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REMOTE CONTROL SYSTEM

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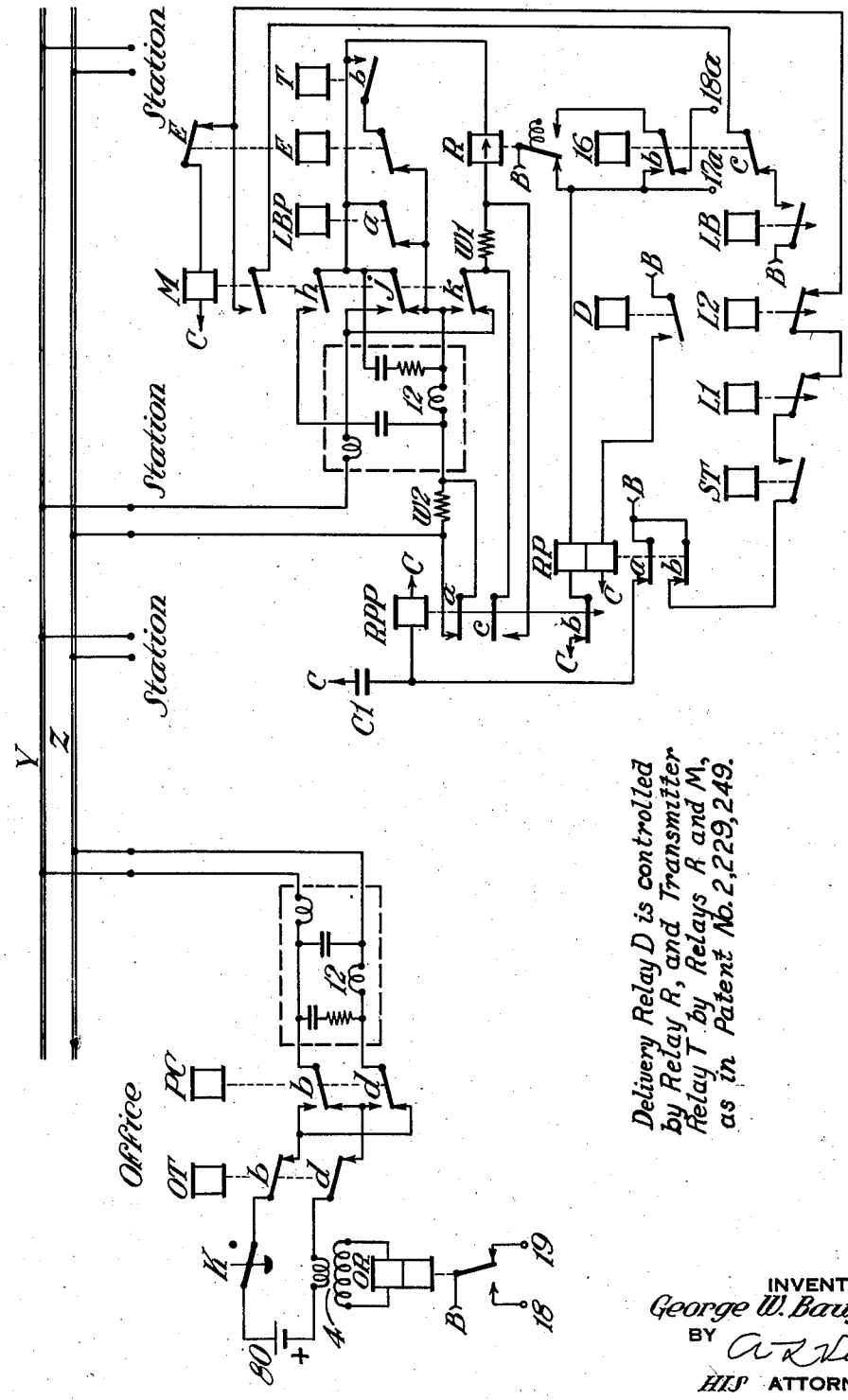

Delivery Relay D is controlled by Relay R, and Transmitter Relay T by Relays R and M, as in Patent No. 2,229,249.

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REMOTE-CONTROL SYSTEM

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My invention relates to improvements in remote control systems of the type in which impulse codes are transmitted between a central office and a plurality of distant stations, and more particularly to apparatus for locating faults affecting the line circuits of such systems and for overcoming the effects of faults.

The prior practice in systems of this character has been generally to connect the line relays and transmitting contacts at the office and stations all in series with the line wires, as shown for example, in the Letters Patent of the United States No. 2,229,249, issued January 21, 1941, to L. V. Lewis, for Remote control systems. A series line circuit has the advantage that a cross or short circuit occurring in the portion of the line circuit leading into any station usually has only a local effect, and in any case does not prevent the system from being maintained in operation between the office and all stations on the office side of the fault. On the other hand, a break in a series line circuit at any point, in the absence of suitable fault detecting means, such for example, as that shown in my Letters Patent of the United States No. 2,011,237, issued August 13, 1935, results in the total disablement of the system.

More recently it has been found of advantage to connect the line relays and transmitting contacts of the remote control system in parallel rather than in series with the line to facilitate the joint use of the line wires without interference by other communication facilities such as the telephone and telegraph, as shown, for example, in Letters Patent of the United States to Baughman et al., No. 2,303,875, issued December 1, 1942. It is inherent in a bridged line circuit that in the event of a break in the line the system remains operative between the office and the location of the break, and it follows that fault detecting apparatus of the sectionalizing type as shown in my prior patent is not applicable.

The object of my present invention is the provision of fault detecting apparatus analogous to that of my prior patent but applicable to such bridged line circuit systems. A further object is to provide means manually controllable from the central office for isolating any station from the system in the event a fault at that station causes interference with the transmission of codes from other stations.

I shall describe one form of apparatus embodying my invention and shall then point out the novel features thereof in claims.

In the accompanying drawing I have illustrated a typical bridged line circuit comprising the line wires Y and Z and the apparatus associated therewith located at the office and at one station, it being understood that in general the circuit will include a number of such stations each having similar connections to the line wires. The remote control apparatus as shown corresponds generally to the above-mentioned Lewis patent modified as shown in Fig. 1 of the Baughman et al. patent, together with two relays RP and RPP and a resistor W2 at each station, and a manual switch K at the office, added in accordance with the present invention.

For an understanding of the various details of operation of the remote control system, reference may be made to these patents, but for an understanding of the present invention it is believed that it will suffice to point out that the line wires are normally energized by current from an office battery **80**, the positive terminal being normally connected to line wire Y and the negative terminal to line wire Z over back contacts *b* and *d* of a pole changer relay PC and of an office transmitter relay OT, through a low pass filter **12**.

At each station, a line relay R, of the high resistance biased polar type, is bridged across the line in series with a resistor W1, the connections including back contacts *j* and *k* of a station master relay M and the coils of a low pass filter **12** similar to the one at the office. Relay R is normally energized to close its left-hand contact, when its left-hand terminal is positive, as is the case when the system is at rest and relays PC and M are both released.

Control codes are transmitted by periodically interrupting the line current by the operation of the office transmitter relay OT, the code operation of which will be repeated by each station line relay as will be obvious.

The office line relay OR is of the stick polar type, and is operated locally by means not shown, in response to control codes. In receiving indication codes relay OR is operated by impulses of alternately opposite polarity delivered by transformer **4** as the line current is varied, the variations being produced by shunting the line wires periodically by the operation of a station transmitter relay T.

The initiation of an indication code is effected by energizing a station starting relay ST, thereby energizing a master relay M over a circuit governed by two timing relays L1 and L2 and a relay E, which relays are controlled by relay R as in the hereinbefore referred to Lewis patent, both timing relays being released only when relay R

is steadily energized, indicating that the line is free. Relay E serves to open the circuit for relay M in the event two or more transmitters are set into operation at the same time, as explained in the patent. As shown herein, the starting circuit controlled by relay ST has been modified in accordance with my invention by including therein a front contact *b* of relay RP. Assuming for the present that relays RP and RPP are both energized, it will be seen that in response to the operation of relay ST, a circuit will be completed from one terminal B of the local current source at contact *b* of relay RP through the master relay M to the other terminal C of the same source, as shown on the drawing. Relay M therefore picks up, closing its front contacts *j* and *k* to complete a connection between line wires Y and Z over back contact *a* of relay LBP, and thereby shunting relay R to cause it to release, the consequent increase in current delivered by battery **80** to the line causing the office line relay OR to reverse. The initial reversal of relay OR causes relay PC to pick up thereby reversing the polarity of the current in the line in the manner explained in the Baughman et al patent, and relay R upon releasing, causes the energization of relays L1, L2, LB and LBP, relay LB holding relay M picked up until relay **16** is operated at the end of the code. Relay M upon picking up completes a circuit for the station transmitter relay T as shown in the Lewis patent, to set relay T into operation, and contact *b* of relay T shunts the line wires periodically and thereby governs the office line relay OR in accordance with the code, relays PC, LB and LBP also remaining picked up until the code is completed. Relay R at the transmitting station responds to the code because of the reversal of its connections to the line by the operation of the pole changer contacts *j* and *k* of relay M, while at each other station at which relay M has not been operated relay R will remain released until the line polarity is restored to normal by the release of relay PC at the end of the code.

The connections of the station filter **12** as shown differ from those at the office, in that the filter condensers are normally disconnected; that is to say, they are connected across the line over front contacts *h* and *j* of relay M only during the transmission of an indication code from the corresponding station. The impedance across the line presented normally to voice frequency current by the station apparatus is thereby materially increased, this arrangement being disclosed in a copending application for Letters Patent of the United States, Serial No. 401,092, filed July 5, 1941, by G. W. Baughman et al., for Remote control systems.

Referring now to the apparatus of my invention, relay RP, as will be clear from the drawing, functions as a stick repeater of relay R and the fault relay RPP is a repeater of relay RP. Relay RP has a pick-up circuit closed in response to the operation of the station delivery relay D, and a holding circuit which closes when relay RP picks up and relay RPP is thereby energized. Relay D functions as shown in Fig. 7 of the above-mentioned Lewis patent; that is, it operates, and consequently picks up relay RP in response to the receipt of the final delivery step of a control code transmitted from the office to the particular station shown. Relay RP upon picking up, completes at its contact *a*, the energizing circuit for relay RPP, and relay RPP then picks up to complete at its contact *b* the holding circuit for relay RP extending to terminal B at the normally closed left-hand contact of the station line relay R. Relay RP is therefore normally energized, and likewise relay RPP; relay RP is operated repeatedly in accordance with the code operation of relay R, as long as relay RPP remains picked up. In normal operation, the longest interval of release of relay R and consequently of relay RP is that required for the transmission of an indication code by another station as above explained, this interval being in practice about three seconds. Thus during the transmission of a series of codes relay RPP will be repeatedly energized if the associated relay R responds to the code and otherwise will be energized momentarily at intervals of three seconds. Relay RPP is arranged to remain picked up under these conditions by the provision of an electrolytic condenser C1 connected across its terminals which provides sufficient energy storage to cause relay RPP to have a release period of from five to ten seconds. Relay RPP will release therefore only when relay R has been released for an abnormal length of time, as would be the case for example, if line wires Y and Z were in contact due to a fault.

If such a fault occurs within the station apparatus, its effect upon the remainder of the system will be nullified by the release of relay RPP as will now be pointed out. The line circuit usually includes a large number of relays R in parallel, and the impedance presented by each relay to the line is made relatively high in order to match their joint impedance with that of the line wires and to render the shunts applied by the transmitter relays T more effective, by connecting an impedance unit or resistor W1 in series with each relay R having an impedance value usually several times that of the relay winding. The added impedance unit or resistor W2 is of the same value as W1, but is normally short circuited by front contact *a* of relay RPP. It will be seen that when relay RPP is released, impedance unit W1, which is located between the station transmitting apparatus and relay R, becomes short circuited by the closing of back contact *c* of relay RPP and is replaced in the relay circuit by the similar impedance unit W2 located between the station transmitting apparatus and the line. It follows that if a short circuit occurs connecting wires Y and Z together through the filter or station apparatus, so that relay R is shunted, relays R, RP and RPP will release, whereupon the impedance presented by the station apparatus to the line will again become relatively high due to the insertion of the impedance unit W2 between this apparatus and the line, to allow the remainder of the system to be operated in a normal manner. On the other hand, if relay R becomes steadily deenergized for any reason in the absence of a fault in its line connections, the impedance presented by the station apparatus to the line will remain unchanged upon the release of relay RPP, relay R remaining operative and in condition to be reenergized and to then receive a control code whereby relay RPP may be reenergized, but the station will be rendered incapable of initiating an indication code, due to the release of relay RP, and the consequent opening of its front contact *b* in the station starting circuit.

The apparatus of my invention will thus clear a line fault automatically if it is due to a short circuit at a station, after which the remainder of the system may be restored to operation by

sending control codes to any other stations which have been affected by the fault.

The aparatus of my invention may also be controlled manually to clear a variety of faults other than short circuits. For example, the local battery at a station may become discharged or other defects may develop to render a station incapable of completing a code although able to initiate one repeatedly. Cut out devices of the thermal relay type are usually provided to take care of situations of this kind, but such devices are also likely to fail to operate as intended when the battery voltage is abnormally low.

In the event of improper operation of the system suspected to be due to a fault at a field station, the central office operator in charge will open the key K for a period of at least fifteen seconds, opening its contact in the line circuit and thereby disconnecting the line battery 80 to release the relays R, RP and RPP, rendering all stations inactive, and then after closing key K to reenergize the relays R, he will send a control code to each station in turn to operate the delivery relays D and thereby pick up the relays RP and RPP. The operation of each relay D as explained in the Lewis patent picks up the associated starting relay ST so that each control code is normally followed by an indication code from the called station. In the present instance this indictaion code informs the operator that relays RP and RPP have been picked up, since otherwise the indication code would fail to be transmitted. If the location of the fault is already known, the control code for the offending station may be omitted so that it will remain isolated and in that case the above described operations result in restoring the remainder of the system to normal operation. On the other hand, if the location of the fault is not known, it may reappear upon the delivery of a control code to a particular station, and its location being thereby made known, the fault may be cleared by repeating the above described operations, but omitting the code which caused the fault to reappear.

If the fault consists of a short circuit of the contacts of relay M or T or the like, or if it is within the receiving apparatus which controls relay T so that it prevents the proper reception of a control code transmitted to the defective station, it is evident that one series of control codes will suffice both to identify the defective station and to restore the remainder of the system.

In the event the voltage of the local source of current at a station fails gradually, less and less energy will be stored by condenser C1 and the release period of relay RPP will be shortened until a point is reached where relay RPP will release when a code is being transmitted from another station. Under these circumstances it is evident that a defective station may isolate itself from the system automatically.

Relay RPP is to be understood to be a slow release relay provided with the usual ferrules or short circuited winding to delay its release, and it will therefore function as an ordinary slow release relay in the event condenser C1 becomes disconnected. If this occurs, the maximum release period obtainable will normally be of the order of one second, allowing relay RPP to drop out when another station transmits a code. If the station apparatus is otherwise in order the only loss will be its ability to initiate indication codes, and it may therefore be kept in operation until the defect is corrected by transmitting control codes to the station, each such code resulting in the initiation of an indication code as already explained.

Although I have herein shown and described only one form of apparatus embodying my invention, it is understood that various changes and modificaitons may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In a remote control system, an office and a station connected by line wires, a normally energized line circuit including a source of current at the office, said line wires and a line relay connected across the line wires at the station, code transmitting apparatus at the station having a normally open transmitting contact included in a connection to said line wires, means including said code transmitting apparatus for closing said contact repeatedly for brief periods to shunt the line relay and thereby effect a periodic variation in the current flowing in said line wires, a fault relay at the station arranged to be actuated in response to a prolonged deenergization of said line relay, and means controlled by said fault relay when actuated for interposing an impedance in said connection to limit the current in the line wires to substantially its normal value even though said transmitting contact is closed, to thereby effectively isolate the code transmitting apparatus from said line wires.

2. In a remote control system, an office and two stations connected by line wires, a normally energized line circuit including a source of current at the office, said line wires and a line relay connected across the line wires at each station, code transmitting and receiving apparatus at each station controlled by the line relay at that station, said transmitting apparatus having a normally open transmitting contact included in a connection to said line wires, means controlled by each line relay when steadily energized for setting the associated code transmitting apparatus into operation to close its transmitting contact repeatedly for brief periods to shunt both line relays and thereby effect a periodic variation in the current flowing in said line wires, a fault relay at each station arranged to be actuated in response to a prolonged deenergization of the line relay at such station, means controlled by each fault relay when actuated for interposing an impedance in the connection between the line wires and said code transmitting apparatus at that station of sufficient value to prevent interference with the normal operation of the line relay at the other station in the event of a fault in said transmitting apparatus, and code responsive apparatus cotrollable by each line relay for restoring the associated fault relay to its normal condition in response to a particular code transmitted over said line wires from said office.

3. In a remote control system, an office and a station connected by line wires, a normally energized line circuit including a source of current at the office, said line wires and a line relay at the station, code transmitters at the office and station adapted to deliver impulse codes to said line wires at times to periodically deenergize said line relay, a fault relay at the station controlled locally by the line relay, means for picking up said fault relay responsive to the operation of said line relay in accordance with a particular code delivered by the office code transmitter, means for releasing said fault relay effectively

only when the line relay remains deenergized for a predetermined time interval which is longer than any interval occurring during the transmission of a series of said impulse codes, and means preventing the initiation of a code by said station transmitter except when the fault relay is picked up.

4. In a remote control system, an office and a station connected by line wires, a normally energized line circuit including a source of current and a manually operable contact at said office, said line wires and a line relay at said station, code transmitters at said office and station adapted to deliver impulse codes to said line wires at times to periodically release said line relay, a fault relay at the station controlled by said line relay, means for picking up said fault relay responsive to the operation of said line relay in accordance with a particular code delivered by the office code transmitter, means for maintaining said fault relay picked up until said line relay is released for a time interval which is longer than occurs in the normal operation of said code tranmitters whereby said fault relay may be selectively released in response to the operation of said manually operable contact, and means preventing the initiation of a code by said station transmitter except when the fault relay is picked up and said line relay is steadily energized.

5. In a remote control system, an office and a plurality of stations connected by line wires, a source of current at the office connected to said line wires, code transmitting apparatus at each station including means for connecting said line wires together to vary the current from said source in accordance with a code, a normally energized line relay at each station and an impedance in series therewith connected across said line wires through the associated code transmitting apparatus, a fault relay at each station arranged to be actuated in response to the deenergization of the associated line relay due to a fault in the code transmitting apparatus at one of said stations, means controlled by each fault relay when actuated for short circuiting said impedance and interposing a similar impedance between the associated code transmitting apparatus and said line wires to effectively isolate the station at which the fault occurs, and means responsive to the operation of each line relay in accordance with a distinctive code to pick up the corresponding fault relay.

6. In a remote control system, an office and a plurality of stations connected by line wires, a code transmitter at each station adapted to be energized from a local source of current for delivering impulse codes to said line wires, a line relay at each station responsive to the codes delivered to said line wires for controlling the associated code transmitter, a fault relay at each station, means for picking up each fault relay in response to the operation of the associated line relay, timing means associated with each fault relay supplied with energy from said local source each time the corresponding line relay is operated and adapted to effect the release of such fault relay during the normal operation of the system in the event of an abnormal decrease in the voltage of the local source, and means responsive to the release of each fault relay for effectively isolating the associated code transmitter from said line wires.

7. In a remote control system, an office and a plurality of stations connected by line wires, a fault relay at each station, a code transmitter at each station having a normally open transmitting contact connected across the line wires in series with an impedance unit of relatively high value, said unit being shunted by a normally closed contact of said fault relay, a line relay at each station connected across the transmitting contact at such station in series with a second impedance unit of relatively high value and adapted to be energized over said line wires, said second impedance being adapted to be shunted by a normally open contact of said fault relay, means at the office for supplying current to the line wires to maintain said line relays normally energized, means for initiating the operation of said code transmitters one at a time to periodically close their transmitting contacts to deliver impulse codes to the line wires to which said line relays are responsive, timing means controlled by each line relay effective if such relay remains deenergized for a time longer than occurs in the normal operation of said transmitting contacts for actuating the associated fault relay to open said normally closed contact and to close said normally open contact, and means for maintaining such fault relay in its actuated position as long as the associated line relay remains deenergized.

8. In a remote control system, an office and a plurality of stations connected by line wires, a fault relay at each station, a code transmitter at each station having a normally open transmitting contact connected across the line wires, a line relay at each station connected across the transmitting contact at such station in series with an impedance unit of relatively high value and adapted to be energized over said line wires, means at the office for supplying current to the line wires to maintain said line relays normally energized, means for initiating the operation of said code transmitters one at a time to periodically close their transmitting contacts to deliver impulse codes to the line wires to which said line relays are responsive, timing means controlled by each line relay effective if such relay remains deenergized for a time longer than occurs in the normal operation of said contacts for actuating the associated fault relay, means controlled by each fault relay when actuated for removing the impedance unit from the circuit for the associated line relay and for interposing a similar unit in said circuit between the associated transmitting contact and the line wires, and means for maintaining such fault relay in its actuated position until the associated line relay becomes energized over the circuit including said second impedance unit.

9. In a remote control system, an office and a plurality of stations connected by line wires, a fault relay at each station, a code transmitter at each station having a normally open transmitting contact connected across the line wires, a line relay at each station connected across the transmitting contact at such station and adapted to be energized over said line wires, means at the office for supplying current to the line wires to maintain said line relays normally energized, means for initiating the operation of said code transmitters one at a time to periodically close their transmitting contacts to deliver impulse codes to the line wires to which said line relays are responsive, timing means controlled by each line relay for actuating the associated fault relay in the event the associated transmitting contact remains closed or is short circuited and such line relay is thereby maintained in its released

position for a predetermined time, means controlled by such fault relay when actuated for interposing an impedance unit in the circuit for the associated line relay between the associated transmitting contact and the line wires, such unit having an impedance value sufficient to render said closed contact or short circuit incapable of effecting the release of the line relays at other stations, and means for maintaining each fault relay actuated until the associated line relay again becomes energized.

10. In a remote control system, an office and a plurality of stations connected by line wires, a normally energized line circuit including a source of current at the office, said line wires and a plurality of line relays connected in parallel across the line wires there being one such relay at each station, a code transmitter at each station having a transmitting contact operable at times to connect the line wires together intermittently through an impedance of relatively low value to periodically deenergize said plurality of line relays, a normally energized slow release relay at each station, a repeater relay at each station for repeating the operating of the associated line relay having an energizing circuit including front contacts of such line relay and of the associated slow release relay, an energizing circuit for each slow release relay including a front contact of the associated repeating relay effective to maintain the slow release relay picked up unless the repeater relay remains released for a time longer than occurs in the normal operation of said transmitting contacts, a delivery relay controlled by each line relay, a circuit closed by each delivery relay when operated by the associated line relay for initially energizing the associated repeater relay to thereby energize the associated slow release relay, and means effective when each slow release relay assumes its released position to interpose an impedance of relatively high value in the connection of the associated transmitting contact to the line wires to render the line relays at other stations nonresponsive to the closing or short circuiting of such contact.

11. In a remote control system, an office and a plurality of stations connected by line wires, a code transmitter at each station for delivering impulse codes to said line wires, a normally energized line relay at each station responsive to the codes delivered to the line wires for controlling the associated code transmitter, a normally energized fault relay at each station, a holding circuit at each station including a front contact of the fault relay and a normally closed contact of the line relay at such station including means effective when the circuit is closed to hold the fault relay energized, energy storage means associated with each fault relay for maintaining such relay energized while its holding circuit is temporarily opened during the code operation of the associated line relay, means responsive to the release of each fault relay for effectively isolating the associated code transmitter from said line wires, a delivery relay controlled by each line relay, and means controlled by each delivery relay for picking up the associated fault relay to complete the holding circuit for such relay.

12. In a remote control system, an office and a plurality of stations connected by line wires, a normally energized line circuit including a source of current at the office, said line wires and a line relay at each station, a code transmitter at each station for delivering impulse codes to said line wires, a fault relay at each station, means for holding each fault relay normally picked up, comprising a holding circuit controlled by front contacts of such fault relay and a contact closed when the associated line relay is picked up, together with energy storage means for maintaining such fault relay energized when its line relay is released for brief periods in response to said impulse codes, means responsive to the release of such fault relay for effectively isolating the associated code transmitter from said line circuit, code responsive means controlled by each line relay for selectively pickup up each fault relay to establish its holding circuit, and means at said office for manually isolating one or more of said code transmitters from said line circuit, comprising a manually operable contact for opening the line circuit temporarily to release the fault relays at all stations together with means for transmitting codes to selectively reenergize the fault relays controlling the remaining code transmitters associated with said line circuit.

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