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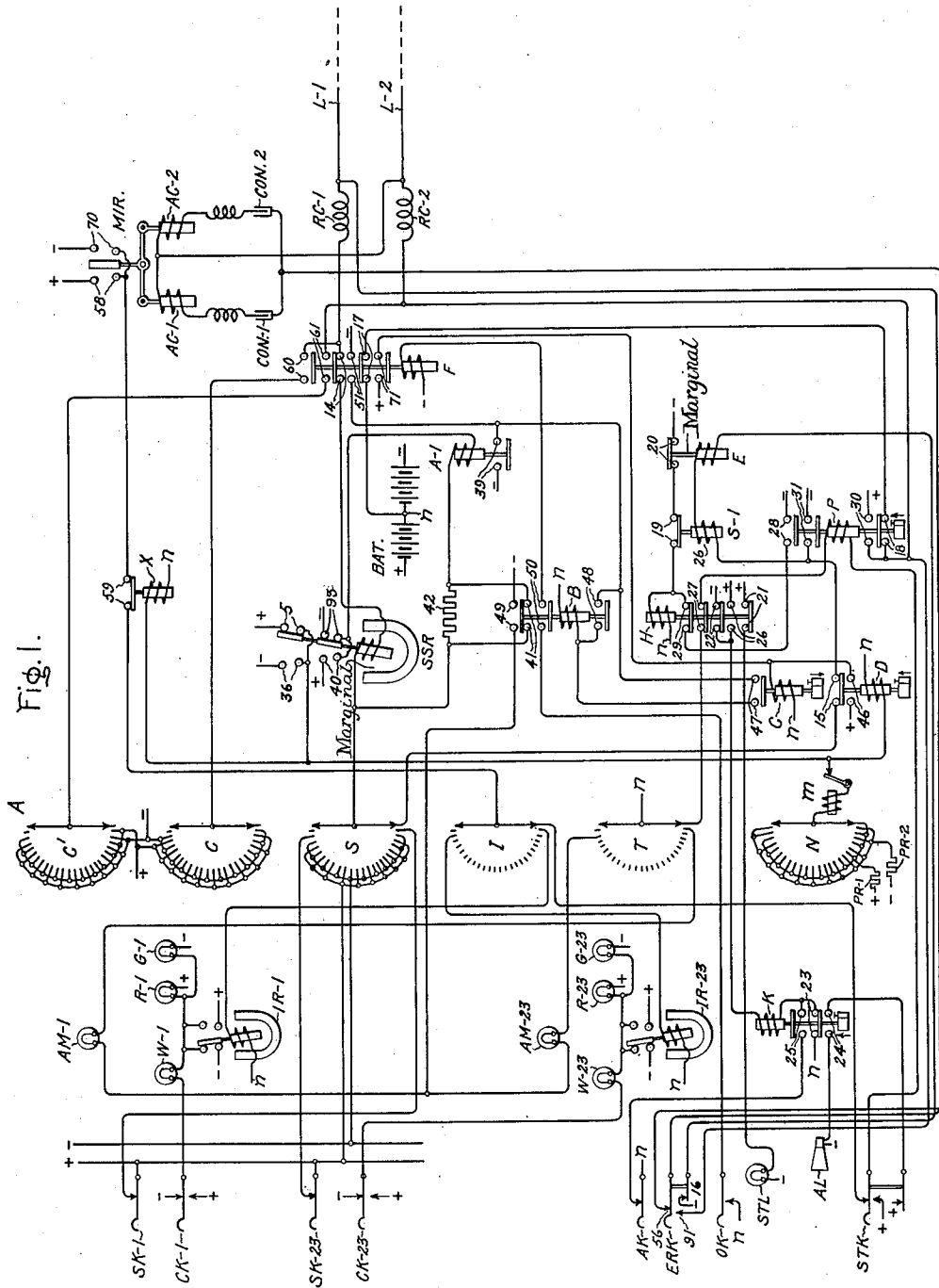
J. H. OLIVER

2,059,896

SUPERVISORY CONTROL SYSTEM

Filed July 8, 1932

2 Sheets-Sheet 1



Inventor:
James H. Oliver,
by *Charles T. Ullan*
His Attorney.

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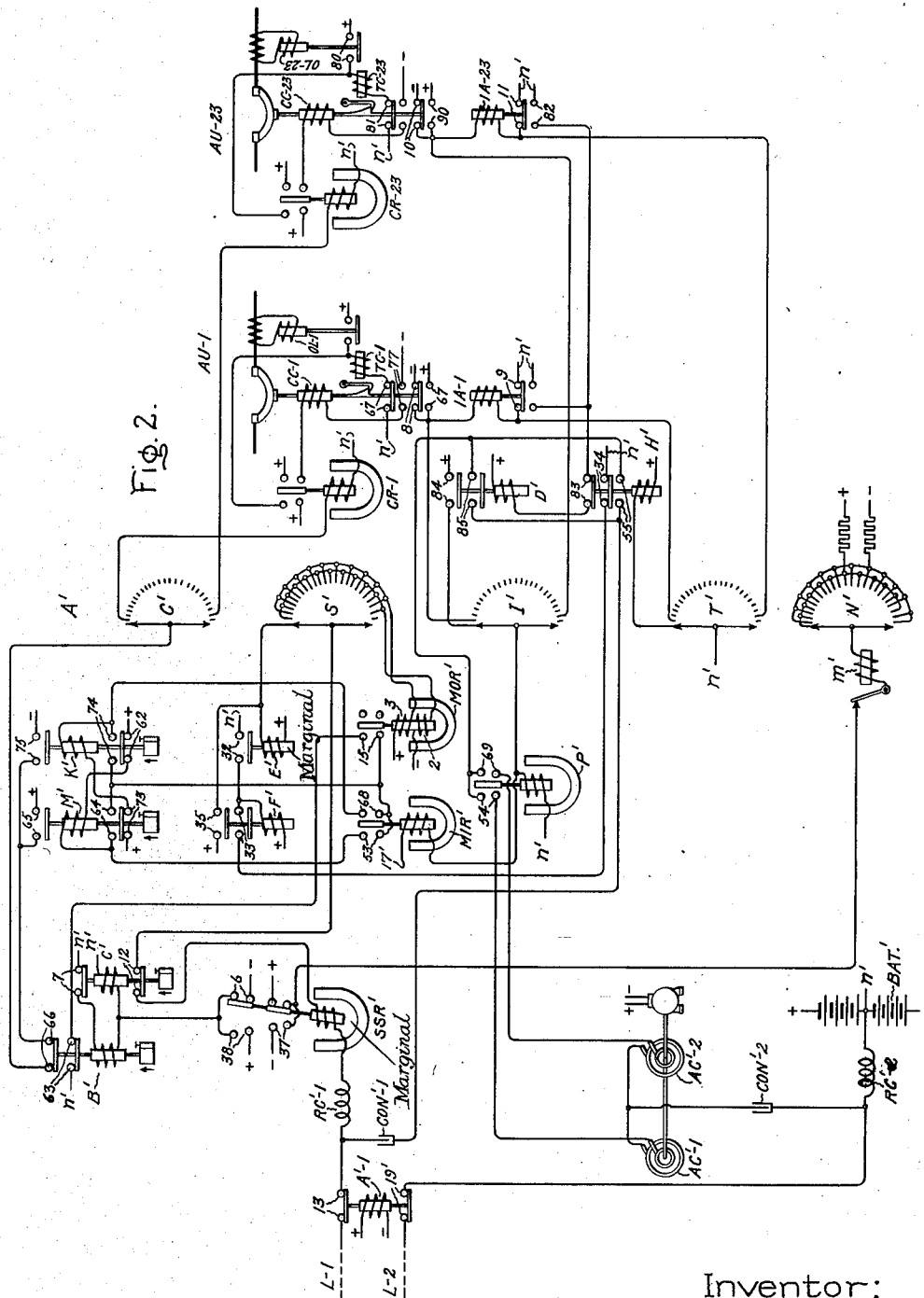
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2 Sheets-Sheet 2



Inventor:
James H. Oliver;
by *Charles E. Miller*
His Attorney.

UNITED STATES PATENT OFFICE

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SUPERVISORY CONTROL SYSTEM

James H. Oliver, Aldan, Pa., assignor to General Electric Company, a corporation of New York

Application July 8, 1932, Serial No. 621,405

20 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 an improvement in the synchronous selector supervisory control system disclosed and claimed in the copending application, Serial No. 260,168, filed March 8, 1928, by Clyde E. Stewart, and assigned to the assignee of this application.

One object of my invention is to provide an improved arrangement of apparatus whereby the synchronous selector supervisory control system disclosed in the aforesaid copending application may be employed to supervise and control a large number of apparatus units over a single pair of line conductors between the dispatcher's office and the remote station in which the apparatus units to be supervised and controlled are located. As disclosed in the aforesaid copending application four line conductors are required between the dispatcher's office and the remote station.

In accordance with my invention, there is provided at the dispatcher's office a group of control keys and signalling devices, such as lamps, for each apparatus unit to be supervised and controlled in the remote station. Suitable selecting means are provided at the dispatcher's office for successively associating in a predetermined sequence these groups of control keys and lamps with the single pair of line conductors extending between the dispatcher's office and the remote station. Similar selecting means are provided at the remote station for successively associating in the same sequence the corresponding apparatus units with the single pair of line conductors. In order that each of the control keys and lamps in the dispatcher's office may be associated with the two line conductors at the same time that the corresponding apparatus unit in the remote station is associated with the two line conductors, suitable means are provided for transmitting impulses over the line conductors in series to effect the synchronous operation of the two selecting means. In accordance with the preferred embodiment of my invention, this synchronous operation of the two selecting means is effected by the alternate transmission of impulses of opposite polarity through the two line conductors in series.

Normally the two selecting means in the two stations are not in operation. At the dispatcher's office there is a common start key which, when operated by the dispatcher, starts the two selecting means into operation to associate each appa-

ratus unit and its corresponding group of control keys and lamps simultaneously with the two line conductors. The operation of the two selecting means is also arranged to be started in response to an automatic operation of any one of the apparatus units while the selecting means are in their respective normal positions.

Whenever a group of control keys and lamps is associated with its corresponding apparatus unit by the selecting means, there is transmitted through the two line conductors a signalling current which corresponds in character to the position of the apparatus unit. This signalling current controls the group of signalling lamps at the dispatcher's office so that it indicates the actual position of the corresponding apparatus unit. Each group of lamps is also arranged to indicate any change that occurs in the position of the corresponding apparatus unit. In accordance with the preferred embodiment of my invention, an alternating current of one frequency is transmitted through the two line conductors in series to the dispatcher's office when an apparatus unit, which is associated with the two line conductors, is in one position and an alternating current of a different frequency is transmitted when the apparatus unit is in a different position. Suitable frequency responsive means are provided at the dispatcher's office for selectively operating the corresponding group of lamps in accordance with the frequency of the signalling current transmitted.

In order that a dispatcher may effect a change in the position of an apparatus unit at the remote station, each group of control keys at the dispatcher's office includes a select key which, when operated by the dispatcher prior to his operation of the start key, causes the two selecting means to stop operating when the group of control keys and lamps associated with the operated select key and the corresponding apparatus unit are simultaneously associated with the two line conductors. A check lamp associated with the operated select key lights, when the selecting means stop in the desired positions, and indicates to the dispatcher that the desired apparatus unit has been selected by the selecting means. The dispatcher then operates a common operate key to effect the operation of the selected apparatus unit. The operation of this operate key causes operating current to flow, through the two line conductors in series, to the remote station where suitable means are provided which operate in response to this operating current to effect the desired operation of the

selected apparatus unit. As soon as the selected apparatus unit changes its position, the character of the signalling current transmitted over the two line conductors to the dispatcher's station is also changed to effect the proper change in the lighting of the corresponding indicating lamps. By successively operating the operate key, the dispatcher can operate the selected apparatus unit as many times as he desires.

After the dispatcher has effected the desired operation of the selected apparatus unit, he restores the corresponding select key to its normal position. This starts the two selecting means into operation again and if no other select key is in its operated position, the selecting means return to their respective normal positions where they stop until either the start key is again operated or an apparatus unit automatically changes its position. When the selecting means reach their normal positions, the start lamp is lighted and a suitable alarm, such as a bell or horn, is operated at the dispatcher's office. The lighting of the start lamp informs the dispatcher that the selecting means are in their respective normal positions and that the supervisory system is in an operative condition and the operation of the alarm informs the dispatcher that the operation of the selecting means has been completed.

When the operation of the selecting means is effected in response to an automatic operation of an apparatus unit, the selecting means operate in the same manner as when the operation thereof is effected by the operation of the start key in the dispatcher's office except that as soon as the selecting means start to operate, an alarm is operated to inform the dispatcher that an apparatus unit has been automatically operated in the remote station. During the operation of the selecting means, the group of lamps associated with the apparatus unit which has changed its position is operated in a manner to indicate to the dispatcher which particular apparatus unit has been operated.

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 thereat 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 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 associate 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 associate 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 hereinafter 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, as shown in the drawings, the line conductor L—1 is connected to the positive terminal of the battery BAT' at the remote station, through the operating winding of the relay SSR', wiper and normal contact of the bank S' and winding of a start relay E'; and to the negative terminal of the battery BAT at the dispatcher's office, through the operating winding of the relay SSR, the wiper and normal contact of the bank S and the windings of the line check relays S—1 and E. The current in this normally completed circuit is neither sufficient to cause the start relay E' to close its contacts nor to cause the line check relay E to open its contacts. The current, however, is sufficient to cause the line check relay S—1 to close its contacts and complete an energizing circuit for the starting indicating relay H.

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 short-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, completes a low resistance shunt circuit around the windings of the relays S—1 and E so that the current flowing through the line conductor L—1 is increased sufficiently to cause the relay E' at the remote station to close 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'. When the windings of the three relays S—1, E and E' are all 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 relay 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 selected apparatus unit by operating a common operate key OK. The operation of this key OK completes an energizing circuit through the contacts of check relay B for an operate relay F' which, 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 the line conductors L—2 and connects the line conductors L—1 and L—2 to the wipers of banks C and C—1 respectively. 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 control current flows through either of these two windings the relay MOR' closes its contacts 15 and completes a circuit for either the auxiliary control relay M' or the auxiliary control relay K' depending upon the position of the selected apparatus unit. If the selected apparatus unit is closed, a circuit is completed through the corresponding contact of bank I' and auxiliary contacts on the selected apparatus unit for a master indicating relay MIR' which is of the polarized type, so that current flows through the

operating winding of the relay MIR' in the proper direction to cause it to close an energizing circuit for the auxiliary control relay M'. If the selected apparatus unit is open, the circuit of the master indicating relay MIR' is completed in such a manner that current flows through its operating winding in the opposite direction and the relay closes an energizing circuit for the auxiliary control relay K'. Therefore, when the master operate relay MOR' closes its contacts, a circuit for auxiliary control relay M' is completed through contacts of the master indication relay MIR' if the selected apparatus unit is closed and a circuit is completed for the auxiliary control relay K' if the selected apparatus unit is open. The auxiliary control relay M', when energized, completes a circuit for the operating coil of the control relay associated with the selected apparatus unit through its corresponding contact of the bank C' so that current flows through the control relay in the proper direction to cause the relay to complete an energizing circuit for the trip coil of the selected apparatus unit. When the auxiliary control relay K' is energized, a similar circuit is completed for the operating coil of the control relay associated with the selected apparatus units except that the current flows in the opposite direction through the operating coil so that the control relay effects the energization of the closing coil of the selected apparatus unit. Therefore, by successively closing the operate key OK, a selected apparatus unit can be successively opened and closed as many times as the dispatcher desires.

In order to prevent the control circuit of an apparatus unit from being completed during the operation of the selector A', a control cut-off relay B' is provided at the remote station. This relay B' controls the circuits of the relays K' and M' so that they are maintained open until after the synchronizing relay SSR' has remained stationary in one of its two positions for a predetermined time.

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. The operating winding of the relay P' is connected in parallel with the operating winding of the master indication relay MIR'. 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 current 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 character 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.

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' in case the potential thereof decreases below a predetermined value.

Detail description of the operation of the system

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. At the dispatcher's office the red lamps R—1 and R—3 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.

At the remote station the wiper and normal contact of the bank T' completes 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 75

of the synchronizing relay SSR' complete an energizing circuit for the line cut-off relay C' between the negative terminal and the neutral terminal *n'* of the battery BAT'. The relay C', in turn, completes through its contacts 7 and the contacts 6 of the relay SSR' an energizing circuit for the control cut-off relay B' 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' 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 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. This check circuit is from the positive terminal of the battery BAT' through the winding of relay E', wiper and normal contact of bank S', contacts 12 of relay C', winding of relay SSR', retardation coil RC'—1, contacts 13 of relay A'—1, line conductor L—1, retardation coil RC—1, contacts 14 of relay F, winding of relay SSR, wiper and normal contact of bank S, contacts 15 of relay D, winding of relay S—1, winding of relay E, contact 16 of key ERK, negative terminal of battery BAT, neutral terminal *n* of battery BAT, contacts 17 of relay F, contacts 18 of relay P, 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'. Also from the normal contact of bank S a parallel circuit is completed to the negative terminal of battery BAT through contacts 41 of relay B and resistor 42 in parallel winding of relay A—1, and contacts 93 of relay SSR.

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 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.

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 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 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 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 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. 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 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 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 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 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 28 completes through contacts 29 of the relay H a locking circuit for the coil of relay H. By opening its contacts 18 the relay P disconnects the line conductor L—2 from the neutral terminal *n* of the battery BAT and by closing its contacts 30 connects this line conductor L—2 to the positive terminal of the battery BAT. By closing its contacts 31, the relay P short-circuits the windings of the relays S—1 and E and the contacts 16 of the emergency reset key ERK so that the normal contact of the bank S is connected directly to the negative terminal of the battery BAT. 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 increased and the resistance is decreased so that the current which flows through the start relay E' at the remote station is increased sufficiently to cause this relay to close its contact 32 and thereby connect 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 oper-

ating 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 winding of the relay E', which has a relatively high impedance, so as to increase the current flowing through the line conductors to a value sufficient to cause the armatures of the synchronizing relays SSR and SSR' to move to their left-hand position.

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 45, 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.

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—I 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—I to close its contacts 39. This check circuit is from the positive terminal of the battery BAT, through the contacts 40 of the relay SSR, winding of relay A—I, contacts 41 of relay B which complete a short circuit around a resistor 42, winding of relay SSR, contacts 14 of relay F, retardation coil RC—I, line conductor L—I, contacts 13 of relay A'—I, retardation coil RC'—I, 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'—I, line conductor L—2, retardation coil RC—2, contacts 18 of relay P which is deenergized as soon as the switch A leaves its normal position, 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—I had been closed when the switches reached their first position, the relay A—I would have been short-circuited by the select key SK—I 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—I 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—I 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—I, 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—I 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—I 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—I so as to notify the dispatcher that the desired apparatus unit AU—I 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—I, first contact 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 parallel connected operating winding of the relays MIR' and P', wiper and first contact of bank I', auxiliary contacts 3 on apparatus unit AU—I to the negative terminal of the battery BAT'. The direction of current flow in this circuit is such as to cause the relay MIR' to close its contacts 53 and the relay P' to close its contacts 54. As long as the relay MOR' maintains its contacts 15 open the circuit through the contacts 53 of the relay MIR' is maintained open. By closing its contacts 54, however, the relay P' completes a signalling circuit from one terminal of the alternating current source AC'—I through the contacts 54 of the relay P', contacts 55 of the relay H' which is deenergized 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 operate key OK which completes an energizing circuit for the operate relay F. This circuit is from the negative terminal of the battery BAT through the winding of relay F, contacts 50 of relay B, contacts of operate key OK, to the neutral terminal *n* of the battery BAT.

By closing its contacts 51 the 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 contacts 40 of relay SSR and connects the line conductor L—1 to the negative terminal of the battery BAT through the wiper and first contact of bank C. 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 through the contacts 18 of relay P and connects the line conductor L—2 to the positive terminal of the battery BAT through 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 contacts 62 of relay K', winding of relay M', contacts 53 of relay

MIR', contacts 15 of relay MOR', contacts 63 of relay B' to the neutral terminal *n*' of the battery BAT'. By closing its contact 64 the relay M' completes a shunt circuit around the contacts 53 of the relay MIR' so that the relay M' remains energized as long as the dispatcher maintains the control key OK in its operated position.

By closing its contacts 65, the relay M' completes a circuit from the positive terminal of the battery BAT' through the contacts 65 of relay M', contacts 66 of relay B', wiper and first contact of bank C', winding of relay CR—1 to the neutral terminal *n*' of the battery BAT'. The current in the circuit is in a direction to cause the relay CR—1 to open its right-hand contacts and 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 coils of the relays MIR' and P' is reversed by the apparatus unit opening its contacts 8 and closing its contacts 67. As a result of this reversal of current the relay MIR' opens its contacts 53 and closes its contacts 68 and 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 relays 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 operate key OK to its normal position after effecting the desired operation of the selected apparatus unit AU—1, the relay F is deenergized and reconnects the line conductors L—1 and L—2 to the wiper of bank S and to the neutral terminal *n* of the battery BAT. In order to insure that the relay B is energized when the relay A—1 closes its contacts after the relay F is deenergized, the relay F, when energized, completes through its contacts 71 an energizing circuit for the time delay drop-out relay C. Therefore, if the relay A—1 closes its contacts 39 within a predetermined time after the relay F is deenergized, an energizing circuit is completed for the relay B through the contacts 47 of the relay C.

In response to the deenergization of the relay F at the dispatcher's office the relay MOR' at the remote station opens its contacts 15 and thereby interrupts the circuit of the control re-

lay M' which, in turn, by opening its contacts 65 interrupts the circuit of the control relay CR—I and the armature of the control relay CR—I, returns to the neutral position.

5 After the dispatcher has opened the selected apparatus unit AU—I, he may effect the closing thereof by again operating the operate key OK which, in the same manner as above described, causes the relay MOR' in the remote station
10 again to close its contacts 15. The closing of the contacts 15 now, however, effects the energization of the relay K' instead of the relay M' because the contacts 68 instead of the contacts 53 of the relay MIR' are closed. The circuit of
15 the relay K' is from the positive terminal of the battery BAT' through the contacts 73 of the relay M', winding of relay K', contacts 68 of relay MIR', contacts 15 of relay MOR', contacts 63 of relay B' to the neutral terminal n' of the
20 battery BAT'.

By closing its contacts 74 the relay K' completes a shunt circuit around the contacts 63 of the relay MIR' so that the deenergization of the relay K' is not effected by the relay MIR' when it changes its position in response to the
25 movement of the apparatus unit AU—I to its closed position. By closing its contacts 75, the relay K' completes a circuit from the negative terminal of the battery BAT' through the con-
30 tacts 75 of relay K', contacts 66 of relay B', wiper and first contact of bank C', winding of control relay CR—I to the neutral terminal n' of the battery BAT'. The current in this circuit is in a direction to cause the control relay CR—I to
35 close its right-hand contacts and thereby complete through the auxiliary contacts 77 on the apparatus unit AU—I an energizing circuit for the closing coil CC—I so that the apparatus unit AU—I is closed.

40 By opening its auxiliary contacts 67 and closing its auxiliary contacts 8 the apparatus unit AU—I reverses the current through the relays MIR' and P' so that the relay MIR' opens its contacts 68 and closes its contacts 53 and the
45 relay P' 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
50 office, the relay MIR operates to open its contacts 70 and close its contacts 58 so that the current through the indication relay IR—I is reversed. The relay IR—I then operates to extinguish the green lamp G—I and to light the
55 red lamp R—I and the white lamp W—I. The dispatcher may extinguish the white lamp W—I by moving the check key CK—I so that its position corresponds to the closing position of the apparatus unit AU—I.

60 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
65 the corresponding group of lamps in the dispatcher's office.

After the dispatcher has effected the desired operation of the selected apparatus unit AU—I, he may effect the return of the selector switches
70 A and A' to their normal position merely by closing the select key SK—I. The closing of this select key SK—I completes a low resistance shunt circuit around the relay A—I so that sufficient current flows through the synchronizing circuit in
75 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
10 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,
15 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
20 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
25 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
30 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—I, E and E' is again completed and the relay S—I by closing its contacts 19 completes the above-described energizing
40 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,
45 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
55 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
60 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
65 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—I and L—2. At
70 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
75

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 deenergization 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 23rd contact of the bank T', winding of relay IA—23, auxiliary contacts 96 on 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, retardation coil RC—1, contacts 91 of emergency reset key ERK, contacts 18 of relay

P, contacts 17 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', retardation coil RC'—1, contacts 13 of relay A'—1, line conductor L—1, contacts 91 of emergency reset key ERK, retardation coil RC—2, 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, apparatus units at said second station, signalling devices at said first station individual to each apparatus unit, two line conductors interconnecting said stations, synchronously operated selecting means at each station having a single position individual to each of said units, said means including means for transmitting current impulses through said conductors in series to effect the synchronous operation of said selecting means, means for stopping each selecting means in the position individual to a unit, means for transmitting through said line conductors in series a plurality of current impulses while said selecting means remain in the positions in which they are stopped, means responsive to each of said current impulses for effecting an operation of the unit individual to the positions in which the selecting means are stopped, and means for operating the signalling devices individual to a unit in accordance with the positions occupied thereby while said selecting means are simultaneously in the positions individual to such unit including means for transmitting through said line conductors in series signalling current varying in character in accordance with the positions of such unit.

2. In a supervisory control system, a first station, a second station, apparatus units at said second station, signalling devices at said first station individual to each apparatus unit, two line conductors interconnecting said station, synchronously operated selecting means at each station having a single position individual to each of said units, said means including means for transmitting current impulses through said conductors in series to effect the synchronous operation of said selecting means, means for stopping each selecting means in a position individual to a unit, means for transmitting through said line conductors in series a plurality of direct current impulses while said selecting means remain in the positions in which they are stopped, means responsive to each direct current impulse for effecting an operation of the unit individual to the positions in which the selecting means are stopped, and means for operating the signalling device individual to a unit in accordance with

the positions occupied thereby while said selecting means are simultaneously in the positions individual to such unit including means for transmitting through said line conductors in series alternating current varying in character in accordance with the positions of such unit.

3. In a supervisory control system, a first station, a second station, apparatus units at said second station, signalling devices at said first station individual to each apparatus unit, two line conductors interconnecting said station, synchronously operated selecting means at each station having a single position individual to each of said units, said means including means for transmitting current impulses through said conductors in series to effect the synchronous operation of said selecting means, means for stopping each selecting means in a position individual to a unit, means for transmitting through said line conductors in series a plurality of impulses of current of one character while said selecting means remain in the positions in which they are stopped, means responsive to each current impulse for effecting an operation of the unit individual to the positions in which the selecting means are stopped, and means for operating the signalling devices individual to a unit in accordance with the positions occupied thereby while said selecting means are simultaneously stopped in the positions individual to such unit including means for transmitting through said line conductors in series signalling current differing in character from the operating current impulses and varying in character in accordance with the positions of the unit.

4. In a supervisory control system, a first station, a second station, apparatus units at said second station, signalling devices at said first station individual to each apparatus unit, two line conductors interconnecting said stations, synchronously operated selecting means at each station having a single position individual to each of said units, said means including means for transmitting current impulses of opposite polarity alternately through said conductors in series to effect the synchronous operation of said selecting means, means for stopping each selecting means in a position individual to a unit, means for transmitting through said line conductors in series a plurality of direct current impulses of the same polarity as the last synchronizing impulse while said selecting means are stopped in the positions thereof individual to the same unit, means responsive to each direct current impulse for effecting an operation of the unit individual to the position in which the selecting means are stopped, and means for operating the signalling devices individual to a unit in accordance with the positions occupied thereby while said selecting means are simultaneously stopped in the positions thereof individual to such unit including means for transmitting through said line conductors in series alternating current varying in character in accordance with the positions of such unit.

5. In a supervisory control system, a first station, a second station, apparatus units at said second station, signalling devices at said first station individual to each apparatus unit, two line conductors interconnecting said stations, synchronously operated selecting means at each station having a single position individual to each of said units, said means including means for transmitting current impulses of opposite polarity alternately through said conductors in series

to effect the synchronous operation of said selecting means, means for stopping each selecting means in a position individual to a unit, means for transmitting through said line conductors in series when each selecting means has stopped in the position individual to the same unit a plurality of direct current impulses of the same polarity as the last synchronizing impulse, means for effecting the operation of the unit in response to each of said last mentioned direct current impulses, and means for controlling the operation of each of said signalling devices when each selecting means is in the position individual to the corresponding unit including means for transmitting through said conductors in series a signal current of one character when the corresponding unit is in one position and of a different character when the corresponding unit is in another position.

6. In a supervisory control system, a first station, a second station, apparatus units at said second station, signalling devices at said first station individual to each apparatus unit, two line conductors interconnecting said stations, synchronously operated selecting means at each station having a single position individual to each of said units, said means including means for transmitting current impulses of opposite polarity alternately through said conductors in series to effect the synchronous operation of said selecting means, means for stopping each selecting means in a position individual to a unit, means for transmitting through said line conductors in series when each selecting means has stopped in the position individual to the same unit a plurality of direct current impulses of the same polarity as the last synchronizing impulse, means for effecting the operation of the unit in response to each of said last mentioned direct current impulses, and means for controlling the operation of each of said signalling devices when each selecting means is in the position individual to the corresponding unit including means for transmitting through said conductors in series an alternating current of one frequency when the corresponding unit is in one position and an alternating current of another frequency when the corresponding unit is in another position.

7. In a supervisory control system, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said station, selecting means for successively associating said apparatus units with said line conductors including means for transmitting current impulses of opposite polarity alternately through said conductors in series and polarity means responsive to said current impulses for effecting the operation of said selecting means, means for causing said selecting means to select an apparatus unit for operation, other polarity responsive means, means including said selecting means for controlling the connection of said other polarity responsive means to said line conductors so that the position of said other polarity responsive means is not reversed in response to the transmission of said current impulses through said conductors, and means for operating a selected apparatus unit including means for transmitting through said conductors in series operating current of the proper polarity to effect a reversal in the position of said other polarity responsive means and means responsive to the operation of said other polarity responsive means for effecting the operation of the selected apparatus unit.

8. In a supervisory control system, a first sta-

tion, 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 and a position individual to each apparatus unit, a relatively high impedance check circuit including a source of current and said conductors in series completed by said selecting means when both are in their normal position, means for decreasing the impedance of said check circuit, manually controlled means at said first station for effecting the operation of said impedance decreasing means, means responsive to the increased current in said check circuit produced by the operation of said impulse decreasing means for effecting the synchronous operation of said selecting means, means responsive to an automatic operation of an apparatus unit at said second station for transmitting a current impulse through said conductors in series when said selecting means are in their normal position, and means responsive to said current impulse for effecting the operation of said impedance reducing means.

9. 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 and a position individual to each apparatus unit, a relatively high resistance check circuit including a source of direct current and said conductors in series completed by said selecting means when both are in their normal position, means for decreasing the resistance of said check circuit, manually controlled means at said first station for effecting the operation of said resistance decreasing means, means responsive to the increased direct current in said check circuit produced by the operation of said resistance decreasing means for effecting the synchronous operation of said selecting means, means responsive to an automatic operation of an apparatus unit for transmitting an alternating current through said conductors in series when said selecting means are in their normal position, and means responsive to said alternating current for effecting the operation of said resistance decreasing means.

10. 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 and a position individual to each apparatus unit, a relatively high impedance check circuit including a source of current and said conductors in series completed by said selecting means when both are in their normal position, means 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 effecting the synchronous operation of said selecting means, means for transmitting a current impulse through said conductors in series while said check circuit is completed, and means responsive to said current impulse for effecting the operation of said impedance reducing means.

11. 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 and a position individual to each ap-

paratus unit, a relatively high resistance check circuit including a source of direct current and said conductors in series completed by said selecting means when both are in their normal position, means for decreasing the resistance of said check current, means responsive to the increased direct current in said check circuit produced by the operation of said resistance decreasing means for effecting the synchronous operation of said selecting means, means for transmitting an alternating current through said conductors in series while said check circuit is completed, and means responsive to said alternating current for effecting the operation of said resistance decreasing means.

12. 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 and a position individual to each apparatus unit, a relatively high impedance check circuit including a source of current and said conductors in series completed by said selecting means when both are in their normal position, means for decreasing the impedance of said check circuit, manually controlled means at said first station for effecting the operation of said impedance decreasing means, means responsive to the increased current in said check circuit produced by the operation of said impedance decreasing means for effecting the synchronous operation of said selecting means, means responsive to an automatic operation of an apparatus unit at said second station for transmitting a current impulse through said conductors in series when said selecting means are in their normal position, means responsive to said current impulse for effecting the operation of said impedance reducing means, a signal, means responsive to a predetermined current in said check circuit for effecting the operation of said signal, and means controlled by said manually controlled means for preventing said current responsive means from effecting the operation of said signal in response to the increase in current produced in said check circuit by the operation of said manually controlled means.

13. In combination, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said stations, selecting means at said second station for associating each apparatus unit with said line conductors, and means for operating an apparatus unit while it is associated with said conductors including means at said first station for causing a current impulse of a predetermined character to flow through said conductors in series while the apparatus unit is being maintained in association with said conductors by said selecting means, a polarized relay at said second station, means including said selecting means for causing a current to flow through the operating winding of said relay in a direction corresponding to the position of the apparatus unit associated with said conductors, and means controlled by the position of said relay for causing said current impulse to effect a certain operation of the apparatus unit associated with said conductor when said relay is in one position and a different operation of the apparatus unit when said relay is in another position.

14. In combination, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said stations, se-

lecting means at said second station for associating each apparatus unit with said line conductors, and means for operating an apparatus unit while it is associated with said conductors including means at said first station for causing a current impulse of a predetermined character to flow through said conductors in series while the apparatus unit is being maintained in association with said conductors by said selecting means, a control circuit individual to each apparatus unit, means controlled by the position of the apparatus unit being maintained in association with said conductors for causing said current impulse to effect a current having certain characteristics to flow in the corresponding control circuit when the apparatus unit is in one position and a current having other characteristics to flow in the corresponding control circuit when the apparatus unit is in another position, and means responsive to said currents for selectively controlling the apparatus unit.

15. In combination, a first station, a second station, apparatus units at said second station, two line conductors interconnecting said stations, selecting means at said second station for associating each apparatus unit with said line conductors, and means for operating an apparatus unit while it is associated with said conductors including an apparatus unit while it is associated with said conductors including means at said first station for causing a current impulse of a predetermined character to flow through said conductors in series while the apparatus unit is being maintained in association with said conductors by said selecting means, a control circuit individual to each apparatus unit, means controlled by the position of the apparatus unit being maintained in association with said conductors for causing said current impulse to effect a direct current to flow in one direction in the corresponding control circuit when the apparatus unit is in one position and in the other direction when the apparatus unit is in another position, and means in each control circuit responsive to the direction of current flow therein for selectively controlling the operation of the corresponding apparatus unit.

16. 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, means for causing current of a predetermined character to flow through said conductors in series when said selecting means are simultaneously in their normal position, means responsive to a predetermined value of said current for effecting the synchronous operation of said selecting means, means for increasing said current to said predetermined value, manually controlled means for effecting the operation of said current increasing means, means responsive to the operation of an apparatus unit for causing current of a different character to flow through said conductor in series when said selecting means are simultaneously in their normal position, and means responsive to said last mentioned current for effecting the operation of said current increasing means.

17. 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, means including manually controlled means at said first station for causing current of a pre-

determined character to flow through said conductors in series when said selecting means are simultaneously in their normal positions, means responsive to said current for effecting the synchronous operation of said selecting means, means responsive to the operation of an apparatus unit for transmitting current of a different character through said conductors in series when said selecting means are simultaneously in their normal positions, and means responsive to said last mentioned current for causing current of said first mentioned predetermined character to flow through said conductor in series.

18. 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, control means for causing direct current of a predetermined value to flow through said conductors in series when said selecting means are simultaneously in their normal positions, means responsive to said direct current for synchronously operating said selecting means, manual control means at said first station for effecting the operation of said control means, means responsive to the operation of an apparatus unit for transmitting alternating current through said conductors in series when said selecting means are simultaneously in their normal positions, and means responsive to said alternating current for effecting the operation of said control means.

19. In a supervisory control system, a first station, a second station, apparatus units at said second station, signalling means at said first station individual to each apparatus unit, selecting means at each station, each selecting means having a normal position and a position individual to each apparatus unit, control means for causing current of a predetermined character to flow through said conductors in series when said selecting means are simultaneously in their normal position, means responsive to said current for effecting the synchronous operation of said selecting means, means controlled by the position of an apparatus unit for transmitting through said conductors in series when both of said selecting means are simultaneously in the positions individual thereto, a signalling current for operating the corresponding signalling means in accordance with the position of the apparatus unit, means responsive to an operation of an apparatus unit for transmitting said signalling current when said selecting means are simultaneously in their normal positions, and means responsive to said signal current when said selecting means are simultaneously in their normal positions for effecting the operation of said control means.

20. In a supervisory control system, a first station, a second station, apparatus units at said second station, signalling means at said first station individual to each apparatus unit, selecting means at each station, each selecting means having a normal position and a position individual to each apparatus unit, control means for causing direct current of a predetermined value to flow through said conductors in series when said selecting means are simultaneously in their normal positions, means responsive to said direct current for effecting the synchronous operation of said selecting means, means controlled by the position of an apparatus unit for transmitting through said conductors in series when said selecting means are simultaneously in the position corresponding thereto, an alternating current of

a predetermined frequency when the unit is in one position and an alternating current of another frequency when the unit is in another position, means responsive to an operation of an apparatus unit for causing an alternating current of one of said frequencies to be transmitted through said conductors in series when said selecting means are simultaneously in their normal position, and means responsive to said alternating currents for effecting the operation of said control means when said selecting means are in their normal position and the operation of said signalling means when said selecting means are in the positions individual to the corresponding apparatus units.

JAMES H. OLIVER.