Oct. 9, 1962 A. C. REYNOLDS, JR 3,058,095

BINARY CODE RELAY

Filed Aug. 22, 1958

2 Sheets-Sheet 1

fig.1.

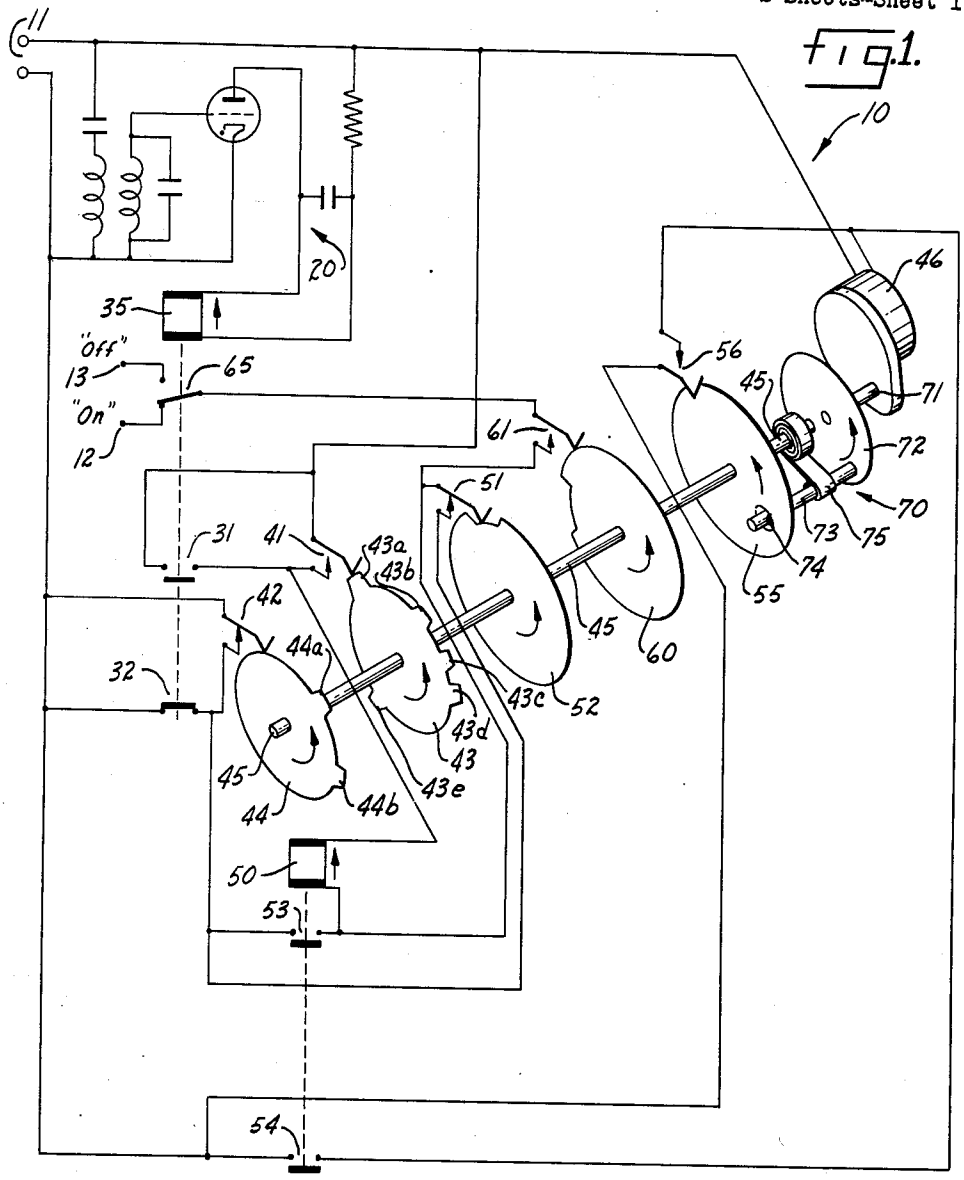
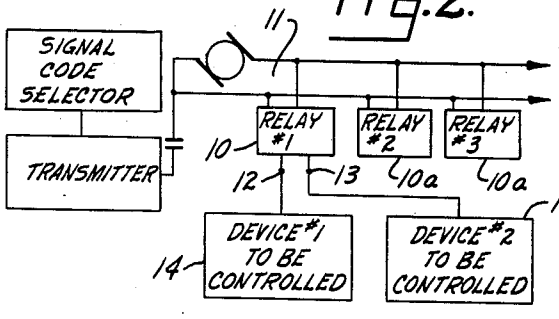


fig.2.



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2 Sheets-Sheet 2

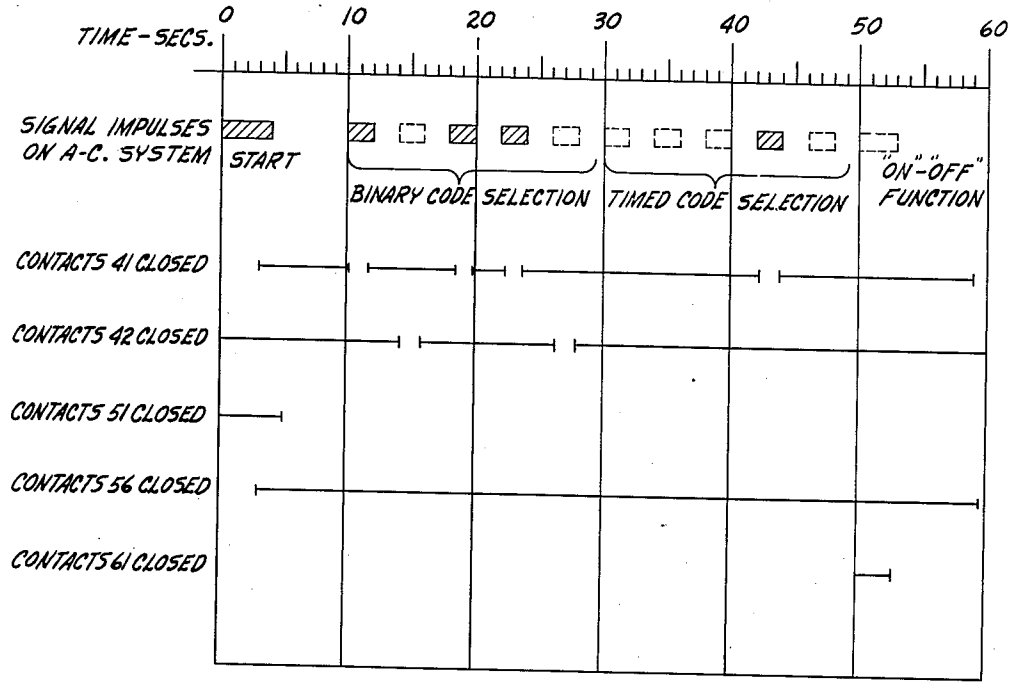


Fig. 3.

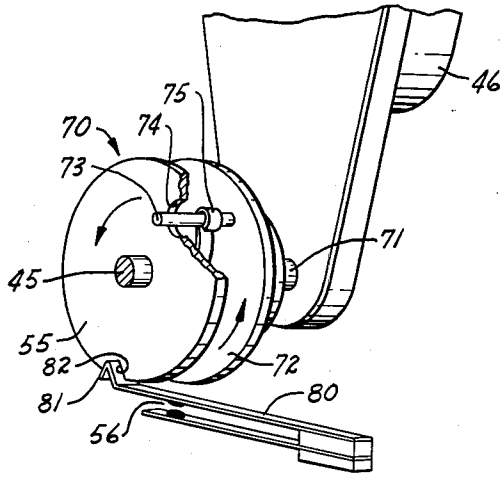


Fig. 4.

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3,058,095

BINARY CODE RELAY

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Filed Aug. 22, 1958, Ser. No. 756,566
9 Claims. (Cl. 340—164)

This invention relates to remotely controlled relays and more particularly to a switch actuating relay responsive to a binary code signal.

Relays of this general type are primarily intended for use in a system which includes a master signal transmitter and a plurality of relays connected to a common power supply line. Each of the relays is adjusted to respond to a particular coded signal pattern and thus the transmitter can selectively actuate any desired relay by sending the proper code on the power line. Systems of this nature have found particular utility when installed on a regular 60 cycle, A.-C. power line with the relays being responsive to high frequency signals superimposed on the line by the transmitter. In this way, appliances receiving power from the line can be remotely controlled from a central station. Reference is made to my Patent No. 2,852,704 and Patent No. 2,852,705, both issued September 16, 1958, and assigned to the same assignee of the present application, which illustrate such a system.

One of the difficulties in setting up a system of the type referred to above is the problem of providing a simple and completely reliable coded signal relay that is immune to spurious transient signals which are found to occur at random in an A.-C. power system. Such transient signals have abrupt wave fronts comprising many frequency components and are commonly generated by various forms of heavy duty electrical equipment which may be installed in the system. Often a spurious signal includes a component having the frequency at which the relays are set to respond and thus a false code is transmitted on the power line which has proved troublesome in remote control systems of this type.

It has been proposed to deal with this problem of transient signals by constructing relays which respond only to signal impulses that are sustained for a predetermined time interval. In a practical case, the interval may be approximately two seconds, that is, each signal impulse of the code signal must be of a predetermined duration, for example two seconds, in order to actuate the relay. In this way, transient signals, which are of only quite short duration, cannot cause false relay actuation.

This solution however, has presented a further problem. When using a signal made up of signal impulses having an appreciable time length, the number of different signals in the code has heretofore been rather small since, for practical considerations, the time interval within which a complete signal is to be sent must be reasonably limited. Again referring to a practical case, it is desirable to complete a signal within a one minute interval. This factor has limited the number of relays on a single circuit which can be selectively actuated by a coded signal.

Accordingly, it is the primary aim of the present invention to provide a novel coded signal responsive relay, immune to spurious, transient signals, which will respond to a single selected code signal of a very large group of possible signals. In this way, a large number of relays embodying the invention can be selectively operated on the same circuit.

It is also an object of the invention to provide a relay of the above type which is simple in design and completely reliable in operation.

With more particularity, it is an object to provide a relay of the type characterized above which is constructed of conventional cam-controlled switches operated by an ordinary timing motor so as to be economical to manufacture. It is a related object to provide such a relay having few parts, and those operating under very light mechanical forces, so that the relay remains reliable and accurate over a long and trouble-free service life.

In one of its more detailed aspects it is an object of the invention to provide a novel relay of the type discussed above which can supply a controlling current impulse to either of two devices in response to a further code signal transmitted remotely from the central control station.

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIGURE 1 is a schematic wiring diagram of a coded signal relay constructed in accordance with the present invention;

FIG. 2 is a fragmentary schematic diagram showing a typical system in which the relay appearing in FIG. 1 may be utilized;

FIG. 3 is a chart detailing the sequence of contact set operation in the relay shown in FIG. 1; and

FIG. 4 is a fragmentary perspective view of a time delay device utilized in the FIG. 1 relay.

While the invention will be described in connection with a preferred embodiment, it will be understood that I do not intend to limit the invention to that embodiment. On the contrary, I intend to cover all alterations, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

Turning now to FIG. 1, there is shown a relay **10** embodying the present invention and provided with terminals **11** adapting the relay for connection to an A.-C. power system. The A.-C. system may include a plurality of similar relays **10***a* in addition to a high frequency transmitter of any conventional type which is effective to superimpose a high frequency signal on the normal 60 cycle A.-C. power system (see FIG. 2). In the illustrated embodiment, the relay **10** is provided with output terminals **12** and **13** which are connected to devices **14** and **15**, respectively, that are controlled by the relay **10** in accordance with the reception of signals on the power system. It will be understood that the relays **10***a* may control additional devices and that, if desired, the relays **10** and **10***a* may be employed to control but a single device **14** or **15**.

In order that the relay **10** may detect high frequency signals transmitted on the A.-C. power system, the relay includes a high frequency signal receiver **20** coupled across the terminals **11**. The receiver **20** may be of any convenient type such as are well known in systems of this nature.

In accordance with the present invention, the relay **10** includes both means responsive to signal impulses in a serial binary code pattern and means for cycling through a serial binary code pattern, the arrangement of these means being such that if the received impulses coincide with the predetermined pattern, the output terminals **12** and **13** are energized to operate one of the devices **14**, **15**. Preferably, the binary, or two-condition, code is simply a "yes-no" or "on-off" code in which there either is or is not an electrical impulse during each interval of a set number of successive timed intervals. In the present case, a binary code is selected in which there are five two-second periods spaced two seconds apart during which there may or may not be an electrical impulse, and these spaced two-second periods comprise the binary code portion of a complete relay actuating signal which has a total time duration

of 60 seconds. The nature of the complete signal including its binary code portion will become evident as this discussion proceeds.

In the illustrated embodiment, the means responsive to the coded signal impulses on the A.-C. power system include sets of contacts **31**, **32** controlled by a relay **35** which is coupled to the receiver **20**. The contacts **31** are normally open and the contacts **32** normally closed. When a high frequency signal impulse is impressed on the A.-C. power system, the receiver **20** is effective to energize the relay **35** so as to close the contacts **31** and open the contacts **32**. These contacts thus close and open respectively in accordance with the serial signal pattern transmitted on the power system.

In the preferred device, the means in the relay **10** for cycling through a predetermined serial binary code pattern comprises sets of contacts **41**, **42** which are controlled by cams **43**, **44**, respectively. The cams **43**, **44** are secured to a cam shaft **45** that is driven by a timing motor **46**. Both of the contact sets **41**, **42** are normally closed but they are opened by lobes on the cams **43**, **44** as the cams are rotated by the timing motor **46**. It will therefore be appreciated that by providing a series of annularly spaced lobes on the cams **43**, **44**, the contacts **41**, **42** can be made to open and close in a predetermined pattern.

In order to energize the output terminals **12**, **13** only if there is coincidence between the relay's predetermined code pattern and the received signal impulse code, the contacts **31**, **32** and **41**, **42** are coupled to a two-condition relay **50** so that the condition of the relay **50** changes unless there is the desired coincidence. In the illustrated embodiment, the relay **50** is energized, or picked up, before the binary code is transmitted on the A.-C. power system, and the contacts **41**, **42** shunt the contacts **31**, **32** so that when the contacts **31** close and the contacts **32** open, the contacts **41** will open and the contacts **42** will close to maintain a circuit through the relay **50** and hold it in.

For initiating the operation of the timing motor **46** and for conditioning the relay **50** prior to transmission of the binary signal, the relay includes a set of normally closed initiating contacts **51** controlled by a cam **52** carried on the shaft **45**. Also, a complete relay actuating signal transmitted on the power system includes an initiating signal impulse. When the first high frequency signal impulse, the initiating signal, is received by the relay **10**, the receiver **20** is effective to energize the relay **35**. This closes the contacts **31** and completes a circuit through the contacts **31**, the relay **50**, the closed contacts **51**, and the closed contacts **42**, that is effective to energize the relay **50**. When relay **50** picks up, it closes two sets of contacts **53**, **54**. Closing of the contacts **54** completes a circuit energizing the timing motor **46**. As the timing motor begins to rotate the cam shaft **45**, a motor seal-in cam **55** secured to the shaft **45** is rotated so as to close the normally open contacts **56** which by-pass the contacts **54** and seal-in the motor **46**.

As the cam shaft **45** begins cycling, the lobe **43***a* on cam **43** releases and allows the contacts **41** to close so that a circuit is completed through the contacts **41**, the relay **50**, the then closed contacts **53** and the contact sets **32**, **42**. Further rotation of the cam shaft causes the cam **52** to open the contacts **51** so as to shift control of the relay **50** to the contact pairs **31**, **32** and **41**, **42** and, because of the circuit just described through contacts **41**, **53**, **32** and **42**, the relay **50** remains energized.

Following the initiating impulse, the binary code portion of the complete relay actuating signal is transmitted as a set of five cam lobes on the cams **43**, **44** operate the contacts **41**, **42** in a predetermined code pattern. In the preferred embodiment, both sets of contacts **41**, **42** are closed at the start of the serial binary signal. Then, in the five successive two-second timed periods, the contacts are alternately opened for brief periods in a predetermined order determined by the cams **43**, **44**. In the illustrated example, the lobe **43***b* opens the contacts **41** during the first of the five periods, then lobe **44***a* opens the contacts **42** during the second period, lobes **43***c* and **43***d* open the contacts **41** during the third and fourth periods, and finally lobe **44***b* opens the contacts **42** during the final fifth period.

If, during the opening and closing of the contacts **41**, **42** by the cams **43**, **44**, a pattern of signal impulses is received on the A.-C. power system so that each time the contacts **41** are open, the contacts **31** are closed, and each time the contacts **42** are opened, the contacts **32** are closed, then the relay **50** will remain energized. It can therefore be seen that the relay **50** will remain energized only if there is coincidence between the predetermined order in which the contacts **41**, **42** are operated and the pattern of a set of five high frequency impulses transmitted on the A.-C. power system.

Since the illustrated relay **10** responds to a binary code of five "digits," there is provided a total of thirty-two possible binary code combinations which can be selected by the proper formation of the cams **43**, **44**. To further multiply the number of possible codes, and thus the number of such relays which can be selectively operated on one A.-C. power system, the complete relay actuating signal includes a timed signal portion as well as the binary signal portion.

The timed signal portion is also divided into five successive two-second intervals spaced two seconds apart. During one of these five timed code periods, a lobe **43***e* on the cam **43** again opens the contacts **41** and, unless a high frequency signal impulse is being simultaneously received by the relay **10**, the relay **50** will be dropped out. The five timed code possibilities are effective to multiply the thirty-two binary code combinations by five, so that the total number of possible code combinations for which the relay **10** may be set equals 160. That is, by properly forming the cams **43**, **44**, 160 different relays can be selectively operated on a single A.-C. power system.

To energize the output terminals **12**, **13** when the proper coded signal has been received and the relay **50** remains energized, an output signal cam **60** is provided controlling a set of normally open contacts **61**. At the end of one complete revolution of the cam shaft **45**, the cam **60** is effective to close the contacts **61** so as to complete a circuit from the relay **50** to the output terminals **12**, **13**. If current is flowing through the relay **50**, that is, if the relay **50** is still picked up, closing of the contacts **61** will transmit a signal impulse to the terminals **12**, **13**.

So that the single relay **10** may control either one of the two devices **14**, **15**, the output terminals **12**, **13** are selectively energized by the contact **61** through a switch **65** controlled by the relay **35**. Normally, the switch **65** completes a circuit from the contact **61** to the output terminal **12**, but when the relay **35** is picked up, the switch **65** completes a circuit from the contact **61** to the terminal **13**. In this way, if a final signal impulse is transmitted on the A.-C. power system at the time during which the contacts **61** are closed by the cam **60**, then an operating signal is transmitted through the switch **65** to the terminal **13** and the device **15**. If, however, no final signal impulse is transmitted then the operating signal caused by closing of the contacts **61** is directed by the switch **62** to the terminal **12** and the device **14**. Thus, a single additional signal impulse permits the relay **10** to selectively control either one of the two devices **14**, **15**.

For the purpose of preventing operation of the relay **10** by spurious, transient signals, a time delay device **70** is provided for coupling the timing motor **46** to the cam shaft **45**. In the present embodiment, the time delay device **70** comprises a spring biased, lost motion driving connection between the output shaft **71** and the cam shaft **45**. The arrangement is such that when the motor

starts rotating, it must overcome the spring force and pick up the lost motion before the cam shaft 45 begins rotation. To provide the lost motion connection, the output shaft 71 of the motor carries a disc 72 which is mounted concentrically with, but independently of, the cam shaft 45. The disc 72 rotates the cam shaft 45 by means of a pin 73 extending axially of the cam shaft through a hole 74 of somewhat greater diameter formed in the cam 55. It can be seen that when the pin is disposed at one edge of the hole 74, the motor 46 must rotate the disc 72 through a distance approximately equal to the diameter of the hole until the pin 73 engages the opposite side of the hole and imparts a rotational force to the cam 55.

To insure that the disc 72 and the motor 46 are properly "backed off" so that the pin 73 is adjacent the proper edge of the hole 74, a torsion spring 75 is fixed to the cam shaft 45 and is tensioned to exert a resilient force against the pin 73 in a direction opposite to that imparted by the motor 46. It can thus be seen that momentary energization of the motor 46, caused by the brief closing of the contacts 31 and momentary energization of the relay 50 as a result of spurious transient signals being picked up by the high frequency signal receiver 20, will only cause the disc 72 to begin revolving so as to carry the pin 73 across the hole 74. Upon the almost immediate de-energization of the motor 46 following the transient signal, the torsion spring 75 will return the pin 73, disc 72 and the motor armature, back to their original starting positions. It will be apparent then that the operation of the relay 10 can be initiated only by energizing the motor 46 for a sustained predetermined period, which will be the case when a true signal impulse of several seconds duration is transmitted on the A.-C. power system. In a practical system, initiating impulses of from three to four seconds duration have been found to be effective.

To hold the cam shaft 45 and the cam 55 in their starting positions against the reactive force exerted by the torsion spring 75, the inherent detenting effect provided by the switch actuator for the contacts 56 is utilized. As can be seen in FIG. 4, the contacts 56 are provided with a resilient switch actuator 80 having a detent portion 81 which drops into a notch-like drop-off portion 82 formed in the cam 55. It will be understood that the engagement of the switch actuator 80 within the drop-off portion 82 will hold the cam 55 and the cam shaft 45 in their respective starting positions with a detent-like action. When the motor 46 remains energized for a time sufficient to bring the pin 73 into engagement with the opposite side of the hole 74, the cam 55 will be rotated so as to bring the detent portion 81 of the switch actuator out of the cam drop-off portion 82 so that the contacts 56 are closed and the operating cycle of the motor 46 initiated.

In order to minimize the resilient force required to be exerted by the torsion spring 75, while insuring that the force is sufficient to "back-off" the disc 72 and the motor 46, the motor preferably includes an automatically operating clutch of the type which is commonly employed for such purposes. In clutch motors of this type, the motor armature is automatically engaged with the power output driving train upon energization of the motor winding, and is disengaged upon the de-energization of the motor winding. An example of a motor of this type having such an automatic clutch construction may be seen by reference to U.S. Patent No. 2,234,040, to Schennels, issued November 9, 1943. It will be sufficient for present purposes to observe that the armature in the motor 46 is coupled to the output shaft 71 only when the motor is energized. When the motor is only briefly energized through the action of a spurious signal causing the contacts 31 to flutter momentarily, the output shaft 71 and the disc 72 are briefly advanced by the motor armature and then are completely disconnected from the armature. Thus, the torsion spring 75 need rotate only the disc 72 and drive shaft 71 back to their initial starting positions, and is not required to rotate the entire armature of the motor 46.

Résumé of Operation

Having observed the structure of the relay 10, a complete understanding of the invention can be best obtained by briefly considering an operating cycle during which the relay is actuated for operating one of the devices 14, 15. Having particular reference to FIG. 3, the complete relay actuating signal includes first an initiating or "start" impulse which has approximately a four second duration. This impulse energizes the relay 35 so as to close the contacts 31 and complete a circuit through the relay 50, the contacts 51, and the contacts 42, which is effective to energize the relay 50. The relay 50 immediately picks up and the contacts 54 are closed energizing the motor 46. Since the contacts 54 remain closed for the duration of the long "start" signal impulse, the lost motion in the device 70 is taken up and the cam shaft 45 begins rotation. This causes the cam 55 to close the contacts 56 and thus complete a circuit sealing-in the motor 46 for one complete revolution of the cam shaft 45.

As the cam shaft 45 rotates, the contacts 41 close and the contacts 51 are opened so as to turn control of the picked-up relay 50 over to the cams 43, 44. The relay 50 remains energized through a circuit including the contacts 53, either set of contacts 31, 41, and either set of contacts 32, 42.

Ten seconds following the start of the initiating signal, the binary code portion of the signal is transmitted on the power system. The cam lobes 43*b*, 43*c*, 43*d*, 44*a* and 44*b* successively open the contacts 41, 42. Each time the contacts 41 are opened, a signal impulse is received closing the contacts 31, and each time the contacts 42 are opened, no signal impulse is received so as to maintain the contacts 32 closed. In this way, the relay 50 remains energized through the binary code portion of the relay actuating signal.

At thirty seconds past the initiation of a coded signal, the timed code portion of the signal begins. Through this period the relay 50 remains energized since both the sets of contacts 32, 42 are closed and the contacts 41 are also closed. However, during one of the five successive intervals during the timed code portion of the signal, the cam lobe 43*e* on the cam 43 is effective to open the contacts 41 at the same time that a signal impulse is transmitted on the power system. The signal impulse closes the contacts 31 throughout the period that the contacts 41 are open and thus maintains the relay 50 in its energized condition.

At fifty seconds past the start of the actuating signal, the cam 60 closes the contacts 61 so that the terminals 12, 13 are energized from the circuit passing through the relay 50. If no final signal is received to energize the relay 35, the contacts 61 complete a circuit through the switch 65 and the terminal 12 to the device 14. If a final "on-off" signal is received, then the relay 35 will pick up and the switch 65 will complete a circuit from the contacts 61 through the terminal 13 to the device 15.

Following the complete relay cycle, that is 60 seconds after the start of the complete relay actuating signal, the cam shaft 45 completes one revolution and the contacts 41 open to drop out the relay 50. This opens the contacts 54 and, simultaneously, the cam 55 opens the contacts 56 so that the timing motor 46 is de-energized and the relay again assumes its standby condition.

It will be understood that the code signal to which the relay 10 is responsive can be easily changed by substituting cams of a slightly different configuration for the cams 43, 44. It will also be observed that the relay 10 can be quite economically constructed since it utilizes

only easily formed, conventional cam-controlled switches, and a timing motor and relays of standard design.

I claim as my invention:

1. In a code responsive relay for connection to a line on which is transmitted a binary code made up of a pattern of successive signal impulses, the combination comprising, a first relay having first contacts normally open and second contacts normally closed, means for energizing said relay responsive to "on" and "off" signal impulses for alternating the condition of said first and second contacts in accordance with the pattern of said impulses, a timing motor, two-condition cam switch means cyclically controlled by said motor so that the condition of said cam switch means is varied in a predetermined code pattern during said cycle, means including a second relay electrically connected to said first relay contacts and said cam switch means so as to particularly respond to signal impulses received in a pattern exactly corresponding to said predetermined code pattern, output terminals alternately connectable to said line through said last named means and said first relay, and means including said cam switch means responsive to exact correspondence between said pattern during said cycle for energizing said one of said output terminals so as to operate a device connected thereto.

2. In a code responsive relay for connection to a line on which is transmitted a code made up of a pattern of successive "on" and "off" signal impulses, the combination comprising, a two-condition relay having first contacts normally open and second contacts normally closed, means responsive to said "on" and "off" signal impulses to energize said relay for alternately opening said second contacts and closing said first contacts in accordance with the pattern of said impulses, a timing motor, a pair of cam controlled contacts cyclically operated by said motor upon receipt of a starting impulse, one of said cam controlled contacts being open and the other closed in a predetermined code pattern during said cycle, code responsive means including said two-condition relay electrically connected both to said first pair of contacts and said cam controlled contacts so that the condition of said code responsive means changes unless signal impulses are received in a pattern exactly corresponding to said predetermined code pattern, output terminals alternately connectable to said line, and means responsive to said code responsive means maintaining an unchanged condition during said cycle for energizing one of said output terminals so as to operate a device connected thereto.

3. In a code responsive relay for connection to a line on which is transmitted a code made up of an initiating signal impulse and a pattern of successive "on" and "off" signal impulses, the combination comprising, a first pair of contacts, means responsive to said "on" and "off" signal impulses for opening one and closing the other of said first pair of contacts in accordance with the pattern of said impulses, a cyclically operable timing motor, a pair of cam controlled contacts intermittently operated by said motor during its cycle so that one of said cam controlled contacts is opened and the other closed in a predetermined code pattern during the cycle, means for cycling said motor when said initiating signal impulse is received, means including a two-condition relay electrically connected both to said first pair of contacts and said cam controlled contacts so that the relay is picked up and held in only if signal impulses are received in a pattern exactly corresponding to said predetermined code pattern, output terminals, and means responsive to said relay maintaining its picked up condition at the end of said cycle for energizing one of said output terminals so as to operate a device connected thereto.

4. In a code responsive relay for connection to a line on which is transmitted a code made up of a pattern of successive "on" and off" signal impulses, the combination comprising, a first pair of contacts, means responsive to said "on" and "off" signal impulses for opening one and closing the other of said first pair of contacts in accordance with the pattern of said impulses, a timing motor energizable by receipt of a starting impulse and continuously operable through a predetermined time cycle, a pair of cam controlled contacts cyclically operated by said motor, one of said cam controlled contacts being open and the other closed in a predetermined code pattern during said cycle, means including a two-condition relay electrically connected both to said first pair of contacts and said cam controlled contacts with each cam controlled contact shunting a respective one of the first pair of contacts so that the condition of the relay changes unless signal impulses are received in a pattern exactly corresponding to said predetermined code pattern, output terminals, and means responsive to said relay maintaining an unchanged condition during said cycle for energizing one of said output terminals so as to operate a device connected thereto.

5. A binary coded relay responsive to a predetermined time sequential binary pulse code consisting of "on" and "off" signals, comprising in combination, first and second line terminals for connection to a source of energization, a holding relay connectable in circuit to each of said line terminals and means operable by said relay when connected and energized establishing an output circuit, a signal responsive relay including switch means connected so as to connect said holding relay to said first line terminal when an "on" signal is received and operable to connect said holding relay to said second line terminal when an "off" signal is received, time controlled switching means operable to connect said holding relay to said first line terminal when a properly sequenced "off" signal is received and operable to connect said holding relay to said second line terminal when a properly sequenced "on" signal is received in a predetermined code whereby upon receipt of said predetermined code, said holding relay maintains establishment of said output circuit.

6. The combination defined in claim 5 further defined in that said holding relay when de-energized disconnects itself from said signal responsive relay and said switch means and when energized connects itself in circuit with said signal responsive relay and said switch means.

7. The combination defined in claim 6 and time controlled switching means for temporarily connecting said holding relay in circuit with said signal responsive relay and said switch means upon initial receipt of a code.

8. The combination of claim 5 and second switching means adapted to connect said output circuit to an output terminal at the termination of receipt of said predetermined code.

9. The combination of claim 7 and second switching means adapted to connect said output circuit to an output terminal at the termination of receipt of said predetermined code.

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