Feb. 12, 1946. P. B. KORNEKE, JR 2,394,786

CARRIER CURRENT CONTROL SYSTEM

Filed Oct. 24, 1942

Fig. 1.

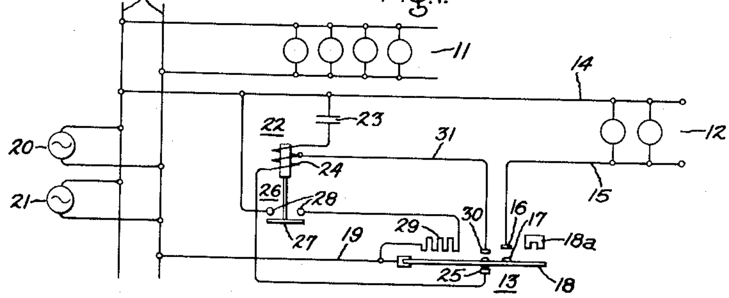


Fig. 2.

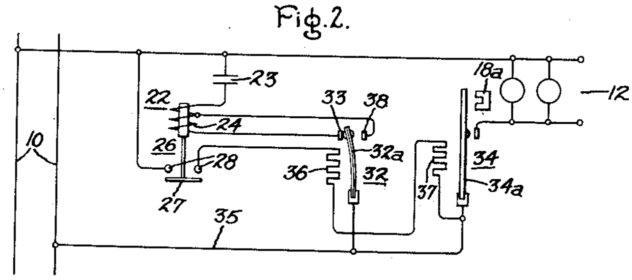


Fig. 3.

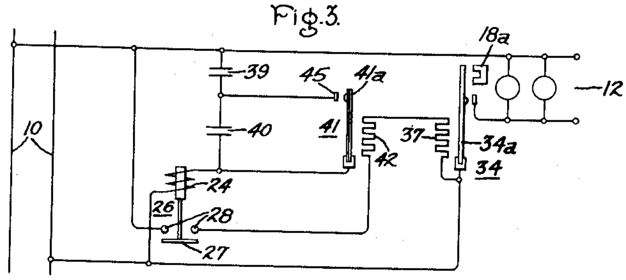
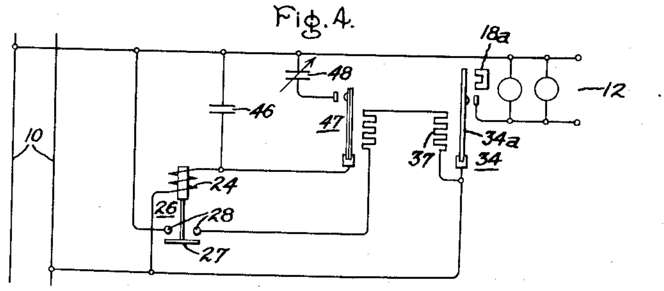


Fig. 4.



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UNITED STATES PATENT OFFICE

2,394,786

CARRIER CURRENT CONTROL SYSTEM

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5 Claims. (Cl. 177—353)

My invention relates to frequency selective systems and more particularly to carrier current control systems and means associated with such systems for controlling remote loads.

Carrier current systems have been used in connection with power systems for controlling the application of a plurality of distant electrical energy consuming devices, such as hot water heaters and street lighting loads, for example.

In one form of carrier current control, relays are employed which are designed to operate in one direction, as for closing a set of contacts, after the transmission of current through the operating winding of the relay for a predetermined time and to cause a different operation, as to open the contacts, upon the receipt of a longer pulse.

One form of device for accomplishing the above purpose comprises a switch control member adapted to be actuated between two positions by a thermostatic member which is energized by a heater connected across the supply source and controlled in direction of movement by variations in the time interval of received carrier current frequency impulses. A suitable switch operator is described in application Serial No. 385,278 to J. L. Woodworth, and assigned to the same assignee as the present invention. The thermostatic device therein described and claimed comprises a strip or bar having two sections end-to-end and a heating winding so arranged that in order to operate a switch a heating current is transmitted for a predetermined time in order to cause the strip to bend in a direction to close the contacts. In order to open the switch contacts, a second impulse of a longer time duration is sent over the power lines in order to cause the heating winding of the relay again to be energized. The longer impulse causes the heating coil to provide sufficient heat to reverse the direction of the bending force of the switch arm from that in the closing operation. After a predetermined time the bending is sufficiently great to pull the contact arm away from the other relay contact and open the circuit associated therewith.

It may be desired to control a large number of different types of devices on a power system by transmitting different frequencies to differently tuned resonant circuits. If frequencies relatively close together are chosen there may be interference and faulty operation of devices. Operation of adjacent power circuits, harmonics, as from fluorescent lamps in the vicinity of a device, and premeditated and unauthoried operation are undesirable. It is an object of my invention to provide a new and improved carrier current control system in which faulty operation caused by interference from within, as well as without, the power system, unauthorized operations, etc., are eliminated or at least minimized.

The novel features which I believe to be characteristic of the invention are set forth with particularity in the appended claims. My invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Figs. 1 to 4 inclusive show various embodiments of my improved carrier current control system.

In carrying out my invention I utilize a resonant circuit for enabling selection of the device to be operated. There is provided means responsive to the receipt of one frequency for rendering the resonant circuit temporarily responsive to a different frequency and the device to be operated can be controlled only following the receipt of the second frequency. Thus, at least two frequencies are necessary to control the device. Similarly, I contemplate the transmission of at least one frequency for restoring the device to its original condition or for operating the device to the opposite condition. My invention is not limited to the use of two frequencies for one operation and one frequency for the reverse operation and I will describe circuit arrangements in which at least two frequencies are necessary for operating a device to one condition and one and two frequencies for operating the device to a different condition.

Referring to Fig. 1, there is illustrated a remote control system including a suitably energized electric power supply line **10**. Inasmuch as the source of supply forms no part of my present invention it is believed unnecessary to describe and illustrate details of the source of supply. There are illustrated two sources **20** and **21** of carrier current of different frequency, as 500 and 1000 cycles, respectively, for example. The power line is adapted to transmit electrical energy to various electrical loads such as those indicated by the numerals **11** and **12**. The load **11** is shown connected directly to the line and, of course, is energized at any time the line **10** is energized. The load **12**, however, is arranged to be operated according to the transmission of predetermined carrier current frequencies over the line **10**. There is provided a load switch **13** for connecting the load **12** to the power line **10**. Thus the load

12 is connected to one side of the power line by a conductor 14 and to the other side of the power line by means of conductors 15, contacts 16 and 17 of the switch 13, the arm 18 of the switch 13, and a conductor 19. There is provided a series resonant circuit 22 comprising a capacitor 23 and an inductance 24 arranged to be connected across the line 10. One side of the resonant circuit is connected to the conductor 14 and the other side is connected to the conductor 19 through contact 25 and the arm 18 of the switch 13 which normally connects the resonant circuit across the line. Now if it be assumed that the resonant circuit is normally tuned to 500 cycles, it will be apparent that upon the transmission of a 500 cycle carrier current impulse a 500 cycle current flows through the series resonant circuit. The inductance 24 may be the winding of a relay 26 having an armature 27 arranged to bridge electrically the contacts 28 when the relay is energized. Thus, when the resonant circuit 22 is passing sufficient current to pick up the relay 26, the contacts 28 will be bridged to connect the heating coil 29 of the switch 13 across the line 10.

The switch 13 may be a thermally operated device such as that described in the above mentioned Woodworth application according to which the arm 18 is a strip which is caused to bend first in one direction and then in the other depending upon the length of the heating period. The 500 cycle impulse if continued a sufficient time, as 10 seconds, for example, will cause sufficient heating of the thermal arm 18 to cause the arm to move upwardly as viewed in Fig. 1 to disconnect the resonant circuit from the line and deenergize the relay 26. However, the heat lag associated with such a thermally operated switch will be sufficient to carry the arm 18 over until it engages the contact 30 which is connected by means of a conductor 31 to a tap on the inductance 24 and thereby changes the resonant frequency of the series circuit. If the new resonant frequency is 1000 cycles the relay is again operated upon the receipt of a 1000 cycle impulse transmitted from the 1000 cycle source. Again current passes through the heater coil 29 and causes the arm 18 to bend further into engagement with the load contact 16 and thereby connect the load to the line. Thus there is provided means responsive to the receipt of carrier current of one frequency for preparing the load connecting means for the closing operation and responsive to the second frequency for connecting the load to the line or, in other words, to complete the closing operation.

Throughout the period of energization of the load 12 the switch 13 is held in engagement with the contacts 16 and 30 by means of the magnet 18*a* so that the resonant circuit remains tuned to the second frequency or 1000 cycles. Therefore, in order to disconnect the load 12, it is necessary to send out a 1000 cycle impulse of sufficient duration to cause the arm 18 to be heated sufficiently to pull away from the magnet and bend away from the contacts 16 and 30. As the arm cools to normal temperature, it will assume its normal position with the arm engaging contact 25, and the resonant circuit 22 is again tuned to 500 cycles.

In Fig. 2 there is illustrated a different embodiment of the invention. Similar devices are indicated by the same numerals used in the discussion of Fig. 1. In this embodiment of my invention there is employed a thermal switch 32 which may have a bimetallic arm 32*a* which normally engages the contact 33 for establishing a series resonant circuit across the line 10 through the condenser 23, the relay coil 24, contact 33, arm 32*a* and a conductor 35. If the same frequencies are used to operate the thermal switch 34, a 500 cycle impulse will cause relay 24 to be energized to bridge the contacts 28 and connect the heating coil 36 of the switch 32 and the heating coil 37 of the switch 34 across the line 10. Switch 34 is preferably of the same type as switch 13. After a current flow for a predetermined time, the arm of the switch 32 bends out of engagement with the contact 33 and deenergizes the relay 24. The heat lag carries the arm over until it makes contact with the switch contact 38, thereby connecting one side of the line to the intermediate tap on the coil 24 and thereby retuning the resonant circuit to a different frequency as 1000 cycles, for example. Upon the receipt of a 1000 cycle impulse the switch or relay 22 is again energized to close the contacts 28 to permit current to pass through the heating coils 36 and 37. If the 1000 cycle impulse continues sufficiently long the heating coil 37 causes the arm of the thermal switch 34 to be moved into engagement with the load contacts and thereby places the load 12 across the line 10. Upon the termination of the 1000 cycle impulse the relay 24 is deenergized thereby deenergizing the heating coils 36 and 37 and the arm of the thermal switch 32 moves to its normally closed position in engagement with the contacts 33.

In order to open the switch 34 an impulse of proper frequency must again be sent along the power line. Inasmuch as the whole of the coil 24 is again included, the circuit is again resonant to 500 cycles and the 500 cycle current closes the relay permitting heating current to flow. After a predetermined time, as ten seconds, the arm 32*a* moves into engagement with the contacts 38, and thereby conditions the resonant circuit for the opening operation. Upon receipt of a 1000 cycle impulse relay 24 again picks up to energize the heating coils 36 and 37 and if the pulse be continued a sufficient time such as 40 seconds, for example, the arm of the thermal switch 34 will be heated until it bends away from the load contact with which it is associated and thereby opens the load circuit. Thus in this arrangement of my invention two frequencies are needed to operate the relay for both closing and opening conditions.

In Fig. 3 there is shown another embodiment of my invention which requires two frequencies to close and two frequencies to open a switch. The circuits shown in Figs. 1 and 2 depend upon time lag in the bending of the thermal responsive arm of the switch. This condition is eliminated in the arrangement shown in Fig. 3. In this form of the invention there is provided a pair of series-connected condensers 39 and 40 in series with the coil 24. A thermal switch 41 having a thermally responsive arm 41*a* is arranged to shunt the condenser 40 when the arm engages contact 45. If it be assumed that the condensers and coil 24 are chosen to resonate at 1000 cycles, upon receipt of a 1000 cycle impulse the relay 24 will be energized to cause the contacts 28 to be bridged for completing a heating circuit through the heating coils 42 and 37 of the thermal switches 41 and 34 respectively. The heating current causes the arm 41*a* to bend into engagement with the contact 45. The thermal capacities of the switches 41 and 34 are chosen so that when the arm 41*a* engages the contact 45 to short out the condenser **40** the arm **34a** has made no appreciable movement toward its load contact. Upon shorting out the condenser **40** the capacity in the resonant circuit is greater and therefore the resonant frequency of the series circuit is less. Then upon receipt of the lower frequency, as 500 cycles, the relay **24** is again energized to permit the contact arm of the switch **34** to be heated up sufficiently to close the load circuit. After the impulse ceases, the arm **41a** returns to its normal position and opens the contact **45**, again tuning the circuit to resonate at 1000 cycles while the arm **34a** is held in its circuit closing position by the magnet **18a**. A similar action takes place for opening the circuit except that the 500 cycle impulse must be continued long enough to cause arm **34a** to bend away from the associated contact.

In Fig. 4 there is illustrated a circuit which is somewhat similar to that describer in connection with Fig. 3. The circuit differs, however, in the provision of parallel instead of series-connected condensers. Thus the resonant circuit under normal conditions comprises a condenser **46** and the coil **24**. However, upon receipt of the first frequency impulse the thermally responsive switch **47** is closed to place a condenser **48** in parallel with the condenser **46** thereby increasing the capacity of the resonant circuit and thereby decreasing the resonant frequency of the circuit. The condenser **48** is illustrated as a variable condenser and may, for example, be provided with a screw adjustment to permit tuning the circuit to a desired frequency.

While I have described the operation of this invention as utilizing two frequencies to cause one type of operation and one or two frequencies for the reverse operation, it will be apparent that by employing a plurality of taps on the coil **24** or by employing more than two condensers or by both means a larger number of frequencies may be required to operate the system. Moreover, while it may be most convenient to impress the plurality of frequencies on the power line at the same time such arrangement is not necessary and the conditioning or presetting frequency may be sent first and followed at a later time by the operating frequency. With the latter arrangement, a variable speed generator might be employed. It will be recognized that the second frequency impulse must be transmitted before the thermal switches are permitted to cool sufficiently to break the operation establishing circuit.

While I have shown a particular embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention in its broader aspects, and I, therefore, aim in the 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. A frequency selective system comprising a member adapted by operating in a progressive manner in response to a control impulse of given duration to perform a circuit controlling operation, means for transmitting a plurality of impulses of different frequencies, a resonant circuit tuned to one of said frequencies and receiving said plurality of frequencies, means associated with said resonant circuit and operative in response to the receipt of impulses of said one frequency for applying a control impulse to said member to start its progressive operation, means also responsive to said control impulse for interrupting the application of said control pulse to said member prior to said predetermined duration and thereby prevent the progressive operation of the member to find circuit controlling condition and for changing for a predetermined period said resonant circuit to resonate at a different frequency, said means associated with the resonant circuit then operating in response to the different frequency for applying an additional control impulse to said member during the presence of said second frequency, said member operating in its progressive manner in response to said additional impulse if of a predetermined duration to finally complete the circuit controlling operation, said member including means for returning it to normal condition if the second impulse is not maintained for a sufficient time to cause its progressive operation to circuit controlling position and for returning it to normal condition during the predetermined time of the changed tuning from the first to second frequency if the second frequency is not present.

2. A frequency selective system comprising a unitary device adapted for operation in a progressive manner in response to control impulses of different predetermined frequencies to perform a circuit controlling operation, means for transmitting said different predetermined frequencies, a resonant circuit tuned to one of said frequencies and associated with said device, operating means associated with said resonant circuit and responsive to the receipt thereby of an impulse frequency to which the same is resonant for effecting progressive operation of said device, means responsive to a predetermined duration of said impulse frequency for interrupting the progressive operation of said device prior to completion thereof and for temporarily changing said resonant circuit to resonate at a different frequency, said operating means being thereby rendered temporarily responsive to a succeeding impulse of another of said different frequencies having a predetermined duration sufficient for causing further progressive operation of said device.

3. A frequency selective system comprising a device having an operating member arranged for progressive operation in response to sequential control pulses of predetermined discrete frequencies to perform a circuit controlling operation, means for supplying to said device pulses at said discrete frequencies, means including a resonant circuit normally tuned to one of said frequencies for applying a presetting impulse to said member to start the progressive operation of said member, means responsive to partial operation of said member for rendering said resonant circuit non-responsive to said one frequency thereby to interrupt said presetting impulse prior to complete operation of said member, means controlled by said partial movement of said member for rendering said resonant circuit temporarily responsive to a second of said frequencies, and means including said temporarily tuned resonant circuit for applying a second control impulse to said member to cause further progressive operation thereof.

4. In a remote control system, a device having a thermal responsive member adapted by operation in a progressive manner to perform a circuit

controlling operation in response to control pulses at predetermined discrete frequencies, a resonant circuit normally tuned to one of said frequencies, a relay controlled by said circuit and responsive to a pulse at said one frequency for applying a control impulse of predetermined duration to said thermal responsive member to effect predetermined partial operation thereof, and means responsive to said partial operation of said thermal responsive member for rendering said relay temporarily non-responsive to said one frequency and responsive to a second frequency prior to complete operation of said member, whereby said relay is conditioned to apply a control impulse to said thermal member in response to a pulse at said second frequency within a predetermined time after said first pulse thereby to cause further progressive operation of said member.

5. In a remote control system in which succeeding pulses of different frequencies are transmitted to a remote point to effect a desired operation at said point, means at said point responsive to said pulses to operate a member from one position through a second position to a third position, said means including a circuit normally tuned to the frequency of the first pulse and in which said pulses are received, means responsive to receipt of said first pulse in said circuit to operate said member from said first position to said second position and to tune said circuit to the frequency of the second pulse, means responsive to receipt of the second pulse to operate said member from the second position to the third position, and means responsive to operation of said member to the third position to effect said desired operation.

PAUL B. KORNEKE, Jr.

Certificate of Correction

Patent No. 2,394,786. February 12, 1946.

PAUL B. KORNEKE, JR.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 7, claim 1, for the word "find" read *final*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of October, A. D. 1946.

[SEAL]

LESLIE FRAZER,
First Assistant Commissioner of Patents.