

Nov. 13, 1928.

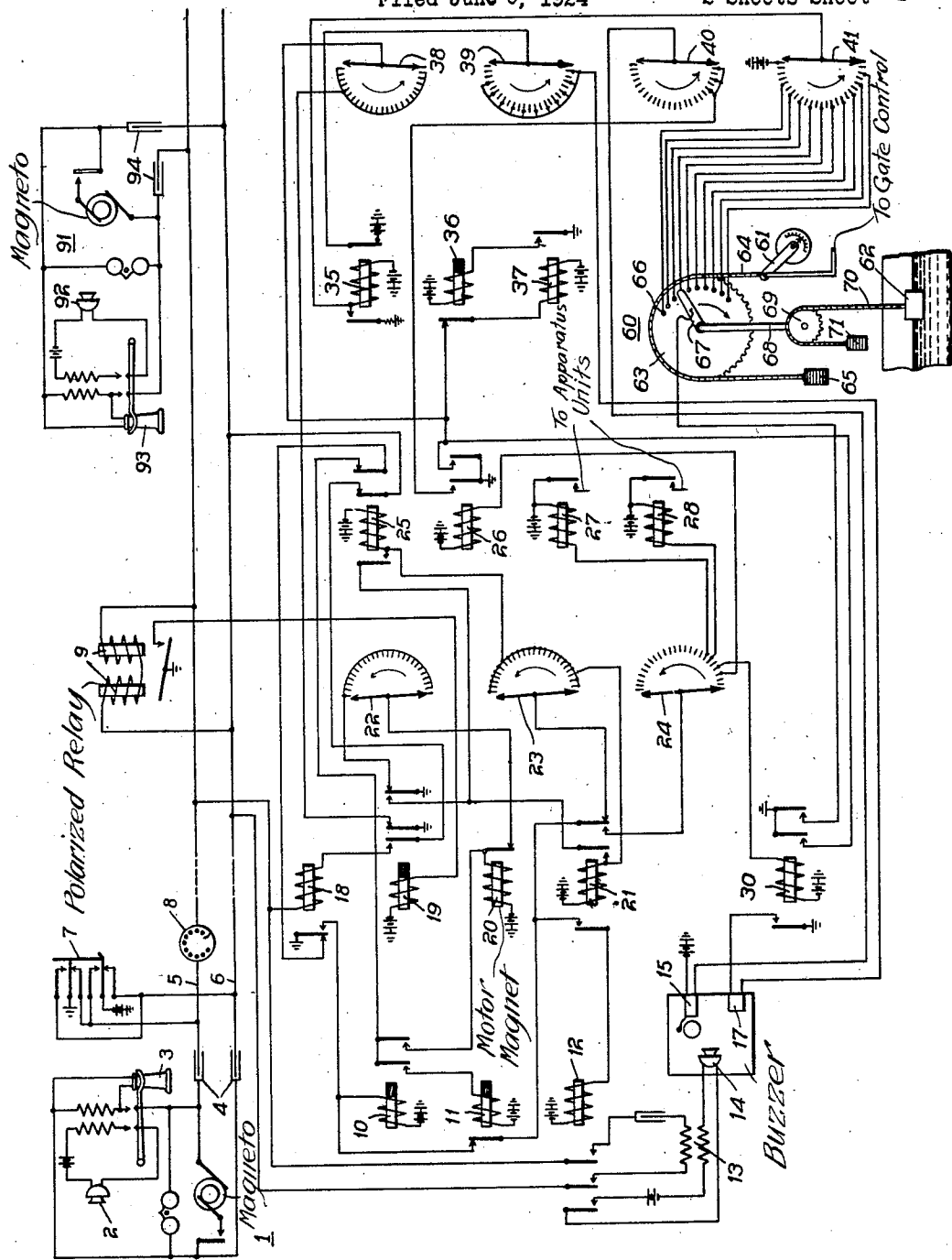
1,691,360

M. E. REAGAN

CONTROL SYSTEM

Filed June 6, 1924

2 Sheets-Sheet 1



WITNESSES:

H. B. Funk
J. E. Hardner

Fig. 1

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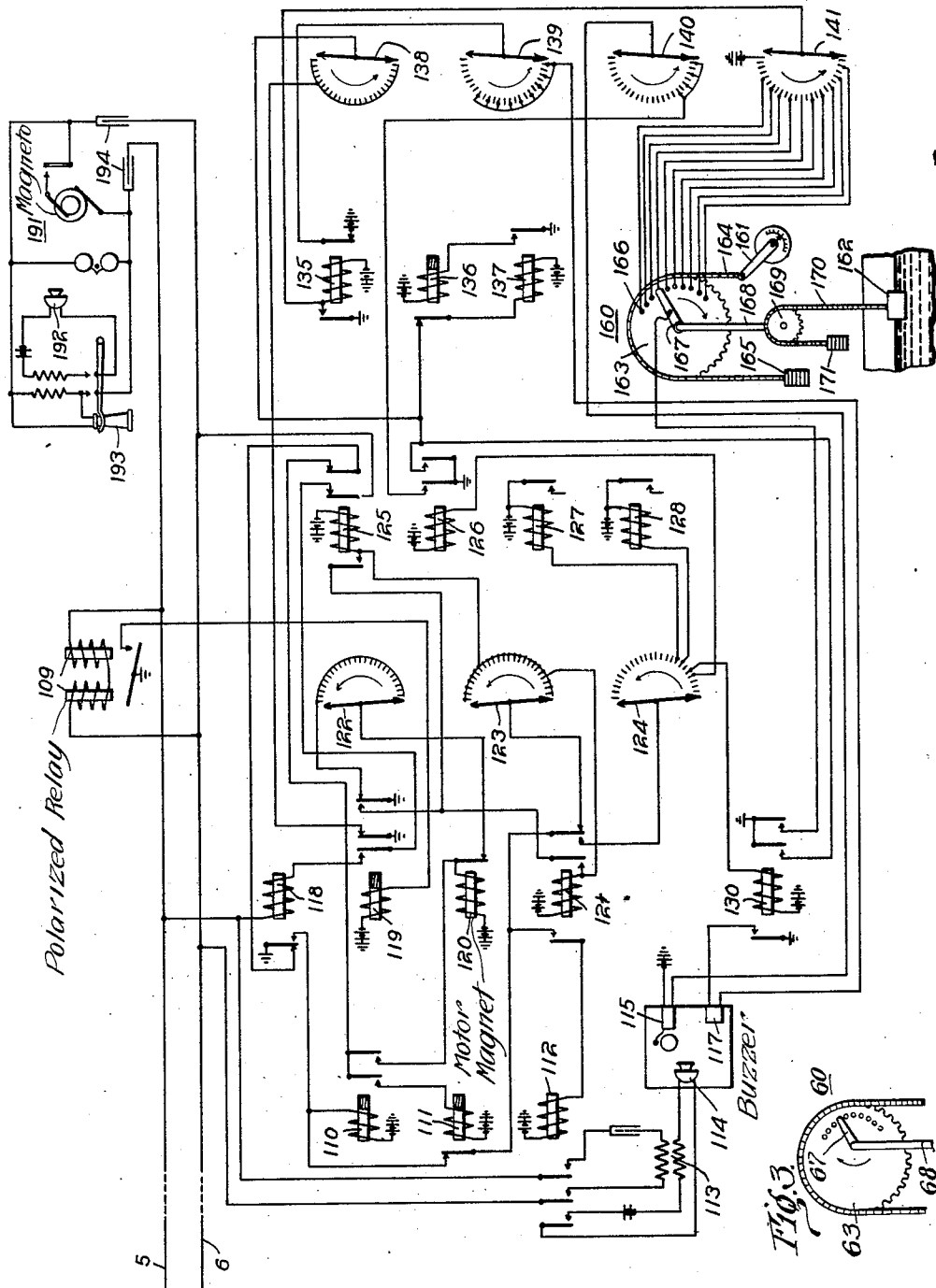
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2 Sheets-Sheet 2



WITNESSES:

H. B. Frank.
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Fig. 2.

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UNITED STATES PATENT OFFICE.

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CONTROL SYSTEM.

Application filed June 6, 1924. Serial No. 718,221.

My invention relates, in general, to control systems and more particularly to supervisory control systems of the type wherein the dispatcher at a central office may supervise and control remotely-disposed electrical equipment.

One object of my invention is to provide an improved supervisory control system for use in supervising and controlling apparatus located in small hydro-electric sub-stations.

A further object of my invention is to provide means for informing the dispatcher of the kilowatt input of the station in a simple and efficient manner.

There are numerous hydro-electric generating stations having automatic control equipment to obviate the necessity for attendants or operators at the stations. Frequently, there is a group of such stations along the course of a stream at distances as great as several miles apart. In such case, the operation of each station depends, to a certain extent, upon the others; for instance, the water supply to each station depends upon the water released by the station above it. Furthermore, the stations may be connected electrically in order to obtain a flexible load distribution. A system of this kind requires supervision and control to coordinate the operation of the several stations to obtain the most economical results under varying load conditions. My invention has been designed to meet such requirements.

In the particular embodiment of my invention which I have elected to describe herein, the load supervisor or dispatcher is provided with a telephone set consisting of a transmitter, a receiver, a ringer and a magnet. He is also provided with a key and a circuit-interrupting or sending device which may be similar in construction to the calling devices used in automatic telephone systems. By means of the key and the sending device, the dispatcher selects the desired station, the apparatus at the other stations being thereupon disconnected from the control trunk. The selected station automatically transmits a distinctive signal to the dispatcher's telephone to provide a check upon the selection.

Upon further operation of the sending de-

vice, supervisory apparatus at the selected station is operated and a supervisory signal is transmitted to the dispatcher's receiver. The supervisory apparatus is operated by a device that is controlled by the gate of the turbine to indicate the gate opening, which is proportional to the load, and by a float suitably arranged to indicate the depth of water in the forebay. Thus by one indication the kilowatt input of the station may be ascertained. The condition of other apparatus may be similarly indicated to the dispatcher. In addition, control apparatus at the substation may be selected by the sending device and operated to perform any desired function, such as starting or stopping the turbo-generators, opening or closing valves or switches, etc. A telephone set is located in each station and so arranged that each station may be signalled and telephonic communications may be had over the control trunk between the several stations.

Other objects of my invention will appear from the following detailed description of a system which embodies the invention, as illustrated on the accompanying drawings.

Referring to the drawings, Fig. 1 illustrates the telephone and control equipment at the control station together with the substation equipment at one generating station, and

Fig. 2 illustrates the apparatus at a second generating station connected to the same control trunk.

Fig. 3 illustrates a modified form of member 60, Fig. 1.

In the drawings, I have shown the relays, switches and other apparatus schematically, as the detailed construction of the same is well known and forms no part of the present invention. The relays may be similar in construction to those disclosed in United States Patent No. 1,189,891 to H. G. Webster. Certain of the relays are sluggish or slow-release relays in which the armature is held up for an interval after the relay is deenergized. Such relays are provided with a copper sleeve upon the heel of the core and I have shown them by a convention which is suggestive of their construction.

Referring to Fig. 1, the dispatcher's equipment 1 comprises a transmitter 2 and a re-

ceiver 3 connected through condensers 4 to the conductors 5 and 6 of the control trunk extending to the substations. The dispatcher is also provided with a key 7 and a circuit interrupting or sending device 8. Through the contacts of the key 7, the conductors 5 and 6 are connected to ground and battery, the connection being reversed from that shown when the key is operated.

- 10 The sending device 8 enables the dispatcher to interrupt the circuit a desired number of times in rapid succession, thereby causing the operation of certain apparatus at the substations, as will appear. Obviously, 15 a simple push-button contact or key might be used instead of the sending device 8, but I prefer to use a calling device such as is commonly employed in automatic telephone systems. The general arrangement of calling 20 devices of this kind is well known and needs no further description.

- At each substation there is a polarized relay 9 or 109, as the case may be, controlling the association of the sending device 8 with the apparatus at the substation. Normally, the relays 9 and 109 are in inactive position with their contacts open. Upon the actuation of key 7, however, the polarity of the control trunk 5, 6 is reversed and the relays 30 9 and 109 are energized and close their contacts. This renders the apparatus at each substation operative, so that it responds to the sending device 8. The sending device 8 is now operated to select the desired substation. The apparatus at the other substations is rendered inoperative by this selection and remains in this condition until the key 7 which is of the type which remains set in the position last placed is again operated 40 to restore the polarized relays to normal. Upon further operation of the sending device 8, desired operations may be effected at the station selected.

- At each station, there are provided circuit-controlling devices, such as 60 and 160, which are controlled by both the gate opening of the turbine and by a head of water in the forebay so that the power input in kilowatts of the station may be indicated 50 to the dispatcher with one operation. The devices 60 and 160 comprise discs 63 and 163 that are operated by means of chains 64 and 164 controlled by devices 61 and 161 that are operated responsive to the gate opening of the turbines. Weights 65 and 165 are attached to the ends of the chains 64 and 164, respectively, in order to cause the operation of the discs 63 and 163.

- The discs 63 and 163 carry ten contacts, 60 such as those at 66 and 166, which are connected to various bank contacts accessible to wipers 41 and 141 of the rotary sending switches at the various substations. Bank contacts, such as 66 and 166, are adapted to 65 be engaged by wipers 67 and 167. The wip-

ers 67 and 167 are operated by shafts 68 and 168 to which are attached gears 69 and 169. The gears 69 and 169 are rotated by chains 70 and 170 that are controlled by the floats 62 and 162. Weights 71 and 171 are attached to 70 the chains 70 and 170, respectively, for giving proper operation of the chains.

It will be noted that the disc member 63 is under the control of the gate and assumes different positions in accordance with the degree of opening of the gate. The position 75 of the disc member 63 determines the contact upon which the wiper 67 rests so that this position is determined by the gate opening. The wiper 67, on the other hand, is under the control of the water level through the shaft 80 68, member 70 and float 62. The particular contact point upon which wiper 67 will rest therefore depends, it will be seen, both upon the gate opening and water level so 85 that this position always determines the power input to the generator. When the water head is low, a larger gate opening is necessary for the same power input as compared to a system with a higher water head. 90

The telephones at the different stations are connected through condensers 4, 94 and 194 to the control trunk 5, 6. The control trunk may therefore be used for signalling and communication whenever it is not in use for supervising and controlling purposes. The telephone circuits are similar to the ordinary local battery magneto circuits. A person desiring to converse with a party at another station listens in his receiver to make sure 100 that the control trunk is not in use and then operates his magneto to ring the code signal of the wanted station in the usual manner. Upon the response of the party at the wanted station by removing his receiver from the 105 switchblock, the talking circuit is completed and conversation may be carried on.

The detailed operation of the system is as follows:

It will be seen that, as the gate opening is 110 varied, the device 61 is operated and, consequently, the disc 63 is rotated to move one of the bank contacts into engagement with the wiper 67. The wiper 67 is moved by the operation of the float 62. The bank contact 115 which is engaged by the wiper 67 thus depends upon the gate opening and the head of water in the forebay. As the result of these two indications giving the input of the station, the bank contact with which 120 the wiper 67 is in engagement gives the approximate kilowatt input of the station. By varying the number of bank contacts, such as 66, the kilowatt input may be indicated to any degree of accuracy desired. 125

When the gate opening is increased, the disc 63 is rotated in a clockwise direction, as indicated by the arrow. When the water level rises, the wiper 67 is rotated in a counter-clockwise direction, as indicated by 130

the arrow. The operation of the device 160 at the second substation is the same as that described.

It has been assumed that the amount of power is directly proportional to the gate opening. Theoretically, the gate opening is not quite directly proportional. To receive absolutely accurate indications, the disc 63 may be eccentric, as shown in Fig. 3, to correspond to the proper proportions.

The dispatcher operates the key 7 to reverse the polarity of the control trunk 5, 6 whereupon relays 9 and 109 close their contacts and establish energizing circuits for the slow relays 19 and 119. A circuit is now closed from grounded battery through the left-hand make contacts of key 7, conductor 5, in parallel through the windings of relays 18 and 118, the front contacts of relays 19 and 119, the back contacts of relays 25 and 125, conductor 6 to ground at the right-hand make contacts of key 7.

Relays 18 and 118 become energized and close through their front contacts energizing circuits for slow relays 10 and 110, whereupon these relays become energized. The described operations are completed within a fraction of a second after the dispatcher operates the key 7.

The dispatcher now selects the desired substation. Assuming this to be the first substation (Fig. 1), he operates the sending device 8 to cause three short interruptions of the control circuit in rapid succession. Relays 18 and 118 respond to these current impulses, becoming deenergized and reenergized three times. The armatures of the slow relays 10 and 110 are maintained in their actuated positions during these impulses because of the rapidity with which the energizing circuits of these relays are reestablished.

Upon the first deenergization of relay 18, a circuit is closed from ground through its armature and back contact, the right-hand outer armature and back contact of relay 25, in parallel through the armatures and front contacts of relay 10 and the windings of slow relay 11 and motor magnet 20 to grounded battery. The relay 11 and the magnet 20 are then energized. The magnet 20 drives the switch wipers 22, 23 and 24 through a suitable pawl-and-ratchet or similar mechanism. The switch wipers travel over rows of contacts or terminals, as indicated, the arrangement being such that, upon each deenergization of the driving magnet 20, the wipers 22, 23 and 24 are stepped in unison from one contact to the next in a counter-clockwise direction. The detailed construction of a switch of this type is shown in United States Patent No. 1,107,153 to E. E. Clement. Another switch of this type is indicated at 38 to 41.

Upon the succeeding reenergization of re-

lay 18, the circuit of the relay 10 is reclosed and the circuit of relay 11 and the motor magnet 20 is broken. The magnet 20 becomes deenergized, stepping the wipers 22, 23 and 24 into engagement with their first contacts. The slow relay 11 does not restore its armatures immediately.

The following deenergization of relay 18 recloses the circuit of the relay 11 and the motor magnet 20, thereby retaining the armature of relay 11 and reenergizing the magnet. Subsequently, the relay 18 is reenergized, deenergizing the motor magnet 20 and stepping the switch wipers into engagement with their second contacts.

Upon the third interruption of the control circuit, the operation of relay 18 and the motor magnet 20 is repeated, whereupon the switch wipers 22, 23 and 24 are stepped into engagement with their third contacts. At the second substation relays 118, 111 and the motor magnet 120 will be operated in exactly the same manner as the corresponding relays 18 and 11 and the magnet 20 at the first substation. The switch wipers 122, 123 and 124 are now in engagement with their third contacts.

The controlling impulses have now ceased and relays 10, 18, 110 and 118 remain energized. After a moment, the slow relays 11 and 111 restore their armatures, the energizing circuits of these relays having been broken by the relays 18 and 118. A circuit is now closed from ground through the armature and front contact of relay 18, the armatures and back contacts of relays 11 and 21, wiper 23 in engagement with its third contact and the winding of relay 21 to grounded battery. The relay 21 is energized and locks up through its middle armature and front contact to ground at the middle armature and front contact of relay 19. It will be understood that this locking contact of relay 21 should be made before the energizing circuit described is broken at the back contact of the same relay, this being accomplished by the proper contact spring adjustment in the usual manner.

A circuit is now closed from ground at relay 18 through the left-hand armature and front contact of relay 21, and the winding of relay 12 to grounded battery. Another circuit is closed from ground at relay 18 through the outer right-hand armature and front contact of relay 21, wiper 24 in engagement with its third contact, and the winding of relay 26 to grounded battery. Relays 12 and 26 become energized. Upon the energization of relay 26, a circuit is closed from ground through its outer armature and front contact, the armature and back contact of slow relay 36 and the winding of the motor magnet 37 to grounded battery. The motor magnet 37 becomes energized and closes the circuit of relay 36. The

energization of relay 36 opens the circuit of the motor magnet 37 whereupon this magnet becomes deenergized, stepping the switch wipers 38, 39, 40 and 41 into engagement with their first contacts. Upon the subsequent deenergization of relay 36, the circuit of the magnet 37 will be reclosed. The described operations will be repeated and the switch wipers 38 to 41 stepped continuously therefore until the relay 26 becomes deenergized.

Upon the engagement of the wiper 40 with its first contact, a circuit is closed from ground through the inner armature and front contact of relay 26, wiper 40 and the magnet of the single stroke bell, represented at 15, to grounded battery. This bell is enclosed in a casing with an ordinary telephone transmitter 14 which is inductively connected through the armatures and front contacts of relay 12 to the control trunk 5, 6. The dispatcher will therefore be able to hear in his receiver 3 the sound of the bell 15. As the wiper 40 is stepped over its contacts, the bell 15 will be actuated three times and, if the dispatcher waits, the three strokes will be repeated indefinitely. In this way, a check is obtained upon the identity of the substation actually selected, the other substations being arranged to send back different signals.

Referring to Fig. 2, upon the deenergization of relay 111, as described, a circuit is closed from ground through the armature and front contact of relay 118, the armatures and back contacts of relays 111 and 121, wiper 123 in engagement with its third contact, and the winding of relay 125 to grounded battery. Relay 125 becomes energized and locks up through its left-hand armature and front contact to ground at the outer armature and front contact of relay 119. In its middle armature and back contact, relay 125 interrupts the circuit of relay 118, whereupon this relay becomes deenergized and causes the deenergization of relay 110. The impulse relay 118 is now open-circuited and will not respond to further operation of the sending device 8.

If the dispatcher had selected the second substation (Fig. 2) by producing four circuit interruptions with the sending device 8, the switch wiper 123 would have come to rest upon its fourth contact, causing the operation of relay 121. Relays 112 and 126 would then be operated and in conjunction with the switch 137, wiper 140, transmitter 114 and bell 115 would signal the dispatcher that station "4" had been selected. The apparatus at the first substation (Fig. 1) would have been rendered inoperative as described in connection with Fig. 2. It is obvious that as many stations may be taken care of in this way as desired, the relay 21 in each station being connected to differ-

ently positioned contacts of the rows with which the switch wipers 23 cooperate and the remaining contacts of these rows being arranged to operate the disconnecting relay 25.

Returning to Fig. 1, let us assume that the dispatcher desires to ascertain the approximate kilowatt load on the substation. He operates the sending device 8 to produce a single interruption of the control circuit. The relay 18 becomes deenergized, whereupon a circuit is closed from ground through the armatures and back contacts of relays 18 and 25 and in parallel through the windings of relay 11 and magnet 20 to grounded battery. The relay 11 and the magnet 20 become energized. Upon the subsequent energization of relay 18, the circuit of the relay 11 and the magnet 20 is broken, whereupon the switch wipers 22, 23 and 24 are stepped into engagement with their fourth contacts. The circuit of relay 26 is now broken and the operation of the bell 15 ceases.

After a short interval, the relay 11 restores its armature, whereupon a circuit is closed from ground at relay 18, through the armature and back contact of relay 11, the right-hand outer armature and front contact of relay 21, the wiper 24 in engagement with its fourth contact, and the winding of relay 30 to grounded battery. The relay 30 becomes energized and closes through its middle armature and front contact an energizing circuit for the motor magnet 37. The motor magnet 37, in conjunction with the interrupting relay 36, steps the wipers 38 to 41 continuously over their associated contacts so long as the wiper 24 remains upon its fourth contact and restores to normal when released.

When the wiper 39 engages its first contact, a circuit is closed from ground through the left-hand armature and front contact of relay 30, the audible signal 17 which may be a bell or buzzer, wiper 39, and the right-hand armature and back contact of relay 35 to grounded battery. A similar circuit is completed when the wiper 39 engages its third, fifth, etc., contacts, so that the load dispatcher hears in his receiver the intermittent operation of the signal 17.

When the wiper 39 is in engagement with its fifteenth contact, the eighth signal impulse is transmitted. When the wiper 39 engages its sixteenth contact, a circuit is closed from grounded battery through the winding of relay 35, wiper 41, contact 67 in engagement with its uppermost contact and the right-hand outer armature and front contact of relay 30 to ground. The relay 35 becomes energized, locks up through its left-hand armature and front contact to ground through a resistance coil, and opens in its right-hand armature and back contact

the described energizing circuit for the signal 17, whereupon the signals cease. When the wiper 41 engages its last contact, a circuit is closed to battery in shunt of the relay 35, thereby unlocking this relay to permit subsequent repetition of the signalling operation. This operation is repeated in an evident manner so long as the wiper 24 remains in engagement with its fourth contact.

The point at which the disconnecting relay 35 operates depends upon the bank contact with which the wiper 67 of the device 60 is in engagement. This bank contact is variable, depending upon the height of the water in the forebay and the gate opening, as described before. The signals sent back to the dispatcher thus indicate the kilowatt output of the station. The switch contacts with which the wiper 67 cooperates are connected to alternate contacts in the bank accessible to the wiper 41 so as to disconnect the signal 17 in the desired manner after a number of impulses have been sent in accordance with the position of the wiper 67.

It will be noted that the seventeenth contact of the bank contact set cooperating with the wiper 39 has been connected so as to operate the signal 17, though this contact is not normally effective. The greatest number of impulses that can normally be sent with the arrangement shown is ten. However, if the circuit through the wipers 31 and 41 to the relay 35 is broken or the relay 35 is rendered ineffective in some other way, eleven signal impulses will be sent by reason of the connection of the seventeenth contact of the wiper 39. This will indicate to the dispatcher that some derangement of the apparatus has prevented it from functioning properly.

If the dispatcher desires to effect some operation at the substation, he operates the sending device to select a relay, such as 27 or 28. These relays are connected to contacts of wiper 24, and upon selecting the desired relay by stepping the switch wipers 22, 23 and 24 under the control of the impulse relay 18 as described, a circuit is closed from battery at the relay through wiper 24, the outer right-hand armature and front contact of relay 21, armature and back contact of relay 11 and armature and front contact of relay 18 to ground. The relay, such as 28, becomes energized and closes a circuit through its armature and front contact for effecting the desired operation. For instance, this circuit closure may be utilized to close or trip the circuit breakers, connecting the substation to the transmission line, or to operate a motor controlling the turbine valve. Any desired number of these controlling relays may be connected to the contacts of wiper 24 in the same manner as 27 and 28.

When the dispatcher has completed the desired operations at the first substation, he restores the key 7 to normal, thereby opening the contacts of the polarized relays 9, 109. Upon the restoration of relay 9, relay 19 becomes deenergized. The deenergization of relay 19 opens the circuits of relays 18 and 21. The deenergization of relay 18 causes the deenergization of relays 10 and 12. Upon the deenergization of relay 19, circuits are closed from ground through the armatures and back contacts of relay 19, wipers 22 and 38, normal contacts of magnet 20 and relay 36 and the windings of the magnets 20 and 37 to grounded battery. The motor magnets 20 and 37 step their respective wipers to normal position, when this described circuit is broken by the wipers 22 and 38. The apparatus at the first substation is now completely restored to normal.

Upon the restoration of relay 109, as described, relay 119 becomes deenergized. In its middle armature and front contact, relay 119 opens the locking circuit of relay 125 whereupon this relay becomes deenergized. In its armatures and back contacts, relay 119 closes energizing circuits for the motor magnets 120 and 137, whereupon the switch wipers are stepped to their normal positions.

Obviously, a greater number of stations may be connected to the control trunk 5, 6 than those shown. As in the case of the stations shown, the selecting relays 21 are connected to separate or unused contacts of the wipers 23 in each station. The additional contacts of the wipers 24 are connected in order to the relays 30, 26, 28 and 27. These relays should be connected in the same order in all stations so that a certain code number represents similar operations in all stations and only the first or station-selecting number is different for each station.

I have described in detail one embodiment of my invention in order that it may be readily understood and in accordance with the requirements of the patent statutes. I do not consider my invention limited to the embodiment herein shown and described, however. In particular, my invention is not limited to any particular type of substation, though I have described it in connection with so-called hydro-electric generating stations, but in certain aspects it is applicable to other stations or installations electrical or otherwise, of radically different nature.

I claim as my invention:

1. In a signalling system, a first station, a second station including a switch comprising a bank of contacts, a movable member comprising a bank of contacts each of which is connected to an individual contact on said switch, means for moving said member in accordance with a variable quantity, a contact member arranged to wipe

over said movable member contacts, means for moving said movable contact member in accordance with a second variable quantity whereby said contact member will engage one of said movable member contacts depending upon both of said variable quantities and a code transmitter means including circuit connections between said switch bank and said movable member for transmitting a code combination of impulses to said first station in accordance with the contact engaged by said contact member.

2. In a signalling system, a first station, a second station including a switch comprising a bank of contacts, a movable member comprising a bank of contacts each of which is connected to an individual contact on said switch, a source of power comprising a body of water having a variable head, a gate having a variable opening for said body of water, means for moving said member in accordance with the variations in opening of said gate, a contact member arranged to wipe over said movable contacts, means for moving said contact member in accordance with the variations in said water head whereby said contact member will engage a contact on said movable contact member under control of both said water head and gate opening and a code transmitter means including circuit connections between said switch bank and said movable member for transmitting a code combination of impulses to said first station in accordance with the contact engaged by said contact member.

3. In a signalling system, a first station, a second station including a normally non-operating switch comprising a bank of contacts, a signalling line connecting said stations, a movable member comprising a bank of contacts each of which is connected to an individual contact on said switch, means for moving said member in accordance with a variable quantity, a contact member arranged to wipe over said movable member contacts, means for moving said movable contact member in accordance with a second variable quantity whereby said contact member will engage one of said movable member contacts depending upon both of said variable quantities, code transmitter means including circuit connections between said switch bank and said movable member and including said signalling line for transmitting a code combination of impulses to said first station in accordance with the contact engaged by said contact member, means including said signalling line for transmitting impulses from said first to said second station, means at said second station responsive to said impulses for starting said switch into operation for transmitting said code to said first station and an audible signalling device at said first station responsive to said code.

In testimony whereof, I have hereunto subscribed my name this 27th day of May, 1924.

MAURICE E. REAGAN.