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(54) Control for electronic lock.

(57) A battery powered (40) electronic locking apparatus comprises a locking member (2) movable between a locking position and an unlocking position, a first electromechanical means (110) coupled to the locking member to drive the locking member from one of the positions to the other position upon activation of the first electromechanical means and a second electromechanical means (111) coupled to the locking member to drive the locking member from the one position to the other position upon activation of the second electromechanical means. A control means (3) activates the first electromechanical means (110) without the second electromechanical means (111) to attempt to drive the locking member from the one position to the other position to conserve power, and subsequently activates the first (110) and second (111) electromechanical means together to attempt to drive the locking mechanism (2) to the other position. This provides movement of the locking member (2) when the battery voltage is low or the locking member is bound. In addition, if one attempt by one (110) or both (110, 111) electromechanical means is unsuccessful, the control means (3) automatically activates (254, 256, 258) one or both of the electromechanical means a second time. This is effective in the event that the failure was due to torque applied by a user to a door handle which bound the locking member.

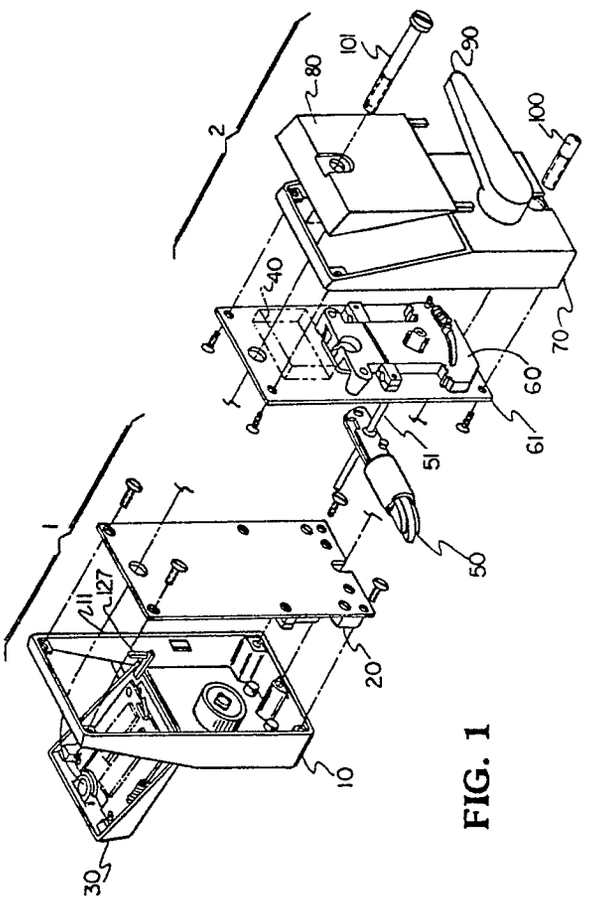

FIG. 1

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CONTROL FOR ELECTRONIC LOCK

The present invention relates to electronic locking apparatus, in particular to a battery powered door lock operator having a locking plate and solenoid means for driving the locking plate, and a control for the lock operator which maximizes the useful life of the battery.

Known electronic door locks are battery powered and utilize a single solenoid to provide the locking function. Such locks are constructed so that the solenoid is energized for the time that the lock is in the unlocked position. Thus, if the lock remains open for 5-6 seconds, the solenoid draws power and drains the battery for that period of time. With this type of lock, it is almost impossible to provide an alternative function, such as a dormitory function in which the lock will be left open for indefinite periods of time, because such a function would consume batteries at an unacceptable rate.

In addition, as the battery drains, the voltage output under load decreases and eventually will be insufficient to drive the solenoid, require a battery change and reduce the reliability of the apparatus. This is despite the fact that at such reduced voltage level, the battery still contains substantial energy.

It is known to utilize solenoids in various configurations for electronic door locking apparatus. For example, U.S. Patent No. 4,132,439 discloses an electronic door lock in which the lock bolt is moved longitudinally by a first solenoid and in which a dead lock element is moved by a second solenoid.

U.S. Patent No. 4,148,092 describes an electronic door lock with a manually operable deadbolt. This lock features a single solenoid positioned such that its plunger is received by a cavity in the manual turning mechanism thereby preventing the lock from being opened manually.

U.S. Patent No. 3,893,723 describes an electronically operated door lock in which two solenoids are disposed opposite each other to lock and unlock the door by moving the locking pin into and out of a cavity in the wall.

U.S. Patent No. 2,224,671 describes an automobile door lock which utilizes a single solenoid instead of a lock spring as a means to prevent opening of the lock.

U.S. Patent No. 2,765,648 discloses an electronic lock for an automobile in which the lock bolt is actuated by a solenoid and a bar actuated by another solenoid is provided to extend into a notch of the lock bolt to retain the lock bolt in the locked position.

U.S. Patent No. 3,897,093 discloses an electronic door lock in which two solenoids actuate a pivotally mounted cradle which provides reciprocal movement of the lock bolt.

It is an object of the present invention to provide a battery powered lock operator and control which function for as long as possible on a single set of batteries.

It is a further object of the present invention to provide a lock operator of the above type which may be driven by standard solenoids, and which is reliable in operation.

The present invention provides an electronic lock apparatus comprising:

a locking member movable between a locking position and an unlocking position.

a first electromechanical means coupled to the locking member to drive the locking member from one of the positions to the other position upon activation of the first electromechanical means.

a second electromechanical means coupled to the locking member to drive the locking member from the one position to the other position upon activation of the second electromechanical means,

battery means for powering the first and second electromechanical means, and

control means for activating the first electromechanical means without said second electromechanical means to attempt to drive the locking member from the one position to the other position, and for subsequently activating the first and second electromechanical means together to attempt to drive the locking mechanism to the other position.

In a preferred embodiment of the locking apparatus according to the invention, the first and second electromechanical means coupled to the locking member comprise first and second solenoids.

In a preferred embodiment of the invention the electronic locking apparatus further comprises voltage sensing means for sensing the voltage of the battery and the control means includes means responsive to the voltage sensing means for activating the first solenoid without the second solenoid to attempt to drive the locking member to the other position when the voltage of the battery means is greater than a predetermined level and activating the first and second solenoids together to attempt to drive the locking member to the other position when the battery voltage is less than the predetermined level.

The invention also resides in an improvement to an electronic locking apparatus having a lock combination memory containing lock combination

data means for reading lock combination data from a key inserted in the electronic locking apparatus, and means for comparing the lock combination data on the key to the lock combination data stored in the lock combination memory. The improvement comprises a locking member movable between a locking position and an unlocking position, solenoid means for attempting to drive the locking member from one of the positions to the other position, and control means responsive to a match of the lock combination data on the key and the lock combination data stored in the lock combination memory for activating the solenoid means for a time period to attempt to drive the locking member to the other position, for sensing whether the locking member is in the other position after activation of the solenoid means, and for automatically activating the solenoid means a second time after the time period has elapsed and the solenoid means becomes deactive without reinsertion of the key in the locking apparatus if the solenoid means was unsuccessful in driving the locking member to the other position in the foregoing attempt. If a user applies a torque to a door handle during the time period that the solenoid means attempts to open the lock, such torque may bind the locking member. However, at the time of the second attempt, the user hopefully has removed his or her hand from the door handle so that the locking member may be opened by the solenoid means.

The invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is an exploded view of an electronic lock including a lock operator and control according to the present invention;

Figure 2 is an exploded view of an outside operating assembly of an electronic lock including the lock operator of Figure 1;

Figures 3-9 show detail of the operation of the lock operator of the electronic lock of Figure 1;

Figure 10 shows the outside operating assembly, including the locking mechanism of the present invention mounted on the back plate of the outside portion;

Figure 11 is a schematic block diagram of electronic components of the control of the electronic lock of Figure 1;

Figure 12 is a flowchart illustrating the mode of operation of and a computer program within the control of the electronic lock of Figure 1 and

Figure 13 is a flowchart illustrating an alternative mode of operation of, and computer program for, the control of the electronic lock of Figure 1.

Figures 1-3 and 10 illustrate an embodiment of an electronic door lock according to the invention. The apparatus comprises an external portion 1 having an external housing 10, an external handle 11, an external operating assembly 20 and an external cover 30, and an internal portion 2 including power source 40, an internal operating assembly 60, and internal housing 70, an internal cover 80 and an internal handle 90. Plates 21 and 61 which include the external and internal operating assemblies are attached to housings 10 and 70, respectively, by means of screws, as shown. Screws 100 and 101 hold the lock in place on a door. A strike box and strike plate are mounted on the door jamb in a conventional manner.

A card reader device suitable for use in an electronic door lock according to the present invention is described in co-pending European Patent Application No. [F.14761] of even date. A suitable latch bolt assembly for the electronic door lock according to the present invention is described in U.S. Patent No. 4,594,864.

The external operating assembly 20 comprises a lock cassette body 29, main solenoids 110 and 111 and auxiliary solenoid 112 supported by the lock cassette body, an actuating member 28, a cam plate 27, a rack plate 26, a locking plate 22 which includes two parts, a top plate 24 and a nose piece 25, a pinion 23 and a back plate 21.

The back plate 21 contains holes 19 through which it may be attached by screws, shown in Figure 1, to tabs 12 and bosses 13 in housing 10. The back plate 21 also contains tabs 15 to align the assembly with a standard hole provided in a door. The back plate 21 is provided with a boss 119 which extends inwardly and provides a bearing surface for the head 118 of the pinion 23. The external operating assembly is attached to the back plate 21 by screws 9 in threaded holes 128 in bosses on the lock cassette body 29. This holds together the entire external operating assembly.

The housing 10 is provided with a central opening 125 into which a generally square shaped projection 126 of the external lever 11 extends. Tabs 127 are positioned so that the projecting legs of the external cover 30 can rest and maintain the cover in a generally horizontal position for servicing, as show in Figure 1. A threaded hole 181 is provided to receive the screw 100 shown in Figure 1.

The main solenoids 110 (left) and 111 (right) are positioned to engage the ears 127 of the top plate 24 to lift the locking plate vertically between the lower locked and the upper unlocked positions. The main solenoids are attached to the lock cassette body 29 by a screw and bracket support 155. Shafts 154 of the main solenoids extend through vertical holes in the support 155.

The auxiliary solenoid 112 is positioned so that its shaft 150 is perpendicular to the top plate 24 and projects into slots 151 and 152 therein. The auxiliary solenoid is attached to the lock cassette

body by a screw and generally circular bracket support 157. A slot 129 is provided through which the actuator pin 130 of the actuating member 28 fits. Vertical sides 140 define a pathway which accommodates the projecting arms 141 of the cam plate 27. The body 29 is also provided with an opening 133 through which the projection 126 of the external handle 11 extends. Threaded holes 128 are provided to attach the entire external operating assembly to the plate 21.

An actuating member 28 is mounted on the internal side of the cassette body 29 with a boss 134 thereof mounted in the opening 133 and the actuator pin 130 fitting through the slot 129. The actuator 28 is provided with a generally square shaped opening 135 into which extends the generally square shaped projection 126 of the handle 11. The actuator includes a circular shaped base portion 136 and a tail end 137 which supports the actuator pin 130 and a locking pin 138. The base portion 136 is provided with a raised V-shaped cam surface 139 which extends inwardly past the plane of the inner surface of tail end 137.

The cam plate 27 contains projecting arms 141 which fits into the pathway defined by the vertical sides 140 of the lock cassette body 29. The cam plate 27 also includes a cam follower surface 142 which engages the V-shaped cam 139 of the actuator 28. The cam follower surface 142 is a tab projecting from the cam plate. The generally rectangular internal cutout 143 of the cam plate 27 accommodates the rack plate 26.

The rack plate 26 is mounted within the cutout 143 of the cam plate 27. The rack plate 26 has a generally rectangular internal cutout 144 which cutout contains gear teeth 115 on one of the longer, or vertical, sides. The gear teeth 115 engage the teeth 114 of the pinion 23. The rack 26 has a lip 145 upon its upper portion which serves to hold the rack 26 in place between the cam plate 27 and the top plate 24. As the rack moves within the cutout portion 148 of the top plate 24, the position of the locking plate, i.e. either locked or unlocked, is not changed. In this manner, the inside door handle can be opened without unlocking the lock.

The nose piece 25 is attached to the top plate 24 by pressing onto the pin 121 on the top plate 24. The nose piece 25 includes a protrusion 146 for engaging the locking pin 138. The top plate 24 includes ears 127 which engage the main solenoids 110 and 111 and apertures such as slots 151 and 152 which engage the shaft 150 of the auxiliary solenoid 112. An internal cutout 148 is provided to accommodate the rack plate 26 and is sized so that the rack 26 can move vertically without changing the position of the locking plate.

The pinion member 23 includes gear teeth 114 in mating engagement with the teeth 115 on the rack plate 26. This pinion member 23 extends perpendicularly to the axis of the latch bolt assembly 50. The pinion member 23 also includes a tubular extension portion 116 which extends through the top plate 24, rack 26, cam plate 27, actuator 28 and cassette body 29 into an opening 117 in the external handle 11. The pinion 23 further includes a head portion 118 which is contained within the boss 119 which extends inwardly on the back plate 21 and provides a bearing surface for the head portion 118. The head portion 118 also has a generally rectangular slot 120 therein of mating cross-section with that of spindle 51 which extends therethrough.

The operation of the locking mechanism will be described in greater detail with reference to Figures 3 to 9:

Figure 3 to 9 shows the locking plate in the lower locked position. In this position, the locking pin 138 engages the protrusion 146 of the nose piece portion 25 of the locking plate. The locking pin 138 is constrained from movement by the protrusion 146 of the nose piece 25 and the wall 153 of the lock cassette body 29. The locking pin 138 is attached to the actuating member 28, which in turn engages the lock handle by means of the generally square shaped projection 126 which fits into the aperture 135 of the actuating member 28. By preventing movement of the locking pin, the handle is also effectively prevented from moving and the lock cannot be opened.

Figures 6 and 9 show the locking plate in the upper, unlocked, position. In this position, the protrusion 146 does not engage the locking pin 138. The locking pin 138, the actuating member 28 and the external handle 11 are then free to move. Movement of the external handle 11 will then withdraw the latch bolt. This is effected as follows. Turning handle 11 rotates the square shaped projection 126 which rotates the actuator 28, which in turn moves the cam plate 27 in a vertical direction. The movement of the cam plate 27 carries with it the rack plate 26. As the rack plate 26 moves upwardly, it causes the pinion 23 to rotate, thus rotating the spindle 51 and withdrawing the latch bolt of the latch mechanism 50.

The locking plate is moved vertically between the lower and upper positions by energizing one or both of the main solenoids 110 and 111. The entire movement can be accomplished in tenths of a second. This is quite significant because the short time of energizing the solenoids minimizes battery draw down. The main solenoids 110 and 111 are mounted on lock cassette body 29 by the screw and bracket 155 and positioned to move the locking plate vertically between the lower locked and upper unlocked positions. The solenoids 110 and 111 may be of any suitable type such as those

manufactured by Ledex, Inc., which produce 0.83 newtons (three ounces of force) at six volts.

The operation of the main solenoids must be synchronized with the operation of the auxiliary solenoid 112. When the locking plate is in the lower locked position, the shaft 150 of the auxiliary solenoid 112 is perpendicular to the locking plate and received in a slot 151 at the top of the locking plate. The shaft 150 effectively prevents the locking plate from being moved vertically into the upper position. Thus, the shaft 150 must be withdrawn immediately prior to the lifting of the locking plate by one or both of the main solenoids 110 and 111.

Figure 4 shows the shaft 150 of the auxiliary solenoid 112 positioned in the slot 151 of the locking plate and preventing upward movement of the locking plate. In this position, the auxiliary solenoid 112 does not draw any power. After activation, the shaft 150 is withdrawn from the slot 151 and offers no obstruction to the upward movement of the locking plate. This is shown in Figure 5. The locking plate is then moved upward by the action of one or both of the main solenoids 110 and 111 as shown in Figure 7. Figure 6 shows the locking plate in the upper unlocked position with both main solenoids energized. The shaft 150 is extended into the slot 152 of the locking plate by means of a spring 180 after the plate has moved past it. This is shown in Figure 8. In this position, the locking plate rests on shaft 150 and is restrained from moving down. Referring to Figure 9, because the locking plate is resting on the shaft 150, the main solenoids 110 and 112 are not energized to maintain the locking plate in the upper position and the shafts 154 of the main solenoids fall back to their initial position. Figure 9 also shows that, in the upper unlocked position, the locking pin 138 can be moved past the protrusion 146 of the nose piece 25. The aperture 120 of the pinion 23 has rotated which will rotate the spindle 51 and withdraw the latch bolt of the latch mechanism 50. The extension spring 131 pulls the actuating member and handle 11 back to their initial positions after the operation.

When it is desired to move the locking plate from the upper unlocked position to the lower locked position, the main and auxiliary solenoids are again activated in a synchronized manner. One or both of the main solenoids 110 and 111 are energized and they lift the locking plate over the shaft 150 of the auxiliary solenoid 112. The auxiliary solenoid 112 is energized and the shaft 150 is withdrawn. Power is cut to the main solenoids and the locking plate falls to the lower locked position. The spring 180 then forces the shaft 150 of the auxiliary solenoid 112 to extend into the slot 151 at the top of the locking plate as discussed previously. The entire operation takes less than one second.

A presence sensor or microswitch 31 is positioned perpendicular to the locking plate so that it is actuated by movement of the locking plate between the upper and lower positions. The purpose of this microswitch is to determine the status of the lock, locked or unlocked, and transmit the information to the electronic control 3.

The internal operating assembly is similar to the external operating assembly described above. The internal operating assembly includes basically the same lock cassette body, actuating member, cam plate, rack plate and pinion and back plate elements as the external operating assembly. The only significant difference is that there is no locking plate or solenoids associated therewith on the inside to prevent movement of the actuating member. Operation of the internal operating assembly from turning the handle through withdrawing the lock bolt assembly is the same as that of the outside operating mechanism.

The battery means 40 may comprise any suitable battery, but preferably comprises three, three volt lithium batteries connected in series. The batteries are attached to the back plate 61 and supply the electronic control 3, the solenoids 110, 111, and 112, and the card reader 31.

The locking apparatus is described in more detail in our co-pending European Patent Application No.
[F.14760] of even date.

As illustrated in Figure 11, the electronic control 3 comprises a microprocessor 200, an associated electrically Eraseable Programmable Read Only Memory (EEPROM) 202 which contains an operating program for the microprocessor and one or more lock combinations, a Random Access Memory (RAM) 203 which contains one or more lock combinations, and electronic drivers 204, 206 and 208 which drive the auxiliary or catch solenoid 112, the main solenoid 110 and the main solenoid 111, respectively. By way of example, the electronic drivers are of the MOSFET type, and the microprocessor 200 and RAM 203 may be provided by a microcomputer. The electronic control 3 also includes a battery level detector 215 which monitors the voltage of the batteries 40 and by way of example, the battery level detector 215 comprises an analog to digital converter having its input connected to the battery output and an output connected to the microprocessor which reads the battery voltage in digital form. A read circuit 205 within the electronic control 3 is connected to the output of the card reader 31 and amplifies the card reader output and converts the output to digital format for reading by the microprocessor 200. In one embodiment of the invention, the battery level detector 215 is used to determine when the battery

voltage has fallen below a level required for satisfactory operation of the electronic control 3 and in another embodiment of the invention described below, serves another function as described below.

One mode of operating the electronic control and the associated solenoids in accordance with the present invention is illustrated in Figure 12 by a flowchart 230, which flowchart includes a computer program or firmware contained within the EEPROM 202. When a key card is inserted into the card reader 31, it activates a start switch (not shown), which constitutes a first step 232 of the algorithm 230. In response, electronic control 3 is powered up (step 233), and the microprocessor 200 sets a variable N equal to zero (step 234). Next, the data on the key card is read (step 236) and then the microprocessor compares one or more lock combinations contained in the data on the key card to one or more lock combinations stored in the RAM 203 or EEPROM 202 to determine whether the key card contains a valid combination suitable to open the lock (step 238). If the key card contains such a valid combination, then the microprocessor 200 activates the electronic driver 204 which in turn drives the auxiliary or catch solenoid 112 and thereby causes it to withdraw from engagement with the locking plate 22 (step 240). Then, the microprocessor 200 determines whether a flag has previously been set (step 242), which flag indicates that in a previous attempt or attempts, a single one of the main solenoids 110 or 111 was unable to lift the locking plate 22. The flag setting will be described in more detail below.

Assuming the flag is not set, the microprocessor proceeds to activate one of the main solenoids 110 and 111 for a predetermined time sufficient to raise the locking plate 22 to its upper, unlocked position (step 246), and maintain it there while the microprocessor deactivates the auxiliary or catch solenoid 112 allowing spring 180 to extend shaft 150 of the solenoid into the recess 152 and thereby maintain the locking plate 22 in its upper position (step 248). By way of example, the single main solenoid 110 or 111 need only be activated and auxiliary solenoid 112 deactivated for approximately 0.1 seconds to accomplish both steps 246 and 248. Then, after the main solenoid has been activated for 0.1 seconds, the microprocessor 200 reads the presence sensor switch 31 to determine whether the locking plate 22 has in fact been lifted to its unlocking position and held by the auxiliary solenoid 112 (steps 250 and 252). If the lifting of the locking plate 22 has been successfully completed, then the locking apparatus 8 is unlocked and the microprocessor 200 will power down (step 214) and the user will be able to open the door by rotating the door handle. However, the locking plate 22 may not have been lifted and maintained in its upper locking position for the following reasons. After prolonged use of the locking apparatus 8, the battery voltage may have fallen to a level at which the single main solenoid 110 or 111 is driven with inadequate power to develop the force necessary to lift the locking plate 22. By way of example, when the battery voltage drops to approximately 5 volts under load, a single solenoid 110 or 111 will probably not have sufficient power to lift the locking plate 22. Also, if the user applies a torque to the door handle, such torque will cause the pin 138 to bear against the nose 25 of the locking plate 22 and cause frictional forces which impede the upward motion of the locking plate 22 and cannot be overcome by the main solenoid.

Under either conditions which prevents the successful lifting of the locking plate 22, the microprocessor proceeds to the step 254 in which it waits a predetermined time before again attempting to lift the locking plate 22. By way of example, the predetermined time is in the interval 1-4 seconds. In this mode of operation, the microprocessor increments the variable N (step 256) and then determines whether the variable N is less than four (step 258). This sets a limit to the total number of attempts at lifting the locking plate 22 before powering down. If the variable N is less than four, the microprocessor proceeds back to the steps 240, 242, 246, 248 and 250 to again attempt to lift the locking plate 24 with one of the main solenoids 110 or 111 and maintain it in its upper position. This loop may be repeated two additional times until the variable N equals 4 at which time, the microprocessor 200 sets the flat (260) referenced above in the step 242 to indicate the inability of the single main solenoid 110 or 111 to lift the locking plate 22. then, the microprocessor 200 powers down (262).

If the user withdraws his or her card and then reinserts the card into the card reader 31 or another user inserts his or her card into the card reader 31, the electronic control 3 will again be powered up by the start switch (steps 232 and 233), the variable N reset to zero (step 234) and the data on the card read (step 236). If the combination on the key card is valid (step 238), the microprocessor proceeds to the step 242 in which it determines whether the flag is set. Because the flag was set in the step 260, the microprocessor proceeds to a step 244 in which the microprocessor activates both of the main solenoids 110 and 111 to attempt to lift the locking plate. It should be noted that a given battery voltage which provides insufficient power for a single main solenoid to lift the locking plate, nearly double the lifting force will be generated by the main solenoids 110 and 111 together. This is because the battery voltage under the load of both solenoids is not appreciably less than the battery voltage under the load of only one

solenoid and the law:

$P = V^2 R$ where P equals the power delivered to each of the main solenoids. V equals the battery voltage under load and R equals the effective resistance of the coil in each of the main solenoids.

The power delivered to each solenoid corresponds to the force that each solenoid develops so that two solenoids provide twice the force as compared to one at a given voltage.

Utilization of both of the main solenoids 110 and 111 under the condition in which the battery voltage is insufficient to drive the single solenoid substantially prolongs the useful life of the batteries. The batteries will sustain a voltage under load which is sufficient to drive the two solenoids 110 and 111 together for substantially longer than they are able to sustain a voltage under load sufficient to drive a single main solenoid 110 or 111. By way of example, the useful life of the battery is extended by approximately forty percent. It should also be noted that if both the main solenoids 110 and 111 were always utilized to lift the locking plate 22, when the batteries are fresh approximately twice the power of the batteries would be consumed in lifting the locking plate 22 than is needed, thus accelerating the drainage of the batteries.

After the step 244, the microprocessor proceeds to deactivate the auxiliary or catch solenoid 112 so that it extends under the force of its spring bias into the recess 152 and thereby maintains the locking plate 22 in its upper position if in fact the solenoid plate has been lifted. The microprocessor 200 then reads the presence sensing switch 31 to determine if the locking plate has been successfully lifted (steps 250 and 252), and, if not, attempts to lift the locking plate with the two solenoids 110 and 111, one, two or three more times after predetermined intervals according to the steps 254, 256, 258, 240, 242, 244, 248 and 250. After a successful lift or three unsuccessful attempts, the microprocessor powers down (step 264).

It should also be noted that if a key card having an invalid lock combination is inserted into the lock, this fact is noted in the step 238 and the microprocessor does not attempt to activate the solenoid(s) and jumps to the step 264 in which it powers down.

In an alternative embodiment of the invention, after the microprocessor performs the step 260 in which it sets the flag, the microprocessor jumps to the step 240 and then steps 242 and 244 to attempt immediately to lift the locking plate by activating both of the main solenoids 110 and 111 simultaneously.

A further embodiment of the invention is shown by flowchart 300 which utilizes the electronic control 3 but with a different computer program stored in the EEPROM 202, according to the flowchart 300, insertion of the key card activates the power switch to power up the electronic control (steps 302 and 304) and initiates the reading of the data on the card (step 306) to determine whether the key card contains a valid lock combination (step 308). If the key card contains a valid combination, the microprocessor activates the auxiliary or catch solenoid 112 to withdraw it from the recess 151. The microprocessor then reads the output of the battery level detector 215 to determine whether the battery provides sufficient voltage to drive a single one of the main solenoids 110 or 111 (step 312). If so, the microprocessor activates one of the main solenoids 110 or 111 (step 316) and then deactivates the auxiliary or catch solenoid 112 (318) so that the auxiliary solenoid will extend into the recess 152 if the locking plate 22 has in fact been lifted. If, on the other hand, the microprocessor reads a battery voltage in the step 312 which is less than a predetermined level capable of driving one of the main solenoids, the microprocessor proceeds to activate both of the main solenoids 110 and 111 (step 314) and then deactivates the auxiliary or catch solenoid 112 (step 318). In this embodiment of the invention, after the step 318, the microprocessor proceeds to power down irrespective of whether the locking plate 22 has been lifted. In a variation to the flowchart 300, after the step 318, the microprocessor may be programmed to repeat the attempt to lift the locking plate in the manner illustrated by the steps 254, 256 illustrated in Figure 12.

Claims

1. An electronic locking apparatus comprising:
a locking member (2) movable between a locking position and an unlocking position,
a first electromechanical means (110) coupled to said locking member (2) to drive said locking member from one of said positions to the other position upon activation of said first electromechanical means,
a second electromechanical means (111) coupled to said locking member (2) to drive said locking member from said one position to said other position upon activation of said second electromechanical means, and
battery means (40) for powering said first (110) and second (111) electromechanical means
characterised in that control means (3, 246, 316) is provided for activating said first electromechanical means (110) without said second electromechanical means (111) to attempt to drive said locking member (2) from said one position to said other position, and for subsequently activating (244, 314) said

first and second electromechanical means (110, 111) together to attempt to drive said locking member to said other position.

2. An electronic locking apparatus according to Claim 1 characterised in that said first and second electromechanical means comprise first and second solenoids.

3. An electronic locking apparatus according to Claim 2 characterised in that said control means (3) includes means for activating (242, 244) said first and second solenoids (110, 111) together to attempt to drive said locking member (2) to said other position when a previous attempt by said first solenoid (110) without said second solenoid (111) to drive said locking member from said one position to said other position was unsuccessful.

4. A locking apparatus as claimed in Claim 3 further characterised in that it comprises sensor means (220) coupled to said control means (3) for sensing the presence of said locking member (2) in said other position to inform said control means (3) when an attempt to move said locking member to said other position was successful.

5. A locking apparatus as claimed in any of Claims 1 to 4 characterised in that said other position of said locking member (2) is said unlocking position, said one position of said locking member (2) is said locking position, and said unlocking position of said locking member (2) is located above said locking position of said locking member (2).

6. A locking apparatus as claimed in any of Claims 3 to 5 characterised in that said control means (3) includes means (254, 256, 258) for making separate, repeated attempts with said first solenoid (110) but without said second solenoid (111) to drive said locking member (2) to said other position, and upon the failure of said repeated attempts to drive said locking member (2) to said other position, attempting to drive said locking member (2) to said other position with said first solenoid (110) and said second solenoid (111) together.

7. A locking apparatus as claimed in any of Claims 1 to 6 characterised in that it comprises
a lock combination memory (202, 203), and
means (31) for reading data from a key card and activating said control means (3) upon matching of data on said key card to a lock combination stored in said lock combination memory (202, 203).

8. A locking apparatus according to Claim 7 characterised in that said control means (3) includes
means (246) for activating said first solenoid (110) without said second solenoid (111) to attempt to drive said locking member (2) to said other position upon a first insertion of said key card and match of said data on said key card to said lock combination, and
means (244) for activating said first (110) and second (111) solenoids together to drive said locking member (2) to said other position after the previous attempt by said first solenoid without said second solenoid to drive said locking member to said other position was unsuccessful (254, 256, 258), a second insertion of said key card and match of said data on said key card read during said second insertion to said lock combination.

9. A locking apparatus according to Claim 8 characterised in that said control means further includes means (242) for setting a flag after one or more unsuccessful attempts by said first solenoid (110) without said second solenoid (111) to drive said locking member (2) to said other position and means (244) for responding to said flag upon a subsequent insertion of said key card to activate said first (110) and second (111) solenoids together to attempt to drive said locking member (2) to said other position.

10. An electronic locking apparatus according to Claim 1 characterised in that it comprises
voltage sensing means (215) for sensing the voltage of said battery means (40), and wherein said control means includes means (312, 316) responsive to said voltage sensing means (215) for activating said first electromechanical means (110) without said second electromechanical means (111) to attempt to drive said locking member (2) to said other position when said voltage of said battery means (40) is greater than a predetermined level and activating (312, 314) said first (110) and second (111) electromechanical means together to attempt to drive said locking member (2) to said other position when said battery voltage is less than said predetermined level.

11. An electronic locking apparatus having a lock combination memory (202, 203) containing lock combination data, means (31) for reading lock combination data from a key inserted in said electronic locking apparatus, and means (238, 308) for comparing said lock combination data on said key to said lock combination data stored in said lock combination memory (202, 203), characterised in that the apparatus comprises:
a lock member (2) movable between a locking position and an unlocking position,
solenoid means (110, 111) for attempting to drive said locking member from one of said positions to the other position, and
control means (3) responsive to a match of said lock combination data on said key and said lock combination data stored in said lock combination memory for activating said solenoid means (110, 111) for a time period to attempt to drive said locking member (2) to said other position, for sensing (220) whether said locking member is in said

other position after activation of said solenoid means, and for automatically activating (254, 256, 258) said solenoid means a second time after said time period has elapsed and said solenoid means has become deactivated without reinsertion of said key in said locking apparatus if said solenoid means was unsuccessful in driving said locking member to said other position in the foregoing attempt.

12. An electronic locking apparatus according to Claim 11 characterised in that said control means (23) includes means (254, 256, 258) for activating said solenoid means (110, 111) said second time one to four seconds after the conclusion of said time period.

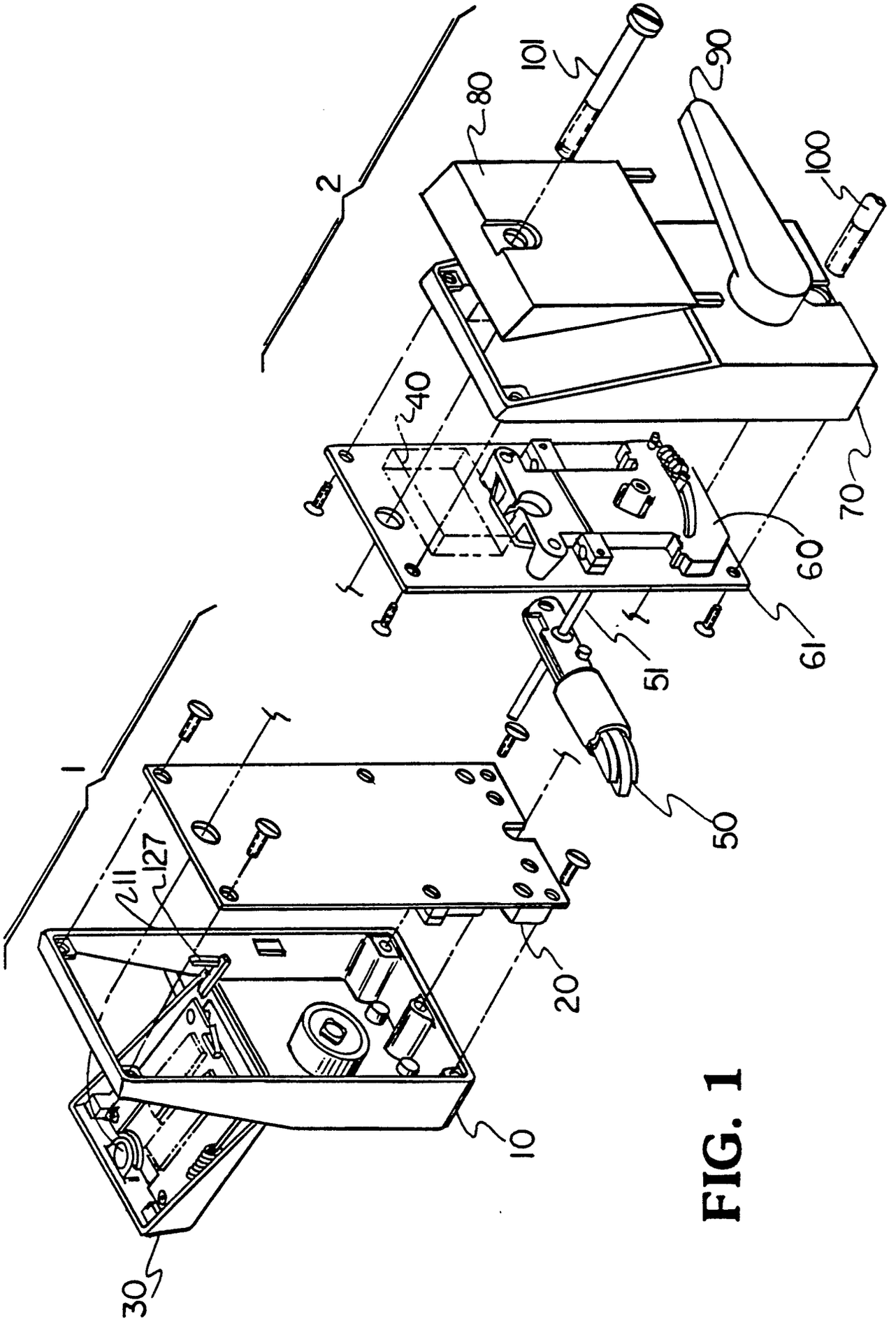


FIG. 1

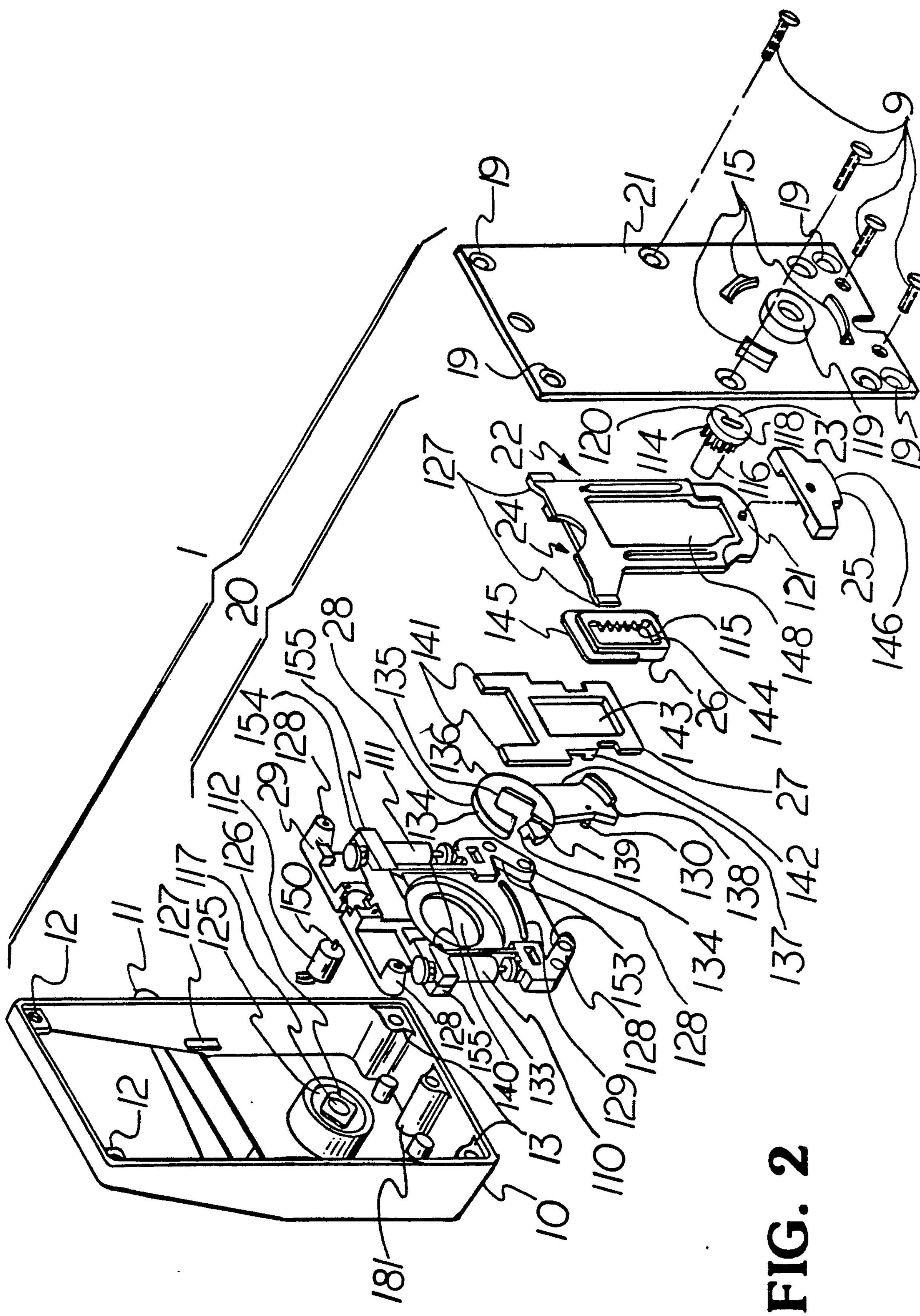


FIG. 2

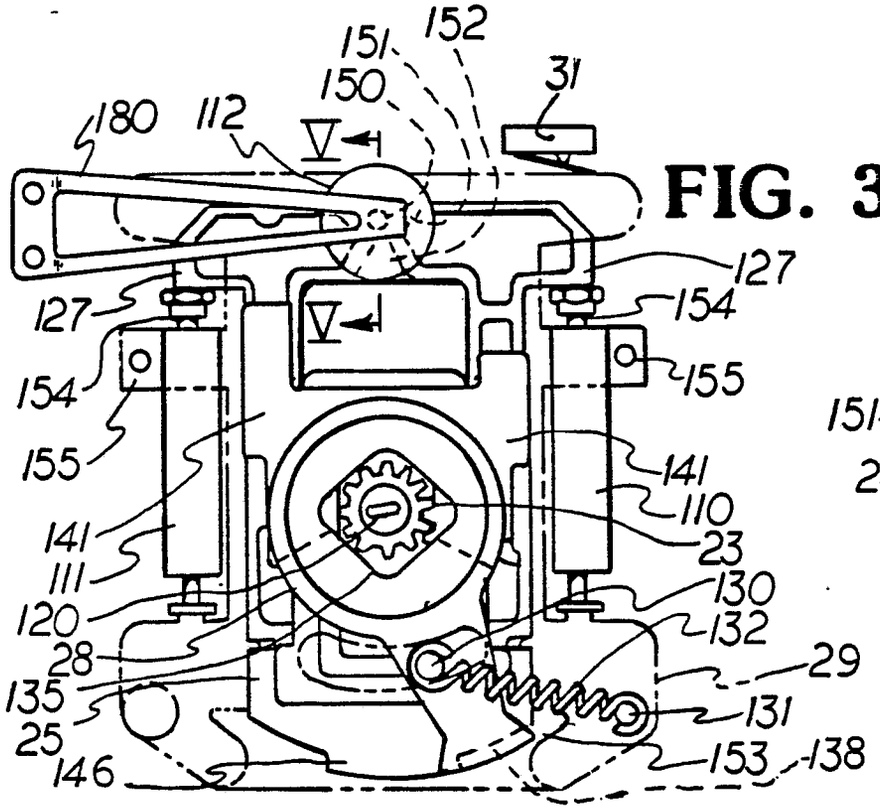


FIG. 3

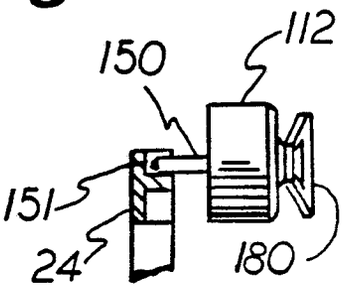


FIG. 4

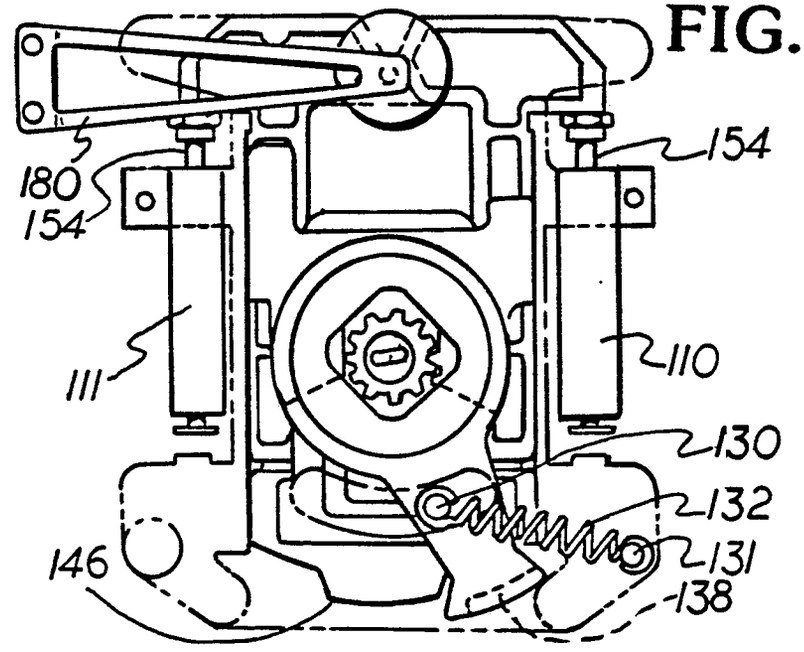


FIG. 6

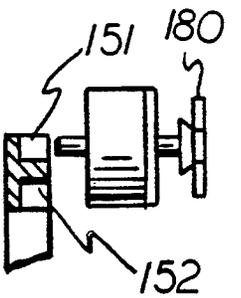


FIG. 5

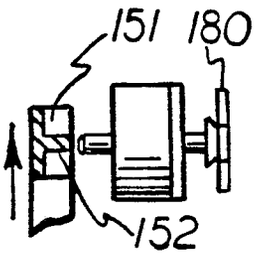


FIG. 7

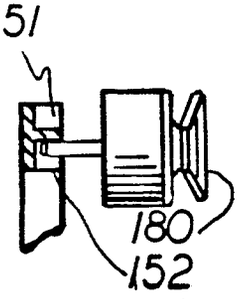


FIG. 8

FIG. 9

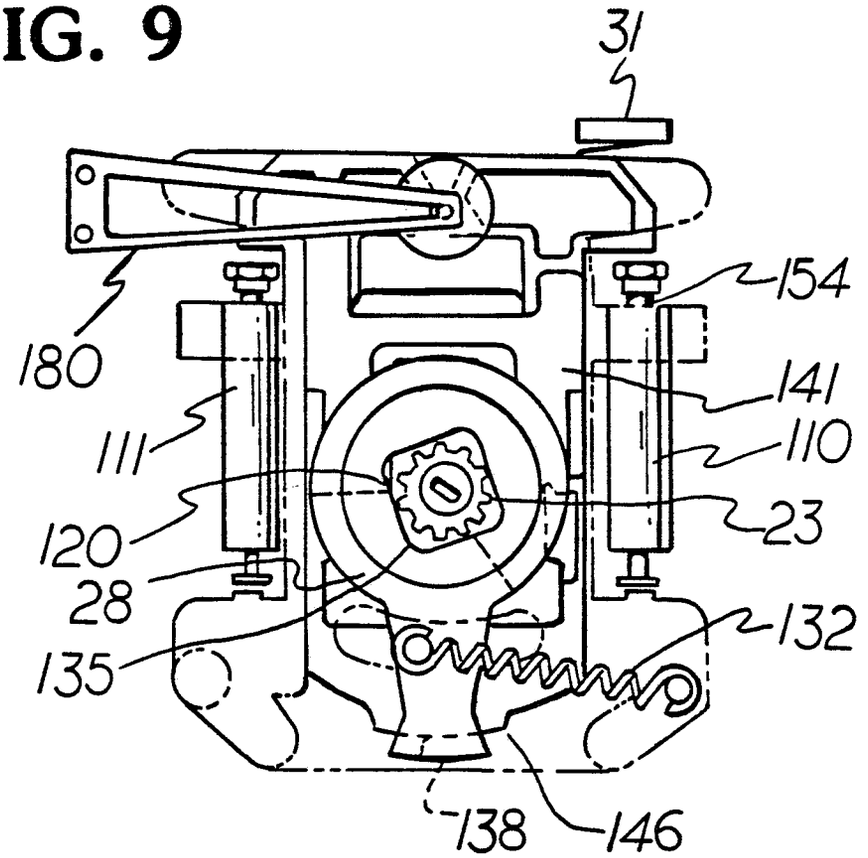


FIG. 10

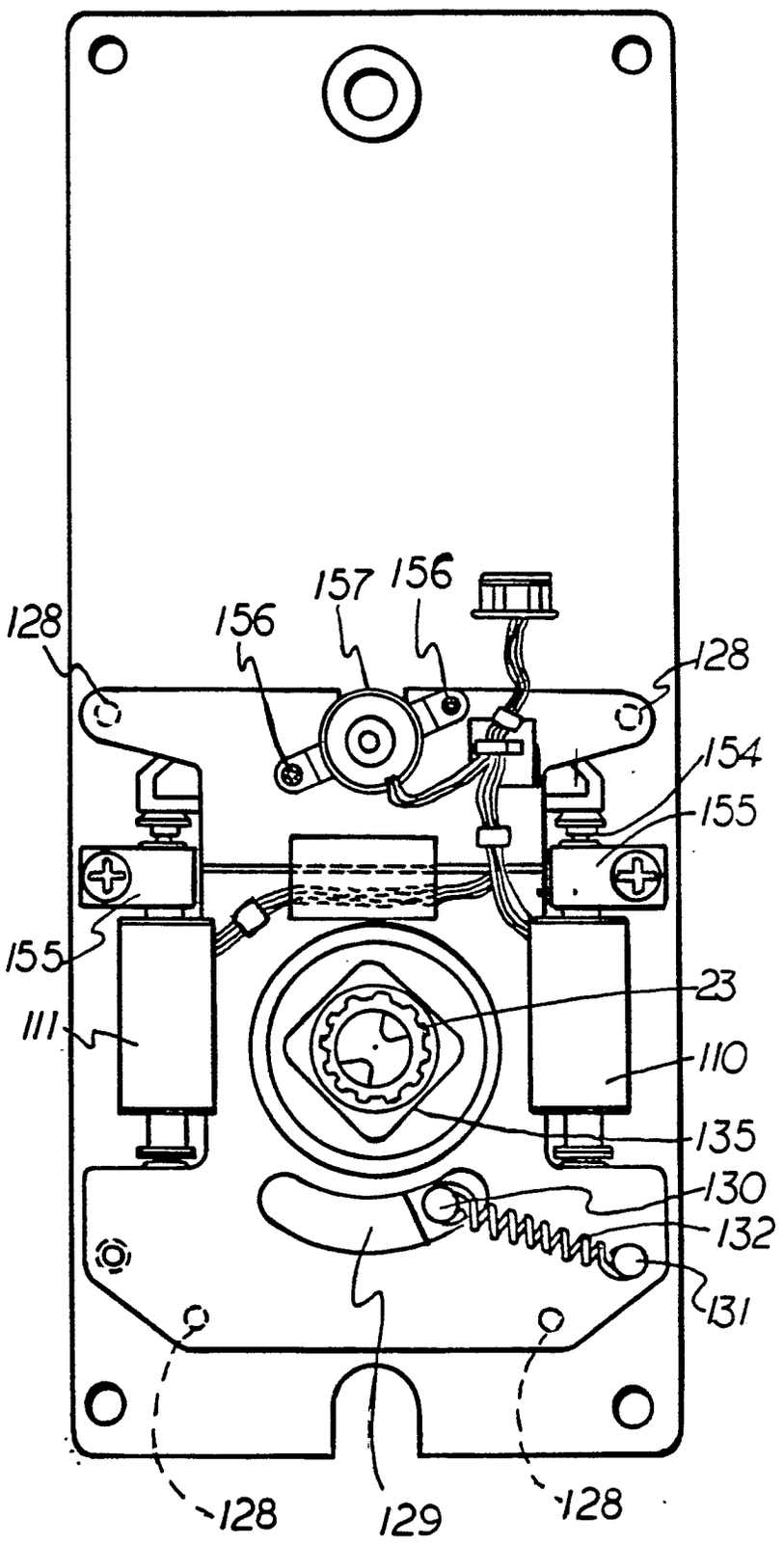

128
156
157
156
128
154
155
155
23
111
110
135
130
132
131
128
129
128

FIG. 11

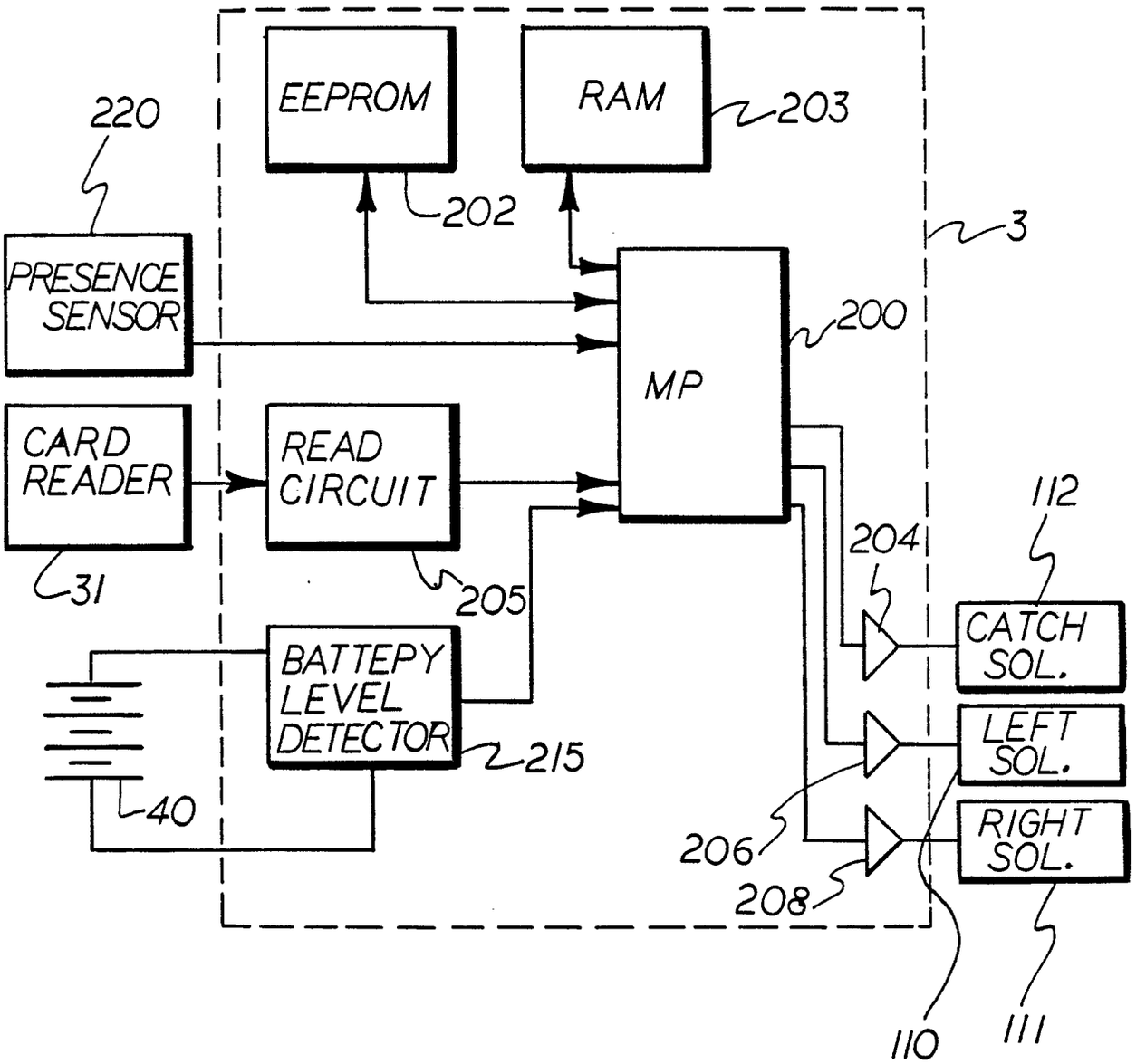

EEPROM
RAM
203
220
202
3
PRESENCE SENSOR
200
MP
CARD READER
READ CIRCUIT
112
204
31
205
CATCH SOL.
BATTEPY LEVEL DETECTOR
215
LEFT SOL.
40
206
RIGHT SOL.
208
110
111

FIG. 12

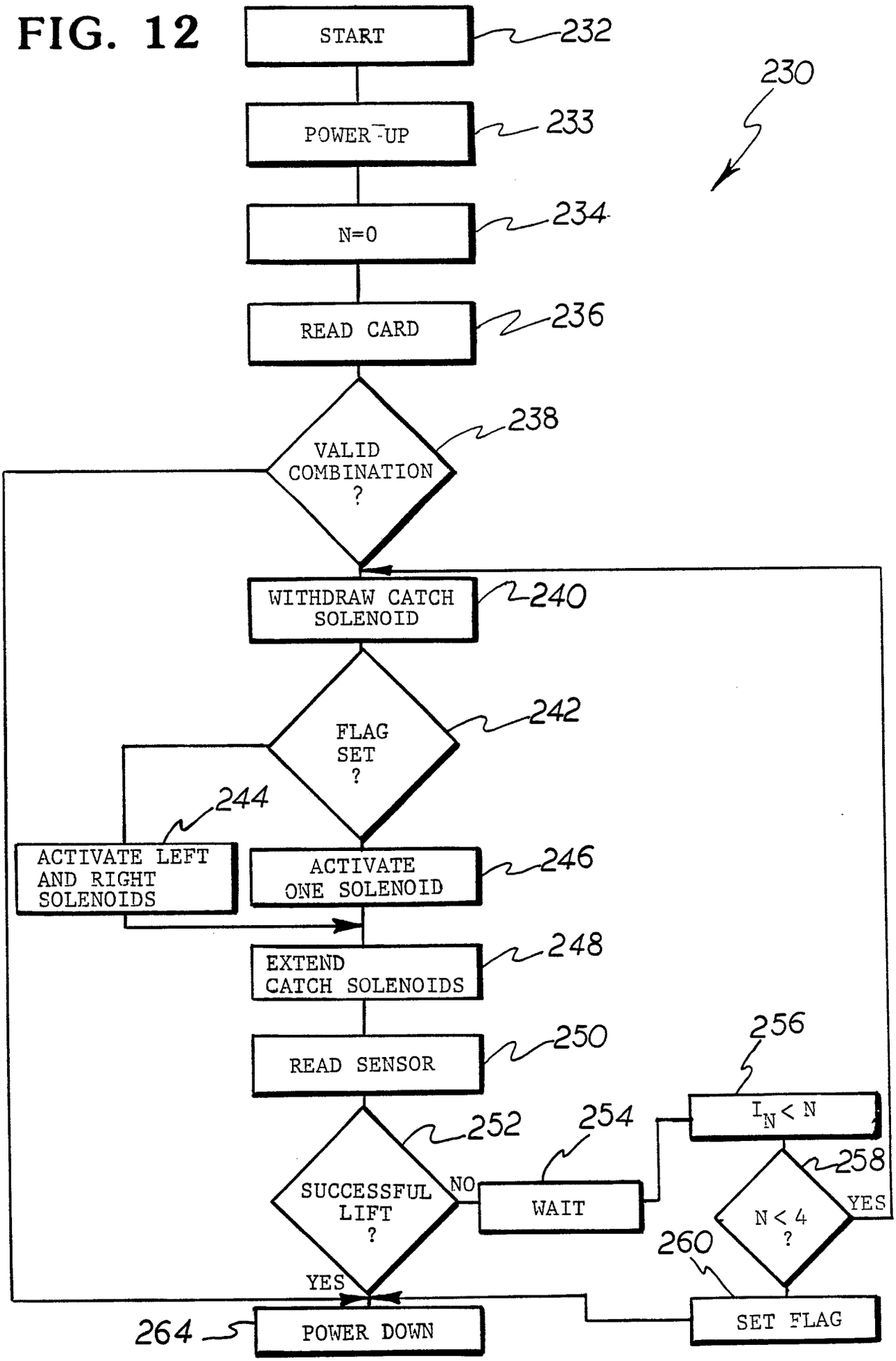
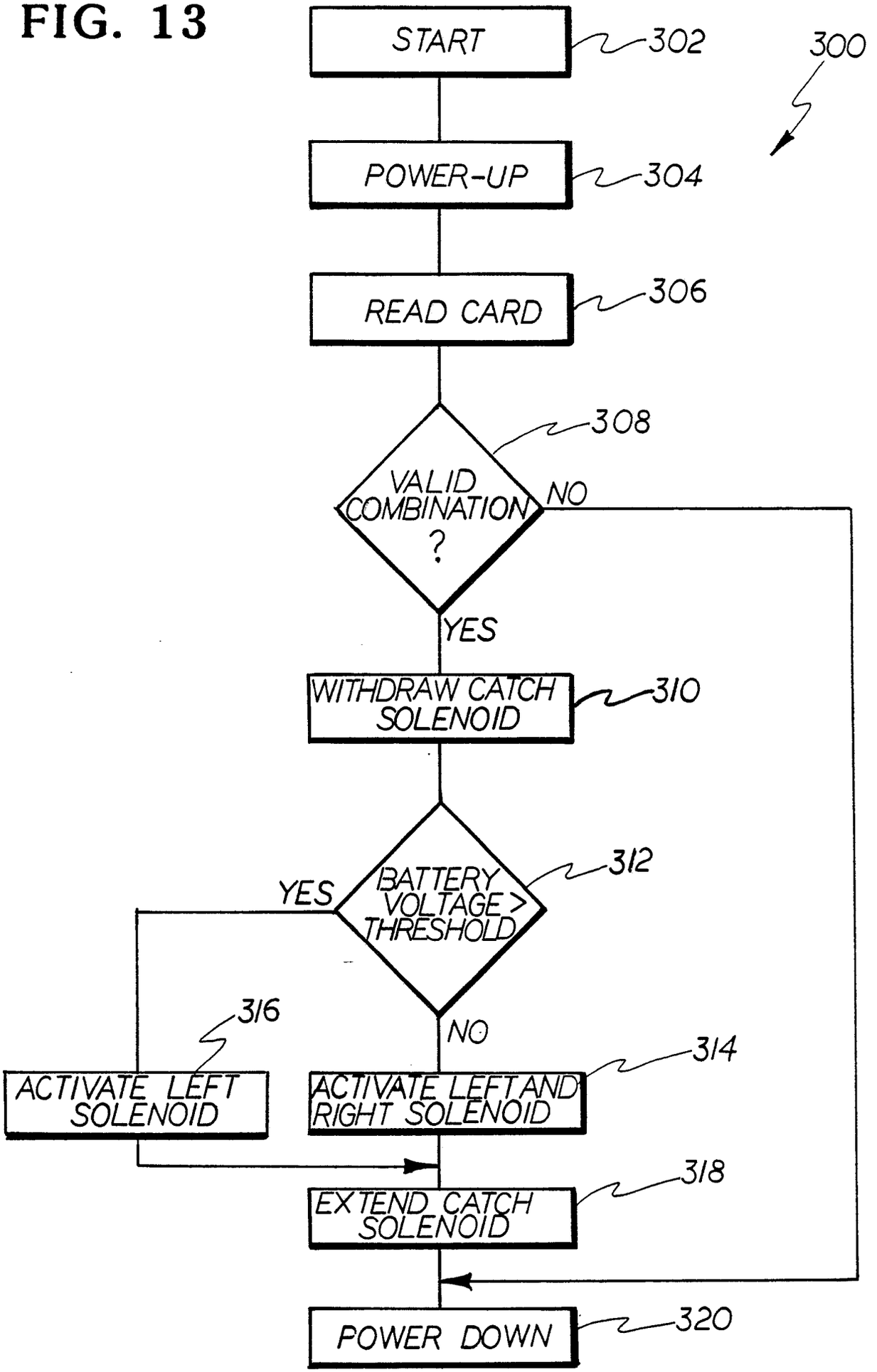

START
232
230
POWER UP
233
N=0
234
READ CARD
236
VALID COMBINATION ?
238
WITHDRAW CATCH SOLENOID
240
FLAG SET ?
242
244
ACTIVATE LEFT AND RIGHT SOLENOIDS
ACTIVATE ONE SOLENOID
246
EXTEND CATCH SOLENOIDS
248
READ SENSOR
250
256
$I_N < N$
252
254
SUCCESSFUL LIFT ?
NO
WAIT
258
N < 4 ?
YES
260
YES
SET FLAG
264
POWER DOWN

FIG. 13


START
302
300
POWER-UP
304
READ CARD
306
308
VALID COMBINATION ?
NO
YES
WITHDRAW CATCH SOLENOID
310
BATTERY VOLTAGE > THRESHOLD
312
YES
NO
316
ACTIVATE LEFT SOLENOID
ACTIVATE LEFT AND RIGHT SOLENOID
314
EXTEND CATCH SOLENOID
318
POWER DOWN
320