United States Patent [19]

Harris

[11] **3,745,273**

[45] **July 10, 1973**

[54] **MOTOR RELEASE ENERGY STORAGE MEANS FOR RETARDED TYPE TIMER MECHANISM**

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[73] Assignee: **Deltrol Corp.,** Bellwood, Ill.

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[21] Appl. No.: **179,422**

[52] **U.S. Cl.** ..... **200/40,** 200/39 R, 200/35 R

[51] **Int. Cl.** **H01h 7/08,** H01h 43/10

[58] **Field of Search** ..... 200/33 R, 40, 35 R, 200/39 R

[56] **References Cited**

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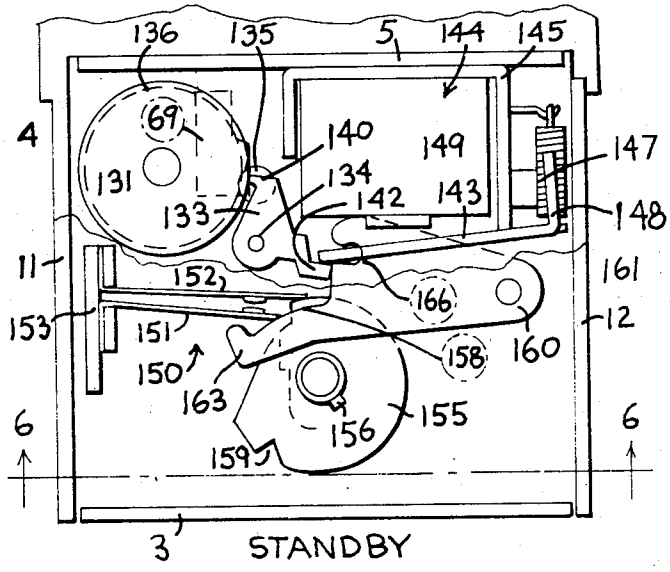
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Primary Examiner—J. R. Scott

[57] **ABSTRACT**

A heavy duty contactor mechanism for refrigeration compressor motors is directly actuated by a timing mechanism controlled by a thermostat. The timing mechanism protects against false starts from thermostat vibration, and interposes a delay between stopping and starting of the compressor sufficient to allow pressures to equalize. Power for operating the contactor switches is stored in a spring while the timer motor is running through the delay period.

20 Claims, 24 Drawing Figures



3 Sheets-Sheet 1

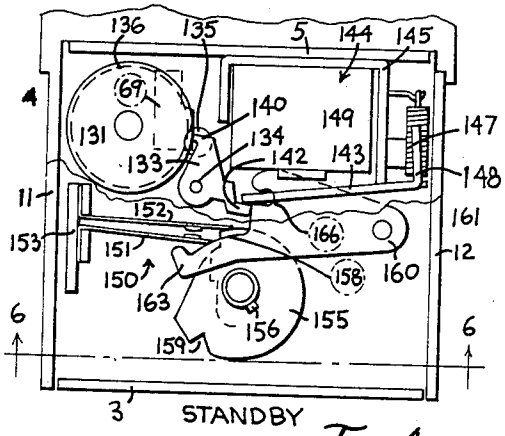


Fig 4

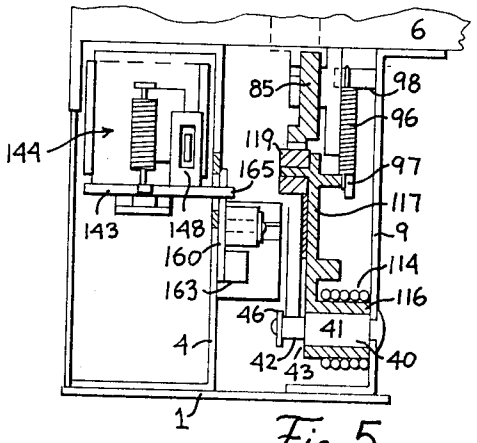


Fig 5

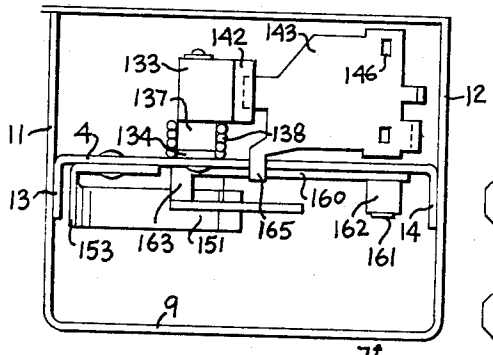


Fig 6

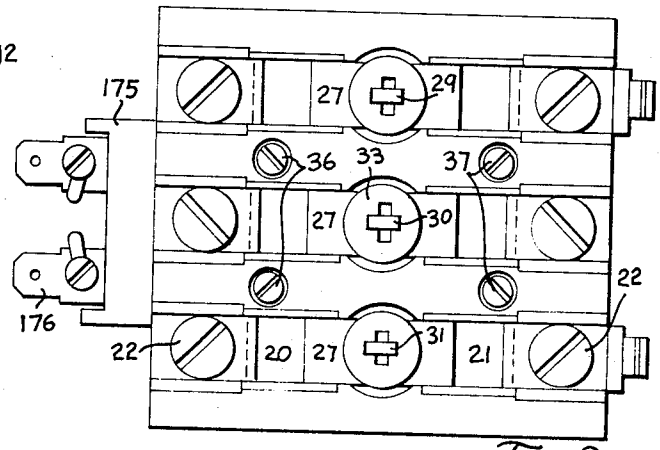


Fig 3

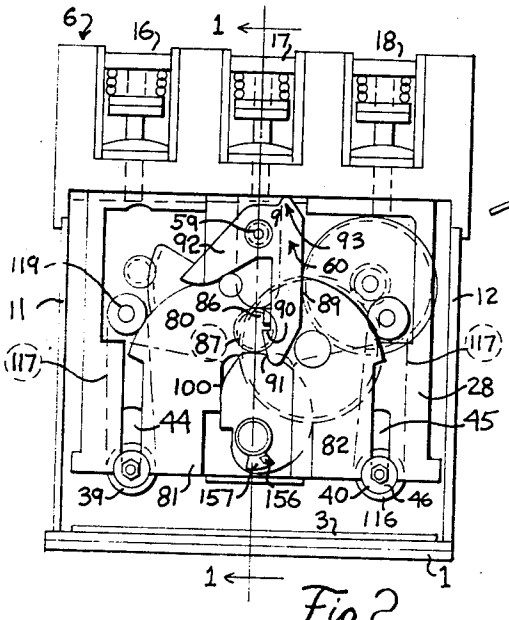


Fig 2

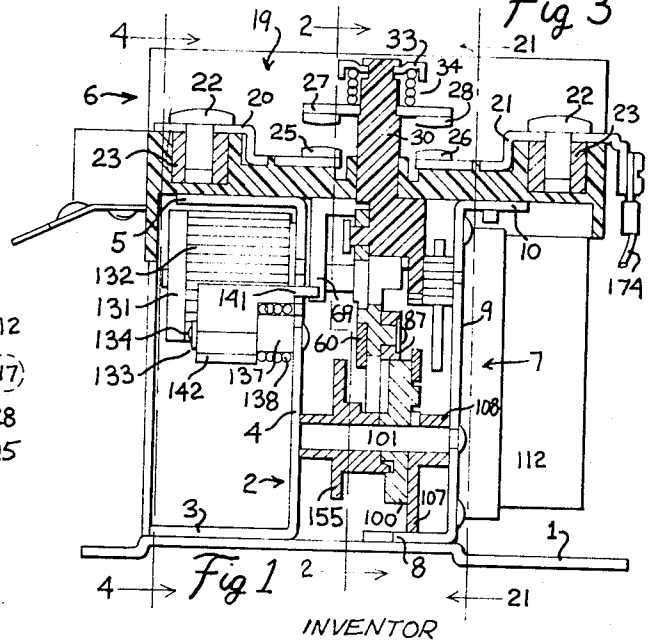
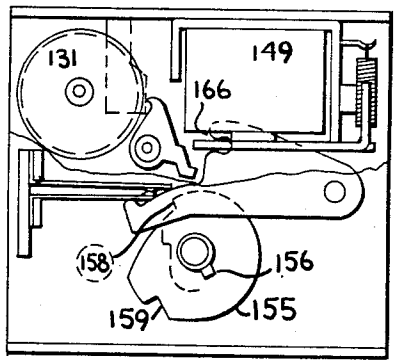


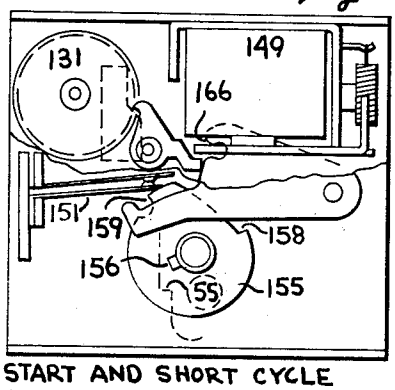
Fig 1

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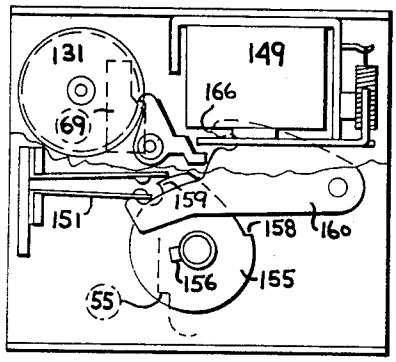
John L. Harris



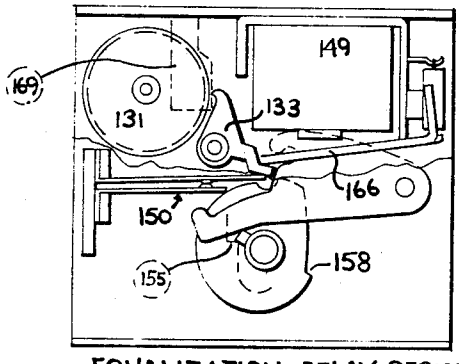
INITIAL DELAY PERIOD Fig 7



START AND SHORT CYCLE ADDER PERIOD Fig 8



RUN Fig 9



EQUALIZATION DELAY PERIOD Fig 10

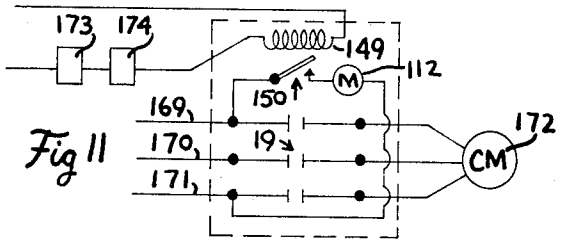
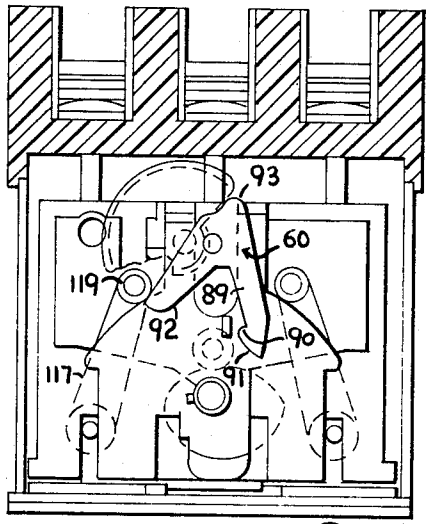


Fig 11



ON Fig 12

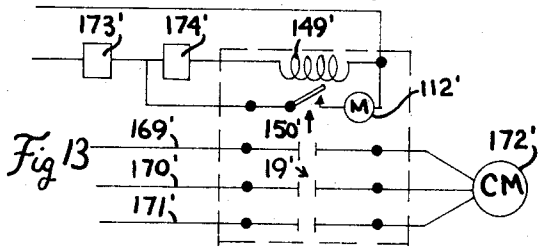
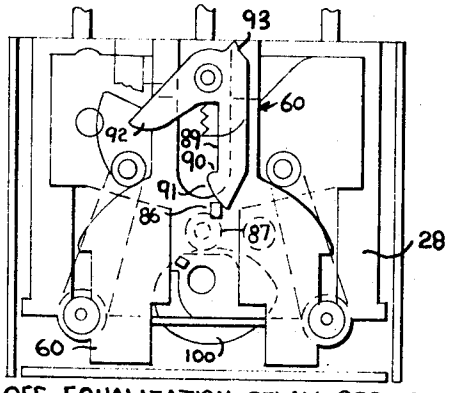


Fig 13



OFF EQUALIZATION DELAY PERIOD Fig 14

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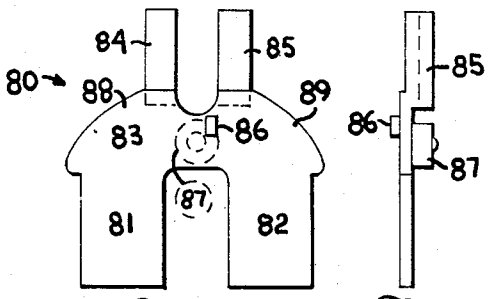


Fig 15

Fig 16

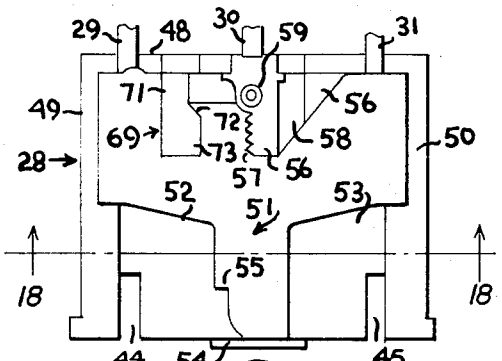


Fig 17

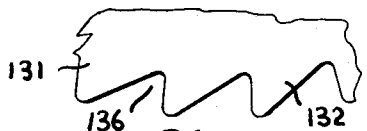


Fig 19

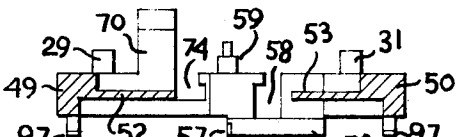


Fig 18

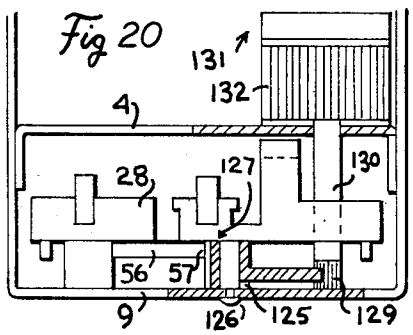


Fig 20

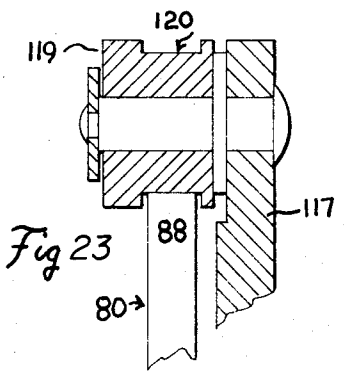


Fig 23

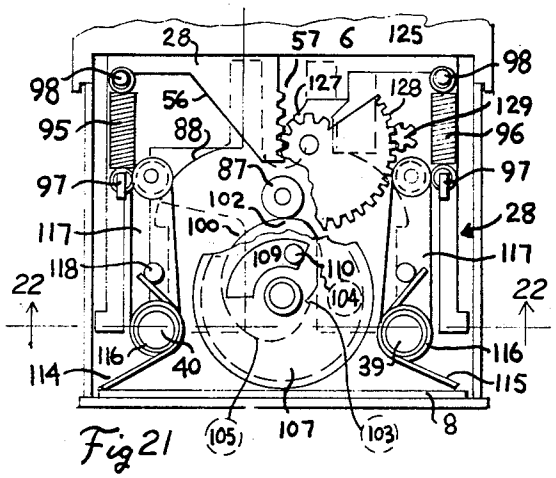


Fig 21

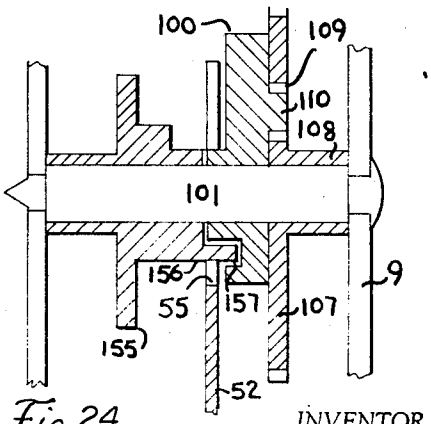


Fig 24

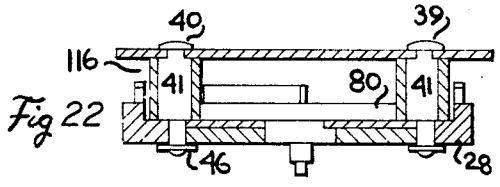


Fig 22

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MOTOR RELEASE ENERGY STORAGE MEANS FOR RETARDED TYPE TIMER MECHANISM

BACKGROUND OF THE INVENTION

In air conditioning and refrigeration systems having motors of three H. P. and above, it is necessary to use a magnetic starter or contactor for handling the current to the compressor motor. These devices include a large expensive electro-magnet, the coil current of which is controlled directly by a thermostat or by a relay controlled by the thermostat.

Unless a time delay mechanism is interposed between the thermostat and coil, damage can result from false starts caused by vibration of the thermostat causing the contactor to bounce in and out. Thus causes rapid making and breaking of the heavy starting inrush current to the motor which can damage both the starter contacts and the motor. Also if the compressor is stopped and immediately restarted, the suction and head pressures on the compressor have a wide differential and the motor will usually not have sufficient starting torque to start the compressor under these conditions. A delay in restart sufficient to allow the pressures to equalize is needed. In some cases, malfunctioning of a part of the system causes the safety controls to stop the compressor. This condition causes rapid starting and stopping (short cycling) of the compressor which is damaging to both the compressor and its motor.

These considerations have led to use of timing systems between the thermostat and compressor contactor which provide the necessary safeguarding delays. These systems are relatively complex and expensive.

BRIEF SUMMARY OF INVENTION

In applicant's invention, the usual magnetic starter is replaced by a new type of starter directly operated by the timing mechanism which provides the desirable time delay features. This eliminates the noise of magnetic starters slamming in and out and also eliminates the loud humming usually occuring with magnetic starters. In addition, it substantially simplifies the control system which reduces costs. It also reduces installation costs as an entire control system is included in a single component.

In applicant's invention, the contactor mechanism is similar in appearance to the usual magnetic starter and the movable contacts are carried by a slide in the same general manner. This slide is actuated by a cam follower which is spring biased against a main cam driven by a timer motor. The control also includes an electro-magnet controlled by a thermostat.

On call for cooling, the electro-magnet is energized which closes a switch for the timer motor. After a 15 second delay, the cam follower rides down a drop-off on the main cam. During this downstroke the cam follower is engaged to the switch slide by a closing pawl and pulls the slide down to engage the contacts, starting the compressor. At the end of the downstroke of the slide, the closing pawl is released and the slide is now held down by a holding pawl.

During the downstroke of the cam follower, it advanced the main cam which in turn advanced a timer motor switch cam which maintains the timer motor switch closed independently of the electro-magnet. The timer motor now runs for approximately two minutes at which time the motor switch opens even though the electro-magnet is still energized.

When the thermostat is satisfied, it drops out the electro-magnet which releases the holding pawl. This allows the switch slide to return to its upper position under its own bias, opening the contacts to stop the compressor. This movement of the switch slide recloses the timer motor switch. The timer now runs for approximately 5 minutes back to the starting position where the timer motor switch opens. During this time, the cam follower is driven back to its upper position and power is stored in its biasing spring for the next cycle.

It is important that the contactor switches open without requiring operation of the timer motor. This is necessary for safety and also to insure proper recycling after a power interruption.

The primary object of the invention is to provide a timing mechanism for actuating a load switch operator to close the switches under the control of a condition responsive device or master controller, which releases the operator instantly for opening the switches, and which utilizes power provided by the timer motor to actuate the operator with rapid action.

When the releasing of the switch operator is achieved by an electro-magnet releasing a latch, it is desirable to use as small an electro-magnet as possible. It is a futher object of the invention to reduce the force required for releasing the latch by providing a motion transmitting means between the switch operator and latch giving a mechanical advantage to the latch in holding the switch operator.

Another object of the invention is to provide an arrangement in which the holding latch has a plurality of latching surfaces allowing for immediate latching engagement in spite of the increased travel resulting from the mechanical advantage.

A further object of the invention is to provide an arrangement for dampening the movement of the switch operator to obtain controlled speed of contact make and break.

Other objects will appear from the following detailed description and appended claims.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a side view partly in section of a time delay contactor embodying the invention, this section being taken on line 1—1 of FIG. 2.

FIG. 2 is an internal front view taken on line 2—2 of FIG. 1.

FIG. 3 is a top view of the contactor.

FIG. 4 is another internal front view taken on line 4—4 of FIG. 1.

FIG. 5 is a side view partly in section of FIG. 4.

FIG. 6 is a bottom view taken on lines 6—6 of FIG. 4.

FIGS. 7, 8, 9, and 10 are views similar to FIG. 4 but showing the different combinations of positions assumed by the parts during a typical cycle of operation.

FIG. 11 is a schematic wiring diagram showing the application of the invention to an air conditioning system.

FIG. 12 is a view similar to FIG. 2 but showing the positions of the switch operating mechanism when the switches are closed.

FIG. 13 is a modified schematic wiring diagram.

FIG. 14 is a partial view similar to FIG. 12 but showing the positions of the parts when the contactor first opens.

FIG. 15 is a plan view of the cam follower.

FIG. 16 is a side view of FIG. 15.

FIG. 17 is a front view of the switch operator slide.

FIG. 18 is a sectional view taken on line 18—18 of FIG. 17.

FIG. 19 is a detailed view of the tooth form on the ratchet wheel.

FIG. 20 is a top view of FIG. 21.

FIG. 21 is a rear view taken on line 21—21 of FIG. 1 with the rear plate removed.

FIG. 22 is a sectional view taken on line 22—22 of FIG. 21.

FIG. 23 is an enlarged sectional view showing the cam follower roller arrangement.

FIG. 24 is an enlarged sectional view of the camshaft assembly.

DETAILED DESCRIPTION OF INVENTION

Referring to FIGS. 1 and 2, reference character 1 indicates a base plate upon which the mechanism is mounted. This base plate carries a U-shaped internal bracket 2 the lower leg 3 of which is attached to the base plate 1. The bracket 2 also includes an upwardly extending portion 4 which supports the operating mechanism. This bracket also includes a horizontal portion 5 which serves as one support for the switch block generally indicated as 6. Also mounted on the base plate 1 is an end bracket generally indicated as 7. This end bracket includes a horizontal portion 8 attached to the base plate, an upwardly extending portion 9, and a horizontal portion 10 which serves as the other support for the switch block 6. As shown in FIG. 6, the bracket 7 also includes side members 11 and 12 which serve to form an enclosure for the operating mechanism. Also as shown in FIG. 6, the upwardly extending portion 4 of bracket 2 includes rearwardly extending ears 13 and 14 which are attachable by screws (not shown) to the side members 11 and 12 respectively.

The switch block 6 illustrated is for a three pole switch and is formed with three channels 16, 17, and 18 (FIG. 2) which receive three identical switches generally indicated as 19. As shown in FIG. 1, each switch 19 includes a left hand terminal bracket 20 and a right hand terminal bracket 21 which are held in place by terminal screws 22 which are threaded into suitable metallic inserts 23 molded into the insulative switch block 6. In order to save space, the switch block 6 is reduced in thickness at the center portion and the terminal brackets 20 and 21 are offset so as to lower the locations of the stationery contacts 25 and 26 carried by these brackets.

Each switch also includes a movable contact bar 27 carrying movable contacts 27*a*. The three movable contact bars 27 are carried and actuated by a slide 28 (FIG. 2). This slide extends transversely across the switch block 6 and has insulative extensions 29, 30, and 31 which extend upwardly through openings in the switch block and support the movable contact bars 27. As shown in FIG. 1 the slide extension 30 is formed with a shoulder which supports the movable contact bar 27. The slide extension is also formed to receive a spring retainer 33 for an overtravel spring 34. The switch block 6 is secured in place by a pair of screws 36 which extend into the horizontal portion 5 of bracket 2. The block 6 is also secured by a pair of screws 37 which extend into the horizontal portion 10 of the case bracket 7.

As shown in FIGS. 2 and 5 the lower end of slide 28 is slideably mounted on a pair of studs 39 and 40 which are attached to the vertical case member 9. Each stud includes a main portion 41 and a reduced portion 42 providing a shoulder 43. As shown in FIG. 2 the slide 28 is formed with slots 44 and 45 which fit over the reduced portions 42 of the mounting studs. The shoulders 43 on the mounting studs serve to locate the slide 28 in spaced relationship with the rear case member 9. The slide is held in place on the reduced portions 42 by washers 46 suitably attached to the studs.

The construction of slide 28 is shown in detail in FIGS. 17 and 18. This slide is preferrably molded and includes a transverse upper member 48 which supports the switch bar extensions 29, 30, and 31. The slide 28 also includes side members 49 and 50 which extend downwardly and which are molded L-shaped at the lower ends shown in FIG. 19. Extending between the lower ends of side members 49 and 50 is a cross over member generally indicated as 51. This cross over member is formed of thin webs 52 and 53 joined at their lower edges by a forwardly extending section 54. The web 52 is formed with an offset providing a shoulder 55 the purpose of which will appear as this description proceeds.

Extending downwardly from the transverse section 48 is a gear rack section 56 provided with gear teeth 57 and formed with a channel 58 which also extends through the transverse portion 48. Extending forwardly from the slide 28 is a projection 59 which supports the closing pawl 60 as shown in FIGS. 1 and 2. Also extending forwardly from the transverse section 48 is a cam member 69. This cam member 69 includes a horizontal section 70 which projects forwardly from the cross over section 48. The cam member also includes a downwardly extending extension 71 having camming surfaces 72 and 73. A slot 74 is formed in the transverse section 48 adjacent the cam extension 70 as shown in FIG. 19.

Mounted inside the confines of switch operator slide 28 is a cam follower generally indicated as 80. The construction of this cam follower 80 is shown in detail in FIGS. 16 and 17. This cam follower has a main generally U-shaped portion consisting legs 81 and 82 connected by a horizontal leg 83. This cam follower also includes two upward extensions 84 and 85 which are offset rearwardly as shown in FIG. 16. Extending forwardly of the cam follower is a lug 86, and mounted on the rear of the cam follower is a roller 87. The cross over section 83 of the cam follower is formed with curved upper surfaces 88 and 89 which serve as camming surfaces as will be described.

The cam follower 80 is mounted within the confines of slide 28, the legs 81 and 82 being in front of webs 52 and 53 of the slide 28. Extension 85 of the cam follower fits into the slot 58 in the slide and extension 84 of the follower fits into slot 74. As shown in FIGS. 2 and 5 the outer edges of the legs 81 and 82 of the cam follower fit in between the reduced portions 42 of the studs 39 and 40 and are held in place by the washers 46. The cam follower is thus slideably mounted with the switch operator slide 28, being guided at its lower end by studs 39 and 40 and being guided at its upper end by extensions 84 and 85 fitting into the slots 74 and 58 of the operator slide.

As shown in FIGS. 2, 12, and 14 the closing pawl 60 is pivotally mounted on stud 59 of the switch operator

slide. This closing pawl includes a downwardly depending portion **89** formed to provide a latching surface **90** and a camming surface **91.** The closing pawl is also formed with a releasing lever portion **92** and a disengaging lever section **93.** The closing pawl **60** when in latching position as shown in FIG. **2** is engageable by the lug **86** formed on the cam follower.

The switch operator **28** is biased upwardly by coil springs **95** and **96** (FIGS. **5** and **21**). The lower ends of these springs fit into extensions **97** molded on the back of the operator slide **28.** The upper ends of these springs are supported on studs **98** attached to the case member section **9.** The springs **95** and **96** thus serve to bias the switch operator means in a direction opening the switches.

As shown in FIGS. **1, 2,** and **21** the cam follower roller **87** rides on a cam **100** which is loosely mounted on a shaft **101** which is staked into the enclosure plate **9.** The cam **100** as shown best in FIG. **21** includes a high portion **102** and a low portion **103** connected by a drop off section **104.** The cam also includes a gradual rise portion **105** which extends from the other side of the low portion **103** to the high portion **102.** The cam **100** is driven in a clockwise direction as seen in FIG. **2** (counterclockwise in FIG. **21**) by a gear **107** which is also supported on the shaft **101.** This gear **107** is provided with a shoulder **108.** As shown more clearly in enlarged FIG. **24** the gear **107** is provided with a slot **109** into which a stud **110** on cam **100** extends. This pin and slot arrangement provides a lost motion drive between the gear **107** and cam **100** and as shown in FIG. **21** the slot **109** is formed to provide in excess of 90° lost motion. This permits advancement of the cam relative to the gear the amount of lost motion provided by the lost motion drive means.

The gear **107** is driven by a timer motor **112** which is mounted on the enclosure plate **9** beneath the switch block **6.** Preferrably the reduction gears are interposed between the timer motor output and gear **107** for reducing the torque required at the timer motor output. In the embodiment of the invention illustrated the timer motor speed and gear reduction are selected to give one revolution of the cam **100** in approximately seven minutes.

The cam follower **80** is biased downwardly to cause the roller **87** to ride the cam by spring biasing means including springs **114** and **115** (FIG. **21**). These springs are mounted on hubs **116** of identical spring levers **117.** As shown in FIGS. **5** and **21,** one spring lever **117** is mounted on the enlarged portion **41** of the stud **40** which also supports the switch operator **28** and the cam follower **80.** The other spring lever **117** is mounted similarly on the stud **39.** The spring levers **117** are provided with rearwardly extending studs **118** upon which the upper legs of springs **114** and **115** bear. The lower legs of these springs rest on horizontal section **8** of the rear housing member **7.**

As shown in FIGS. **5** and **21** the spring levers **117** extend upwardly behind the cam follower **80** and are provided with rollers **119** which extend forwardly and ride the camming portions **88** and **89** of cam follower **80.** As shown in the enlarged FIG. **24,** the roller **119** is formed with a slot **120** the inside surface of which rides the cam follower. As the spring levers **117** are accurately positioned by hubs **116,** the grooves in rollers **119** serve to position the upper end of the cam follower which in turn positions the upper end of the switch operator **28** into which the cam follower fits. This arrangement facilitates assembly of the unit as the switch operator is held in the correct position before installation of the switch block **6.**

It will be apparent that the springs **114** and **115** serve to bias the spring levers inwardly and that the rollers riding the camming surfaces **88** will cam the switch operator downwardly when this motion is allowed by the cam **100.** Preferably the camming surfaces **88** are characterized to reduce the rate of travel of the cam follower as it moves downwardly. This compensates for loss in spring tension of the springs **114** and **115** as the spring levers move inwardly and the cam follower moves downwardly. This arrangement also gives a relatively large motion per increment of movement of the spring levers when the switch operator is being moved to close the air gap between the stationery and movable contacts. It also gives relatively small motion of the cam follower per increment of movement of the spring levers after the contacts engage and provides a mechanical advantage for the springs **114** and **115** in applying contact pressure to the closed contacts.

As shown in FIGS. **20** and **21,** a gear sector member **125** is pivoted on a stud **126** attached to the rear housing member **9.** This gear sector member includes a pinion portion **127** having teeth meshing with the gear rack teeth **57** on the switch slide **28.** The gear sector **125** also includes a gear portion **128** having teeth meshing with pinion teeth **129** formed on shaft **130.** This shaft has a bearing portion extending into the housing member **9.** It also extends forwardly through the plate **4** and carries a ratchet wheel **131** having ratchet teeth **132.** The ratchet wheel **131** is preferably massive as shown and serves as a fly wheel for controlling the speed of movement of the gear rack **57.** It will be apparent that upward or downward movement of the switch slide **28** will cause rotation of the gear sector member **125** about its pivot **126** and that this in turn will cause rotation of the ratchet wheel **131.** It will also be apparent that the gearing provided is of the step up type causing the motion at the periphery of the ratchet wheel to be much greater than the up or down motion of the switch slide **28.**

Referring to FIGS. **4** and **5,** a holding pawl or latch member **133** is mounted on a stud **134** carried by the cross plate **4.** This holding pawl **133** has an upper pointed portion **135** which is arranged to enter the slots **136** on the ratchet wheel **131.** The preferred configuration of the ratchet wheel is shown enlarged in FIG. **20.** The holding pawl **133** is formed with a hub portion **137** (FIGS. **1** and **6**) adjacent plate **4** and this hub is surrounded by a torsion type spring **138** which serves to bias the holding pawl toward engagement with the ratchet wheel **136.** The cross plate **4** is provided with an opening **140** through which a lug **141** formed on closing pawl **133** extends. This lug extends into the path of the cam member **69** which is part of the switch operator **28.**

The holding pawl **133** is also formed with a lever section **142** which extends into engagement with the clapper **143** of a clapper type electro-magnet generally indicated as **144.** This electro-magnet includes a frame **145** which is secured to the horizontal portion **5** of housing member **2.** This frame **145** also has ears **146** extending into openings in the clapper **143.** This provides a pivotal support for the clapper on the frame. This clapper is biased downwardly as seen in FIG. **4** by

means of a biasing spring **147** and is held in position by retaining means **148** as well known in the art. It will be apparent that when the coil **149** of the electro-magnet **144** is energized, the clapper will be drawn upwardly against the force of the biasing spring **147.** This will remove the free end of the clapper from engagement with the holding pawl **133** and thus permit this pawl to engage the ratchet wheel **131.** When the coil **149** is deenergized, the spring **147** will pull the clapper **143** downwardly, this engaging the lever portion **142** of the holding pawl **133** for rotating it to disengage the ratchet wheel **131.**

Power to the timer motor **112** is controlled by a timer motor switch generally indicated as **150.** This switch consists of a lower relatively short switch blade **151** and an upper longer blade **152.** These switch blades are suitably mounted on an insulating bracket **153** which is L-shaped as shown in FIG. **6** having one leg attached to the cross plate **4.** These blades are biased downwardly and both ride a timer motor switch cam **155.** As shown in FIGS. **1** and **24** the timer motor switch cam **155** is carried by the shaft **101** in front of the main cam **100.** This switch cam is provided with a driving lug **156** which extends into a slot **157** formed in the main cam **100.** The lug **156** and slot **157** provide a lost motion drive means for driving the switch cam **155** in controlled relationship with the cam **100.** As shown in FIG. **2** the width of the slot **157** is greater than the lug **156,** thus providing a lost motion drive between the two cams. In FIG. **2** and other figures the slot **157** and lug **156** are shown in full lines for clarity of illustration.

As shown in FIGS. **4** and **7** through **10,** the switch cam **155** is provided with two drop-offs **158** and **159.** The drop-off **158** is located between two relatively low levels on the cam **155** and the drop-off **159** is located between two higher levels. In other words the two drop-offs are located at different distances from the axis of rotation of the cam. As shown in FIG. **4,** the cam **155** is positioned at a point where the short lower switch blade **151** has just dropped off the drop-off section **158.** The longer blade **152** is still held up by the cam and this has caused the contacts on the two blades to be disengaged as shown. When the cam is rotated to the point where the upper blade **152** drops off, the contacts reengage and only the lower blade rides the cam surface thus maintaining the contacts in engagement until the switch blades are separated at the next drop-off on the cam.

In addition to being operated by the cam **155,** the switch **150** is also controlled by a lever **160** which is pivoted on a stud **161** mounted on the cross plate **4.** As shown in FIG. **6,** the lever **160** is formed with a hub **162** fitting over stud **161,** the main portion of the lever extending adjacent the cross plate **4.** At its outer end this lever is formed with an inward extension **163** which extends beneath the lower switch blade **151** for operating the same. As shown in FIG. **6** the electro-magnet clapper **143** is formed with an extension **165** which passes through a suitable opening in plate **4** and into a slot **166** in lever **160.** As shown in FIG. **4** the electro-magnet **144** is deenergized and the clapper **143** in its lower position. This has positioned the switch lever **160** to cause its operating portion **163** to be disengaged from the switch blade **151** thus allowing the motor switch contacts to be opened. When the electro-magnet **144** is energized, the upward motion of the clapper **143** raises lever **160** to close the motor switch **150.**

FIG. **11** shows a typical wiring diagram for an air conditioning system in which applicant's device is equipped with a line voltage timer motor. The three load switches **19** are separately connected to line wires **160, 170,** and **171** and the other sides of the switches are connected to the three leads of the compressor motor **172.** The timer motor switch **150** is connected to the input terminal receiving line wire **169** and the timer motor is connected to the input terminal receiving line wire **171.** As shown in FIGS. **1** and **3** the input terminals for the two outer load switches are provided with auxiliary terminals **174** for facilitating connection of the timer motor circuit. The electro-magnet coil **149** is connected in circuit with a safety control or controls **173** and thermostat **174.** Assuming conditions are correct in the system, the safety control **173** is normally closed and the thermostat **174** energizes the coil **149** on call for cooling and deenergizes it when the thermostat is satisfied. As shown in FIGS. **1** and **2** the switch block **175** is formed with an auxiliary terminal block **175** receiving terminals **176.** This facilitates making external connections to the coil **149.**

FIG. **13** shows a typical wiring diagram for a unit having a low voltage timer motor. In this diagram the load switches **19'** are individually connected to the line wires **169', 170',** and **171'** and also to the individual motor leads of the compressor motor **172'.** The timer motor **112'** is connected into the low voltage circuit along with the coil **149'.** Preferably the safety control **173'** controls power to the motor switch **150'** and the thermostat **174'** controls only the power to the electromagnet coil **149'.**

OPERATION

With the parts in the positions shown in FIGS. **1, 2,** and **4,** the control is in the "Standby" position awaiting the command of the thermostat **174** to call for compressor operation. In this position the cam follower roller **87** is at the top level of the cam **100** and the cam follower **80** is at a position in which its lug **86** is above the latching surface **90** on closing pawl **60.** At this time the switch operator **28** is in its upper position causing all of the switches to be open and the engaging surface **93** on closing pawl **60** bears against the lower surface of the switch block **6** which has caused this pawl to be at its clockwise limit of rotation with the latching surface **90** under abutment **86** on the cam follower. As the cam follower **80** is at the top of its stroke, the spring levers **117** are at their outer-most positions and springs **114** and **115** have been wound for a cycle of operation. The timer motor switch **150** at this time is open due to blade **151** having dropped down the drop-off **158** on the motor switch cam **155.** The solenoid coil **149** is deenergized and thus clapper **143** and motor switch operator **160** are in their lower positions. The holding pawl **133** is held in disengaged position by clapper **143** and also by the switch operator cam **69.**

When the thermostat **174** calls for cooling, it energizes the electro-magnet coil **149** which raises clapper **143** in turn operating the lever **160** which lifts switch blade **151** to close the timer motor switch **150.** The parts are now in the positions shown in FIG. **7.** The timer motor now runs and drives the camshaft assembly clockwise as seen in FIGS. **2** and **4.** After approximately **15** seconds of timer motor operation (initial delay period) the cam follower roller **86** rides down the drop-off of the main cam **100** this advancing the cam

100 approximately 90° which motion is permitted by the lug 110 on the cam advancing in the slot 109 in gear 107. The downward motion of the cam follower and forward motion of the cam is caused by the spring lever rollers riding inwardly across the camming surfaces 88 of the cam follower 80.

During this downward motion of the cam follower, lug 86 on the follower engages the latching surface 90 of the closing pawl 60 and the switch operator 28 is pulled downwardly closing the load switches. During this motion, the gear rack teeth 57 on the switch operator rotates the gear sector 125 which in turn rotates shaft 130 in a counterclockwise direction. This causes rotation of the ratchet wheel 131 in a counterclockwise direction as seen in FIG. 4. At this time, the holding pawl 133 is held away from the ratchet wheel by the camming surface 69 on the switch operator.

As the switch operator approaches the bottom of its stroke, the roller 119 on the left hand spring lever 117 engages the releasing lever 92 on the closing pawl 89 causing this pawl to rotate clockwise toward releasing position. Also as the switch operator is lowered, the camming surface 69 releases the holding pawl 133 so that this pawl may move into engagement with the teeth on ratchet wheel 131. When the switch operator reaches the end of its design stroke, the latching surface 90 releases the lug 86 on the cam follower which is now held from returning by engagement of the holding pawl 133 with the ratchet wheel 131. The design stroke of the cam follower is greater than that of the switch operator to allow for manufacturing variations. Thus after the closing pawl 89 is released the cam follower continues downward allowing additional inward motion of the spring lever 117 this causing substantial clearance between the latching surface 90 and the lug 86 on the cam follower.

As the cam 100 advanced during the downstroke of the cam follower and switch operator, it also advanced the motor switch cam 155 due to lug 156 on cam 155 being engaged by the driving end of the slot 157 in cam 100. This caused the motor switch cam 155 to advance to the position shown in FIG. 8. At this time, the lower switch blade is riding the top level of the cam 155. The switch contacts are therefor closed and also the lower blade 151 has been lifted beyond the range of movement of the lever 160. At this time the driving lug 156 on cam 155 has advanced to the position shown and is in the path of the abutment 55 on switch operator 28.

Summarizing the operation thus far, the thermostat on call for cooling energizes the electro-magnet which closes the timer motor switch as shown in FIG. 7. When the timer motor runs approximately 15 seconds, the cam follower roller rides down the main cam which advances this cam and also the switch cam to the position of FIG. 8 in which the timer motor switch is maintained closed. During the downward motion of the cam follower, the closing pawl is engaged which pulls the switch operator downwardly against the action of its biasing springs and closes the main contacts. When the switch operator reaches the bottom of its stroke the closing pawl is disengaged and the holding pawl 133 engages the ratchet wheel 131 for holding the switch operator in contact closed position. At the end of the closing stroke the parts assume the positions shown in FIGS. 8 and 12.

The timer motor will now continue to run and drive the gear 107 forwardly which is counterclockwise as seen in FIG. 21 which is a back view. Initially this movement of the gear will not cause rotation of the cams 100 and 155 as the pin 110 on cam 100 advanced in the slot 109 in the gear during the closing motion of the contact mechanism. After approximately 2 minutes of operation, the gear will have taken up the lost motion and have driven the cams 100 and 155 to the position shown in FIG. 9 where the lower switch blade 151 has dropped off the high drop-off section 159 on cam 155. This causes the motor switch 151 to open as shown. The motor switch opens at this time even though the electro-magnet is energized due to the cam now having moved the motor switch beyond the range of movement of the electro-magnet operated lever 160.

The control mechanism will remain in this condition with the main switches closed and timer motor switch open as long as the thermostat continues to call for cooling. When the thermostat becomes satisfied, it opens the circuit to the coil 149 of the electro-magnet and its clapper 166 drops as shown in FIG. 10. This dropping of clapper 166 rotated the holding pawl clockwise releasing it from the ratchet wheel 131. This allows the biasing springs 95 and 96 to raise the switch operator to its upper position as shown in FIG. 2 where the main switches are again opened, this stopping the compressor. On initial upward motion of the switch operator the cam 69 which is part of the operator engaged the extension 141 of the holding pawl 133 to hold it released from the ratchet wheel 131. The purpose of this arrangement is to prevent damage to the ratchet wheel or holding pawl in the event the electro-magnet should become energized during the opening stroke of the switch operator. It also insures a complete opening stroke of the switch operator anytime the electro-magnet is deenergized and avoids any possibility of the switches becoming locked in a partially open position.

Also during the opening stroke of the switch operator, the camming abutment 55 of this operator engages the driving lug 156 of the motor switch cam 155. This advanced the switch cam 155 from the position shown in FIG. 9 to the position shown in FIG. 10 in which the motor switch 150 is reclosed. As this switch is in sole control of the timer motor, the timer motor 112 will now operate and drive the camshaft assembly back to the point shown in FIGS. 2 and 4. At this time the lower switch blade 151 of the timer motor switch drops down the lower drop-off section 158 of the cam 155.

When the switch operator 28 reached the top of its stroke the engaging lever portion 93 of the closing pawl 89 became in contact with the lower surface of the switch block as shown in FIG. 14. This rotated the holding pawl clockwise bringing the latching surface 90 back into the path of the lug 86 on the cam follower 80. As the cam follower is raised by cam 100 the lug 86 on this follower engages the camming surface 91 on the closing pawl which forces the closing pawl out of the path of the lug. This motion is allowed by a slight downward motion of the switch operator 28 against the action of its biasing springs. As the cam follower rises, it cams the spring levers 117 outwardly rewinding springs 114 and 115 for the next cycle. As the follower reaches the top of its stroke the lower edge of the lug 86 clears the latching surface 90 of the holding pawl which permits the holding pawl to be rotated to the position shown in FIG. 2 by the action of the engaging lever section 93 on the lower surface of the switch block 6. The

control system is now ready for the next cycle of operation when the thermostat calls for cooling.

Summarizing the operation on call for cooling the thermostat energizes the electro-magnet which closes the timer motor switch starting the timer motor. After 15 seconds of timer motor operation, the cam follower rides down the incline of the cam which pulls the switch operator to closed position due to the holding pawl being engaged. At the end of the switch operator stroke the holding pawl is released and the switch operator is held in closed position by the holding pawl. During this main switch closing action, the timer motor switch is maintained closed independently of the electro-magnet and the timer motor will run for approximately 2 minutes, being stopped by reopening of the motor switch. When the thermostat is satisfied it deenergizes the electro-magnet which releases the holding pawl allowing the biasing springs to raise the switch operator for opening the main switches. This opening movement of the switch operator **28** reclosed the timer motor switch for restarting the timer motor. Approximately 5 minutes after this occurs the cam follower has been raised, storing power in a spring means for the next cycle. The timer motor switch **3** opens and the electro-magnet is once again conditioned for reclosing the switch on call for cooling by the thermostat.

It should be noted that in the arrangement described, power from the timer motor is stored in a spring means which is available to operate the switch closing means under the command of the thermostat. Also when the switch is closed, the switch closing means is released so that the switch opening means can open the switches instantly without requiring any operation from the timer motor. When the switch opening means operates by release of the holding pawl on the ratchet wheel the switch opens and once the opening movement is started it continues for the full stroke. It should also be noted that the linkage between the switch operator and the holding pawl provides a considerable mechanical advantage to the holding pawl in holding the switch operator in closed position. This lowers the force on the holding pawl and consequently it can be released by a small force from the electro-magnet even though the opening force on the switch operator is considerable.

From the foregoing it will be apparent that the present invention provides a simplified control system which is especially useful in air-conditioning or refrigeration systems where time delays are desirable. While the invention is of particular utility in such systems it is not limited thereto as many features have uses in other applications. As many modifications may be made in the construction and application of the invention it is desired to be limited only by the scope of the appended claims.

I claim:

1. In a control system for a condition changer, the combination of, a power source for energizing the condition changer, a main switch interposed between the power source and condition changer and directly controlling the power thereto, switch operator means for said main switch movable between two positions, one position causing closure of the switch and the other causing opening of said switch, means for actuating said switch operator means, said actuating means including a timing means having a timer motor, spring means, closing means actuated by said spring means for actuating the operator means to close said switch, opening means capable of opening said switch instantly after closure thereof and without requiring operation of said timer motor, a condition responsive device, means connecting said condition responsive device to the closing means and opening means in a manner to actuate the closing means to close the switch on call for condition change and to open the switch when the call for condition change is satisfied, and means actuated by said motor for winding said spring means, said winding means being constructed and arranged to be independent of the position of the main switch.

2. The combination recited in claim **1** in which the spring means must be rewound by the timer motor after each switch closure in order to effect a subsequent closure, whereby a delay is insured between successive starts of the condition changer.

3. The combination recited in claim **1** in which the condition responsive means is arranged to start the timing means on call for condition change, and means actuated by the timing means following such starting for causing operation of the closing means.

4. The combination recited in claim **2** in which the condition responsive means is arranged to start the timing means on call for condition change, and means actuated by the timing means following such starting for causing operation of the closing means.

5. The combination recited in claim **3** including a timer motor switch for controlling the timer motor, means for opening said timer motor switch after closure of the main switch, means for reclosing the timer motor switch when the main switch is opened, and means for reopening the timer motor switch a predetermined time thereafter.

6. The combination recited in claim **4** including a timer motor switch for controlling the timer motor, means for opening said timer motor switch after closure of the main switch, means for reclosing the timer motor switch when the main switch is opened, and means for reopening the timer motor switch a predetermined time thereafter.

7. In a control system for a power operated device, the combination of, a power source for energizing said device, a load switch arranged to control the power to said device, an operator for said load switch, said operator being movable between two positions, one position causing closure of the switch and the other causing opening thereof, means biasing said switch toward its open position, a timer motor, spring loaded means wound by said timer motor, pawl means associated with the switch operator, means whereby said pawl means releasably connects said spring loaded means to said switch operator and holds the operator in switch closed position, master control means, means whereby said spring loaded means is released in response to operation of said master control means, means whereby said spring loaded means actuates the switch operator through said pawl means to close the main switch, and means for releasing said pawl means under the command of said master control means for allowing opening of the switch by the biasing means.

8. The combination set forth in claim **7** in which the pawl means consists of two separate elements, one element serving as a closing pawl and the other as a holding pawl, means for releasing the closing pawl when the switch closes, the holding pawl being released at the command of the master control means.

9. The combination set forth in claim 7 in which the spring loaded means is moved in one direction by the timer motor and is allowed to move in the opposite direction when released, thereby requiring operation of the timer motor between successive releases of the switch operator.

10. The combination recited in claim 8 in which the closing pawl is released by the spring loaded means at a predetermined position thereof.

11. In a control system for a power operated device, a main switch controlling the power operated device, said main switch having an operator movable between two positions, one position causing closure of the switch and the other position causing opening of said switch, timing means for actuating said switch operator, said timing means including a timer motor, a cam driven by said motor, said cam having a rise portion and a drop-off portion, a cam follower riding the cam, spring means wound by the cam follower when raised by the cam, closing means actuated by the spring means when the cam follower drops down the drop off portion of the cam for closing said switch, opening means capable of opening said switch instantly after closure thereof and without requiring operation of the timer motor, switching means for controlling the timer motor, master control means, means causing the timer motor to operate in response to one condition of the master control means, causing the cam follower to drop down the drop off portion of the cam and allow the closing means to be actuated by the spring means for closing the switch, means for opening the timer motor switching means to stop the timer motor after closure of said switch, means responding to another condition of the master control means for causing the opening means to open the switch, and means for reclosing the timer motor switching means when said switch is opened.

12. The combination set forth in claim 11 in which the cam means is driven by the motor by a drive means providing lost motion and in which the drop-off portion of the cam is shaped to cause the cam to be advanced by the cam follower riding down the sloping portion, and means utilizing such advance motion of the cam for maintaining the timer motor switching means closed for a period of time after closure of the switching means.

13. The combination set forth in claim 11 in which the cam means is driven by the motor by a drive means providing lost motion and in which the drop-off portion of the cam is shaped to cause the cam to be advanced by the cam follower riding down the sloping portion, and means utilizing such advance motion of the cam for actuating the timer motor switching means.

14. The combination set forth in claim 13 in which the timer motor switching means is cam operated by a lost motion cam, means actuated by the opening means for advancing the lost motion cam, and means operated by such advancing motion of the cam for closing the timer motor switching means.

15. In a timing mechanism, timing means including a timer motor, a main switch operated by the timing means, a timer motor switch arranged to control the timer motor, a timer motor cam arranged to actuate the timer motor switch, drive means whereby the timer motor cam is driven by the timer motor and can be advanced beyond the point driven by the timer motor, means for advancing the cam when the main switch is operated in one direction, and means for advancing the cam when the main switch is operated in the opposite direction.

16. In a multiple pole contact mechanism, the combination of, a switch block, a first pair of stationary contact and terminal members mounted on said block, a first movable contact member arranged to bridge said stationary contacts, a second pair of stationary contact and terminal members mounted on said block and spaced from said first pair, a second movable contact member arranged to bridge said second pair of stationary contacts, a switch operator slide extending through said base member, said slide extending between the two pairs of stationary contacts and having means carrying the two movable contact members, means for mounting said slide for moving to engage or disengage said contacts, operating means for the slide mounted on the side of the switch block away from said contacts, said operating means including a timer motor, spring means wound by the timer motor, closing means actuated by said spring means for closing the contacts, opening means for opening the contacts, and control means for selectively actuating said closing means and opening means.

17. The combination recited in claim 16 in which the control means includes means for starting the timer motor, and timing means operated by the timer motor for actuating the closing means.

18. The combination recited in claim 16 including a timer motor switch for controlling the timer motor, means for opening the timer motor switch after actuation of the closing means, means for reclosing the main switch upon actuation of the opening means, and means for reopening the timer motor switch a predetermined time thereafter.

19. The combination recited in claim 16 in which the means for winding the spring means is constructed and arranged to be independent of the position of said slide.

20. The combination recited in claim 19 in which the spring means is moved in one direction by the timer motor and allowed to move in the opposite direction by the control means in actuating said closing means.

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