My invention relates to a remote control and indicating system, and more particularly to an electrical system for controlling from a transmitting station the condition of a device at a receiving station and for simultaneously indicating at the transmitting station the condition of the controlled device.

An object of my invention is to provide an improved remote control and indicating system of the above type which requires only two electrical connections between the transmitting and the receiving station.

It is a further object of my invention to provide an improved remote control and indicating system which permits the condition of a remotely located device to be continuously changed and indicates at the transmitting station the amount of the change.

It is a still further object of my invention to provide an improved remote control and indicating system which permits sequential operation of a plurality of remotely located devices and indicates at the transmitting station the operation of the remotely controlled devices.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof may be best understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 is a diagrammatical representation of a remote control system illustrating my invention and Fig. 2 is a modification of the system shown in Fig. 1.

Referring to Fig. 1 of the drawing a transmitting station indicated generally at 10 is connected to a receiving station indicated generally at 11 by the conductors 12 and 13. According to my invention the controlled device at the receiving station, which has been illustrated by way of example as a motor operated valve 14, is controlled by a switch 15 located at the transmitting station and the condition of the motor driven valve 14 is indicated at the transmitting station by the signal lights 16, 17, and 18. The manner in which my control system functions to give this result will now be given in detail.

The conductors 12 and 13 are connected at the transmitting station to unidirectional potential supply lines 19 and 20 by the conductors 21 and 22 and a double-pole double-throw switch 15 which is arranged so that when the switch 15 is in one contact engaging position the conductors 12 and 13 are energized with a unidirectional voltage of one polarity and when the switch 15 is thrown in the opposite contact engaging position they are energized with a unidirectional voltage of the opposite polarity. The valve 14 is driven by an electric motor 23 through suitable gearing 24 and the motor is energized from a pair of direct current supply lines 25 and 26. The motor 23 has two reversely wound series field windings 27 and 28 so arranged that when one field winding is energized the motor will rotate in one direction and when the other is energized the motor will rotate in the opposite direction in a well-known manner. A polarized relay 29 having a movable switch member 30 and stationary contacts 31 and 32 is connected across the conductors 12 and 13 at the receiving station 11. When the polarity of the conductors 12 and 13 is in one direction the movable switch member 30 will move to the left engaging contact 31 and when the polarity is in the reverse direction the switch arm 30 will move to the right engaging contact 32. By connecting the motor fields 27 and 28 to the contacts 31 and 32 and connecting the movable switch member to one side of the direct current supply line 25, 26 as illustrated in the drawing the motor driving the valve may be made to rotate in one direction or the other depending upon the polarity of the voltage impressed upon the conductors 12 and 13. Thus it will be evident that when the control switch 15 is moved to one contact engaging position the polarized relay 29 will be energized in one direction causing the motor to rotate and open the valve 14. When the controlled switch 15 is moved to the other contact engaging position, the polarity of the unidirectional voltage applied to the conductors 12 and 13 will be reversed causing the polarized relay to be energized and move in the opposite direction which in turn causes the motor 23 to rotate in the opposite direction and close valve 14. When the switch 15 is in the intermediate position, as shown, the motor 23 is deenergized.

In remote control systems of the present type it is desirable to have an indicating device or devices at the transmitting station so that the operator can tell whether or not the desired control has been effected. For this purpose I have provided indicating devices in the form of electric lamps 16, 17 and 18 which may be arranged to be sequentially operated during the movement of the valve from the closed to the open position so that the operator can tell at any time the approximate degree of opening of the valve 14.

The sequential operation of the indicating
lamps 16, 17 and 18 is accomplished by applying an alternating voltage to the conductors 12 and 13 at the receiving station, the magnitude of which is made dependent upon the degree of opening of the motor valve 14. To do this the conductors 12 and 13 are connected to alternating voltage supplying lines 28, 29 and 30 through a voltage divider 35. It will be obvious by reference to the drawing that as the adjustable slider contact 36 of the voltage divider 35 moves to the left the alternating voltage applied to the conductors 12 and 13 will be decreased and vice versa. The sliding contact 36 of the voltage divider 35 is attached to a threaded nut 37 which engages a threaded portion 37 of a shaft driven by the valve operating motor 22. Thus the position of the slider 35 on the potentiometer and the resulting voltage applied to the conductors 12 and 13 at the receiving station are correlated with the degree of opening of the valve 14.

The indicating lamps 16, 17 and 18 are energized from the alternating current supply lines 38, 40 through normally open contacts of voltage sensitive relays indicated generally at 41, 42 and 43. The voltage sensitive relays may be of any suitable type and are arranged to become sequentially energized as the voltage applied across lines 38, 40 is increased thereby causing the lamps 16, 17 and 18 to become sequentially lighted. I have shown the voltage sensitive relays as being of the so-called "non-linear series resonant" type which, in operation, depend on the occurrence of the phenomenon known as ferroresonance. A more complete description of relays of this type may be found in Patent 2,923,786, Suits, granted August 5, 1959, which is assigned to the same assignee as the present application. The relay 41 comprises a series connected condenser 46 and iron cored saturable reactor 47 having suitable impedences connected to the variable alternating voltage lines 39, 40 through a voltage adjusting resistor 48. A solenoid 49 controlling normally open contacts 50 in series with the energizing circuit of lamp 16 is connected across the condenser 46. When the voltage applied across the series connected condenser and reactor reaches a predetermined value, the current in the circuit suddenly jumps to a high value resulting in an increased voltage drop across condenser 46 causing solenoid 49 to pick up closing contacts 50 to energize signal lamp 16. By manipulating the voltage adjuster 48, the relay 41 can be made to respond to the desired voltage applied across the line 39, 40. When the applied voltage drops below a predetermined value the solenoid 49 drops out opening contacts 50 and deenergizing signal lamp 16. By selecting a proper value of a resistor 51 connected in series with the condenser 46 and reactor 47, the pick-up and drop-out voltage may be made substantially the same which feature is desirable to avoid error in signal operation.

The construction and operation of relays 62 and 63 are the same as relay 41 and corresponding parts have been given corresponding numbers primed to differentiate the relays.

By suitably adjusting the voltage adjusters 46, 48 and 48' the relays 41, 42 and 43 can be made to pick up sequentially as the voltage applied to line 39, 40 is increased and to drop out sequentially as the voltage is decreased.

As pointed out before the alternating voltage applied to conductors 12 and 13 is made to correspond to the degree of opening of the valve 14.

In some cases the lines 44, 45 may be connected directly to the conductors 12 and 13 at the transmitting station 10 and the signal lamps 15, 17 and 18 will become progressively energized as the voltage applied to the conductors 12 and 13 at the receiving station is increased as a result of the opening of valve 14. Similarly the lamps will become energized as the valve 14 moves to the closed position. In other cases, however, where the wires 12 and 13 are small gauge and the distance between the transmitting and receiving station is considerable, the voltage drop along the conductors 12 and 13 is great and only a reduced voltage is available at the transmitting station which is insufficient to operate the voltage sensitive relays 61, 62 and 63. To remedy this I provide a magnetic amplifier to amplify the voltage variations applied to the lines 44 and 45. The amplifier comprises a saturable reactor illustrated schematically at 52 having a direct current input winding 52a and an alternating current output winding 52b. The alternating voltage appearing across the conductors 12 and 13 at the transmitting station is rectified by a full wave rectifier 53, which may be of the diode oxide type, and the resulting unidirectional current is fed to the winding 52a of the saturable reactor 52 with the result that the impedance of winding 52a varies in accordance with the alternating current appearing across conductors 12 and 13. A constant voltage transformer 55 having a primary winding connected to the alternating current supply lines 38 and 40 is used to energize the voltage sensitive relays 41, 42 and 43 to avoid error in operation due to fluctuation in the voltage at line 25. One side of the secondary winding of transformer 55 is connected to line 46 while the other side is connected to the line 44 through the winding 52a of the saturable reactor. The voltage applied to line 44, 45 depends on the impedance of winding 52a which in turn depends on the current in winding 52a and correspondingly the alternating voltage appearing across conductors 12 and 13. This arrangement amplifies sufficiently the indicating voltage applied to line 44, 45 to properly operate the signal lamps.

To prevent the unidirectional voltage applied to line 12, 13 from interfering with the operation of the alternating current circuits I provide blocking condensers 55 and 56. Also to prevent alternating current from flowing in the direct current circuits the choke coils 51 and 54 are utilized.

The operation of the remote control and indicating system shown in Fig. 1 will now be described. The control elements shown in Fig. 1 are in the position they assume when the valve 14 is in the closed position. If now the operator at transmitting station 10 desires to open valve 16, the switch 53 is moved to the contact engaging position which causes the polarized relay to become energized in one direction and motor 23 to rotate in a direction to open the valve. As the motor rotates the sliding contact 36 moves to the left increasing the voltage applied to conductors 12 and 13. This increasing alternating voltage is amplified at transmitting station 10 and the voltage applied to lines 44, 45 also correspondingly increases. When the valve has opened a predetermined amount, relay 41 picks up energizing signal lamp 16. Similarly the valve continues to open, signal lamps 15, 17 and 18 become sequentially energized. The lamp 18 may be arranged to light when the valve 14 reaches the wide open position so that the operator will
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know when to open switch 15 and stop the drive motor 23.

If the operator then moves the switch 15 to the opposite contact engaging position, the polarized relay will be energized in the opposite direction and the motor 23 will rotate in a direction to close the valve 14, which moves back towards its initial position decreasing the alternating voltage applied to the conductors 12 and 13 and consequently causing the signal lamps 16, 17 and 18 to become deenergized in a reverse order. The relay 41 may be adjusted so that lamp 16 of the valve 14 reaches the closed position and the operator will know when to return the switch 15 to the center or deenergized position.

It is obvious that a greater or smaller number of signal lamps and relays may be used. However, the greater the number of signal lamps provided, the more accurately the position of the remotely controlled device can be determined by the operator since smaller increments of change can be made to operate a signal lamp. It is also obvious that instead of signal lamps, other well-known forms of indicating devices could be used such as, for example, differently toned bells or buzzers, etc. without departing from my invention in its broader aspects.

While I have illustrated the system as being used to control a valve, it will be apparent to those skilled in the art that the system may be used to control many other devices such as, for example, a voltage regulator, circuit breaker, etc. without departing from my invention.

The modification shown in Fig. 2 of the wiring is generally similar to that shown in Fig. 1 and corresponding parts have been given the same reference numerals. However, in the Fig. 2 modification, the control of the device or devices located at the receiving station is accomplished by changing or altering a different characteristic of the unidirectional voltage applied to the conductors 12 and 13. In this modification the magnitude of the unidirectional voltage applied to the conductors 12 and 13 at the transmitting station is changed instead of reversing the polarity as in the Fig. 1 arrangement.

In addition, a series of voltage sensitive relays responsive to the magnitude of the unidirectional voltage across the conductors 12 and 13 are used to effect the desired control. Also in this arrangement I have shown the remote control system arranged to provide sequence control a plurality of separate electrical load devices 15, 16, and 17.

Coming now to the specific details of the embodiment illustrated in Fig. 2, conductors 12 and 13 are connected to the unidirectional voltage supply lines 19, 20 through a voltage divider 21 having a sliding contact 22. It is evident that by moving the contact 22 the unidirectional voltage applied to the conductors 12 and 13 at the transmitting station may be conveniently varied.

At the receiving station 11 are located three voltage sensitive relays 61, 62, and 63, which may be, as shown, similar in construction to the indicating relays 41, 42 and 43 described in connection with Fig. 1. These relays are energized from the secondary winding of a constant voltage transformer 64, the primary winding of which is energized from the alternating current supply line 33, 34 through lines 65, 66. The voltage applied to these relays is controlled by the variable impedance winding 68 of the saturable reactor 67. By connecting the saturating winding 69 of the saturable reactor 67 across the conductors 12 and 13 at the receiving station the impedance of winding 68 and consequently the voltage applied to relays 61, 62 and 63 varies in accordance with the magnitude of the unidirectional voltage supplied the line 12, 13 at the transmitting station. By properly adjusting the voltage adjusters 70, 70' and 70' the solenoids 71, 71' and 71'' of relays 61, 62, and 63 may be made to pick up sequentially as the unidirectional control voltage is increased and vice versa. The electrical load devices 75, 76 and 77 are connected to the supply line 33, 34 through normally open contacts 72, 73, 74 which are controlled respectively by the solenoids 71, 71' and 71''.

Conductors 12 and 13 are connected at the receiving station to the alternating current supply lines 33, 34 through the series connected resistors 75a, 76a, 77a. These resistors are shunted by circuits including the normally open contacts 78, 79 and 80 which are also controlled by the solenoids 71, 71' and 71''. The remainder of the Fig. 2 arrangement is the same as that of Fig. 1. The operation of the remote control and indicating system shown in Fig. 2 is as follows. If the unidirectional voltage applied to the conductors 12 and 13 is increased by moving the sliding contact 60 to the right, relay 61 picks up closing contacts 72 and 78. The closing of contact 72 connects the load device 75 to the lines 33, 34, and the closing of contact 78 shunts out resistor 75a and thereby increases the alternating voltage applied to conductors 12 and 13. This increased alternating voltage causes relay 41 to pick up energizing the signal light 16 which informs the operator that the load device 75 has been energized. Similarly if the unidirectional voltage applied to conductors 12 and 13 is increased further relay 62 will pick up closing contacts 73 and 79 to energize load 76 and to shunt out resistor 75b causing energization of light 17. Finally if the unidirectional voltage is increased still further relay 63 picks up closing contacts 74 and 80 to energize load 77 and to shunt out resistor 75c causing energization of light 18. If the unidirectional voltage is then decreased the reverse of the above described operation will take place. Thus the operator can energize load 75 alone, loads 15 and 16 together, and also all three loads 15, 16 and 17 and the energization of these loads will be indicated to him by the signal lights 16, 17 and 18.

While I have shown the relays 61, 62 and 63 as controlling the separate load devices they may be used to change the operating condition of a single load device. For example, they might be used to control the speed of an electric motor by changing the resistance of the motor circuit without departing from my invention.

In the remote control and indicating system I have illustrated in Figs. 1 and 2, the unidirectional voltage is applied to the conductors 12 and 13 at the transmitting station to effect the desired control and the alternating voltage is applied to the line at the receiving station to control the operation of the signal lights. However, it is obvious that this arrangement could be reversed whereby the unidirectional voltage is applied to the line and energized to operate the indicating lights and the alternating voltage to effect the desired control.

While I have shown and described particular embodiments of my invention, it will occur to those skilled in the art that various changes and modifications may be made without departing from my invention, and I, therefore, aim in the
6. appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a remote control system for controlling from a transmitting station the position of a device at a receiving station, the combination comprising a pair of conductors interconnecting said stations, means for reversibly connecting said conductors to a source of unidirectional voltage at the transmitting station, a relay connected to said conductors at the receiving station responsive to the polarity of the unidirectional voltage impressed on said conductors at the transmitting station, a reversible motor for progressively changing the position of said device, an energizing circuit for said motor including the contacts controlled by said relay arranged so that the direction of rotation of said motor is determined by the polarity of the voltage impressed on said conductors, means independent of the position of said device for connecting said conductors at the receiving station to a source of alternating voltage, means for progressively altering the magnitude of the alternating voltage supplied to said conductors in accordance with the position of said device, and a plurality of relays connected at said transmitting station to be responsive to the alternating voltage across said conductors, said relays being set to respond to progressively different alternating voltages whereby said relays respond in sequence as the position of the control device progresses, and signal means associated with and controlled by each relay.

2. In a system for indicating at a transmitting station the position of a remote device located at a receiving station, said device being electrically actuable progressively between two extreme positions from said transmitting station, the combination comprising a pair of conductors interconnecting said stations, means including said conductors for controlling said device from said transmitting station, a source of variable voltage connected to said conductors at said receiving station, means controlled by said device for varying said voltage progressively as said device is progressively actuated from one extreme position to the other, a plurality of voltage-sensitive signal devices connected at said transmitting station to be responsive to the voltage supplied to said conductors at said receiving station, said signal devices being set to respond to progressively different voltages so that said signal devices respond in sequence as the position of said remote device progresses from one extreme position to the other whereby an operator at the transmitting station may, by observing the condition of energization of said signal devices, determine the position of said remote device.

3. In a system for indicating at a transmitting station the position of a remote device located at a receiving station, said device being electrically actuable progressively between two extreme positions from said transmitting station, the combination comprising a pair of conductors interconnecting said stations, means including said conductors for controlling said device from said transmitting station, a source of variable voltage connected to said conductors at said receiving station, means controlled by said device for varying said voltage progressively as said device is progressively actuated from one extreme position to the other, a plurality of voltage-sensitive signal devices connected at said receiving station, said devices being set to respond in sequence as the position of said remote device progresses from one extreme position to the other whereby an operator at the transmitting station may, by observing the condition of energization of said signal devices, determine the position of said remote device.

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