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J. L. WOODWORTH

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CONTROL SYSTEM

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Fig. 1.

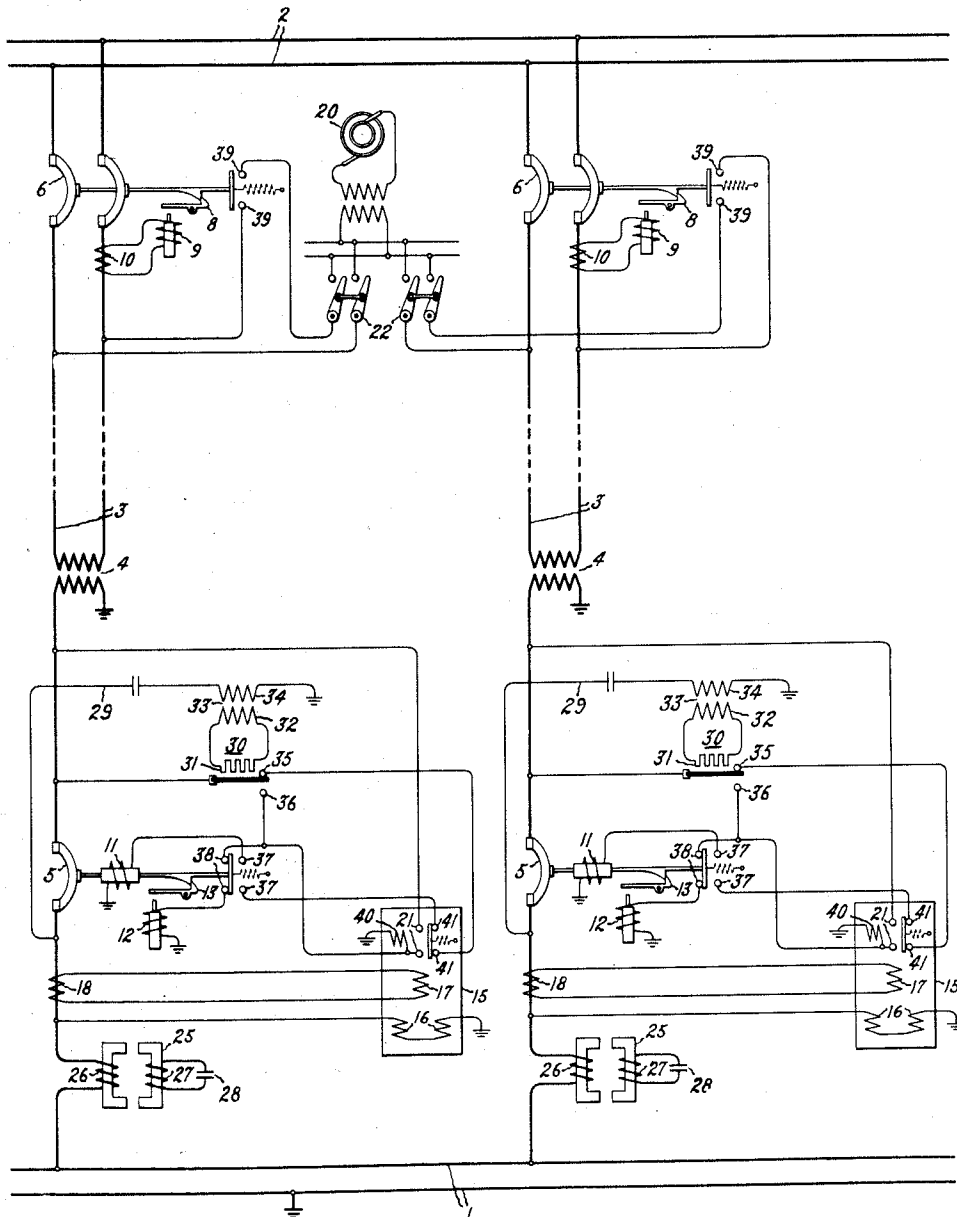
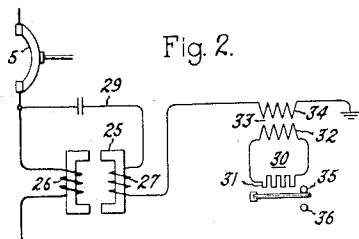


Fig. 2.



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UNITED STATES PATENT OFFICE

1,966,229

CONTROL SYSTEM

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Application December 5, 1933, Serial No. 700,962

10 Claims. (Cl. 171-97)

My invention relates to control systems for circuit breakers and particularly to a control system for controlling the operation of a network circuit breaker in a feeder supplying current to a network, and one object of my invention is to provide an improved arrangement for effecting the opening of such a network circuit breaker by supplying carrier current to the feeder. More particularly, the object of my invention is to provide an improved network circuit breaker control system of the type disclosed and claimed in the copending application of W. J. McLachlan, Serial No. 694,589, filed October 21, 1933 and assigned to the same assignee as this application.

My invention will be better understood from the following description, when taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the accompanying drawing, Fig. 1 is a diagram of a control system for a network circuit breaker embodying my invention, and Fig. 2 is a diagram showing a modification of the control arrangement shown in Fig. 1.

Referring to Fig. 1 of the drawing, 1 is an alternating current network which is arranged to be supplied with electric energy from a suitable alternating current supply circuit 2 by means of a plurality of feeders 3, two of which are shown in the drawing. In order to simplify the disclosure, single-phase circuits are shown, but it is obvious that my invention is equally applicable to poly-phase circuits.

Each feeder 3 includes a step-down power transformer 4, the low voltage secondary winding of which is arranged to be connected to the network 1 by means of suitable switching means 5 and the high voltage primary winding of which is arranged to be connected to the supply circuit 2 by suitable switching means 6. The transformers 4 and the secondary switching means 5 are usually located near the network 1, whereas the primary switching means 6 are usually in the main station or substation containing the supply circuit 2.

The switching means 6, which may be of any suitable type, examples of which are well known in the art, are usually arranged in any suitable manner so that they may be opened and closed by an operator and are also preferably arranged so that they are automatically opened in response to overload conditions on the respective feeders. As shown, each switching means 6 is an overload circuit breaker of the well known latched-in type which is adapted to be closed manually and which is adapted to be opened by releasing a latch 8

either manually or automatically by means of an overload coil 9 connected in series relation with the respective feeder 3 by means of a current transformer 10.

The switching means 5 may be of any suitable type, examples of which are well known in the art. As shown in the drawing, each switching means 5 is a latched-in circuit breaker and includes a closing coil 11 which, when energized, closes the circuit breaker and a trip coil 12 which, when energized, releases a latch 13 that holds the circuit breaker in its closed position.

In order to effect the immediate opening of a circuit breaker 5 when a fault occurs on its associated feeder 3 or transformer 4 and causes a large reversal of energy to flow through the circuit breaker 5, each feeder is provided with a suitable reverse power relay 15. As shown, each relay 15 has a potential coil 16 which is permanently connected across the network 1 and a current coil 17 which is connected in series relation with the secondary winding of the associated transformer 4 by means of a current transformer 18. Each reverse power relay 15 is arranged to close its normally open contacts 21 when the reverse power exceeds a predetermined amount. The closing of the contacts 21 is arranged to complete an energizing circuit for the trip coil 12 of the associated circuit breaker 5 so as to effect the opening thereof.

Preferably, the reverse power relays 15 are set so that they close their respective contacts 21 and open their respective contacts 41 in response to relatively large reversals of energy in their respective feeders only. Also the reverse power relays are preferably designed in any suitable manner, examples of which are well known in the art, so that the amount of reverse power required to cause a relay to close its contacts 21 varies directly with the network voltage.

In order that an operator at the main station may effect the opening of any of the network circuit breakers 5 so as to disconnect the associated feeder 3 from the network 1, I provide at the main station a suitable relatively low voltage source of carrier current 20 and suitable means, such as switches 22, for individually connecting this source 20 to each feeder 3. The frequency of this carrier current source 20 is preferably higher than the normal frequency of the supply circuit 2 and of such a value that it can be readily transmitted through the power transformer 4. I find that a frequency of about 720 cycles gives very satisfactory results for this purpose but it is to be understood that my invention is not limited to this frequency.

ited to a carrier current of any particular frequency.

In series relation with each feeder 3, I provide a suitable choke 25 which is designed in any suitable manner, examples of which are well known in the art, so that its impedance to current of normal frequency is low but its impedance to the carrier current is relatively high. In Fig. 1, the choke 25 is shown as a transformer with separate primary and secondary cores separated by an air gap. The primary winding 26 of the choke 25 is connected in series with the associated feeder and the secondary winding 27 is connected to a suitable condenser 28. In shunt relation with the primary winding 26 of each choke 25, I connect a separate shunt circuit 29 resonant to the frequency of the carrier current. As shown in Fig. 1, each shunt circuit 29 is also connected in shunt with the network 1 but if desired each of these circuits may be connected only in shunt with the primary winding 26 of the associated choke 25 or a portion thereof. In series relation with each shunt circuit 29, I provide a suitable current responsive timing device, such as a thermal relay 30 having its heating element 31 connected to the secondary winding 32 of a suitable transformer 33, the primary winding 34 of which is connected in series with the shunt circuit 29. Each thermal relay 30 is provided with a normally closed contact 35 and a normally open contact 36 respectively connected in the closing and tripping circuits of the associated network circuit breaker 5 so as to control the connection of these circuits across the secondary winding of the associated distribution transformer 4. Each closing circuit also includes auxiliary contacts 37 on the associated circuit breaker 5 so that it can be energized only when the associated circuit breaker 5 is open. Similarly, each tripping circuit also includes auxiliary contacts 38 on the associated circuit breaker 5 so that it can be energized only when the associated circuit breaker is closed.

The operation of the arrangement shown in Fig. 1 is as follows: When the operator desires to take any particular feeder 3 out of service, he first opens the associated circuit breaker 6 so as to disconnect the feeder from the supply circuit 2. The feeder 3, however, is still energized from the energized network 1 because the associated circuit breaker 5 is still closed. The operator then closes the switch 22 associated with the feeder 3 to be taken out of service so as to connect the carrier current source 20 thereto. In order to insure that the associated circuit breaker 6 is open before the source 20 is connected to a feeder 3, it may be desirable in some cases to connect the auxiliary contacts 39 on the associated circuit breaker 6 in series with the contacts of each switch 22.

The connection of the carrier current source 20 to a feeder 3 causes carrier current to be supplied by the associated transformer 4 to the network. This carrier current will produce a voltage drop across the primary winding of the choke 25 in the feeder 3 to which the source 20 is connected and also a voltage drop across the network 1. Since the voltage drops across the choke 25 in the feeder 3, to which the source 20 is connected, and across the network 1 are in series and the sum of these two voltage drops is impressed across the shunt circuit 29 associated with the feeder 3 to which the source 20 is connected, whereas the voltage drop across each of the other shunt circuits 29 is the voltage drop

across the network 1 less the voltage drop across the primary winding 26 of its associated choke 25, the relay 30 in the shunt circuit 29 associated with the feeder 3 to be disconnected receives more current than any of the other relays 30. Consequently, this particular relay 30 is the first to open its contacts 35 and close its contact 36 thereby connecting the tripping coil 12 of associated circuit breaker 5 across the secondary winding of the associated distribution transformer 4 which is still energized from the network 1, so that the circuit breaker 5 in the feeder to be taken out of service is opened. As soon as this circuit breaker 5 opens, the carrier current source 20 is disconnected from the network 1 so that all of the other carrier current relays 30 are prevented from effecting the opening of their associated circuit breakers 5.

In order that a carrier current relay 30 may be restored to its normal position after its associated circuit breaker 5 has been opened, without waiting for the carrier current source 20 to be disconnected from the associated feeder, I connect the primary winding 26 of each choke 25 between the associated circuit breaker 5 and the network 1 and connect the associated shunt circuit 29 to the feeder at a point intermediate the associated circuit breaker 5 and primary winding 26. Therefore, when any carrier current relay 30 has effected the opening of its associated circuit breaker 5, it immediately starts to return to its normal position and after a predetermined time interval opens its contacts 36 and closes its contact 35.

Since the time of operation of a thermal relay varies inversely with the magnitude of the current supplied thereto, it will be seen that it is particularly adapted to give the selective operation desired. Also the time delay resetting feature is important in cases where each feeder 3 supplies a plurality of parallel connected transformers as it insures that all of the parallel connected network circuit breakers have time to open before the closing circuit of any of them can be completed again. This arrangement, therefore, prevents pumping.

After a feeder 3 has been taken out of service, it may be put back again by the operator closing the associated circuit breaker 6 so as to connect the feeder to the supply circuit 2. As soon as the feeder is energized, the closing coil 11 of the associated circuit breaker 5 is energized to effect the closing thereof to reconnect the feeder to the network.

In case of a fault in any feeder 3 or its associated transformer 4, the excessive current in the feeder causes the trip coil 9 connected thereto to be energized sufficiently to effect the opening of the associated circuit breaker 6. Energy also is fed to the fault from the network 1 and this reverse flow of energy causes the associated reverse power relay 15 to close its contacts 21 thereby completing an energizing circuit for the trip coil 12 of the associated circuit breaker 5 to effect the opening thereof. Each reverse power relay 15 is preferably provided with a holding winding 40 which is energized by the closing of its contacts 21 and which maintains the relay contact 21 closed as long as the associated distribution transformer 4 is energized. Also the normally closed contacts 41 of the relay 15 may be connected in the circuit of the closing coil 11 of the associated circuit breaker 5 so that it cannot be reclosed as long as the relay 15 is in its tripping position. In this manner pumping of a circuit breaker 5 may be prevented in systems

in which a single feeder 3 supplies a number of transformers 4 in parallel and all of the associated circuit breakers 5 do not open simultaneously.

5 In the modification shown in Fig. 2, I have connected the secondary winding 27 of each choke 25 in series in the associated shunt circuit 29. By connecting the secondary winding 27 in the feeder to which the carrier current source 20 is connected so that the voltage induced therein is added to the voltage drop impressed across the associated shunt circuit 29, it is evident that the voltages induced in the secondary windings 27 of the other chokes 25 oppose the voltage drop impressed across them. Consequently, this modification results in an increase in the current supplied to the carrier current relay 30 associated with the feeder to be disconnected and a decrease in the currents supplied to the other relay 30.

20 While I have, in accordance with the patent statutes, shown and described my invention as applied to a particular system and as embodying various devices diagrammatically indicated, changes and modifications will be obvious to those skilled in the art, 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.

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

1. In combination, a network, a plurality of feeders supplying current to said network, each feeder including switching means connecting it to said network, and means for effecting the selective operation of any one of said switching means to disconnect the associated feeder from said network including a source of alternating current having a predetermined frequency, means for connecting said source to the feeder to be disconnected from said network, impedance means connected in each feeder, each impedance means being arranged so that the impedance thereof to currents normally flowing therein is low relative to the impedance thereof to currents of the frequency of said source, and a voltage controlled means associated with each of said series impedance means and controlled by the voltage drop across the associated impedance means for controlling the opening of said switching means.

2. In combination, an alternating current network, a plurality of feeders supplying current of a predetermined frequency to said network, each feeder including switching means connecting it to said network, and means for effecting the selective operation of any one of said switching means to disconnect the associated feeder from said network including a source of alternating current having a different predetermined frequency, means for connecting said source to the feeder to be disconnected from said network, impedance means connected in each feeder, each impedance means being arranged so that the impedance thereof to currents of said first mentioned frequency is low relative to the impedance thereof to currents of the frequency of said source, a circuit tuned to the frequency of said source connected in shunt relation to each impedance means and current responsive means connected to each shunt circuit for controlling the opening of the associated switching means.

3. In combination, an alternating current network, a plurality of feeders supplying current of a predetermined frequency to said network, each feeder including switching means connecting it

to said network, and means for effecting the selective operation of any one of said switching means to disconnect the associated feeder from said network including a source of alternating current having a different predetermined frequency, means for connecting said source to the feeder to be disconnected from said network, impedance means connected in each feeder, each impedance means being arranged so that the impedance thereof to currents of said first mentioned frequency is low relative to the impedance thereof to currents of the frequency of said source, a circuit tuned to the frequency of said source connected in shunt relation to each impedance means and a time relay for each shunt circuit controlled by the current therein for controlling the opening of the associated switching means.

4. In combination, an alternating current network, a plurality of feeders supplying current of a predetermined frequency to said network, each feeder including switching means connecting it to said network, and means for effecting the selective operation of any one of said switching means to disconnect the associated feeder from said network including a source of alternating current having a different predetermined frequency, means for connecting said source to the feeder to be disconnected from said network, impedance means connected in each feeder, each impedance means being arranged so that the impedance thereof to currents of said first mentioned frequency is low relative to the impedance thereof to currents of the frequency of said source, a circuit tuned to the frequency of said source connected in shunt relation to each impedance means and a thermal relay for each shunt circuit having its heating element connected thereto and controlling the opening of the associated switching means.

5. In combination, a network, a plurality of feeders supplying current to said network, each feeder including switching means connecting it to said network, and means for effecting the selective operation of any one of said switching means to disconnect the associated feeder from said network including a source of alternating current having a predetermined frequency, means for connecting said source to the feeder to be disconnected from said network, impedance means connected in series relation in each feeder between the associated switching means and said network, each impedance means being arranged so that the impedance thereof to currents normally flowing therein is low relative to the impedance thereof to currents of the frequency of said source, a circuit tuned to the frequency of said source connected across each feeder on the network side of each switching means and in shunt relation with the associated series impedance means, and current responsive means connected to each shunt circuit for controlling the opening of the associated switching means.

6. In combination, an alternating current network, a plurality of feeders supplying current of a predetermined frequency to said network, each feeder including switching means connecting it to said network, and means for effecting the selective operation of any one of said switching means to disconnect the associated feeder from said network including a source of alternating current having a different predetermined frequency, means for connecting said source to the feeder to be disconnected from said network, impedance means connected in series relation

in each feeder between the associated switching means and said network, each impedance means being arranged so that the impedance thereof to currents of said first mentioned frequency is low relative to the impedance thereof to currents of the frequency of said source, a circuit tuned to the frequency of said source connected across each feeder on the network side of each switching means and in shunt relation with the associated series impedance means, and a time relay connected to each shunt circuit and controlled by the current therein for controlling the opening of the associated switching means.

7. In combination, an alternating current network, a plurality of feeders supplying current of a predetermined frequency to said network, each feeder including switching means connecting it to said network, and means for effecting the selective operation of any one of said switching means to disconnect the associated feeder from said network including a source of alternating current having a different predetermined frequency, means for connecting said source to the feeder to be disconnected from said network, impedance means connected in series relation in each feeder between the associated switching means and said network, each impedance means being arranged so that the impedance thereof to currents of said first mentioned frequency is low relative to the impedance thereof to currents of the frequency of said source, a circuit tuned to the frequency of said source connected across each feeder on the network side of each switching means and in shunt relation with the associated series impedance means, and a thermal relay for each shunt circuit having its heating element connected thereto and controlling the opening of the associated switching means.

8. In combination, an alternating current network, a plurality of feeders supplying current of a predetermined frequency to said network, each feeder including a power transformer and a circuit breaker for connecting the secondary winding to the network, each circuit breaker including a closing circuit and a tripping circuit, means for effecting the selective opening of any one of said circuit breakers including a source of alternating current of a different frequency, means for connecting said source to the primary winding of the transformer associated with the circuit breaker to be opened, impedance means connected in secondary winding of each transformer, each impedance means being arranged so that the impedance thereof to currents of said first mentioned frequency is low relative to the impedance thereof to currents of the frequency of said source, and means associated with impedance means and controlled by the voltage drop across the associated impedance means for completing the tripping circuit of the associated circuit breaker and for preventing the closing circuit thereof from being completed for a predetermined time after the opening thereof.

9. In combination, an alternating current network, a plurality of feeders supplying current of a predetermined frequency to said network, each feeder including a power transformer and a circuit breaker for connecting the secondary winding to the network, each circuit breaker including a closing circuit and a tripping circuit, means for effecting the selective opening of any one of said circuit breakers including a source of alternating current of a different frequency, means for connecting said source to the primary winding of the transformer associated with the circuit breaker to be opened, impedance means connected in secondary winding of each transformer, each impedance means being arranged so that the impedance thereof to currents of said first mentioned frequency is low relative to the impedance thereof to currents of the frequency of said source, a circuit tuned to the frequency of said source connected in shunt relation to each impedance means, a time relay for each shunt circuit controlled by the current therein for effecting the completion of the tripping circuit of the associated circuit breaker and for maintaining the opening circuit thereof open for a predetermined time after the circuit breaker opens, and means controlled by the opening of a circuit breaker for connecting the associated closing circuit to the secondary winding of the associated transformer.

10. In combination, an alternating current network, a plurality of feeders supplying current of a predetermined frequency to said network, each feeder including a power transformer and a circuit breaker for connecting the secondary winding to the network, each circuit breaker including a closing circuit and a tripping circuit, means for effecting the selective opening of any one of said circuit breakers including a source of alternating current of a different frequency, means for connecting said source to the primary winding of the transformer associated with the circuit breaker to be opened, impedance means connected in series relation with each transformer secondary winding and said network between the associated circuit breaker and the network, each impedance means being arranged so that the impedance thereof to currents of said first mentioned frequency is low relative to the impedance thereof to currents of the frequency of said source, a circuit tuned to the frequency of said source connected across each transformer secondary winding on the network circuit of the associated circuit breaker and in shunt relation with the associated series impedance means, and a thermal relay for each shunt circuit having its heating element controlled by the current therein and having contacts in the tripping and closing circuits of the associated circuit breaker whereby only one of these circuits can be completed at any instant.

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