Jan. 21, 1947. W. C. RHEUBOTTOM 2,414,609

ELECTRICAL TESTING SYSTEM

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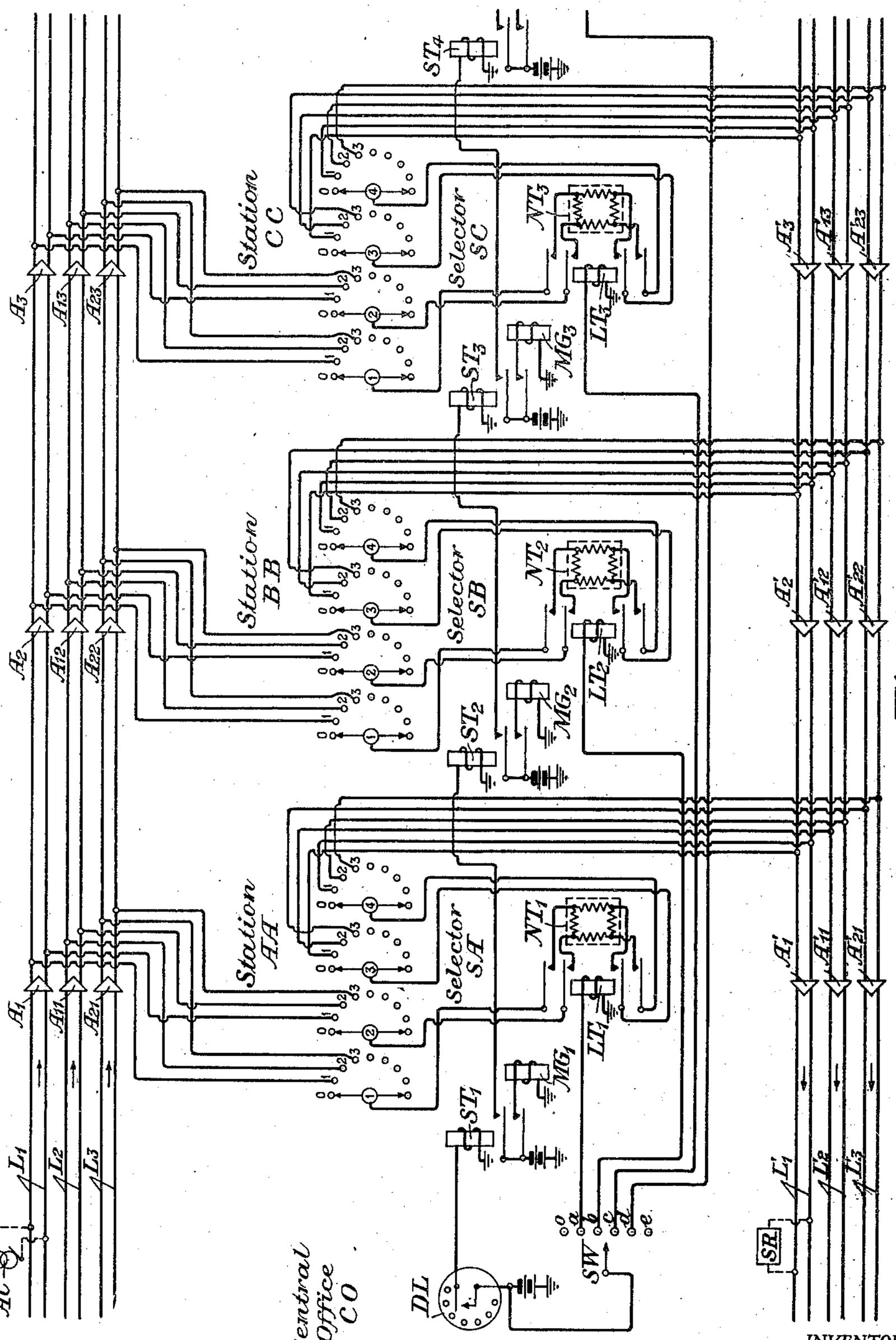

Fig. 1

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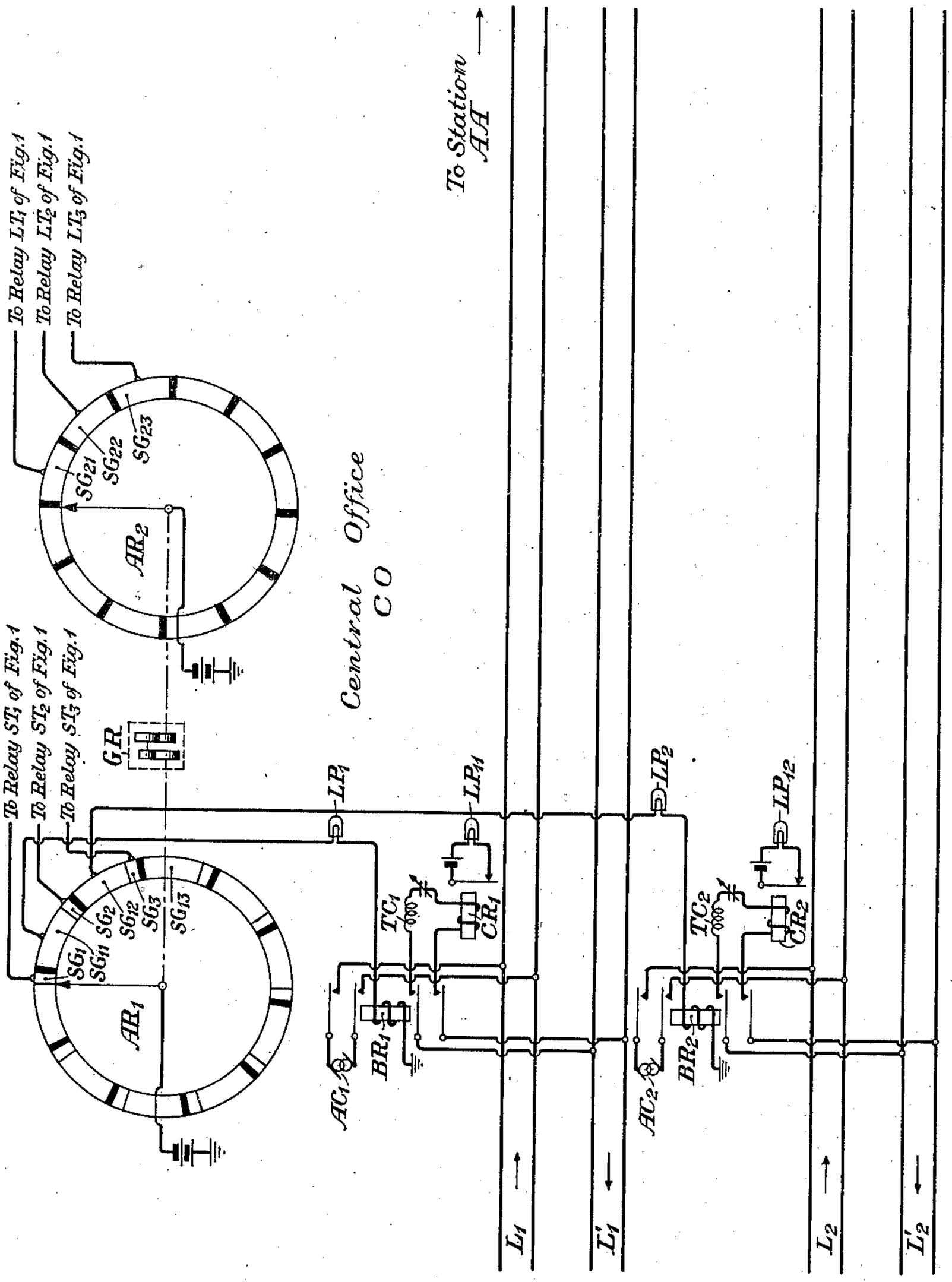

Fig. 2

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ELECTRICAL TESTING SYSTEM

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This invention relates to testing systems, and more particularly to testing systems for determining whether any of a plurality of transmission systems are out of order. Still more particularly, this invention relates to apparatus for determining the section of a transmission system that may be out of order.

In type K carrier systems, for example, a plurality of four-wire transmission systems are enclosed within a single cable, each four-wire system being divided into two pairs or lines, one pair or line serving to transmit the signals of a plurality of channels in one direction and the other pair or line serving to transmit the signals of a like number of channels in the opposite direction. Each pair or line of the four-wire system includes a plurality of repeaters of well-known type which, in general, are spaced several miles from each other, each repeater being usually located at an unattended station. When trouble arises in one of the four-wire systems, it has hitherto been the practice to dispatch a repairman to the different stations along the route to locate the trouble and have it repaired. The practice of having the repairman travel from station to station along the route to locate the approximate position of the fault, of course, consumes a good deal of time and is quite costly.

It is proposed, therefore, to improve the practice of locating the section of any one of the various four-wire transmission systems that may be out of order by installing apparatus at the central switching point and at each of the various stations along the route to permit tests to be made to determine the faulty section. Each station along the route may have a step-by-step selector and relays, all of which may be controlled by switching apparatus at the central point. The apparatus at the central switching point may be operated to step all of the selectors at the stations along the route so as to select the particular four-wire system that is to be tested. The apparatus at the central switching point may also be operated to connect an impedance pad across both pairs or lines of the selected four-wire system at any one of the various stations so as to enable the attendant at the central switching point to perform tests to determine whether the fault may be found between the central switching point and the first station along the route, or in the section between any two adjacent stations. Thus, by progressively connecting impedance pads across the four-wire system at different points along the route, the attendant at the central station will soon determine the particular section of the four-wire system that is out of order.

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This invention will be better understood from the more complete description hereinafter following when read in connection with the accompanying drawings, in which Figure 1 illustrates one form of apparatus which may be employed to carry out the invention, and Fig. 2 illustrates a modification of certain of the apparatus shown in Fig. 1 to permit automatic or continuous tests to be performed to determine which of the sections of the various four-wire systems are in good condition and which are out of order.

Referring to Fig. 1 of the drawings, three of a plurality of four-wire systems are shown extending between a central office CO and three of a plurality of stations which are designated AA, BB, CC. The two-wire lines or pairs L_1 and L_1' comprise one of the four-wire systems, the lines or pairs L_2 and L_2' comprise another of the four-wire systems and the lines or pairs L_3 and L_3' comprise still another of the four-wire systems. The pairs L_1 and L_1' are typical of each of the various four-wire systems, the pair L_1 including repeaters A_1, A_2 and A_3, for example, which are located at stations AA, BB and CC, respectively, and are arranged to transmit signals in one direction, while the other pair L_1' of this four-wire system includes similar repeaters A_1', A_2' and A_3' located at the same stations and arranged to transmit signals in the opposite direction. The central office equipment may include a dial DL, or other switching device, which may be operated to select any one of the various four-wire systems to be tested, and another switch SW which may be operated to select the station at which a suitable impedance pad may be bridged across the selected four-wire system. The stations AA, BB, CC include selectors SA, SB and SC, together with impedance pads or networks NT_1, NT_2, NT_3, respectively, and relay apparatus which will aid in operating the station equipment.

Assume that there is trouble on the four-wire transmission system L_1—L_1', and that it is desired to locate the section of the system where the trouble may be found. The attendant at the central office CO will first operate the dial switch DL to select the faulty four-wire system L_1—L_2. By dialing number 1, for example, a single pulse will be transmitted to relay ST_1 to operate that relay at station AA. The closure of the contact of the lower outer armature of relay ST_1 will cause the magnet MG_1 of the selector SA to be energized. The closure of the contact of the lower inner armature of relay ST_1 will cause current

to flow to relay ST_2 at station BB to energize the latter relay. The closure of the contact of the lower outer armature of relay ST_2 will likewise energize the magnet MG_2 of selector SB at station BB and the closure of the contact of the lower inner armature of relay ST_2 will cause current to flow to relay ST_3 at station CC to operate that relay. The closure of the contact of the lower outer armature of relay ST_3 will cause the magnet MG_3 of selector SC to be energized, and so on. As soon as the contact of the dial switch DL at the central office CO is opened, the relay ST_1 will be released. This will release magnet MG_1 and cause the selector SA at station AA to step to its terminal number 1. The release of relay ST_1 will likewise release relay ST_2, thereby deenergizing the magnet MG_2 and causing the selector SB at station BB to be advanced to its terminal number 1. The release of relay ST_2 will in turn release relay ST_3 and cause the deenergization of magnet MG_3, whereupon the selector SC at station CC will be advanced to its terminal number 1.

It will now be observed that at station AA the tip and ring conductors of line L_1 are connected through terminals numbers 1 of arcs 1 and 2 of selector SA to the upper outer and upper inner armature of relay LT_1, respectively. At the same time the lower inner and lower outer armatures of relay LT_1 are connected through the brushes of the arcs 3 and 4 of the same selector and their terminals number 1 to the tip and ring conductors of line L_1', respectively. As relay LT_1 is normally unoperated, the circuit between the pairs L_1 and L_1' of the four-wire system selected by selector SA will still remain open. Moreover, the same four-wire system of pairs L_1 and L_1' will also be selected at station BB and be prepared for subsequent tests. So at station CC.

Should the attendant at the central office CO now desire to test the section of the selected four-wire system L_1—L_1' between the central office CO and station AA, he will move the switch SW to its terminal *a*. This will cause relay LT_1 at station AA to be operated. The operation of relay LT_1 will connect the network NT_1 between the upper two armatures of the relay LT_1 and its lower armatures. The network NT_1 will now be bridged across the pairs L_1—L_1' of the selected four-wire system. The attendant may now listen to the signals, if any, flowing over line L_1 from the central office CO to station AA, then through the network NT_1, and back over the portion of the line L_1' between the same station AA and the central office CO and observe whether the signals are of the desired level. On the other hand, the attendant may connect to line L_1 a generator of alternating current, such as A. C. of some predetermined frequency which may not interfere with signaling over the system, and receive over line L_1' the current of generator AC at the indicating device SR. If the current received is of insufficient amplitude, the receiving device SR will indicate that fact to the attendant. If the received signals or alternating current is not at the required level, the trouble may then be ascribed to the section of the four-wire system between the central office CO and station AA, and the attendant may then dispatch a repairman to this section of the system to make the necessary repairs.

If the section of the system extending to station AA is in good condition, the attendant at the central office CO will then operate the switch

SW to its position *b*. As soon as switch SW leaves contact *a*, relay LT_1 releases, removing the network NT_1 from the circuit. The closure of contact *b* will now cause the operation of relay LT_2 at station BB and thereby bridge the pad NT_2 across the pairs L_1 and L_1' of the same four-wire system at station BB. The attendant may then connect the generator AC and the receiver SR across the pairs L_1 and L_1', respectively, as before, and determine whether the received current is of the desired amplitude. If the level is insufficient, the attendant will then fix the position of the fault as being in the section of the four-wire system L_1—L_1' between stations AA and BB. Thus, by operating the switch SW to any of its terminals the attendant may bridge the impedance pad located at any one of the various stations across the selected four-wire system and proceed to determine the section of the system that is in trouble.

When the trouble on the selected system has been located the attendant will then return the switch SW to its initial position *o*, and operate the dial mechanism DL to return the step-by-step selectors at the various stations to their normal positions. This may be done by the dial mechanism shown, for example, or by any other apparatus well known in the art.

If the attendant desires to select and test the four-wire system L_3—L_3', for example, he may operate the dial apparatus DL by dialing number 3 and thereby step all of the various selectors SA, SB, SC . . . to their terminals number 3. The four-wire system L_3—L_3' having been selected, the attendant will then connect any one of the various pads NT_1, NT_2, NT_3 . . . at stations AA, BB, CC, . . . respectively, across the selected four-wire system L_3—L_3'. He may then send current from the generator AC over line L_3 and observe whatever response is available at the receiver or indicator SR. By following this procedure, the attendant will readily determine the particular section of the selected four-wire system L_3—L_3' that may be in trouble.

It will be understood that only three four-wire systems have been shown for illustrative purposes and that in a carrier system of the type K type many such systems may be included within a single cable, all of which may be tested by the apparatus of this invention. It will be similarly understood that only three stations AA, BB and CC have been shown, but that there may be many such stations between the central office CO and a similar central office (not shown) some distance away, all of which would be controlled from a single station such as CO.

Fig. 2 illustrates a modification of the apparatus at the central office CO of Fig. 1, the modification being designed to enable tests of the conditions along the different sections of the various four-wire systems to be made continuously. Two rotors AR_1 and AR_2 may be coupled to each other by gears, such as GR_1, or by other means of well-known type, so that the rotor AR_2 may rotate through several revolutions while the rotor AR_1 travels through but one revolution. The rotor AR_1 may contact a plurality of segments, two of which correspond to each of the various four-wire systems. Ten pairs of such segments are shown on the drawings, the segments SG_1 and SG_{11} corresponding to the four-wire circuit L_1—L_1', segments SG_2 and SG_{12} corresponding to the four-wire circuit L_2—L_2', segments SG_3 and SG_{13} corresponding to four-wire circuit L_3—L_3', etc. The rotor AR_2 may progressively contact segments

SG_{21}, SG_{22}, SG_{23}, etc., each of which corresponds to one of the various stations, such as AA, or BB, or CC, etc., of Fig. 1, and twelve such segments are shown associated with rotor AR_2. In the illustration given, the rotor AR_2 will be required to travel through one revolution in the time required for the rotor AR_1 to travel through one-tenth of a revolution.

When both rotors AR_1 and AR_2 are started in motion, contact will first be momentarily established between rotor AR_1 and segment SG_1, whereupon the relay ST_1 of Fig. 1 will be operated, as already described. As soon as rotor AR_1 contacts the insulation between segments SG_1 and SG_{11}, the circuit to relay ST_1 will be broken, thereby releasing relay ST_1. This will be followed by the advance of selectors SA, SB, SC, etc., of Fig. 1 to their respective terminals number 1 as already explained. When rotor AR_1 contacts segment SG_{11}, the relay BR_1 will be operated over a circuit completed from battery through the rotor AR_1 and its segment SG_{11}, lamp LP_1, the winding of relay BR_1 and ground. The closure of the upper make contacts of relay BR_1 will connect the generator AC_1 across the line L_1 at the central office CO. The closure of the lower make contacts of relay BR_1 will connect a tuned circuit TC in series with the winding of a relay CR_1 across the line L_1' at the central office CO. The tuned circuit TC_1 may be resonated at the frequency of the current of generator AC_1. The relay CR_1, which receives the current traversing the tuned circuit TC_1, will control an indicating device, such as lamp LP_{11}.

As soon as the rotor AR_2 has contacted segment SG_{21}, relay LT_1 of Fig. 1 will be operated in the manner already described, to bridge the network NT_1 across the lines L_1 and L_1' of the first four-wire system at station AA. Current will then flow from the generator AC_1 over the line L_1 of station AA, then through the network NT_1 (of Fig. 1) and back over the line L_1' through the tuned circuit TC to the winding of relay CR_1. If insufficient current traverses the winding of relay CH_1, the latter relay will remain unoperated, thereby illuminating lamp LP_{11}. The simultaneous illumination of lamps LP_1 and LP_{11} will indicate that there is a fault in the section of the four-wire system between the office CO and station AA. If there is no fault in this section, then lamp LP_1 will alone be illuminated.

While the rotor AR_1 is still in contact with segment SG_{11}, the rotor AR_2 will be advanced to segment SG_{22} to operate relay LT_2 of Fig. 1. This will bridge the network LT_2 across the lines L_1 and L_1' of the same four-wire system at station BB. The current of generator AC_1 will now flow over the line L_1 of this four-wire system to station BB and back again to the central office CO, as already described, to determine whether a fault may be present in the section between stations AA and BB. The rotor AR_2 will then continue through its cycle while rotor AR_1 remains in contact with segment SG_{11}, and the various sections along the route will be tested for a fault.

At the completion of the first revolution of rotor AR_2, the rotor AR_1 will then successively contact segments SG_2 and SG_{12} to again make and break the circuit of relay ST_1 of Fig. 1, thereby stepping the various selectors SA, SB, SC, etc., to their terminals number 2. The rotor AR_2 will then continue through its next cycle to bridge networks NT_1, NT_2, NT_3, etc., progressively across the second four-wire system L_2—L_2' at the various stations AA, BB, CC, etc., respectively, to perform

similar tests on all sections of the four-wire system L_2—L_2'. Thus, all sections of the various four-wire system will be tested in succession and this cycle will be repeated. It will be understood that networks NT_1, NT_2, NT_3 . . . may be designed to present equal or unequal loss values throughout, or these networks may be designed to present diminishing loss values corresponding to their increased distances from office CO, as may be required.

The arrangement of this invention is not to be construed as limited to a carrier system, nor to a system which may have repeaters at various points along the line. The apparatus of this invention is generally applicable to all types of circuits, including telegraph circuits, voice frequency circuits, and power circuits, to determine the location of a fault in any section of any of these various circuits.

While this invention has been shown and described in certain particular embodiments merely for illustrative purposes, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. Testing apparatus for determining the section of a four-wire system that may be defective, comprising a plurality of impedance pads, each positioned at a different point along the system, and means for selecting ony one of said pads and bridging it between the two pairs of wires of said system, whereby current flowing over one of said pairs of wires will traverse the bridged pad and return over the other pair.

2. Testing apparatus for determining the section of a four-wire system that may be defective, comprising a plurality of impedance pads each of which is positioned at a different point along the path of the system, means for selecting any one of said pads and bridging it between the two pairs of wires of said system, means for transmitting current over one of said pairs of wires, through the selected path and back over the other of said pairs, and means for indicating the magnitude of the returned current.

3. Testing apparatus for locating the section of a four-wire system that may be defective, comprising a plurality of impedance pads each of which is positioned at a different point along the system, means for successively connecting the various pads between the two pairs of wires of said system, means for transmitting current over one pair and through the pad connected to the system and back over the other pair, and means for determining whether the magnitude of the returned current exceeds a predetermined value.

4. Testing apparatus for a plurality of four-wire systems all traversing a common route passing through a plurality of different points, comprising means for selecting any desired one of said four-wire systems at all of said points, a plurality of impedance pads each of which is located at one of said points, means for successively connecting the various pads between the two pairs of wires of the selected system, means for transmitting current over one pair of wires of the selected system and through the pad connected to said system and back over the other pair of wires of the selected system, and means for indicating whether the magnitude of the returned current exceeds a predetermined value.

5. In a testing system for a plurality of four-wire circuits all of which are routed through a plurality of stations, each four-wire circuit including two pairs of wires transmitting currents in opposite directions, the combination of a plurality of step-by-step selectors, a plurality of networks, one selector and one network being located at each station, means for stepping all of said selectors equally to select any one of said four-wire circuits, means for selecting any one of said net-works and bridging it across the two pairs of the selected four-wire circuit, and means for determining whether the impedance of the selected four-wire circuit and the selected network exceeds a predetermined value.

6. The combination of a plurality of four-wire circuits enclosed in a common cable, the route of

which passes through a plurality of different stations, each four-wire circuit including two pairs of wires transmitting currents in mutually opposite directions, a plurality of selectors, a plurality of networks, one selector and one network being located at each station, means for operating all of said selectors so as to select any desired four-wire circuit at all of said stations, means for bridging the network at any desired station across the two pairs of wires of the selected four-wire circuit, and means for determining whether current transmitted over one pair of wires of the selected circuit, through the bridging network and back over the other pair of wires of the selected circuit is above a predetermined value.

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