

July 14, 1931.

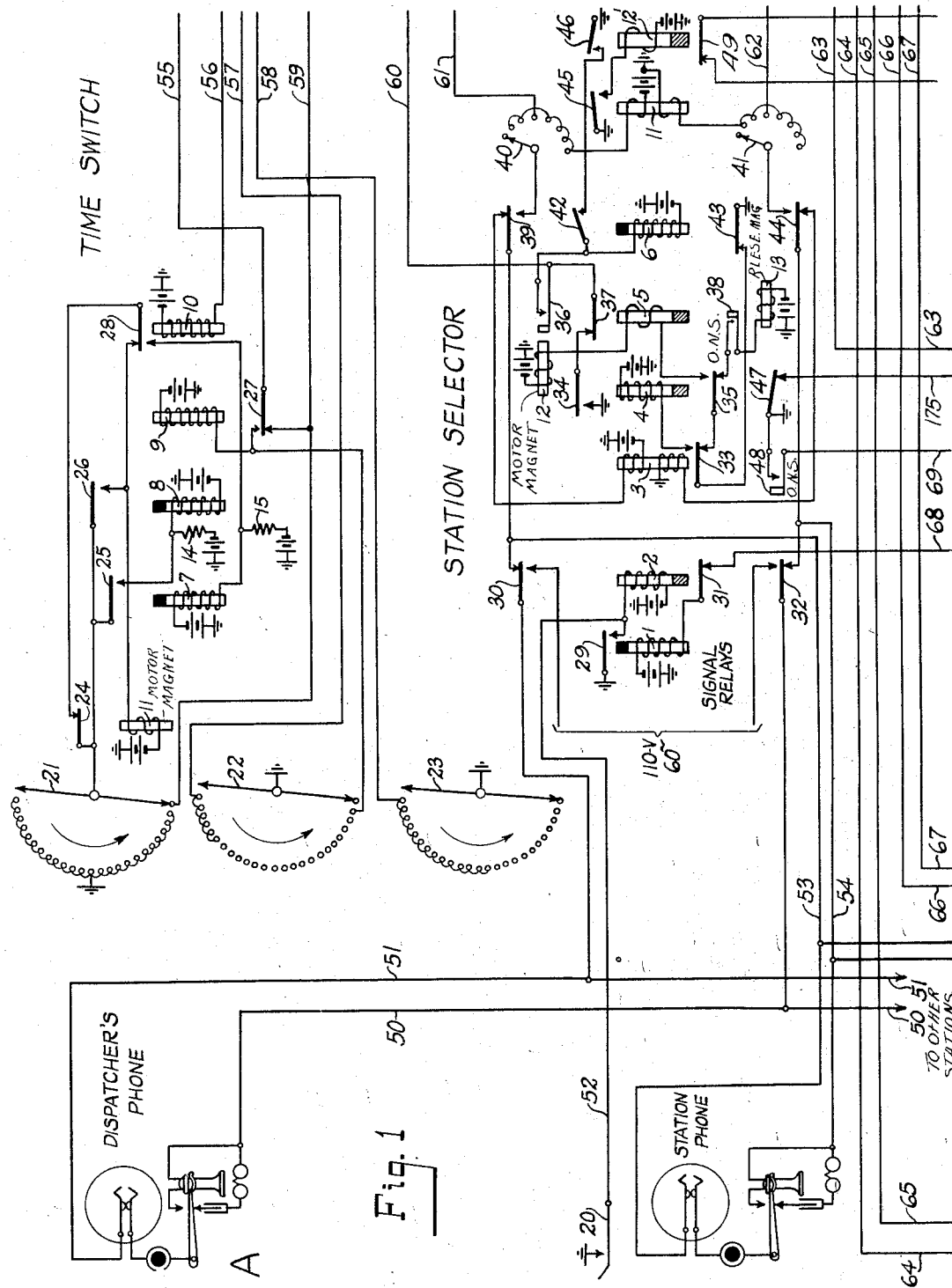
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1,814,524

REMOTE CONTROL SYSTEM

Filed Aug. 3, 1927

4 Sheets-Sheet, 1



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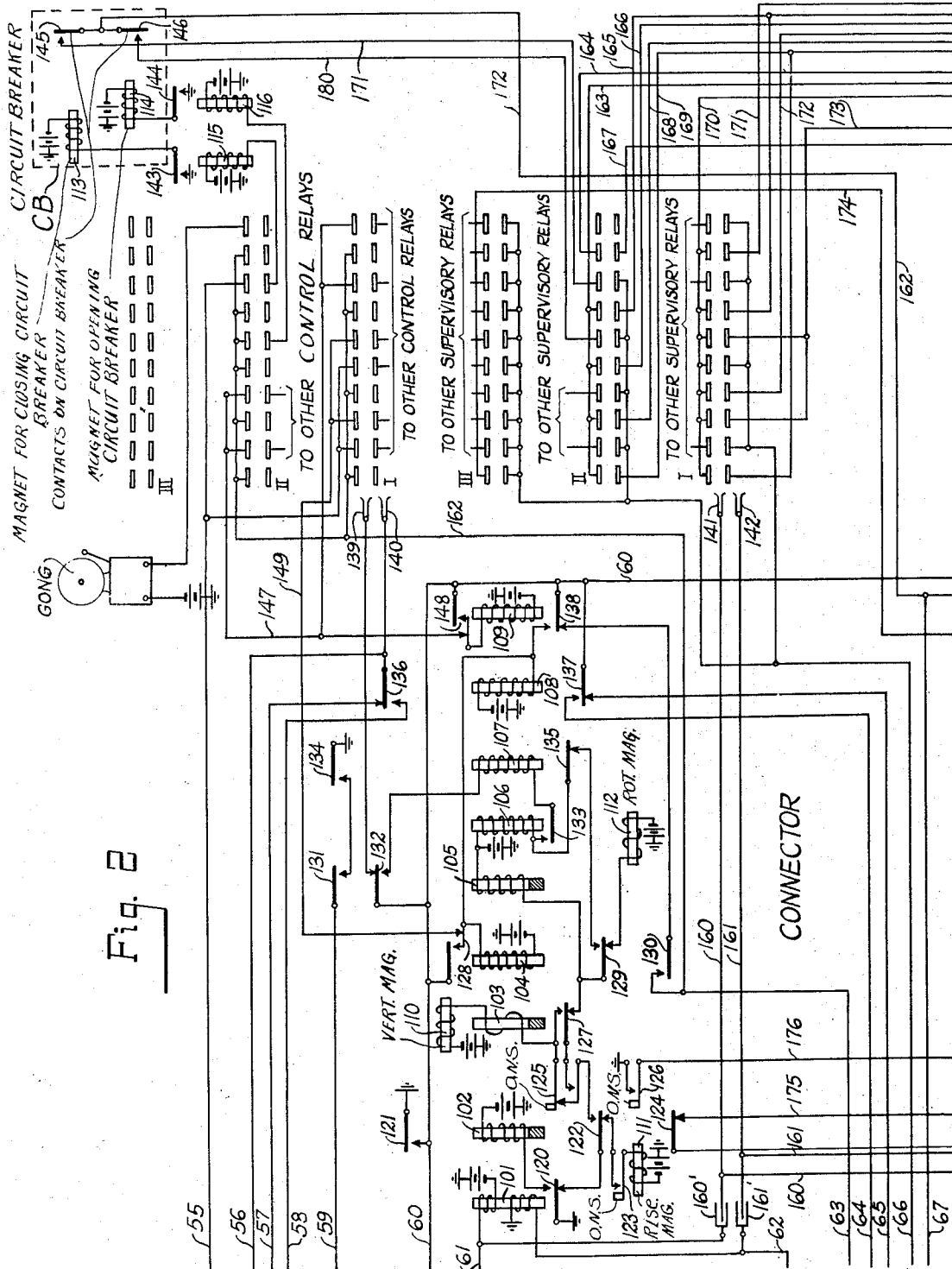
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REMOTE CONTROL SYSTEM

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4 Sheets-Sheet. 2



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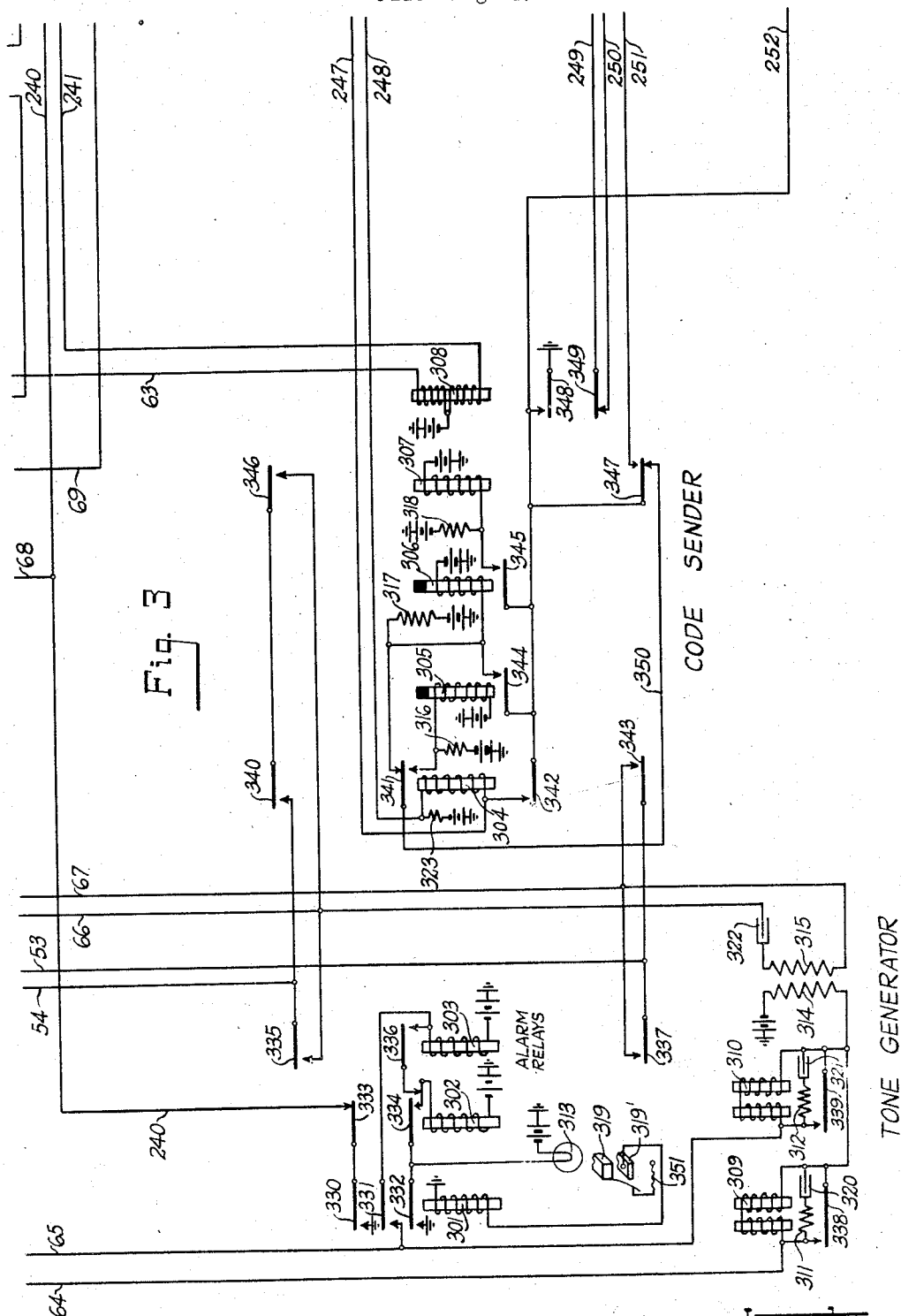
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4 Sheets-Sheet. 3



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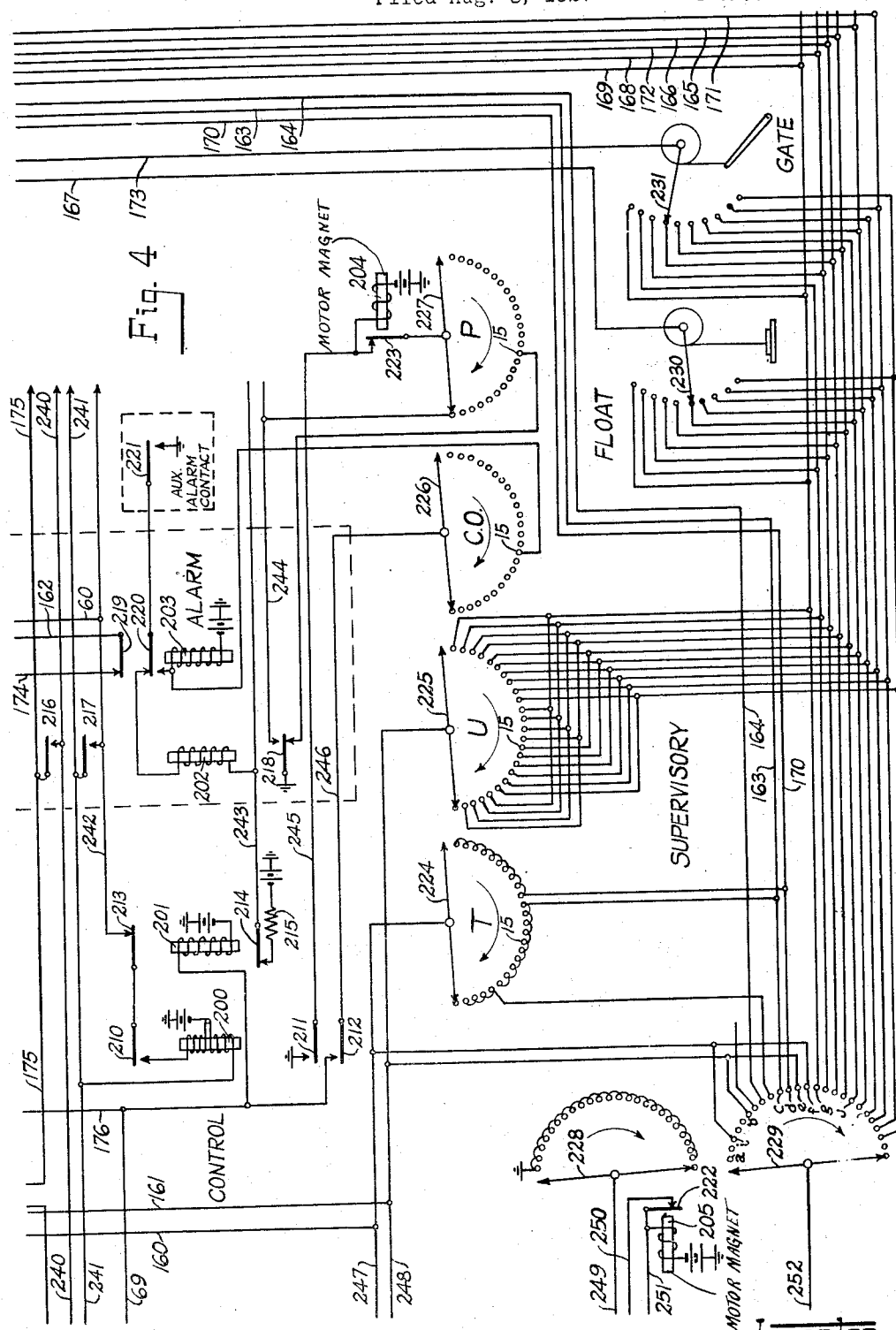
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1,814,524

REMOTE CONTROL SYSTEM

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4 Sheets-Sheet. 4



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UNITED STATES PATENT OFFICE

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REMOTE CONTROL SYSTEM

Application filed August 3, 1927. Serial No. 210,241.

This invention relates in general to remote control systems, more particularly to such systems in which a plurality of power switching devices are selected and operated from a remote point by impulses transmitted over a trunk line to the station containing the devices, and the principal object of the invention, briefly stated, is the provision of a new and improved remote control system, the improvements tending to make the system more reliable in its functioning.

A further object of the invention is to provide a new and improved remote control system of the audible type, that is one in which the position of the switch selecting device is indicated by means of an audible signal, as are the positions of the various switching devices also indicated by audible signals.

A further object of the invention is the provision of a remote control system of the so called tandem type, that is a system in which a plurality of substations are controlled and supervised over a trunk line extending from the dispatcher's office to the various stations, the selecting mechanisms at the stations being connected across the trunk line in multiple with one another.

A further object of the invention is to provide a new and improved audible type supervisory system, in which the change of position of a circuit breaker in one of the substations signals the dispatcher's station, and upon the dispatcher's response to that signal, the code sending machine at the substation containing the device which changed position, will operate to send a code of signals over the trunk line to the dispatcher. This code of signals informs the dispatcher the station containing the device which changed position, the device number, and the change made, that is whether or not the device opened or closed itself.

A further object of the invention is to provide a new and improved telemetering system, in which the position of indicating device at the substation, such as a water level meter or the like, can be ascertained at the dispatcher's office by means of an audible signal transmitted from the code switch at the substation.

Further objects not specifically mentioned here will be best understood from the detailed description and claims which follow.

The drawings comprising Figs. 1 to 4 inclusive, when arranged with Fig. 2 to the right of Fig. 1, Fig. 3 underneath Fig. 1 and Fig. 4 underneath Fig. 2, with corresponding lines in alignment, show sufficient details of the system to enable a clear understanding of it.

Referring to Fig. 1 now in more detail, I show a dispatcher's station comprising the telephone A and connected to the substations by the trunk conductors 50 and 51. The dispatcher's telephone may be any well known automatic telephone, provided with the usual talking instrumentalities and in addition a calling device through the manipulation of which trains of impulses are transmitted over the trunk to the switches at the various substations. The trunk conductors terminate in the station selectors, one of which is shown in Fig. 1. A station selector at each of the substations is bridged across the trunk. In order to avoid an unnecessary complication of the drawings only one substation is pictured, the station selector being shown in Fig. 1. The equipment shown in the drawings is duplicated in each of the substations. In Fig. 1, I also show the station telephone, which is a duplicate of the dispatcher's telephone referred to above. To the right and at the upper part of Fig. 1 I show a time switch, comprising a step by step switching mechanism containing wipers 21 to 23 inclusive, motor magnet 11, and the relays 7 to 10 inclusive. The operation and purpose of this time switch will be best understood from the detailed description which follows hereinafter. The station selector, comprising relays 1 to 6 inclusive and the switching element containing wipers 40 and 41, operates in response to the first series of impulses sent out by the dispatcher's station, to select the equipment at one of the substations on the trunk line. The transmission of one digit, 3 for example, will select one substation, although all of the station selectors on the trunk will be operated. The wipers of the station selector in the substation which is selected by the digit

3 will encounter trunk lines leading to the connector switch in that station, and the wipers of the other station switches will encounter contacts leading to a holding bridge.

5 The switch mechanism of the station selector, comprising wipers 40 and 41, magnet 12, and magnet 13, may be a so called "minor switch" as is used in automatic telephone systems, and shown in Fig. 82 on page 94 of the book "Automatic Telephony" by Smith and

10 Campbell, a publication of the McGraw Hill Book Company. This minor switch, has a group of wipers which are moved in one plane by impulses transmitted to the driving magnet.

15 If for example, the digit 3 is dialled into the switch the wipers will be moved 3 steps to the third bank contact set, and will remain in that position until the release magnet is energized to withdraw a holding pawl

20 from the wiper assembly. When the pawl is withdrawn, the wipers are restored to their normal position by means of a spring. The particular minor switch shown in the figure referred to above, is equipped with six contacts in the rows over which the wipers sweep,

25 this switch responding to not more than six impulses. This minor switch may also be constructed for a somewhat larger capacity, that is, the wipers may have access to as many as ten contacts if it is desired that they should.

30 The time switch mechanism comprising wipers 21 to 23 and magnet 11, may be the well known rotary line switch, employed in automatic telephone systems. A switch of

35 this type is shown in Fig. 48 on page 51 of the above referred to book, the mechanism and circuit of the switch being explained in detail in the paragraph entitled Rotary line switch, beginning at the top of page 51. In

40 the preferred embodiment of the switch, the wipers are double ended, have no normal position, and move over an arc containing 25 contacts. The armature arrangement of the driving magnet 11 is such that the wipers

45 are advanced when the magnet deenergizes rather than when the magnet energizes.

In Fig. 2 I show a connector switch, through the operation of which the various devices at the substation are selected and

50 operated. This switch comprising relays 101 to 109 inclusive and wipers 139 to 142 inclusive may be the well known Strowger connector switch, such as is employed in automatic telephone systems and shown in Fig.

55 50 on page 53 of the above referred to book. The wipers of the switch are moved in two planes, first in a vertical plane to select the level and then in a horizontal plane to select a contact in that level. The wipers have

60 access to a bank of contacts, usually consisting of ten levels, with ten contact sets in each level. By positioning the wipers of this switch upon a particular set of contacts, a particular device, such as the circuit breaker

CB, is selected and operated, the details of the operation being explained hereinafter.

In Fig. 3 I show a code sender, a group of alarm relays, and a tone generator. The code sender comprises in addition to the relays 304 to 308 shown in Fig. 3, switch mechanism comprising wipers 228 and 229 shown in Fig. 4, this switch mechanism being operated in response to the positioning of the wipers of the connector upon the particular set of contacts to transmit a code of impulses back over the trunk line to the dispatcher's telephone, to apprise him of the exact location of the switch wipers. This code will consist of three sets of impulses, the first indicative of the station which he has selected, the second indicative of the level upon which the connector switch has been set, and the third indicative of the particular contact set in that level.

In Fig. 4 I show a supervisory switch comprising wipers 224 to 227 inclusive which are driven by the magnet 204. The control relays for this switch comprise relays 200 and 201. I also show alarm relays 202 and 203, which are a pair of relays individual to one of the devices or functions of that device which is to be supervised by the equipment. When the device associated with relays 202 and 203 changes its position, those relays are energized to control the supervisory switch, which is operated to position its wipers upon the bank contact set assigned to that particular device. Positioning of the wipers of the supervisory switch arranges the code sender to send a code of impulses indicative of the device which changed its position. In Fig. 4 I also show a float controlled switch and a gate controlled switch, those switches being operated by their respective devices to arrange the code sender to transmit a code of impulses indicating the position of the devices.

Having thus described my invention in general, I will now describe its operation.

Throughout the drawings I have shown a plurality of batteries, whereas in an installation of the invention shown, there would be but one battery in each substation, preferably with its positive pole grounded.

As pointed out above, the connector switch at the substation is a 100 point switch, that is, its wipers are moved in a vertical direction over ten levels of contacts each of which contains ten contact sets. With a switch of this kind it is possible to control a large number of switching devices. However, an audible type system such as is shown in the present disclosure, is best suited for the control of a smaller number of units. The drawings, which are made by way of example only, show the system arranged to control not more than 25 switching functions. The wiper sets of the conductor, are normally spaced ten steps apart, so that each wiper has access to

a bank of 100 contact sets, as can easily be seen in the Fig. 50 on page 53 of the above referred to book. However, in the present instance it is not necessary that the wipers have access to 100 contact sets, and therefore the wipers 139 and 140 are spaced five steps away from the wipers 141 and 142, and both wipers engage contacts in the one bank assembly. By this arrangement when the switch is at normal, wipers 141 and 142 rest one step below the first or lower most level of the bank, and wipers 139 and 140 when at normal rest opposite the fifth level of the bank. If the switch is stepped up one step, wiper set containing wipers 141 and 142 stand opposite the first level, and wipers 139 and 140 stand opposite the sixth level of the bank. By this arrangement it will be seen that each of the wiper sets has access to 50 contacts, that is five levels of ten contact sets each.

As is pointed out above, the connector shown in Fig. 2 is reached through the third contact set of the station selector shown in Fig. 1, so that in order to control the switching devices in the substation pictured in the drawings, the dispatcher must first dial the digit 3, to select the particular substation. Assume now that the dispatcher desires to close the circuit breaker CB, he will remove the receiver from the switch hook of the telephone A, and manipulate the calling device to transmit the digit 3. The station selectors are stepped around three steps, at the end of which wipers 40 and 41 encounter conductors 61 and 62, leading to the connector. The wipers of the other station selectors on the trunk lines 50 and 51 have also been moved three steps to the third contact set, which is connected to a holding bridge, the purpose of which will be pointed out hereinafter.

In the selected substation, at the end of the dialling of the digit 3, the switch through relay 6 energizes and connects the trunk conductors 50 and 51 through to the connector switch over conductors 61 and 62 respectively. The line relay of the connector switch is energized, closing a circuit for the release relay, which energizes and returns a ground potential over the release trunk conductor to hold the station selector in its operated position by maintaining the relay 6 energized. Since it is assumed that the dispatcher desires to close the circuit breaker CB, he will next dial the digit 2, responsive to which line relay of the connector will be energized momentarily to close the circuit to the vertical magnet, which operates to elevate the wipers two steps, bringing them to rest opposite the second level, that is the level in which the contacts through which CB is closed are located. The dispatcher next dials the digit 7 responsive to which the line relay falls back and closes a circuit to the rotary magnet, which operates to rotate the wipers

into the second level, bringing them to rest upon the seventh contact in that level.

When the wipers are brought to rest on the seventh contact set in the second level, the code sender is started, operated to send out digits 3—2—7, which are audible to the dispatcher and inform him that the wipers of the connector switch in the substation 3 are located upon the 27th contact set, that is up two and in seven steps. The dispatcher upon hearing the code signal, may continue with the operation started, may abandon it, or may wait for a repetition of the signal. If the dispatcher waits, code sender will repeat the same code, continuing to do so until the dispatcher performs another operation, that is either hangs up or reoperates his calling device to continue the control which he has started. Assume that the digits 3—2—7 are received correctly, and that the 27th contact set is the one which the dispatcher desired to select, he will then proceed to operate the circuit breaker CB. To do this the dispatcher operates his calling device to transmit an additional impulse. Responsive to the receipt of the additional impulse, the wipers of the connector are stepped over one step onto the eighth contact set in the second level, that is the 28th contact set. In this position the wipers prepare a circuit to the auxiliary relay, through the operation of which the circuit breaker is closed. The time switch is started and closes the prepared circuit to the auxiliary relay for a definite interval of time. The auxiliary relay operates, closing the circuit to the magnet of the circuit breaker which closes the breaker. As soon as the time interval elapses, the time switch opens the circuit of the auxiliary relay, permitting that relay to deenergize and open the circuit of the operating magnet of the circuit breaker, however, if the circuit closed is in proper condition the circuit breaker will be held closed by the usual mechanical latching device on the breaker. If, however, the circuit closed by the circuit breaker is faulty and the current flowing through the breaker is excessive, the automatic release becomes effective as soon as the time switch opens the circuit of the auxiliary relay, permitting the circuit breaker to open and clear itself from the faulty circuit. As soon as the auxiliary relay is operated and the circuit breaker closes, the dispatcher is apprised of the closure of the breaker by a steady tone transmitted back to him through auxiliary contacts on the circuit breaker.

Having completed the operation he set out to do, the dispatcher then hangs up his receiver and the connector switch, the time switch, the station selectors, and the code sender are restored to their normal positions under control of local circuits.

The interval of time during which the auxiliary relay associated with the selected con-

tact set remains energized, is dependent upon the setting of the time switch. If the function to be performed is one requiring a relatively long period of time, such as for example the opening of a gate to a turbine in a hydro electric station, a different set of wipers on the time switch is brought into use, and the interval during which the auxiliary relay remains energized is relatively longer. The details of this operation will be best understood from the detailed description which follows hereinafter.

Assume now that a circuit breaker in one of the substations automatically opens, responsive to an abnormal condition upon the circuit controlled by it. Associated with each circuit breaker is a set of alarm relays, one of which is energized when the circuit breaker opens. The energization of this alarm relay starts the supervisory switch of the substation, operating that switch to position its wipers upon the contact set associated with the alarm relay. The positioning of the supervisory switch on this contact set, arranges the code sender to send in a code indicating which circuit breaker has opened. When the supervisory switch is positioned upon this contact set, the code sender is made ready to transmit the code, and the signal relay associated with the station selectors is operated to transmit ranging current over the trunk, to ring the bells of the dispatcher's telephone. The dispatcher upon hearing the signal, removes his receiver, whereupon the code sender is started to transmit the selected code together with the code indicating the substation in which the circuit breaker is located. If the dispatcher hears the signal the first time the code is sent he may hang up and proceed to take whatever steps he deems necessary to correct the trouble condition. If, however, he fails to hear the code, he can wait and the code will be repeated indefinitely until he performs a further act to stop it.

Each of the substations upon the trunk line is provided with protective fuses to protect the equipment from damage. If one of these fuses blows, an alarm signal is brought in, to the alarm relays, which energize to close a circuit to the signal relays to operate them, to apply ringing current to the trunk line to signal the dispatcher. The dispatcher upon hearing the signal removes his receiver and hears a steady tone indicating a blown fuse.

In case that the dispatcher desires to know the position of any device in the substation, he may dial a number selecting that device, responsive to the positioning of the wipers upon the desired contact set, he hears a tone which apprises him of the open or closed condition of the device being supervised. If the dispatcher desires to know the height of the water in the forebay of a hydro electro plant,

he dials a number assigned to that function, whereupon the code switch is operated under the control of a float controlled wiper, sending in a code of impulses indicative of the height of the water in the bay. Similarly by dialling a different number, the dispatcher may supervise the position of the gate leading to the turbine of the hydro electric station, here again receiving a code indicating the position of the gate. In these two supervisions, the total range covered by the water in the fore bay or the gate opening is divided into ten equal parts, and the code is a number somewhere between 1 and 10, for example if the code 5 was received it would indicate that the water in the forebay stood at $\frac{5}{10}$ of its maximum depth, or if the gate was being supervised and the code 5 was received it would indicate that the gate was $\frac{5}{10}$ open.

Remotely controlled substations of the kind shown in the drawings are frequently visited by an inspector who checks over the apparatus to see that it is in proper condition. It may happen that the inspector desires to converse with the dispatcher relative to conditions at the substation, and to do this the station telephone is employed. The inspector to signal the dispatcher operates the push button key associated with the telephone, whereupon the signal relays are operated to momentarily transmit signalling current over the trunk line to the dispatcher's telephone. The dispatcher answers the signal, and the inspector at the substation removes his receiver to talk to the dispatcher. The transmitters of both telephones receive battery supply from the line relay of the station selector, and upon the completion of the conversation both receivers are restored and all equipment is in its normal position.

If the dispatcher, knowing that the inspector is at a particular substation, desires to converse with the inspector, he may signal him by dialling a three digit number set aside for the purpose, there being a number of this kind for each substation on the trunk. Responsive to the dialling of this digit, the wipers of the connector are elevated and rotated to a particular contact set, from which the station gong is rung. The dispatcher replaces his receiver momentarily to release the switch train to stop the gong. The inspector upon hearing the gong removes the receiver from the telephone and carries on his conversation with the dispatcher.

Having thus described my invention in general I will now proceed with a detailed description of its operation.

Dispatcher closes the circuit breaker CB

Assume now that the dispatcher desires to close the circuit breaker CB, which is located in the substation No. 3. He removes the receiver from the switch hook of the telephone A, closing a circuit traceable from

ground through the lower winding of the line relay 3 of the station selector, through spring 44 and its break contact, spring 32 and its break contact, trunk conductor 50, through the receiver, switch hook, transmitter and calling device of the telephone A, trunk conductor 51, spring 30 and its break contact, spring 39 and its break contact, through the upper winding of the relay 3 to battery. In multiple with line relay 3, are the line relays of the other station selectors, which are bridged across the trunk in identically the same manner as the line relay 3. These line relays energize over this circuit, the line relay 3 closing the circuit for the release relay 4, which is traceable from ground through springs 43, spring 33 and its make contact, through the winding of the relay 4 to battery. Relay 4 energizes over this circuit, and at springs 34 places ground on release trunk conductor 60, for purposes which will be brought out hereinafter. At springs 35, relay 4 prepares a point in the impulsing circuit. At springs 47, relay 4 removes ground from conductor 175 and armature 216 for preventing the transmission of alarm signals when the trunk line 50—51 is in use. The dispatcher next manipulates the calling device of his telephone, to transmit the digit 3, since the circuit breaker that he desires to close is located in substation No. 3. The operation of the calling device, momentarily opens the circuit between trunk conductors 50 and 51, thereby opening the circuit of the line relays bridged across the trunk. Line relay 3 falls back, opening the circuit of the release relay 4. However, the release relay 4 is equipped with a copper slug on its core, making it slow to release, so that during the operation of the calling device the relay remain in its energized position. Relay 3 falls back, closing a circuit for the motor magnet 12, that circuit being traced from ground at spring 43, through spring 33 and its break contact, spring 35 and its make contacts, through the winding of series relay 5, through the winding of the motor magnet to battery. The motor magnet energizes over the circuit, advancing the wipers 40 and 41 one step. When the calling device again closes the circuit across the trunk conductors, relay 3 re-energizes, opening the circuit of the motor magnet 12, permitting that magnet to deenergize preparatory to taking another step. The wipers are retained in their first position by means of a detent shown and explained in the above referred to text. Series relay 5, being slow to release, does not immediately fall back, in fact remains in its energized position throughout the transmission of impulses to the magnet 12. Since the dispatcher has dialled the digit 3, the line relay 3 will receive three interruptions, transmitting three impulses to the magnet 12 to position the wipers 40 and 41 upon the third bank contact set, that is the contact to which the conductors 61 and 62 are connected.

When the calling device has restored to normal, the dispatcher manipulates it preparatory to transmitting the second digit, during which manipulation the line relay 3 of the station selector comes to rest energized. The circuit of the relay 5 and the magnet 12 is therefore opened, and the relay 5 deenergizes, closing at springs 37 a circuit for the switch through relay 6, traceable from ground through springs 34, springs 37, off normal springs 36, which were closed upon the first step taken by the wipers 40 and 41, through the winding of the relay 6 to battery. Relay 6 energizes over this circuit, at springs 39 and 44 connects the trunk conductors 50 and 51 through the wipers 40 and 41 to the conductors 61 and 62. Relay 101 of the connector energizes over the circuit traceable from ground through the lower winding of that relay, conductor 62, wiper 41, spring 44 and its make contact, spring 32 and its break contact, trunk conductor 50, through the telephone to trunk conductor 51, spring 30 and its break contact, spring 39 and its make contact, wiper 40, conductor 61, through the upper winding of the relay 101 to battery. The energization of relay 6 opens at springs 39 and 44 the circuit of relay 3 of the station selector, permitting that relay to deenergize and open the circuit of relay 4. Relay 4 deenergizes, the deenergization of relays 3 and 4 prepares points in the circuit of the release magnet 13. However, release magnet 13 is not operated at this time because its circuit is held open by springs 43 of the relay 6, thereby insuring that the station selector will remain in its operated position as long as the relay 6 remains energized.

The energization of relay 101 of the connector closes a circuit for the release relay 102, which energizes and at springs 121 places a ground upon the release trunk conductor 60, that ground completing a circuit through the relay 6 of the station selector, to maintain that relay energized as long as the dispatcher's telephone receiver is off of the switch hook. The dispatcher having dialled the digit 3, all of the station selectors on the trunks 50 and 51 will be moved up to their third position. Only the station selector shown in Fig. 1, which is assumed to be the substation No. 3, will encounter contact set to which a connector is connected. The remaining selectors will encounter a holding bridge, closed through in the following manner. It will be noted that in the Fig. 1, all of the contacts over which wiper 40 is connected, except the third, are multiplied and connected through the upper winding of the relay 11. It will also be noted that all of the contacts except the third of the bank over which wiper 41 rotates are multiplied and

connected to the lower winding of the relay 11. In the other substations, the third bank contact is in this multiple, and the conductors such as 61 and 62 are connected to one of the other contacts. Consequently the other station selectors in assuming the position three close a circuit for the relay 11, energizing that relay. The energization of the relay 11 closes a circuit through springs 45, through the winding of relay 12', to battery, for energizing the relay 12'. Relay 12' at spring 46 closes circuit from ground to springs 42 of the relay 6, so that when the relay energizes it closes a circuit through the make contacts 46, springs 42 through the winding of relay 6, to battery, maintaining relay 6 energized. Thus it will be seen that in the selected substation the dialling of the digit 3 closes a circuit through to the connector switch of that substation, and in the remaining substations on the trunk dialling of the digit 3 closes the circuit of the holding bridge, in both cases the switching relay 6 of the station selector is maintained energized by a ground put on a return conductor by a slow acting relay, so that the relay 6 will remain energized as long as the dispatcher's receiver is off of its switch hook.

Connector operation

Returning now to the operation of the connector in the substation 3, the dispatcher next dials the digit 2. In dialling this digit, the circuit of the relay 101 is momentarily opened two times, closing the circuit from ground through spring 120 and its break contact, spring 122 and its make contact, the relay 102 being slow to release remains in its operated position, although its circuit is opened at springs 120, off normal spring 125 and its break contact, through the winding of slow acting relay 103, through the winding of the vertical magnet 110 to battery. The vertical magnet energizes over this circuit, elevating the shaft, not shown, containing wipers 139 to 142 inclusive, one vertical step. Upon the operation of the shaft, off normal spring 125 operates, closing a circuit for the vertical magnet through spring 125 and its make contact, through spring 127 of the series relay 103, thence through the series relay and the magnet 110 to battery. Upon the first operation of the shaft, off normal springs 126 close to place a ground on conductor 176, thereby energizing relay 201. Relay 201 opens springs 213, 214, to prevent the operation of the automatic supervisory apparatus at this time. This operation will be explained in detail hereinafter. When the relay 101 again energizes, magnet 110 deenergizes, but the series relay 103 remains in its energized position. The next impulse traverses the circuit just traced through off normal spring 125 and its make contact and the spring 127,

thence through the circuit to the magnet 110, to energize that magnet to advance the switch wipers another step vertically. After the second impulse has been transmitted the relay 101 comes to rest energized, opening the circuit of the relay 103 for a sufficiently long interval of time to permit that relay to deenergize.

The dispatcher now manipulates his calling device to transmit the digit 7, the last digit of the call number of the circuit breaker CB, this manipulation momentarily opening the circuit of the relay 101 seven times. Each time the circuit of relay 101 is open it falls back, transmitting an impulse of current to the rotary magnet and to the relay 105 in multiple, that circuit including spring 120 and its break contact, springs 122 and its make contact, off normal spring 125 and its make contact, spring 127 and its break contact, thence over parallel paths, the one through the winding of the relay 105 to battery, the other through spring 129 and its break contact, through the winding of the rotary magnet 112 to battery. Relay 105 energizes upon the first impulse and remains energized throughout the series of seven impulses. Rotary magnet 112 energizes upon each impulse, each energization advancing the wipers one step in a rotary direction. At the end of the seventh impulse, the wipers are resting up on the 27th contact set of the bank of the connector, from which position they prepare to control the circuit breaker CB.

Check code

Before proceeding further with the control of the circuit breaker CB, the dispatcher is apprised of the exact location of the wipers of the connector switch by a code of signals, which he hears in his telephone receiver. Shortly after the last rotary impulse has been transmitted to the magnet 112, relay 105 restores, closing a circuit from grounded release trunk conductor 60, through spring 132 and its break contact, wiper 139, now engaging the seventh contact of the second level of its bank, conductor 162, conductor 63, through the upper winding of relay 308 to battery. Relay 308 energizes over this circuit, operates springs 349 to disconnect the motor magnet 205 of the code sending switch from the wiper 228, for a purpose which will be apparent hereinafter. At springs 348, relay 308 closes a circuit from ground to conductor 252, thence over two paths, one to the wiper 229 of the code switch, for a purpose which will be explained later, and the other through spring 347 and its break contact, conductor 350, spring 341 and its break contact, thence over parallel paths one through the resistance 317 to battery, the other through relay 306 to battery. Relay 306 energizes over this

circuit, and at springs 345 closes a circuit from grounded conductor 252 through parallel paths, the one through resistance 318 to battery and the other through relay 307 to battery. Relay 307 energizes, and at springs 347 opens the initial circuit of relay 306, however, relay 306 does not deenergize immediately because it is made slow acting by a copper slug placed upon its core. At spring 347 and its make contact, relay 307 closes a circuit from grounded conductor 252, conductor 251, through the winding of motor magnet 205 of the code stepping switch to battery, energizing that magnet preparatory to advancing the wipers of the switch one step. After a brief interval, relay 306 falls back, opening a circuit of relay 307 which falls back immediately, opening the circuit of the motor magnet 205, and reestablishing the circuit of relay 306. As magnet 205 deenergizes, the wipers of the code switch are stepped ahead one step, without particular effect at this time. The reenergization of relay 306 restarts the above cycle of operation resulting in the energization of relay 307 and the magnet 205, this interaction of the relays and magnets continuing in the same manner until the wiper 229 encounters the contact *i*. When wiper 229 encounters contact *i*, a circuit is closed from ground conductor 252, through that wiper and contact to the conductor 247, thence through the winding of relay 304, through resistance 323 to battery, energizing the relay 304 which locks itself to grounded conductor 252 through springs 342, independent of the wiper 229. The energization of relay 304 closes a circuit from the tone generator, to the trunk line 51, so that the tone is audible to the dispatcher every time the code stepping switch takes a step. This tone traverses a circuit from the upper terminal of the winding 315 of the tone generator, through condenser 322, through springs 346, which are closed when the relay 307 is energized, through springs 340, conductor 54, spring 32 and its break contact, trunk conductor 50, through the receiver, transmitter and calling device of the dispatcher's telephone A, conductor 51, spring 30 and its break contact, conductor 53, spring 343 and its make contact, conductor 67, to the lower terminal of the tone generator winding 315. The tone is induced in the winding 315 by transformer action, from pulsating current in the winding 314, that winding becoming energized when the connector was taken into use and release trunk conductor 60 grounded, over circuit from that conductor through spring 137 and its break contact, conductor 63, through the winding of buzzer 310, through the winding 314 of the tone generator transformer, to battery. Buzzer 310 energizes over this circuit and at spring 339 places a short circuit

around itself. Armature 339 is released after an interval, removing the short circuit from the winding 310 which again energizes. Thus it will be seen that the buzzer 310 will operate to cause a variation in the flow of current through the winding 314, that current increasing when the winding of buzzer 310 is short circuited and decreasing when it is not short circuited. The variation of current through the winding 314 produces an alternating current of corresponding frequency in the winding 315.

As is pointed out before, the relay 307 of the code sender is energized on each step of the sender, each energization closing the spring 346 to send an impulse of the tone out over the trunk to transmit a signal to the dispatcher. The code switch takes three steps, transmitting an impulse of tone upon each step, to bring the wiper 229 into engagement with the contact *b*. When the wiper 229 encounters the contact *b*, a circuit is closed from grounded conductor 252 through that wiper and contact to conductor 248, thence to the junction of the winding of relay 304 and the resistance 323, that ground serving to short circuit the relay 304, permitting that relay to deenergize and open springs 340 and 343. Opening these springs disconnects the tone generator from the trunk line, so that the dispatcher does not hear the tone when the relay 307 energizes. The dispatcher at this time has heard three impulses of tone, telling him that he has selected a device in substation No. 3. Code sending switch continues to advance, step by step in the manner pointed out hereinbefore, until the wiper 229 encounters the contact *c*, at which time a circuit is closed from the grounded conductor 252 through that wiper and contact of conductor 163, bank contact 27 of the bank over which wiper 141 passes, that wiper, conductor 160, conductor 247, through the winding of relay 304, through resistance 323 to battery. Relay 304 is energized over this circuit, locking itself as before through springs 342 to the conductor 252, and closing springs 340 and 343 to reconnect the tone generator to the trunk line. The code sending switch takes two more steps, transmitting two impulses of tone to the trunk line, and bringing the wiper 229 into engagement with contact *e*, at which time the previously traced circuit is closed to place ground on conductor 248, short circuiting the relay 304, and ending the transmission, of tone impulses to the trunk line as explained hereinbefore. The dispatcher having heard two impulses of tone knows that the wipers of the connector switch are resting on a contact in the second level. The code sending switch takes another step, bringing wiper 229 into engagement with the contact *f*, thereby placing a ground on conductor 347, to reenergize the relay 304, to reconnect the tone generator to the trunk line.

The code switch now takes seven additional steps, to bring wiper 229 into engagement with contact *h*, and to transmit seven impulses of tone to the trunk line. When the wiper 229 encounters the contact *h*, ground on conductor 252, completes a circuit through said wiper and contact, conductor 165, the seventh bank contact in the second level over which wiper 142 passes, that wiper, conductor 161, conductor 248, thence back to the junction of resistance 323 and the relay 304, short circuiting the relay 304 to remove the tone generator from the trunk line as before. This completes the transmitting of the code indicating the position of the wipers of the connector switch. The dispatcher having heard the code 3—2—7 knows that the connector switch in the No. 3 office is resting upon the 27th contact set of its banks. The code sending switch continues to advance, wiper 229 completing the one half revolution starts in again to send another code by encountering the contact *i*. If the dispatcher is in doubt as to any of the digits of the code, he merely waits a moment, whereupon the code is repeated as the wiper 229 passes over its bank a second time. The repetition of the code operation is exactly the same as has been described and will not be repeated.

Assuming that the dispatcher hears the code correctly and desires to proceed with the control of the circuit breaker CB, he next dials the digit 1, momentarily opening the circuit of the line relay 101 of the connector switch, causing that relay to fall back and transmit another impulse of current to the rotary magnet 112, and to the relay 105 over the circuit described hereinbefore. The connector switch operates, advancing the wipers onto the next or 28th contact set of the bank. At the end of the transmission of the impulse, relay 105 falls back, closing the circuit from grounded release trunk conductor 60 to spring 132 and its break contact, wiper 139 and the 28th bank contact engaged thereby, conductor 55 spring 27 and its break contact, normal position contact engaged by wiper 21, springs 24, spring 28 and its break contact, through the winding of magnet 11 to battery, energizing that magnet. Motor magnet 11 upon energizing, opens springs 24, and prepares to advance the wipers 21 to 23 inclusive one step. When the magnet deenergizes, the wipers are advanced. A circuit may now be traced from ground through wiper 22 and the first bank contact engaged thereby, conductor 57, spring 136 and its break contact, thence over parallel paths, one through conductor 56, through the winding of the relay 10 to battery, and the other through wiper 140, now engaging the 28th bank contact, through the winding of relay 115 to battery. Relay 115 and relay 10 energize over this circuit, the latter to open at springs 28 a point in the initial energizing circuit of the magnet 11 of the time switch, and to close in its place a circuit for the relay 7. When the motor magnet 11 deenergizes and closes springs 24, a circuit may be traced from ground on the bank over which wiper 21 rotates and that wiper, through springs 24, spring 28 and its make contact, thence through parallel paths, the one through resistance 15, to battery, and the other through the winding of relay 7 to battery. Relay 7 energizes over this circuit, and at springs 25 closes a circuit from the ground picked up by wiper 21 through the winding of relay 8 to battery and through the resistance 14 to battery. Relay 8 pulls up over this circuit, and at springs 26 closes a circuit for the motor magnet 11, energizing that magnet, which at springs 24 opens the circuit of relay 7. Relay 7 and relay 8 are both equipped with copper slugs on their cores, to make them slow operating. When the circuit of relay 7 is opened, that relay falls back after an interval and opens the circuit of relay 8, permitting that relay to fall back after a similar interval. The deenergization of relay 8 opens the circuit of motor magnet 11, permitting that magnet to deenergize and advance the wipers of the time switch one step. When the motor magnet 11 has deenergized, and reclosed springs 24, the circuit of relay 7 is again closed, and the cycle of operation just described will be repeated as long as the wiper 21 encounters grounded contacts. Thus it will be seen that the time switch, when once started will interrupt its own circuit by the interaction of motor magnet 11 and the relays 7 and 8, and step around in a buzzer like fashion, moving its wipers over its banks. Wiper 22, maintains a ground upon conductor 57, as long as it is encountering multiplied contacts. Since the speed of operation of the time switch is practically constant, and under the control of the relays 7 and 8, the length of time that the conductor 57 is maintained grounded depends upon the number of contacts multiplied together. In the present case, four contacts are shown multiplied, and the conductor 57, will be grounded during the length of time required by the wiper 22 to pass over those four contacts. As long as conductor 57 is grounded, the auxiliary relay 115 of the circuit breaker CB will be closed, and at springs 143 will maintain a circuit for the operating magnet 113 of the breaker. The length of time that the relay 115 is closed, is sufficient to permit the breaker to fully operate, but is not any longer than is necessary for that breaker to operate, so that in case the circuit closed through the circuit breaker is in trouble and an excessive current flows through the breaker, the automatic release on the breaker can function to open it. If the circuit through magnet 113 were to be closed permanently, energization of the tripping magnet by an overload con-

dition would not be effective to open the circuit breaker. After the time switch has taken a sufficient number of steps to bring the wiper 22 to engagement with its 24th bank contact, circuit for relay 9 is closed, from ground through that wiper and contact, through the winding of the relay to battery. The energization of relay 9 disconnects conductor 55 from conductor 59 and locks relay 9 to conductor 55. The time switch takes one more step, bringing the wiper 21 into engagement with the 25th bank contact to which the conductor 59 is connected, and since that contact is ungrounded, the time switch will come to rest thereon.

When the circuit breaker CB closes, it closes the contacts 145, thereby completing the circuit whereby the tone produced by the tone generator is audible to the dispatcher, that tone traversing a circuit from the winding 315 through the condenser 322, conductor 66, 28th bank contact and wiper 142 which is engaging that contact, conductor 161, through the condenser 161', conductor 62, wiper 41, springs 44, springs 32, trunk conductor 50, through the telephone at the dispatcher's station, conductor 51, springs 30, springs 39, wiper 40, conductor 61, condenser 160', conductor 160, wiper 141, to 28th bank contact engaged thereby, conductor 171 springs 145, conductor 162, conductor 67, to the lower terminal of the tone generator winding 315. As has been previously explained, the buzzer 310 is operating, and the dispatcher will hear an uninterrupted low pitch tone, informing him that the circuit breaker CB has been closed.

The dispatcher has now completed the cycle of operation incidental to closing the circuit breaker CB, and will, therefore, replace his receiver upon the switch. The restoration of the receiver opens the circuit across conductors 50 and 51, permitting the line relay 101 of the connector to restore, and open the circuit of relay 102, which restores after a brief interval. The restoration of the line relay 101 and release relay 102, closes a circuit for the release magnet 111 of the connector, that circuit being traceable from ground through spring 120 and its break contact, spring 122 and its break contact, off normal spring 123, through the winding of the magnet 111 to battery. The energization of release magnet 111 releases the connector switch to normal in the well known manner, explained in detail in the above referred to text. The restoration of the release relay 102, at spring 121, removes ground from the release trunk conductor 60, thereby unlocking all relays which were locked energized to this conductor, and removing the holding circuit from the relay 6 of the station selector, permitting that relay to fall back. Relay 6 upon falling back closes the springs 43, completing the circuit from ground thru springs 33 and its break

contact, spring 35 and its break contact, off normal spring 38, through the winding of release magnet 13 to battery, energizing that magnet to release the station selector to its normal position. In the other substations bridged across the trunk, the replacing of the receiver on the switch hook releases the line relay 11, permitting that relay to fall back and open the circuit of the release relay 12', which falls back and opens the holding circuit of the switching relay 6 of those station selectors, whereupon the station selectors restore to normal in the manner just pointed out. The equipment is now all back in its normal position, in readiness for the next operation.

Automatic supervision

In a substation using the remote control system shown in the drawings, there are a plurality of switching functions which may be performed automatically, for example a circuit breaker may open responsive to a load condition, or a bearing on one of the rotating machines may become overheated and the thermostatic switch may operate to shut down that machine. It is essential that the dispatcher at the control station be informed whenever an automatic operation takes place in any one of the substations. For this purpose an automatic supervisory system is employed. In Fig. 4 I have shown relays 202 and 203 which are alarm relays, there being as many pairs of these relays as there are functions to be reported by the automatic supervisory apparatus at the substation. Associated with each relay pair is an auxiliary contact, such as contact 221 shown in the dotted square to the right of relay 203. This contact is closed by an abnormal condition, such as the opening of circuit breaker, the heating up of a bearing, etc. For example the springs 221 might be closed by the circuit breaker CB when that circuit breaker moves to its open position. It will be assumed for the purpose of illustration that the contacts 221 are closed when a bearing on the machine becomes overheated. Closing the springs 221 closes the circuit of relay 202, traceable from ground to springs 221, springs 220, to the winding of relay 202, conductor 243, springs 214, resistance 215, to battery. If at the moment the above circuit is closed by springs 221, the connector is off normal, springs 214 of the relay 201 will be opened, as explained above, and the circuit of relay 202 will be without battery. The supervision is therefore stored until the connector returns to normal, at which time relay 201 restores and battery is again supplied to relay 202, to complete the above mentioned circuit. Relay 202 energizes over this circuit, operating springs 216, 217 and 218. In closing springs 216, relay 202 closes a circuit from ground through springs 47, springs 49,

springs 124 of the connector, conductor 175, springs 216, conductor 240, conductor 68, springs 31 of the signal relays, through the winding of relay 1 to battery, energizing the relay 1. Relay 1 upon energizing at springs 29 closes circuit for relay 2, energizing that relay to operate the springs 31 and open the circuit of signal relay 1. Relay 2 also operates springs 30 and 32, closing a circuit from the alternating current source to the trunk conductor, that alternating current traversing a circuit through the bell and condenser at the dispatcher's telephone to ring the bell to apprise the dispatcher of a trouble condition at substation. The operation of springs 217 of relay 202, prepares circuit to the code switch, which will be explained hereinafter. The operation of the springs 218, places the ground on conductor 244, to complete a circuit through wiper 227 and its normal position contact, through springs 223, through the winding of the motor magnet 204 to battery. The motor magnet 204 energizes, opening its own circuit at springs 223, permitting its armature to fall back and advance the wipers 224 to 227 one step. It should be noted that when relay 202 is in its normal position ground through spring 218 and its back contact is connected to the 15th bank contact of the bank over which wiper 227 rotates. Similarly each of the other relays, corresponding to relay 202, when in their normal position places ground on its respective contact in the bank over which wiper 227 rotates. It is assumed at the moment that relay 202 is the only one which is energized, so that when wiper 227 advances in the direction indicated by the arrow, it will encounter ground potential. The circuit of magnet 204 will again be completed from this ground potential picked up by the wiper 227, and that magnet will operate in a buzzer like manner advancing the wipers 224 to 227 step by step. When contact 15 is encountered, the wipers come to rest, since relay 202 is in its energized position and contact 15 is ungrounded. Wipers 224 to 227 are now all standing on their respective 15th bank contacts, wiper 224 preparing a circuit through which the code sender will be controlled to send the digit 2, wiper 225 being positioned to prepare the code sender to send the digit 5, and wiper 226 being prepared to control the cut-off of the code sender.

The dispatcher upon hearing his telephone ringing, will know that something has taken place in one of the substations connected with the trunk line, and will attend to the call by removing the receiver from the switch hook of his telephone, and closes the previously traced circuit to the line relay 3 of the station selector, energizing those relays which close at springs 33, the circuit for release relay 4. The energization of the release relay 4 closes a circuit from grounded spring 34, spring 37, release trunk conductor 60, springs 217 of the relay 202, conductor 241, through the lower winding of the relay 308 to battery, with a parallel path from conductor 241 through the lower winding of relay 260 to battery. Relay 200 energizes over this circuit, locking itself through its upper winding and springs 210 to the release trunk conductor 60. At springs 211, relay 200 closes a circuit for the motor magnet 204 of the alarm switch, energizing that magnet preparatory to advancing the wipers 224—227. At springs 212, relay 200 closes a point in the cut-off circuit of the supervisory switch, for purposes which will be explained hereinafter. Relay 308 energizes over the above traced circuit, to start the code sender in the manner hereinbefore pointed out. The code sender operates to send the digit 3, indicating that the alarm originated in substation No. 3, then sends the digit 2, under the control of wiper 224, of the supervisory switch, and the 15th bank contact engaged by that wiper, the circuit of start conductor 247 being completed, from grounded conductor 252, wiper 229 engaging contact *c*, conductor 163, 15th bank contact and wiper 224, conductor 247, through the winding of relay 304 to battery. Relay 304 energizes over this circuit, to start the transmission of code signals to the dispatcher in the manner pointed out before. When wiper 229 encounters contact *e* the code is stopped, and it is restarted when the wiper 229 encounters contact *f*, the details of this starting and stopping being the same as pointed out hereinbefore. When the wiper 229 encounters the contact *j*, after five impulses have been sent, a circuit is completed from that contact through the fifth multiple to the contact 15 upon which the wiper 225 is now resting, conductor 248, thence to junction of resistance 323 and the relay 304, to deenergize the relay 304 in the manner pointed out hereinbefore. Thus it will be seen that the dispatcher upon answering the supervisory alarm will hear the code 3—2—5. This alarm informs him that the 25th alarm relay set has been operated, from that data he knows the nature of the fault and may take whatever steps are necessary to correct it.

Assume now that the dispatcher desires to do nothing further about the alarm he has just received, he will hang up his receiver, deenergizing line relay 3, closing a circuit momentarily from ground through springs 43, springs 33, spring 35 and its make contact, relay 5, magnet 12 to battery. Closing this circuit operates magnet 12, to move the station selector off normal, closing the off normal contacts 48, whereupon ground is projected through off normal contacts 48, conductor 69, thence through conductor 176 to relay 201 of the supervisory control to battery, energizing the relay 201. Ground on conductor 176 is also projected through springs 212, con-

ductor 246, wiper 226 and the 15th bank contact engaged thereby, through the winding of alarm relay 203 to battery, energizing the alarm relay 203, which locks itself in energized position through springs 220 and alarm contacts 221. The energization of relay 203 opens the circuit of relay 202, permitting that relay to fall back and restore the springs 218, thereby replacing ground potential upon the 15th bank contact over which wiper 227 rotates. The energization of relay 201, operates springs 213 to open the circuit of relay 200, which falls back immediately. Relay 200 opens the circuit of motor magnet 204, permitting that magnet to deenergize and advance the wipers 224-227 one step. Wiper 227, now picks up ground potential, closing the circuit for magnet 204, which energizes and opens its own circuit at springs 223, the magnet operating in a buzzer like action to advance the wipers step by step until the normal position is reached, at which time wiper 227 loses its ground potential and the supervisory switch comes to rest. The deenergization of relay 202 also opens springs 217, thereby permitting relay 308 of the code sender to deenergize, to stop the sending of the code.

On call supervision

Inasmuch as this system provides no visual indication of the position of the various devices at the substations, it may occur that the dispatcher loses track of some of the devices, and does not know whether they are in operated or nonoperated position. He may ascertain their position by dialling the numbers associated with the open or closed positions of the device, and listening for the tone, or he may make use of a more rapid supervision provided solely for the purpose of checking the position of the devices which operation will now be explained. In the drawings, Fig. 2, I have shown a third level bank of the connector set aside for on call supervision. Each of the alarm relays such as relay 203 is equipped with a pair of contacts, similar to contacts 219, through which the on call supervision tone is made audible to the dispatcher. As explained hereinbefore in connection with relay 203, the operation of auxiliary alarm contacts 221 transmits an automatic supervisory signal to the dispatcher, at the end of which relay 203 is energized and locked in its energized position thru the auxiliary alarm contact. As long as this contact remains closed, relay 203 will remain in its energized position. In order to get the on call supervision of a device, for example the device which relay 203 is associated, the dispatcher removes his receiver from the telephone, and dials 331. The first digit operates the station selector as hereinbefore pointed out to select the connector, the second digit elevates the shaft containing the wipers of the connector

three steps opposite the third level of the bank, and the third or last digit rotates the wipers into engagement with the first contact in that level. If relay 203 is in its normal position, the dispatcher will hear a tone, that tone being audible to him over circuits from the upper terminal of the tone generator winding 315, through the condenser 322, conductor 66, lower contact of the third level of the bank engaged by wiper 142, conductor 161, condenser 161', thence over the previously traced circuit through the station selector and trunk line to the telephone, back over conductors 51 and 61 to the condenser 160', conductor 160, wiper 141, the upper contact of the third level engaged by the wiper 141, conductor 174, springs 219, now assumed to be closed, conductor 162, conductor 67, to the lower terminal of the winding 315 of the tone generator. As has been pointed out before, the placing of ground upon the release trunk conductor 60 by the release relay 102 of the connector, completes a circuit through that conductor at springs 137, conductor 65, through the low tone buzzer 310 and the winding 314 of the tone generator to battery, energizing the buzzer to operate the tone generator to produce the low pitch tone. Therefore, if the relay 203 is in its normal position, the dispatcher will hear a steady low pitch tone indicating that the auxiliary contacts associated with the relay 203 are not closed and that the device is operating under the condition which maintains those contacts open. If, on the other hand, relay 203 is closed by the closed condition of the auxiliary alarm contacts the dispatcher upon dialling 331 will not get any tone and will know that the auxiliary contacts are closed. If the dispatcher desires to supervise another device which is assumed to be connected to the second contact set of the third level, he reoperates his calling device to transmit an additional digit 1, whereupon the wipers of the connector are stepped one step in a rotary direction to engagement with the second contact set of the third level. The relay similar to 203 is associated with this contact set and if the contacts of that relay similar to contacts 219 are closed, the dispatcher will hear a tone as before. If he desires to supervise the next contact set of the group, he dials another 1, whereupon the wipers of the connector are stepped another step into engagement with the third bank contact of the third level. In this manner, by continuing to dial the digits 1, the dispatcher can supervise the ten relays associated with the ten contact sets in the third level, noting the open or closed condition of each relay. If more than ten devices are to be supervised in this manner, when the tenth contact of the third level is reached the dispatcher will release the connection and dial 341, or 351, to elevate the connector shaft into engagement with the

fourth or fifth level which may also be set aside for this purpose if desired. However, in a substation of the type best adapted to be controlled by an audible type remote control system, it is not probable that more than ten devices will need to be supervised sufficiently often to warrant the special provision noted in connection with the on call supervision and the setting aside of one level of the switch bank for that purpose will be adequate.

On call water level readings

If for example the substation 3 is a hydro electric station, the dispatcher will find it necessary to frequently ascertain the height of the water in the forebay, as a guide to the load that can be carried by the station. To get this reading the dispatcher dials the digit 329, to select the 29th contact set in the bank of the connector switch of the substation 3, that selection taking place in the manner previously described need not be repeated at this time. When the relay 105 in the connector switch falls back after the dialling of the last digit, a circuit is completed from grounded release trunk conductor 60, spring 132 and its break contact, wiper 139, now engaging the ninth contact in the second level, conductor 162, conductor 63, through the upper winding of the relay 308 to battery. Relay 308 energizes over this circuit to start the code sender in operation in the manner hereinbefore pointed out. Wiper 140 encounters an open contact and consequently accomplishes no functions at this time. Wipers 141 and 142, encounter the contacts to which the conductors 164 and 167 are respectively connected, thereby arranging the sender to transmit the digit 3—4—5, the 5 being variable and dependent upon the position of the float controlled wiper 230. The sender in starting, first sends the digit 3 as has been hereinbefore explained. The wiper 229 then steps ahead into engagement with the contact to which conductor 164 is connected, thereby starting the sending of the code 4 in a manner hereinbefore pointed out. When the wiper 229 encounters the stop conductor 248, the code is terminated and is started again when wiper encounters conductor 247 in a manner hereinbefore pointed out. The code proceeds until the wiper 229 encounters the fifth units contact *j*, which is multiplied to the contact upon which wiper 230 is resting. The circuit for the stop conductor 248 is completed through conductor 167, 29th bank contact engaged by wiper 142, conductor 161, to conductor 248, the ground placed thereon by the grounded conductor 252 shorting out the relay 304 to end the code, in the manner hereinbefore pointed out. Since the relay 108 of the connector is not energized when the wipers of the connector are positioned upon contacts 29, the low pitch buzzer 310 will be started

and the code will be a low pitch tone. The code sending machine continues to transmit the code 3—4—5 as long as the dispatcher leaves his receiver off the switch hook, so that if he does not correctly hear the code the first time he may have it repeated.

Raising a water gate

After the dispatcher has determined the height of the water in the forebay, he may find it advisable to raise the gates controlling the supply of water to the hydro electric machine at the substation 3. To do this he dials the digit 314, to operate the station selector and the connector to position the wipers of the latter upon the 14th set of contacts in the banks. The 5th contact in the 1st level of the bank over which wiper 140 sweeps is connected to an auxiliary relay similar to relay 115 through the operation of which the gate motor for raising the water gate is prepared for operation. The 6th contact in the first level of the bank over which wiper 140 sweeps, that is the 16th contact set, is connected to an auxiliary relay similar to the relay 115 through the operation of which the gate motor for raising the gate is operated. These relays have been omitted, since they are duplicates of the relay 115 and their inclusion would result in an unnecessary complication of the drawings. The particular arrangement employed to raise the gates is not a matter of the present invention, several devices of this kind are old and well known to those skilled in hydro electric engineering. Responsive to the positioning of the wipers upon the 14th set of contacts in the bank the code switch is started in a manner hereinbefore pointed out, to transmit the code 3—1—4 to inform the dispatcher the exact location of the switch wipers. After the dispatcher has listened to the code and made certain that the wipers are in the position he desires them to be, he reoperates his calling device to transmit digit 1, whereupon the line relay 101 falls back and transmits an impulse of current to the rotary magnet 112, to move the wipers into engagement with the 15th set of bank contacts. At the end of the impulse, relay 105 falls back, closing a circuit from grounded release trunk conductor 60 through springs 132 and its break contact, wiper 139, the 5th bank contact of the first level engaged by that wiper, to conductor 55 for starting the time switch as previously described. The timing switch is operated in the manner previously described to close the circuit to the relay, similar to relay 115, connected to the fifth contact in the 1st level over wiper 140. This relay energizes and prepares the gate motor for operation so that the motor may be controlled from the next contact or the 16th contact to raise the gate step by step. When the gate motor has been properly prepared for operation, a pair of springs similar to springs 145 or 146,

will be closed to send back a steady tone in a manner similar to that previously described. When the dispatcher hears the steady tone, indicating that the gate motor is properly prepared for operation, the dispatcher will reoperate his calling device to transmit the digit 1, whereupon the wipers of the connector are moved into engagement with the 16th set of bank contacts in the 1st level. At the end of the impulse, relay 105 falls back, closing the circuit from grounded release trunk conductor 60 through spring 132 and its break contact, wiper 139, the sixth bank contact of the first level engaged by that wiper, conductor 149, through the normally closed contact controlled by spring 128 and thence over parallel paths, the one through the winding of relay 104 to battery, and the other through the winding of relay 108 to battery. Relay 104 energizes over this circuit, locks itself to release trunk conductor 60 through springs 128, and operates springs 129 to open the circuit of the rotary magnet 112 and to prepare a circuit for the relays 106 and 107. The relay 104 operates springs 130, closing the circuit from release trunk conductor 60 through the springs 138, springs 130 to conductor 63 and thence over the previously traced circuit to energize relay 308 to start the code sender. Relay 108 energizes, and at springs 136 opens the circuit from the conductor 57 and the bank contacts over which wiper 22 of the time switch operates and closes in its place a circuit from the wiper 140 to conductor 58 to the bank over which the wiper 23 rotates. At springs 137, relay 108 opens the circuit from the release trunk conductor 60 and the conductor 65 of the low pitch buzzer 310 of the tone generator, and closes in its place circuit through conductor 64 and the high pitch buzzer 309, so that the audible signals subsequently heard during the remainder of the operation will be high pitched, to inform the dispatcher that he is controlling the gate at the substation, this change of tone of the buzzer being necessary because of a slight difference in operation on the part of the dispatcher when he is controlling the gate. Everything is now in readiness for the closing of the circuit to operate the gate motor, the dispatcher dials an additional digit, which may be any digit greater than 1, for convenience the digit 3. Line relay 101 falls back three times, transmitting an impulse of current over the previously traced circuit through springs 129 and its make contact, hence through springs 135, through the winding of relay 106 to battery. Relay 106 energizes over this circuit, and at springs 133 prepares a point in the circuit of relay 107. However, relay 107 is short circuited during the time that the circuit of relay 106 is closed, since relay 105 has operated in multiple with relay 106 as hereinbefore explained. At the end of the first impulse, relay 107 is no longer short circuited, and pulls up over a circuit from grounded release trunk conductor through spring 132, through the winding relay 107, springs 133, winding relay 106, to battery. Relay 107 opens at springs 135 the previously traced circuit thru relay 106, however, that relay is maintained energized in series with relay 107, and the additional two impulses dialled by the dispatcher serve no other purpose than to keep the relay 105 in its energized position. A circuit may now be traced from ground through springs 134, springs 131, conductor 59, through the normal position contact engaged by wiper 21 of the time switch, that ground completing the circuit previously traced to start the time switch in operation. On the first step of the operation of the time switch, a circuit is closed from grounded wiper 23, the first bank contact engaged thereby, conductor 58, spring 136 to make contact, and thence over parallel paths, the one over conductor 56 to the relay 10 of the time switch, the other through wiper 140, now engaging the sixth contact of the first level, thence through the winding of the auxiliary relay controlling the gate raising motor. The circuit of the auxiliary relay controlling the gate motor will be maintained as long as wiper 23 encounters contacts which are multiplied together. The number of these contacts is variable, and can be changed to suit the requirements of the particular gate motor being used. It is assumed that the number of contacts in the bank of wiper 23 are multiplied together, is sufficient to keep the auxiliary relay closed long enough to cause the motor to raise the gate one step, and that that one step is $\frac{1}{10}$ of the total gate opening. This assumption is merely arbitrary and made for the purpose of explaining the operation of the code switch, and may be varied to meet the requirements of a particular installation. The time switch makes one complete revolution, coming to rest in the position shown, and removing the ground from wiper 140 when the wiper 23 runs off of the multiplied contacts.

As soon as relay 308 is energized, as explained, the code switch is operated in the manner previously described, first to send the digit 3, then to send the digit 1, and then to send the digit depending upon the position of gate wiper 231. If the gate wiper is in the position shown in the drawings, the sender will send 4 as the next digit. The tone of the signals audible to the dispatcher will be high pitched, informing him that he is controlling a gate. If after hearing the signal indicating the position of the gate the dispatcher decides to open it another step, he reoperates his calling device to transmit another digit 3, relay 101 falling back to close the circuit of relay 105, that relay energizing and remaining energized throughout the transmission of the digit, to transmit a

pulse of current over the conductor 59 to start the time switch in operation in the manner hereinbefore described. The time switch wiper 23 sends another impulse of ground out over conductor 58 thence through the wiper 140 to the auxiliary relay controlling the gate raising motor. The code switch continues to run, in transmitting the digits 3 and 1, and altering the third digit in accordance with the position of the wiper 231. In this manner, the dispatcher may raise the gate as many steps as he desires, he gets continuous supervision back in the form of audible code, informing him of the exact position of the gate. When he gets the gate set to his satisfaction, he replaces his receiver, whereupon the time switch, station selector, the connector and the code sender are restored to normal under the control of local circuits in the manner hereinbefore pointed out.

Closing a high tension circuit breaker

In each service station controlled by the audible type system shown, there will be one or more devices which require special supervision because of the nature of the circuit controlled by those devices. For example, the closing of a high tension circuit breaker is an operation of relatively high importance, consequently when the dispatcher closes such a breaker he should be informed in a special manner that the breaker has closed, to differentiate the operation from the closing of an ordinary low tension breaker in the substation. For this purpose, I have provided a slightly different arrangement in the banks of the connector, so that when the high tension circuit breaker is closed, the audible tone which the dispatcher hears through the contacts controlled by the breaker, is a high pitch tone, the receipt of which informs the dispatcher that the breaker that he has just closed is a high tension breaker. This illustration is given by way of example only, as any of the devices in the substation which are of sufficient importance to warrant it, can be operated in the manner now to be pointed out. Assume now that the dispatcher desires to close the high tension circuit breaker, he will operate his calling device to transmit the digit 321, the first to select the substation No. 3, the second to position the wipers of the connector in that substation opposite the second level of the banks, and the third to position those wipers on the first contact in that level. This operation is the same as has been hereinbefore described. When the slow acting relay 105 falls back after the transmission of the last impulse, the circuit is closed through wiper 139 now engaging the first contact in the second level, thence over the conductor 162 to start the code sender in the manner previously explained. The code sender operates, to transmit to the dispatcher the digit 321,

to inform him that he has positioned the connector switch on the twenty-first contact set. Assuming that this is the correct digit, the dispatcher reoperates his calling device to transmit another digit to move the wipers of the connector switch onto the next or twenty-second contact set of the banks. When the relay 105 falls back and closes the circuit of the wiper 139, it completes a circuit through the second contact in that level, conductor 147, through the winding of relay 109 to battery. Relay 109 energizes over this circuit, and at springs 148 locks itself to the grounded release trunk conductor 60. Spring 138 moves against its make contact and closes a circuit from the release trunk conductor 60 through relays 108 and 104 in parallel, energizing those relays in the manner previously pointed out. The operation of spring 138 away from its break contact, opens the circuit extending through spring 130 and its make contact and the conductor 63 to start the code switch, so that when the relay 104 energizes, the relay 308 of the code sender deenergizes and the code switch comes to rest. The operation of relay 108 transfers the release trunk conductor ground from conductor 65 to conductor 64, to stop the low pitch buzzer 310 and start in its place the high pitch buzzer 309. The dispatcher now dials an additional operating digit, preferably the digit 3, to start the time switch in the manner hereinbefore described, that time switch transmitting an impulse of current from wiper 23 over conductor 58 through spring 136 and its make contact to the wiper 140 and thence to the auxiliary relay controlling the closing of the high tension circuit breaker. This auxiliary relay is a duplicate of the relay 115, and has been omitted from the drawings to avoid an unnecessary complication. When the circuit breaker closes, the auxiliary contact, similar to contact 145 of the circuit breaker CB, are operated, completing a circuit from the tone generator through the wipers 141 and 142 to the trunk line leading to the dispatcher's telephone. This circuit is identical with the circuit previously explained and will not be repeated at this time. The dispatcher hears the tone, which in this case is a high pitch tone since buzzer 309 is operated, and because the tone is high pitch, the dispatcher knows that the circuit breaker he has just operated is a high tension circuit breaker.

Fuse alarm

The equipment at each of the substations is provided with fuses, those fuses being of the alarm type, are arranged to control the transmission of a signal to the dispatcher in case the fuse blows. Assume now that the fuse 351 blows, connects the main bus bar 319 to the alarm bus bar 319', thereby supplying battery to the alarm relay 301. This relay

energizes over this circuit, and at springs 330 places ground on conductor 240 to complete a circuit through springs 333, conductor 240, conductor 68, through springs 31, through
 5 the winding of relay 1 to battery. Relay 1 energizes over this circuit, closing a circuit for relay 2, which energizes and at springs 30 and 32 applies ringing current to the trunk conductors 50 and 51, in the manner
 10 hereinbefore pointed out. Relay 301 at spring 332 closes circuit for the alarm lamp 313, lighting that signal lamp to indicate in the substation the location of the blown fuse. The dispatcher upon hearing the signal, re-
 15 moves his receiver from the switch hook, closing the circuit for line relay 3 of the station selector, that relay energizing closes the circuit for the release relay 4, which energizes and puts the ground upon release trunk
 20 conductor 60 through springs 34 and 37. A circuit may now be traced from the grounded release trunk conductor 60 through spring 137, conductor 65, through the low pitch buzzer 310 and the winding 314 of the
 25 tone generator to battery, and also through the springs 331, through the winding of relay 303 to battery. Relay 303 energizes over this circuit, and closes a circuit through
 30 springs 336 for the relay 302. Relay 302 energizes and at springs 233 removes the ground from conductor 240 and conductor 68 to remove signalling current from the trunk
 35 conductor. Relay 302 locks itself through springs 334 to ground through springs 332, so that relay 302 will remain in its energized position until the blown fuse is replaced. The operation of relay 303, closes springs
 40 335 and 337, so that when the dispatcher removes his receiver, he will hear a steady low pitch tone informing him that fuse is blown in one of the substations. With this information at hand the dispatcher can take whatever steps are necessary to replace the blown
 45 fuse, he may either call an attendant at the substation, or take such steps as to determine the location of the fuse, and its relative importance, to decide whether or not it must be immediately replaced.

Calling a substation attendant.

Automatic substations of the type controlled by remote control systems, are frequently visited by an inspector or in some
 55 cases are attended by an attendant during a part of the day. In case the dispatcher wants to get in touch with an attendant at one of the substations, for example the substation 3, he can signal that attendant by
 60 dialling the digit 320. Responsive to the receipt of these digits, the connector switch at the substation 3 is positioned on the tenth set of contacts in the second level of its bank, from which position it controls the signalling of the attendant. When the relay
 65 of the connector falls back after the dialling

of the digit 0, a circuit is closed from grounded release trunk conductor 60 through spring 132 and its break contact, wiper 139, the tenth contact in the second level now engaged by
 70 that wiper, through the winding of the gong, to battery. The gong operates over this circuit, to call the substation attendant to the telephone. The dispatcher now replaces his receiver for a moment, releasing the connector
 75 switch, to stop the ringing of the gong. When he again removes his receiver, his transmitter is supplied with battery through the winding of the line relay 3 of the station selector, over the previously traced circuit
 80 including the trunk conductors 50 and 51. When the attendant answers the phone, his transmitter is supplied with battery from the line relay of the station selector over circuit traceable from ground through the lower
 85 winding of that relay, spring 44 and its break contact, conductor 54, through the receiver hook switch transmitter and calling device of the station telephone, conductor 53,
 90 through spring 39 and its break contact, through the upper winding of the relay 3 to battery. When the conversation is finished, both parties replace their receivers, and the substation equipment returns to normal.

Attendant calls the dispatcher.

It may happen that the attendant at the substation desires to converse with the dispatcher, and for this purpose the push button key 20 is provided. This key is associated with the station telephone, and when
 100 the inspector closes the key, it completes a circuit through the winding of relay 2, energizing that relay which at springs 30 and 32 applies ringing current to the trunk
 105 conductors 50 and 51 in the manner hereinbefore pointed out. The attendant then restores the key to normal, to remove the ringing current, and when the dispatcher answers two parties may converse, the transmitters
 110 being set from the line relay 3 in the manner hereinbefore pointed out.

From the foregoing general description of adaptations of my invention, it will be seen that through the various strappings of the
 115 bank terminals of the connector switches in the substations, a great variety of operations can be performed. In the one case, the dispatcher first dials the connector switch onto a contact set adjacent to the one through
 120 which the device is closed, he receives the check-back tone indicating the position of the connector, dials an additional digit to move the wipers onto the contacts controlling the device to immediately operate the
 125 device. He is apprised of the operation of the device by means of a low pitch buzzer tone transmitted direct to him through contacts on the device itself. In another case, the dispatcher dials the connector switch
 130

onto the contact set adjacent to the contacts controlling the device, he receives a check-back code, dials an additional digit to move the connector onto the contacts through which the device is controlled, and then dials an additional digit to operate the device. When the device is operated, the high pitch tone is audible to the dispatcher to apprise him that that particular device has been operated. Still another case, the dispatcher dials to a contact set adjacent to the set through which the device is controlled, receives a code indicating the position of his connector switch, dials an additional digit to move the connector switch onto the contact set controlling the device, and receives back a code indicating the position of the device. He may now control the device in steps, dialling a digit for each step, and upon the completion of the operation of the device through one of its steps he receives a code indicating the actual position of the device. These and many other adaptations are possible through the combination of circuits disclosed in the drawings, and while I have chosen to show my invention in connection with a particular type of apparatus I have done so by way of example only, as there are many other adaptations to which my invention can be put without departing from the scope of it.

Having thus described my invention, what I consider new and desire to have protected by Letters Patent is pointed out in the appended claims.

What is claimed is:

1. In a remote control system, a selecting switch having access to a plurality of groups of contacts, a plurality of switching devices each accessible to said switch through separate ones of said groups of contacts, means for operating said switch to position it upon various ones of said contact groups, means responsive to the positioning of said switch on one contact group for first transmitting a code indicating the position of the switch, means responsive to a reoperation of said first means to move the switch to another contact of the group for operating the device, means responsive to said operation for transmitting a signal indicating the operation, means responsive to the positioning of said switch on another contact group for first transmitting a code indicating the position of the switch, means responsive to a reoperation of said first means to move the switch to another contact of the group, for then transmitting a second code indicating the position of the device, and means responsive to a reoperation of said first means then operating the device.

2. In a remote control system, a selecting switch having a plurality of positions, switching devices accessible through said switch positions, means including a calling

device for moving said switch to said positions to select said devices, means controlled by said switch in one of said positions for starting a code sending means to transmit a checking code for indicating the position of said switch and for preparing an operating circuit for the selected device, means in said switch responsive to another operation of said calling device for moving said switch to close said prepared operating circuit, means controlled by said switch in another of said positions for selecting another of said means for starting said code sending means to transmit a checking signal for indicating the position of said switch, means then responsive to a further operation of said calling device to reoperate said code sending means to transmit a code indicating the position of the selected device, and means responsive to another operation of said calling device for operating said selected device.

3. In a remote control system, a plurality of groups of devices, a remote control station from which said devices may be operated, automatic means for operating said devices, a finder switch having access to said devices, a sender, means responsive to an operation of one of said devices for starting said finder to find the device, means controlled by the finder for arranging said sender to send a code indicating the device operated, and the operation performed, and means controlled from said control station for starting said sender to transmit said code and a code indicating the group.

4. In a remote control system, a switching device, a selecting switch having a bank of contacts, through certain ones of which said device is controlled, a sender, means responsive to an operation of said sender for positioning said selecting switch in a position adjacent to said certain contacts, means controlled by said switch in said position to indicate the position of the switch, means responsive to a further operation of said sender for moving said selecting switch onto said certain contact set and for sending an impulse of given length to the device to operate it, and means controlled by the device for transmitting a signal through said switch to indicate the successful operation of said device.

5. In a remote control and supervisory system, a plurality of substations, a dispatcher's station including a dispatcher's switching device, a plurality of switching devices in said substations, means for automatically operating one of said devices in one of said substations, means responsive to said operation for signalling said dispatcher's station, and automatic means at said substation initiated responsive to the manual operation of the dispatcher's switching device and controlled by the operated device for transmitting to the dispatcher's station a code of impulses which

indicate the substation containing the device, the device, and the operation performed.

6. In a remote control system, a plurality of devices, a dispatcher's switching device, means for automatically operating said devices, alarm relays associated with said devices, a finder switch, a sender switch, means responsive to an operation of a device for operating the associated alarm relay, means controlled by said relay for sounding an alarm, means also controlled by said alarm relay for starting said finder switch to find said relay, means controlled by said finder for arranging said sender to send a code indicating said relay, and means responsive to the manual operation of the dispatcher's switching device in answer to said alarm for starting said sender to transmit said code in audible impulses to indicate the operation of said device.

7. In a remote control system, a plurality of groups of devices, a dispatcher's switching device, means for automatically operating said devices, alarm relays associated with said devices, a finder switch, a sender switch, means responsive to an operation of a device for operating the associated alarm relay, means controlled by said relay for sounding an alarm, means also controlled by said alarm relay for starting said finder switch to find said relay, means controlled by said finder for arranging said sender to send a code indicating said relay, and means responsive to the manual operation of the dispatcher's switching device in answer to said alarm for starting said sender to transmit a three digit audible code indicating the groups containing the operated device, the device, and the operation performed.

8. In a remote control system, a plurality of groups of devices, means for automatically operating said devices, relays associated with said devices, a finder switch, a sender switch, means responsive to an operation of a device for operating the associated relay, means controlled by said relay for starting said finder switch to find said relay, means controlled by said finder for arranging said sender to send a code indicating said relay, manually controlled means for starting said sender, and means whereby the sender transmits a code of audible impulses characteristic of the device and operation performed responsive to the operation of said manual means.

9. In a remote control system, a plurality of switching devices, controlling magnets therefor, a selecting switch having contacts, means for operating said selecting switch on particular ones of said contacts to select a particular one of said switching devices, means for holding said switch on said contacts, a timing switch associated with said selecting switch, and means in said selector for repeatedly initiating the operation of

said said timing switch, means in the timing switch for continuing its operation after its initiations to repeatedly close a circuit to the controlling magnet of the selected device for definite intervals while said selector remains on said contacts.

10. In a remote control system, a plurality of switching devices, controlling magnets therefor, a selecting switch, means for operating said selecting switch to select a particular one of said switching devices in order, a timing switch associated with said selecting switch, means in said selector for operating said timing switch to close a circuit to the controlling magnets of the selected devices for an interval dependent upon the device selected.

11. In a remote control system, a plurality of switching devices, a selecting switch having wipers for access to said devices, means for operating the wipers of said switch to select a particular device, means responsive to said operation for indicating the position of said wipers, means for reoperating the wipers of said switch without releasing the same to close a circuit to said selected device and for maintaining it closed for a predetermined definite interval to operate the device, and means controlled by the device for transmitting a signal through said switch to indicate the device and the successful operation of it.

12. In a remote control system, a plurality of switching devices, a selecting switch having access to said devices, means for operating said switch to select a particular device, means responsive to said operation for indicating the position of said switch, means for reoperating said switch to close a circuit to said selected device and for maintaining it closed for a definite interval to operate the device, and means controlled by said device for transmitting a continuous tone of a particular pitch to indicate the position and nature of the device.

13. In a remote control system in which a selecting switch is manually set by a dispatcher to select one of a plurality of groups of contacts, to thereby select certain devices, means responsive to the selection of one of said groups for operating a signal transmitting means to indicate said selection, means responsive to a further manual operation of the selecting means by the dispatcher for operating the selected device, means responsive to the selection of another of said groups for operating said signal transmitting means to indicate said selection, means responsive to a further manual operation of the selecting means by the dispatcher for reoperating said signal transmitting means to indicate the condition of the selected device, means responsive to a second further manual operation of the selecting means by the dispatcher for operating the selected device, and means

responsive to an operation of a device for operating said signal means to indicate said operation.

14. In a remote control and supervisory system, a plurality of substations, a dispatcher's station, a trunk line between said stations, a plurality of devices in each of said substations, means for automatically operating one of said devices, means responsive to said operation for automatically applying alternating current to said trunk line to signal said dispatcher's station to indicate the automatic operation of any device, and automatic means started from the dispatcher's station and controlled by the automatic operation of said device for transmitting a code of impulses to indicate the substation containing the device, the device and the operation performed.

15. In a remote control system, a plurality of devices of different classes, a selector switch having access to said devices, means for operating said selector switch to select one of said devices, means controlled by the position of the selector switch for transmitting a signal indicating said selection, means for operating said selected device, and means responsive to the operation of the device for altering said signal to indicate the class of the device which operated.

16. In a remote control system, a plurality of switching devices, controlling magnets therefor, a selector switch, a single control line extending from a remote control point to said selector switch, a timing switch associated with said selector switch, means controlled over said line for operating said selector switch to select a particular one of said switching devices and to initiate the operation of said timing switch, and means in said timing switch for continuing its operation after its initiation to repeatedly close a circuit to the controlling magnet of the selected device for predetermined time intervals.

17. In a remote control system, a plurality of switching devices of different character, controlling magnets therefor, means for selecting a particular one of said devices, and means including a timing switch common to said devices and operated responsive thereto for closing a circuit to the controlling magnet of the selected device for an interval dependent upon the character of the device selected.

In witness whereof, I hereunto subscribe my name this 1st day of August, A. D. 1927.

MARTIN L. NELSON.