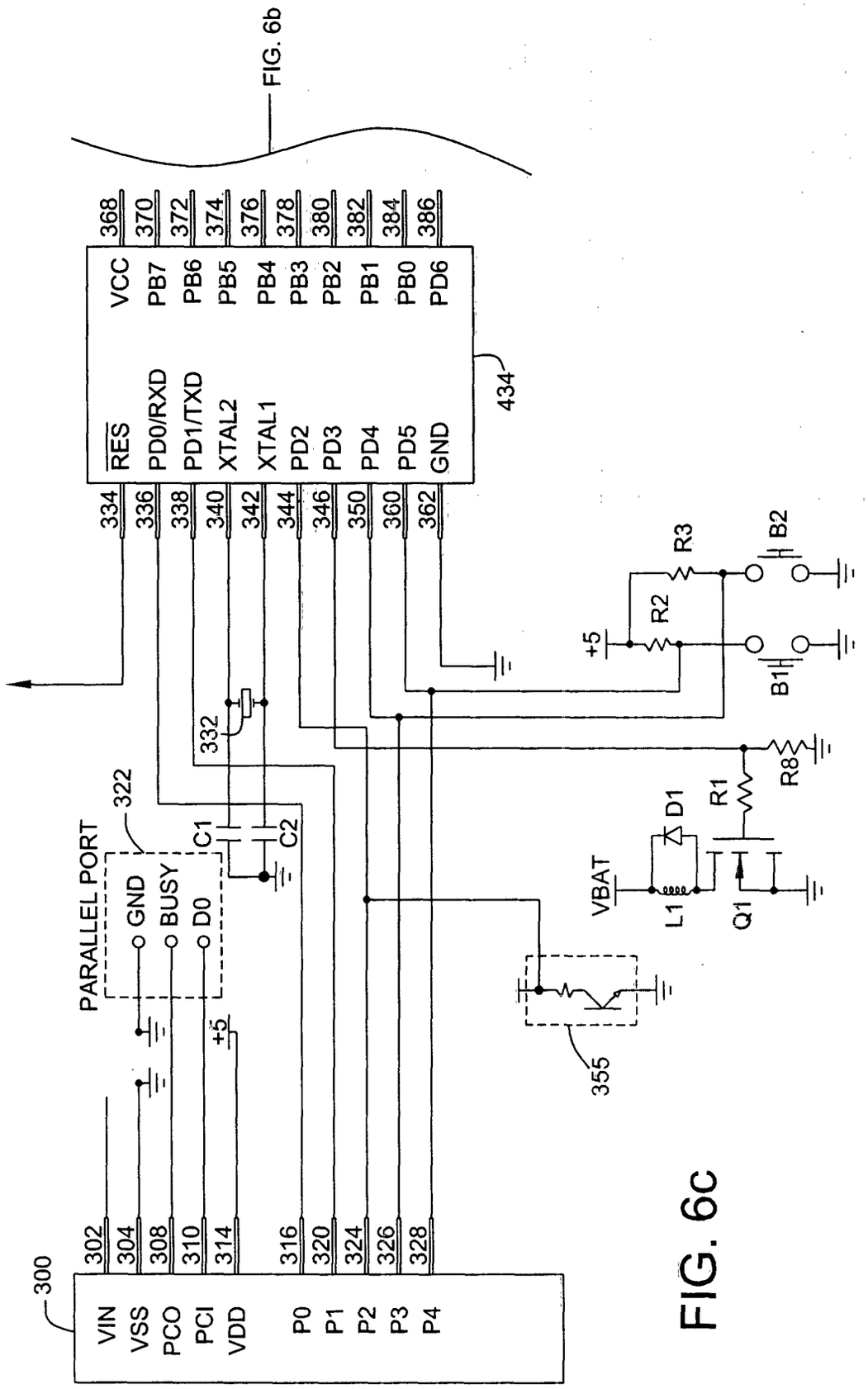


FIG. 6b
368
370
372
374
376
378
380
382
384
386
VCC
PB7
PB6
PB5
PB4
PB3
PB2
PB1
PB0
PD6
RES
PD0/RXD
PD1/TXD
XTAL2
XTAL1
PD2
PD3
PD4
PD5
GND
434
334
336
338
340
342
344
346
350
360
362
332
R3
B2
R2
+5
B1
R8
R1
D1
VBAT
L1
Q1
355
322
PARALLEL PORT
GND
BUSY
D0
C1
C2
+5
300
302
304
308
310
314
316
320
324
326
328
VIN
VSS
PCO
PCI
VDD
P0
P1
P2
P3
P4

FIG. 6c

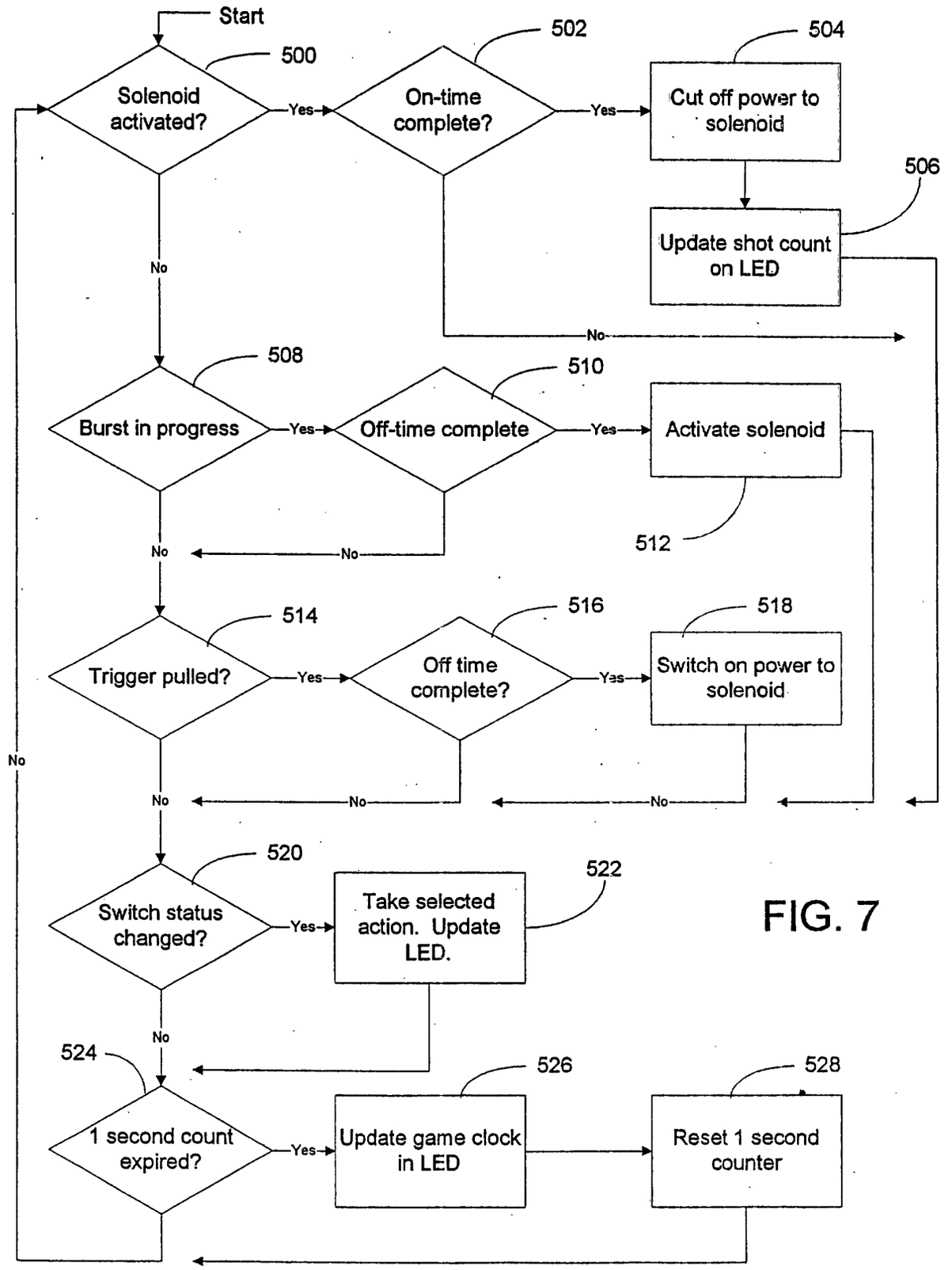

Start
500
Solenoid activated?
Yes
502
On-time complete?
Yes
504
Cut off power to solenoid
506
Update shot count on LED
No
No
508
Burst in progress
Yes
510
Off-time complete
Yes
Activate solenoid
512
No
No
514
Trigger pulled?
Yes
516
Off time complete?
Yes
518
Switch on power to solenoid
No
No
No
No
520
Switch status changed?
Yes
522
Take selected action. Update LED.
No
524
1 second count expired?
Yes
526
Update game clock in LED
528
Reset 1 second counter

FIG. 7

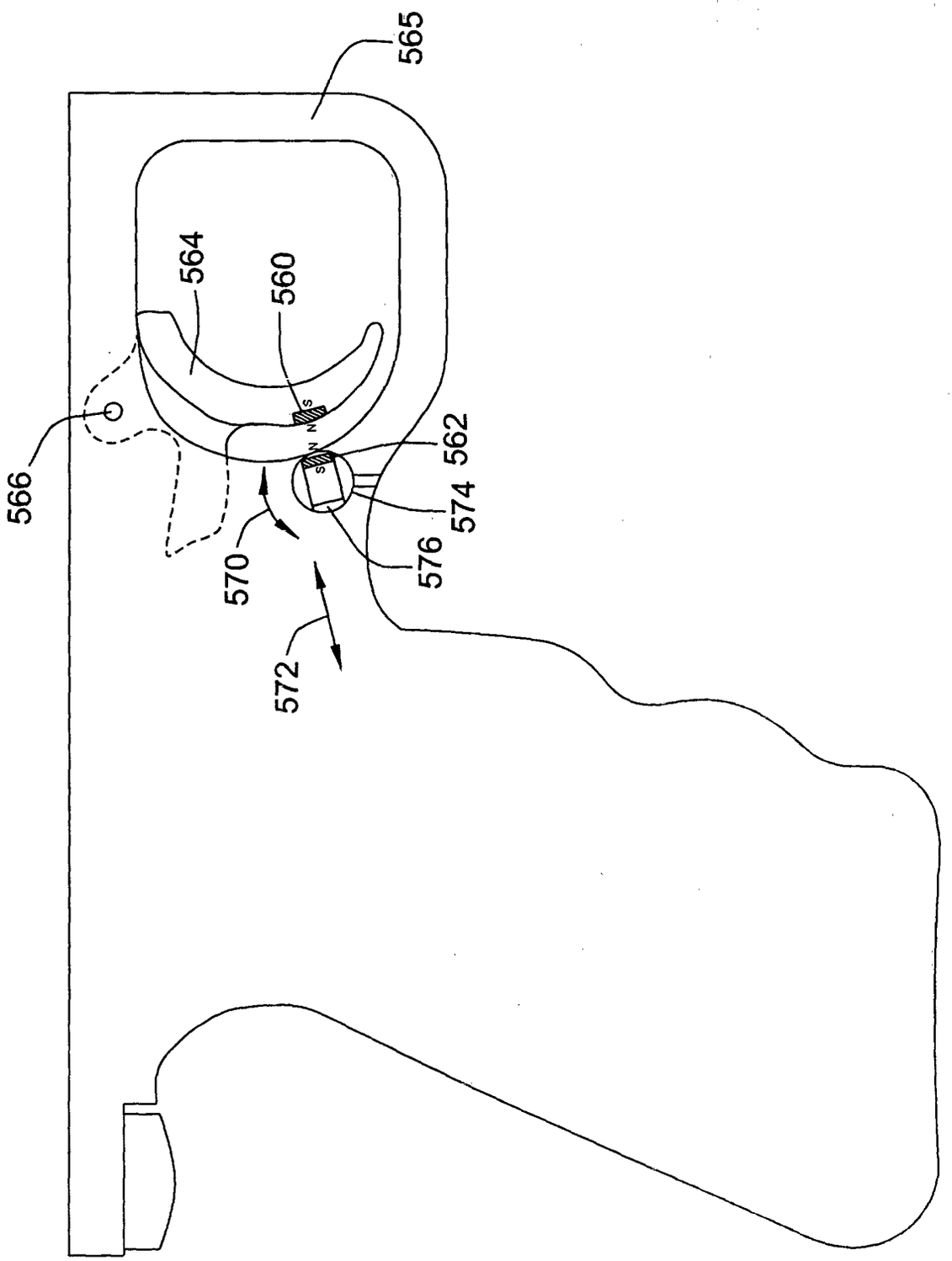


FIG. 8

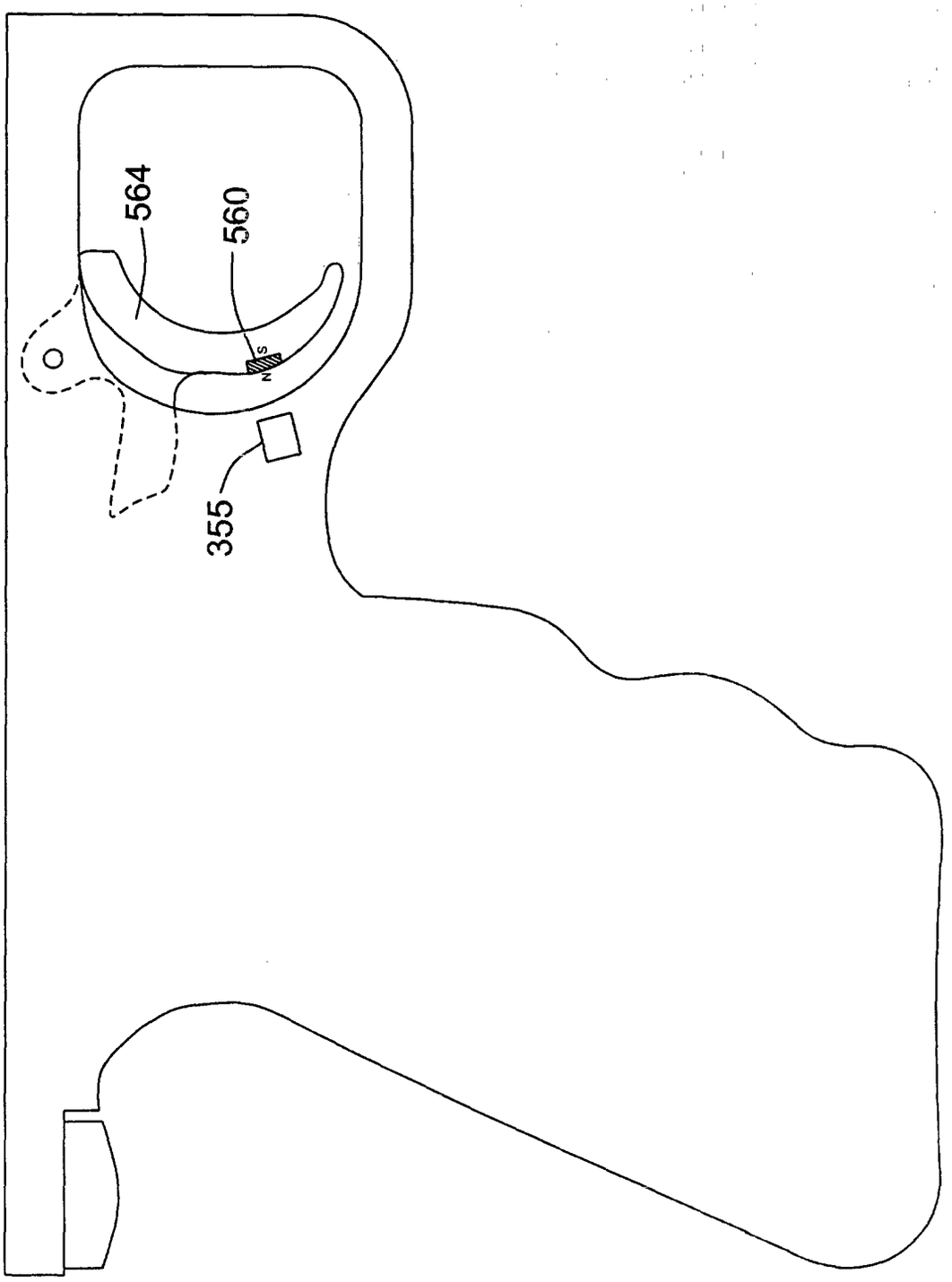


FIG. 9