

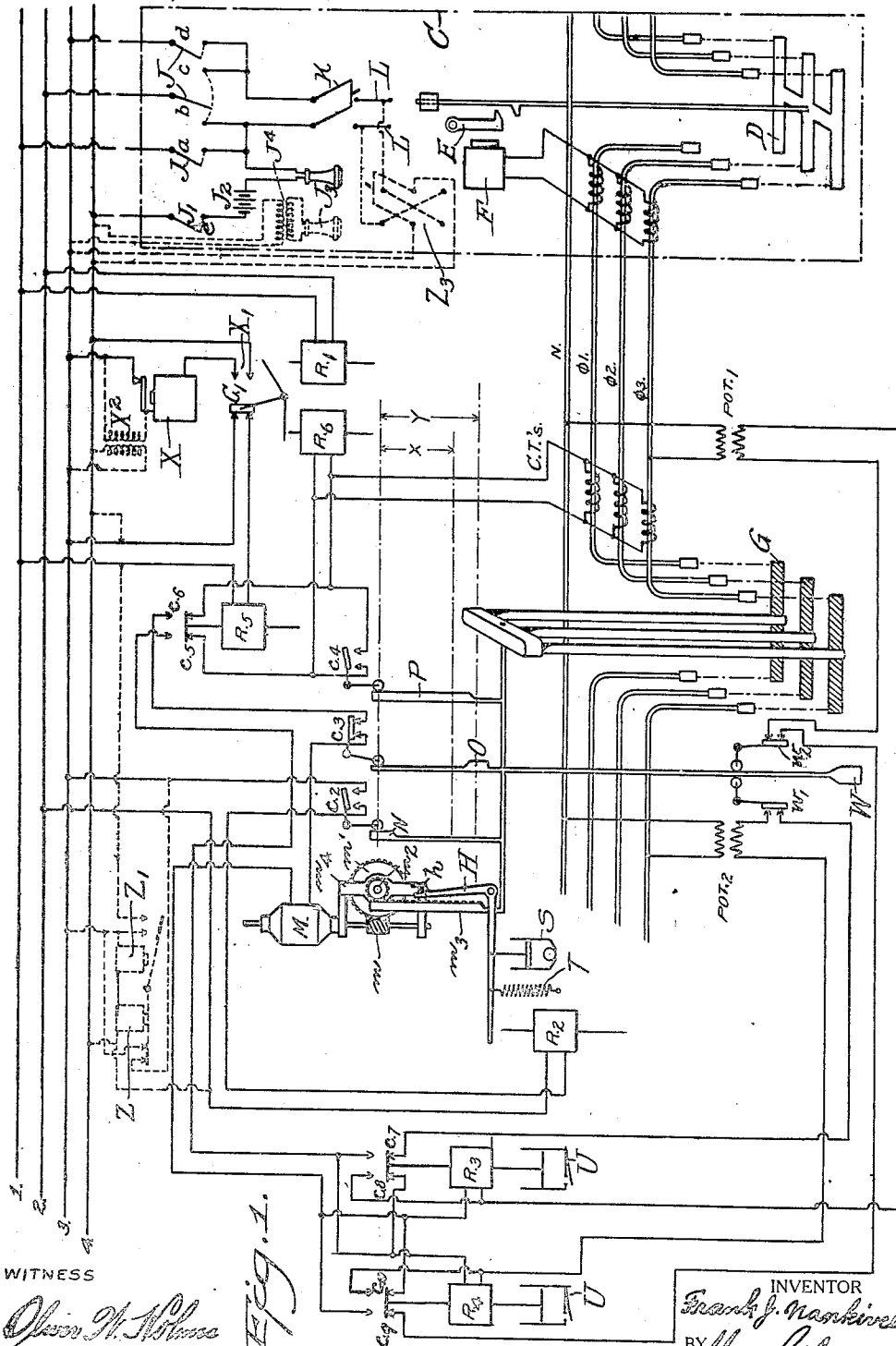
Jan. 14, 1930.

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1,743,795

FAULTY LINE SECTION CUT-OUT

Original Filed Aug. 15, 1924 2 Sheets-Sheet 1



WITNESS

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Fig. 1.

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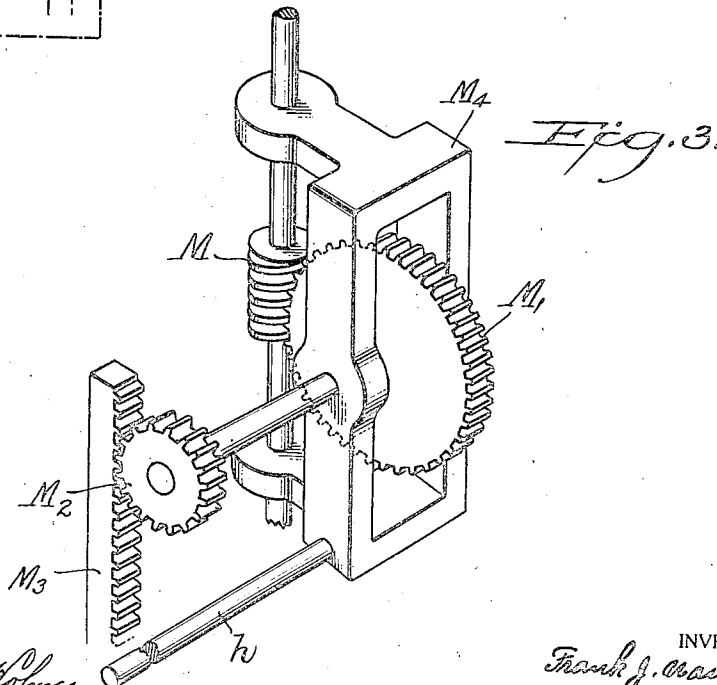
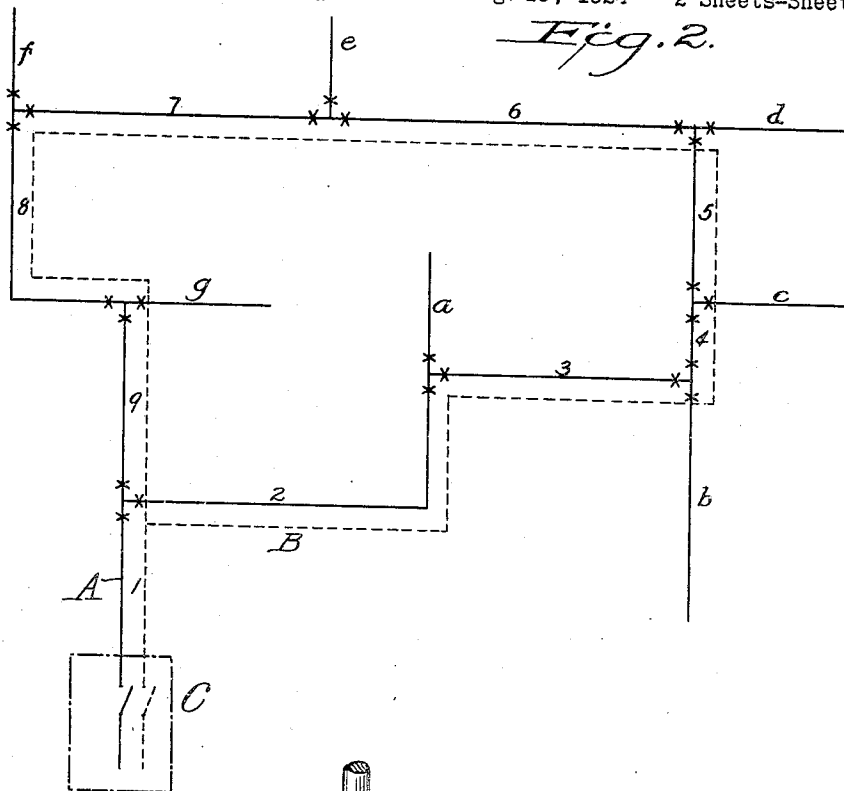
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FAULTY LINE SECTION CUT-OUT

Original Filed Aug. 15, 1924 2 Sheets-Sheet 2



WITNESS

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FAULTY-LINE-SECTION CUT-OUT

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In systems of electric distribution, it is customary to divide the service conductors into sections to which power is supplied from a central station by feeders. The feeders are connected to the sections and to each other by sectionalizing switches, whereby any section of the feeders or distribution system may be connected or disconnected from the source, which becomes necessary when a short-circuit occurs or repairs are to be made. These sectionalizing switches are manually operated and if a short-circuit occurs, dependence is placed upon an automatic overload switch, or circuit breaker, at the central station to open the circuit and prevent further damage.

The object of my invention is to provide means whereby a faulty section may be cut off from the central station as soon as the operator learns by the opening of the overload switch that trouble has occurred. This may be accomplished by the use of auxiliary circuits extending out from the central station and reaching all sectionalizing switches that it may be desired to operate, and relay apparatus located at each switch which is so connected with the auxiliary circuit as to enable the operator to perform the following acts:—

First, by manipulation of suitable switches in the auxiliary circuits at the central station he can open all the sectionalizing switches. Second, by further manipulation of the switches in the auxiliary circuits, he can close these sectionalizing switches in succession by power derived from the main circuit, so that upon closing his main line switch the sectionalizing switch nearest the central station will be closed first. This will bring about the closing of the next sectionalizing switch and so on until they are all closed up to the faulty section. Third, when such closing of the sectionalizing switches in sequence brings the faulty section in circuit and, therefore, again trips the main switch, a condition of circuits is established at the sectionalizing switch thus closing on the faulty section which will render "dead" the switch-closing means at that point. This being the case, it is only necessary with the aid of the auxiliary circuits to again open all the sectionalizing switches and allow them to automatically

close again after the closing of the line switch to re-establish connection with all the sections on the station side of the faulty one. When by the operation of the auxiliary circuits the exploration has discovered the faulty section and opened its sectionalizing switch, a signal device located at that point and in communication with a reception device at the central station enables the operator to determine at which section the trouble has occurred, so that steps may be immediately taken to remedy the fault.

The service conductors are sometimes arranged in the manner of a loop, so that all parts of the system in the loop may get power in more than one way. In such a case, when a fault occurs on any given section, it becomes necessary to open two sectionalizing switches, one on either side of the fault, and in my present invention means are provided whereby the sectionalizing switch may be operated by power from either of the disconnected sections, relay connections being so arranged that whichever section is first ready to supply the power for the closing of the sectionalizing switch will render the other section inoperative during that particular operation of the switch and also will set up a state of affairs that will enable the operator by repeating the manipulations of the auxiliary circuits to disconnect the other section switch and thus entirely isolate the faulty section.

The invention may be best understood by reference to the accompanying drawing in which:—

Figure 1 is a diagram showing the central station and a distribution system with my invention applied thereto.

Figure 2 is a sketch of a complete system of distribution showing the relation of the auxiliary circuit to the main circuit and the sectionalizing switches.

Figure 3 is a perspective view of a mechanism for operating the sectionalizing switch.

Referring first to Figure 2, A represents a main distribution circuit having feeders in sections indicated by 1 to 9 with branches indicated by *a* to *g*, the location of the sectionalizing switches being indicated by crosses. B is an auxiliary circuit reaching to all the

sectionalizing switches and extending to the central station C.

Referring to Figure 1, the dot and dash line C indicates the central station in which is located a main line switch D, which in its closed position is held closed by a latch E, the switch opening by gravity when tripped by overload relay F releasing the latch E. The diagram illustrates a three-phase distribution system with a neutral wire. At G is shown a sectionalizing switch. These sectionalizing switches are of the gravity type, that is to say, they are opened by dropping of their own weight when the mechanism that holds them closed is tripped. The switch is closed by an electric motor shown at M, which has a worm m operating on a worm wheel m' , a pinion m_2 and a rack m_3 , the rack being connected to the switch G so that when it is elevated, the switch is closed. A suitable tripping mechanism is shown and consists of a bell crank H, which impinges on a pin h (see Figure 3) whereby the frame m_4 that carries the pinion m_2 may be turned around on the shaft of the motor so as to force the pinion out of engagement with the rack, thus enabling the sectionalizing switch to drop of its own weight.

At each sectionalizing switch there is a transformer connected with the line on the side towards the central station (in case of a loop this will be on both sides) and this transformer, when energized, furnishes power for the operation of the motor M. These transformers are designated by Pot. 1 and Pot. 2, as shown in the drawings, as one furnishes potential from the first section to cause the motor to close the switch onto the second section and vice versa. There are also located at each sectionalizing switch current transformers indicated in the drawing by C. T's, the purpose of which is to reproduce line current on a miniature scale and actuate the relay R_6 when the sectionalizing switch is closed against a short circuit. It should be stated here that a characteristic of the sectionalizing switches is that they make an initial contact when the switch travels the distance marked x , at which point, if there is a short circuit on the next section, the overload main line switch in the central station will open the main line and become fully closed a short interval of time later when the motor M has carried the switch its complete travel indicated by y . In my present invention I take advantage of this characteristic of sectionalizing switches, but in the broader aspects of my invention any other feature that operates differently in case of a short circuit may be made use of.

The essential thing to be noted here is that the motive mechanism operating the sectionalizing switch is adapted to first make an initial contact of the switch and then, unless otherwise interrupted, may continue its motion for a short period of time after the ini-

tial contact is made, at which time the switch may be said to be completely closed although in the broader aspects of my invention it would not be necessary for the switch itself to make further movement.

I will now describe the means whereby I propose to discover and isolate a faulty section. To do this I may make use of auxiliary circuits 1, 2 and 3, which by means of switches J in the central station may be connected with contacts a , b , c , and d that are in turn connected with a double pole switch K that will be used to connect the auxiliary circuits with a source of power L. Each sectionalizing switch has attached to it three cams N, O and P operating respectively three switches c_2 , c_3 and c_4 in such a way that when the sectionalizing switch is entirely open, c_2 is open, c_3 is closed and c_4 is open. When the switch makes contact indicated by travel x , c_2 is closed, c_3 is closed and c_4 is open, and when the switch is entirely closed, c_2 is closed, c_3 is open and c_4 is closed. R_1 to R_6 are relays. R_1 operates to close a switch C_1 when energized by the closure of switches J on contacts a and c . When C_1 is thus closed R_5 , by the closure of switch J on contacts a and d , can be made to break c_5 and close c_6 , which, if the main line has current, will cause the motor M to operate to close the sectionalizing switch. Relay R_2 is for the purpose of tripping the motor-operated mechanism previously described, by impinging against the arm of the bell crank H. A dash pot S, the piston of which is connected to the bell crank, will prevent the quick return of the tripping mechanism, so as to give time for the switch to open entirely. A spring T is shown as a means for bringing the gearing back into mesh. Relays R_3 and R_4 are for the purpose of acting as mutual cut-outs, each for the other, so that whichever operates first the other will be incapacitated. This is for the reason that it is desired to have only the potential transformer on one side of the sectionalizing switch, in case power is coming from both sides, to operate at a time. A time element is necessary for these relays and is furnished by the dash pots U, which cause these relays to operate slowly when energized and have a quick return when deenergized. Relay R_6 is for the purpose of opening contact C_1 which will cause the interruption of the motor circuit by breaking c_6 and this will happen when R_6 is energized by the C. T's only in case there is a short on the next succeeding section. If there is no short on the next section, the sectionalizing switch will make its full travel and completely close, and then the motor circuit will be broken at c_3 after which c_4 will close, short-circuiting R_6 so that the latter will be unable to kick open C_1 , which otherwise it would do when subsequently a short is encountered further along in the system.

At W is shown another cam attached to the sectionalizing mechanism that operates to break the circuit of Pot. 1 and Pot. 2 when the sectionalizing switch is entirely closed. This should open the switches w_1 and w_2 immediately after cam O opens c_3 . By opening these circuits, which are connected with the power lines, safety in regard to overheating and in advertent operation is attained.

A clearer understanding of the functions of the mechanism thus far described will be obtained from the following description:—

When the station operator has a short-circuit on a feeder and finds that he cannot keep his line switch closed, he closes his double-pole, single-throw knife switch to put power on his control wires. He then closes the contacts a , b , c and d in the following sequence:

1. a and c .
2. b and d and closes line switch.
3. a and d (short will open switch again).
4. b and d and closes line switch.
5. a and d (short will open switch again).
6. b and d and closes line switch.
7. a and d (injured section will be cut off and the rest of the feeder will be in service again). The operator may then open his double-pole single-throw knife switch and so remove the power from his control lines.

The cycle of operation at the disconnect will be as follows:

On making contacts a and c —power from the station switchboard will actuate R_1 and make contact C_1 .

On making contacts b and d —power from the station switchboard will pass through c_2 , which will be closed when the sectionalizing switch is closed and will actuate R_2 . This will trip the switch opening release and allow the sectionalizing switch to fall out. The slow return element or dash pot S will insure the complete opening of the sectionalizing switch. As the sectionalizing switch opens, the cams will open contacts c_2 and c_4 and close contact c_3 . All sectionalizing switches on the control circuit will be opened by this operation.

The operator will then close his line switch again. If the fault or short-circuit is on the first section of the feeder, the line switch will trip out once more, indicating that the trouble is on the first section. If the first section is in good shape, the power will stay on that first section. Assuming the power to energize the right hand side of the diagram, Pot. 1 will deliver power to R_3 through c_5 . R_3 will act to open c_7 and close c_8 . The opening of c_7 prevents the operating of R_4 when the primary side of Pot. 2 becomes energized. The closing of c_8 energizes the motor circuit. If the power energizes the left-hand side of the diagram, Pot. 2 will deliver power to R_4 through c_7 . R_4 will act to open c_9 and close c_{10} . The opening of c_9

prevents the operating of R_3 when the primary side of Pot. 1 becomes energized. The closing of c_{10} energizes the motor circuit. In other words, no matter which side of the disconnect receives power first, the potential transformer on that side will cut out the potential transformer on the other side and supply current for operating the motor. In the remote possibility of the power coming on both sides of the disconnect at the same instant, the quicker of the two relays 3 or 4 will cut out the potential transformer on the opposite side and supply the motor with current.

On making contacts a and d —power from the station switchboard will pass through C_1 and actuate R_5 , which will open c_5 and close c_6 . The closing of c_6 completes the motor circuit and the motor M will start to run on power from one or other of the potential transformers and close the sectionalizing switch. If the fault or short-circuit is on the second section of the feeder, the fact will make itself known as soon as the switch has traveled a distance x (which is the travel necessary to make initial contact of the sectionalizing switch). Short-circuit current will flow through line and will cause R_6 to open C_1 . Opening C_1 will cut off the control power from R_5 , which will open c_6 and stop the motor, then close c_5 and shunt R_6 , thus preventing its becoming injured by overheating. Following this, the line switch in the station will trip out again, and indicate to the operator that he has encountered the trouble and that he can only supply power to his first section without making repairs. He must then open his sectionalizing switches once more by making contacts b and d and close his line switch on the first section. If the second section is in good shape, the motor will carry the switch the complete distance y . Upon completing its travel O will open c_3 and so stop the motor while P will close c_4 and so shunt R_6 , thus preventing it from opening C_1 when the fault is uncovered on some subsequent section. As soon as the first sectionalizing switch is closed without encountering the fault, the second sectionalizing switch will start to close as a result of the power supplied to the next potential transformer. It is to be observed that contacts a and d are to be left closed until the fault is located. Upon the closing of the second sectionalizing switch, the third will close and so on until the section where the fault is located is reached. Upon reaching the fault, R_6 on the last closed sectionalizing switch will trip and open C_1 . Since all the disconnects on the station side of the last closed sectionalizing switch will have made the complete travel y , their contacts c_4 will be closed, preventing their relays R_6 from operating. In other words, only the R_6 on the sectionalizing switch which has not yet traveled beyond

the distance x will operate. Here the line switch at the station will trip out and indicate to the operator that he has encountered the fault.

- 5 Contacts b and d must now be made again to open up all the sectionalizing switches once more.

The operator will then close his line switch again.

- 10 Upon closing contacts a and d the second time, all the sectionalizing switches will close, one after the other, up to the one which has encountered the fault. This cannot close because its contact C_1 is open.

- 15 If the feeder is of the loop type, the cycle of events will travel out from the station on all the sections and branches so long as the power stays on the feeder to operate the motors. The first branch to encounter the fault will cause the power to be cut off by tripping the line switch. At the same time it will prevent the sectionalizing switch on that section from operating to close a second time until the contacts a and c are made to reset the contact C_1 . When the line switch opens up after the first trial, the operator has located one end of the faulty section but he has yet to locate the other end. Upon making the contacts a and d for the second time the sectionalizing switch which has first encountered the fault cannot close again as noted, but the sectionalizing switch on the other end of the faulty section which has not had a chance to close and trip its relay R_a because the power was interrupted by the tripping of the station line switch, will now come in contact with the fault and repeat the cycle of the sectionalizing switch on the first end. Its C_1 will be opened by its R_a and the station switch will trip for the second time.

Again the operator will have to make contacts b and d to open up all the sectionalizing switches.

Again he must close his line switch.

- 45 He then makes contacts a and d for the third time. Since this time the contacts C_1 on both ends of the faulty section will be open, these sectionalizing switches cannot close and the faulty section will be isolated and the rest of the feeder will be in operation again.

- 50 The operator can then report the trouble and send a repair gang out to find and clear it up.

- 55 While this description applies to a three-phase, four wire loop feeder, modifications can be made to make it fit other conditions. If the feeder is not looped, only one potential transformer will be necessary. This is to be placed on the station side of the sectionalizing switch. Also it follows that no relay will be required to supply the necessary power to the motor from this potential transformer. In combinations of loops and branches, the sectionalizing switches on the looped sections will need two potential transformers and the

branches will require only one. In some cases only two control wires will be necessary as the neutral of the feeder may be used. Single-phase operation will merely be a simplification of the three-phase. Direct current feeders will require the use of shunts in place of the current transformers and possibly resistances in place of potential transformers. The tripping and closing mechanism may be any of the devices used for that purpose. A segmental gear may be used in place of the rack and the cams may be in a variety of forms, or even dispensed with altogether. In this latter case, electrical contacts will have to be placed directly on the mechanism.

80 An additional wire 4 will enable the operator, by closing switch J_1 on contact e connected to a signal receiving device such as a battery J_2 and telephone J_3 to receive the signal from the apparatus X , which may be a buzzer having a certain note, or any code signal device. The buzzer is brought into operation when C_1 is opened as it then closes on contacts X_1 as C_1 will only be open and X_1 closed at the sectionalizing switch which leads to the faulty section. The information thus obtained will enable the operator to save considerable time in directing the repair man to the location of the fault.

85 Assume now that the operator has just been through the operations of closing his sectionalizing switches for the first time and has had his station switch open up and indicate that as the switches closed one after another, one came in contact with the troubled section. In coming in contact with the troubled section, the C T's would cause R_a to trip and open C_1 and close the new contact. With this contact closed the station operator can close his switches d and e and listen to his telephone receiver. Current from the battery will circulate through control wires 3 and 4, the buzzer, and the receiver. The buzzer in interrupting the circuit periodically at a predetermined frequency will give out a distinct tone that the operator can recognize as belonging to a certain definite sectionalizing switch.

100 After recognizing one switch, the operator can proceed with his work of opening the switches and closing them again. When the station switch opens a second time after the operator has begun sectionalizing, the operator will know that he has encountered the other end of his troubled section. He can then listen again to his receiver and will be able to hear two buzzers working. By the difference in tone or frequency he can determine the second switch location. Then he can proceed to tell the trouble man where to look for the trouble. The action of the buzzer will further be a check on the proper operation of the relay R_a .

105 It is also possible to do away with at least one control wire, if the ground is used for

return, or if D. C. current is used on the control circuits with polarized relays and a switch at the central station for sending a D. C. current over the control wires first in one direction and then in the other. The latter alternative is shown in Figure 1 in dotted lines in connection with wires 3 and 4, Z and Z₁ being the polarized relays, the relay Z being adapted to operate in connection with C₂ and R₂ and the relay Z₁ being adapted to operate in connection with C₁ and R₅. There will in this case, of course, be a reversing switch as shown at Z₃ in the central station connected on the one side with a source of direct current and on the other side with wires 3 and 4. When D. C. control current is used, the battery J₂ may be omitted and the signal sent out by apparatus X may be transmitted to the receiving device J₃ by induction through repeater coils X₂ and J₄. It may even be desirable to omit R₁ and reset c₁ by hand since a trouble man must visit the location of the fault before the sectionalizing switches connected to the faulty section can be again closed. In this case still another control wire may be omitted.

While I have described a preferred embodiment of my invention, it will be understood that there are many other ways of carrying out the invention and in my copending application Serial No. 20,133, filed April 2, 1925, an alternative method is therein shown and claimed which is to be understood as coming within the scope of the broader claims herein made.

To those skilled in the art it will be apparent that I have disclosed a system for automatically exploring an electrical distribution system in such a way as to discover and automatically cut out a faulty section.

I claim:

1. The combination comprising a source of power, distributing conductors divided in sections, sectionalizing switches connecting said sections in series, a switch connecting the distributing conductors to the source of power and adapted to open the circuit in the event of overload, means for opening all the sectionalizing switches, means for closing the sectionalizing switches in succession commencing with the one nearest the central station, means at each sectionalizing switch operating when the said switch closes on a faulty section, to lock out the said switch against subsequent reclosure so that upon repeating the opening and the successive closing of the sectionalizing switches, the faulty section will remain cut out.

2. A combination according to claim 1 in which the power to close the sectionalizing switch is supplied from the main line.

3. The combination comprising an electrical distribution system having sections with sectionalizing switches between them, a central station, a switch at the central station

connected to the distributing system and adapted to open the circuit of said system in the event of overload, means controlled from the central station for simultaneously opening all of the sectionalizing switches, and means for causing them to close in succession by power supplied from the main line, the power from one side of the switch operating the switch to put power on the other side.

4. A combination according to claim 3 in which a loop system of distributing conductors is used with means for making operative connection with a section on one side of the sectionalizing switch while preventing operative connection with the section on the other side.

5. The combination comprising an electrical distribution system having sections with sectionalizing switches between them, a central station, a switch at the central station connected to the distributing system and adapted to open the circuit of said system in the event of overload, means controlled from the central station for simultaneously opening all of the sectionalizing switches, and means for causing them to close in succession by a switch closing motor, operatable by current from either side of the switch, with means for preventing its operation from one side when it has been started from the other side.

6. In a system of electrical distribution supplied with power through an overload circuit breaker and having a plurality of sections, sectionalizing switches for disconnecting such sections from adjacent sections, motive mechanism for said switches adapted to cause the switch to make an initial contact and upon further movement to cause the switch to become completely closed and means for differentiating between a sectionalizing switch making initial contact and one completely closing.

7. In a system of electrical distribution having a plurality of sections connected in series, sectionalizing switches for disconnecting such sections, auxiliary switch control circuits extending to the sectionalizing switches, means operatable from one of such auxiliary circuits to cause the opening of all the said switches, and means operatable from another of said auxiliary circuits to cause the closing of said switches one after the other beginning with the one nearest the central station.

8. In combination, an electric circuit comprising a plurality of sections and sectionalizing switches connecting said sections in series, a source of current, an overload circuit breaker between said source and said circuit, means for effecting the opening of all of the sectionalizing switches between the faulty section and the overload circuit breaker when a fault occurs on any section, and means associated with each sectionalizing switch for effecting the closing thereof when the ad-

jacent section nearer the source is energized and for locking it out against a subsequent reclosure whenever it is reclosed at a time when there is an overload connected to the other adjacent section.

9. In combination, an electric circuit comprising a plurality of sections and sectionalizing switches connecting said sections in series, a source of current, an overload circuit breaker connecting said source to one of the end sections of said circuit, means for effecting the opening of all of the sectionalizing switches between the faulty section and said overload circuit breaker after said circuit has been opened by a fault on any one of said sections, means associated with each switch for reclosing it in response to the energization of the adjacent section nearer said source, and means associated with each switch and responsive to a predetermined abnormal electrical condition of an adjacent section for rendering the associated reclosing means inoperative to effect a subsequent reclosure thereof when said predetermined abnormal electrical condition occurs within a predetermined time after any reclosure.

10. In combination, an electric circuit comprising a plurality of sections and sectionalizing switches connecting said sections in series, a source of current, an overload circuit breaker connecting said source to one of the end sections of said circuit, means for effecting the opening of all of the sectionalizing switches between the faulty section and said overload circuit breaker after said circuit has been opened by a fault on any one of said sections, means associated with each switch for reclosing it in response to the energization of the adjacent section nearer said source, means associated with each switch and responsive to the current there-through for rendering its associated reclosing means inoperative to effect a subsequent reclosure thereof when the current through the associated switch exceeds a predetermined value, and means controlled by each switch for rendering the associated current responsive means inoperative to prevent further reclosures of the switch after it has remained closed for a predetermined time.

11. In combination, an electric circuit comprising a group of series connected sections with a sectionalizing switch between each two adjacent sections, means for effecting the opening of all of said switches, means associated with each switch for reclosing it when an adjacent section is energized, lockout means responsive to a predetermined electrical condition of an adjacent section for rendering each reclosing means inoperative to effect a subsequent reclosure of the associated switch whenever it is reclosed and there is a fault on the adjacent section, and means controlled by each switch for rendering its associated lockout means unresponsive to said

predetermined electrical condition after the switch has remained closed for a predetermined time.

12. In combination, two electric circuits; a switch connecting said circuits, automatic reclosing means for said switch, a relay responsive to a predetermined abnormal electrical condition on one of said circuits for controlling said reclosing means in a predetermined manner, and means controlled by the position of said switch for rendering said relay unresponsive to said predetermined abnormal condition after said circuits have remained connected together for a predetermined time.

13. In combination, two electric circuits, a switch connecting said circuits, automatic reclosing means for said switch, an overcurrent relay for controlling said reclosing means in response to the current through said switch when closed, and means controlled by said switch for rendering said overcurrent relay inoperative to control the operation of said switch in response to the current through said switch after said circuits have been connected together for a predetermined time.

14. In combination, two electric circuits, a switch connecting said circuits, automatic reclosing means for said switch, a current transformer having its primary connected in series with one of said circuits, an overcurrent relay connected to the secondary of said current transformer and controlling the operation of said reclosing means, and means controlled by the position of said switch for short-circuiting said relay after said circuits have remained connected together for a predetermined time.

15. In combination, an electric circuit comprising a plurality of sections connected in series by sectionalizing switches, means for supplying current to each of the two end sections of said circuit, an overload circuit breaker between each end section of said circuit and the means for supplying current thereto, means for effecting the opening all of said sectionalizing switches after a fault on a section has opened both of said overload circuit breakers, and means associated with each switch for reclosing it in response to the energization of either of its adjacent sections and for locking it out against a subsequent reclosure whenever it is reclosed at a time when there is a fault on the adjacent section.

16. In combination, an electric circuit comprising a plurality of sections connected in series by sectionalizing switches, means for supplying current to each of the two end sections of said circuit, an overload circuit breaker between each end section of said circuit and the means for supplying current thereto, means for effecting the opening all of said sectionalizing switches after a fault on a section has opened both of said overload circuit breakers, means associated with each

switch for reclosing it in response to the energization of either of its adjacent sections, and means associated with each switch and responsive to a predetermined abnormal electrical condition on an adjacent section for rendering the associated reclosing means inoperative to reclose the switch when said predetermined abnormal condition occurs within a predetermined time after the switch has connected the adjacent sections together.

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