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Masters et al.

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[54] **CONTROL SYSTEMS ESPECIALLY FOR DIESEL ENGINE INSTALLATIONS**

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[73] Assignee: **said Absalom, by said Masters and Bache**

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[52] **U.S. Cl.**.... **123/139 AZ,** 123/139 ST, 123/198 DB

[51] **Int. Cl.**..... **F02b 77/08**

[58] **Field of Search**... 123/139 AZ, 198 D, 198 DB, 123/198 DC, 139 ST

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Assistant Examiner—W. Rutledge, Jr.
Attorney, Agent, or Firm—Markva & Smith

[57] **ABSTRACT**

A control system of a compression-ignition or so-called diesel engine installation which includes a fuel injection pump, wherein control mechanism of said fuel injection pump is operatively-connected to bias means biassing it to an inoperative "off" position, setting means are provided for setting said pump to an operative "on" or "engine running" position, and hold means are provided for retaining said pump in said operative on or engine-running position, said hold means being electrically operable whereby opening of an electrical circuit to said hold means causes the pump automatically to be returned to said inoperative off position by said bias means.

13 Claims, 12 Drawing Figures

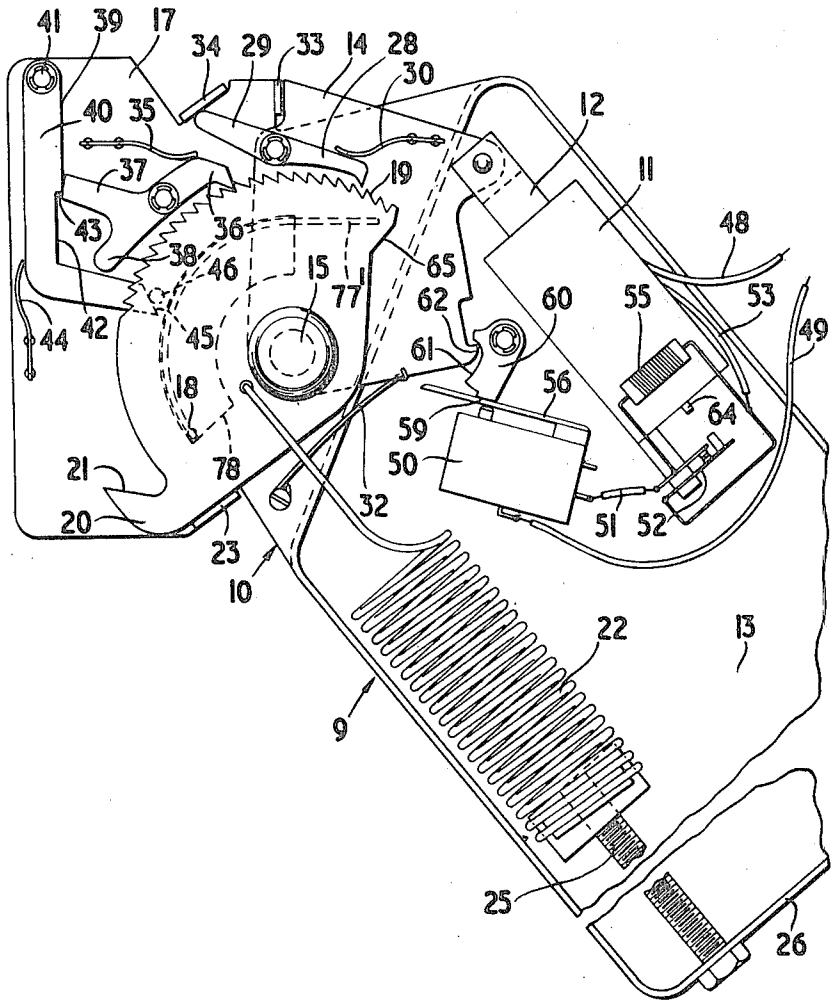
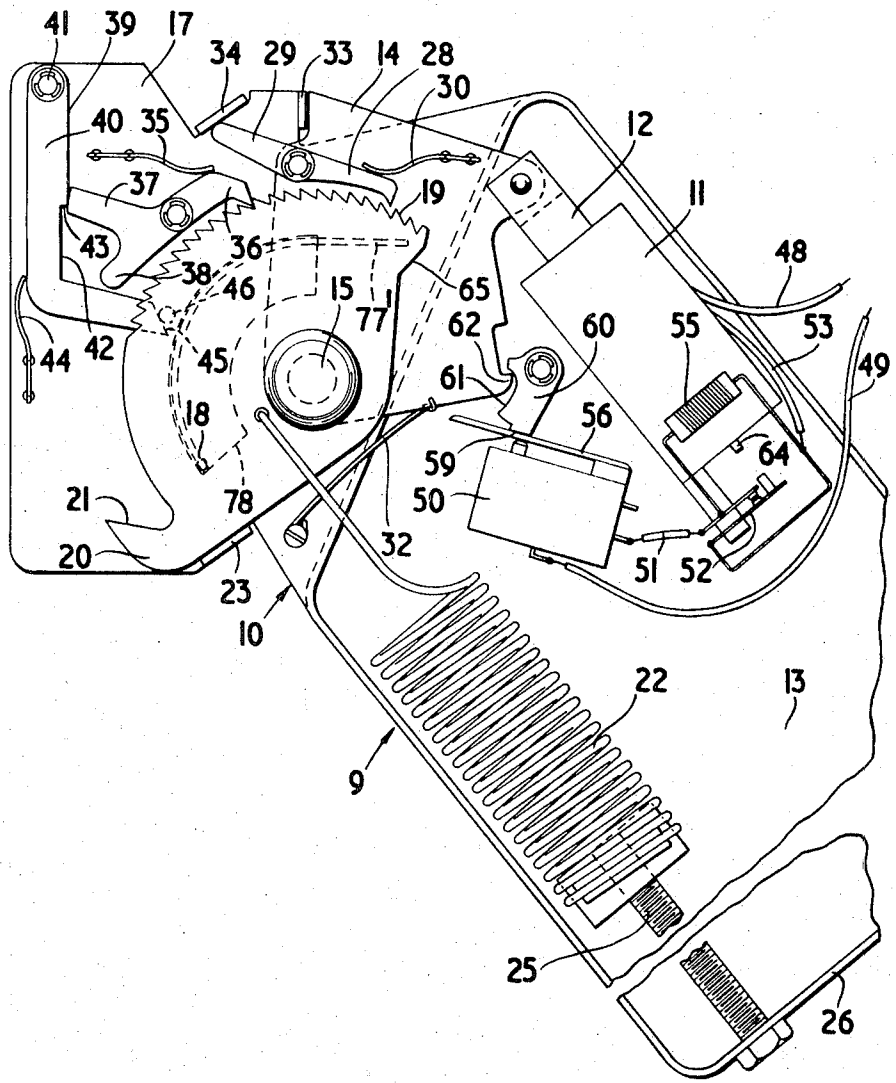


FIG. 1.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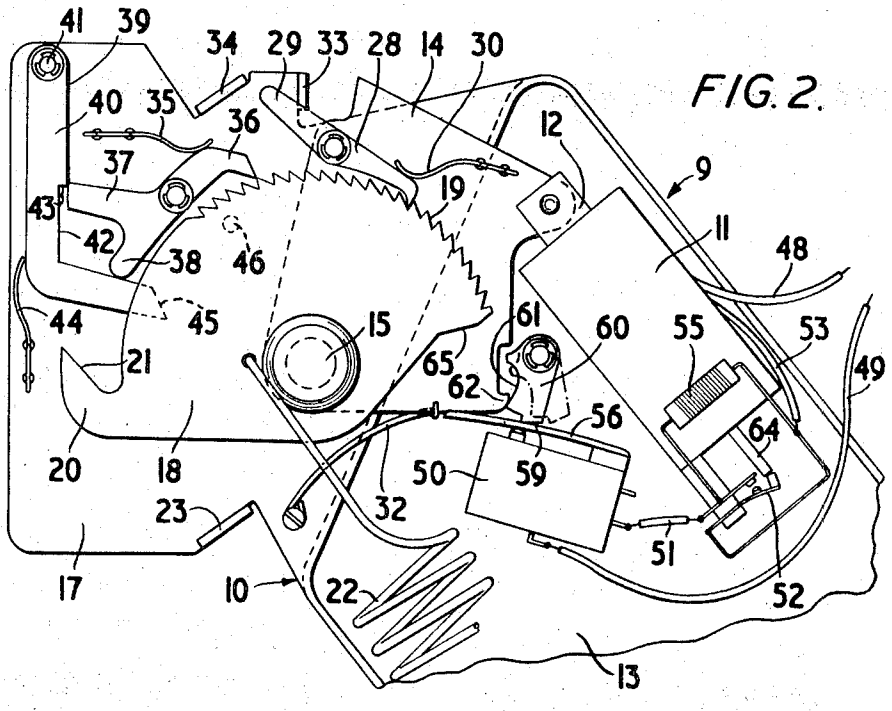
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FIG. 2.

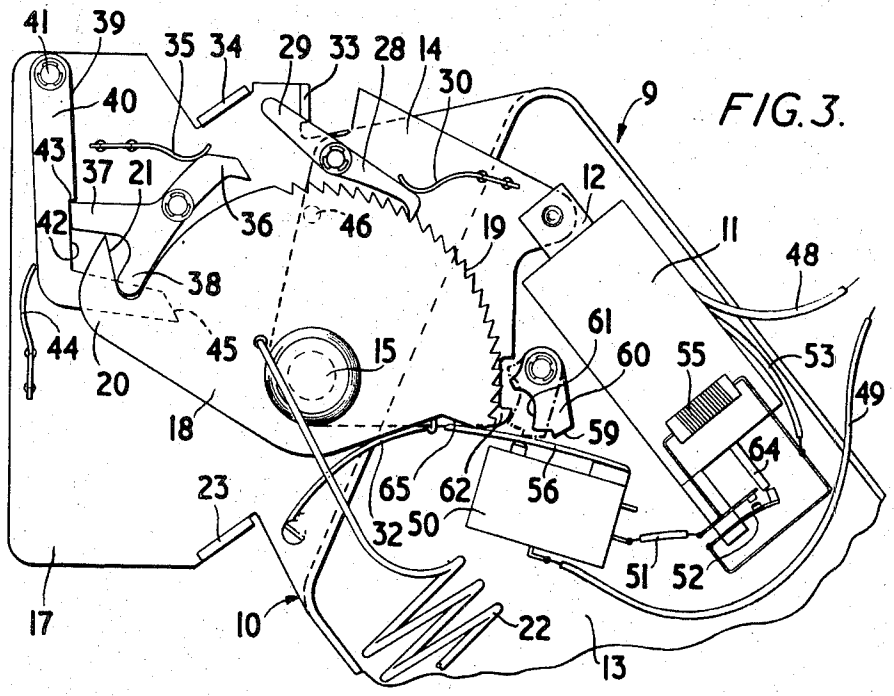
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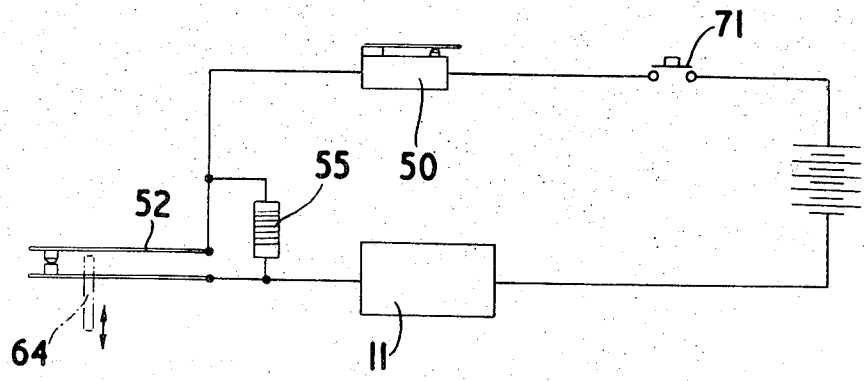
FIG. 3.

FIG. 4.



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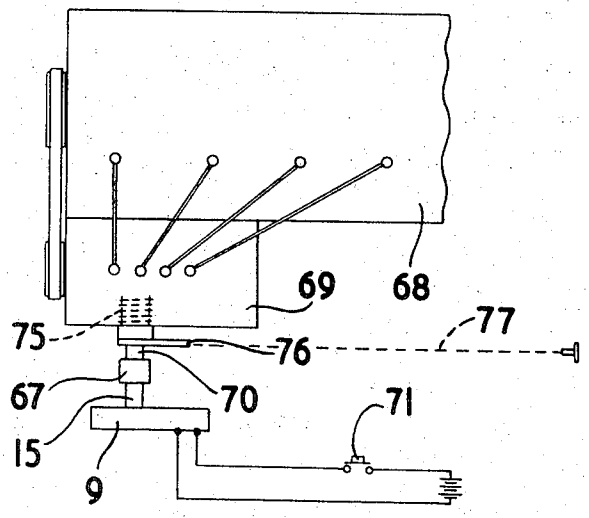

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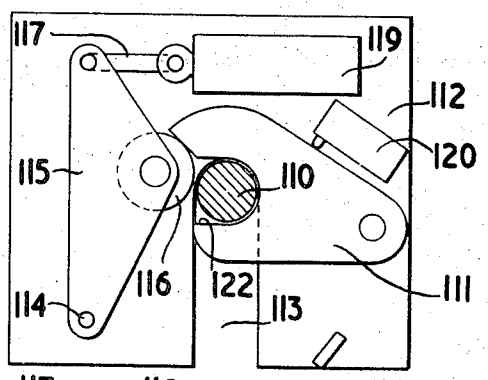

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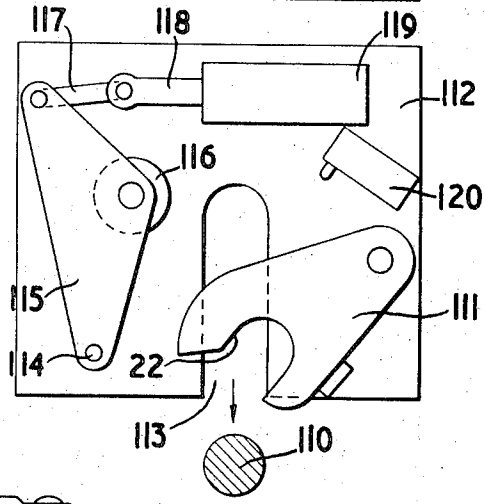

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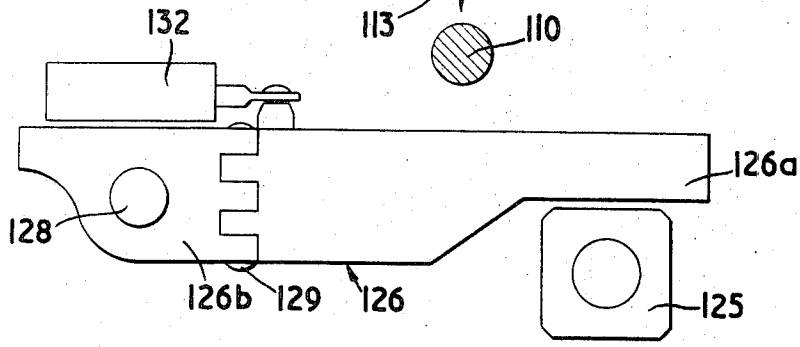

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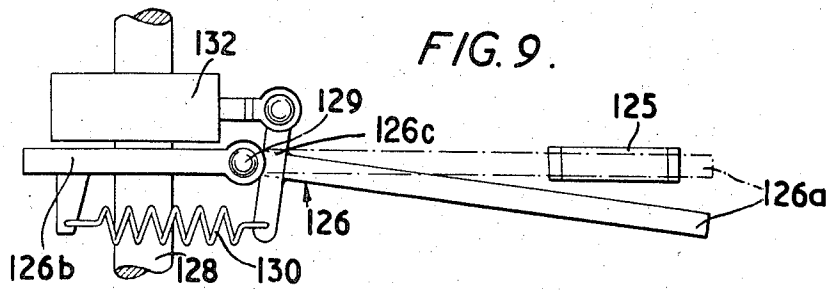

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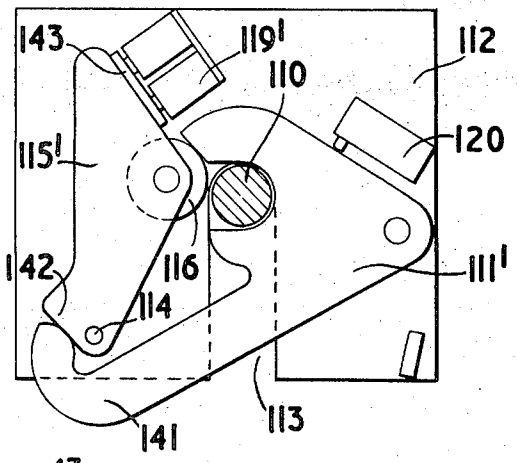


FIG. 11.

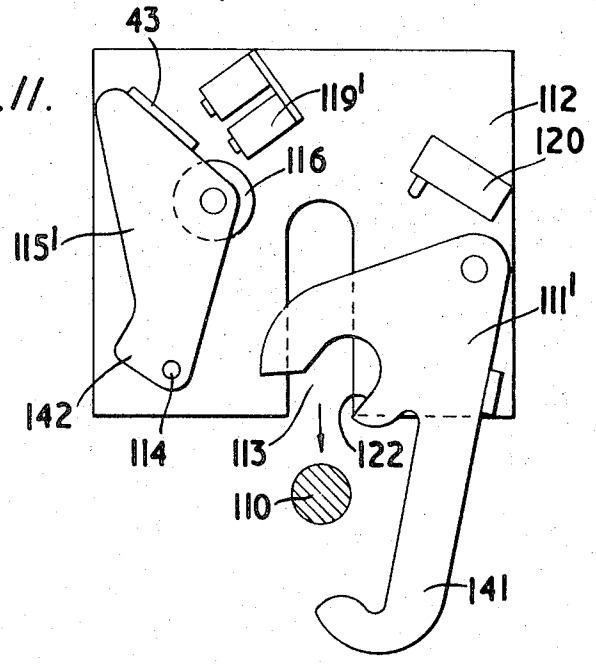
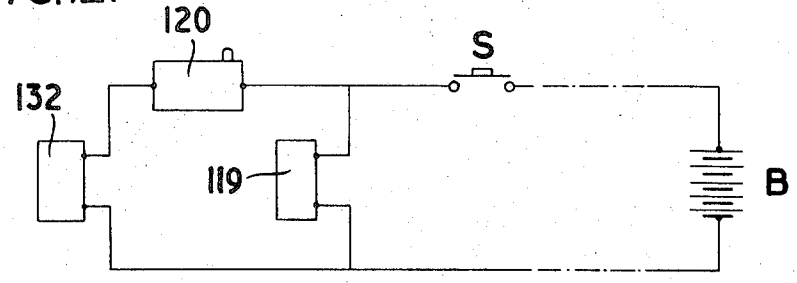


FIG. 12.



CONTROL SYSTEMS ESPECIALLY FOR DIESEL ENGINE INSTALLATIONS

BACKGROUND OF THE INVENTION

The present invention relates to control systems especially applicable to compression-ignition or so-called "diesel" engine installations and to operating mechanisms or devices especially suited for use in said control systems.

More particularly, in one aspect, the invention provides safety or security control systems for compression-ignition or so-called diesel engine installations which include a conventional fuel injection pump, said installations forming, for example, the power unit of a vehicle. The invention also provides control system operating mechanisms or devices of which one very satisfactory form comprises an electro-mechanical actuator of improved construction which is capable of being applied to control a conventional diesel engine fuel injection pump.

It will be appreciated that there is commonly a demand for many forms of internal combustion engine installations, especially in power driven vehicles or water-craft for example, to be fitted with an effective control system for safety and/or security purposes whereby they can readily be immobilized, and simple electrical control systems are often favored and can often present advantages especially in relation to ease of control and co-ordination with other systems. In vehicles and other installations powered by petrol engines having conventional electrical ignition circuits, electrical safety and-/or security control systems may readily be devised which function by opening the ignition circuit to stop and to prevent running of the engine.

But, in installations powered by compression-ignition or diesel engines, such as used in a majority of commercial vehicles for example, there is no electrical ignition circuit which can readily be controlled as with a petrol engine, and stopping and running of the engine is usually controlled by movement of a pump control member of a mechanical fuel injection pump, this pump control member being conventionally biased by spring means to an operative "on" position and being adapted to be moved to an inoperative "off" position by a manually operable control cable connected to an operating lever fixed to a control shaft portion of said control member.

Accordingly, one object of the invention is to provide improved control systems and operating mechanisms applicable for use in controlling a conventional fuel injection pump of diesel engine installations of the kind hereinabove referred to.

SUMMARY OF THE INVENTION

Thus, according to one aspect of the invention, in a control system of a compression-ignition or so-called diesel engine installation which includes a fuel injection pump, said fuel injection pump is operatively-connected to bias means biasing it to an inoperative off position, setting means are provided for setting said pump to an operative on or "engine running" position, and hold means are provided for retaining said pump in said operative on or engine-running position, said hold means being operated electrically whereby opening of the electrical circuit to said hold means causes the pump automatically to be returned to said inoperative off position by said bias means.

In one form of preferred embodiment the fuel injection pump is set to an operative on or engine-running position by means of an electro-mechanical actuator operated automatically upon completing an appropriate electrical energizing circuit. Since, however, to stop and to prevent running of the engine, the extent of movement or displacement of the control member necessary to set the injection pump is, at least with most existing equipment, sufficiently large to render unsatisfactory use, for example, of a direct acting solenoid or like electromagnetic device, a special construction of electro-mechanical actuator is required.

Thus, from another aspect, the invention broadly provides an electro-mechanical actuator having a solenoid device adapted to be energized intermittently and to operate repetitively and continuously through successive operating cycles thereby to advance, stepwise and unidirectionally, a drive member from an initial position to a terminal position when the actuator is connected to an electric supply, said drive member being adapted for operative connection to an injection pump of a compression-ignition or so-called diesel engine installation, or to any other adjustably displaceable member, especially in a vehicle, to control the setting thereof.

From a further aspect, the invention also provides a control system wherein a fuel injection pump of a compression-ignition or so-called diesel engine installation is operatively-connected to a drive member of an electro-mechanical actuator including an electrical drive device, such as an electromagnetic or solenoid device, adapted to be energized intermittently, when the actuator is connected to an electric supply, and to operate repetitively and continuously through successive operating cycles thereby to advance, stepwise and unidirectionally, said drive member from an initial position to a terminal position thereby to control the setting of said fuel injection pump. Preferably, the actuator, when energized, sets the injection pump to its operative on or engine-running position, and, when de-energized, the injection pump sets to the off position by bias means which may be incorporated in the actuator and which substantially counter-balances the usual conventional spring bias of the injection pump control mechanism.

The invention further provides an electro-mechanical actuator comprising a solenoid device having an armature which moves through an operating stroke and a return stroke in each operating cycle of the solenoid device, said armature being operatively-connected to a drive member through ratchet means so as to move said drive member unidirectionally in each said operating cycle, means to cause said solenoid device to be energized intermittently and to operate repetitively and continuously through successive operating cycles thereby stepwise to advance the drive member from an intial inoperative position to a terminal operative position when the actuator is connected to an electric supply, holding means to prevent retrograde movement of the drive member during said advance, and means to return the drive member to its initial position and reset the actuator when the electric supply is disconnected.

In an actuator of the above kind, the armature is conveniently in the form of a reciprocable plunger which may be connected to a movably-mounted intermediate member carrying a pawl adapted to engage ratchet teeth carried by the drive member. Furthermore, in a

preferred construction, the drive member is mounted for angular movement and may comprise a sector or quadrant plate rotatably mounted on a drive shaft which also forms a pivotal axis for the aforesaid intermediate member, and the holding means may conveniently include a holding pawl, carried by a stationary part, which remains in engagement with the ratchet throughout the advance of the drive member, catch means being provided to maintain this holding pawl out of engagement during resetting of the actuator.

Conveniently, the repetitive cycling operation of the aforesaid solenoid device of the actuator is controlled by a circuit interrupter comprising switch means arranged to be opened and closed in response to movement of the armature until the drive member reaches its terminal position, whereupon the solenoid device is then maintained in an energized condition. Auxiliary switch contacts may be provided, however, which switch in a "hold" circuit to reduce the current flowing through the solenoid at this terminal stage.

In other embodiments, arrangements are provided wherein the fuel injection pump is set automatically to an operative on or engine-running position, subject to completion of an appropriate electrical control circuit, by cranking or turning the engine, the drive force necessary for overcoming the bias means in carrying out said setting operation being provided by the drive force operative to crank or turn the engine.

Thus, in a satisfactory arrangement of the latter kind the setting means comprises a cam driven by the engine and arranged to co-operate with a tappet, lever or other cam follower operatively-connected to the control member of the injection pump.

In this case, preferably the cam follower is displaceable between an operative position in which it is adapted to be engaged by the cam and an inoperative position in which it is unable to engage said cam, and means are provided which moves the cam follower to said inoperative position as soon as setting of the injection pump to the on or engine-running position is completed, whereby the functional co-operation between said cam and cam follower ceases after the first revolution of the engine while the electrical control circuit is energized.

In the above arrangement, the hold means comprises a mechanical latch, such as a form a gate latch, which co-operates with the stop control rod or member of the injection pump control mechanism, or part connected thereto, and which is held closed to maintain the injection pump in the on or engine-running position by means of an electro-magnetic device energized by the electrical control circuit so that when the latter is opened, the latch also opens and enables the bias means to return the injection pump to its inoperative off position.

BRIEF DESCRIPTION OF DRAWINGS

By way of example, the invention will be further described by reference to the accompanying drawings, wherein:

FIG. 1 is a plan view illustrating one form of actuator for use in control systems in accordance with the invention, said actuator being shown in its initial inoperative condition;

FIG. 2 is a similar view to FIG. 1, with part broken away, showing an intermediate stage during operation of the actuator.

FIG. 3 is a view similar to FIG. 1 but showing the final terminal stage when the actuator is in its operative condition;

FIG. 4 is a circuit diagram;

FIG. 5 indicates a manner of use in a vehicle or safety security system;

FIG. 6 illustrates diagrammatically one arrangement of gate latch mechanism, shown in a closed condition, constituting the hold means of a control system in accordance with another embodiment of the invention;

FIG. 7 shows the latch mechanism of FIG. 6 in an open condition;

FIG. 8 is an elevational view illustrating one form of arrangement of setting means associated with the latch mechanism of FIGS. 6 and 7;

FIG. 9 is a plan view of the setting means of FIG. 8;

FIG. 10 illustrates another modified form of latch mechanism shown in a closed condition;

FIG. 11 shows the latch mechanism of FIG. 10 in an open condition; and

FIG. 12 is a circuit diagram.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring first to FIGS. 1 to 5 of the drawings, the actuator 9 illustrated therein includes a stationary base member 10 having a main platform portion 13 upon which is mounted a solenoid 11 having a reciprocable plunger 12. Plunger 12 is pivotally connected at its outer end to an angularly-movable intermediate rocker plate member 14 pivoted upon a shaft 15 which is rotatably mounted in bearings (not shown) upon an offset portion 17 of the base member 10.

The shaft 15 also carries, fixed thereon, a drive member 18 in the form of a sector-shaped plate having, along its arcuate peripheral edge, a series of ratchet teeth 19 and, at the trailing end, a projecting claw-like formation 20 providing an inclined cam edge surface 21.

Drive member 18 is biased in a counter-clockwise sense by an extension coil spring 22 and normally lies in the initial position shown in FIG. 1 wherein it rests against an abutment stop 23 provided by an upstanding lug on the base member 10. As shown, spring 22 is anchored, through an adjustable screw coupling 25, to an upstanding flange or rim 26 of the base portion 13.

For co-operation with the ratchet teeth 19, the intermediate plate member 14 carries a pivoted drive pawl 28 having an extension arm 29. Pawl 28 is biased, by a light wire spring 30, to turn in a clockwise sense so as to move into engagement with the ratchet teeth 19 of drive member 18. But, plate member 14 is biased, by a spring 32, to turn in a counter-clockwise direction. In its normal initial position, when the solenoid 11 is de-energized, plate members 14 rests, as shown in FIG. 1, against an abutment stop formed by an upstanding lug 33 on the base member 10. In this position, the extension arm 29 engages an inclined cam surface provided by a further upstanding lug 34 on base member 10, causing the pawl 28 to be held out of engagement with the ratchet teeth 19.

A holding pawl 36 is pivotally mounted on portion 17 of base member 10 and is biased by a light wire spring 35 so as normally to be maintained in engagement with the ratchet teeth 19 thereby to prevent retrograde movement of the drive member 18 during operation, as hereinafter described.

Holding pawl 36 has a pair of divergent extension arms 37 and 38. Extension arm 37 engages an edge portion 39 of an L-shaped catch lever 40. Catch lever 40 is pivotally mounted at 41 upon the portion 17 of base member 10 and is biased by a light wire spring 44 so as to be pressed against the end of arm 37 of pawl 36. As shown, the edge portion 39 is recessed at 42 to provide a square cut shoulder 43, thereby to present a stepped formation. The pawl arm 37 normally lies clear of the recessed part 42 but adjacent the shoulder 43.

The shorter limb of the catch lever 40 projects under the plate-like drive member 18 and terminates in an inclined end edge face 45 which, in the position of FIG. 1, lies adjacent a pin 46 fixed to said drive member 18.

Solenoid 11 is adapted to be connected to an external electric supply by way of conductors 48 and 49. Conductor 48 is connected directly to one end of the solenoid winding, but the other conductor 49 is connected to one pole of a micro-switch 50. An opposite pole of micro-switch 50 is connected by way of conductor 51 and normally-closed blade switch contacts 52 and conductor 53 to the other end of the solenoid winding, switch contacts 52 being joined in parallel across a resistor 55.

Micro-switch 50 has an operating arm 56 and, in this embodiment, is biased to provide a normally-open setting. In the initial condition of the actuator, however, as shown in FIG. 1, the operating arm 56 is held down so as to keep the micro-switch 50 closed by abutting engagement of a substantially straight end edge surface 59 of a pivoted detent member 60 carried by portion 13 of base member 10.

As illustrated, a side edge surface of the detent member 60 is formed with a concavity 61 within which meshes a profiled tooth 62 provided by a corner formation of the intermediate rocker plate 14.

The mode of operation of this acutator may now be described, starting from the initial position of FIG. 1. Upon connecting the conductors 48 and 49 to the external electric supply, the solenoid 11 is energized and draws in the plunger 12. The rocker plate 14 is thereby rotated in a clockwise direction so that, as the extension arm 29 moves clear of cam surface 34, drive pawl 28 moves into engagement with the ratchet teeth 19 and advances the drive member 18 against the action of bias spring 22. During this movement holding pawl 36 is lifted and rides over the ratchet teeth 19 but, as indicated in FIG. 2, it does not move quite far enough for arm 37 to clear shoulder 43 and enter the recessed part 42 of the catch lever 40.

As is also shown in FIG. 2, when the solenoid plunger 12 approaches completion of its operating stroke, an axially-extending projection 64 carried by its innermost end engages and opens the blade switch contacts 52 and brings into circuit the resistor 55. At this stage, however, the tooth 62 of the rocker plate 14 angularly displaces detent member 60 in a counter-clockwise direction sufficiently for the point of contact of the end surface 59 with the micro-switch arm 56 to pass over a "dead-center", whereupon the detent member 60 swings free (as indicated in broken lines in FIG. 2) and releases arm 56. The micro-switch 50 therefore then opens and the solenoid 11 is de-energized.

Upon de-energization, the plunger 12 and rocker plate 14 then return towards their initial positions under the influence of bias spring 32 drive pawl 28 rides over the ratchet teeth 19 until it is again lifted by engagement of the extension arm 29 with cam surface 34, the drive member 18 being held in its new position by holding pawl 36. During this stage, however, as the rocker plate approaches its initial position, the corner tooth 62 moves back into mesh with the concavity 61 of the detent member 60 and re-sets the latter, thereby re-closing the micro-switch 50 so that the solenoid 11 is again energized. This cycle of operation therefore then repeats, and successive cycles continue advancing the drive member undirectionally and stepwise until a terminal position is reached as indicated in FIG. 3.

In this terminal position, the leading edge 65 of the sector plate 14 constituting the drive member 18 contacts the operating arm 56 of the micro-switch 50. Consquently, arm 56 is depressed notwithstanding release of the detent member 60, thereby keeping the micro-switch 50 closed and maintaining the solenoid 11 energized although the current through the latter is reduced to a convenient "holding value" at this stage by resistor 55.

As the drive member 18 reaches this terminal position, the inclined cam surface 21 of the claw-like projection 20 at the trailing end moves into engagement with the extension arm 38 of holding pawl 36. Arm 38 is angularly displaced sufficiently for arm 37 to enter the recessed part 42 of catch lever 40, and pawl 36 is held well clear of the ratchet teeth 19.

The actuator device then remains in this operative condition so long as the conductors 48 and 49 remain connected to the external electric supply. Upon disconnecting the supply, however, the solenoid 11 is de-energized and the plunger 12 and rocker plate 14 return towards their initial positions thereby releasing the drive member 18. The latter therefore also returns under the influence of bias spring 22 since the holding pawl 36 is still held out of engagement with the ratchet teeth 19 by the catch lever 40.

Finally, as the drive member 18 reaches its initial position again, the pin 46 contacts end face 45 of the shorter limb of catch lever 40 which is thereby deflected to release holding pawl 36, and the actuator is re-set as shown in FIG. 1.

As indicated in the diagram of FIG. 5, actuator device 9 as discussed hereinabove provides a safety and/or security control system for a vehicle powered by a compression-ignition or so-called "diesel" engine 68 associated with a mechanical fuel injection pump 69. The shaft 15 rotated by the drive member 18 may be connected, by a suitable coupling 67, directly to the usual control shaft or spindle 70 of the injection pump 69. Therefore, when the actuator 9 is operated, such as by a key operated switch 71 in the supply leads, and the drive member 18 reaches its terminal position, said control shaft or spindle 70 of the injection pump 69 is moved to its operative on or engine-running position. On switching off the actuator 9, the control shaft or spindle 70 coupled to shaft 15 is returned to its off position by the action of bias spring 22 and the injection pump is put out of action. Since also the injection pump control shaft or spindle 70 is usually biased to the on position by a spring (indicated at 75) incorporated in or associated with the pump structure, it will be appreciated that such pump spring 75 will to some extent counterbalance the actuator bias spring 22 so that the effort required by the solenoid 11 can be reduced to a minimum. The bias spring 22 is of course of sufficient strength to overcome the effect of the pump spring 75

during the return movement, and the degree of counterbalancing can readily be controlled by the screw adjuster **25** which, in this particular embodiment, is provided for adjusting the tension of the bias spring **22**.

In some cases, however, it may be convenient to remove the existing injection pump spring **75** and to provide the actuator **9** with a pair of bias springs adapted and arranged to act in opposition upon the drive member **18** thereof in such a manner as to exert varying and different leverages which approximately compensate for changes in tension during operation, thereby to maintain a substantially constant biasing torque upon the drive member **18** and shaft **15**.

Normally, in diesel engine installations to which the present invention is not applied, the control shaft or spindle **70** of the injection pump **69** carries a lever arm **76** to which is connected a manually operable control cable, indicated at **77** in broken lines in FIG. **5**, which is operated to set said pump to its off position.

There are cases where it is not convenient for the actuator **9** to be fitted by coupling the shaft **15** directly to the injection pump control shaft or spindle **70** as described above. For example, when it is to be fitted as a conversion item to an existing vehicle or diesel engine installation and is not installed during manufacture or initial assembly, the drive member **18** may be adapted to be connected to a control cable **77'** replacing the usual manual control cable **77**. This can conveniently be carried out in a modification of the device described by securing to the drive member **18** an additional pulley or sector plate **78**, grooved around the periphery, to which the control cable **77'** is anchored, as indicated by the superimposed outlines in FIG. **1**.

In another modification, the mechanical micro-switch **50** may, if desired, be replaced by a suitable solid state electrical switching device which may be more advantageous in respect of operating speed and reliability.

As compared with use of a direct acting solenoid, it will be appreciated that the actuator device hereinbefore described provides a relatively smooth progressive action rather than an instantaneous violent action so that a most efficient utilization of power is obtained. It is especially suited for use in the manner set forth in providing a very convenient and effective safety or security control system for diesel engine installations. The actuator device, however, may usefully be utilized in other forms of control systems. As an example of application to another form of vehicle safety control system, it may be mentioned that the actuator could also conveniently be adapted to function as a stepping motor, especially by omitting the micro-switch **50** and by supplying it with a series of successive energizing electrical pulses, used, for instance, in resetting and effecting by remote control a fine adjustment of vehicle headlamps if the trim of the vehicle is substantially altered according to the load carried.

Referring now to FIGS. **6** to **12**, diagrammatically alternative forms of control systems and operating mechanism, are illustrated. Firstly, in the latch mechanism of FIGS. **6** and **7**, a control lever arm rod member **110** (for example, the arm **76** of pump **69** indicated in FIG. **5**) is operatively connected to the injection pump of a compression-ignition or so-called diesel engine installation. A pivoted latch plate **111** is mounted on a base plate **112** which has a vertical slot **113**, open at its lower end, to accommodate the control rod member **110**.

Also, pivoted at **114** to the base plate **112** is a keeper plate member **115** which carries a rotatable roller **116**. Keeper member **15** is connected at its upper end, through a link **117**, to the plunger **118** of a solenoid **119**. A normally-closed micro-switch **120** operates in conjunction with the setting means for the injection pump as hereinafter described.

When the injection pump is in its normal inoperative off position, which is maintained by a suitable biasing spring especially fitted thereto (not shown), the control rod member **110** is in the position shown in FIG. **7**, the latch mechanism then being in an open condition. On setting the injection pump to its on or engine-running position, the control rod member **110** swings up and is raised vertically to the position shown in FIG. **6**, and in so doing it engages the arcuate recess or pocket **122** formed in the latch plate **111** and enters into the vertical slot **113**, lifting the latch plate angularly at the same time.

Assuming that, at this stage, the solenoid **119** is energized, the keeper plate member **115** is also moved into the position shown in FIG. **6**. As the latch plate **111** is forcibly raised by the control rod member **110** during setting of the injection pump, the arcuate leading edge of said plate **111** will forcibly engage the roller **116** of the keeper plate member **115** and deflect the latter, against the pull of solenoid **119**, until it is able to ride over and clear said roller as the rod member **110** reaches the closed upper end of slot **113**.

So long as the solenoid **119** remains energized, the latch mechanism is then maintained in the closed condition and the control rod member **110** is held in its raised position at the upper closed end of the slot.

Upon subsequently de-energizing the solenoid **119**, however, the keeper plate member **115** is released so as to move back freely on its pivot mounting, thereby opening the gate arrangement and permitting the latch plate **111** and control rod member **110** to fall and return to the position of FIG. **7** under the influence of gravity and of the aforesaid bias spring of the injection pump which re-sets into the inoperative "off" position.

In FIGS. **8** and **9**, the setting means for initially setting the injection pump into the operative on or engine-running position, comprises a multi-lobed cam **125**, adapted to be driven by the engine of the vehicle, and a lever **126**, forming a cam follower, secured to a control shaft **128** operatively connected to the control mechanism of the injection pump. The shaft **128** may, for example, correspond to, or be operatively connected through gearing or other movement amplification means, to the shaft **70** in FIG. **5** of the pump **69**. The cam **125** may, for example, be mounted on the usual engine crankshaft pulley which drives the customary fan and generator. Thus, when the engine is turned, such as on starting, the cam **125** is rotated and engages the lever **126**, the latter is deflected and thereby turns the control shaft **128** through an angular distance sufficient to set the injection pump to said on or engine-running position.

In order that the setting means shall not operate unless an associated electrical control circuit is also energized, and so that the cam **125** does not continue to engage the cam follower lever **126** while the engine is running, means are provided for selectively rendering the setting mechanism inoperative. Thus, in this particular

embodiment, the lever 126 which is shown as extending substantially horizontally, is formed of two parts 126*a* and 126*b* connected together by a vertically disposed hinge coupling 129. The outer portion 126*a* of said lever is normally deflected laterally and maintained out of alignment with the inner portion 126*b*. A bias extension spring 130 is connected between laterally projecting arms or lugs carried by the two lever portions 126*a* and 126*b*, respectively, to deflect lever portion 126*a*.

As shown most clearly in FIG. 9, in this deflected position, the outer lever portion 126*a* lies clear of the cam 125 so that the setting mechanism is inoperative.

To activate the setting mechanism and render it operative, a solenoid 132 is provided which, when energized, acts upon an arm 126*c* which is carried by lever portion 126*a*. Arm 126*c* projects laterally on the side opposite to the bias spring 130, and the lever portion 126*a* is thereby deflected, against the action of spring 130, into alignment with the inner portion 126*b* and into co-operative relationship with the cam 125.

The basic form of the electrical control circuit is shown in FIG. 12. The security or safety control system includes a main control switch S, for example a key operated switch, and a battery B. It will be seen that energization of solenoid 119 of the hold or latch mechanism is dependent only upon the position of control switch S, but the solenoid 132 of the setting mechanism is connected in series with the micro-switch 120 previously referred to. Micro-switch 120 is normally-closed so that upon closing switch S, solenoid 132 is also energized thereby activating the setting mechanism. As soon as the engine is cranked or turned, the cam 125 engages and displaces lever 126 and sets the injection pump to the on or engine-running position, the latch mechanism then being closed. But when the latch mechanism closes, the latch plate 111 engages the micro-switch 120, as indicated in FIG. 6, and the latter is opened, thereby de-energizing solenoid 132 so that the setting mechanism returns to its inoperative condition.

In FIGS. 10 and 11, a modified latch mechanism is illustrated in which the solenoid 119 is replaced by an electro-magnet 119′ as this may enable production costs to be reduced. In this case, the movement of the latch plate 111′ is utilized to move the keeper plate member 115′ into an operative position during setting of the injection pump. For this purpose, the latch plate 111′ is formed with an extension arm 141 adapted to engage a projecting extension 142 of the keeper plate member 115′ so as to displace the latter as required. Then, when the keeper plate member 115′ reaches its operative position, it is retained there by the electromagnet 119′ which may act upon a suitable soft iron armature 143 carried by said keeper plate member 115′. The gate latch is again held in its closed condition until the electro-magnet 119′ is de-energized.

We claim:

1. A control system of a compression-ignition or diesel engine installation which includes a fuel injection pump having a shut-off control mechanism, said control system comprising:

a. biasing means operatively connected to the shut-off control mechanism of the fuel injection pump to bias said pump to an inoperative off position,

b. an electro-mechanical actuator responsive to a supply of electrical current for automatically setting the fuel injection pump to an operative on or engine-running position,

c. said electro-mechanical actuator including drive means, a solenoid device, means to cause said solenoid device to be energized intermittently and to operate repetitively and continuously through successive operating cycles, and means adapted to advance the drive means stepwise and unidirectionally from an initial position to a terminal position when the solenoid device is energized,

d. said drive means being operatively connected to the fuel injection pump,

e. an electrical supply circuit means for providing a supply of electrical current to the solenoid device,

f. switch means for opening the supply circuit to stop the supply of electric current, and

g. means for causing the drive means to return the pump automatically from said on position to the inoperative off position by the biasing means when the electric current is stopped.

2. A control system as defined in claim 1 wherein the solenoid device has an armature which moves through an operating stroke and a return stroke in each operating cycle of the solenoid device, and said advancing means for said drive means includes a drive member and ratchet means operatively connecting said armature to said drive member to move the drive member unidirectionally in each said operating cycle.

3. A control system for a fuel injection pump of a compression-ignition or diesel engine installation, said control system comprising:

a. an electro-mechanical actuator including a drive member adapted to control the fuel injection pump, ratchet means, and an electromagnetic drive device adapted to be energized intermittently in response to an electrical signal and to operate repetitively and continuously through successive operating cycles,

b. said drive member being operatively connected to advance between an initial position and a terminal position to control the setting of the fuel injection pump,

c. said electromagnetic drive device sets and holds the drive member in an operative on position when energized,

d. said actuator including means to return the drive member from said on position to the off position by associated biasing means when the electromagnetic device is de-energized,

e. said biasing means being incorporated in the actuator,

f. said electromagnetic device having an armature which moves through an operating stroke and a return stroke in each operating cycle of the electromagnetic device,

g. said ratchet means operatively connecting said armature to said drive member to move the drive member unidirectionally in each said operating cycle.

4. A control system as defined in claim 3 wherein the armature is a reciprocal plunger connected to a movably mounted intermediate member carrying a pawl adapted to engage ratchet teeth carried by the drive member.

5. A control system as defined in claim 4 wherein the drive member is mounted for angular movement and comprises a sector plate,

a drive shaft carries said sector plate and forms a pivotal axis for the aforesaid intermediate member,

a holding pawl remains in engagement with the ratchet teeth throughout the advance of the drive member, and

catch means maintain the holding pawl out of engagement with the ratchet teeth when the drive member is in the terminal position.

6. A control system as defined in claim **5** wherein the repetitive cycling operation of the electromagnetic device of the actuator is controlled by a circuit interrupter comprising switch means arranged to be opened and closed in response to movement of the armature until the drive member reaches its terminal position, whereupon the electromegnetic device is then maintained in an energized condition.

7. A control system of a compression-ignition or diesel engine installation which includes a fuel injection pump having a shut-off control mechanism, said control system comprising:

a. an electro-mechanical actuator energizable in response to an electric current for automatically setting the fuel injection pump to an "on" position,

b. said electro-mechanical actuator including drive means, a solenoid device connected to the drive means, means to cause said solenoid device to be energized intermittently and to operate repetitively and continuously through successive operating cycles, and means adapted to advance the drive means stepwise and unidirectionally from an initial position to a terminal position when the solenoid device is energized,

c. said drive means being operatively connected to the fuel injection pump.

8. A control system of a compression-ignition or diesel engine installation which includes a fuel injection pump having a fuel shut-off mechanism movable between an inoperative off position and an operative on position which permits engine running, said control system comprising:

a. an electro-mechanical actuator for setting the fuel shut-off mechanism in an on position when the actuator is supplied with electric current,

b. said electro-mechanical actuator including drive means having a drive member and ratchet means, solenoid device having a movable armature and being responsive to an electric current, said circuit interrupter means,

c. said drive member being operatively connected to the fuel shut-off mechanism of the injection pump and movable between first and second positions correlated respectively with the off and on positions of said mechanism,

d. said ratchet means operatively connecting said armature to the drive member,

e. said circuit interrupter means being connected in series with the solenoid device for interrupting the electric current to cause the solenoid to be energized intermittently and to operate repetitively and continuously through successive operating cycles when electric current is supplied, and

f. means including said ratchet means adapted to advance the drive member stepwise and inidirectionally between said first and second positions when the solenoid device is energized.

9. A control system as defined in claim **8** wherein the armature of the solenoid device moves through an operating stroke and a return stroke in each operating cycle of the solenoid device and operates the circuit interrupter means.

10. A control system as defined in claim **8** wherein means including biasing means operably connected to the drive member and adapted to return the drive member from said second position to said first position thereby automatically returning the injection pump fuel shut-off mechanism to the off position when the supply of electric current to this solenoid is disconnected.

11. A control system of a compression-injection or diesel engine installation which includes a fuel injection pump having a fuel shut-off mechanism movable between an inoperative off position and an operative on position which permits engine running, said control system comprising:

a. an electro-mechanical actuator responsive to an electric current for setting the fuel shut-off mechanism in the on position,

b. said electromechanical actuator including drive means having a drive member and ratchet means, solenoid device having a movable reciprocal plunger, and current interrupter means,

c. said drive member being operatively connected to the fuel shut-off mechanism of the injection pump and movable between first and second positions correlated respectively with the on and off positions of said mechanism,

d. said ratchet means operatively connecting said plunger to the drive member,

e. said current interrupter means being connected in series with the solenoid device to cause the solenoid to be energized intermittently and to operate repetitively and continuously through successive operating cycles when electric current is supplied thereby to advance the drive member stepwise and unidirectionally between the first and second positions,

f. said reciprocal plunger being movable though an operating stroke and a return stroke in each operating cycle of the solenoid device and being connected to operate the current interrupter means,

g. the ratchet means comprising ratchet teeth carried by the drive member and a pawl being operatively connected to said plunger for engaging the ratchet teeth, and

h. holding means for preventing retrograde movement of the drive member during the stepwise advance movement effected by the operation of the solenoid device.

12. A control system as defined in claim **11** wherein the drive means includes a drive shaft and the drive member moves angularly about the axis of said shaft,

the holding means comprises a holding pawl which remains in engagement with the ratchet teeth throughout the advance of the drive member.

13. A control system as defined in claim **12** wherein catch means maintain the holding pawl out of engagement with the ratchet teeth during resetting of the actuator when the drive member moves from said second position to said first position.

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