Nov. 10, 1970 H. FELDMAN 3,539,894

GARAGE DOOR CONTROL CIRCUIT

Filed May 27, 1968 3 Sheets-Sheet 1

Fig. 1.

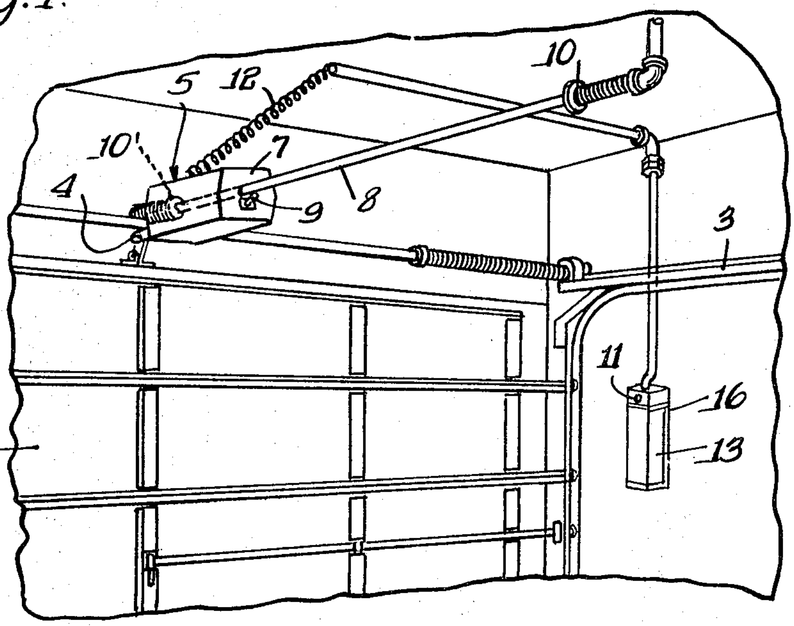
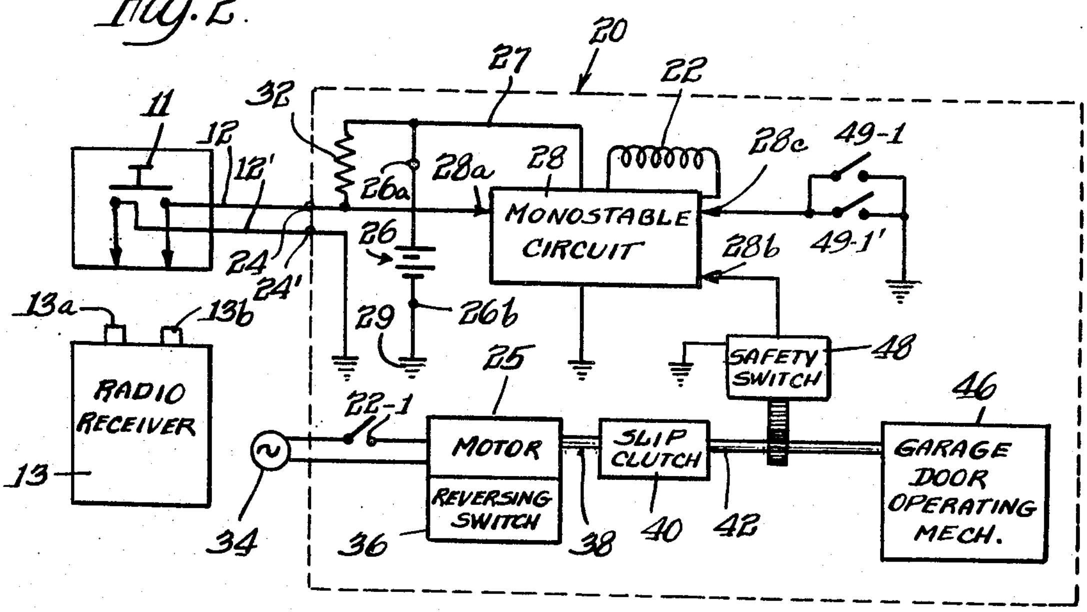


Fig. 2.



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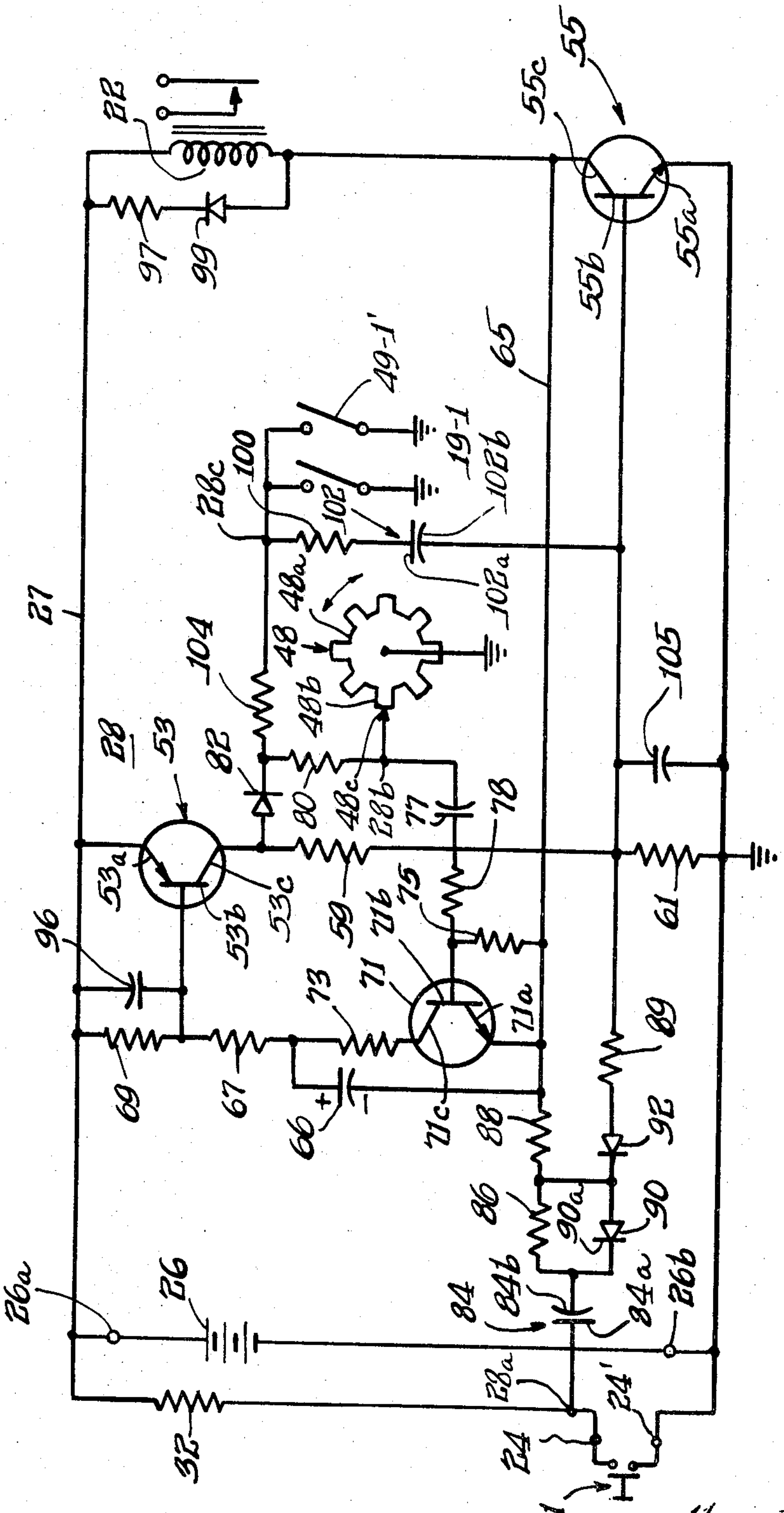

Fig. 3.

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GARAGE DOOR CONTROL CIRCUIT

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Fig. 4.

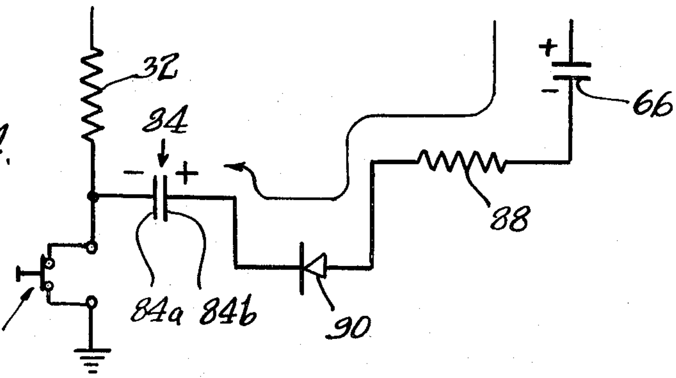


Fig. 5.

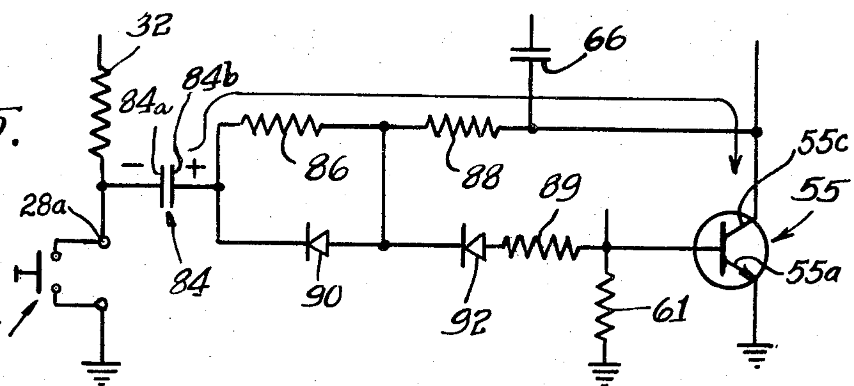


Fig. 6.

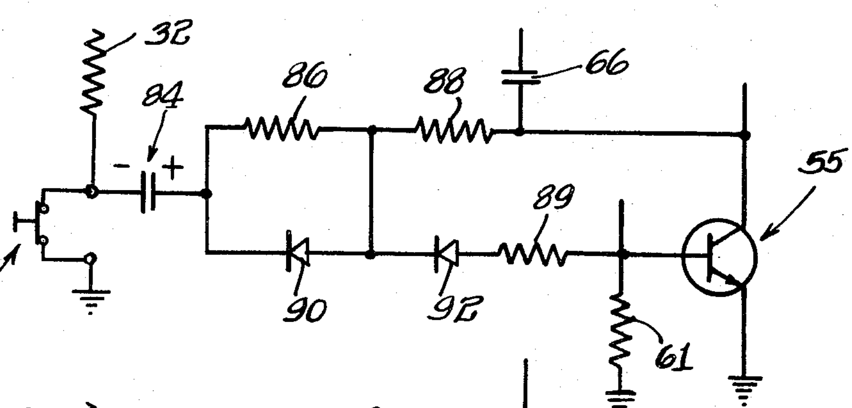
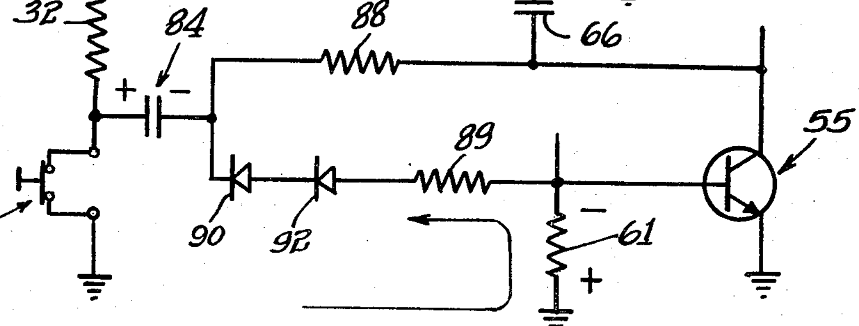


Fig. 7.



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3,539,894
GARAGE DOOR CONTROL CIRCUIT

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Filed May 27, 1968, Ser. No. 732,253
Int. Cl. H02h 7/085
U.S. Cl. 318—463 8 Claims

ABSTRACT OF THE DISCLOSURE

A garage door control circuit responsive to the speed of rotation of the output shaft of a slip clutch coupled between a drive motor output shaft and the garage door, the control circuit including a monostable circuit responsive to the speed of the slip clutch output shaft and having a normal stable state which deenergizes said motor and an unstable state which operates said motor, and means for holding the monostable circuit in its unstable state while the slip clutch output shaft is running at a normal speed and permitting the monostable circuit to return to its stable state when the slip clutch output shaft operates at a lower speed indicating substantial slippage between the slip clutch output shaft and the motor output shaft.

This invention relates primarily to garage door control circuits for starting and stopping the motors which operate the garage doors, particularly motors as used in radio controlled garage door operators. However, the invention has other possible applications where, for example, a motor controls the movement of a member between extreme limits and it is desirable to shut the motor off when a physical obstruction to such movement occurs.

Modern residential garage door operators are nearly always equipped with a radio receiver for starting and stopping the door in response to transmitted pulsations generated by a transmitter in the owner's automobile. The radio control, for reasons of economy, convenience of use and reliability of operation, is a single channel communication system analogous to a single pair of wires in a wire communications system. The output of the receiver generally provides a momentary, circuit closing, ground signal across the output terminals of the receiver when the garage door opening or closing operation is desired. Consequently, it is universal practice to provide the starting and stopping functions by sequential action of the motor controller in the door operator mechanism. This sequential control thus requires only a pair of wires running from the receiver output terminals and one or more manually operable wall mounted pushbutton switches inside the garage or home which provide a momentary circuit closing ground signal when a garage door opening, closing or stopping operation is desired.

A large variety of sequential or stepping type relays are available for controlling the garage door operator motor. The earliest versions of these relays use a ratchet and pawl mechanism. Each impulse indexes a shaft to provide a fixed amount of rotation. Cams attached to the shaft operate contacts that open and close with alternate impulses. Other versions employ a rocker arm arrangement that operates in toggle fashion to provide the alternate action. One of the most popular types uses a mechanism that latches on the first impulses and unlatches with the second impulses. These relays are commonly known as sequence, ratchet, mechanically held, or single coil impulse relays.

The use of mechanical sequence relays like those described above are used in many door operators being manufactured today. These relays are generally more

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expensive than the general purpose types, often costing two or three times as much. Furthermore, they are far less reliable than general purpose relays and as a result have always accounted for a large part of the failures and service costs in residential garage door operators.

The present invention provides a more economical and reliable system for controlling the garage door operator motor by replacing mechanical sequence relay circuits with a solid state sequencing or toggle control circuit which controls a general purpose relay and which is designed to be operated also by safety and limit switches for stopping the motor automatically when the garage door reaches the end of its path of travel or is prevented from reaching the normal end of its path of travel by an obstruction or the like. Furthermore, it is usually desirable that the safety and limit switches be given priority over the pushbutton and radio control, so that the limits will not be overrun nor the safety defeated by a failure in the radio control, a short circuit in the pushbutton wiring or someone deliberately holding a button down. The circuit to be described provides for these features with no added cost.

Motor drive arrangements for garage door operators commonly employ a mechanical slip clutch to limit the load on the drive motor where the garage door movement is obstructed between its extreme limits of travel. Adjustment of this slip clutch is usually made in the field so that the linear output effort exerted by the garage door operator is not greatly in excess of that required to reliably move the door. Thus, the force exerted upon an object or person which obstructs the door can be minimized for reasons of safety.

It is also highly desirable, in the event that the door is obstructed, to remove power from the motor to reduce the hazard potential and to protect the garage door mechanism from damage. Many styles of mechanically actuated centrifugal type safety switches have been employed for this purpose. These mechanical type safety switches all suffer from several disadvantages which are eliminated by the present invention. Mechanically actuated centrifugal safety switches are difficult to produce in a small size for the very low rotational rates of the output shaft of garage door motor output shafts (commonly about two revolutions per second). Since it is often most convenient and desirable to have the slip clutch operative between the motor output shaft and the driven element, a centrifugally operated switch required to sense an obstruction of the door which causes the clutch to slip must be capable of responding at the low rotational rates of the slip clutch output shaft.

Furthermore, it is desirable to have some delay in the response so that the slip clutch output shaft is permitted to rotate at low rotational rates (compared to the normal running rate) for short periods of time such as may be required to overcome the inertia of the door in starting, or overcoming a binding area at some point in the door's travel. This delay permits the safety shut-off system to operate with lower settings of the clutch adjustment without inadvertent or unwanted shut-off. The result of this permissible lower clutch setting is smoother acceleration of the door and greater safety because the maximum output effort of the garage door operator is set at a lower level that would be required with a fast acting centrifugal switch, such as the mechanical type which cannot be easily adjusted for very low rotational rates.

The present invention replaces the centrifugal switch preferably by a simple switch which opens and closes at a rate which is a function of the speed of the slip clutch output shaft. The switch is connected to a monostable circuit in a manner to be described.

A monostable circuit is a circuit which has a stable state and an unstable state. The circuit is triggered to its unstable state by a pulse at an input terminal and returns automatically to its stable state after a given predetermined delay period unless externally prevented from doing so. In the preferred form of the present invention, the aforesaid switch is connected to the monostable circuit so the circuit is held in its unstable state as long as the slip clutch output shaft turns at a normal speed. If an obstruction slows down the slip clutch output shaft to a given low speed for a minimum period which is greater than that required to accelerate the garage door from rest to normal speed, the monostable circuit returns to its stable state to de-energize the motor. The monostable circuit most advantageously a flip-flop type of monostable circuit so it can also be operated to its stable state while the slip clutch output shaft is operating at full speed by signals generated by momentary closure of the limit switches or the manually initiated pushbutton or radio signal operated switches connected to inputs of the monostable circuit.

The above and other advantages and features of the present invention will become apparent upon making reference to the specification to follow, the claims and the drawings wherein:

FIG. 1 shows the inside of a garage provided with the various components which make up a radio controlled garage door operating system;

FIG. 2 is a block diagram of an exemplary garage door control circuit of the invention;

FIG. 3 shows a preferred control circuit of the invention;

FIG. 4 shows the charge path for the control capacitor of the circuit of FIG. 3 when the monostable circuit is triggered into its unstable condition by the grounding of the input terminal by the pressing of a pushbutton switch;

FIG. 5 shows the discharge of the control capacitor due to the bouncing of the pushbutton switch contacts which reopens the input circuit;

FIG. 6 shows the condition of the circuit of FIG. 5 when the bouncing pushbutton contacts reclose; and

FIG. 7 shows the condition of a circuit like FIG. 5 when the bouncing pushbutton contacts reclose but with part of the circuit removed.

FIG. 1 shows, in part, a garage door operator system installed in a garage having a garage door **1** which rides on side tracks **3**, only one of which is shown. The means for closing and opening the garage comprises a door operating unit having a carriage arm **4** which connects to the garage door at one end and to the housing **7** of the operator unit **5** at the other end. The housing **7** is movably supported on a guide rod **8**. The housing **7** includes a garage door drive motor (not shown) which, when energized, will cause a drive wheel to frictionally ride along the guide rod **8** and thus cause the entire housing **7** to move along the guide rod **8**. As the housing **7** moves on the guide rod **8**, the carriage arm **4** attached thereto will move the garage door **1** along with it. When the housing **7** reaches one extreme position, a limit switch operating arm **9** will engage a stationary flange **10** and stop the motor, the housing **7** and garage door **1** coupled thereto. In the other extreme position of the housing **7**, a limit switch operating arm (not shown) like the arm **9** will engage a flange **10'** similar to flange **10** to operate a limit switch causing de-energization of the motor.

The housing **7** includes, in addition to the motor various other equipment such as an operator circuit (not shown in FIG. 1) which controls the operation of the garage door drive motor.

The garage door drive motor may be of a type where the motor reverses in direction each time it is re-energized. In such case, the motor reverses automatically by a centrifugal switch which sets up a starting winding thereof in opposite polarity with respect to a running winding thereof each time the motor comes to rest.

The garage door operator unit is actuated from the vicinity of the garage by manual pushbutton switch **11** shown mounted on the wall of the garage. A pair of conductors **12** extend in a conduit from the switch **11** to the door operator circuit within the housing **7**.

When the user desires to open the garage door, he presses the manual pushbutton switch **11**, whereupon the drive motor in the housing **7** becomes energized and effects movement of the housing **7** to the right which raises the garage door. When the door reaches the end of its path of travel, a limit switch shuts off the motor. When the manual switch **11** is depressed again, the garage door drive motor becomes energized again and moves the housing **7** to the left which lowers the garage door. A limit switch automaitcally terminates the operation of the motor when the garage door is completely closed. Depression of the pushbutton switch **11** during movement of the garage door between its extreme position will stop the garage door drive motor. Also, a safety switch (not shown) is provided which will stop the garage door drive motor if a force is applied against the door tending to stop its movement.

It is common to incorporate remote radio control from the user's car, in addition to the manual control as described, over the operation of the garage door. To this end, a transmitter (not shown in FIG. 1) is installed in the user's automobile. The transmitter usually includes a pushbutton control which when depressed will cause the transmitter to generate an amplitude modulated signal. The modulation frequency of the radio signal is varied within a given location encompassing the range of the transmitter involved, so that the signal from a given transmitter will only operate the desired garage door.

The radio signal is received by a radio receiver which is sometimes incorporated within the housing **7**. In such case, when trouble develops in the receiver, the inaccessibility thereof usually requires a service man to disconnect the radio receiver and bring the same to a radio servicing shop. The preferred control circuit of the present invention allows the radio receiver to be energized solely from the voltage appearing across the terminals of the pushbutton switch **11**. A special unique receiver circuit is required for this purpose. Such a receiver is disclosed in copending application Ser. No. 495,563, filed Oct. 13, 1965. In such case, it is very advantageous to mount the radio receiver identified by reference numeral **13** in FIG. 1, on a mounting frame **16** including the manual pushbutton switch **11**. The connections between the radio receiver and the mounting frame may be a simple removable type plug-in or similar connections. Thus, when the radio receiver **13** is mounted in place on the frame **16**, the radio receiver is automatically connected to the terminals of the switch **11**. If the radio receiver needs servicing, the user merely pulls the exposed receiver from the frame **16** and takes the same to a service shop. thereby saving much time and expense for all concerned.

The control circuit of FIG. 2, identified generaly by reference numeral **20**, has the important advantage that it is a very reliable and economical circuit needing only a single conventional direct current relay **22**. Also, the main control terminals **24–24'** of the circuit **20** provide a direct current voltage which is capable of providing standby power for the radio receiver **13**.

The armature of the relay **22** controls one or more sets of contacts. In the circuit shown in FIG. 2, the relay has a pair of normally-open motor control contacts **22–1**. When the relay is energized, the armature of the relay is pulled into a position where the contacts **22–1** will close to energize the motor **25**.

The source of voltage for energizing the relay **22** is a source of direct current voltage **26** having terminals **26*a*** and **26*b*** across which the direct current output voltage thereof appears. One of these terminals **26*b***, which will be designated as a negative voltage terminal for convenience, is connected to a common reference point or ground **29**, and the other terminal **26*a***, which is the positive terminal, is coupled through a conductor **27** to a monostable circuit **28** which controls the relay **22**.

The aforementioned main control terminals **24–24'** are connected by wires **12–12'** across the terminals of the pushbutton wall switch **11** which is assumed to be normally-open, so that the control terminals **24–24'** are normally-open circuited. The control terminals **24–24'** are connected to the output terminals **13a–13b** of the radio receiver **13**, so that the terminals **24–24'** are momentarily short circuited by either depression of the switch **11** or the reception by the radio receiver **13** of a radio signal. The radio receiver **13** is unique in that the terminals **13a–13b** serve as output terminals and power-receiving terminals for the receiver. As above indicated, such a radio receiver is disclosed in said application Ser. No. 495,563.

One of the control terminals **24'** is preferably connected to ground and the other terminal **24** is connected through a resistor **32** to the conductor **27** leading to the positive terminal **26a**. The resistance of resistor **32** is preferably made small (e.g. one tenth) relative to the standby impedance across the power receiving terminals **13a–13b** of the radio receiver **13**, so that practically all of the voltage of the source of direct current voltage **26** will normally appear across the control terminals **24–24'** when the same are connected to the power receiving terminals of the radio receiver and practically all of the power normally delivered by the source of voltage will be supplied to the radio receiver rather than being absorbed by the resistor **32**. (It should be understood that in accordance with the invention, the power for operating the receiver need not be supplied from across the control terminals **24–24'**).

When the control terminals **24–24'** are momentarily short circuited for the first time, an input **28a** of the monostable circuit **28** receives a pulse (negative pulse) which triggers it to its unstable state. The relay **22** is connected to the monostable circuit **28** so it becomes energized during the unstable state of the monostable circuit. The energization of relay **22** closes motor control contacts **22–1** coupled between a source of voltage, shown as an alternating current voltage source **34**, and the garage door drive motor **25**. It is assumed that the motor **25** is of a type which includes within the same a well known centrifugal switch mechanism **36** which automatically changes the connections to the field windings thereof to reverse the direction of the drive motor each time the motor stops. The drive motor **25** has a drive shaft **38** connected to a slip clutch **40** having an output shaft **42** which drives the garage door operating mechanism **46** which imparts movement to the housing **7** in the embodiment shown in FIG. 1. The shaft **42** is coupled to a safety switch **48** which is preferably a switch which is open and closed at a rate depending on the speed of rotation of the shaft **42**. The safety switch is connected to an input **28b** of the monostable circuit so that it holds the monostable circuit in its unstable state as long as the switch opens and closes at a rate indicating that the slip clutch output shaft is rotating at normal speed. The effect of the safety switch can be overcome so as to return the monostable circuit to its stable state by closure of the switch **11** or the reception of a radio signal of proper frequency by the receiver **13** or by the closure of limit switch contacts **49–1** or **49–1'**, connected to input **28c** of the monostable circuit **28**. The de-energization of the relay **22** opens contacts **22–1** to de-energize the drive motor **25**.

If the speed of operation of the safety switch **48** is decreased to a given lower speed because the garage door is arrected for any reason, the monostable circuit automatically returns to its stable state to de-energize the motor **25**.

Refer now to FIG. 3 which illustrates a preferred transistor monostable circuit **28** which is similar to the circuit shown in FIG. 3 of copending application Ser. No. 732,115 filed on the same date as this application. This circuit **28** includes a PNP transistor **53** having an emitter **53a**, base **53b** and collector **53c** and a NPN transistor **55** having an emitter **55a**, base **55b** and collector **55c**. The PNP transistor **53** forms part of a first branch circuit connected across the positive and negative terminals **26a** and **26b** of the source of D.C. voltage **26** and the NPN transistor **55** forms part of a second branch circuit in parallel with the first mentioned branch circuit across the voltage source terminals **26a** and **26b**. The emitter **53a** of the transistor **53** is connected to the positive voltage source terminal **26a**, and the collector **53c** is connected to a resistor **59**, in turn, connnected to a resistor **61** which completes the first mentioned branch circuit. (The resistors **59** and **61** are sometimes referred to as load impedance means.) The second mentioned branch circuit includes a second load impedance means which, in the embodiment of the invention now being described, is the relay **22**. One end of the relay **22** is connected to the voltage source terminal **26a** and the other end is connected to the collector **55c** of the transistor **55**. The emitter **55a** of the transistor **5** is connected to the negative voltage source terminal **26b** which is shown grounded.

The base **55b** of the transistor **55** is connected to the load impedance means of the transistor **53**, so that conduction of the transistors **53** will effect conduction of the transistor **55**. In the circuit illustrated, the base **55b** is connected to the juncture of resistors **59** and **61**. Once the transistor **55** becomes conductive, the conduction of the connection from the collector **55c** of the transistor **55** to transistor **53** is at least temporarily maintained by the the base to emitter circuit of the transistor **53**. To this end, a conductor **65** extends between the collector **55c** and one plate of a capacitor **66** whose other plate is connected to the end of a current-limiting resistor **67**. The other end of the resistor **67** is connected to the base **53b** of the transistor **53**. To improve the reliability of the circuit and the thermal stability of the transitsor **53**, a resistor **69** is preferably connected between the base **53b** and the emitter **53a** of the transistor **53**.

In the stable state of the monostable circuit, the transistors **53** and **55** are both non-conductive so the circuit takes little or no current from the battery **26**. When, as above explained, the circuit is triggered into a conductive state, the transistor **53** will first become conducting and then the transistor **55** will become conducting. The drive power for the transistors **53** and **55** must be maintained if the transistors **53** and **55** are to continue in a conductive state. When the transistor **53** is initially triggered into a conductive state, the capacitor **66** instananeously acts as a short circuit so that the transistor **53** receives drive power through a circuit extending through the resistor **67** and the emitter and collector of the transistor **55**. However, the capacitor **66** then begins to charge up to a given limiting voltage, and, when the capacitor becomes fully charged, the capacitor acts as an open circuit interrupting the drive power to the transistors **53** and **55** which then become non-conductive.

As previously indicated, one of the aspects of the present invention is the manner in which the monostable circuit is held in its unstable condition as long as the slip clutch output shaft continues to move at a normal speed. To this end, means for inhibiting the full charge of the capacitor **66** is provided comprising a transistor **71**, preferably a NPN transistor, having an emitter electrode **71a** connected to the bottom plate of the capacitor **66**, a collector electrode **71c** connected through a resistor **73** to the upper plate of the capacitor **66**, and a base **71b** connected to the emitter **71a** through a resistor **75**. In a manner to be described, the transistor **71** is rendered alternately conductive and non-conductive at a rate depending upon the speed of rotation of the slip clutch output shaft **42**. When the transistor **71** becomes conductive, the capacitor **66** will discharge partially through the transistor **71** which thereby inhibits the full charging of the capacitor **66**. When the transistor **71** is non-conductive, the capacitor **66** continues to charge to a limiting value. When the transistor **71** is alternately rendered conductive and non-conductive at a relatively high rate, the capacitor **66** is never able to fully charge so that the monostable circuit cannot return to its stable non-conductive state. However, when the transistor **71** is rendered non-conductive at a relatively low rate, during the relatively long period that the transistor **71** is non-conductive, the capacitor **66** has a chance to fully charge, thus enabling the circuit to be returned to its stable non-conductive state.

The means for alternatively rendering the transistor **71** conductive and non-conductive is the safety switch **48** which is coupled to the slip clutch output shaft **42**. As shown in FIG. 3, the safety switch **48** may comprise a commutator like a rotor **48*a*** having circumferentially spaced peripheral ribs **48*b*** which are engaged by a wiper blade **48*c***. The rotor **48*a*** is connected to ground so the wiper blade **48*c*** is periodically grounded at a rate depending on the speed of rotation of the rotor **48*a***. The wiper blade **48*c*** is connected through a capacitor **77** and a resistor **78** to the base **71*b*** of the transistor **71** and is connected through a resistor **80** and a rectifier **82** to the collector **53*c*** of the transistor **53**. It can thus be seen that in each interval during which the wiper blade **48*c*** does not contact any of the rotor segments **48*b***, the capacitor **77** will charge through a circuit including the emitter and collector of the transistor **53**, conductor **65**, rectifier **82**, resistor **80**, resistor **78**, resistor **75** and the collector and emitter of the transistor **55**. The positive voltage pulse developed across the reistor **75** during each charging of the capacitor **77** will develop a positive voltage on the base **71*b*** of the transistor **71** which will render the same conductive. Transistor **71** will be non-conductive in the absence of such a pulse. When the wiper blade **48*c*** contacts a grounded rib **48*b*** on the rotor **48*a***, the resultant grounding of the capacitor **77** will cause the discharge of the capacitor **77**. The rectifier **82** serves the function of preventing a leakage current path to the base **55*b*** of the transistor **55** when the circuit is supposedly in a non-conductive state. In the absence of the rectifier **82**, a leakage path can be traced through the relay **22**, the conductor **65**, resistor **75**, resistor **78**, resistor **80**, resistor **59**, and the conductor connected to the base **55*b*** of the transistor **55**.

Although a variety of means may be utilized to trigger the monostable circuit to its unstable state, it is most advantageous from the standpoint of economy, simplicity and reliability that such means include a capacitor **84** having one plate **84*a*** preferably connected directly to the input **28*a*** of the circuit and another plate **84*b*** coupled to the positive voltage source terminal **26*a*** through a resistor **86** of relatively large value, a resistor **88** of a relatively small value, and a circuit branch including the capacitor **66** in parallel with resistor **73** and transistor **71**, resistor **67**, and resistor **69** in parallel with the emitter to base electrode of the transistor **53**. Although, in some cases, the resistor **88** may be eliminated completely, it is preferably present for a number of reasons including the isolation of the capacitor **84** from the collector **55*c*** of the transitsor **55**.

The resistor **86** is shunted by a rectifier **90** having its cathode **90*a*** connected to the capacitor connected side of the resistor **86**. As will appear, the rectifier **90** by-passes the resistor **86** during the charging of the capacitor **84** when the input **28*a*** is grounded, but forces the capacitor **84** to discharge through the relatively large resistor **86** when the input **28*a*** is grounded at an instant when the capacitor **84** is reverse charged, that is when the left plate **84*a*** is positive with respect to the right plate **84*b***. The capacitor **84** discharges through a circuit including the resistor **86**, rectifier **92** and resistor **89** connected to the load resistor **61** of the transistor **53**. The rectifier **92**, among other things, isolates the base **55*b*** of transistor **55** from the positive voltage terminal **26*a*** when power is initially turned on.

The grounding of the input **28*a*** is accomplished by the interconnection of the control terminals **24–24′** in the manner described. Thus, when the input **28*a*** is grounded by the circuit described, a charge path is established for the capacitor **84** extending through resistors **69**, **67**, **88**, capacitor **66** and rectifier **90**, as best illustrated in FIG. 4, where the plate **84*b*** of the capacitor **84** will be positive with respect to the other plate **84*a***. The flow of this charging current through resistor **69** develops a drive voltage for transistor **53** (FIG. 3) which triggers it into conduction. The resulting current flow will generate a positive voltage across resistor **61** coupled to the base **55*b*** of transistor **55** to trigger it into conduction to energize relay **22** and start the movement of the garage door. The inertia of the garage door will require a certain time to reach full speed. It is important, therefore, that the time it takes capacitor **66** to fully charge from zero be longer than the period during which transistor **71** is non-conductive in the interval between successive positive pulses generated across resistor **75** as the slip clutch output shaft speeds up from rest. Resistor **67** in series with capacitor **66** is made sufficiently large to prevent capacitor **66** from fully charging during the longest of these intervals. A capacitor **96** placed across resistor **69** provides the circuit with immunity from short duration electrical disturbances of the type generated from near-by motors, sparking switches, etc. which could undesirably trigger the monostable into the conductive state. Similarly, capacitor **105** placed across resistor **61** operates in conjunction with resistor **61** to provide a similar immunity against such false triggering of the circuit.

When ground is removed from the input **28*a***, as by cessation of the radio signal or release of the pushbutton switch **11**, a discharge and reverse charge path for the capacitor **84** is established as shown in FIG. 5 through a circuit including the resistor **32** connected between the input **28*a*** and the positive voltage source terminal **26*a***, resistor **86**, resistor **88**, and the collector **55*c***, and emitter **55*a*** of the then conducting transistor **55**. The capacitor recharges to a voltage where the plate **84*a*** connected to the input **28*a*** will be positive with respect to the plate **84*b***. The resistor **86** makes the discharge circuit time constant so long that a momentary opening of the pushbutton switch **11** used to ground input **28*a*** due to bouncing of the pushbutton conducts when it is depressed will not allow the capacitor to reverse charge until the pressure on the pushbutton switch is released. If the capacitor is allowed to reverse charge during such contact bouncing, the second reclosure of the bouncing contacts would cause discharge of the capacitor through the disharge circuit including the resistor **86**, rectifier **92**, resistor **88** and resistor **61** where a negative voltage would be developed across resistor **61** which would render the transistor **55** and the whole monostable circuit non-conductive to de-energize the motor **25**. FIG. 7 illustrates how the second reclosure of the bouncing pushbutton contacts would cause an undesired resetting of the circuit if resistor **86** and rectifier **90** were removed permitting the reverse charging of the capacitor **84** under these conditions. FIG. 6 illustrates how the reclosure of the bouncing pushbutton switch **11** before capacitor **84** reverse charges cannot establish flow of current through resistor **61** to reset the circuit. The desired reverse charging of the capacitor **84** obtained by the cessation of the radio signal or release of the pushbutton switch, may be used to manually stop the motor by a subsequent reclosure of the pushbutton switch **11** which causes the discharge of the capacitor through resistor **61** in a manner like that shown in FIG. 7.

When the transistor **55** is rendered non-conductive for any reason, the sudden cessation of current flow through the transistor **55** will result in the generation of a relatively high voltage across the inductance of the relay **22**. This voltage causes current to flow through the resistors **67** and **69** in the base circuit of transistor **53** which renders the transistor **53** non-conductive. It should be noted that the capacitor **84** then has a possible charge path through resistors **67** and **69** which, if such path were allowed to be established, would prevent the turning off of the transistor **53**. Thus, the voltage build-up across the relay **22** prevents the establishment of this circuit when transistor **55** is triggered into its non-conductive state. The time constant of the circuit in which relay **22** acts must be such as to prolong the effect of this voltage until capacitor **84** becomes substantially fully charged through a D.C. path including the relay **22**.

To prevent the generation of an excessive voltage across the relay **22** when transistor **55** becomes non-conductive, a resistor **97** connected in series with a rectifier **99** is placed across the relay. When the transistor **55** becomes non-conductive, the rectifier **99** and the resistor **97** forms an alternate path for flow of current in the relay. However, the resistor **97** provides only a partial path for the current flow through the relay. The remainder of the current flows through the base circuit of the transistor **53** to keep the transistor **53** in a non-conductive state as just explained.

As above indicated, although the monostable circuit **28** may be turned off by the manual operation of the pushbutton switch **11**, or the slowing down of the slip clutch output shaft **42** by an obstruction to the movement of the garage door, the circuit is normally rendered non-conductive or reset by the closure of limit switches **49–1** or **49–1'** as the garage door reaches one of its limits of travel. The monostable circuit is hereby reset by the generation of a negative voltage across the resistor **61** coupled to the base **55*b*** of the transistor **55** through a circuit including a resistor **100** and a capacitor **102** connected in series between one of the terminals of the limit switches **49–1** and **49–1'** and the resistor **61**. The other terminals of the limit switches **49–1** and **49–1'** are grounded. A resistor **104** is connected between the ungrounded terminals of the limit switches **49–1** and **49–1'** and the juncture of the rectifier **82** and resistor **80**. It should thus be seen that, when the transistor **53** is in a conductive state, the capacitor **102** will charge to a voltage where the upper plate **102*a*** is positive with respect to the lower plate **102*b*** through a circuit including resistor **104**, resistor **100** and resistor **61**. When the limit switch **49–1** or **49–1'** is closed, the capacitor **102** discharges through a number of resistors including resistor **61**, thereby creating a negative voltage across the resistor **61** which will render the transistor **65** non-conductive. The limit switches **49–1** and **49–1'** can be relatively inexpensive switches where bouncing or other momentary opening of the contacts **49–1** or **49–1'** is possible because the action of switches **49–1** and **49–1'** is such that any momentary closure can only produce a turn-off command to the monostable circuit. Successive closures of the limit switch can only attempt to turn transistor **55** off, which is redundant after the first closure.

Exemplary values for many of the circuit parameters in FIG. 1 are as follows:

Resistor **32**—100 ohms
Capacitor **84**—0.22 microfarads
Resistor **86**—2.2 megohms
Resistor **86**—10,000 ohms
Resistor **67**—5,000 ohms
Resistor **69**—5,000 ohms
Capacitor **66**—25 microfarads
Resistor **97**—330 ohms
Resistor **104**—10 megohms
Capacitor **102**—0.1 microfarads
Resistor **75**—22,000 ohms
Resistor **78**—33,000 ohms
Capacitor **77**—0.1 microfarads
Resistor **80**—10,000 ohms
Capacitor **96**—.05 microfarads
Resistor **59**—10,000 ohms

Resistor **61**—10,000 ohms
Resistor **89**—3,300 ohms
Capacitor **105**—0.1 microfarads
Relay **22**—resistance typically 300 ohms, inductance 2.4 (minimum) millihenries
Resistor **73**—270 ohms
Resistor **100**—3,300 ohms

It should be understood that numerous modifications may be made in the most preferred form of the invention described above, without deviating from the broader aspects thereof.

I claim:

1. In a system for controlling the movement of a member from a first to a second position, said system including an electric motor having a shaft coupled to a slip clutch having an output shaft which is coupled to said member and slows down relative to said motor shaft when free movement of said member is hindered, and control means which has a motor operating condition which effects energization of said motor and a non-operating condition which effects de-energization of said motor, and control signal generating means for generating a signal to operate said control means to said operating condition, the improvement comprising a monostable circuit which controls said control means, said monostable circuit having a first stable state which operates said control means to said nonoperating condition and an unstable state which operates said control means to said operating condition, said monostable circuit including a capacitor which, when it is charged to a given level, effects the return of said monostable circuit to said stable condition, and charge inhibiting means responsive to the speed of rotation of said slip clutch output shaft for inhibiting the charge of said capacitor in accordance with the speed of said slip clutch output shaft, the degree of inhibition thereof being sufficient to keep said capacitor from reaching said given charge level when the slip clutch output shaft is rotating at normal speed and being insufficient to keep said capacitor from reaching said given charge level when the slip clutch output shaft is rotating at a much lower than normal speed.

2. The system of claim **1** wherein there is provided delay means for inhibiting the effect of said capacitor on said monostable circuit when charged to said given level for a given period sufficient to permit the movable member to be accelerated by said motor from rest to its normal speed.

3. The system of claim **1** wherein said charge inhibiting means comprises switch means in parallel with said capacitor, means for alternately rendering said switch means conductive and non-conductive at a rate depending upon the speed of said slip clutch output shaft, the switch means being non-conductive for a sufficient period to permit said capacitor to charge to said given level only when said clutch output shaft is at said lower speed.

4. The system of claim **3** wherein said monostable circuit includes first and second complimentary transistors each having a base terminal and collector and emitter load terminals; a source of D.C. voltage having first and second voltage output terminals across which a D.C. voltage appears; first load impedance means; second load impedance means; means for connecting the load terminals of said first transistor and said first load impedance means in series in the order named between said first and second voltage output terminals of said source of D.C. voltage; means for connecting said second load impedance means and the load terminals of said second transistor in series in the order named between said first and second voltage terminals of said source of D.C. voltage; means for connecting said first load impedance means to the base terminal of said second transistor for effecting conduction of said second transistor when current flows through the terminals of said first transistor and the first load impedance means; means coupling the base terminal of said first transistor through said capacitor to the load terminal of the second transistor remote from said second voltage output terminal for rendering said first and second transistors non-conductive when said capacitor becomes substantially fully charged; and means for coupling said signal generating means to the base of said first transistor to trigger the same into conduction upon momentary operation thereof.

5. In a system for controlling the movement of a member between extreme limits, said system including an electric motor having a shaft coupled to a slip clutch having an output shaft which is coupled to said member and slows down relative to said motor shaft when free movement of said member is hindered, the improvement comprising: a flip-flop type monostable circuit for controlling the energization and de-energization of said motor, said monostable circuit having a stable state which effects the de-energization of said motor and an unstable state which effects energization of said motor, means responsive to the speed of operation of said slip clutch output shaft for holding said monostable circuit in said unstable state while said slip clutch output shaft is operating at a normal speed and for allowing said monostable circuit to return to said stable state when the speed of operation of said slip clutch output shaft drops to a speed below said normal speed, and control means for instantaneously terminating the unstable state of said flip-flop monostable circuit independently of the speed of said input shaft to de-energize the motor.

6. The system of claim **5** wherein there is provided delay means which inhibits the return of the monostable circuit from its unstable to its stable state despite the operation of said slip clutch output shaft at a speed below the normal speed for a period sufficient to permit the movable member to be accelerated from rest to its normal speed.

7. In a trigger circuit including a source of D.C. voltage having first and second voltage output terminals across which a D.C. voltage appears; first normally open contacts operable momentarily from an open to a closed condition; a capacitor having a pair of plates, said switch means coupling one of the plates of said capacitor to one of said voltage output terminals; first control impedance means; first capacitor charge circuit-forming means connecting the other plate of said capacitor to said control impedance means and the other voltage output terminal for charging said capacitor in one direction when said switch contacts are first momentarily closed; means coupling the voltage across said control impedance means during said charging of said capacitor therethrough to trigger the circuit from an initial state into a given state; first capacitor discharge and reverse charge circuit-forming means including means coupled between said other plate of the capacitor and said one voltage output terminal and between the one plate of said capacitor and said other voltage output terminal for effecting the discharge and then the reverse charging of said capacitor when said momentarily operated contacts return to their open condition; second control impedance means; second capacitor discharge circuit-forming means coupling said second control impedance means between said other plate of said capacitor and said one voltage output terminal for discharging said capacitor through said second control impedance means upon the second operation of said switch means to said closed condition; and means coupling the voltage across said second control impedance means during said discharging of said capacitor for resetting said trigger circuit to said initial state; the improvement comprising means for preventing the bouncing of said contacts from resetting said trigger circuit comprising a rectifier coupled in series with said capacitor during said charging thereof for permitting charge current to flow thereto during said first mentioned closure of said contacts but blocking the discharge thereof when said contacts momentarily open and suddenly reclose a second time before the capacitor has a chance to reverse charge, and a relatively large impedance in parallel with said rectifier and connected in the discharge and reverse charging circuit of said capacitor for slowing down the discharge of said capacitor during the first opening of said contacts for preventing the reverse charging of said capacitor during said momentary opening of said contacts to prevent the resetting of the trigger circuit during the bouncing of said contacts.

8. The system of claim **5** wherein said member is a garage door movable between extreme garage opening and closing positions, and said control means includes first means responsive to a manual operation for triggering said monostable circuit to said unstable state and second means responsive to the movement of the garage door to either of said extreme positions for triggering said monostable circuit to said stable state.

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