

July 26, 1938.

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SUPERVISORY CONTROL SYSTEM

Filed May 18, 1937

2 Sheets-Sheet 1

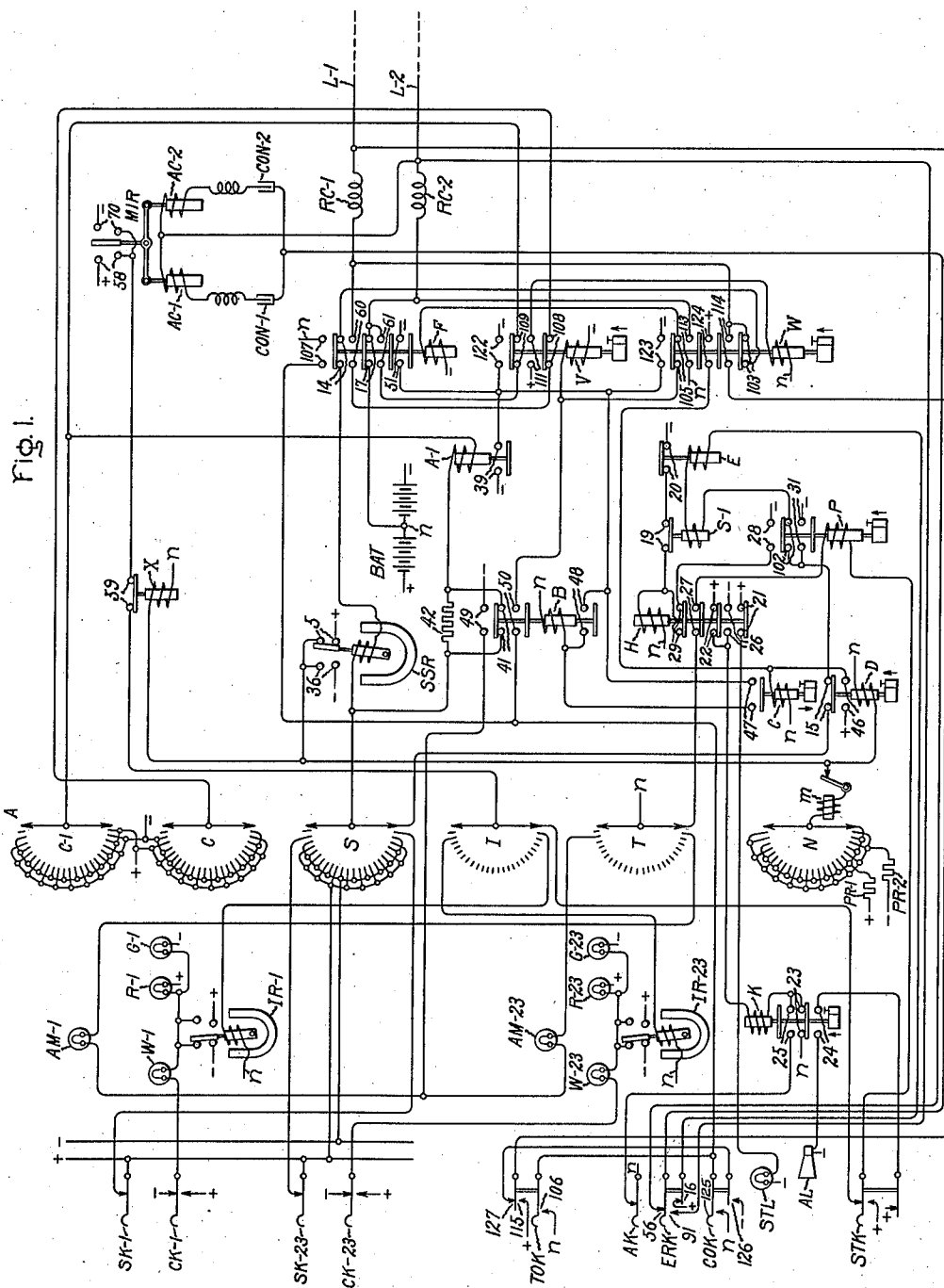


Fig. 1.

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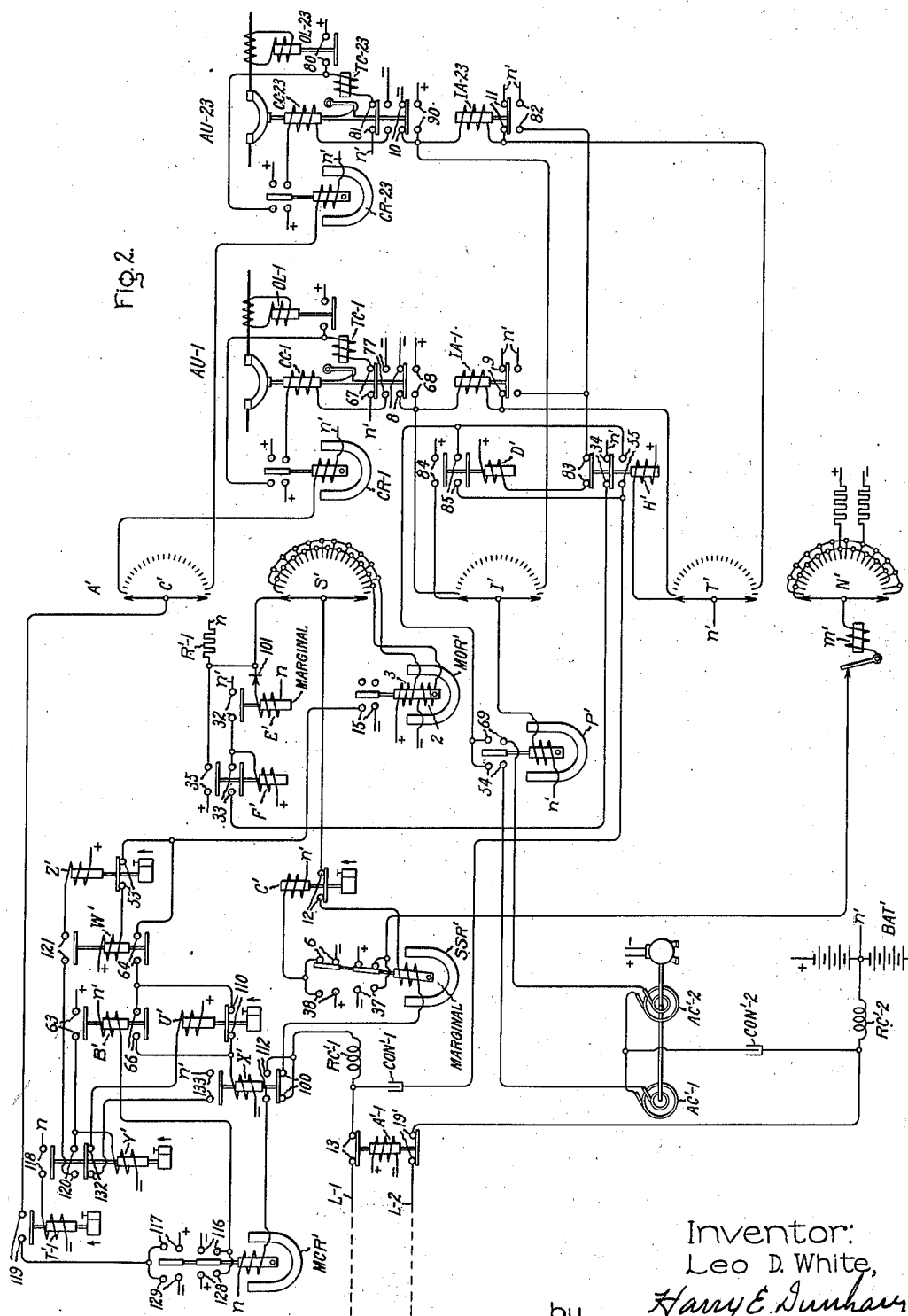
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SUPERVISORY CONTROL SYSTEM

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2 Sheets-Sheet 2



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SUPERVISORY CONTROL SYSTEM

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Application May 18, 1937, Serial No. 143,316

11 Claims. (Cl. 177—353)

My invention relates to supervisory control systems for supervising and controlling apparatus in a remote station from a control station such as a dispatcher's office and particularly to improvements in two-wire synchronous selector supervisory control systems of the type disclosed in United States Letters Patent 2,059,896, granted November 3, 1936, to the assignee of this application.

One object of my invention is to provide an improved arrangement of apparatus for effecting the operation of a selected unit in a supervisory control system of the type disclosed in the aforesaid Letters Patent so that an undesired operation of the selected unit may not be effected due to an incorrect indication of the position thereof being received at the dispatcher's office.

Another object of my invention is to provide an improved arrangement for starting a supervisory control system of the type disclosed in the aforesaid Letters Patent.

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

Referring to the accompanying drawings, Figs. 1 and 2 when taken together diagrammatically illustrate a supervisory control system embodying a preferred embodiment of my invention, the apparatus and circuits at the dispatcher's office being shown diagrammatically in Fig. 1 and the apparatus and circuits at the remote station being diagrammatically shown in Fig. 2.

General description of the system

In the arrangement shown in the drawings two line conductors L—1 and L—2 extend between the dispatcher's office and the remote station. At the remote station a selector switch A' is provided for successively associating the apparatus units therewith with the two line conductors L—1 and L—2 in a predetermined sequence. At the dispatcher's office a similar selector switch A is provided for successively associating the corresponding groups of control keys and indicating lamps with the two line conductors L—1, L—2 in the same sequence. Preferably each selector switch is of the well known type which comprises a plurality of banks of contacts, each of which has associated therewith a cooperating wiper, and a suitable motor magnet for simultaneously moving all of the wipers in a step by step manner over the contacts in the respective banks. Any other suitable selecting means

examples of which are well known in the art may be used however. As shown in the drawings the switch A' consists of five banks of contacts C', S', I', T' and N', a cooperating wiper for each bank and an operating magnet m' for the five wipers; and the switch A consists of six banks of contacts C—1, C, S, I, T and N, a cooperating wiper for each bank and an operating magnet m for the six wipers. Each bank contains 25 contacts so that each switch has 25 different positions. Normally each switch is in its zero or normal position, as shown. Each of the other positions, except the last, is allotted to a different apparatus unit so that with the arrangement shown twenty-three different apparatus units can be supervised. In order to simplify the disclosure, however, only the individual control devices and circuits for the apparatus units AU—1 which is allotted to the first position of each switch and for the apparatus unit AU—23 which is allotted to the twenty-third position of each switch, are shown. It will be evident, however, that a similar apparatus unit may be allotted to each of the other twenty-one positions between the first and twenty-third positions of the switches.

As shown in the drawings, the apparatus units AU—1 and AU—23 are circuit breakers of the well known latched-in type but it is obvious that each apparatus unit may be any other suitable control device. Each apparatus unit is provided with a suitable closing coil, such as CC—1 for apparatus unit AU—1 and CC—23 for the apparatus unit AU—23, and with a suitable trip coil, such as TC—1 for the apparatus unit AU—1 and TC—23 for the apparatus unit AU—23. Associated with each apparatus unit is a control relay, such as CR—1 and CR—23 for the apparatus units AU—1 and AU—23 respectively, which selectively controls the energization of the closing and trip coils of the associated apparatus unit. As shown, these control relays are polarized relays of the well known type whose armature returns to the neutral position when deenergized after each operation. Each control relay has its respective winding connected between the contact in bank C' which is allotted to the associated apparatus unit and the neutral terminal n' of a battery BAT' which is provided at the remote station. Therefore, with this arrangement it will be seen that when the wiper associated with the bank C' is in engagement with a contact which is allotted to an apparatus unit, the direction of current flow through the wiper and contact of bank C' determines

whether the associate control relay completes the closing coil circuit or the trip coil circuit of the associate apparatus unit.

As shown, the circuit of each trip coil is also arranged to be completed by an overload relay such as OL—1 and OL—23 for the units AU—1 and AU—23 respectively which is so connected as to be responsive to an abnormal current through the associate circuit breaker.

At the dispatcher's office the group of control relays and indicating lamps corresponding to the apparatus unit AU—1 consists of a two position select key SK—1 which is operated when it is desired to have the selector switches A and A' stopped with their wipers in engagement with the first contacts in the respective banks, a two position control key CK—1 which controls the operation of the indicating lamps, a red lamp R—1 which, when energized, indicates that the apparatus unit AU—1 is in its closed position, a green lamp G—1 which when lighted indicates that the apparatus unit AU—1 is in its open position, a white lamp W—1 which when lighted indicates that the position of the apparatus unit AU—1 does not correspond with the position of the control key CK—1 and an amber light AM—1 which when lighted indicates that the switches A and A' have stopped with their wipers in engagement with the contacts allotted to the apparatus unit AU—1. The group of control keys and lamps corresponding to the apparatus unit AU—23 similarly consists of a select key SK—23, a control key CK—23, a red lamp R—23, a green lamp G—23, a white lamp W—23 and an amber lamp AM—23.

Each group of control keys and indicating lamps has associated therewith an individual indicating relay, such as IR—1 and IR—23 for the lamps corresponding to the apparatus units AU—1 and AU—23 respectively, which determines by its position whether the associate red or green lamp is lighted. Each indicating relay also determines in conjunction with the associate control key whether the associate white lamp is lighted. As shown in Fig. 1, the relays IR—1 and IR—23 are in positions to effect the lighting of the lamps R—1 and R—23 respectively since the corresponding apparatus units AU—1 and AU—23 are shown in their closed positions. Since the control keys CK—1 and CK—23 are also shown in their closed positions the positions of these keys agree with the positions of the corresponding apparatus units and, therefore, the white lamps W—1 and W—23 are not lighted. It will be seen, however, that if either of the control keys were in its other position, the associate white lamp would be lighted.

Each indicating relay is shown as a polarized relay of the well known type whose armature remains in the last position to which it is operated. The operating coil of each indicating relay is connected between the neutral terminal *n* of a battery BAT at the dispatcher's office and the bank I contact allotted to the corresponding apparatus unit. For example, the operating coil of the relay IR—1 is connected between the battery terminal *n* and the first contact in bank I, and the operating coil of relay IR—23 is connected between the battery terminal *n* and the twenty-third contact in bank I. The direction of the current through the operating coil of each indicating relay is determined by the position of the corresponding apparatus unit in a manner which will be herein-after described.

In order that each group of control keys and indicating lamps may be associated with the two

line conductors L—1 and L—2 at the same time the corresponding apparatus unit is associated therewith, it is essential that the wipers of the two switches shall engage their corresponding contacts at the same time. This result is obtained by completing a synchronizing circuit through the two line conductors when both switches occupy corresponding positions and providing means which responds to the current flowing through the synchronizing circuit for effecting the simultaneous operation of the motor magnets of the two switches. In the arrangement shown, the line conductor L—2 is normally connected to the mid or neutral terminals *n* and *n'* of the batteries BAT and BAT' respectively. The line conductor L—1 is normally connected to the wipers of the banks S and S' respectively. In the dispatcher's office the adjacent contacts of the bank S are connected to the opposite polarity terminals of the battery BAT through the normally closed contacts of the corresponding select keys. For example, the first and twenty-third contacts of the bank S are respectively connected to the positive terminal of the battery BAT through the normally closed contacts of the select key SK—1 and SK—23. At the remote station the adjacent contacts of the bank S' are connected to the opposite polarity terminals of the battery BAT'. The corresponding contacts of the two banks S and S', however, are connected to opposite polarity terminals of the respective batteries. For example, the first contact of the bank S is connected to the positive terminal of the battery BAT, and the first contact of the bank S' is connected to the negative terminal of the battery BAT'. Therefore, as the wipers of the two switches A and A' simultaneously engage successive contacts in their respective banks, current impulses of opposite polarity flow through the two line conductors L—1 and L—2 in series. At the dispatcher's office these current impulses of opposite polarity cause a two-position polarized relay SSR, the operating winding of which is connected in series with the line L—1, alternately to reverse the position of its armature. In the remote station the current impulses of opposite polarity cause a similar two-position polarized relay SSR', the operating winding of which is connected in series with the conductor L—1, alternately to reverse the position of its armature. The alternate operation of the armatures of the two relays SSR and SSR' effects the energization of the motor magnets *m* and *m'*, the circuits of which are respectively completed through the contacts of the banks N and N' of the selectors A and A'. When the selector switches A and A' are in their normal positions, which are the positions in which they are shown in the drawings, the line conductor L—1 is connected to the neutral terminal of battery BAT' at the remote station by a circuit which includes in series the operating winding of the relay SSR', the wiper and normal contact of bank S' and the resistor R'—1; and to the positive terminal of battery BAT at the dispatcher's office by a circuit which includes in series the operating winding of relay SSR, the wiper and normal contact of bank S and the windings of relays S—1 and E. The current which normally flows through this completed check circuit is of such a small value that the only relay which is operated thereby is the line check relay S—1 which, by closing its contacts, completes an energizing circuit for the starting indicating relay H.

The resistor R'—1 at the remote station has connected in parallel therewith a series circuit

including the operating winding of the start relay E' and a half-wave rectifier 101. However, the normal direction of current flow through the resistor R'—1 is such that the half-wave rectifier 101 prevents the relay E' from being energized.

The starting indicating relay H, when energized, completes a circuit for a start light STL at the dispatcher's office which, when lighted, informs the dispatcher that the selector switches are in their respective normal positions and that the line conductors are neither open nor short-circuited. If the line wires were open circuited, the circuit through the relay S—1 would be open and, therefore, the circuit of the relay H would be open at the contacts of the relay S—1 and the start light STL would not be lighted. If the two line conductors were short-circuited, the relay E would be energized sufficiently to open its contacts in the energizing circuit of the relay H so that the start light STL would not be lighted.

In order that the dispatcher may start the two selector switches A and A' operating when they are in their normal positions, there is provided at the dispatcher's office a start key STK which, when operated, completes an energizing circuit for a start relay P through the wiper and normal contact of the bank T.

The start relay P, when energized, opens at the contacts 102, the normally completed check circuit through the windings of relays S—1, E—1 and SSR at the dispatcher's office and the relays SSR' and E' at the remote station so that the line conductor L—1 is disconnected from the positive terminal of battery BAT and connects at its contacts 31 the negative terminal of battery BAT to the line conductor L—1 independently of the windings of relays S—1 and E. Consequently, the direction of current flow through the line conductors L—1 and L—2 is reversed so that the start relay E' at the remote station is energized and closes its contacts. An energizing circuit is then completed for an auxiliary start relay F' which, in turn, completes a locking circuit for its operating coil and also a shunt circuit around the winding of the start relay E' and resistor R'—1. When the winding of relay E' and the resistor R'—1 are short-circuited, sufficient current flows through the windings of the relays SSR and SSR' to cause their respective armatures to move to their other position and thereby effect the operation of the motor magnets m and m' to move the switches A and A' to their first positions. The synchronous operation of the selector switches then continues until either the selector switches return to their normal positions or a contact in bank S is reached whose associated select key has been operated by the dispatcher. As soon as the wiper associated with the bank S engages such a contact, the selector switches stop since the synchronizing circuit is then open at this point. Therefore, it will be seen that the dispatcher can cause the selector switches to move from their normal position to any desired position merely by first operating the select key associated with the desired position and then operating the start key STK.

When the selector switches A and A' stop with their wipers on the contacts corresponding to an operated select key, a circuit is completed at the dispatcher's office for the amber light associated with the operated select key. This amber light circuit is completed through the individual contact of bank T corresponding to

the selected apparatus unit and contacts of a position check relay B which are closed only after the selector switches have established the proper connections. The operation of the relay B is controlled by a time delay pick-up relay D which is connected so that, when in its deenergized position, it completes an energizing circuit for a time delay drop-out relay C. The winding of the relay D is connected so that, when the selector switch A is in operation, the relay is in its deenergized position and the relay C is energized, but after the selector switch A has remained in any of its positions for a predetermined time, the relay D operates and interrupts the energizing circuit of the relay C. The relay C, when energized, closes contacts in the energizing circuit of the relay B. This energizing circuit of the relay B also includes contacts of the relay A—1 which is alternately connected between the wiper associated with bank S and the positive and negative terminals of the battery BAT by the operation of the relay SSR. Whenever the select key in series with a contact of the bank S is closed, the relay A—1 is short-circuited when the cooperating wiper associated with the bank S engages such a contact. When, however, the wiper stops in engagement with such a contact whose associated select key has been opened by the dispatcher, the relay A—1 is sufficiently energized to complete an energizing circuit for the relay B before the time relay C operates to open its contacts in the energizing circuit of the relay B. The relay B in addition to completing the circuit of the amber light associated with the operated select key also completes a locking circuit for its operating coil so that the relay B is not deenergized by the relay C when it opens its contacts in the energizing circuit of the relay B after the selector switch A has been stopped for a predetermined time.

After the selector switches A and A' have established the proper connections to the desired apparatus unit, the dispatcher can operate the selected apparatus unit by operating a common operate key COK of the selected apparatus unit which is in a predetermined position and by operating a common operate key TOK if the selected apparatus unit is in another predetermined position. The operation of either of these two operate keys completes through contacts of check relay B energizing circuits for the quick operating relay F and the time delay relay V. Relay F, when energized, disconnects the relay SSR and the wiper associated with bank S from the line conductor L—1 and the neutral terminal n of battery BAT from line conductor L—2 and connects line conductors L—1 and L—2 to the wipers of banks C and C—1, respectively, through contacts of time relay V while it is in its deenergized position. In each of the banks C and C—1 the adjacent contacts are connected to opposite polarity terminals of the battery BAT but corresponding contacts of the two banks are also connected to opposite polarity terminals. For example the first, third etc. contacts of bank C and the second, fourth etc. contacts of bank C—1 are connected to the negative terminal of battery BAT whereas the first, third etc. contacts of bank C—1 and the second, fourth etc. contacts of bank C are connected to the positive terminal of the battery BAT. Therefore, the direction of the operating current which flows through the two line conductors when the relay F is energized depends upon the position of the switch A. The operating current also is always in the same direction

as the last synchronizing current impulse. For example in the arrangement shown the synchronizing current impulse which causes the switches to move from their zero to their first position flows from the remote station through the conductor L—1 to the dispatcher's office and back to the remote station through line conductor L—2. When the switches are in their first position the operating current flows from the remote station through line conductor L—1 to the dispatcher's office and back to the remote station through line conductor L—2. Therefore this operating current is in a direction to maintain the armature of the synchronizing relay SSR' in the remote station in the position to which it was last operated in response to the last synchronizing current impulse. The direction of this operating current, however, is such as to operate a polarized master operate relay MOR' in the remote station so that it closes its contacts. This relay MOR' has two operating windings 2 and 3 which are respectively connected to alternate contacts of bank S' and which are arranged so that the synchronizing current which flows through them in the different positions of the switch A causes the relay MOR' to maintain its contacts 15 open.

When, however, a reverse current flows through either of these two windings, the relay MOR' closes its contacts 15 and completes a circuit for a relay W'.

After an operate key has been in its operated position for a predetermined time, time relay V operates and disconnects the line conductors L—1 and L—2 from the wipers of banks C and C', respectively, and completes an energizing circuit for a time relay W which in turn connects the line conductor L—2 to the neutral terminal *n* of battery BAT and the line conductor L—1 to the positive terminal X of battery BAT if the operate key TOK has been operated and to the negative terminal—of battery BAT if the operate key COK has been operated. Therefore, the operation of either operate key effects first the transmission over the line conductor L—1 and L—2 of a preparatory impulse corresponding in polarity to the polarity of the last synchronizing impulse and then the transmission of an operating impulse corresponding to the particular operate key which has been operated.

At the remote station, the termination of the preliminary operate impulse effects the energization of the relay X' in series with the relay W'. The energization of the relay X' transfers the connections at the remote station so that the relay SSR' is disconnected from the line conductors L—1 and L—2 and the operating winding of the polarized relay MCR' is connected across the line conductors. Therefore, this polarized relay MCR' is selectively operated in response to the polarity of the second operate impulse and controls the direction of the current flow through the control relay associated with the selected apparatus unit through its corresponding contacts of bank C' so that the control relay completes an energizing circuit for the trip coil of the selected apparatus unit if the operate key TOK has been operated and completes an energizing circuit for the closing coil of the selected apparatus unit if the operate key COK has been operated. Therefore, by alternately operating the key TOK and COK a selected apparatus unit can be opened and closed as many times as the dispatcher desires. However, if the dispatcher operates the key COK while the selected apparatus unit is closed or

the key TOK while the selected apparatus unit is open, a false operation of the selected unit is not effected because the control relay associated therewith is selectively operated in accordance with the polarity of the operate impulse.

In order to effect the operation of each group of signal lamps at the dispatcher's office in accordance with the position of the corresponding apparatus unit in the remote station during each operation of the selector switches A and A', two suitable sources of alternating current of different frequencies AC'—1 and AC'—2 are provided at the remote station and means are provided in each position of the selector switch A' allotted to an apparatus unit for selectively connecting the sources of current across the two line conductors L—1 and L—2 in accordance with the position of the corresponding apparatus unit. In the arrangement shown in the drawings, the source of current AC'—1 is arranged to be connected across the line conductors L—1 and L—2 when the selected apparatus unit is in one position and the source AC'—2 is arranged to be connected across the line conductors when the apparatus unit is in its other position.

The connection of the sources AC'—1 and AC'—2 across the line conductors is controlled by an auxiliary master indication relay P' of the polarized type. In each position of the switch A', allotted to an apparatus unit, the winding of the relay P' is connected by the wiper associated with the bank I' to auxiliary contacts on the corresponding apparatus unit. If the apparatus unit is closed, current flows in a direction through the operating winding of the relay P' to cause the relay to effect the connection of the source AC'—1 across the line conductors L—1 and L—2, whereas if the apparatus unit is open current flows in the opposite direction through the operating winding of the relay P' so that the relay effects the connection of the source AC'—2 across the line conductors. Therefore, as long as the switch A' is in a position allotted to an apparatus unit, signalling current corresponding in character to the position of the apparatus unit, is transmitted over the line conductors in series to the dispatcher's office.

At the dispatcher's office suitable frequency responsive means is provided for controlling the groups of signal lamps in response to the frequency of the signalling current transmitted thereto from the remote station. As shown, this frequency responsive means is a master indication relay MIR, of the balanced relay type, which has two opposing windings AC'—1 and AC'—2 normally connected in parallel across the line conductors L—1 and L—2. The circuit of the winding AC'—1 is designed so that it is tuned to the frequency of the source AC'—1 and the circuit of the winding AC'—2 is designed so that it is tuned to the frequency of the source AC'—2. The master indication relay MIR selectively controls the polarity connected to the wiper associated with bank I so that as the circuits of the indication relays are successively completed by the wiper, current flows through each indication relay in the proper direction to cause it to effect the lighting of the associate group of signal lamps in accordance with the position of the corresponding apparatus unit. For example, if the apparatus unit is closed when the selector switches A and A' are in the position allotted to that apparatus unit, the source AC'—1 is connected across the line conductors and the cur-

rent in the winding AC—1 of the master indication relay MIR is greater than the current in the winding AC—2. Consequently, the relay MIR connects the positive terminal of the battery BAT to the wiper associated with bank I so that current flows through the operating winding of the indication relay in the proper direction to effect the lighting of its associate red lamp. If, however, the apparatus unit is in its open position, the source AC'—2 is connected across the conductors instead of the source AC'—1 and, therefore, the relay MIR connects the wiper associated with the bank I to the negative terminal of the battery BAT instead of to the positive terminal. Consequently, the indication relay corresponding to the apparatus unit is operated so as to effect the lighting of its associate green lamp.

In order that the master indication relay MIR may have sufficient time to change its position before the circuit through the wiper associated with the bank I is completed thereby when the switch A moves from one position to the next, the circuit through the wiper associated with the bank I also includes the contacts of a relay X. The winding of the relay X is alternately connected to the positive and negative terminals of the battery BAT by the synchronizing relay SSR. The relay X is designed so that it opens its contacts each time the selector switch A is moved from one position to the next. In this way the circuit through the wiper of the bank I is maintained open for a sufficient length of time after the selector switch reaches its new position to allow the master indication relay MIR to assume a position corresponding to the position of the apparatus unit allotted to the new position of the selector switch before the circuit through the bank I is completed.

In order to effect the automatic operation of the selector switches A and A' from their normal position when an apparatus unit in the remote station automatically changes its position, each apparatus unit has associated therewith an indication auxiliary relay such as IA—1 and IA—23 for the apparatus units AU—1 and AU—23 respectively. The circuit of each indication auxiliary relay is normally completed through auxiliary contacts on the associate apparatus unit so that when the apparatus unit changes its position, the corresponding indication auxiliary relay becomes deenergized. If the selector switch A' is in its normal position so that the zero position relay H' is energized, the deenergization of any indication auxiliary relay completes a circuit for a start relay D'. The relay D' then completes through the wiper and zero contact of the bank I' a circuit for the operating winding of the auxiliary master indication relay P' so that current flows through this operating winding in the proper direction to effect the connection of the alternating current source AC'—1 across the line conductors L—1 and L—2. This alternating current causes the master indication relay MIR at the dispatcher's office to operate and complete through the wiper and normal contact of the bank I and a normal contact of the start key STK an energizing circuit for the start relay P. The start relay P then effects the starting of the selector switches A and A' in the same manner as when it is energized in response to the closing of the start key STK. The selector switches then continue to operate until they reach their normal position. As the wipers of the bank I and I' pass over their respective contacts, signal currents corresponding in charac-

ter to the positions of the associate apparatus units are transmitted over the line conductors. The position of each indication relay in the dispatcher's office is, therefore, checked and if it does not agree with the corresponding apparatus unit, it is operated to the position corresponding thereto. In the group of lamps associated with the automatically operated apparatus unit in the remote station, the white lamp is lighted to show the dispatcher which apparatus unit has changed its position.

As soon as the selector switch A' reaches the position allotted to the apparatus unit which has changed its position, an energizing circuit is completed for the associate deenergized indication auxiliary relay through the wiper and corresponding contact in bank T'. The indication auxiliary relay then completes a locking circuit for its operating coil which is independent of the corresponding contact in the bank T.

In order to prevent the alternating current circuit which is used as signalling current from operating any of the direct current devices, suitable retardation coils RC—1 and RC'—1 are respectively connected in series with the line conductor L—1 at the dispatcher's office and at the remote station and similar retardation coils RC—2 and RC'—2 are respectively connected in series with the line conductor L—2 at the dispatcher's office and at the remote station. The source AC'—1 and AC'—2 and the windings AC—1 and AC—2 are connected to the line conductor L—1 at points intermediate the retardation coils RC—1 and RC'—1 and to the line conductor L—2 at points intermediate the retardation coils RC—2 and RC'—2.

In order to prevent the direct current impulses from flowing through the sources AC'—1 and AC'—2 and the windings AC—1 and AC—2, a suitable condenser CON'—1 is provided in the connection between the sources AC'—1 and AC'—2 and the line conductors L—1, a suitable condenser CON'—2 is provided in the connection between the sources AC'—1 and AC'—2 and the line conductor L—2, and suitable condensers CON—1 and CON—2 are respectively connected in series with the windings AC—1 and AC—2 of the master indication relay MIR.

At the dispatcher's office there is provided a suitable alarm AL such as an electric horn. The circuit of this alarm is controlled by an alarm relay K the circuit of which is controlled by the starting indication relay H so that each time the relay H changes its position, the circuit of the alarm relay is opened to effect the operation of the alarm AL. Since the relay H is energized each time the switches A and A' move to their normal position and is deenergized each time the switches A and A' leave their normal position, the relay K is deenergized to effect the operation of the alarm each time the selector switches leave their normal position in response to an automatic operation of an apparatus unit and each time the switches A and A' return to their normal position. In order to prevent the alarm from being operated when the selector switches A and A' start in response to the operation of the start key STK, the circuit of the alarm includes normally closed contacts on the start key STK. A suitable alarm key AK is provided for controlling the circuit of the relay K so that either a short or a continuous operation of the alarm may be effected in response to the deenergization of the relay K.

At the dispatcher's office there is also provided

an emergency reset key ERK which is operated by the dispatcher to effect the resetting of the selector switches to their normal position if for any reason they do not return automatically.

- 5 At the remote station a battery potential relay A'—1 whose operating coil is connected directly across the terminals of the battery BAT', is provided for completely disconnecting the line conductors L—1 and L—2 from the battery BAT' 10 in case the potential thereof decreases below a predetermined value.

Detail description of the operation of the system

- 15 The operation of the arrangement shown in the drawings is as follows: When the apparatus units AU—1 and AU—23 are closed and the selector switches A and A' are in their normal position, the various control devices occupy the positions in which they are shown in the drawings. 20 At the dispatcher's office the red lamps R—1 and R—23 are lighted, the circuits of these lamps being respectively completed through the left-hand contacts of the indication relays IR—1 and IR—23. The contacts 5 of the synchronizing relay SSR complete energizing circuits for the relay X and the relay D between the neutral terminal *n* and the positive terminal of the battery BAT.

- 30 At the remote station the wiper and normal contact of the bank T' complete an energizing circuit for the zero position check relay H' between the positive terminal and the neutral terminal *n'* of the battery BAT'. The contacts 6 of the synchronizing relay SSR' complete an energizing circuit for the line cut-off relay C' 35 between the negative terminal and the neutral terminal *n'* of the battery BAT'. The indication auxiliary relay IA—1 is energized by a circuit which is completed between the negative terminal and the neutral terminal *n'* of the battery BAT' 40 by the auxiliary contacts 8 on the apparatus unit AU—1 and the contacts 9 of the relay IA—1. A similar circuit is completed for the indication auxiliary relay IA—23 through the auxiliary contacts 45 10 on the apparatus unit AU—23 and the contacts 11 of the relay IA—23.

- Also when the selector switches are in their normal position, a check circuit is completed to effect the lighting of the start lamp STL if the supervisory system is in an operative condition and to effect the operation of the alarm AL if the line conductors L—1 and L—2 are either open or short-circuited or if the potential of the battery BAT' at the remote station is below a predetermined value. 55

- This check circuit is from the neutral terminal of the battery BAT' through resistor R'—1, wiper and normal contact of bank S', contacts 12 of relay C', winding of relay SSR', contacts 100 60 of relay X', retardation coil RC'—1, contacts 13 of relay A'—1, line conductor L—1, retardation coil RC—1, contacts 103 of relay W, contacts 14 of relay F, winding of relay SSR, wiper and normal contact of bank S, contacts 15 of relay D, 65 contacts 102 of relay P, winding of relay S—1, winding of relay E, contact 16 of key ERK, positive terminal of battery BAT, neutral terminal *n* of battery BAT, contacts 17 of relay F, retardation coil RC—2, line conductor L—2, contacts 19' of relay A'—1, retardation coil RC'—2 to the neutral terminal *n'* of battery BAT'. 70

- The normal current in this check circuit is sufficient to cause the relay S—1 to close its contacts 19 but is not sufficient to operate any of the 75 other relays whose windings are connected in this

check circuit. The relay S—1 by closing its contacts 19 completes an energizing circuit for the check relay H. This circuit which also includes the contacts 20 of the relay E is connected between the negative terminal and the neutral terminal *n* of the battery BAT. When the relay H is energized, its contacts 21 complete a circuit for the start lamp STL which, when lighted, informs the dispatcher that the supervisory system is in an operative condition. At its contacts 22 the relay H maintains a locking circuit for the alarm relay K completed between the positive terminal and the neutral terminal *n* of the battery BAT. This locking circuit for the alarm relay K also includes the contacts 23 of the relay K. 15

If either line conductor becomes open or the potential of the battery BAT' at the remote station fails so that the battery potential relay A'—1 opens its contacts 13 and 19', the above 20 traced check circuit is opened and the relay H is deenergized. By opening its contacts 21 the relay H opens the circuit of the start light STL and by opening its contacts 22 the locking circuit of the alarm relay K is opened. By closing 25 its contacts 24 the alarm relay K completes a circuit for the alarm AL through the lower normally closed contacts of the start key STK. With the alarm key AK in the position shown, an energizing circuit is completed for the alarm 30 relay K as soon as the relay H reaches its deenergized position. This energizing circuit is completed from the negative terminal of the battery BAT through the contacts 26 of the relay H, winding of relay K, contacts 25 of relay K, normally closed contacts of alarm key AK to the neutral terminal of the battery BAT. By closing 35 its contacts 23, the alarm relay K completes a locking circuit for its winding which is independent of the contacts of the alarm key AK. 40 Therefore, when the alarm key AK is in the position shown, the alarm AL is operated for only a short time. If, however, the alarm key AK is in its other position so that its contacts are open, the above-traced energizing circuit of the alarm relay 45 K is not completed by the closing of the contacts 26 of the relay H and, therefore, the alarm continues to operate until the dispatcher moves the alarm key AK to the position shown.

If a short circuit occurs across the line conductors, the increased current which flows through the check circuit under this condition causes the relay E to open its contacts 20 in the circuit of the relay H. Relay H then becomes deenergized and extinguishes the start lamp STL 55 and effects the operation of the alarm AL in the manner above described.

It will now be assumed that the supervisory system is in an operative condition and that the dispatcher desires to operate the apparatus unit 60 AU—1 to its open position. The dispatcher first operates the select key SK—1 corresponding to the apparatus unit AU—1 so that the contacts of the select key are open. The opening of these contacts disconnects the first contact in the bank S from the positive terminal of the battery BAT. The dispatcher then operates the start key STK so that its upper contacts are opened and its lower contact is closed. A circuit is then completed from the positive terminal of the battery 70 BAT through the lower contacts of the start key STK, winding of start relay P, contacts 27 of relay H, wiper and normal contact of bank T to the neutral terminal *n* of the battery BAT. Start relay P then operates and by closing its contacts 75

28 completes through contacts 29 of the relay H a locking circuit for the coil of relay H. By opening its contacts 102, the relay P disconnects the line conductor L—1 from the positive terminal of the battery BAT and by closing its contacts 31 connects this line conductor L—1 to the negative terminal of the battery BAT without the windings of the relays S—1 and E and the contacts 16 of the emergency reset key ERK in series. As a result of the operation of the relay P, the voltage impressed across the line conductors L—1 and L—2 at the dispatcher's office is reversed so that current flows through the rectifier 101 and the start relay E' at the remote station. This relay E' closes its contact 32 and thereby connects the winding of the auxiliary starting relay F' between the positive terminal and the neutral terminal *n*' of the battery BAT'. By closing its contacts 33, the relay F' completes a locking circuit for its operating coil through the contacts 34 of the zero position relay H' so that the relay F' remains energized until the selector switch A' has left its zero position. By closing its contacts 35, the relay F' completes a shunt circuit around the high resistor R'—1 so as to increase the current flowing through the line conductors to a value sufficient to cause the armatures of the synchronizing relay SSR and SSR' to move to their left-hand position.

30 In the dispatcher's office the synchronizing relay SSR, by closing its contacts 36, completes an energizing circuit for the motor magnet *m* from the negative terminal of the battery BAT through the interrupter contact and winding of motor magnet *m*, wiper and normal contact of bank N and protective resistor PR—1 to the positive terminal of the battery BAT. The motor magnet *m* then operates in a manner well known in the art to effect the movement of the selector switch A to its first position. When the wiper associated with the bank N engages its first contact which is connected to the negative terminal of the battery BAT through protective resistor PR—2, the circuit of the motor magnet *m* is not again completed through the contacts 36 of the synchronizing relay SSR because both terminals of the motor magnet are now connected to the negative terminal of the battery BAT. By opening its contacts 5 and closing its contacts 36, the synchronizing relay SSR also reverses the current through the time delay pick-up relay D so that it maintains its contacts 15 open and its contacts 46 closed for a predetermined time while the selector switch A is moving from one position to another. By closing its contacts 46, the relay D completes an energizing circuit for the time delay drop out relay C. This relay C is designed, however, so that the contacts 47 thereof remain closed as long as the selector switch A is operating from one position to another and for a short time after it stops in any position. Therefore the relay C does not open its contacts 47 until after the switch A has been stopped for a predetermined time.

65 In the remote station the synchronizing relay SSR', by closing its contacts 37, completes a similar energizing circuit for the motor magnet *m*' which effects in a well known manner the movement of the selector switch A' to its first position. By opening its contacts 6 and closing its contacts 38, the synchronizing relay SSR' also reverses the current through the relay C' so that the relay C' by opening its contacts 12 maintains the synchronizing circuit open for a predetermined time after the switch A'

reaches its first position. Relay C', therefore, controls the speed at which the selector switches move from one position to the next.

Since the contacts of the select key SK—1 have been opened by the dispatcher, no circuit is completed through the wiper and first contact of the bank S when the switch A reaches its first position. A high resistance check circuit, however, is completed which causes the relay A—1 to close its contacts 39. This check circuit is from the positive terminal of the battery BAT, through the wiper and first contact of bank C—1, winding of relay A—1, contacts 41 of relay B which complete a short circuit around a resistor 42, winding of relay SSR, contacts 14 of relay F, contacts 103 of relay W, retardation coil RC—1, line conductor L—1, contacts 13 of relay A'—1, retardation coil RC'—1, contacts 100 of relay X', winding of relay SSR', contacts 12 of relay C', wiper and first contact of bank S', winding 2 of relay MOR', negative terminal of battery BAT', neutral terminal *n*' of battery BAT', retardation coil RC'—2, contacts 19' of relay A'—1, line conductor L—2, retardation coil RC—2, contacts 17 of relay F to the neutral terminal *n* of battery BAT.

While the current in this check circuit is in the opposite direction to the last synchronizing current impulse, and therefore is in the proper direction to effect the movement of the armatures of the synchronizing relays SSR and SSR' to their right-hand position, the magnitude of the current is not sufficient to do so. Therefore the switches A and A' stop in their first position. If the contacts of the select key SK—1 had been closed when the switches reached their first position, the relay A—1 would have been short-circuited by the select key SK—1 and consequently the contacts 39 would not have been closed. Also the current through the windings of the synchronizing relays SSR and SSR' would have been sufficient and in the proper direction to cause the armatures of the relays SSR and SSR' to move to their right-hand position and effect the operation of the motor magnets *m* and *m*' to move the switches to their second position. Therefore, it will be seen that the relay A—1 closes its contacts 39 only when the selector switches stop in the position corresponding to an operated select key.

By closing its contacts 39 the relay A—1 completes an energizing circuit for the relay B. This circuit is from the negative terminal of the battery BAT through the contacts 39 of relay A—1, contacts 47 of the relay C, winding of relay B to the neutral terminal *n* of the battery BAT. By closing its contacts 48, relay B completes a circuit around the contacts 47 before the relay C operates to open them. Therefore, it will be seen that the relay A—1 has to close its contacts 39 within a predetermined time after the selector switch A stops in any position in order to effect the energization of the relay B.

By opening its contacts 41, the relay B removes the short circuit from around the resistor 42 in the circuit of the relay A—1 so that the relay will open its contacts 39 more quickly when its operating coil is deenergized. By closing its contacts 49 the relay B completes a circuit to light the amber light AM—1 so as to notify the dispatcher that the desired apparatus unit AU—1 has been properly selected by the selector switches. This circuit is from the negative terminal of the battery BAT through the contacts 49 of the relay B, amber light AM—1, first con-

tact and wiper of bank T to the neutral terminal *n* of the battery BAT.

As soon as the switch A' reaches its first position, a circuit is completed from the neutral terminal *n*' of the battery BAT', through the operating winding of relay P', wiper and first contact of bank I', auxiliary contacts 8 on apparatus unit AU—1 to the negative terminal of the battery BAT'. The direction of current flow in this circuit is such as to cause the relay P' to close its contacts 54 and complete a signalling circuit from one terminal of the alternating current source AC'—1 through the contacts 54 of the relay P', contacts 55 of the relay H', which is de-energized as soon as the switch A' leaves its normal position, condenser CON'—1, contacts 13 of relay A'—1, line conductor L—1, contacts 56 of key ERK, then through two parallel circuits one including the condenser CON—1 and winding AC—1 in series and the other including condenser CON—2 and winding AC—2 in series and then through line conductor L—2, contacts 19' of relay A'—1, condenser CON'—2 to the other terminal of the source AC'—1.

Since the circuit of the winding AC—1 of the relay MIR is tuned to the frequency of the source AC'—1, more current flows through the winding AC—1 than flows through the winding AC—2 when the source AC'—1 is connected across the line conductors. Therefore, the relay MIR closes its contacts 58 in response to the signalling current and completes between the positive terminal and the neutral terminal *n* of the battery BAT a circuit which includes the contacts 59 of the relay X, wiper and first contact of bank I and the operating winding of the indicating relay IR—1. The current in this circuit, however, is in a direction to maintain the left-hand contacts of the relay IR—1 closed. Therefore, the red lamp R—1 remains lighted.

After the amber light AM—1 lights, thereby informing the dispatcher that the desired apparatus unit AU—1 has been properly selected by the selector switches, and he notes also that the red lamp R—1 is still lighted thereby indicating that the apparatus unit is still closed, the dispatcher operates the common trip key TOK, which completes an energizing circuit for the relay F. This circuit is from the negative terminal of battery BAT through windings of relay F, contacts 105 of relay W, contacts 50 of relay B, contacts 106 of trip key TOK to the neutral terminal *n* of battery BAT. An energizing circuit for the winding of time relay V is also completed at the same time since this winding is connected in parallel with the winding of relay F and contacts 105 of relay W.

The closing of contacts 107 of relay F completes a shunt circuit around contacts 106 of key TOK. The closing of contacts 51 of relay F completes a circuit around the contacts 39 in the locking circuit of relay B so as to maintain the relay B energized as long as the relay F is energized. By opening its contacts 14 and closing its contacts 60 relay F interrupts the connection between the line conductor L—1 and the positive terminal of the battery BAT through the windings of the relays SSR and A—1 and the wiper and first contact of bank C—1 and connects the line conductor L—1 to the negative terminal of the battery BAT through the wiper and first contact of bank C, and contacts 108 of relay V. By opening its contacts 17 and closing its contacts 61 the relay F interrupts the connection between the line conductor L—2 and the neutral

terminal *n* of battery BAT and connects the line conductor L—2 to the positive terminal of the battery BAT through contacts 109 of relay V and the wiper and first contact of the bank C—1. Therefore, the result of the operation of relay F is to apply full potential of battery BAT across the line conductors in such a manner as to oppose the potential of half of the battery BAT' at the remote station. Therefore, the current through the line conductors is reversed in response to the operation of the relay F.

At the remote station this reverse current which flows through the operating winding of the relay SSR' and the winding 2 of the relay MOR' is in a direction to maintain the armature of the relay SSR' in its left-hand position. Therefore, this reverse current does not change the position of the armature of the relay SSR'. The direction of this reverse current, however, is such as to cause the relay MOR' to close its contacts 15 and complete a circuit from the positive terminal of the battery BAT', through the winding of relay W', contacts 53 of relay Z', contacts 15 of relay MOR', to the negative terminal of the battery BAT'.

By closing its contacts 64, relay W' connects the winding of relay X' and contacts 110 in a series-circuit around the contacts 15 of relay MOR', but relay X' does not operate because its winding is short-circuited by the contacts 15.

At the dispatcher's office, the operation of the relay V after the key TOK has been operated for a predetermined time effects the opening of the contacts 108 and 109, thus removing the preparatory control impulse from the line conductors L—1 and L—2. The closing of the contacts 111 of relay V completes an energizing circuit for the time of relay W.

The removal of the preparatory control impulse effects at the remote station the de-energization of the relay MOR', causes its contacts 15 to open, and thereby removes the short circuit from around the winding of relay X' so that the relays X' and W' are energized in series. The opening of contacts 100 of relay X' disconnects the remote station synchronizing circuit from the line conductor L—1 and the closing of contacts 112 of relay X' connects the master control relay MCR' across the line conductors so that it may respond to the polarity control impulse.

When the relay W at the dispatcher's office operates, the closing of its contacts 113 connects the line conductor L—2 to the neutral terminal *n* of battery BAT and the closing of its contacts 114 connects the line L—1 to the positive terminal of battery BAT through the contacts 115 of key TOK. Thus a positive control impulse is transmitted over the line conductors L—1 and L—2. The opening of contacts 105 of relay W effects the de-energization of relay F. However, the relay V remains energized through the contacts 106 of key TOK so that the positive tripping impulse remains on the line conductors until the key TOK is released, and the circuit for relay B remains completed through contacts 48 and the parallel connected contacts 122 of relay V and contacts 123 of relay W.

At the remote station the positive tripping impulse causes the master control relay MCR' to close its contacts 116 and 117. The contacts 116 complete an energizing circuit for relay B'. The closing of contacts 66 of relay B' completes a shunt circuit around the contacts 110 of relay U' in the series circuit including the windings

of relays X' and W'. The closing of contacts 63 of relay B' completes an energizing circuit for time delay relay Y' which in turn by closing its contacts 118 completes an energizing circuit for relay T'-1. The closing of contacts 119 of relay T'-1 completes a circuit from the positive terminal of battery BAT' through contacts 117 of relay MCR', contacts 119 of relay T'-1, wiper and first contact of bank C', and winding of relay CR-1 to the neutral terminal n' of the battery BAT'. The current in this circuit is in a direction to cause the relay CR-1 to close its left-hand contacts, thereby completing through the auxiliary contact 67 on the apparatus unit AU-1 an energizing circuit for the trip coil TC-1. The energization of the trip coil TC-1 effects the opening of the apparatus unit AU-1.

As soon as the apparatus unit AU-1 opens, the current through the operating coil of relay P' is reversed by the apparatus unit opening its contacts 8 and closing its contacts 68. As a result of this reversal of current, the relay P' opens its contacts 54 and closes its contacts 69. By opening its contacts 54 the relay P' disconnects the source AC'-1 from across the line conductors and by closing its contacts 69, it connects the source AC'-2 across the line conductors.

Since the circuit of the winding AC-2 of the relay MIR at the dispatcher's office is tuned to the frequency of the source AC'-2, the relay MIR operates in response to the connection of the source AC'-2 across the line conductors to open its contacts 58 and close its contacts 70. The relay MIR thereby reverses the direction of current flow through the indication relay IR-1 so that it opens its left-hand contacts and closes its right-hand contacts. The opening of the left-hand contacts of the relay IR-1 interrupts the circuit of the red lamp R-1 so that it is extinguished. By closing its right-hand contacts, the relay IR-1 completes a circuit for the green lamp GR-1 directly across the positive and negative terminals of the battery BAT and a circuit for the white lamp W-1 through the contacts of the control key CK-1. The dispatcher can extinguish the white lamp W-1 by moving the control key CK-1 so that its position agrees with the new position of the apparatus unit AU-1.

When the dispatcher restores the trip key TOK to its normal position after effecting the tripping of the selected apparatus unit AU-1, the relays V and W are de-energized to remove the positive tripping impulse from the line wires L-1 and L-2 so that the master control relay MCR' at the remote station opens its contacts 116 and 117 to effect the de-energization of the relays B' and CR-1. The opening of the contacts 63 of relay B' removes a short circuit from around the winding of time relay Z' which becomes energized in series with relay Y' through contacts 120 of relay Y' and contacts 121 of relay W'. The opening of contacts 53 of relay Z' interrupts the series circuit for the windings of relays W' and X' so that they are restored to their normal positions and line L-1 is reconnected to the synchronizing circuit at the remote station. The opening of the contacts 121 of relay W' effects the de-energization of the relays Y' and Z' so as to reestablish the normal selected condition of the control relays at the remote station.

The de-energization of the relays V and W at the dispatcher's office when the key TOK is released,

re-establishes the heretofore described energizing circuit for relay A-1 which in turn completes an energizing circuit for relay B through contacts 47 of relay C and contacts 39 of relay A-1. In order to insure that the contacts 47 of relay C are closed when relay A-1 closes its contacts in response to the removal of a control impulse from the line conductors L-1 and L-2, the relay W, when energized, completes through its contacts 124 an energizing circuit for the time delay drop-out relay C.

After the dispatcher has opened the selected apparatus unit AU-1, he may effect the closing thereof by depressing the master close key COK. The closing of the contacts 125 of key COK, which are connected in parallel with contacts 106 of key TOK, complete an energizing circuit for relay F from the negative terminal of battery BAT, winding of relay F, contacts 105 of relay W, contacts 50 of relay B and contacts 125 of key COK to the neutral n of battery BAT. The closing of contacts 125 of key COK also completes an energizing circuit for the winding of time relay V which is connected in parallel with the series-connected winding of relay F and contacts 105 of relay W.

The energization of the relay F effects, in the manner heretofore described, the transmission over the line conductors L-1 and L-2 of a preparatory control impulse of the same polarity as the last synchronizing impulse and the subsequent operation of the time relay V effects, in the manner heretofore described, the de-energization of relay F to remove the preparatory control impulse from the line conductors L-1 and L-2 and the energization of the time relay W. When the relay W operates, the closing of its contacts 113 connects the line conductor L-2 to the neutral terminal n of battery BAT and the closing of its contacts 114 connects the line conductor L-1 to the negative terminal of battery BAT through contacts 127 of key TOK and contacts 126 of key COK. Thus, a negative closing impulse is transmitted over the line conductors L-1 and L-2.

At the remote station, the preparatory control impulse effects the operation of relays MOR', W', and X', and the connection of the master control relay MCR' across the line conductors in the manner heretofore described. The negative closing impulse causes the master control relay MCR' to close its contacts 128 and 129. The closing of contacts 128 completes an energizing circuit for relay B' which in turn effects, in the manner heretofore described, the sequential operation of the relays Y' and T'-1. The closing of the contacts 119 of relay T'-1 completes a circuit from the negative terminal of battery BAT' through contacts 129 of relay MCR', contacts 119 of relay T'-1, wiper and first contact of bank C' and winding of relay CR-1 to the neutral terminal n' of battery BAT'. The current in this circuit is in a direction to cause the control relay CR-1 to close its right-hand contacts and thereby complete through the auxiliary contacts 77 on the apparatus unit AU-1 an energizing circuit for the closing coil CC-1 so that the apparatus unit AU-1 is closed.

By opening its auxiliary contacts 68 and closing its auxiliary contacts 8, the apparatus unit AU-1 reverses the current through the relay P' so that it opens its contacts 69 and closes its contacts 54. The relay P', therefore, disconnects the signal source AC'-2 from across the

line conductors and connects the source AC'—1 across the line conductors. Therefore, at the dispatcher's office, the relay MIR operates to open its contacts 70 and close its contacts 53 so that the current through the indication relay IR—1 is reversed. The relay IR—1 then operates to extinguish the green lamp G—1 and to light the red lamp R—1 and the white lamp W—1. The dispatcher may extinguish the white lamp W—1 by moving the check key CK—1 so that its position corresponds to the closing position of the apparatus unit AU—1.

If, for any reason such as a premature release of an operate key, the preparatory control impulse is not followed by an operating impulse within a predetermined time, it is desirable to effect the de-energization of the series-connected relays W' and X' so as to re-establish the normal selected condition of the control relays at the remote station. This result is accomplished in the arrangement shown by having the relay X', when energized by the removal of the preparatory control impulse, complete an energizing circuit for time relay U' from the positive terminal of battery BAT' through winding of relay U', contacts 132 of relay Y', and contact 133 of relay X' to the neutral terminal of battery BAT'. If the preparatory control impulse is followed immediately by the operating impulse, relay Y' is operated to open the energizing circuit of relay U' before this relay can operate. However, if the preparatory control impulse is not followed by the operating impulse within the operating time of the time relay U', the opening of the contacts 110 of relay U' effects the deenergization of the relays X' and W' so as to re-establish the normal selected condition of the control relays at the remote station.

It will be seen, therefore, that after an apparatus unit has been selected the dispatcher can open and close it as many times as he desires and that each change in the position of the selected apparatus unit is indicated instantly by the corresponding group of lamps in the dispatcher's office.

After the dispatcher has effected the desired operation of the selected apparatus unit AU—1, he may effect the return of the selector switches A and A' to their normal position merely by closing the select key SK—1. The closing of this select key SK—1 completes a low resistance shunt circuit around the relay A—1 so that sufficient current flows through the synchronizing circuit in the proper direction to effect the movement of the armatures of the synchronizing relays SSR and SSR' to their right-hand position and thereby respectively complete energizing circuits for the motor magnets *m* and *m'* which move the selector switches A and A' to their second position. The synchronizing circuit is then completed through the second contacts of the banks S and S' so that current flows through the circuit in the reverse direction. This reverse current causes the armatures of the synchronizing relays SSR and SSR' to move to their left-hand position so that the circuits of the motor magnets *m* and *m'* are completed to move the selector switches A and A' to their third position. If all of the selector keys are in their normal position, it will be seen that reverse current impulses are in this manner alternately transmitted through the synchronizing circuit as the switches move from position to position and that the switches are operated in synchronism until they reach their 24th position where the synchronizing circuit is

open at the banks S and S'. The 23rd and 24th contacts of the bank N, however, are connected together so that as soon as the wiper of the bank N engages the 24th contact of the bank, the circuit of the motor magnet *m* is again completed and the motor magnet effects the movement of the switch A from its 24th position to its normal position. Similarly, the 23rd and 24th contacts of the bank N' are connected together so that as soon as the wiper of the bank N' engages its 24th contact the circuit of the motor magnet *m* is again completed and the motor magnet effects the movement of the switch A' to its normal position.

When both of the switches A and A' reach their normal position, the above-traced check circuit through the relays S—1, E and E' is again completed and the relay S—1 by closing its contacts 19 completes the above-described energizing circuit for the relay H which, in turn, by closing its contacts 21 completes the circuit of the start light STL. Also by opening its contacts 26 and closing its contacts 22, the relay H momentarily interrupts the circuit of the alarm relay K which, by closing its contacts 24, completes a circuit for the alarm AL through the lower normal contacts of the start key STK which is now in its normal position.

It will now be assumed that while the selector switches A and A' are in their normal position, the current through the closed apparatus unit AU—23 in the remote station increases to a value sufficient to cause the overload relay OL—23 to close its contacts 80 so that a circuit is completed through the trip coil TC—23 and the auxiliary contacts 81 on the apparatus unit. The energization of the trip coil TC—23 effects the opening of the apparatus unit AU—23. By opening its auxiliary contacts 10 the apparatus unit AU—23 interrupts the heretofore described locking circuit of the indication auxiliary relay IA—23. By closing its contacts 82 the relay IA—23 completes through the contacts 83 of the zero position relay H' a circuit for the start relay D'. By closing its contacts 84 the relay D' completes a circuit for the operating winding of the relay P' so that it closes its contacts 54 and connects through contacts 85 of the start relay D' the source AC'—1 across the line conductors L—1 and L—2. At the dispatcher's office the signal current which is transmitted over the line conductors as a result of the source AC'—1 being connected thereto causes the relay MIR to close its contacts 58 and complete a circuit from the positive terminal of the battery BAT through the contacts 58 of the relay MIR, contacts 59 of relay X, wiper and normal contact of bank I, upper normal contacts of start key STK, winding of relay P, contacts 27 of relay H, wiper and normal contact of bank T to the neutral terminal *n* of battery BAT. Start relay P then operates in the manner above described and effects the starting of the selector switches A and A' which continue in operation until they again reach their normal position. Since the start key STK is in its normal position when the selector switch A leaves its normal position, the alarm AL is operated in this case in response to the de-energization of the alarm relay K.

As the wipers of the two switches stop momentarily on each contact, an indication of the position of the associate apparatus unit is transmitted in a manner above described to the corresponding indication relay in the dispatcher's office. Thus, the position of each apparatus unit is checked

each time the selector switches are moved to the corresponding positions. In the case assumed, when the selector switch A' reaches its twenty-third position, source AC'—2 is connected across the line conductors so that the relay MIR at the dispatcher's office is operated to cause the relay IR—23 to reverse its position and thereby extinguish the red lamp R—23 and light the green lamp G—23 and the white lamp W—23. The lighting of the white lamp W—23 informs the dispatcher which apparatus unit has changed its position and has caused the selector switches to operate.

At the remote station when the switch A' reaches its twenty-third position, a circuit is completed from the neutral terminal n' of the battery BAT' through the wiper and twenty-third contact of the bank T', winding of relay IA—23, auxiliary contacts 90 on the apparatus unit AU—23 to the positive terminal of the battery BAT'. Relay IA—23 by closing its contacts 11 completes a shunt circuit around the wiper and 23rd contact of bank T' so that the relay remains energized after the switch A' leaves its 23rd position. Therefore, the starting relay D' is not again energized through the contacts 82 of the relay IA—23 when the switch A' reaches its normal position.

If at any time the operator desires to check the position of the signal lamps at the dispatcher's office, he can do so merely by operating the start key STK. The selector switches A and A' will then complete a cycle of operation during which the indicating circuit for each apparatus unit is completed to the corresponding control relay so that it will operate to automatically check the lighting of the corresponding signal lamps.

If at any time the two selector switches get out of synchronism, the dispatcher can restore each switch to its normal position by operating the emergency reset key ERK so that its contacts 91 complete a shunt circuit across the line conductors L—1 and L—2. This shunt circuit completes a local operating circuit for each synchronizing relay which operates independently of the other to effect the return of its associate selector switch to its normal position. The circuit of the relay SSR is completed either from the positive or the negative terminal of the battery BAT depending upon the position of the switch A, wiper of bank S, winding of relay SSR, contacts 14 of relay F, contacts 103 of relay W, retardation coil RC—1, contacts 91 of emergency reset key ERK, retardation coil RC—2, contacts 11 of relay F to the neutral terminal n of battery BAT. The circuit of the relay SSR' is from the positive or negative terminal of the battery BAT' depending upon the position of the switch A', through either the winding 2 or the winding 3 of relay MOR' to the wiper of bank S', then through contacts 12 of relay C', winding of relay SSR', contact 100 of relay X', retardation coil RC'—1, contacts 13 of relay A'—1, line conductor L—1, contacts 91 of emergency reset key ERK, line conductor L—2, contacts 19 of relay A'—1, retardation coil RC'—2 to the neutral terminal n' of the battery BAT'. Each synchronizing relay then operates in an obvious manner to effect the return of its associate selector switch to its normal position.

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.

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

1. In a supervisory control system, a first station, a second station, two line conductors interconnecting said stations, selecting means at each station, each selecting means having a normal position, a relatively high impedance check circuit including a source of direct current and said conductors in series completed by said selecting means when both are in their respective normal positions, means for reversing the direction of current flow through said check circuit, means responsive to said reversal of current for decreasing the impedance of said check circuit, means responsive to the increased current in said check circuit produced by the operation of said impedance decreasing means for transmitting over said conductors impulses of opposite polarity, and means responsive to said impulses for effecting the synchronous operation of said selecting means.

2. In a supervisory control system, a first station, a second station, two line conductors interconnecting said stations, selecting means at each station, each selecting means having a normal position, a relatively high impedance check circuit including a source of direct current and said conductors in series completed by said selecting means when both are in their respective normal positions, means for producing a relatively large amount of reverse current in said check circuit, means responsive to said relatively large amount of reverse current for transmitting over said conductors impulses of opposite polarity, and means responsive to said impulses for effecting the synchronous operation of said selecting means.

3. In a supervisory control system, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said stations, selecting means at each station, each selecting means having a normal position, a relatively high impedance check circuit including a source of direct current and said conductors in series completed by said selecting means when both are in their respective normal positions, means for producing a relatively large amount of reverse current in said check circuit, means responsive to said relatively large amount of reverse current for transmitting over said conductors in series impulses of opposite polarity, means responsive to said impulses for effecting the synchronous operation of said selecting means, and manually controlled means for effecting the operation of said reverse current producing means.

4. In a supervisory control system, a first station, a second station, two line conductors interconnecting said stations, selecting means at each station, each selecting means having a normal position, a relatively high impedance check circuit including a source of direct current and said conductors in series completed by said selecting means when both are in their respective normal positions, means for reversing the direction of current flow through said check circuit, means responsive to said reversal of current for decreasing the impedance of said check circuit, means responsive to the increased current in said check circuit produced by the operation of said impedance decreasing means for transmitting over said conductors impulses of opposite polarity, means responsive to said impulses for effecting

the synchronous operation of said selecting means manually controlled means at said first station for effecting the operation of said current reversing means, and means responsive to the operation of an apparatus unit for effecting the operation of said reverse current producing means.

5. In a supervisory control system, a first station, a second station, two line conductors interconnecting said stations, selecting means at each station, each selecting means having a normal position, a check circuit completed by said selecting means and both in their respective normal positions and including a source of direct current and a relatively high impedance connected in parallel to a series-connected half-wave rectifier and a relay winding, said rectifier being connected so that no current from said source flows through said relay winding, means for reversing the current through said circuit whereof said relay winding is energized, means responsive to the energization of said relay winding for short-circuiting said impedance, means responsive to the increased current in said check circuit produced by short circuiting said impedance for transmitting over said conductors impulses of opposite polarity, and means responsive to said impulses for effecting the synchronous operation of said selecting means.

6. In a supervisory control system, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said stations, selecting means at said second station having a position individual to each of said units, means for transmitting current impulses of opposite polarity alternately through said conductors in series, means responsive to said impulses for effecting the operation of said selecting means, means for stopping said selecting means in a position individual to a unit, means for transmitting through said conductors in series while said selecting means remains in the position individual to a unit, a preparatory direct current impulse of the same polarity as the last synchronizing impulse followed by an impulse code individual to the desired operation of the selected unit, and means responsive to said last-mentioned impulses for operating the selected unit if it is not in the position corresponding to said impulse code.

7. In a supervisory control system, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said stations, selecting means at said second station having a position individual to each of said units, means for transmitting current impulses of opposite polarity alternately through said conductors in series, means responsive to said impulses for effecting the operation of said selecting means, means for stopping said selecting means in a position individual to a unit, means for transmitting through said conductors in series while said selecting means remains in the position individual to a unit a preparatory direct current impulse of the same polarity as the last synchronizing impulse followed by a direct current impulse of a predetermined polarity depending upon the desired operation of the selected unit, and means responsive to the polarity of said last-mentioned direct current impulse for operating the selected unit if it is not in the position corresponding to said last-mentioned direct current impulse.

8. In a supervisory control system, a first station, a second station, apparatus units at said

second station, two line conductors interconnecting said stations, selecting means at said second station having a position individual to each of said units, means for transmitting current impulses of opposite polarity alternately through said conductors in series, means responsive to said impulses for effecting the operation of said selecting means, means for stopping said selecting means in a position individual to a unit, means for transmitting through said conductors in series while said selecting means remains in the position individual to a unit, a preparatory direct current impulse of the same polarity as the last synchronizing impulse followed by an operating direct current impulse of one polarity when it is desired to have the selected unit in one predetermined position and of the opposite polarity when it is desired to have the selected unit in another predetermined position, polarity responsive means normally unresponsive to said last-mentioned direct current impulses, means responsive to said preparatory impulse for rendering said polarity responsive means responsive to the following direct current impulse, and means controlled by said polarity responsive means for selectively operating the selected unit in accordance with the polarity of the operating impulse.

9. In a supervisory control system, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said stations, synchronously operated multiple position switching means at each station having a single position individual to each unit, said means including means for transmitting current impulses of opposite polarity alternately through said conductors in series, means responsive to said impulses for effecting the synchronous operation of said switching means, means at said first station for stopping each switching means in the position thereof individual to a desired unit, means for transmitting through said conductors in series while each switching means remains in its respective position individual to a selected unit a preparatory direct current impulse of the said polarity as the last synchronizing impulse followed by an impulse code individual to the desired operation of the selected unit, and means responsive to said last-mentioned impulses for operating the selected unit if it is not in the position corresponding to the transmitted impulse code.

10. In a supervisory control system, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said stations, synchronously operated multiple position switching means at each station having a single position individual to each unit, said means including means for transmitting current impulses of opposite polarity alternately through said conductors in series, means responsive to said impulses for effecting the synchronous operation of said switching means, means at said first station for stopping each switching means in the position thereof individual to a desired unit, means for transmitting through said conductors in series while each switching means remains in its respective position individual to a selected unit a preparatory direct current impulse of the same polarity as the last synchronizing impulse followed by a direct current impulse of a predetermined polarity depending upon the desired operation of the selected unit, and means responsive to the polarity of said last-mentioned direct current impulse for operating the selected

unit if it is not in the position corresponding to said last-mentioned direct current impulse.

11. In a supervisory control system, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said stations, synchronously operated multiple position switching means at each station having a single position individual to each unit, said means including means for transmitting current impulses of opposite polarity alternately through said conductors in series, means responsive to said impulses for effecting the synchronous operation of said switching means, means at said first station for stopping each switching means in the position thereof individual to a desired unit, means for transmitting through said conductors in series while each switching means remains in its respective posi-

tion individual to a selected unit a preparatory direct current impulse of the same polarity as the last synchronizing impulse followed by an operating direct current impulse of one polarity when it is desired to have the selected unit in one predetermined position and of the opposite polarity when it is desired to have the selected unit in another predetermined position, polarity responsive means normally unresponsive to said last-mentioned direct current impulses, means responsive to said preparatory impulse for rendering said polarity responsive means responsive to the following direct current impulse, and means controlled by said polarity responsive means for selectively operating the selected unit in accordance with the polarity of the operating impulse.

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