

July 3, 1934.

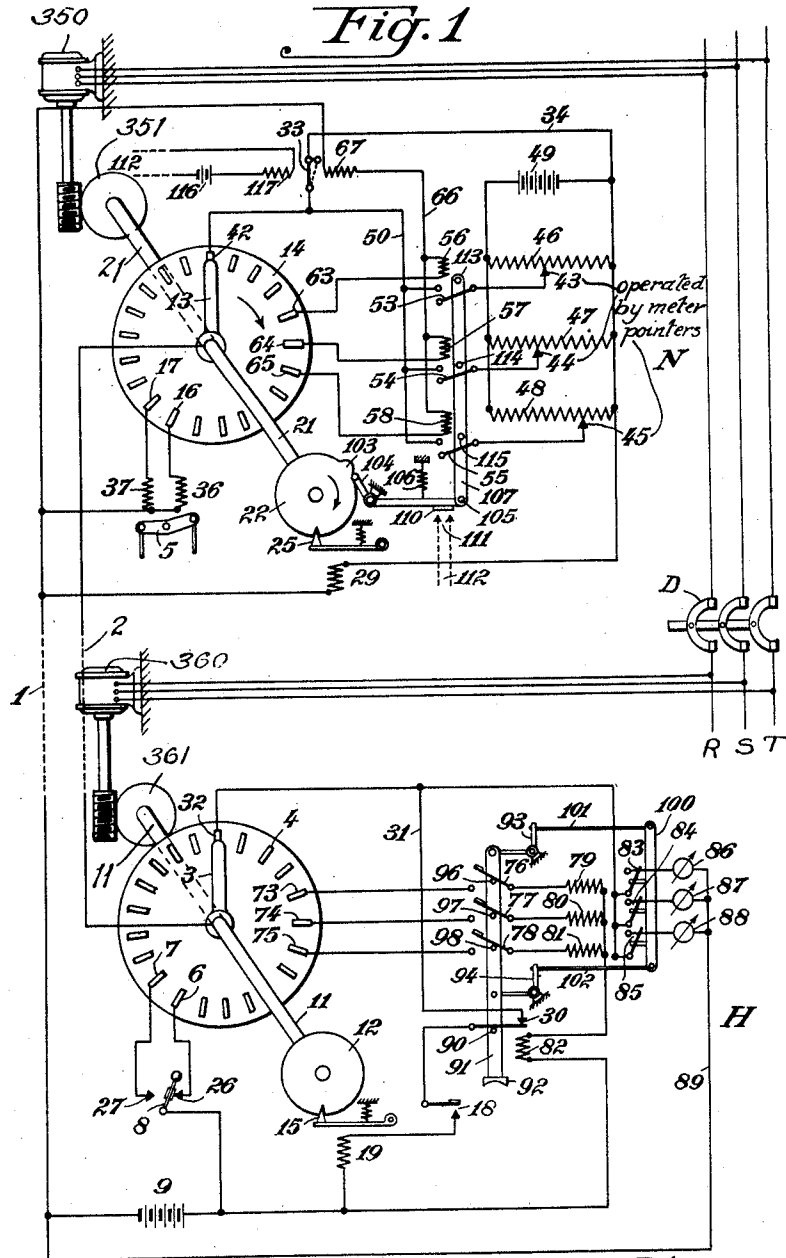
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1,965,393

ARRANGEMENT FOR THE OPERATION OF A SUBSTATION FROM A REMOTE MAIN STATION

Filed Oct. 29, 1927

4 Sheets-Sheet 1



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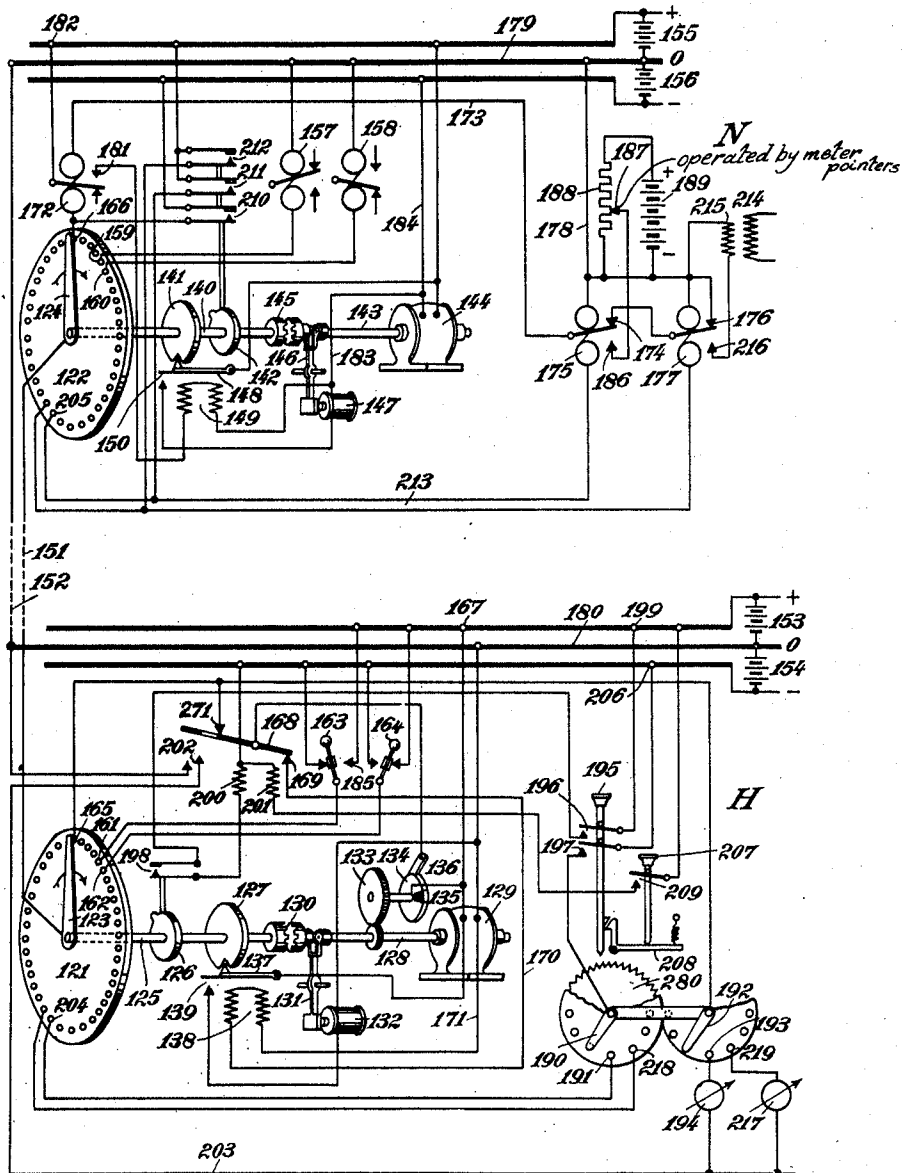
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Filed Oct. 29, 1927

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Fig. 2



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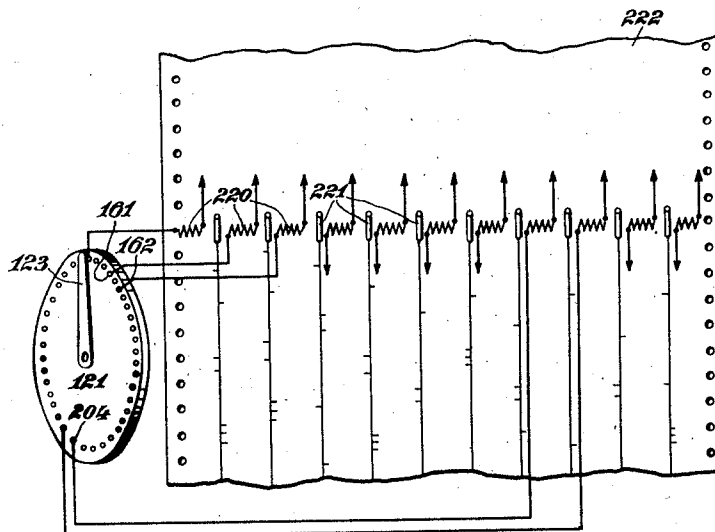
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Filed Oct. 29, 1927

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Fig. 3



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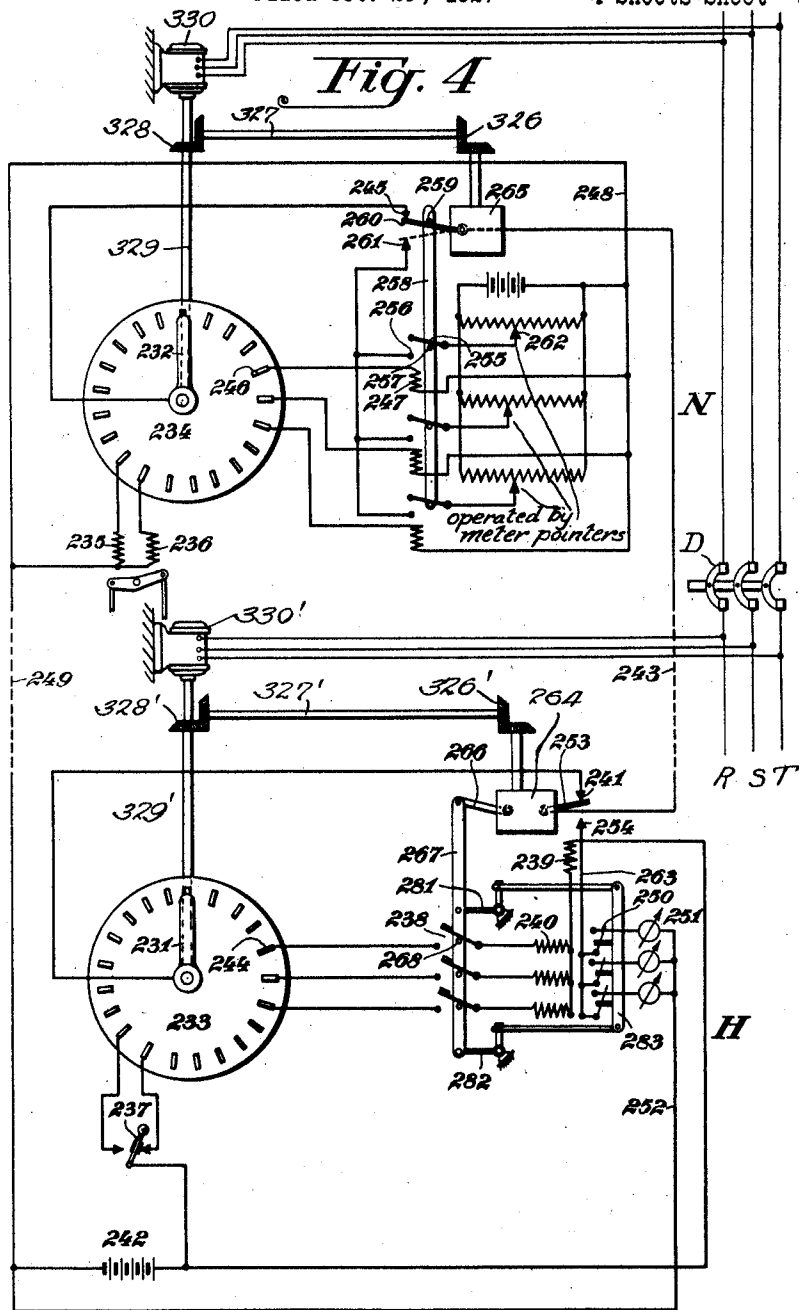
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UNITED STATES PATENT OFFICE

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ARRANGEMENT FOR THE OPERATION OF A
SUBSTATION FROM A REMOTE MAIN
STATION

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Application October 29, 1927, Serial No. 229,620
In Germany November 3, 1926

13 Claims. (Cl. 177—351)

For the purpose of throwing or actuating switches, altering the excitation of electrical machines or effecting similar control movements at a remote sub-station from a main station or room, a contact arm at each station is caused to pass over a series of working contacts. The current impulses produced thereby excite, at the sub-station, actuating magnets which bring about the intended control movement. The synchronism of the two arms is secured by any desired means. In order however to be able to operate a sub-station from a main station in such a manner as to be able to dispense completely with any separate attendants at the sub-station, it is desirable also to transmit to the main station the position of the measuring instruments which are installed at the sub-station, or to switch in microphones which make it possible to hear the noise of the operation occurring at the sub-station or the like. The short temporary electric connections which are closed by the revolving contact arms, are unsuitable for this purpose. It is important to avoid the necessity of having more than two wires, namely a lead and a return, between the main station and the sub-station.

For this reason, according to the present invention there are provided actuating magnets which at the sub-station connect the electric instruments or devices to the line wire in such a manner that their electric connection to the corresponding devices in the main station remains for a long time undisturbed by the actuating magnets. The contact arms may continue to rotate, provided only that care is taken to avoid the simultaneous passage of disturbing current impulses through the working contacts and through the line.

The contact arms could however also be stopped as long as required which is advisable more particularly in the case of arrangements or installations in which the contact arms are in any case stopped at regular intervals for ensuring synchronous running. The measuring, listening, telephoning and the like are then effected during a prolonged stoppage of the contact arms.

When the devices or instruments in question have finished their work, they must be switched off again. This switching off can be brought about by a clockwork installed at the sub-station, which clockwork is started simultaneously with the switching on of the devices responsive to an electric current, and automatically switches off again the devices after a given period of time which has been found by experience to be the most suitable, so that the actuating magnets

can resume their activity. The operation of these devices could also be stopped by a control operation from the main station. To this end, one working magnet in the main station remains ready for use even during the activity of said devices. It is true that the said magnet will be then traversed also by the currents of the said devices. The magnet is however dimensioned in such a manner that the currents in question are not sufficient to energize it. As soon however as a stronger current impulse is sent from the main station, the magnet will be energized, and will switch off again the said devices.

A construction according to the invention is illustrated diagrammatically by way of example in Figure 1, Fig. 2 is a diagrammatic view showing another form of our invention; Fig 3 is a detail view of a registering device employed in conjunction with the apparatus shown in Fig. 2; and Fig. 4 is a diagram showing still another embodiment of our invention.

The distant or remote sub-station N is to be operated from the main station H. According to Fig. 1, these stations are connected together by line wires 1 and 2. At the main station, a contact arm 3 passes or moves over a contact disc 4, at the sub-station a corresponding contact arm 13 moves over the contact disc 14. As an example for carrying out a control movement in the sub-station N, there will be described the actuation of a rocker 5 which can be used for instance for switching in and out oil switches. The rocker 5 is controlled by two actuating magnets 36 and 37. Owing to the energizing of the magnet 36, such rocker had been brought to the position shown in the drawings. If the rocker is to be thrown to the other position, the magnet 37 must be energized. The windings of the magnets 36 and 37 are connected to the working contacts 16 and 17 on the contact disc 14. To these working contacts correspond the working contacts 6 and 7 on the contact disc 4 at the main station. The latter contacts are connected to the contacts 26 and 27 of a hand operated switch 8. When the latter is placed on the contact 27, at the moment when the two contact arms 3 and 13 touch their working contacts 7 and 17, there will be produced a current impulse which will go from the battery 9 through the hand operated switch 8, contact 27, working contact 7, contact arm 3, line wire 2, contact arm 13, working contact 17, working magnet 37, line wire 1, back to the battery 9. The actuating magnet 37 will be energized, and will throw the rocker 5 to its other position.

For driving each of the contact arms 3 and 13, we use an electric motor 360, 350 respectively which is connected to the spindle 11, 21 respectively of its contact arm by a suitable gearing 361, 351 respectively. The motors 360, 350 are supplied with current from the power mains R, S, T, a cut-out switch D being preferably provided to enable the sub-station to be cut off from the power mains. To the spindle 11 of the contact arm 3 is rigidly secured a locking disc 12 which is provided with a single recess. A locking pawl 15 engages with the said recess as soon as the disc has completed its revolution and thus also stops the rotation of the motor 360. The contact arm 3 then remains on the "rest" contact 32. In the same way the contact arm 13 remains on the rest contact 42 when the locking tooth 25 engages with the gap of the disc 22 which is mounted on the spindle 21 of the contact arm 13. This stops the rotation of the motor 350. If the contact arms are to start moving again, a starting key 18 is depressed. In this way, a circuit is closed which goes from the battery 9 through the actuating magnet 19, the starting key 18, the closed contact 30, the wire 31, the rest contact 32, the contact arm 3, the wire 2, the contact arm 13, the rest contact 42, the closed switch 33, the wire 34, the actuating magnet 29 and through the line wire 1 back to the source of current 9. In this way, the magnets 19 and 29 are energized and pull back simultaneously the locking pawls 15 and 25 out of their locking position, so that the contact arms can make the next revolution. The driving electric motors can be easily adjusted in such a manner that the contact arms execute a single revolution with a sufficiently uniform speed.

At the sub-station N are installed for instance three measuring instruments, the position of the pointers of which is to be transmitted according to the invention of the main station H. These measuring instruments therefore are of the transmitting instrument type. To the pointers are connected sliding contacts 43, 44, 45, which during the movement of the pointers, slide over resistances 46, 47, 48. In practical construction these resistances will therefore preferably be made circular shape. These three resistances are connected in parallel to a source of current 49 so that the sliding contacts take from these resistances a voltage which is accurately determined by the position of the pointers. The negative pole of the source of current 49 is connected through the actuation magnet 29 to the line wire 1. The sliding contacts 43, 44, 45 can be connected by means of switches 53, 54, 55 to the wire 50 which leads to the rest contact 42 of the disc 14. The switches 53, 54, 55 are normally open, but can also be closed by electro-magnets 56, 57, 58 which are connected with one of their terminals to the working contacts 63, 64, 65 and with the other terminal to the wire 66 which is connected through an actuating magnet 67 to the line wire 1. To the working contacts 63, 64, 65 on the disc 14 corresponds the working contacts 73, 74, 75 on the disc 4. From the latter connection wires lead through the hand operated keys 76, 77, 78 to electro-magnets 79, 80, 81. Their other terminals are connected through an electro-magnet 82 to the positive pole of the source of current 9. When one of the electro-magnets 79, 80, 81 is energized, it closes that one of the three switches 83, 84, 85, which belongs to it, and in this way establishes connection between the rest contact 32 of the disc 4, and one

of the measuring instruments 86, 87, 88, the second terminals of which are connected through the wire 89 to the line wire 1. The arrangement operates in the manner described below, the mechanical parts of the arrangement being for the present left out of consideration.

If for instance at the main station there is to be read the indication of that measuring instrument at the sub-station N, with the pointer of which moves the sliding contact 44, the hand operated key 77 at the main station H must be depressed. As soon as the rotating contact arm 3 touches the working contact 74, a current will pass from the source of current 9 through the electro-magnet 82, the electro-magnet 80, the hand operated key 77, the working contact 74, the contact arm 3, the line wire 2, the contact arm 13, working contact 64, actuating magnet 57, wire 66, actuating magnet 67 and through the line wire 1, back to the battery 9. In this way the electro-magnets 82, 80, 57 and 67 will therefore be energized. Owing to the energizing of the magnet 82, the switch 30 will be opened and will remain in the open position. This will break the circuit in which the electro-magnets 19 and 29 are included; when energized, these magnets cause the contact arms 3 and 13 to start again after their stoppage. The energizing of the electro-magnet 80, will close the switch 84 which connects the measuring instrument 87 to the rest contact 32. The energizing of the actuating magnet 57, will close the switch 54 which connects the sliding contact 44 through the wire 50 to the rest contact 42. Owing to the energizing of the actuating magnet 67, the switch 33 will be opened. Under other conditions, the starting current impulse passes through said switch, as described above. But when the switch 33 is opened as just referred to, the starting current impulse must pass from the actuating magnet 29 through a portion of the resistance 47, sliding contact 44, switch 54 and wire 50 to the rest contact 42. The operation of the various switches does not for the present close any other circuit, as the prepared connections all lead to the rest contacts 32 and 42. As soon however as the contact arms 3 and 13 reach these rest contacts, the measuring instrument 87 will be connected to the voltage taken by the contact 44. For the contact 44 is then connected through the switch 54, wire 50, rest contact 42, contact arm 13, line wire 2, contact arm 3, rest contact 32, and switch 84, to the measuring instrument 87, the other pole being connected through the wire 89, line wire 1, actuating magnet 29 to the voltage dividing resistance 47. The measuring instrument 87 indicates the voltage on this resistance and therefore the position of the pointer 44, during an unlimited time. A depression of the key 18 would not interrupt the measurement as the starting current circuit is broken by the switch 30.

If the measurement is to be terminated, a key 92 is depressed. This key is secured to the end of a slide 91 which is provided with stop or tappet pins 90, 96, 97, 98. On these stop pins rest the switch levers 30, 76, 77, 78. The hand operated key 77 when it was closed, moved the stop pin 97 out of its position of rest, and in this way moved down the whole slide 91. By a pressure on the key 92, the slide 91 will be moved in the opposite direction. The stop pin 97 then opens the switch 77, and the stop pin 90 closes the switch 30. The breaking of the starting current circuit is thereby cancelled.

The slide 91 is connected by bell crank levers

93 and 94 and by connecting rods 101 and 102 to a bridge 100. The latter carries stop pins for the three switches 83, 84 and 85. During the upward movement of the slide 91, the bridge 100 is moved to the right, the corresponding stop pin opening the previously closed switch 83 or 84 or 85. If the starting key 18 is now depressed, the battery 9 will send a current impulse through the electro-magnet 19, the starting key 18, the again closed switch 30, wire 31, rest contact 32, contact arm 3, line wire 2, contact arm 13, rest contact 42, wire 50, the still closed switch 54, sliding contact 44, resistance 47, actuating magnet 29 and through the line wire 1 back to the battery 9. The actuating magnet 29 will be therefore energized, and will attract the locking pawl 25, while the electro-magnet 19 will pull back the locking pawl 15. Both contact arms 3 and 13 start rotating again. Immediately at the beginning of the starting movement, a finger or cam 103 arranged on the locking disc 22, will press against a bell crank lever 104. The other end point 105 of this bell crank lever will therefore move down in opposition to the pull of a spring 106. In this way, a slide 107 will be temporarily pulled down, its stop pins 113, 114, 115 opening that one of the three switches 53, 54, 55 which was previously closed. Moreover the bell crank lever 104 temporarily closes, by means of its contact piece 110, two contacts 111. These are connected by a double conductor 112, of which for the sake of clearness only the two ends are shown, through a source of current 116 to the electro-magnet 117. This electro-magnet closes the switch 33 which up to that time remained in its open position. In that way the starting current can pass again from the rest contact 42 through the wire 34 to the actuating magnet 29. Thus, all the parts resume their normal position, and the regular operation of the device can continue.

The starting key 18 which for the sake of simplicity is shown and described as a hand operated key, could be of course operated automatically at regular time intervals. The automatic device for that purpose could also continue to run during the carrying out of a measurement, without the measurement being disturbed, as the starting circuit is broken by the switch 30.

The arrangement could also be improved in another respect. Thus for instance it must be taken into account that in the case of a great distance between the main station and the sub-station, the resistance of the line wires 1 and 2 has a considerable influence. The windings of the electro-magnets operated through the line wires must then also have a high resistance, and for this reason it is advisable to avoid connecting a plurality of actuating magnets, in series. In such a case, the actuating magnets would be preferably built as relays which in their turn switch in a magnet for performing mechanical work. Moreover, the number of the working contacts could be reduced by half by installing at least in the main station two sources of current, one or the other of which can be connected to the working contacts. The diagram of connections of an arrangement with these improvements is given in Figure 2.

At the main station H and at the sub-station N, there are contact discs 121 and 122 on which travel the contact arms 123 and 124. The contact arm 123 is mounted on a spindle 125 which carries a cam disc 126 and a locking disc 127 and can be coupled to the shaft 128 of the motor 129 by means of a coupling 130. The coupling is

controlled by the lever 131 and by the electro-magnet 132. The shaft 128 through a gearing 133 drives a contact disc 134 which is provided with a conducting sector 135. The latter makes one contact with the sliding brush 136 for each revolution of the disc 134.

A locking pawl 137 engages with a recess of the locking disc 127. When it is withdrawn from its locking position by the starting magnet 138, such pawl will engage the contact 139.

The contact arm 124 at the sub-station N is mounted on a spindle 140. The latter carries a locking disc 141 and a cam disc 142, and can be coupled to the shaft 143 of the electro-motor 144 by means of a coupling 145. The latter is controlled by the electro-magnet 147 by means of a lever 146. The locking pawl 148 engages with the locking disc 141. As soon as it is attracted by the starting magnet 149, this pawl engages the contact 150. The contact arms 123 and 124 are connected together by the line wire 151. At the main station H are connected in series two sources of current 153 and 154, and at the sub-station N the two sources of current 155 and 156. The point of connection of the two batteries is marked at both stations with zero and connected to the line wire 152. The working contacts of the contact disc 122 are connected to polarized relays by which local circuits are closed for the control of any movements at the sub-station. In Fig. 2 we have shown by way of example the two polarized relays 157 and 158 which are connected to the working contacts 159 and 160. To these contacts correspond at the main station the working contacts 161 and 162 which are connected to the control switches 163 and 164 operated by hand.

The arrangement so far as it has been described above, operates in the following manner:—let it be assumed that the contact arms 123 and 124 are stationary on their rest contacts 165 and 166 whilst the electric motors 129 and 144 are running all the time. As soon as the contact disc 134 driven from the motor 129 makes a contact between its conducting sector 135 and the contact brush 136, a local circuit will be closed in the main station as well as a circuit through the distant line. The local circuit goes from the point 167 of the positive pole through the conducting sector 135, the sliding brush 136, the auxiliary switch 168, its contact 169, wire 170, starting magnet 138, wire 171 back to the zero or neutral point of the source of current. The starting magnet 138 withdraws the locking pawl 137 from its locking position; the pawl engages the contact 139, owing to which the electromagnet 132 receives current and consequently meshes the coupling 130.

The line circuit which is closed by the contact disc 134, goes from the point 167 through 135 and 136, the auxiliary switch 168, its contact 271, rest contact 165, contact arm 123, line wire 151, contact arm 124, rest contact 166, relay 172, wire 173, the closed contact 174 of the polarized relay 175, the closed contact 176 of the polarized relay 177 through the wire 178 to the neutral conductor 179 and through the line wire 152 back to the neutral conductor 180 which leads to the other pole of the source of current 153. The polarized relay 172 is energized and closes its contact 181. This closes the following local circuit: from the point 182 of the positive pole of the source of current through the contact 181, starting magnet 149, wire 183 and wire 184 back to the negative pole of the source of current. The starting magnet 149 pulls the pawl 148 back out of the

locking position, owing to which the contact 150 is closed. In this way, the coupling magnet 147 receives current and meshes the coupling 145. Both contact arms 123 and 124 make then simultaneously one revolution. Immediately at the beginning of this revolution the cam disc 142 closes at the sub-station a contact 210. In this way the polarized relay 172 receives a negative current impulse and is thereby brought back to its position of rest.

Let it now be assumed that the polarized relay 157 has closed an oil switch of an electric heavy current line, which is to be opened again by an operation from the main station H. To this end, the control switch 163 is actuated or thrown to close a contact 185; as soon as the contact arms 123 and 124 touch the working contacts 159 and 161, a circuit will be closed which can be readily followed in the drawings, this operation causing a change in the position of the armature of the polarized relay 157. If then the oil switch is to be closed again, the control switch 163 is brought back to the position shown. During the rotation of the contact arms, the relay 157 receives a current impulse of the opposite direction, and brings its contact blade back to the position shown. In the same way, the control switch 164 controls the polarized relay 158.

The above mentioned polarized relays 175 and 177 are intended to connect to the line at the sub-station the measuring instruments, the position of the pointer of which is to be transmitted to the main station. The contact 186 of the relay 175, which is open at the time, leads to the contact 187 of the voltage dividing resistance 188. The contact 187 moves simultaneously with the pointer of the measuring instrument to be read. The resistance 188 is constantly traversed by the current of the source of current 189, the negative pole of which is connected through the wire 178 to the neutral conductor 179. The voltage taken by the contact 187 on the resistance 188, corresponds without any uncertainty to the position of the pointer of the measuring instrument. If this pointer position is to be transmitted to the main station H so that it can be read there, the contact lever 190 is first moved to the contact 191. This contact lever is positively connected to a second contact lever 192, so that the latter touches the contact 193. To the contact 193 is connected the voltmeter 194 on which the desired indication can be read. As soon as the switch levers 190 and 192 are set, a preparation or measuring key 195 is depressed. It engages with its lower end a ratchet wheel 280 which is rigidly secured to the contact lever 190 and thus prevents any subsequent shifting of the two contact levers. Moreover the measuring key closes the two contacts 196 and 197. This at first does not close any circuits, but the contact arm 123 first completes the revolution which it is making at the time. Only after it has just started the next revolution, the cam disc 126 closes a contact 198. This causes a current to pass from the point 199 of the positive pole of the source of current through the contact 196, contact 198 and electro-magnet 200 back to the negative pole. The energized electro-magnet 200 turns the change-over switch 168 into its other position. The switch 168 not only opens gaps at the contacts 169 and 271, but also closes the contact 202. In this way the voltmeter 194 is connected to the line wire 152 through the wire 203. If the starting current circuits were opened direct by the measuring key 195, it could happen that the contact

arms would stop before the control currents referred to below, have performed their work.

This will be understood in view of the fact that the contact 197 of the measuring key 195 has prepared a control circuit which is to connect the voltage divider 187 to the line. The selection of this voltage divider has been prepared by the setting of the change-over switch 190. As soon as the contact arms 123 and 124 during the further rotation reach the working contacts 204 and 205 corresponding to each other a control current will pass from the point 206 of the negative pole of the source of current through the contact 197, the change-over switch 190, contact 191, working contact 204, contact arm 123, line wire 151, contact arm 124, working contact 205 through the polarized relay 175, the neutral conductor 179 and the line wire 152 back to the zero-point of the source of current. The polarized relay 175 therefore opens the contact 174 and closes the contact 186. This has at first no further influence on the control processes, and any control operations that may be still sent through the working contacts to be passed, will be still executed. When however the two contact arms reach their rest contacts 165 and 166, they will be unable to start again. It is true that the contact disc 134 closes its contacts at regular time intervals in the same way as up to that time, but the two starting current circuits are broken by the gaps at the contacts 169 and 271. On the other hand the voltage divider 187 is connected to the voltmeter 194 in the following manner:—voltage divider 187, contact 186, wire 173, relay 172, rest contact 166, contact arm 124, line wire 151, contact arm 123, rest contact 165, contact lever 192, voltmeter 194, wire 203, closed contact 202, line wire 152, zero or neutral conductor 179, wire 178, bottom portion of the resistance 188, back to the voltage divider 187. The voltmeter 194 will therefore for any length of time indicate the position of the measuring instrument installed at the sub-station, reproduced by the voltage divider 187. The measuring current passes through the polarized relay 172, but does not influence it. For first the measuring current is insufficient for the purpose, secondly in this case special provision is made to ensure that the measuring direct current passes through the relay 172 in the direction in which it does not move the relay armature into its other position.

When the measurement is finished, a key 207 is depressed. In this way there is disengaged a locking pawl 208 by which the measuring key 195 was held fast in its working position. This key can now return to its position of rest under the action of a spring not shown. Moreover the key 207 closes a contact 209. In this way an electro-magnet 201 is supplied with current and returns the auxiliary switch 168 to its normal position. The latter closes again the gaps at the contacts 169 and 271 for the starting current, and if now the contact disc 134 again closes contact, the starting currents will be again caused to operate at the main station, the starting current follows the usual path. At the substation however the contact 174 is still open, and the contact 186 closed. Consequently the starting current goes from the rest contact 166 through the relay 172 and the wire 173, through the contact 186, contact 187 and the lower portion of the resistance 188, back to the zero conductor 179 and to the line wire 152. The voltage on the switched in portion of the resistance 188 is of such direction that it assists the energizing of the starting relay

172. The latter therefore closes its contact 181 in the usual manner, whereby the arm 124 is caused to rotate. Shortly after it started its rotation, the cam disc 142 closed the contacts 210, 211, and 212. Through the contact 210, the relay 172 receives a negative current impulse at every revolution, and through the contact 211 and the wire 213, the relay 175 receives a positive current impulse by which it is brought back to its position of rest. The circuit is as follows: From the positive pole of battery 155 to contacts 211 and the conductor connecting the lower contact 211 with the wire 213, through this wire to the polarized relay 175, wire 178 and negative pole of battery 155. If previously the position of the armature of the polarized relay 177 had been reversed, such armature would be brought to the proper position by the current flowing from the positive pole of battery 155 to the contacts 212 and from the lower contact 212 through the conductor extending to the wire which is indicated immediately below the wire 213 and leads to the relay 177, the circuit being completed through the wire 178 to the other pole of battery 155.

The relays 175, 177 etc., remain each time in their position and must be moved into the other position by a separate current impulse. Instead of that, they could also be held fast in the position of rest by means of springs; to prevent them from leaving again their working position under the action of the said springs, they could be held fast in the working position by an automatically switched-in "rest" circuit. This circuit could have a portion common to all the relays 175, 177 etc., so that the cam of the disc 142 has to open only one contact in order to allow any of these relays to spring back to the position of rest.

If the current intensities or voltages of alternating currents at the sub-station are to be read at the main station then instead of a voltage divider, for the transmission there can be utilized also direct the secondary winding of an instrument transformer. By way of example the drawings show a voltage transformer at the sub-station, the primary winding 214 of said transformer being connected to the heavy current conductor, while the secondary winding 215 is connected at one end through the wire 178 to the neutral conductor 179, and at the other end to the contact 216 of the polarized relay 177. The voltmeter 217 at the main station indicates the voltage given by the secondary winding 215 when the contact levers 190 and 192 are placed on the contacts 218 and 219.

In order to enable a direct current indicator or ammeter to be used at 217, the secondary current of the voltage transformer could be converted into direct current by means of a mechanical rectifier, a valve or the like. The direct current will also be less influenced by the relay 172 situated in the circuit, than the alternating current. If a valve is used as a rectifier, its hot wire can be switched in by the relay 177 simultaneously with the secondary winding 215.

The use of contact levers 190 and 192 precludes the possibility of two measuring instruments being switched in by mistake at the same time; their rigid coupling ensures that in all cases the correct instruments of the sub-station and of the main station will be connected together.

In many cases it is desirable to record the connections and measurements effected through the distant operating arrangement. A simple device for the purpose utilizes the currents passing

through the working contacts of the main station to control scribes or pencils which make records on a moving record strip or band. In order to avoid complicating the drawings, the recording device is shown separately in Figure 3. From the working contacts of the contact disc 121 wires lead through small electro-magnets 220. The latter are polarized, so that they move the pencils, secured to short levers 221, to one or to the other side according to the direction of the current. As long as the device is at rest, the pencils trace straight lines on the moving record band 222. Each current impulse passing through a working contact produces however a marking stroke to the right or to the left, and with the help of these strokes, the activity of the arrangement can be subsequently followed exactly. From the magnets 220, wires lead to the control levers and from the latter further, exactly as shown in Figure 2. For instance, the magnet coil 220 shown at the extreme left in Fig. 3 is in the circuit connecting contact 165 with contact 171 and with switch 192. The second magnet coil from the left is in the circuit connecting the contact 161 with the control switch 163. In a similar manner, the other magnet coils 220 are connected in the circuits associated with the several contacts of the contact disc 121.

As already stated in the preamble, the electrically responsive devices or instruments switched in in the main station and at the sub-station, could also be switched out again by clockworks. The diagram of connections of such an arrangement is shown in Figure 4. The contact arms 231 and 232 pass over the working contacts of the contact discs 233 and 234. The actuating magnets 235 and 236 are controlled by the control switch 237 in the same way as shown in the constructions illustrated by Figs. 1 and 2. In the same way as in Figure 1, a constantly working connection is established by depressing a key, for instance the key 238. The latter is connected to a working contact 244, and as soon as the contact arm 231 during its rotation reaches the said contact, a current impulse will pass from the source of current 242 through an electro-magnet 239, an electro-magnet 240, the switch 238, working contact 244, contact arm 231 through the closed contact 241 of the switch 253, the line wire 243, the closed contact 245 of the switch 260, contact arm 232, actuating contact 246, working magnet 247, wire 248, line wire 249, back to the source of current 242. The electro-magnet 240 closes a switch 250, and the electro-magnet 239 throws the contact lever 253 to the position in which the contact 241 is broken and a contact 254 closed. At the sub-station, the actuating magnet 247 switches in a switch 255 so that the latter closes the contact 256. The switch rests on a stop pin 257, which is secured to a slide 258. A stop pin 259 of this slide throws the switch 260 so that the contact 245 is opened, and the contact 261 closed.

Owing to the opening of the contacts 241 and 245, the contact arms 231 and 232 are switched off from the line wire 243, so that current impulses can no longer pass through the working contacts. On the other hand, the voltage divider 262 is connected to the indicator instrument 251. The measuring current follows the path:—voltage divider 262, switch 255, contact 256, contact 261, switch 260, line wire 243, switch 253, contact 254, wire 263, switch 250, measuring instrument 251, wire 252, line wire 249, through the wire 248 back to the voltage divider 262.

Each of the two switches 253 and 260 is mounted on a spindle of a clockwork 264 and 265 respectively. Owing to the throwing over of the switches 263 and 260 at the beginning of the measurement, the clockworks have been set going, and after the expiration of a given time, for instance of one or more minutes, each clockwork automatically turns its switch back to the initial position. The switch 260 at the same times also moves the slide 258 which, by means of its stop pin 257, again opens the switch 255. The clockwork 264 moves at the same time an arm 266 which pulls a slide 267 upwards. The latter by means of its stop pin 268, opens also the contact 238 and, through the bell crank levers 281, 282 and the bridge 283, also the switch 250. The measuring instruments are thus switched off, and the control currents can pass now in a normal manner through the working contacts and the contact arm.

In this arrangement it is immaterial how the synchronous running of the contact arms 231 and 232 is ensured. They could be stopped after each revolution as was the case in the constructions described above. They could however also run continuously, for instance when they are driven by synchronous motors 330, 330' which are connected to mains R, S, T which are common to the main station and to the sub-station. In such a case it is advisable to drive the clockworks 264 and 265 also by the motors. The motors 330, 330' drive the contact arms 232 and 231 respectively by means of shafts 329 and 329' respectively, and the clockworks 264, 265 are driven from said motors through the medium of said shafts, by way of gearing 328', 328, intermediate shafts 327', 327, and gearing 326', 326 respectively. A cut-out switch D is preferably provided, as in the construction described with reference to Fig. 1, to enable the sub-station to be cut off from the power mains. By reversing the switches 253 and 260 there is, for instance, brought into action a coupling over which, after a certain number of revolutions, the required setting-back movements take place. But any other method of maintaining the synchronism of the contact arms is suitable for this construction.

What we claim as our invention and desire to secure by Letters Patent is:—

1. An arrangement for the operation of a remote sub-station from a main station, comprising a series of contacts at each of said stations, a rotatable contact arm located at each of said stations and arranged to engage the respective series of contacts, a line connecting said stations, electrically responsive electric devices located at each of said stations, electro-magnetic relays located at the sub-station and connected individually with contacts of the sub-station switches located at the main station and arranged to be connected individually with contacts of the main station, at least one source of electricity, electric conductors connecting said source of electricity, switches, contacts and relays for energizing the corresponding relays temporarily when the switches are selectively operated and the contact arms engage the corresponding contacts, certain of the electromagnetic relays located at the sub-station being operative to connect said electrically responsive devices at the sub-station with the line and, through it, with the corresponding electrically responsive devices at the main station, and means for maintaining the connections established by said certain electro-magnetic relays for a period of time greater than the length

of time during which a contact arm engages one of the contacts of its series, said means simultaneously operative to keep open the circuits of the non-selected switches to prevent the transmission of other currents over said line.

2. An arrangement according to claim 1, in which the said means for maintaining the connections established by certain electromagnetic relays includes means for holding the contact arms stationary during the operation of the electrically responsive devices.

3. An arrangement according to claim 1, in which the said means for maintaining the connections established by certain electro-magnetic relays includes, at the main station and at the sub-station, a rest contact engaged by the respective contact arms while they are stationary during the operation of the electrically responsive devices, and means for securing synchronous movement of the two contact arms by stopping them simultaneously, from time to time, when they are in engagement with said rest contacts, an auxiliary switch at the main station, a circuit including said switch, for starting the two contact arms, a manually operated preparation key, located at the main station, for preparing the opening movement of said auxiliary switch, and means operative during the rotation of the contact arm at the main station to fulfill such movement.

4. An arrangement according to claim 1, in which there is provided, at the main station, a switch and contacts engaged by said switch, one at a time, said contacts being connected individually with the respective electrically responsive devices, so that only one of such devices can be in circuit at the same time, another switch positively connected with the first-mentioned switch, and a contact engaged by said second switch and having connections for causing the corresponding electrically responsive device to be inserted in the circuit at the sub-station.

5. An arrangement according to claim 1, in which there is provided, at the main station, a switch and contacts engaged by said switch, one at a time, said contacts being connected individually with the respective electrically responsive devices, so that only one of such devices can be in circuit at the same time, another switch positively connected with the first-mentioned switch, and a contact engaged by said second switch and having connections for causing the corresponding electrically responsive device to be inserted in the circuit at the sub-station, an auxiliary switch at the main station, a circuit including said auxiliary switch, for starting the two contact arms, a manually operated preparation key, located at the main station, for preparing the opening movement of said auxiliary switch, means operative during the rotation of the contact arm at the main station to fulfill such movement, and means, connected with said preparation key, whereby the latter, in its working position, locks the said two positively-connected switches.

6. An arrangement according to claim 1, in which there is provided, at the main station, a switch and contacts engaged by said switch, one at a time, said contacts being connected individually with the respective electrically responsive devices, so that only one of such devices can be in circuit at the same time, another switch positively connected with the first mentioned switch, and a contact engaged by said second switch and having connections for causing the

corresponding electrically responsive device to be inserted in the circuit at the sub-station, an auxiliary switch at the main station, a circuit including said auxiliary switch, for starting the two contact arms, a manually operated preparation key, located at the main station, for preparing the opening movement of said auxiliary switch, means operative during the rotation of the contact arm at the main station to fulfill such movement, and means, connected with said preparation key, whereby the latter, in its position of rest, interrupts the circuit of the second-mentioned of said two positively-connected switches.

7. An arrangement according to claim 1, in which the said means for maintaining the connections established by certain electromagnetic relays includes, at the main station and at the sub-station, a rest contact engaged by the respective contact arms while they are stationary during the operation of the electrically responsive devices, and means for securing synchronous movement of the two contact arms by stopping them simultaneously, from time to time, when they are in engagement with said rest contacts, an auxiliary switch at the main station, a circuit including said switch, for starting the two contact arms, a manually operated preparation key, located at the main station, for preparing the opening movement of said auxiliary switch, which movement is completed through the action of the contact arm at the main station, and an additional key for restoring the said preparation key and said auxiliary switch to their normal positions.

8. An arrangement according to claim 1, in which the electrically responsive device at the sub-station consists of a voltage divider having a contact which, by the movement of the pointer, is shifted relatively to the resistance of such voltage divider.

9. An arrangement according to claim 1, in which there is provided, at the sub-station, an additional electromagnetic relay for cutting out the electrically responsive devices, such relay being in circuit with said electrically responsive devices and remaining connected with the line and ready for operation, during the operation of said devices, said relay being so constructed that the currents of said devices will not suffice for energizing it, and means for transmitting a current impulse from the main station, to disconnect the said electrically responsive devices and again energizing the other electromagnetic relays by the energizing of said additional electromagnetic relay.

10. An arrangement according to claim 1, in which the electrically responsive devices at the main station are of the indicating type, while the electrically responsive devices at the sub-station are of the transmitting instrument type.

11. An arrangement according to claim 1, in which the said means for maintaining the connections established by certain electro-magnetic

relays includes, at the sub-station, a rest contact located in the path of the contact arm of said sub-station and adapted to be engaged by said arm, and connections from said rest contact to complete a circuit to the line and to the electrically responsive devices.

12. An arrangement according to claim 1, in which the said means for maintaining the connections established by certain electromagnetic relays includes, at the sub-station, an additional electromagnetic relay connected with means by which, during the operation of the electrically responsive devices, such relay remains connected with the line and ready for operation, said relay being so constructed that the currents of said devices will not suffice for energizing it, and means for transmitting a current impulse from the main station, to disconnect the said electrically responsive devices and again energizing the other electromagnetic relays, means for holding the contact arms stationary during the operation of the electrically responsive devices, and means, operated by one of said electromagnetic relays when such relays is energized, for opening the circuit of the said additional relay which normally starts the contact arm, and for simultaneously, by the energizing of said additional electromagnetic relay, connecting therein at the point where it has been opened the corresponding electrically responsive device with said circuit.

13. An arrangement according to claim 1, in which the said means for maintaining the connections established by certain electromagnetic relays includes, at the sub-station, an additional electromagnetic relay connected with means by which, during the operation of the electrically responsive devices, such relay remains connected with the line and ready for operation, said relay being so constructed that the currents of said devices will not suffice for energizing it, and means for transmitting a current impulse from the main station, to disconnect the said electrically responsive devices and again energizing the other electromagnetic relays, means for holding the contact arms stationary during the operation of the electrically responsive devices, and means, operated by one of said relays when such relay is energized, for opening the circuit of the said additional electromagnetic relay which normally starts the contact arm, and for simultaneously, by the energizing of said additional relay, connecting the corresponding electrically responsive device with said circuit at the point where it has been opened, and means, connected with the contact arm of the sub-station, to cause said arm, at the beginning of its movement, to disconnect from the circuit at such sub-station, any of said electrically responsive devices that may have been in circuit.

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