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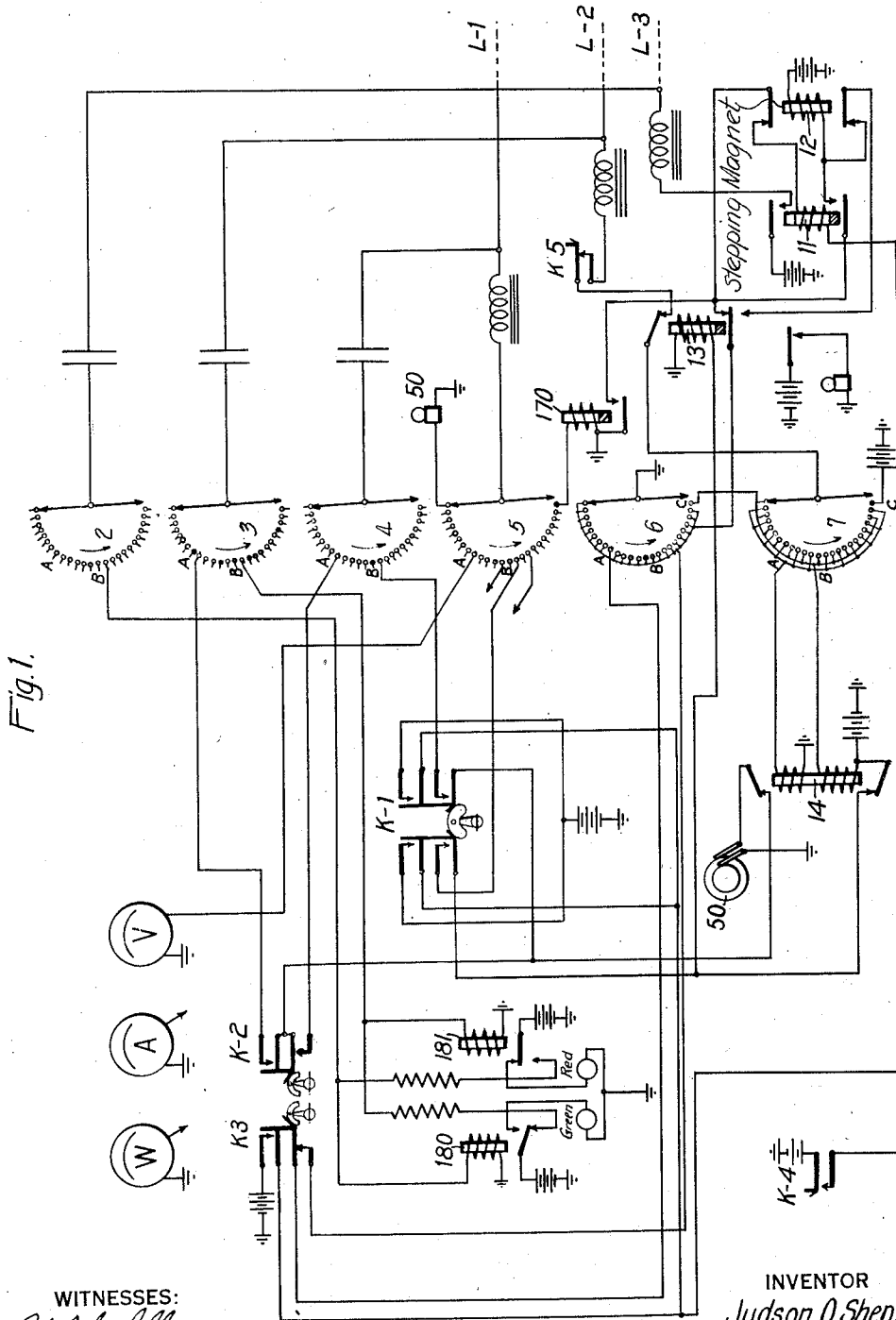
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1,786,780

SUPERVISORY AND CONTROL SYSTEM

Filed Dec. 17, 1925

4 Sheets-Sheet 1



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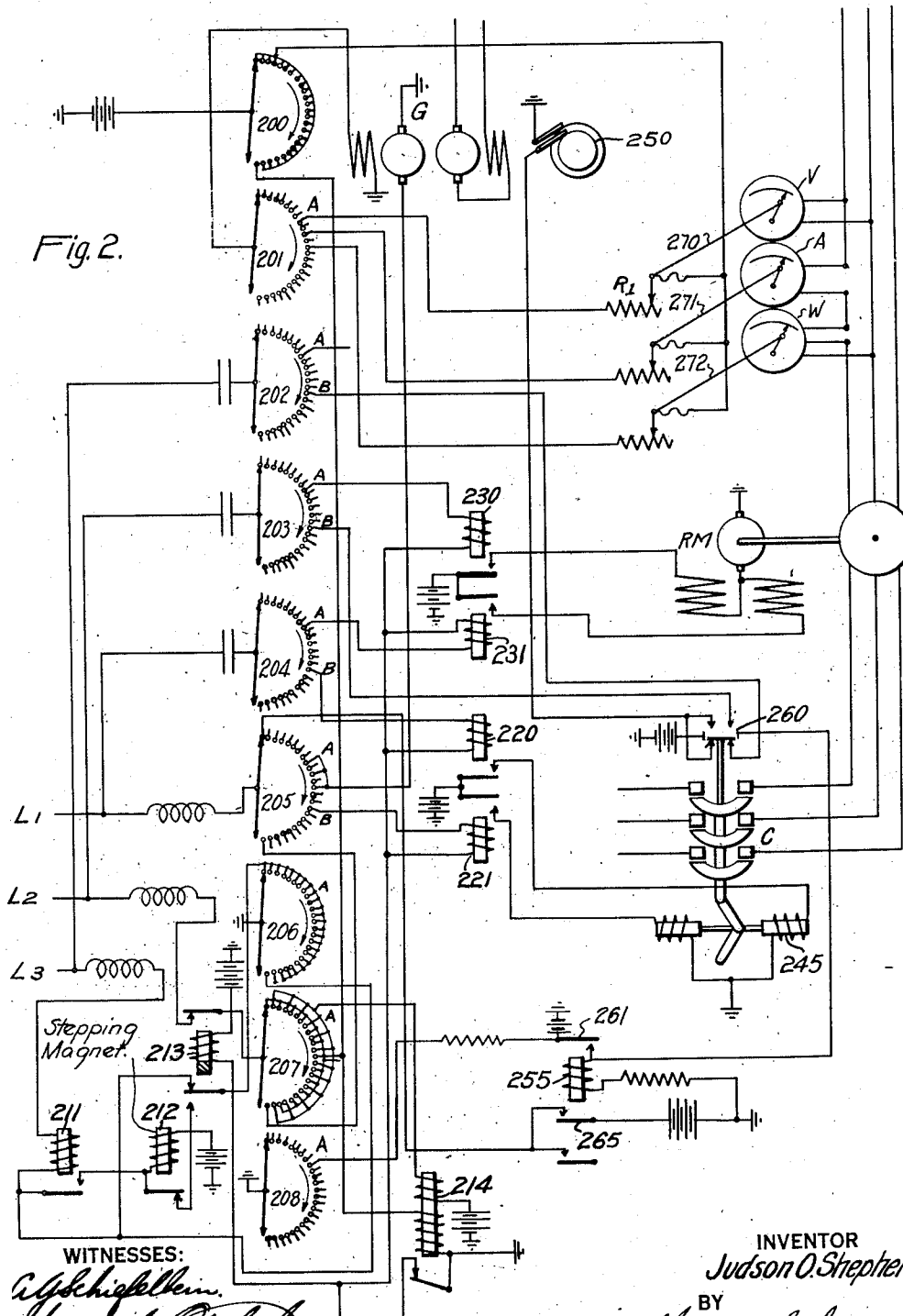
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4 Sheets-Sheet 2

Fig. 2.



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SUPERVISORY AND CONTROL SYSTEM

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4 Sheets-Sheet 3

Fig. 3.

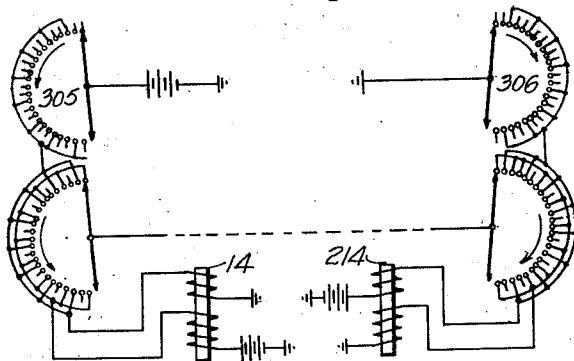


Fig. 4.

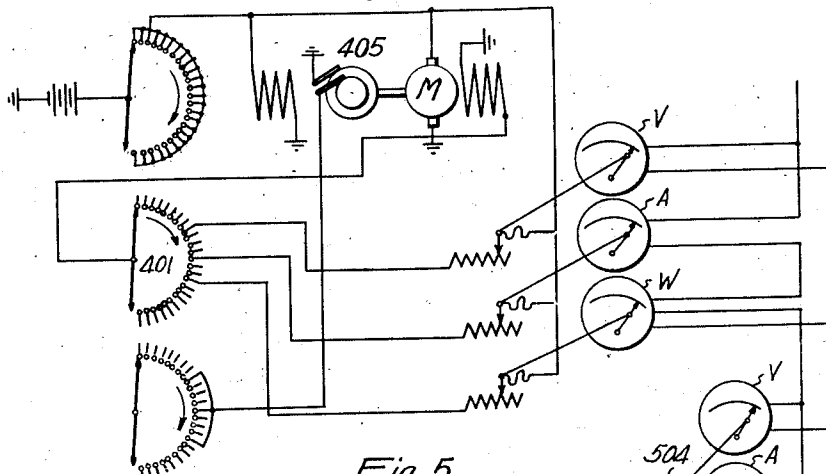
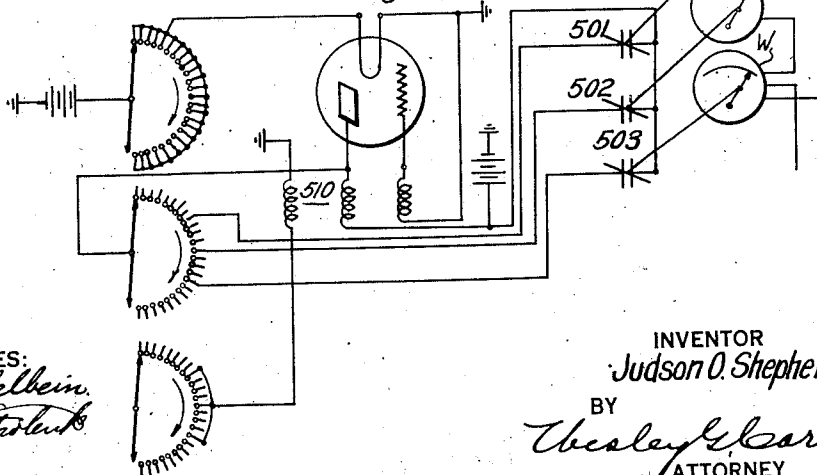


Fig. 5.



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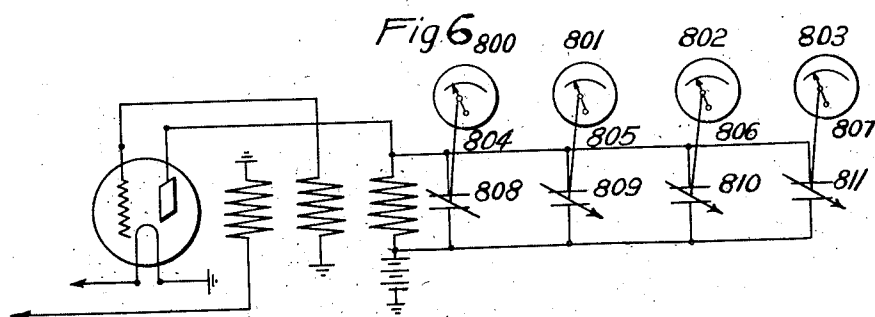
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4 Sheets-Sheet 4



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SUPERVISORY AND CONTROL SYSTEM

Application filed December 17, 1925. Serial No. 76,026.

My invention relates in general to control systems and more particularly to systems for selectively controlling and supervising from a central point remotely disposed electrical equipment.

One object of my invention is to provide selective circuits whereby the dispatcher at a central station is enabled to select and operate apparatus units in a distant electrical station or substation.

Another object of my invention is to provide means for indicating to the dispatcher an operation of a selected unit.

Another object of my invention is to provide synchronously operating selecting devices for selecting an apparatus unit at the distant station.

Another object of my invention is to prevent operation of any device at the substation when the selectors fall out of synchronism.

Another object of my invention is to provide an intermittently energized relay which maintains synchronism and simultaneously controls the opening and closing of the operating circuits.

Another object of my invention is to provide means for attracting the attention of the dispatcher in the event that the selecting devices fall out of synchronism.

Another object of my invention is to provide means for enabling the dispatcher to detect any non-synchronous conditions of the selecting devices.

Another object of my invention is to provide means for operating a distantly controlled device and for simultaneously observing the effects thereof.

Another object is to provide an arrangement for transmitting meter readings using frequencies as a unit.

There are other objects of the invention which together with the foregoing will be described in the detailed specification which is to follow. Referring now to the drawing, sufficient apparatus and circuits have been shown by means of conventional diagrams to enable my invention to be readily explained and understood.

Fig. 1 is a diagrammatic view of the elec-

trical circuit at the dispatcher's office embodying my invention.

Fig. 2 is a similar view of the circuits at the substation.

Fig. 3 is a modification of the synchronous apparatus shown in Figs. 1 and 2.

Figs. 4 and 5 are views of modified forms of devices for transmitting meter indications.

Fig. 6 is a detail view of means for totalizing meter indications.

In Fig. 1 is shown the circuit arrangement at the dispatcher's office embodying my invention, including operating contact banks 2 to 5, the details of which are described in the patent to Clement No. 1,107,153, stop bank 6, synchronous bank 7, synchronizing relay 14, dispatcher's keys K—1, K—3, K—2 and K—4; meters V, A and W, supervisory relays 180 and 181 and sources of energy and operating relays. Similarly in Fig. 2 the substation includes operating banks 202 and 205, stop bank 206, synchronizing bank 207, synchronizing relay 214, circuit breaker 260, rotary converter R. M., meters, sources of energy and the several relays required.

In following out my invention, a dispatcher closes a key to operate a mechanism at a distant substation. Closing the key causes the selector switches to rotate until they reach the contact on the switch to which the key is connected. A similar switch at the distant station rotates in synchronism and stops at the contact to which the mechanism to be operated is connected. The dispatcher's key is thus connected to the mechanism which it is desired to operate and the said mechanism may be operated. Then by the use, of alternating and direct current, immediate indications can be sent back to the dispatcher to indicate the operations which have taken place. A better understanding of my invention will be obtained by the following description of its operation.

Let it be assumed that the dispatcher desires to inspect all the mechanism at the distant station. To do this, he operates an inspection key K—4, closing a circuit from ground through battery and this inspection key through the winding of slow-release relay 11, back contact of the upper armature

of relay 12 and front contact of the lower armature of slow-release relay 13, bank 6, through its wiper to ground. This will energize slow-release relay 11 and operate its armatures.

As a result a circuit will be completed from ground through battery, stepping magnet 12, the lower armature of slow-release relay 11, the upper contact of the lower armature of slow-release relay 13, through operating bank 6 through its wiper to ground. The energization of stepping magnet 12 will move its pawl to position preparatory to move the wipers of banks 2 to 7 one step. They will not, however, be moved at this time.

Energization of the stepping magnet 12 has the effect of opening the circuit of slow-release relay 11 at the upper armature of the stepping magnet 12. After a short interval of time, relay 11 will be deenergized. As a result, its lower armature will open the energizing circuit of the stepping magnet 12 which thereby allows its pawl to spring back and step the wipers of banks 2 to 7. Another effect of deenergization of the stepping relay 12 is to again close the circuit of relay 11 at its upper armature.

Relay 11 will be energized a second time and will close the circuit of the stepping magnet 12 at its lower armature as traced before. Stepping magnet 12 will again be energized to open the circuits at the upper and lower armatures. This cycle will be repeated rotating the wipers of banks 2 to 7 from contact to contact.

Simultaneously with this operation, a circuit over L—3 is closed from ground through battery, upper armature of slow-release relay 11 over L—3 through the winding of relay 211, the upper contact of the lower armature of slow-release relay 213, bank 206 through its wiper to ground. Energization of relay 211 will close a circuit from ground through battery, stepping magnet 212, armature of relay 211, front contact of the lower armature of slow-release relay 213, bank 206 through its wiper to ground. Energizing of stepping magnet 212 will position its pawl for stepping the wipers of banks 200 to 208 one step.

Upon the deenergization of relay 11, the circuit for relay 211 is broken at the upper armature of relay 11 and it in turn opens the circuit for magnet 212. Deenergization of magnet 212 steps the wipers of banks 200 to 208 one step. This continues simultaneously with the stepping of wipers of banks 2 to 7. As the wipers pass the various contacts on the banks 202 to 205, they successively connect various apparatus units at the substation to the lines.

Simultaneously, the banks 2 to 5 connect equivalent apparatus units at the office to the same lines to give indications of the condition of these units. Thus when the wipers

reach the position A illustrated in the drawing, a circuit is completed from ground through the field winding of generator G, wiper of bank 201, contact A over resistance element R₁, bank 200, its wiper and battery to ground.

The voltmeter V, responsive to the voltage of the bus bars shown, has connected to its indicator a lever arm which as it moves with the indicator varies the resistance R₁ corresponding to the changes of the voltmeter indications. This variation will vary the field current of the generator G to produce changes in generated voltages. A circuit is completed at this time from ground through the armature of generator G, bank 205, contact A, wiper of bank 205 over line L—1, wiper of bank 5, contact A of bank 5 and through the voltmeter at the dispatcher's office to ground. The voltmeter indicates the voltage of the bus bars at the substation. Similarly, indications of various other characteristics such as amperes and watts may be transmitted over the other contacts.

This invention contemplates as one feature the operation of mechanism at a distant station from the dispatcher's office. This is illustrated as follows: It may be assumed that it is desired to open the oil switch shown at the substation. The key K—1 is moved to close the contacts at its right. This will result in the circuit being extended from ground through battery at the right upper contacts of key K—1, slow-release relay 11, upper back armature of stepping relay 12, front contact of the lower armature of relay 13, bank 6 and its wiper and ground. This will energize relay 11, which as before described, will energize magnet 12 to prepare to step the wipers of banks 2 to 7 one step. The stepping will continue until the wipers have reached contacts B.

At this point, a circuit will be completed from ground through the source of alternating currents 50, upper armature of relay 14 through the lower right hand contact of key K—1, contact B of the bank 4, its wiper over the line L—1, wiper of bank 204, contact B, relay 220 and lower armature of the relay 214 to ground. Energization of relay 220 closes circuit from ground through battery, front contact of armature of relay 220, the winding of magnet 245 to ground. The magnet 245 is arranged to open the oil switch.

The wipers will not, however, remain on the contacts at this time but will continue stepping as already explained until they have reached their normal position. At this position if the key K—1 is released, there will be no circuit for relay 11 so that the wipers will remain at their normal position. It is however, often desirable for the dispatcher to know whether the oil switch really changed its position as a result of the closing

of K—1. This can be determined by closing either the switch key K—1 so that the wipers make a second rotation or by operating inspection key K—4. Upon the second rotation of the wipers when they reach contact B on the banks, a circuit will be completed from ground through the source of alternating current 250 at the substation lower contacts of the oil switch, contact B of bank 202, its wiper, line L—3, bank 2 at the dispatcher's office, its wiper, contact B and through relay 180 to ground. Energization of relay 180 will cause its armature to engage its upper front contact and close a circuit from ground through the battery, the armature 180 and green lamp to ground. This will indicate to the dispatcher that the oil switch has been opened.

Simultaneously, a locking circuit which formerly held relay 181 energized from ground through battery, armature of relay 180, and relay 181 to ground is now opened by the movement of the armature of relay 180. The armature of relay 181 will be released to engage its lower contact and a locking circuit for relay 180 will thereupon be closed from battery through the lower position of the armature of relay 181 and relay 180 to ground.

The circuits thus far traced have indicated means whereby the dispatcher can inspect apparatus located at a distant station and also control its operation. The operations, however, in these instances have to be rapid since the wipers do not stop for any considerable length of time on any of the contacts. It is, however, often desirable to perform some operations which require a considerable length of time. In such cases, it is desirable to stop the wipers at the contacts where the operations are to be performed. The circuit associated with key K—3, operates to perform this function.

Assume that the dispatcher desires to control the induction regulator at the distant station. To do this, stop key K—3 is moved so as to close its upper contact and open the lower contact. Closing the upper contact results in a circuit from ground through battery upper contact of stop key K—3, winding of slow-release relay 11, upper back contact of the armature of relay 12, upper contact of the lower armature of slow-release relay 13, bank 6 and its wiper to ground. As already explained, this will result in stepping the wipers of banks 2 to 7 and 200 to 208. This will continue at both stations until the wiper reaches contact A.

Contact A, on bank 6 unlike the other contacts on this bank is electrically disconnected from the others. Normally when the wiper passes this contact the circuit just traced completes itself through the lower contact of key K—3, from the bank and to contact A, wiper to ground. The circuit, however, is opened

this time at the lower contact of K—3, so that relay 11 does not get its energizing current and the wipers are all stopped at this point.

As already explained, this will stop the wipers of the banks 200 to 208 simultaneously on point A. The operator will now move the switch key K—2 to the upper position if he desires to increase the voltage of the trunk line and switch key K—2 will be moved to close the contacts at its lower portion to decrease voltage.

Let it be assumed that the operator desires to increase the voltage. In such case, a contact in the upper position will be closed. When the wipers reach position A, a circuit may, if desired be completed from ground through the source of alternating currents 50, the upper armature of relay 14, upper contact of key K—2, contact A of bank 3, its wiper, line L—2, wiper of bank 203, contact A, relay 230, front contact of relay 214 to ground. Energization of relay 230 will close the circuit from ground to battery, its armature and contact through the winding RM. This will result in an increase in voltage of the trunk lines shown and the voltmeter V will change its indication which will be indicated at the main station as already explained.

The operator is thus enabled by moving switch key K—2 in either direction to effect the induction regulator and simultaneously note by means of his voltmeter the change occurring at the distant station.

After an operation has been performed such as that performed by the keys K—3 and K—2 it is often desirable to return the wipers to their normal position as rapidly as possible. The operation whereby relay 11 operates step magnet 12 is necessarily slow to insure faithful operation as has already been discussed. In order to return the switch wipers with greater rapidity than can be accomplished by the above-mentioned arrangement, key K—5 is opened for an instant. This will open the circuits of relays 14 and 214 which is equivalent to nonsynchronous condition and relay 12 will act as a vibrator as will be explained. Similarly, relay 212 at the substation will independently rapidly return its wipers to their normal position.

It is very important that in systems as herein disclosed there be an invariable safeguard against the operation of an incorrect mechanism. Such false operation might occur if the wipers at the dispatcher's office fall out of synchronism with the wipers in the distant station. The system disclosed is a novel means for maintaining synchronism.

As the wiper 7 moves from contact to contact, it is alternately connected first to the upper and then to the lower winding of relay 14. Similarly at the distant station as the wiper of bank 207 moves from contact to contact it is connected alternately to the upper

windings and the lower winding of relay 214. With the wipers on the third or any odd numbered contact in Fig. 1 a circuit is completed from ground through the battery, lower winding of relay 14, odd numbered contact, and wiper of the bank 7, upper armature of the slow-release relay 13 key K—5 selecting supervisory trunk line L—2, armature of slow-release relay 213, wiper of bank 207 through the lower windings of relay 214 to ground. This will result in the energization of relay 14 at the dispatcher's office and relay 214 at the distant station. The armature will close its circuits as shown. On the next step, the circuit is completed from ground through the upper winding of relay 14, bank 7, its wiper, armature of slow-release relay 13, key K—5, line L—2, armature of slow-release relay 213, bank 207 through its wiper, upper winding of relay 214 and battery to ground.

It will be noted that as long as the wipers are in synchronism a circuit will always be completed either from battery through the lower winding of relay 14 over the line through the lower winding of relay 214 and ground or from ground through the upper winding of relay 14 over the line through upper winding of relay 214 and battery to ground. As long as relays 14 and 214 remain energized, the circuits formerly traced which are dependent for their completion upon the closing of the contacts at the armatures of the relays 14 and 214 will be in condition for operation. If they should however, fall out of synchronism and bucking potentials are connected to the line at each station, relays 14 and 214 will be deenergized and the operating circuits will be opened at their armatures. In such case, it will be impossible for the dispatcher to operate the mechanism at the distant station. It is apparent therefore that the operator will either operate the correct mechanism or none at all.

It should be noted at this time that slow-release relay 13 is normally energized over a circuit from ground through battery at lower armature of relay 14, the winding of the slow-release relay 13 to ground. Similarly relay 213 is energized from ground through lower armature of relay 214, winding of the slow-release relay 213 and battery to ground.

When, for some reason, the wipers at one station fall out of synchronism with the wiper at the other station and relays 14 and 214 are deenergized, as already explained, the circuits just traced for relays 13 and 213 are opened at the lower armature of relays 14 and 214 respectively. Relays 13 and 213 are slow-release for the reason that it is desirable that they hold their contact closed during the short periods that the relays 14 and 214 are deenergized while the wipers pass from one contact to another.

Now, however, upon the wipers falling out

of synchronism relays 14 and 214 remain deenergized for a substantial length of time with the result that relays 13 and 213 are deenergized to open the circuits of line L—2 at the dispatcher's office and at the distant office.

At the lower contact of armature 13, a circuit is now completed from ground through battery, winding of stepping magnet 12 through its lower armature, armature of relay 13 deenergized bank 6 through its wiper to ground. Stepping magnet 12 becomes a vibrator in the circuit just traced. The wipers of the banks 2 to 7 are moved step-by-step until they reach the contacts C where ground is removed from the vibrator circuit of the stepping magnet described.

At the distant station, deenergization of relay 213 results in a circuit from ground to battery stepping magnet 212, its lower armature, the armature of relay 213 deenergized, bank 206 through its wiper to ground. Relay 212 acts as a vibrator in this circuit and steps the banks 200 to 208 step-by-step until they reach the contact C where ground is removed from the described vibrator circuit of the stepping magnet. At contact C, a circuit is completed at the dispatcher's office from ground through the wiper of bank 6 contact C to bank 7 through lower winding of relay 14, battery and ground. Energization of relay 14 closes its upper and lower armature and closes a circuit for relay 13 already traced.

Nothing additional necessarily occurs, however, at this time because relay 213 at the substation may be deenergized and the line L—2 still disconnected at the armature of relay 213. When the wipers 200 to 208 have reached the contact C, a circuit is completed from ground through battery to the wiper of bank 200 and the lower winding of relay 214 to ground.

Energization of relay 214 completes an energizing circuit for relay 213 as already traced. A circuit is now completed from ground at the dispatcher's office through battery through contact C, bank 7, its wiper over the armature of relay 13, line L—2, armature of relay 213, wiper of bank 207, its contact C, contact C of bank 205, its wiper over lines L—1, wiper of bank 5, contact C, and supervisory relay 170 to ground.

Energization of supervisory relay 170 indicates that the wipers are now again in synchronism since the circuit has been completed from ground at the supervisory station through contact C over the selecting supervisory trunk line through the contact C at the distant station on one bank, a similar contact on a second bank and over operating trunk line L—1 through a similar contact C on bank 5. An impulse circuit has therefore been completed from one station over one line through mechanism at the substation and back over the second line. The

circuit can only be completed when this mechanism is in synchronism. This indicates that there is no break or any open circuit over the lines just traced. The selectors are therefore in condition to repeat their stepping for the selection which was formerly attempted.

A circuit is completed by the energization of supervisory relay 170 from ground through its lower armature, the armature of magnet 12, slow-release relay 11 and back through battery to ground of the particular key which started the operation, as for example, key K—4, as it is assumed this was the original source that started the operation. Energization of relay 11 will complete a circuit for magnet 12 which prepares to step the banks 2 to 7. The deenergization of relay 12 will step the banks to their original normal position. The energization of relay 11 also completes an energizing circuit for the relay 211 in the manner described above, which, in turn, completes an energizing circuit for the stepping magnet 212 which is energized preparatory to moving switches to their normal first contact. Upon the deenergization of stepping magnet 212 these switches are restored to normal simultaneously with the restoration of the switches at the office. This cycle will now be repeated.

It should be noted in the operations just traced that, as the wipers step from one contact to the second, the checking relays 14 and 214 are deenergized and as a result disconnect the line from the sources of operating energy. These circuits are not closed until the wiper reaches the next contact and the circuit has been checked as correct whereupon relays 14 and 214 are energized and again close the circuits. This accomplishes further checking against false operation of any mechanism at the distant station should the selectors fall out of synchronism.

It may happen that the wiper at the dispatcher's office, falls two steps out of synchronism with the wipers at the distant station. Although such an operation is very unlikely, this would result in the false operation in the system just disclosed. An arrangement for preventing such an error is disclosed in the modified synchronizing scheme shown in Fig. 3. In this modified form, an extra bank 305 is used. The checking relays 14 and 214 Fig. 3 have two windings as shown and are alternately connected to the contacts except that every third contact remains disconnected. In the second bank every third contact is connected together and joined to the contacts on the first bank which are connected to the upper winding. At the distant station, the contacts on the second bank are connected to the upper winding.

As the wipers pass from contact 1 to contact 2, the circuits for energizing these

relays are the same as described in the original modification. As the wipers pass to the third contact, however, a local circuit is completed for energizing relay 14 from ground through battery through the third contact of the extra bank and upper winding of relay 14 to ground and an independent local circuit is completed for energizing relay 214 from ground, wiper and third contact of bank 306 and upper winding of relay 214 to battery and ground.

If the wiper at the dispatcher's office were at the third contact, while the wiper at the substation were on either contacts 2 or 4, a circuit would be completed for the relay 14 but relay 214 would have no circuit and would be deenergized opening the relay 213 as already explained, which in turn opens the supervisory trunk line L—2 and both mechanisms would return to normal position as already explained.

Should the brushes fall two steps out of synchronism, that is wiper at the dispatcher's office being on contact 3 with the wiper at the substation on contact 1, the relay 214 would fail to energize due to a break in the circuit at the wiper at the dispatcher's office. The selectors are then out of synchronism as explained before and will return into their normal position.

One of the novel features of my invention resides in the arrangement whereby the lines are duplexed by means of impedance coils and condensers shown in each of the lines L—1, L—2 and L—3. Direct-current impulses and alternating-current impulses may be transmitted over the line simultaneously by reason of the filter condensers through which only alternating-current impulses can pass and the filter impedance coils through which only direct currents can flow.

It often happens that a change in condition of a unit automatically occurs at the substation. It is understood, of course, that the circuit breakers are automatic as diagrammatically shown. When such a change takes place, it is desirable to immediately call the attention of the dispatcher to it. For this purpose, an alarm signal is connected to the first contact of bank 5 at the dispatcher's station. When, for example, circuit breaker C at the substation changes from its open position, as shown to its closed position, a circuit is closed from battery across the normally open contacts 260 winding of relay 255 to ground. Relay 255 energizes and forms a locking circuit for itself over armature 261. At armature 265, a circuit is completed from ground through battery armature 265 and its front contact, contact of bank 205, through its wiper over line L—1 bank 5 through the alarm device 50 to ground. The alarm signal will call the dispatcher's attention to the fact that some apparatus has changed its condition at the distant station. He can now operate his inspection key as already described

and by watching his supervisory lamps, determine which piece of apparatus has changed its condition. The other contacts shown in shunt with that made by the armature at relays 255 are those of analogous relays connected to other apparatus units. The bank contact for the alarm device, it should be noted, is placed on the first contact of the bank because the wiper is normally at this position and will immediately receive any alarm signal. Upon rotation of the wiper of bank 208 to contact A, the battery supply will be shunted from the relay 255 through contact A to ground causing the relay 255 to deenergize.

In Fig. 2, I have disclosed one means whereby changes and characteristics of the power lines, such as voltages and currents can be indicated at the dispatcher's office by causing the equivalent changes in a common generator. Another modification of this arrangement is disclosed in Fig. 4. In these arrangements, the meters have connected to them levers which cause changes in a resistor. These changes vary the current in the field circuit of the motor M through bank 401 and its wiper. Changes in the field current of the motor M changes its speed thereby changing the speed of rotation of the alternating current generator 405 connected to the same shaft. The change of speed of the alternator changes its frequency which thus varies in proportion to the change of the indication of the volt meter. At the receiving station, a frequency meter connected in the circuit as the meters shown in Fig. 1 is graduated to indicate volts or amperes according to the frequency.

Another modification of this same idea is disclosed in Fig. 5. The condensers 501 to 503 shown in this figure are in the oscillating circuit of the audion tube. Variations in voltage cause changes in the capacitance of the condenser 501 by means of the lever arm 504 shown and simultaneously change the frequency in the oscillating circuit. This frequency variation is then transmitted through the transformer over the line as described above. The details of this oscillator are described in Morecroft's "Principles of Radio Communication," Fig. 109, page 488.

It is often desirable to obtain the total value of any electrical characteristic such as the total current flowing in all the circuits at the sub-station. This operation is known as totalizing. A novel form of such totalizing system is disclosed in Figure 6, in which the instruments 800 to 803 measure any desired quantity such as current. Each of the instruments 800 to 803 controls an indicating lever arm 804 to 807 individual thereto which, in turn, controls the capacity-varying members such as plates on individual condensers 808 to 811 to vary their capacity in accordance with the meter readings, as is well un-

derstood by those skilled in the art. The condensers 808 to 811 are connected in an oscillating circuit 814 which is connected to the three-element tube 815. As is well known to those skilled in the art, variations in the capacity of the condensers 808 to 811 vary the tuning of the oscillating circuit 814 which, in turn, varies the frequency of the signals in line 816. These frequencies, which are a function of the totalized reading of meters 800 to 803 then operate remote, frequency-responsive devices in any well known manner.

In the foregoing description, I have disclosed my system as applied to an automatic supervisory control. The system, however, obviously may be applied to other than the particular arrangement made. My invention is not limited to the particular arrangement of the apparatus illustrated but may be variously modified without departing from the spirit and scope thereof as indicated in the appended claims.

I claim as my invention:

1. In an electrical system, two stations, apparatus units at both stations, conductors connecting said stations, means including a source of energy at said first station for transmitting electrical control signals over said conductors, step-by-step selector switches at each station connected to said conductors for simultaneously associating equivalent apparatus units at each station with each other over said conductors, stepping means individual to each switch for operating said switches, means controlled over one of said conductors for operating said switch stepping means at each station simultaneously whereby said switches are maintained in synchronism, electro-magnetic synchronism detecting means having circuit connections including said switches at each station and one of the conductors completed only when said switches are in synchronism, means responsive to the energization of said electro-magnetic synchronism detecting means for directly connecting said source of energy to said conductors, and means including said switches when in synchronism and said conductors whereby one of said apparatus units at one station controls the application of said energy to an associated apparatus unit at the other station.

2. In a supervisory control system, a first station, a second station, a source of energy at each station, a step-by-step switch at each station, each having a plurality of contacts and a wiper therefor, a line connecting said wipers, an electro-magnet at each of said stations comprising a first and second winding, means for connecting one terminal of the first winding at each station to all the odd contacts on the switches thereat, means for connecting one terminal of the second winding at each station to all the even contacts on said switches, means for connecting the sec-

ond terminal of the first winding at each station to the opposite terminals of said sources of energy and the second terminal of the second winding at each of said stations to opposite remaining terminals of said sources of energy, a circuit connecting corresponding terminals of each of the sources of energy, stepping magnets for each of said switches, electro-magnetic means at said first station for controlling the circuits to said stepping magnets at each station, means whereby said first mentioned electro-magnet at each station controls said electro-magnetic means thereat, and means controlled by said stepping magnet at said first station for controlling the operation of said first station electro-magnetic means, whereby said stepping magnet at each station is alternately energized and deenergized to operate said switches at each station from contact to contact in synchronism.

3. In a supervisory control system, a first station, a second station, a source of energy at each station, a step-by-step switch at each of said stations each having a plurality of contacts and a wiper therefor, a line connecting said wipers, an electro-magnet at each of said stations comprising a first and second winding, means for connecting one terminal of the first winding at each station to all the odd contacts on the switches and one terminal of the second winding at each station to all the even contacts on said switches, means for connecting the other terminal of the first winding at each station to the opposite terminals of the sources of energy and the other terminal of the second winding at each of said stations to opposite terminals of the sources of energy, a circuit connecting corresponding terminals of each of the sources of energy, stepping magnets for each of said switches, electro-magnetic means at said first station for controlling the circuits to said stepping magnets at each station, means whereby said first-mentioned electro-magnet at each station controls said electro-magnetic means thereat, means controlled by said stepping magnet at said first station for controlling the operation of said electro-magnetic means thereat whereby said stepping magnet at each station is alternately energized and deenergized and operates the switches from contact to contact in synchronism, apparatus units at said second station, operating means individual thereto at said first station, a source of energy at said first station connected to said operating means thereat, means including said source of energy and said switches whereby said operating means selectively controls said apparatus units, and means controlled by said first-mentioned electro-magnet for disconnecting said source of energy from said operating means when said switches are out of synchronism.

4. In a supervisory control system, a first

station, a second station, a source of energy at each station, step-by-step switches at each station, each having contacts and wipers therefor, electro-magnetic means at each of said stations comprising a first and second winding, means for connecting one terminal of the first winding at each station to the odd numbered contacts on the switch thereat and one terminal of the second winding at each station to the even numbered contacts on the switch thereat, means for connecting the opposite terminal of the first-mentioned winding at each station to opposite terminals of the sources of energy and the opposite terminal of the second windings to opposite terminals of the sources of energy, a circuit connecting corresponding terminals of the sources of energy, a signalling line connecting said switch wipers whereby said electro-magnetic means at each of said stations are maintained energized while said switches are in synchronism, a stepping magnet at each of said stations for stepping the wipers thereat, an electro-magnet at said first station for controlling the circuit to said stepping magnet at said first station, an electro-magnet at said second station for controlling the circuit to said stepping magnet at said second station, and means controlled by said first mentioned electro-magnetic means at each of said stations for controlling the circuits to said second mentioned stepping magnet controlling electro-magnets while said first mentioned electro-magnets are energized.

5. In a supervisory control system, a first station, a second station, a step-by-step switch with a number of contacts and wipers therefor and a source of energy at each of said stations, electro-magnetic means at each of said stations comprising a first and second winding, means for connecting one terminal of the first winding at each station to the odd-numbered contacts on said switch and one terminal of the second winding at each station to the even-numbered contacts on said switch, means for connecting the opposite terminal of the first mentioned winding at each station to opposite terminals of the sources of energy and the opposite terminal of the second winding to opposite terminals of battery, a circuit connecting corresponding terminals of the sources of energy, a signalling line connecting said switches whereby said electro-magnetic means at each of said stations are maintained energized while said switches are in synchronism, a stepping magnet at each of said stations, an electro-magnet at said first station for controlling the circuit to said stepping magnet at each of said stations, an electro-magnet at said second station for controlling the circuit to said stepping magnet at said second station and means controlled by said first mentioned electro-magnetic means at said station for controlling the circuits to said stepping mag-

net controlling electro-magnets while said first mentioned electro-magnets are energized, apparatus units at said second station, operating means individual thereto at said first station, a source of energy at said first station connected to said operating means, means including said operating means said last mentioned source of energy and said switches for selectively operating said apparatus units at said second station, and means controlled by said first mentioned electro-magnetic means for disconnecting said energy source from said operating means when said switches are out of synchronism.

6. In a supervisory control system, a first station, a second station, a source of energy at each station, a step-by-step switch at each of said stations, a first relay winding one terminal of which is connected to alternate contacts of said step-by-step switch at said first station, a second relay winding one terminal of which is connected to the remaining alternate contacts on said switch at said first station, a first relay winding, one terminal of which is connected to alternate contacts on said switch at said second station and a second relay winding at said second station one terminal of which is connected to the remaining alternate contacts on said switch, means for connecting the opposite terminal of the first winding at each of said stations to opposite terminals of sources of energy thereat and the opposite terminals of the second winding at each of said stations to opposite terminals of the source of energy thereat, a circuit connecting corresponding terminals of the sources of energy, a signalling line connecting said switches, a stepping magnet individual to each of said switches and means controlled by said windings at each station for controlling the circuits to said stepping magnet at each of said stations, and means controlled by said first and second relay at said first station for controlling the application of said source of energy to said line.

7. In a supervisory control system, a first station, a second station, a source of energy at each station, a step-by-step switch at each of said stations, a line connecting said switches, an electro-magnet at each of said stations comprising a first and second winding, means for connecting one terminal of the first winding at each station to all the odd contacts on the switches and one terminal of the second winding to all the even contacts on said switches, means for connecting the opposite terminals of the sources of energy and the opposite terminals of the second winding at each of said stations to opposite terminals of the sources of energy, a circuit connection between said sources of energy, stepping magnets for each of said switches, electro-magnetic means at each station for controlling the circuits of said step-

ping magnets, means whereby the electro-magnetic means at said first station controls the operation of said second station electro-magnetic means, and means whereby said first station stepping magnet controls the circuit of said first station electro-magnetic means, whereby the stepping magnets are alternately energized and deenergized to operate the switches step-by-step in synchronism.

In testimony whereof, I have hereunto subscribed my name this tenth day of November, 1925.

JUDSON O. SHEPHERD.