Dec. 1, 1942. W. A. DERR 2,303,440

CONTROL SYSTEM

Filed July 27, 1940 2 Sheets-Sheet 1

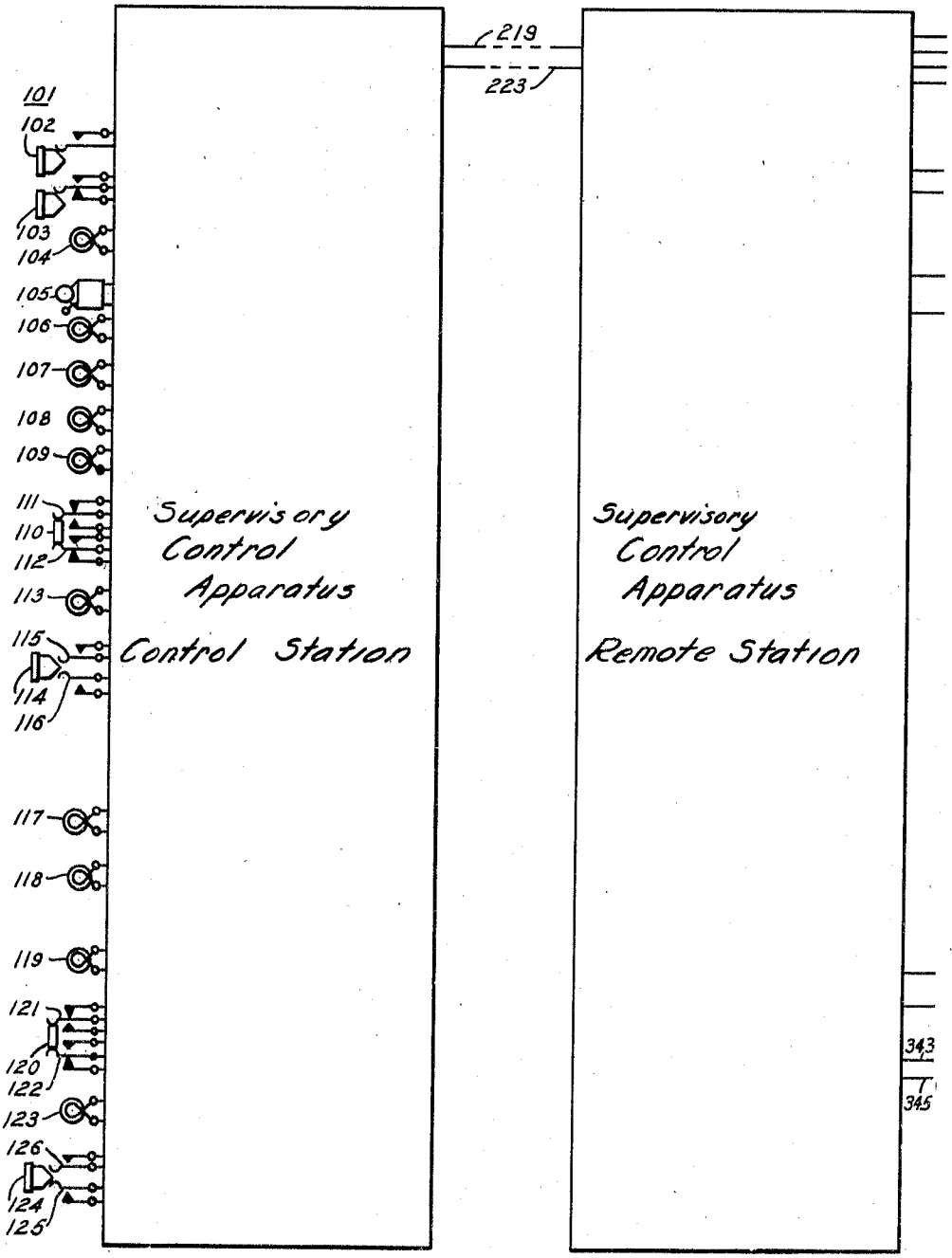

Fig. 1.

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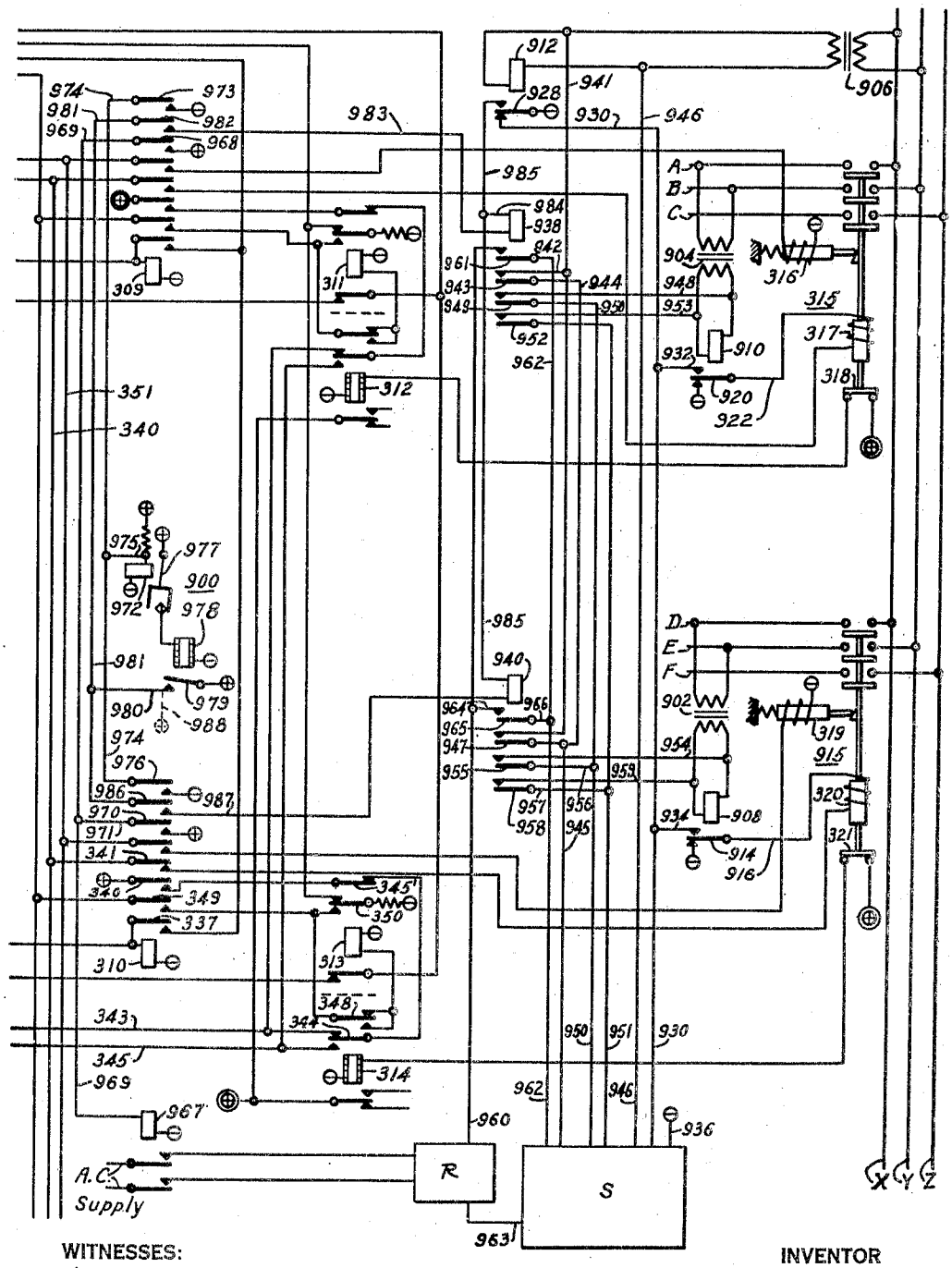

Fig. 2.

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CONTROL SYSTEM

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3 Claims. (Cl. 171—118)

My invention relates, generally, to control systems and, more particularly, to remote control systems such as those commonly known as supervisory control systems.

In the operation of remotely disposed power stations, substations, and the like, it is often necessary to determine whether two systems of alternating current power which are to be tied together are in synchronism and to close the tie circuit breaker only when they are in synchronism.

Supervisory control systems are not well adapted to the remote indication of synchronism and the simultaneous indication of synchronism and circuit breaker control. This is particularly true of supervisory control systems operating over carrier current channels because of the difficulties involved in maintaining a continuous indication of a variable quantity over carrier current channels.

An object of my invention is to provide a supervisory control system which shall function in response to control operations at a control station for a circuit breaker at a remote station to automatically close the circuit breaker only after the condition of synchronism between the circuits on the two sides of the breaker has been reached.

Another object of the invention is to provide a supervisory control system which shall function in response to selective control operations at a control station for a plurality of circuit breakers at a remote station to cause a single automatic synchronizing mechanism to automatically close the selected circuit breaker only after the condition of synchronism between the circuits on the two sides of the breaker has been reached.

A further object of the invention is to provide a supervisory control system which shall function in response to control operations at a control station for a circuit breaker at a remote station which in turn is controlled by an automatic synchronizing device, to connect the synchronizing device in controlling relation with the circuit breaker a predetermined time after the control operation at the control station.

Another object of the invention is to provide a remote control system which shall function in response to control operations at a control station for a circuit breaker at a remote station to close the circuit breaker immediately in response to the control operations in the event that no potential is present on one side of the circuit breaker, and to close the circuit breaker only after the condition of synchronism between the circuits on the two sides of the circuit breaker has been reached in the event that potential is present on both sides of the circuit breaker.

These and other objects and advantages of the invention will be apparent from the following detailed description taken in connection with the accompanying drawings, the two figures of which, taken together, represent diagrammatically a supervisory control system embodying the principal features of my invention.

For convenience in illustrating and describing the principles of the invention and for the purpose of enabling it to be more easily understood, the invention and the manner in which its preferred embodiment may be employed is illustrated and described in the accompanying drawings and specification as applied to and operating in conjunction with the supervisory control system disclosed and described in detail in the United States patent to H. P. Boswau, No. 2,091,301, issued August 31, 1937. Accordingly, the coding, selecting, and control apparatus at the control station except the manually controlled apparatus and indicating apparatus have been shown boxed, and the coding, selecting and control apparatus at the remote station except the apparatus directly associated with the controlled and supervised apparatus has been shown boxed. Reference may be had to the above identified Boswau patent for a complete description of the structure and operation of the boxed apparatus and the relation of the apparatus of this invention to the apparatus of the patented system is readily apparent from the similar positions of the elements of apparatus and their associated connections and the identical and similar reference characters applied to the identical and similar elements of apparatus.

In practicing the invention the circuit breakers associated with points Nos. 1 and 4 of the Boswau patent No. 2,091,301 are disposed to connect alternating current conductors A—B—C and D—E—F, respectively, to common bus conductors X—Y—Z. The bus X—Y—Z may be the main bus of a remote power station and the buses A—B—C and D—E—F may be buses connected to separate generators which are to be operated in parallel and connected to the common bus X—Y—Z. The point No. 1 circuit breaker 315 and the point No. 4 circuit breaker 915 may be selected for operation by the selective manual controls at the control station and the coding, selecting and control relays at the control station and the remote station including the code control operating relays 309 and 310, respectively, at the remote station as set forth in the Patent No. 2,091,301 to which reference is made for the complete explanation of the apparatus and its functioning to effect the selection for operation of the circuit breakers 315 and 915.

After the desired breaker is selected for operation an automatic synchronizer S which is supplied with direct current by a battery eliminator or rectifier R is connected to complete the circuit of the closing coil of the selected breaker when the condition of synchronism of the two

buses to which the breaker is connected is reached.

When the rectifier R is of the electronic type an interval of time is necessary after it is connected to the alternating current supply before it is fully operative to supply the required direct current. A timing device 900 is provided to delay the connection of the rectifier to the synchronizer and the synchronizer in control relation a desired time interval after the connection of the rectifier to the alternating current supply.

In the event that no potential exists on one side of the selected circuit breaker the control operation originated at the control station will operate the selected breaker immediately without synchronizer control.

Considering the system more in detail, potential transformers 902, 904 and 906 are connected to single phases of the buses D—E—F, A—B—C and X—Y—Z, respectively, and have relays 908, 910 and 912 connected in their respective secondary circuits.

In order to complete the energizing circuit for the closing coil 320 of the circuit breaker 315, it is necessary that one side of the coil be connected to negative battery as indicated in the hereinbefore referred to Boswau Patent No. 2,091,301. This connection to the negative battery is provided by a contact armature 914 of the relay 908, when the relay 908 is deenergized. The circuit extends from negative battery through the contact armature 914 and its associated back contact element and a conductor 916 to one side of the winding of the closing coil 320 for the circuit breaker 315. In a similar manner the connection to negative battery for the closing coil 317 of the circuit breaker 315 is provided by the contact armature 920 of the relay 910 and this circuit extends from negative battery through the contact armature 920 and its associated back contact element and a conductor 922 to the winding of the closing coil 317.

When there is potential on the bus A—B—C the relay 910 will be energized and the connection of the closing coil 317 to negative battery will be provided by the contact armature 928 of the relay 912 in the event that no potential exists on the bus X—Y—Z. This connection to negative battery extends from negative battery through the contact armature 928 and its associated back contact element, conductors 930 and 932, contact armature 920 of the relay 910 and its associated front contact element and the conductor 922 to the winding of the closing coil 317.

In the event that the bus D—E—F is energized and the bus X—Y—Z is not energized when it is desired to close the circuit breaker 315, the connection of the closing coil 320 to negative battery will be provided through a circuit which extends from negative battery through the contact armature 928 of the relay 912 and its associated back contact element, the conductor 930, a conductor 934, contact element 914 of the relay 908 and its associated front contact element and conductor 916 to the winding of the closing coil 320.

Thus when either of the circuit breakers 315 or 315 is selected and operated for closure, it will close immediately if potential does not exist on both sides of the breaker.

If potential exists on both sides of the selected breaker, it will be necessary to control the closure of the breaker by the automatic synchronizer S which will apply negative potential to the selected closing coil automatically when synchronism exists.

The circuit whereby the synchronizer applies negative potential to the closing coil 317 of the circuit breaker 315 extends from negative potential through a conductor 936 to the automatic synchronizer S, through conductors 930 and 932, the contact armature 920 and its associated front contact element, and the conductor 922 to the winding of the closing coil 317. A similar circuit for the closing coil 320 for the relay 915 extends from the negative battery through the conductor 936, the automatic synchronizer S, conductors 930 and 934, a contact armature 914 of the relay 908 and its associated front contact element and conductor 916 to the winding of the closing coil 320.

The automatic synchronizer S is connected to respond to the potentials of the bus X—Y—Z and the selected bus A—B—C or D—E—F which is to be connected to the bus X—Y—Z by synchronizer control relays 938 and 940 which are associated with the individual buses A—B—C and D—E—F, respectively.

The synchronizer control relay 938, when energized, connects the secondary winding of the potential transformer 906 to the automatic synchronizer S through a circuit which extends from one side of the secondary winding of the transformer 906 through conductors 941 and 942, the contact element 943 of the relay 938, conductors 944 and 945, the automatic synchronizer S and conductor 946 to the other side of the secondary winding of the transformer 906.

At the same time the relay 938 connects the secondary winding of the potential transformer 904 to the automatic synchronizer S through a circuit which extends from one side of the secondary winding of the transformer 904 through a conductor 948, a contact element 949 of the relay 938, a conductor 950 to the automatic synchronizer S, a conductor 951, a contact element 952 of the relay 938 and a conductor 953 to the other side of the secondary of the potential transformer 904.

Similarly, when the synchronizer control relay 940 is energized, it controls a circuit which extends from one side of the secondary of the potential transformer 906 through the conductor 941, a contact element 947 of the relay 940, the conductor 945, the automatic synchronizer S and the conductor 946 to the other side of the secondary winding of the transformer 906.

The relay 940 also controls a circuit extending from one side of the secondary of the potential transformer 902 through a conductor 954, a contact element 955 of the relay 940, conductors 956 and 950, the automatic synchronizer S, the conductor 951, a conductor 957, a contact element 958 of the relay 940 and a conductor 959 to the other side of the secondary winding of the transformer 902.

When either of the synchronizer control relays 938 or 940 is energized it closes a circuit conducting direct current power from the battery eliminator or rectifier R to the automatic synchronizer S. This circuit controlled by the relay 938 extends from the rectifier R through a conductor 960, a contact element 961 of the relay 938, a conductor 962, the automatic synchronizer S and a conductor 963 to the rectifier R. The corresponding circuit controlled by the relay 940 extends from the rectifier R, through the conductor 960, a conductor 964, a contact element

965 of the relay 940, a conductor 966, the conductor 962, the automatic synchronizer S and the conductor 963 to the rectifier R.

The rectifier R is energized by connection to the alternating current supply by a relay 967 in a circuit controlled by the selected one of the code control operating relays 309 and 310, the circuit controlled by the relay 309 extending from positive battery through a contact element 968 of the relay 309, a conductor 969 and the winding of the relay 967 to negative battery. The corresponding energizing circuit for the relay 967 controlled by the relay 310 extends from positive battery through a contact element 970 of the relay 310, a conductor 971, the conductor 969 and the winding of the relay 967 to negative battery.

When either of the code control operating relays 309 or 310 is energized, a shunting circuit for a normally energized pendulum relay 972 which is a part of the timing device 900 is completed by the selected code control operating relay. This shunting circuit controlled by the relay 309 extends from negative battery through a contact element 973 of the relay 309, conductors 974 and 975 to the positive side of the winding of the relay 972. The corresponding shunting circuit controlled by the relay 310 extends from negative battery through a contact element 976 of the relay 310 and conductors 974 and 975 to the positive side of the winding of the relay 972.

Upon the completion of the shunting circuit for the winding of the relay 972 the contact pendulum 977 will be freed by the deenergization of the relay 972 and will alternately break and make an energizing circuit for the winding of a slow-to-release relay 978 which is controlled by the contact elements of the pendulum 977. The slow-to-release relay 978 which has heretofore been held energized in a circuit controlled by contacts of the pendulum 977 will maintain its contact armature 979 in open circuit position between the opening and closing of its energizing circuit by the pendulum 977 until the interval between the circuit break and make is sufficient to permit the contact armature 979 to drop or until the contact elements of the pendulum 977 fail to make the energizing circuit of the relay 978.

The contact armature 979 of the relay 978 controls the energizing circuit for the synchronizing control relays 938 and 940, the energizing circuit for the relay 938 extending from positive battery through the contact armature 979 and its associated back contact element, conductors 980 and 981, a contact element 982 of the relay 309, a conductor 983, the winding of the relay 938, conductors 984 and 985, the contact armature 928 of the relay 912 and its associated front contact element to negative battery. The corresponding circuit for the synchronizer control relay 940 extends from positive battery through the contact armature 979 and its associated back contact element, the conductors 980 and 981, a contact element 986 of the relay 310, a conductor 987, the winding of the relay 940, the conductor 985, the contact armature 928 of the relay 912 and its associated front contact element to negative battery.

Operation

In the operation of the system, when it is desired to connect the bus A—B—C to the bus X—Y—Z by closing the circuit breaker 315, the operator at the control station will momentarily actuate the point select key 114, which, through the coding, selecting and control systems at the control and remote stations, will energize the code control operating relay 309. The operator will also actuate the point control twist key 110 to control position which is at right angles to the trip position shown in the drawings and actuate the master control key 102. If one of the buses A—B—C or X—Y—Z is not energized, the circuit breaker 315 will be closed immediately through the control circuits providing negative potential to the winding of the closing coil 317 as hereinbefore described.

In the event that potential exists on both of the buses A—B—C and X—Y—Z, relays 910 and 912 will both be energized and it will be necessary for the automatic synchronizer S to connect the closing coil 317 to negative battery to complete the closing circuit for the winding of the closing coil 317.

When the code control operating relay 309 is energized the rectifier R is connected to the alternating current supply by the energization of the relay 967 through the circuit controlled by the contact element 968 of the relay 309 as hereinbefore described. Also when the relay 309 is energized the shunting circuit for the relay 972 of the timing device 900 is shunted to start the timing interval which will complete the energizing circuit for the synchronizing control relay 938 after the time interval determined by the characteristics of the timing device 900.

After the expiration of this time interval which is sufficient to permit the rectifier R to be conditioned for operation, the synchronizing control relay 938 will be energized and will connect the secondary windings of the potential transformers 904 and 906 which are associated with the buses A—B—C and X—Y—Z to the automatic synchronizer S and at the same time will complete the circuit supplying direct current to the automatic synchronizer S from the rectifier R.

When the condition of synchronism exists between the buses A—B—C and X—Y—Z, the automatic synchronizer S will respond to this condition of synchronism and close the circuit thus providing negative battery for the winding of the closing coil 317 of the circuit breaker 315 as hereinbefore described, and the circuit breaker 315 will be closed.

The operation of the system to close the circuit breaker 915 connecting the buses D—E—F and X—Y—Z when the condition of synchronism between the buses is attained is the same as that described hereinbefore for the control of circuit breaker 315 except that the circuit breaker 915 is controlled by its individual code control relay 319 and synchronizer control relay 940.

The automatic timing device 900 is provided for the purpose of delaying the connection of the rectifier R to the automatic synchronizer S and the automatic synchronizer S to the control potentials from the power buses in the event that the rectifier R is of such construction as to require a time interval between its energization by the alternating current and its efficient functioning to provide direct current for the automatic synchronizer. Such rectifiers are those employing electronic tubes which require an interval of energization before they operate efficiently.

In the event that a type of rectifier which will operate efficiently immediately upon energization of the alternating current is used, it will not

be necessary to use the automatic timing device 900 to delay the actuation of the selected synchronizer control relay 938 or 940. In this event the timing device 900 and its shunting circuits controlled by the contact elements 973 and 976 of the code control operating relays 309 and 310 may be eliminated and the conductor 930 may be connected to positive battery by a permanent connection through a conductor 938 as shown in broken lines in the drawings.

The control of the circuit breakers 315 and 915 to trip the circuit breakers and the supervisory operations of the breakers are the same as those described in detail in the hereinbefore referred to Patent No. 2,091,301, and are unaffected by the auxiliary control apparatus for the closing of the circuit breaker.

While the principles of the invention have been disclosed in connection with the selective operation of only two circuit breakers, it is to be understood that the same principles may be applied to the operation of as many circuit breakers as is desired using the single automatic synchronizer S.

It will be seen that I have provided a control system which shall function in response to selected control operations at a control station for a plurality of circuit breakers at a remote station to close the selected circuit breaker immediately in response to the control operations in the event that no potential is present on one side of the circuit breaker, to close the selected circuit breaker only after the condition of synchronism between the circuits on the two sides of the breaker has been attained in the event that potential is present on both sides of the breaker, which shall employ a single automatic synchronizer for a plurality of the selectively operated circuit breakers, and which in the event that a battery eliminator or rectifier requiring a time delay before full operation, is employed, shall delay the connection of the automatic synchronizer with the selected circuits which are to be synchronized.

In compliance with the requirements of the Patent Statutes, it will be seen that I have shown and described herein the preferred embodiment of my invention. It is to be understood, however, that the invention shown and described herein is capable of modification by one skilled in the art, the embodiment shown herein being merely illustrative of the principles of my invention.

I claim as my invention:

1. In a system for selectively controlling from a control station a plurality of circuit breakers at a remote station each disposed to tie together two alternating-current systems, a single synchronism responsive device at the remote station including an electrically operated mechanism which requires an appreciable interval of energization before the synchronism responsive device will operate properly, means including a remote selective control system operating over a single channel between the stations responsive to selective control operations at the control station for selecting the desired one of the circuit breakers for operation, means responsive to the said selective control operations at the control station for energizing said electrically operated mechanism, time delay means for automatically connecting said synchronism responsive device to respond to synchronism between the two alternating-current systems to which the selected circuit breaker is connected after the said required interval of energization of the electrically operated mechanism, and means whereby the synchronism responsive device thereafter automatically closes the selected circuit breaker when the condition of synchronism is reached.

2. In a system for selectively controlling from a control station a plurality of circuit breakers at a remote station each disposed to tie together two alternating-current systems, a single synchronism responsive device at the remote station including an electrically operated mechanism which requires an appreciable interval of energization before the synchronism responsive device will operate properly, means including a remote selective control system operating over a single channel between the stations responsive to selective control operations at the control station for selecting the desired one of the circuit breakers for operation, means responsive to the said selective control operations at the control station for energizing said electrically operated mechanism, time delay means for automatically connecting said synchronism responsive device to respond to synchronism between the two alternating-current systems to which the selected circuit breaker is connected after the said required interval of energization of the electrically operated mechanism in the event that there is potential on the two systems, means whereby the synchronism responsive device thereafter automatically closes the selected circuit breaker when the condition of synchronism is reached, and means responsive to the said selective control operations at the control station for closing the selected circuit breaker in the event that there is no potential on one of the two systems to which the selected circuit breaker is connected.

3. In a supervisory control system having selective control means at a control station and selective means at a remote station operating over a single channel between the stations and responsive to the operation of the selective control means for selectively operating a plurality of circuit breakers at the remote station each of which is disposed to tie together two alternating-current systems, said selective means at the remote station including a selective relay associated with each of the said circuit breakers, means including potential relays responsive to potentials on the systems associated with the selected circuit breaker and a contact of the selected selective relay for closing the selected circuit breaker in the event that there is no potential on one of the systems associated with the selected breaker, a synchronism responsive device at the remote station having an electrically operable mechanism which requires an interval of energization before the device will function properly, means whereby the selected selective relay causes said electrically operated mechanism to be energized, a timing device, means whereby the selected selective relay actuates said timing device, means including the said potential responsive relays whereby the timing device, after the said required interval, connects the synchronism responsive device to respond to synchronism between the systems associated with the selected circuit breaker in the event that there is potential on the two systems, and means whereby the synchronism responsive device thereafter automatically closes the selected circuit breaker when the condition of synchronism is reached.

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