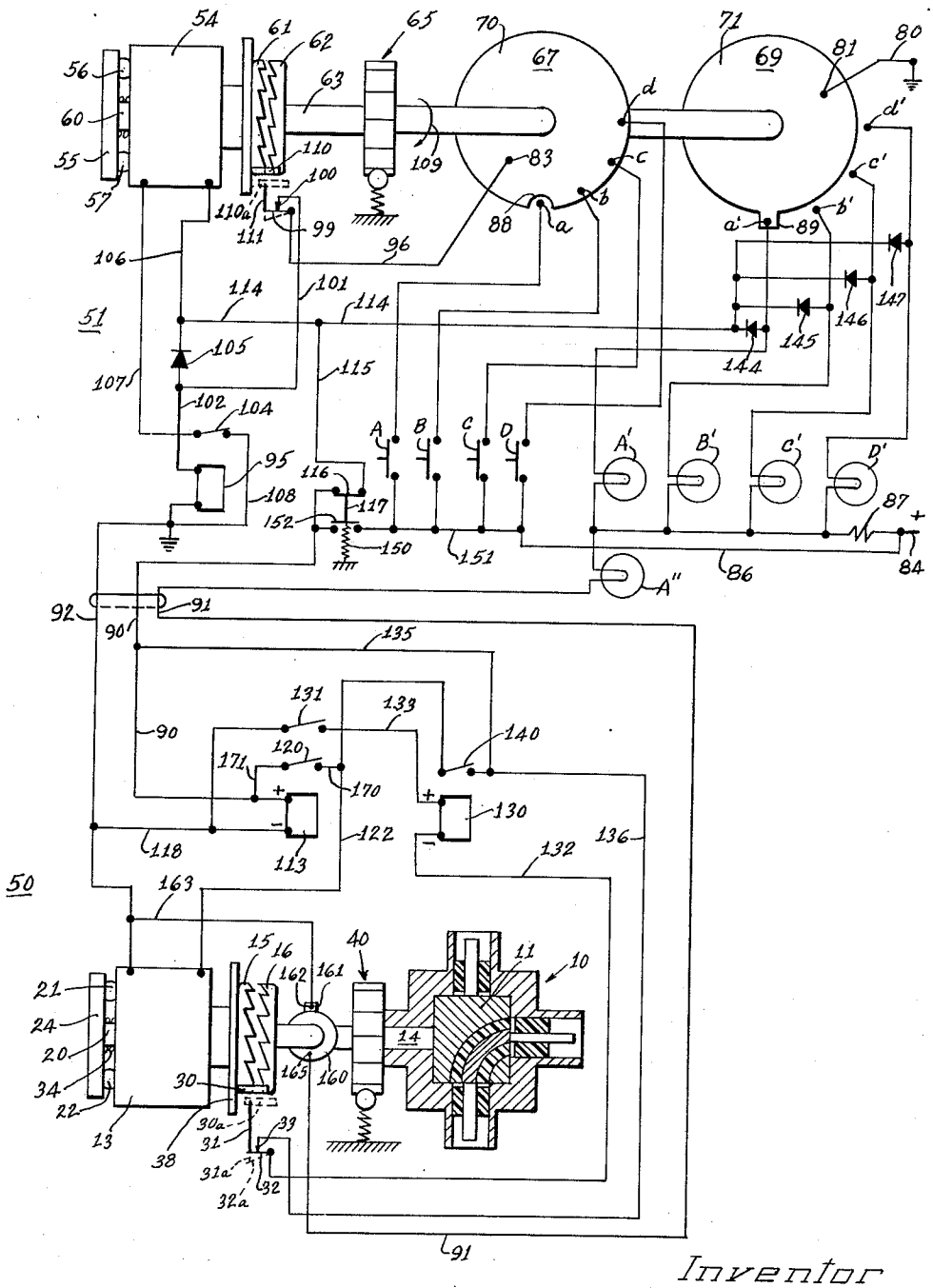
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FAILURE INDICATING CIRCUIT FOR SLAVE DRIVEN UNIT

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FAILURE INDICATING CIRCUIT FOR SLAVE DRIVEN UNIT

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This invention relates to a failure indicating circuit and particularly to such a circuit for a slave driven unit.

It is a particular object of the present invention to provide a reliable failure indicating circuit of maximum simplicity.

It is another object of the present invention to provide a failure indicating circuit for a slave driven unit wherein the failure indicating circuit operates over the same connecting wires which connect the slave circuit with the master control circuit.

A further object of the present invention is to provide a novel coaxial switch positioning system wherein switch position is selected at a remote station.

Yet another important object of the invention is to provide a remotely controlled coaxial switch system which will give a failure indication at the control station and which system utilizes a minimum number of wires for coupling the control station with the coaxial switch actuating circuit.

Another object is to provide novel means for synchronizing the position of indexing mechanism at a control station with the position of the coaxial switch rotor being controlled from said station and for indicating when synchronization has been achieved.

Other important objects, features and advantages of the present invention will be apparent from the following detailed description taken in connection with the accompanying drawings, in which:

The single FIGURE shows a diagrammatic illustration of the present invention as applied to the remote control of a coaxial switch.

As shown on the drawings:

In the illustrated embodiment, a coaxial switch **10** has a rotor member **11** which is to be selectively moved to a plurality of switching positions. By way of example, there may be 12 switching positions separated by 30 degrees, and in the illustrated embodiment the circuit connections for four successive ones of such positions have been illustrated. The rotor **11** is to be moved to the selected position by means of a rotary solenoid **13** of conventional construction which is coupled to the shaft **14** of rotor **11** by means of a suitable set of driving jaws **15** and **16** which in the illustrated embodiment cooperate to rotate the rotor shaft **14** through 30 degrees in each actuation of the solenoid **13**. The rotary solenoid may be of the conventional type illustrated in Schunemann and Thoren U.S. Patent No. 2,840,786 and may include an armature **20** which is shifted to the right as seen in the drawings each time the solenoid **13** is energized. Ball means such as indicated at **21** and **22** cooperate with a cam plate **24** secured for movement with the armature **20** to cause the armature and the driving jaw **15** connected therewith to rotate as the armature **20** is projected from the solenoid **13**. The parts are so arranged that upon each energization of the solenoid **13**, the driving jaw **15** is moved into engagement with the driving jaw **16** and rotated an angular distance of 30 degrees. An interrupter mechanism is conventionally associated with such a rotary solenoid and may comprise an interrupter arm **30** mounted for movement with the driving jaw **15** and arranged after completion of 30 degrees of rotation to actuate a switch arm **31** to open switch contacts **32** and **33**. In the present embodiment, it is important

that the interrupter mechanism **30**, **31** open contacts **32** and **33** only after the driving jaw **15** substantially completes its driving stroke. Spring means are diagrammatically indicated at **34** for urging the cam plate **24** to the left as seen in the drawing to return the armature **20** and driving jaw **15** to their original angular and axial positions after each energization of the solenoid **13**. The switch contacts **32**, **33** of course, return to closed position as soon as the solenoid **13** is deenergized and the driving jaw **15** and interrupter arm **30** begin to return to initial position. By way of example only, arm **30** may be positioned at the outer periphery of circular flange **38** and may travel downwardly and inwardly (into the plane of the drawing). The arm **30** engages the switch arm **31** at the end of its stroke to press the arm **31** downwardly. The arm **30** has sufficient arcuate extent to maintain its contact with arm **31** during the remainder of its stroke. The final position of arms **30** and **31** and contact **32** are indicated in dotted outline at **30***a*, **31***a* and **32***a*. Suitable means may be provided (not shown) for guiding the vertical reciprocation of arm **31** and for resiliently returning contact **32** and arm **31** to their initial positions as arm **30** is returned to its original position by spring **34** after deenergization of solenoid **13**.

Any suitable detent means such as diagrammatically indicated at **40** may be utilized on the rotor shaft **14** to insure that the rotor **11** is precisely positioned in each successive switching orientation. A twelve position detent mechanism for the rotor shaft is illustrated in said Schunemann and Thoren Patent No. 2,840,786.

For driving the coaxial switch actuating system designated generally by the reference numeral **50** as a slave unit from a remote master station indicated generally at **51**, a master solenoid **54** is provided which may have the same construction as the solenoid **13** including a cam plate **55** cooperating with ball means such **56** and **57** to translate axial projection of the armature shaft **60** into rotation thereof, the rotational movement of driving jaw **61** on shaft **60** being transmitted to driving jaw **62** and shaft **63**. Shaft **63** may have a suitable detent means **65** similar to the detent means **40** and may carry wafer switch means **67** and **69** including conductive rotors **70** and **71** and stationary contacts *a*, *b*, *c* and *d* and *a'*, *b'*, *c'* and *d'* respectively. A ground is continuously supplied to the conductive rotor **71** by means of line **80** and sliding contact **81** which continuously engages rotor **71**. A sliding contact **83** makes continuous contact with the conductive rotor disk **70**. Push buttons A, B, C and D connect positive line voltage from supply line **84** through line **86** to the respective contacts *a*, *b*, *c* and *d* of disk **70**. Line **84** also supplies positive potential through resistor **87** to indicator lamps A', B', C' and D' whose other terminals are connected to contacts *a'*, *b'*, *c'* and *d'* of conductive disk **71**. With the coaxial switch in the position shown, lamp A' will be lit to indicate that the rotor is in what may be termed the A position where cut-away portion **88** of disk **70** isolates contact *a* and the projection **89** from conductive disk **71** engages the contact *a'* to supply ground from line **80** to the upper terminal of lamp A'.

Only two wires indicated at **90** and **91** plus a ground connection (indicated diagrammatically by line **92**) are required to connect the master control circuit **51** with the actuated slave circuit **50** as will be apparent from the following description of the operation of the illustrated system.

If it is desired to move the rotor **11** from the A position shown to a position such as B, C or D, the corresponding pushbutton B, C or D is depressed momentarily to energize the relay **95**. For example, if pushbutton B is depressed, relay **95** is energized by completion of an electric circuit extending from line **84** of positive polarity,

through pushbutton B, contact *b*, disk 70, contact 83, line 96, interrupter contacts 99, 100, line 101, line 102, and the energizing coil of relay 95 to ground. Energization of relay 95 closes relay contact 104 and this causes energization of solenoid 54 from line 101 through rectifier 105, line 106, solenoid 54, line 107, contact 104 and line 108 to ground. Energization of solenoid 54 shifts armature shaft 60 to the right and cam plate 55 cooperating with balls 56 and 57 rotates the shaft 60 as it is driven axially. This produces a 30° rotation of driving jaw 62 and shaft 63 in the clockwise direction as indicated by arrow 109. When the driving jaw 61 has rotated through substantially 30°, interrupter arm 110 will have travelled arcuately downwardly substantially 30° to the position indicated at 110*a* to engage interrupter arm 111 and open contact 99 to deenergize solenoid 54 and relay 95.

Actuation of pushbutton B also energizes latching relay 113 to energize solenoid 13. The energizing circuit for relay 113 extends from line 101 through rectifier 105, line 114, line 115, contact 116 of synchronizing pushbutton 117, line 90, latch coil of relay 113, line 118 and line 92 to ground. Closure of relay contact 120 of relay 113 energizes solenoid 13 by applying positive polarity voltage from conductor 90 through contact 120 and line 122 to one terminal of solenoid 13, the other terminal being grounded by line 92.

Latching relay 130 is not energized by closure of contact 131 of relay 13 during normal operation since the relay is so polarized as to be latched only when a negative polarity voltage is applied to line 132 with line 133 grounded. Relay 130 is unlatched when a positive polarity voltage is applied to line 132 with line 133 grounded. Since pushbutton B applies a positive voltage to line 132 of relay 130 via line 90, line 135, line 136, and interrupter contacts 32 and 33, the relay remains unlatched.

When interrupter contact 99 is opened, solenoid 13 is deenergized and produces an electromotive force of polarity to apply a negative voltage to line 122 relative to line 92 which is a function of the inductance of the solenoid 13 and the rate of change of current therein when the interrupter contacts 99 and 100 are opened. This induced electromotive force applies a negative polarity to the upper terminal of relay 113 via line 122 and contact 120 unlatching the relay.

If, for any reason, driving jaw 15 has failed to rotate the required 30° while solenoid 13 is energized, contacts 32, 33 will not have opened and the induced electromotive force due to deenergization of solenoid 13 will latch failure indicating latching relay 130 from line 122 through contact 120, line 90, line 135, line 136, interrupter contacts 32, 33 and the line 132 to the lower terminal of latching relay 130, the upper terminal of latching relay 130 being connected to line 92 through line 133 and contact 131. The characteristics of relay 113 and the associated circuitry are such as to insure that relay 130 is latched before the induced electromotive force from solenoid 13 is effective to unlatch relay 113.

Thus, in the event of a failure of the solenoid 13 to execute a driving stroke of 30°, relay 130 is latched to apply a ground from line 92 through solenoid 13, line 122, contact 140 of latching relay 130, line 135, line 90, lines 115 and 114 and through each of rectifiers 144, 145, 146 and 147 to energize each of lamps A′, B′, C′ and D′. Thus, the simultaneous lighting of all of the coaxial switch position indicating lamps signals a failure in the operation of the system.

It will, of course, be understood that the characteristics of the interrupter switch 32, 33 and solenoid 13 are such that the switch will normally remain open until the induced E.M.F. from solenoid 13 has unlatched relay 113. After this, of course, spring 34 returns jaw 15 to its initial position and allows contacts 32, 33 to reclose. On the other hand, if the contacts 32, 33 are still closed at the time of deenergization of solenoid 13, latching relay 130 will be energized and latched before the electromotive force from the solenoid 13 has taken effect to unlatch the relay 113.

It will be understood that the failure indication is achieved over the same two lines 90, 92 which are used to couple the control system 51 with the slave circuit 50, thus providing maximum simplicity and reliability in the operation of the failure indicating circuit.

The switch 117 is normally maintained in its upper position as shown in the drawings by means of a compression spring 150 and may be depressed manually to apply a positive actuating voltage to line 90 via lines 86 and 151 and contact 152 of the pushbutton 117 to step the coaxial switch rotor 11, in case the master indexing mechanism 67, 69 of the master circuit 51 is out of correspondence with the actual position of rotor 11 of coaxial switch 10. To signal the correspondence in angular positions of the master circuit 51 and slave circuit 50, a conductive disk 160 is secured to shaft 14 of rotor 11 and has a conductive contact 161 movable therewith which is adapted to engage a stationary contact 162 when the switch rotor 11 is in the A position shown in the drawings. Whenever rotor 11 is in the position shown in the drawings, ground is applied from line 92 over line 163 to contact 162 and through disk 160 to stationary continuous contact 165 and then via line 91 to an auxiliary A position lamp A″ to energize the lamp A″. Similarly, when the master control mechanism 51 is in the A position, lamp A′ will be energized. When both lamps A′ and A″ are lit, the master control circuit 51 is in angular correspondence with the slave circuit 50. If lamp A′ is lit, but lamp A″ is not lit, pushbutton 117 is actuated repeatedly until the lamp A″ lights indicating that the switch rotor 11 is in the corresponding angular position.

Summary of Operation

Summarizing the operation of the device, to move the coaxial switch rotor 11 to a new position, the corresponding pushbutton B, C or D, for example, is held depressed until the corresponding position indicating lamp such as B′, C′ or D′ is lit indicating that the rotor 11 has moved to the selected position. If, however, in any of the successive actuations of the slave solenoid 13, its driving jaw 15 fails to complete the required 30° driving stroke, switch contacts 32, 33 remain closed, and upon deenergization of solenoid 13 by opening of interrupter contacts 99, 100 associated with master solenoid 54, an E.M.F. is generated by solenoid 13 of polarity to apply a negative voltage to line 122 relative to grounded line 92 which energizes latching relay 130 through the circuit from line 122, through line 170, contact 120 of latching relay 113, line 171, line 90, line 135, line 136, contacts 32, 33 and line 132 to the lower terminal of latching relay 130 and from the upper terminal of latching relay 130 through line 133, relay contact 131 to line 92. This latching of relay 130 will occur before contacts 120 and 131 of latching relay 113 open because the unlatching current for relay 113 is generated by the E.M.F. from solenoid 13. When latching relay 130 is latched indicating a fault, a ground is applied from line 92 through solenoid 13, line 122, contact 140 of relay 130, line 135, line 90, line 115, and line 114, and through rectifiers 144—147 to light all of lamps A′, B′, C′ and D′ indicating a failure. In normal operation, latching relay 130 is not latched because the polarity of applied voltage at line 132 is positive and is that operative for unlatching relay 130 but opposite to that required for latching of relay 130.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. A remotely controlled actuating system comprising a slave driven unit having an actuating electromagnetic

device for energization to cause the slave unit to execute successive incremental movements, electrically energized failure signalling means operatively associated with said slave driven unit and controlling actuation of said failure indicating means at said remote control station, and means responsive to a failure of said slave driven unit for coupling said electrically energized failure signalling means to said actuating electromotive device for energization by the induced electromotive force generated by said actuating electromotive device upon deenergization thereof by said remote control station to actuate said failure indicating means at said remote control station.

2. A remotely controlled actuating system comprising a slave driven unit having an electromagnetic device for energization to cause the slave unit to execute a predetermined movement, a remote control station for controlling energization of said electromagnetic device and having failure indicating means associated therewith, connecting conductor means linking said remote control station with said slave driven unit for supplying energizing current from said remote control station to said electromagnetic device, electrically energized failure signalling means controlling actuation of said failure indicating means at said remote control station via said connecting conductor means, and means responsive to a failure of said slave driven unit to execute said predetermined movement to couple said electrically energized failure signaling means to said electromagnetic device, said electromagnetic device when deenergized by said remote control station generating an induced electromotive force capable of energizing said electrically energized failure signalling means to thereby actuate said failure indicating means at said remote control station in the event of a failure of said slave driven unit.

3. A remotely controlled actuating system comprising a slave driven unit having an electromagnetic device for energization to cause the slave driven unit to execute successive incremental movements, said electromagnetic device being capable of generating a substantial induced electromotive force upon deenergization thereof, a remote control station for controlling energization of said electromagnetic device and having a failure indicating means associated therewith, switch means having normally closed contacts which are opened momentarily each time the electromagnetic device successfully completes an incremental actuation of said slave driven unit but which remain closed in the event of a failure of said slave driven unit to execute an incremental movement, electrically energized failure signalling means controlling actuation of said failure indicating means at said remote control station and connected with said electromagnetic device under the control of said normally closed contacts of said switch means for energization by the induced electromotive force generated by said electromagnetic device upon deenergization thereof by said remote control station whereby if said normally closed contacts remain closed at the time of deenergization of said electromagnetic device said electrically energized failure signalling means actuates said failure indicating means at said remote control station.

4. A remotely controlled actuating system comprising a slave driven unit having an electromagnetic device for energization to cause the slave driven unit to execute successive incremental movements, said electromagnetic device being capable of generating a substantial induced electromotive force upon deenergization thereof, a remote control station for controlling energization of said electromagnetic device and having failure indicating means associated therewith, switch means having normally closed contacts which are opened momentarily each time the electromagnetic device successfully completes an incremental actuation of said slave driven unit but which remain closed in the event of a failure of said slave driven unit to execute an incremental movement, electrically energized failure signalling means controlling actuation of said failure indicating means at said remote control station and connected with said electromagnetic device under the control of said normally closed contacts of said switch means for energization by the induced electromotive force generated by said electromagnetic device upon deenergization thereof by said remote control station whereby if said normally closed contacts remain closed at the time of deenergization of said electromagnetic device said electrically energized failure signalling means actuates said failure indicating means at said remote control station, said electrically energized failure signalling means being polarity sensitive to respond to a reverse current generated by said electromagnetic device while being insensitive to energizing current from the remote control station to said electromagnetic device for energizing said device.

5. A remotely controlled actuating system comprising a slave driven unit having an electromagnetic device for energization to cause the slave driven unit to execute successive incremental movements, said electromagnetic device being capable of generating a substantial induced electromotive force upon deenergization thereof, a remote control station for controlling energization of said electromagnetic device and having failure indicating means associated therewith, switch means having normally closed contacts which are opened momentarily each time the electromagnetic device successfully completes an incremental actuation of said slave driven unit but which remain closed in the event of a failure of said slave driven unit to execute an incremental movement, electrically energized failure signalling means controlling actuation of said failure indicating means at said remote control station and connected with said electromagnetic device under the control of said normally closed contacts of said switch means for energization by the induced electromotive force generated by said electromagnetic device upon deenergization thereof by said remote control station whereby if said normally closed contacts remain closed as the time of deenergization of said electromagnetic device said electrically energized failure signalling means actuates said failure indicating means at said remote control station, said electromagnetic device comprising a rotary step-by-step solenoid having a driving clutch member normally rotatable through a predetermined arc during each energization of said solenoid, and said switch means being responsive to the successful completion of the arcuate travel of said clutch member to open said normally closed contacts and prevent energization of said electrically energized failure signalling means.

6. A remotely controlled actuating system comprising a slave driven unit having an electromagnetic device for energization to cause the slave driven unit to execute successive incremental movements, said electromagnetic device being capable of generating a substantial induced electromotive force upon deenergization thereof, a remote control station for controlling energization of said electromagnetic device and having failure indicating means associated therewith, switch means having normally closed contacts which are opened momentarily each time the electromagnetic device successfully completes an incremental actuation of said slave driven unit but which remain closed in the event of a failure of said slave driven unit to execute an incremental movement, electrically energized failure signalling means controlling actuation of said failure indicating means at said remote control station and connected with said electromagnetic device under the control of said normally closed contacts of said switch means for energization by the induced electromotive force generated by said electromagnetic device upon deenergization thereof by said remote control station whereby if said normally closed contacts remain closed at the time of deenergization of said electromagnetic device said electrically energized failure signalling means actuates said failure indicating means at said remote control station, said elec-

tromagnetic device comprising a rotary step-by-step solenoid having a driving clutch member normally rotatable through a predetermined arc during each energization of said solenoid, and said switch means being responsive to the successful completion of the arcuate travel of said clutch member to open said normally closed contacts and prevent energization of said electrically energized failure signalling means, said electrically energized failure signalling means comprising a latching relay which is latched in response to current flow produced by the induced electromotive force from the rotary solenoid and which is unlatched by current flow in the opposite direction for energizing said rotary solenoid.

7. A slave actuating system for control from a remote station comprising a slave driven unit including an electromagnetic device for energization from the remote station to execute a predetermined movement, electrically energized failure indicating means, and means for connecting said electrically energized failure indicating means with said electromagnetic device in the event of a failure of said slave driven unit to execute said predetermined movement when energized from the remote station for energization of the electrically energized failure indicating means by the induced electromotive force generated by the electromagnetic device upon deenergization thereof.

8. A slave actuating system for control from a remote station comprising a slave driven unit including an electromagnetic device for energization from the remote station to execute successive incremental movements, switch means operatively associated with said slave driven unit and having normally closed contacts which are opened each time the slave unit successfully completes an incremental movement but which remain closed in the event of a failure of said slave driven unit, and polarity sensitive electrically energized failure indicating means connected with said electromagnetic device under the control of said normally closed contacts for energization by the induced electromotive force generated by the electromagnetic device upon deenergization thereof in the event of a failure, said polarity sensitive failure indicating means being responsive to the polarity of the induced voltage generated by said electromagnetic device but being insensitive to the polarity of voltage applied to said electromagnetic device from the remote station.

9. A remote control system comprising a control station, a remote station remote from said control station, an electric switch at said remote station having a plurality of switching positions and having switch actuating means for shifting said switch between said switching positions, said control station having control means for energizing said switch actuating means to selectively move said switch to any one of said switching positions and having a plurality of indicators, conductor means extending between said control station and said remote station for connecting said control means with said switch actuating means, movable means at said control station coupled to said control means for actuation in synchronism with said switch actuating means to move to respective positions corresponding to the respective switching positions of said switch, said movable means having means for energizing respective ones of said indicators at respective positions of said movable means to indicate the position of said movable means and thereby the position of said switch in the absence of a failure, and means coupled to said switch actuating means and to said conductor means and responsive to a failure of said switch actuating means to transmit a failure indication to said control station via said conductor means.

10. A remote control system comprising a control station, a remote station remote from said control station, an electric switch at said remote station having a plurality of switching positions and having switch actuating means for shifting said switch between said switching positions, said control station having control means for energizing said switch actuating means to selectively move said switch to any one of said switching positions and having a plurality of indicators, conductor means extending between said control station and said remote station for connecting said control means with said switch actuating means, movable means at said control station coupled to said control means for actuation in synchronism with said switch actuating means to move to respective positions corresponding to the respective switching positions of said switch, said movable means having means for energizing respective ones of said indicators at respective positions of said movable means to indicate the position of said movable means and thereby the position of said switch in the absence of a failure, and means coupled to said switch actuating means and to a plurality of said indicators via said conductor means and responsive to a failure of said switch actuating means to energize said plurality of said indicators by means of current flow along said conductor means, thereby signalling that the movable means is out of synchronization with the switch.

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