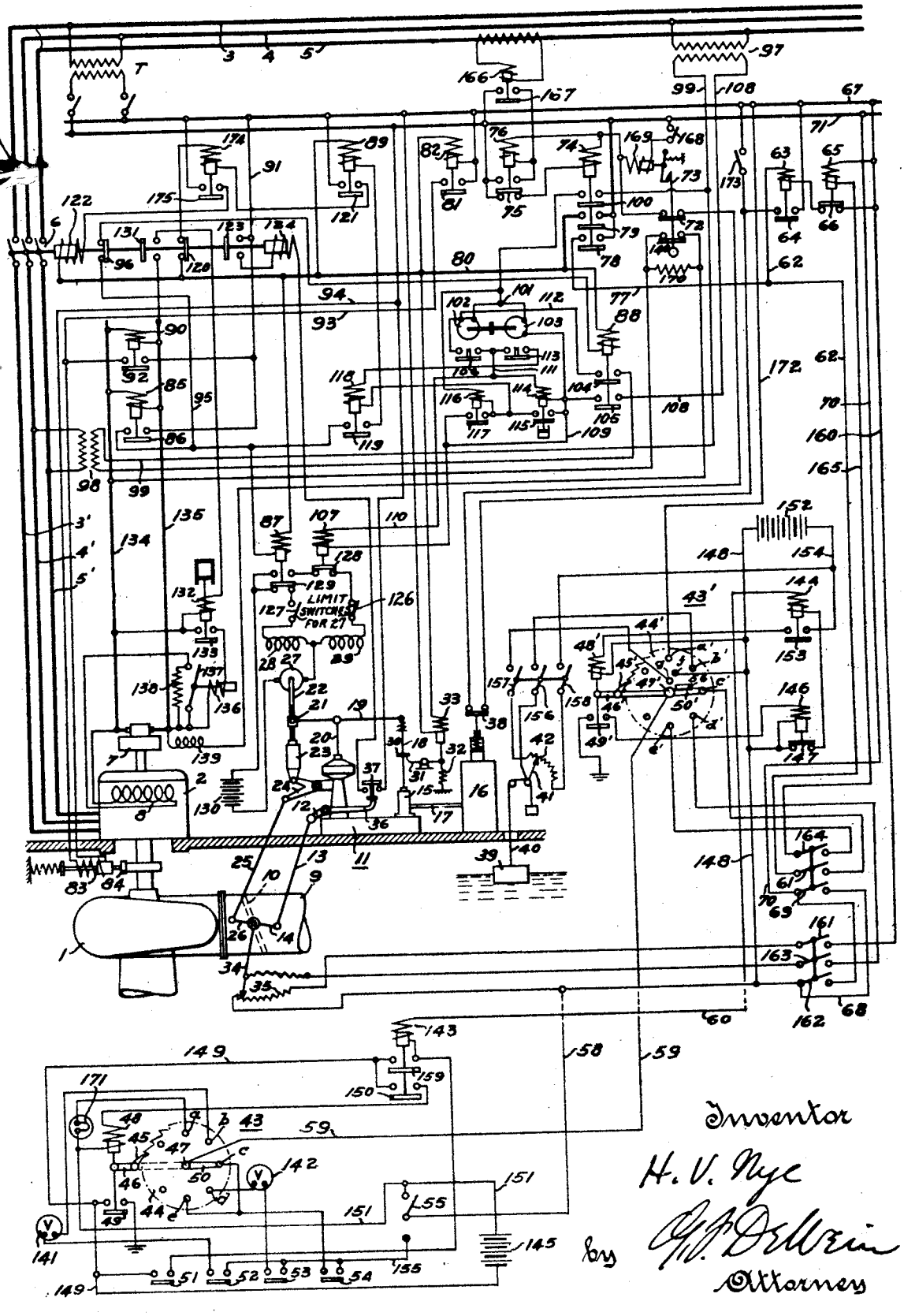
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SYSTEM OF DISTRIBUTION

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SYSTEM OF DISTRIBUTION

Application filed April 4, 1927. Serial No. 180,710.

This invention relates to systems of distribution and more particularly to systems in which use is made of an electrical generating unit comprising a prime mover and generator which unit may be started and stopped automatically either by control at the generating station or from a distance.

It is an object of the invention to provide such a system which may be simply and efficiently controlled and in which the operator at the distant control station may determine, more particularly by measurement, various conditions at the generating station.

Other objects will appear hereinafter as the description of the invention proceeds.

The novel features of the invention will appear from this specification and the drawing accompanying the same, forming a part thereof, and illustrating one embodiment of the invention, and all these novel features are intended to be pointed out in the claims.

The single figure of the drawing shows in diagrammatic form how the invention may be applied in the control of a hydroelectric generating station.

Referring to the drawing the prime mover 1 is here shown as a hydraulic turbine, although other forms of prime mover may be utilized. The turbine 1 is adapted to drive a generator 2 which is connectible to a distribution system comprising in the illustrated instance the three phase line 3, 4, 5. As will be obvious from a reading of the specification and claims many of the features of the invention may be applied in systems other than alternating current. Connection of the generator 2 to the lines 3, 4, 5 may take place through the lines 3′, 4′, 5′ connected to the generator, and by means of a circuit breaker 6. An exciter 7 for the generator may be provided and driven if desired from the same shaft as the generator. The exciter is adapted to feed a field winding 8 of the generator 2.

The prime mover may have operating fluid led thereto through a conduit 9 and the admission of operating fluid may be controlled by means of a gate 10. For the sake of simplicity the admission controlling means has been shown as a butterfly valve though it is of course obvious that such control may take place in the usual manner as by means of the guide vanes of the turbine or a needle nozzle, in case the prime mover is of the hydraulic type, or by other means suitable to the particular type of prime mover whether of hydraulic or other type. The turbine 1 may be controlled by means of a governor indicated generally by the reference numeral 11. The servo-motor of the governor has not been shown in detail inasmuch as the details thereof form no part of the present invention. The servo-motor is adapted to swing an operating crank 12 connected by means of a rod 13 to a crank 14 associated with the gate 10. Fluid under pressure may be admitted to the servo-motor to move the crank 12 one way or the other by means of a regulating valve 15 of any suitable known form. A tank 16 indicates any suitable source of fluid under pressure, the fluid being led to the regulating valve 15 through a pipe 17. The regulating valve 15 is provided with an operating stem 18 suitably pivoted to one end of a floating lever 19. The position of the floating lever may be controlled by means of a speed responsive shaft 20. The shaft 20 may be caused to rise and fall in response to flyballs contained within the casing diagrammatically indicated and the flyballs may be driven in any suitable manner from the prime mover or generator. The other end of the floating lever 19 may be provided with a nut 21 suitably swiveled and this nut is threaded to receive a screw 22 which is suitably operatively related to one element of a dash pot or compensating device 23 of any well known form. The dash pot 23 has the other of its members pivotally connected to a bell crank 24 in turn connected by means of a rod 25 to a crank 26 operating in unison with the gate 10. The screw 22 may be rotated by means of a split field motor 27, or any other suitable form of reversible motor. The motor 27 is provided with two field windings 28, 29. Rotation of the screw 22 in one direction or the other causes the nut 21 to raise or lower the corresponding end of the floating lever 19 to change the speed setting of the governor.

The stem 18 of the regulating valve is here shown as provided with a collar 30 which is engaged by a pivoted finger 31 biased in a clockwise direction by means of a spring 32. The bias of spring 32 may be overcome by means of a solenoid 33. When the solenoid 33 is deenergized the finger 31 acts to place the regulating valve 15 in the position in which fluid under pressure is admitted to the servo-motor to cause the crank 12 to rotate in a counter clockwise direction to thereby close the gate 10.

In order to provide for an indication corresponding to the gate opening a member such as an arm 34 is provided to move in unison with any portion of the gate operating mechanism, the arm 34 being here shown as attached to the gate shaft itself. This arm may be provided with a contact forming the movable element of a potentiometer and adapted to move over and contact with a potentiometer resistance 35. Also adapted to move in unison with the gate operating mechanism is an arm 36 here shown as associated with the crank 12. The arm 36 is adapted to open a switch 37 when the gate reaches its closed position for a purpose to be hereinafter set forth.

The source of supply 16 of fluid under pressure is here shown as provided with means responsive to the fluid pressure of said source for operating a switch 38 connected as will appear. When the fluid pressure in tank 16 is below a predetermined amount the switch 38 is open and when the pressure rises to a predetermined amount the switch 38 is closed.

In order to provide for an indication proportional to the supply of operating fluid for the prime mover a float 39 may be utilized which float is connected by a cord 40 to a counter weight and adapted to swing an arm 41 which may form the movable element of a potentiometer and is adapted to make contact with a potentiometer resistance 42.

The apparatus at the distant station from which the generating unit may be controlled includes a selector indicated in general by a numeral 43. The selector includes a dial 44 fastened to a shaft 47 and provided with teeth adapted to be engaged by a pawl 45 carried by an arm 46. The arm 46 is movable independently of shaft 47 though it is preferably pivoted concentrically with said shaft. The outer end of arm 46 may be reciprocated by means of a solenoid 48. When the solenoid 48 is energized a switch 49 closes its contacts for a purpose to be described. Operating in unison with the dial 44 is an arm 50 which is adapted to make contact with any one of a plurality of relatively stationary contacts a, b, c, d, e. At the generating station is provided a selector 43′ having parts 44′, 45′, 46′, 47′, 48′, 49′, 50′, a', b', c', d' and e', corresponding to the parts of the selector 43 indicated by the corresponding unprimed reference characters. The selector 43′ is provided with an additional movable contact 56 suitably mounted on and insulated from the arm 50′. The contact 56 is adapted to bridge relatively stationary contacts f, g, when the arm 50′ makes contact with the contact b'.

At the remote control station a number of control switches 51, 52, 53 and 54 are provided and the connections of the system will be best understood by a consideration of the operations performed when particular ones of the control switches are closed. If it be assumed that the parts of the system are as shown in the drawing, except as hereinafter noted, a double throw switch 55 at the control station being closed on its lower contact, and that the switch 54 be closed we may trace a circuit from the lefthand contact of switch 54 to contact c, arm 50 to a conductor 59 extending from the control station to the generating station and connected to arm 50′, to contact c' through a contact 61 of a three pole switch which is assumed closed, through a conductor 62 through a relay coil 63 through contact 66 of a relay 65 to a bus 67. From the righthand contact of switch 54 a circuit may be traced through conductor 155, switch 55, a conductor 58 which extends from the control station to the generating station, through conductor 68, through switch contact 69, to conductor 70, to a bus 71: It is apparent that it is not material whether the three pole switch comprising members 161, 163, 162 is closed or not. The buses 67, 71 are supplied from two of the conductors of the system 3, 4, 5 by means of a transformer T. The circuit thus traced causes the energization of relay 63 and the closure of its contact 64 thereby completing a circuit from bus 67, through contact 64, fluid pressure responsive switch 38, contact 72 of a latched-in switch 73, an operating coil 74 of a master relay, through a movable contact 75 of a relay 76, to the bus 71. The relay 76 is normally deenergized and the circuit just traced is through its normally closed or back contacts. The energization of coil 74 causes the closure of the master relay thereby closing its contacts 78, 79 and 100. The closure of contact 78 provides a maintaining circuit for relay 63, from bus 67, through contact 66, coil 63, conductor 77, contact 78, to bus 71. The closure of contact 79 of the master relay connects an auxiliary bus 80 to the bus 71 and the energization of bus 80 energizes solenoid 33 thereby swinging finger 31 in a counter clockwise direction to thereby free the stem 18 of the regulating valve. The regulating valve then moves to a position in which fluid under pressure is admitted from tank 16 to the servo-motor to open the gate 10 under the control of the governor. At a

predetermined small opening of the gate 10 the switch 37 closes.

Energization of bus 80 also energizes a brake control relay 82 as is clear. The closure of contacts 81 of the brake control relay energize a control means for a brake shoe 84 conducted to engage a rotating part of the generating unit in any suitable manner. The brake controlling means is here diagrammatically shown as a solenoid 83 adapted to overcome the biasing spring of the brake 84 to thereby release the brake. The coil 83 is energized from bus 67 through contact 81, conductor 93, coil 83, conductor 94, to bus 71.

When the unit has come up to a predetermined speed the voltage of the exciter 7 is sufficient to energize a relay 85 connected across the exciter buses 134, 135. The closure of a contact 86 of relay 85 permits, through its control of relays 87, 88 and 89, the rest of the apparatus to operate as will appear. The relay 87 is energized from bus 67, through conductor 91, contact 86, coil 87, to auxiliary bus 80. The relay 87 is provided with a contact 129 which normally closes back contacts and when coil 87 is energized it closes front contacts for completing a circuit from one terminal of a source of current 130 through contact 129, through a normally closed relay contact 128, through a limit switch 126, through the field winding 29 and the armature of the motor 27 to the other terminal of the source. The motor 27 now runs in such a direction that the nut 21 will be moved to raise the speed setting of the governor. The switch 126 may be suitably operated in any manner by a predetermined travel of nut 21 or of revolutions of screw 22. The speed setting of the governor may be thus gradually raised and the opening of the gate 10 will be still further increased to thereby increase the speed of the unit. Simultaneously with the closure of relay 85, a relay 88 is energized from bus 67, conductor 91, contact 86, conductor 95, an auxiliary contact 96 associated with and closed when the circuit breaker 6 is open, through coil 88, to bus 80. The energization of relay 88 closes a pair of contacts 104, 105. The closure of these contacts supplies an automatic synchronizing device. This automatic synchronizing device may be, in certain aspects of the invention, of any suitable form and adapted to close predetermined circuits when the frequencies of the generator 2 and the distribution system, when of the alternating current type, are substantially equal. The automatic synchronizer as here shown includes a pair of motors 102, 103 adapted to run at the same speed when the frequencies of the generator and system are equal. The motors are fed from a pair of transformers one of which 97 is shown as having its primary connected to the lines 4, 5 and the other of which 98 is shown as having its primary connected to the lines 4', 5'. The secondaries of transformers 97, 98 have their lefthand and upper terminals respectively, as viewed in the drawing, connected by means of a common conductor 99. A circuit may be traced from conductor 99 through contact 100 of the master relay 74 to a common point of connection between two of the motor terminals, through motor 102, through contact 104 of relay 88 to the lower terminal of transformer 98. From the common point of connection 101 the circuit may be traced through motor 103 through contact 105 of relay 88 and conductor 108 to transformer 97. The motors 102, 103 are adapted to drive a differential which controls a contact 106, and the motors also control a contact 113 which is adapted to be closed by the motors when the generator and distribution system are in phase, all as shown and described in applicant's Patent No. 1,685,746, issued September 25, 1928.

Inasmuch as the particular form of this device forms no part of the present invention and is claimed in said copending application no further description thereof is necessary except as to the particular manner in which it is utilized in the present system. Assuming the system 3, 4, 5 to be of the 60 cycle type the synchronizing apparatus may be so adjusted that the contact 106 will close when the frequency of the generator is say 59 cycles. The closure of contact 106 completes a circuit for a relay 107 as follows: from conductor 108, through contact 105, conductor 109, relay coil 107, conductors 110, 111, contact 106, conductor 112, contact 104 to the lower terminal of and through transformer 98, conductor 99, through transformer 97 back to conductor 108. The contacts 128 of relay 107 consequently open every time transformers 97 and 98 are in phase and reclose when they are out of phase. It will be remembered that by the closure of the front contacts of relay 87 the motor 27 has been caused to increase the speed setting of the governor. The opening and closing of relay 107, the rapidity of which depends upon the difference in speed or frequency as between the generator and system, causes the motor 27 to cease rotation for longer intervals as the unit approaches synchronous speed. When the generator and system are substantially in phase a retarded relay 114 is effectively operated to close its contacts 115. It will be noted that the operating coil of relay 114 is fed in parallel with relay 107 and therefore a certain amount of current will flow through it every time the generator and system are in phase. If the energization is only momentary the movable member of the relay will tend to drop back to its initial position but as the impulses become longer the member will not drop completely back before another impulse is received so that the movable member gradually approaches the circuit closing position and closes when substantial

phase equality exists for a sufficiently long period. Closure of contact 115 energizes a relay 116 through conductor 108, contacts 105 and 115, coil 116, conductor 101, contact 100 to conductor 99. The relay 116 closes a contact 117 which short circuits contact 115 so that it is immaterial whether the retarded relay 114 drops back or not. A more accurate response to phase equality is secured by the operation of contact 113 the closure of which energizes a relay 118. The contact 113 is closed effectively when the motors 102, 103 are exactly in phase. The relay 118 is energized through conductor 109, contact 117, coil 118, contact 113 to conductor 111. The closure of relay 118 energizes relay 89 through conductor 91, contact 86, contact 119, coil 89 to auxiliary bus 80, thereby energizing a cut-off contactor 174 which closes its contact 175. The cut-off contactor is energized from bus 67, contact 121, coil 174 and an auxiliary switch 120 controlled by the circuit breaker 6 and normally closed when the circuit breaker is open, to bus 80. The closure of the cut-off contactor 174 energizes a closing magnet 122 for the circuit breaker 6 from bus 67 through contact 175 to bus 80.

Without reference to the details of the circuits and auxiliary devices, as hereinbefore described in detail, the sequence of operation of the principal devices set in action, when it is desired to put the generator on the line, is as follows. The selectors 43, 43′ being in the proper position, as shown on the drawing, the switch 54 is closed thereby energizing relay 63 which in turn energizes master relay coil 74 the closure of which maintains the circuit of relay 63. The energization of master relay 74 frees the turbine governor for action by energizing coil 33, and causes release of the brakes through energization of relay 82. The gate 10 is consequently opened under control of the governor and when the unit has come up to a predetermined speed the relay 85 closes its contact 86 thereby permitting the remainder of the apparatus to function. Closure of contact 86 causes relay 87 to set the motor 27 in operation to raise the speed setting of the governor thereby still further opening the gate 10. Meanwhile the relay 88 has also been energized through contact 86, thereby setting in operation the automatic synchronizing device which includes motors 102, 103. When the frequency of the generator has risen to, say, 59 cycles, the automatic synchronizing device closes contact 106 thereby closing the circuit of relay 107 which acts, as hereinbefore described in detail, to gradually reduce the resultant speed of motor 27 as the generator approaches the frequency and phase of the line. By the time there is substantial phase equality, relay 114 is closed thereby energizing relay 116 thus making possible the energization of relay 118 when the automatic synchronizer closes its contact 113 upon phase equality between generator and line. The closure of relay 118 causes energization of the relay 89 which in turn causes energization of cut-off contactor 174 and the closing magnet 122, thus closing the circuit breaker 6 and connecting the generator to the line.

The closure of the circuit breaker 6 is adapted to operate a number of auxiliary contacts of which 96 and 120 are opened, and 131 and 123 are closed. The closure of contact 123 energizes a holding magnet 124 from bus 67, contact 123, coil 124 through the gate operated switch 37 to bus 71. The opening of auxiliary contact 120 deenergizes the cut-off contactor 174 which thereby deenergizes the closing magnet 122. The opening of the auxiliary contact 96 deenergizes relay 88 thereby stopping the automatic synchronizer motors 102, 103 and also deenergizing relays 114, 118, 116 and 107. The relay 107 being no longer alternately energized and deenergized remains closed and the motor 27 consequently continues to run in a direction to increase the speed setting of the governor until stopped by a limit switch 126. The limit switch 127 now closes but inasmuch as relay 87 is energized the closure of switch 127 produces no immediate effect.

The closure of auxiliary contact 131 energizes a retarded relay 132 from the exciter buses 134, 135 and the closure of contact 133 of relay 132 energizes a relay 136 from the exciter buses thereby short circuiting a resistance 138 in series with the main field 8 of the generator thereby causing the generator to take a load.

The exciter 7 is provided with a field winding 139 fed from exciter bus 135 through said field winding, through a contact 140 of the latched in switch 73 to exciter bus 134. Across the contacts 140 is connected a resistance 170 for a purpose to be hereinafter described.

A relay 90 responsive to exciter voltage is provided for shorting the contacts of brake control relay 82 as is clear from the drawing. The relay 90 closes at a predetermined exciter voltage and one of its functions is to prevent the application of the brakes until the speed of the unit, and therefore the exciter voltage, has dropped to a predetermined value.

If the operator at the remote control station desires to test or measure the water level at the generating station he first throws switch 55 into its upper position and closes switch 51. This energizes relays 143 and 144 the circuit for which may be traced from battery 145, conductor 149, switch 51, coil 143, conductor 60 which extends to the generating station, coil 144, a relay contact 147, conductor 148, through a conductor 58 extending between the generating and control stations, through switch 55 to the other side of battery 145. The energization of relay 143

closes a holding circuit for itself through a contact 159 as is clear. The closure of a contact 150 of relay 143 causes the energization of the solenoid 48 from battery 145, conductor 149, contact 150, coil 48, conductor 151 to the other side of the battery. The energization of solenoid 48 causes the arm 46 to swing in a clockwise direction thereby causing the pawl 45 to move the contact arm 50 in the same direction one notch. The energization of relay 144 causes the energization of solenoid 48′ from a battery 152, conductor 148, coil 48′, a contact 153 of relay 144, conductor 154 to the other side of battery 152. The energization of solenoid 48′ causes the pawl 45′ to rotate contact arm 50′ in a clockwise direction the same amount that contact arm 50 is rotated by solenoid 40. The energization of solenoids 48 and 48′ causes the closure of contacts 49, 49′ respectively controlled by these solenoids thereby closing a circuit from conductor 149 to contact 49 to ground, to contact 49′ to a relay coil 146, conductors 148, 58 through switch 55, to the other side of battery 145, thereby causing relay 146 to open its contact 147 and deenergizing relays 143 and 144 to thereby cause the cores of solenoids 48, 48′ to drop back to the deenergized position. The circuit through contacts 49, 49′ previously traced is consequently opened and relay 146 is deenergized thereby reclosing contact 147. If the switch 51 is still closed or is closed again the same cycle of operations will be repeated until the contact arm 50 is rotated in a clockwise direction sufficiently to reach the desired contact, in this instance contact *b*. At the same time the contact arm 50′ will reach the contact *b*′.

When the operator sees that the correct contact is made by the arm 50 he stops the notching action by opening the switch 51 and throws the switch 55 into its lower position. He then closes the switch 52 and reads the water level on a volt meter 141 which may be calibrated in terms of head of water. The volt meter 141 is fed from the potentiometer 42 in the following manner. The potentiometer 42 itself is fed from conductor 148 through contacts *f*, *g* which are bridged by a contact 56 carried by arm 50′ when the arm 50′ is in position *b*′, through a switch member 157 through potentiometer 42, switch member 158 to the other side of the battery 152. The circuit for the volt meter may be traced as follows: from switch 55, conductor 155, switch 52, volt meter 141, contact *b*, arm 50, conductor 59, through arm 50′ contact *b*′, through a switch contact 156 to the movable contact arm 41 of the potentiometer. From the other side of switch 55 the circuit passes through conductors 58, 148, through auxiliary contacts *f*, 56, *g*, switch member 157 to the lefthand terminal, as viewed in the drawing, of the potentiometer 42. The volt meter 141 is consequently fed by the drop of potential between the lefthand terminal of potentiometer 42 and the point of contact between 42 and contact arm 41. This voltage drop is obviously proportional to the head of water.

Separate batteries 130 and 152 have been shown for the sake of convenience in illustration. It is, however, clear that a single source of current may be used.

If the operator desires to determine the degree of gate opening he proceeds as hereinbefore described to step the contact arms 50, 50′ around until contact is made with contacts *d*, *d*′. The switch 55 is then again thrown to its lower position and a switch 53 is closed, the operator reading the amount of gate opening on a volt meter 142 suitably calibrated. The potentiometer 35 which is controlled by means of the gate is fed with current as follows: from bus 67 through a conductor 160, a switch contact 161, through potentiometer 35 to a switch contact 162 through conductor 70 to bus 71. The volt meter 142 is fed from contact arm 34, a switch contact 163 to contact *d*′, arm 50′, conductor 59, contact arm 50, contact *d*, volt meter 142, switch 53, conductor 155, switch 55, conductor 58, to the lefthand terminal of potentiometer 35 as viewed in the drawing. The voltage fed to the volt meter 142 is consequently proportional to the opening of gate 10.

The float potentiometer 42 is as described preferably fed from a storage battery rather than from the a. c. buses 67, 71 as is potentiometer 35, because greater accuracy of the reading of water level is desired. Otherwise the potentiometer 42 might as well be fed from the a. c. buses.

Assuming that the generating station has been started and is running and it is desired to stop the same at will the operator may run the contact arms 50, 50′ in a manner hereinbefore described until contact is made with contacts *e* and *e*′. The switch 55 is then again thrown down and the switch 54 is closed. A circuit is thereby established from the lefthand side of switch 54 as viewed in the drawing to contact *e*, contact arm 50, conductor 59, contact arm 50′, contact *e*′, a switch contact 164, a conductor 165 through a coil 65, controlling a relay contact 66, to bus 67. From the righthand side of switch 54 a circuit is completed through switch 55, conductor 58, conductor 68 (if switch 162 is open), a switch contact 69, conductor 70 to bus 71. The energization of relay 65 causes the deenergization of relay 63 and consequently the deenergization of the master relay 74. All relays fed from auxiliary bus 80 are consequently deenergized resulting also in the deenergization of coil 33 so that the regulating valve 15 is returned to a position in which fluid is admitted to the servo-motor of the governor to move the gate 10 to closed position. The relay 87 drops and closes its back

contact 129 so that the motor 27 is energized from battery 130 through limit switch 127 and field winding 28, thereby running motor 27 in a direction to decrease the speed setting of the governor. The motor 27 runs until stopped by the limit switch 127, the limit switch 126 then re-closing bringing these parts again to the position shown on the drawing. Deenergization of the brake control relay 82 does not however at once apply the brakes for the reason that relay 90, being fed from the exciter buses still holds contact 92 closed. When the speed decreases to a predetermined value by reason of the closure of gate 10 the relay 90 is effectively deenergized at a predetermined exciter voltage and the brakes are applied by the deenergization of brake control magnet 83.

When the gates are almost closed the gate control switch 37 opens thereby deenergizing holding coil 124 of circuit breaker 6. The circuit breaker 6 consequently opens and the opening of auxiliary switch 131 opens the circuit of relay 132 thereby inserting resistance 138 in the generator field winding circuit. The system is now in the same condition as shown in the drawing and the unit is shut down.

Under abnormal conditions the sequence of stopping operations is somewhat different. For example, if there should be an overload a relay 166 closes its contacts 167 thereby completing a circuit from bus 71, contact 167, the coil 76 controlling relay contact 75, contact 72 of the latched-in switch 73 through pressure controlled switch 38, contact 64 to bus 67. The opening of contact 75 at the same time closes a holding circuit for coil 76 and opens the circuit of master relay 74. The opening of master relay 74 deenergizes the relays connected to bus 80 and the unit is shut down as hereinbefore described. The holding circuit for relay 76 may be traced from bus 71 through the front or upper contacts of relay 76, coil 76, contact 72, pressure switch 38, relay contact 64 to bus 67. It is to be noted that the opening of contacts 78 of relay 74 breaks the holding circuit for relay 63 thereby causing relay 63 to open. The contacts 64 of relay 63 in opening in turn break the holding circuit for relay 76 which is therefore restored to its lower position thus putting the circuits in condition for restarting of the plant.

In case abnormal conditions such as hot bearings or internal difficulties arise in the generating unit a switch 168 is automatically closed by such abnormal conditions thereby completing a circuit from bus 71 through contact 168, through a trip coil 169 for the latched-in switch 73, through a contact 72 of the latched-in switch, through pressure switch 38, to contact 64 to bus 67. The latched-in switch 73 is consequently released and the opening of contact 72 thereof deenergizes the master relay 74 resulting in the shutting down of the unit as previously described. The opening of contact 140 of the latched-in switch at once results in the introduction of resistance 170 in the field winding circuit of the exciter 7 thereby killing the generator field so as to prevent damage in case the closure of switch 168 has been due to internal electrical difficulty in the generator. The unit cannot be re-started if it has been shut down due to the closure of switch 168 until an attendant visits the station and manually re-closes the latched-in switch 73.

The sequence of operation of the principal elements of the control system in shutting down the hydro-electric plant from the control station without reference to the circuits and the auxiliary devices is as follows: The operator moves switch 55 to its upper position and closes switch 51 until contact arms 50 and 50′ are notched around to position *e* and *e′* respectively. The operator then moves switch 55 to its lower position and then closes switch 54. The closure of switch 54 energizes relay 65 which in opening deenergizes relay 63. Relay 63 in opening deenergizes master relay 74 which in turn deenergizes the auxiliary bus 80 thereby deenergizing relays 87 and 82 and also solenoid 33. The deenergizing of solenoid 33 causes the governor servo-motor to move the gate 10 towards its closed position thereby reducing the load on the generator. Relay 87 in opening closes its back contacts 129 and causes motor 27 to decrease the speed setting of the governor to its starting position. The opening of relay 82 leaves the control of brake 84 solely dependent on relay 90 which remains closed until the voltage of exciter 7 drops below a predetermined value. Switch 37 is opened when the gates are nearly closed thereby deenergizing the holding coil 124 which causes the main line circuit breaker 6 to open. The circuit breaker 6 in opening opens contact 131 which in turn deenergizes relay 132 thereby inserting resistance 138 in circuit with the generator field.

The sequence of operation of the principal elements of the system upon occurrence of an abnormal condition, such as overload, is briefly summarized as follows: Upon occurrence of excessive overload the relay 166 closes its contact thereby energizing relay 76 which in moving deenergizes master relay 74. Relay 74 in turn deenergizes the auxiliary bus 80 and breaks the holding circuit for relay 63 which in opening deenergizes relay 76 and restores this relay (76) to its initial position. The remainder of the sequence is precisely the same as above described.

Shut down due to the closure of switch 168 which is responsive to abnormal conditions such as hot bearings and the like is briefly restated as follows: Closure of switch 168 energizes trip coil 169 and causes contacts 140

and 72 of latched-in switch 73 to open. Contact 140 in opening inserts resistance 170 in series with the field winding of the exciter 7 to reduce the generator voltage substantially to zero. Contact 72 in opening deenergizes master relay 74 which in turn deenergizes the auxiliary bus and the remainder of the sequence is substantially the same as above described.

If the operator desires to test whether the selector arms 50, 50′ are operating synchronously he runs the arm 50 to the contact *a* in the manner hereinbefore described. If the arm 50′ has been at the same time run to contact *a′* a circuit will be established as follows: from bus 67 through conductor 172, button *a′*, arm 50′, conductor 59, arm 50, contact *a* through a device here shown as a lamp 171, through conductor 151 to the upper contact of switch 55, through conductors 58, 68, 70 to bus 71. The device 171 is therefore supplied with current from the buses 67, 71 and will thus indicate the synchronous operation (or lack of it) of the arms 50 and 50′. The device 171 may of course be a volt meter which may be utilized to test the voltage of the line 3, 4, 5.

The novel features of the herein disclosed signaling system are claimed in applicant's co-pending divisional application Serial No. 558,525, filed August 21, 1931.

It should be understood that it is not desired to limit the invention to the exact details of construction shown and described, for obvious modifications may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In a system for controlling electrical apparatus from a distance, a prime mover, a generator driven thereby, an exciter for said generator, a gate for controlling the admission of operating fluid to said prime mover, a speed governor for controlling said gate, means for releasing said governor to start said prime mover from rest, and means responsive to a predetermined exciter voltage for causing said governor to slowly increase the speed of said prime mover.

2. In a system for controlling electrical apparatus from a distance, a distribution system, a prime mover, a generator driven thereby, an exciter for said generator, a gate for controlling the admission of operating fluid to said prime mover, a speed governor for controlling said gate, means for releasing said governor to start said prime mover from rest, means responsive to a predetermined exciter voltage for causing said governor to slowly increase the speed of said prime mover, means for connecting said generator to said distribution system, and means for preventing the connection of said generator until said exciter voltage rises to a predetermined value.

3. In combination, an a. c. distribution system, a prime mover, an a. c. generator driven thereby, a speed governor for controlling the admission of operating fluid to said prime mover to bring said prime mover up to a predetermined speed, and means for raising the speed setting of said governor at a predetermined average rate while said prime mover is a predetermined amount below synchronous speed and for decreasing said average rate when said prime mover is nearing synchronous speed.

4. In combination, an a. c. distribution system, a prime mover, an a. c. generator driven thereby, a speed governor for controlling the admission of operating fluid to said prime mover to bring said prime mover up to a predetermined speed, means for raising the speed setting of said governor at a predetermined average rate while said prime mover is a predetermined amount below synchronous speed and for decreasing said average rate when said prime mover is nearing synchronous speed, means for connecting said generator to said system, and means responsive to the operation of said connecting means for increasing said average rate.

5. In combination, an a. c. distribution system, a prime mover, an a. c. generator driven thereby, a speed governor for controlling the admission of operating fluid to said prime mover, to bring said prime mover to a predetermined speed, means for connecting said generator to said distribution system, means responsive to substantial equality of frequency as between said generator and distribution system for controlling the operation of said connecting means, means for raising the speed setting of said governor at a predetermined average rate while said prime mover is a predetermined amount below synchronous speed and for decreasing said rate when said prime mover is nearing synchronous speed.

6. In combination, an a. c. distribution system, a prime mover, an a. c. generator driven thereby, a speed governor for controlling the admission of operating fluid to said prime mover, to bring said prime mover to a predetermined speed, means for connecting said generator to said distribution system, means responsive to substantial equality of frequency and phase as between said generator and distribution system for controlling the operation of said connecting means, means for raising the speed setting of said governor at a predetermined average rate while said prime mover is a predetermined amount below synchronous speed and means responsive to the phase relation between said generator and system for decreasing said rate when said prime mover is nearing synchronous speed.

7. In combination, an a. c. distribution system, an a. c. generator, means effectively op-

erated by a predetermined difference in frequency between said generator and system, means cumulatively responsive to a predetermined extent to intermittent phase equality between said generator and system, means effectively operated momentarily each time said generator and system are in phase, and means controlled by joint operation of the said two phase responsive means and said frequency responsive means for connecting said generator to said system.

8. In combination, an a. c. distribution system, an a. c. generator, a field winding for said generator, a resistance in said field winding, means for automatically connecting said generator to said system in response to substantial equality of frequency and phase between said generator and system, and means responsive to the operation of said connecting means for short circuiting said resistance.

9. In combination, a distribution system, a prime mover, a generator driven thereby, means for connecting said generator to said system, a brake for said prime mover, means fed from said distribution system for causing the release of said brake, and means for preventing the application of said brake while said prime mover is above a predetermined speed independently of failure of voltage on said distribution system.

10. In combination, a distribution system, a prime mover, a generator and exciter driven thereby, means for connecting said generator to said system, a brake for said system, a relay fed from said distribution system for controlling said brake and means responsive to a predetermined rise in exciter voltage as said prime mover increases in speed from rest for depriving said relay of control.

11. In combination, a distribution system, a prime mover, a generator driven thereby, means for connecting said generator to said system, means for controlling the admission of operating fluid to said prime mover, means for causing said controlling means to move toward closed position, and means responsive to said closing movement for causing opening of said connecting means when said control means has been closed a predetermined amount.

12. In combination, a distribution system, a prime mover, a generator driven thereby, means for connecting said generator to said system, a brake for said prime mover, means for controlling the admission of operating fluid to said prime mover, means for causing said controlling means to move toward closed position, means responsive to a predetermined reduction in speed of said prime mover for applying said brake, and means responsive to said closing movement for causing opening movement of said connecting means when said controlling means has been closed a pretermined amount.

13. In combination, a distribution system, a prime mover, a generator driven thereby, means operable by fluid under pressure for controlling the admission of operating fluid to said prime mover, a source of fluid under pressure, means including a master relay for causing said controlling means to start and stop said prime mover, and means responsive to a predetermined minimum pressure of said source for opening the circuit of said master relay.

14. In combination, an a. c. distribution system, an a. c. generator, means for exciting said generator, means for connecting said generator to said system in response to substantial equality of frequency and phase as between said generator and system, and means responsive to the operation of said connecting means for increasing the excitation of said generator.

15. In a system for controlling electrical apparatus from a distance, a distribution system, a prime mover, a generator driven thereby, an exciter for said generator, a gate for controlling the admission of operating fluid to said prime mover, a speed governor for controlling said gate, means for releasing said governor to start said prime mover from rest, means for connecting said generator to said distribution system, an operating-current supply-circuit for said connecting means, a contact in said supply-circuit, means for supplying operating current for said controlling means from said distribution system, and means responsive to a predetermined exciter voltage for closing said contact.

16. In combination, an a. c. distribution system, a prime mover, an a. c. generator driven thereby, means including a motor for controlling the speed of said prime mover, a relay having a back contact in the circuit of said motor, and means for supplying the operating winding of said relay with electromotive force which is the vector sum of electromotive forces supplied by said generator and system.

17. In combination, an a. c. distribution system, a prime mover, an a. c. generator driven thereby, means for connecting said generator to said system, means including a motor for controlling the speed of said prime mover, a relay having a back contact in the circuit of said motor, means for supplying the operating winding of said relay with electromotive force which is the vector sum of electromotive forces supplied by said generator and system, means for interrupting said supply in response to the operation of said connecting means, and a limit switch operable by said motor in the circuit of said motor.

In testimony whereof, the signature of the inventor is affixed hereto.

HENRY V. NYE.