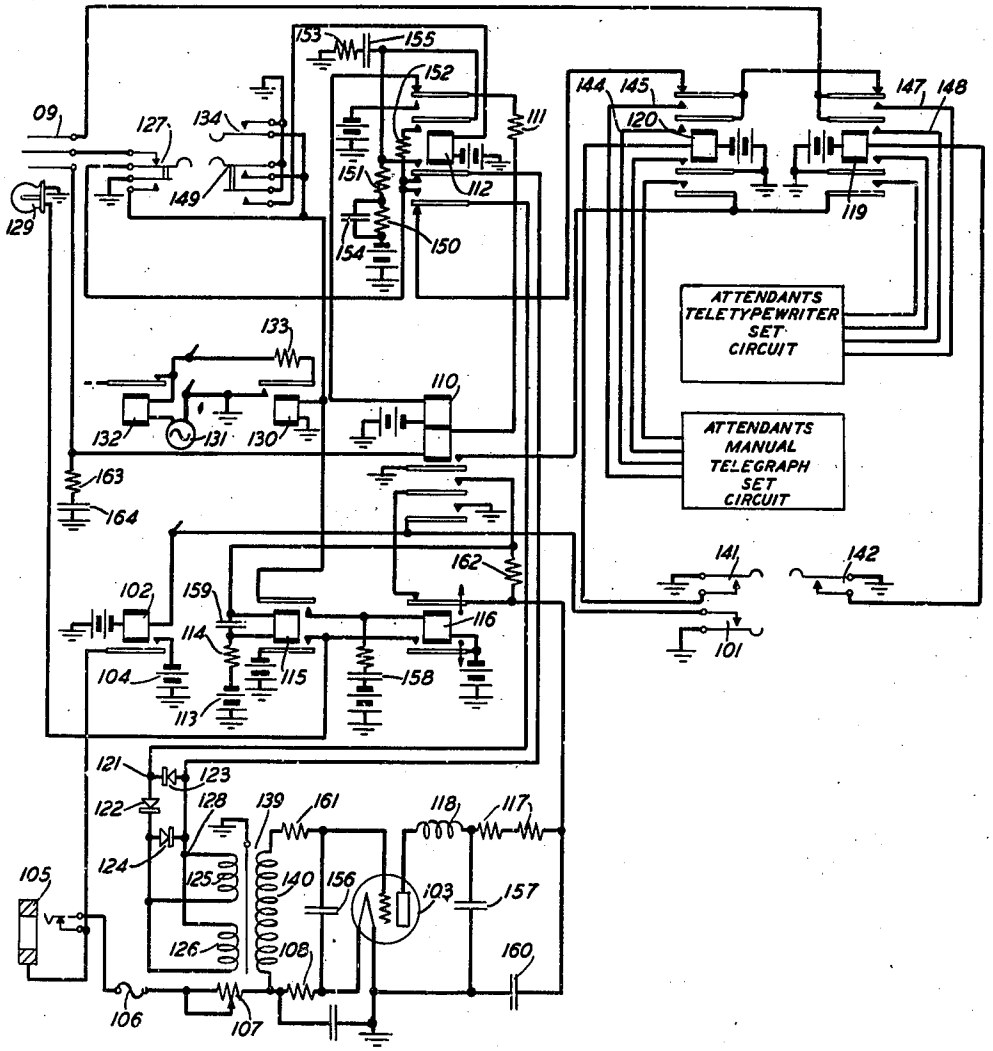
Oct. 19, 1943. T. A. MARSHALL 2,332,451

TELEGRAPH TROUBLE INDICATOR CIRCUIT

Filed Nov. 20, 1940 2 Sheets-Sheet 1

FIG. 1



INVENTOR
T. A. MARSHALL
BY
J. W. Schmied
ATTORNEY

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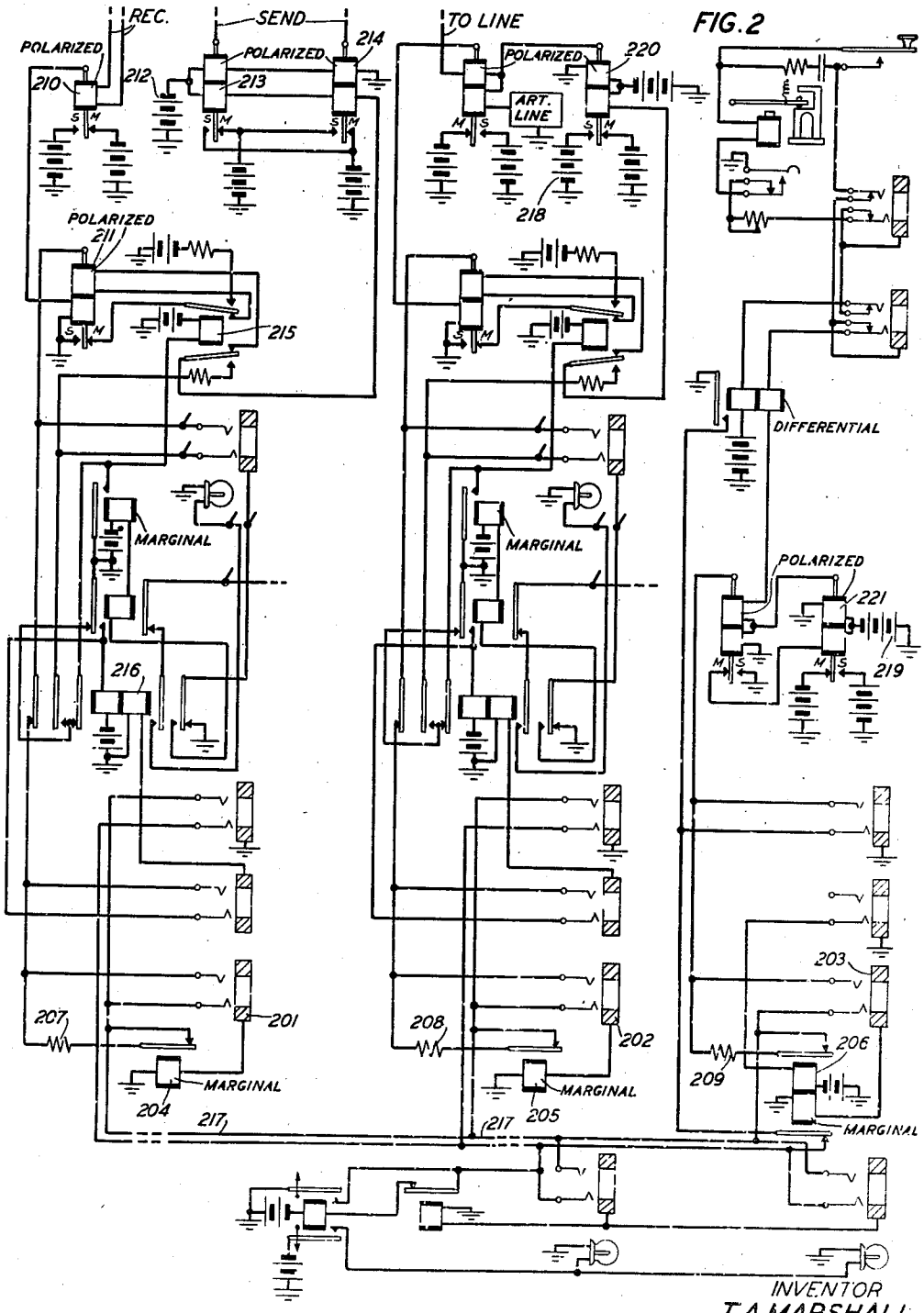
FIG. 2



INVENTOR
T. A. MARSHALL
BY J. W. Schmied
ATTORNEY

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TELEGRAPH TROUBLE INDICATOR CIRCUIT

Tola A. Marshall, Floral Park, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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18 Claims. (Cl. 178—69)

This invention relates to telegraph testing equipment and more particularly to a trouble indicator circuit or to a hit indicator as it is generally known in the art.

An object of this invention is the improvement of hit indicator circuits for use in maintaining telegraph circuits.

A new type of telegraph operation known as inverse neutral repeater hub circuit operation is at present being widely applied. Inverse neutral repeaters are described in the patents to Kinkead 2,056,277, October 6, 1936, Kinkead 2,077,936, April 20, 1937 and Cummings 2,069,224, February 2, 1937. The administration of networks built up of such circuits is described in the copending application of Bonorden et al. Serial No. 362,548 filed October 24, 1940. The maintenance of such circuits involves new problems. The provision of a satisfactory hit indicator for such circuits is one of the important problems involved in the operation of such circuits. Reference is made to the copending applications of J. A. Mahoney Serial No. 301,358, filed October 26, 1939 and of A. R. Bonorden Serial No. 317,809, filed February 8, 1940, now Patent No. 2,275,126, granted March 3, 1942, which disclose arrangements for maintaining such circuits. The present invention is an improved hit indicator for use in the maintenance of inverse neutral repeater concentration groups.

The invention will be understood from the following description when read with reference to the associated drawings in which:

Fig. 1 shows a typical trouble indicator circuit of this invention designed to indicate trouble in an inverse neutral repeater concentration group;

Fig. 2 shows a half duplex inverse neutral repeater concentration group including facilities for cooperating with the circuit of Fig. 1 so that troubles occurring in the concentration group may be detected.

General description of an inverse neutral telegraph repeater concentration group

The arrangement per Fig. 2 is well known, except for the additions necessary to modify it so that it will cooperate with the trouble indicator circuit of the invention herein.

Fig. 2 shows a concentration group comprising two telegraph lines and a local station circuit each equipped with an inverse neutral telegraph repeater. The group is arranged for half duplex operation. The three inverse neutral repeaters are interconnected through a group of concentration jacks individual to each of the three circuits. The three circuits are extended to a common neutral electrical point known as the hub of the concentration. One of the jacks in each concentration group is a testing jack designed to cooperate with the trouble indicator cord circuit of this invention. The testing jack as it is known is the bottom jack of each three concentration jacks associated with each repeater of Fig. 2. These jacks are indicated as **201**, **202** and **203**. A resistance of small magnitude is inserted in series in each of the transmitting conductors which join the individual inverse neutral repeaters to the hub. These resistances are indicated as **207**, **208** and **209**. A relay having a winding in series with the sleeve of each of jacks **201**, **202** and **203** is controlled from the trouble indicator cord circuit. The relays are indicated as **204**, **205** and **206**.

The operation of Fig. 2 is described in detail in the copending application of Bonorden et al. mentioned above. It will be described herein in a general way in so far as it is necessary to an understanding of the manner in which it cooperates with the present invention.

The circuits are shown in the marking condition. For this condition relay **210**, which receives signals from a distant central terminal, is in the marking condition. It maintains the auxiliary receiving relay **211** also in the marking condition. For this condition the leg of the inverse neutral repeater connects negative battery to the hub of the repeater. The circuit may be traced from negative battery **212** through the bottom windings of sending relays **213** and **214**, bottom armature and make contact of the full duplex versus half duplex control relay **215**, which is operated for a half duplex concentration, top winding of relay **211**, top make contact and armature of relay **215**, right-hand or marking contact and armature of relay **211**, left-hand outermost armature and break contact of relay **216**, test resistance **207**, armature and break contact of test relay **204**, to the hub of the concentration **217**.

For the marking condition the legs of the inverse neutral repeaters in the other line and in the station circuit connect negative battery also to the hub. For the line negative battery **218** is connected to one end of the circuit which ultimately extends through test resistance **208** to hub **217**. For the station negative battery **219** is connected to one end of the circuit which ultimately extends through test resistance **209** to hub **217**. Thus all legs end in negative battery of the same magnitude for the marking condition. No current flows in any leg and therefore there

is no ohmic drop across any test resistance while the marking condition prevails.

When the distant terminal connected to the left-hand line transmits a spacing signal toward the hub, it is received by relay 210. The armature of relay 210 is actuated to engage its alternate contact. Relay 211 responds. The armature of relay 211 connects ground to the leg which extends through test resistance 207 to hub 217. Current flows from battery 218 and battery 219 through test resistances 208 and 209 in parallel toward the hub, and from the hub through test resistance 207 to ground on the spacing contact of relay 211. There is an ohmic drop in resistances 208 and 209. Resistances 207, 208 and 209 are all of the same value. The combined current which flows through resistances 208 and 209 toward the hub flows through resistance 207 in the reverse direction, that is to say, away from the hub. The armatures of the sending relays 220 and 221 are actuated to transmit spacing signals to the distant connected terminal and to the local station respectively.

Attention is especially directed to the fact that there is no ohmic drop in any test resistance in the various legs of an inverse neutral concentration group while the repeaters in the group are in the marking condition, as no current flows for that condition. For the spacing condition, on a branch which is receiving from its associated distant terminal or local station and transmitting toward the hub, there is an ohmic drop in a certain direction dependent in magnitude upon the number of branches connected into the hub to which it is transmitting. In the case of any branch connected into a hub which is receiving from another branch connected to the hub, there is an ohmic drop in the reverse direction from the drop for the condition when the branch is sending and, in the usual concentration, wherein more than two branches are interconnected in a group, the drop for the receiving condition is smaller than for the transmitting condition.

In tracing the transmission branch which interconnected the inverse neutral repeater to the hub 217 of the concentration group, it was shown to extend through the back contact and armature of the testing relay. The testing relay is arranged so that it requires a relatively high current to operate it. The cooperating trouble indicator cord circuit is arranged so that when observations are being made on a branch the resistance of the connected sleeve circuit is high to prevent the operation of the testing relay. When a branch is found to be causing trouble, the resistance of the sleeve circuit of the trouble indicator cord circuit is changed, by operating a key, to a lower value which permits the test relay to operate and thereby cuts the branch which is causing the trouble off from the concentration.

The tip of each testing jack in Fig. 2, such as 201, 202 or 203, is connected in parallel with the terminal of the test resistance such as 207, 208 or 209 which is further from the hub. The ring of the testing jack is connected in parallel with the terminal of the testing resistance which is nearer the hub. The tip and ring of each testing jack are therefore connected across each test resistance and the trouble indicator circuit per Fig. 1 which will now be described is arranged so that it is responsive to ohmic drops in the test resistance of a certain magnitude and in a certain direction to indicate trouble on the branch.

Receiving an indication of trouble

Refer now to Fig. 1.

The circuit per Fig. 1 is made ready for use by the operation of key 101. This operates relay 102. Relay 102 controls the connection of battery to the filament of tube 103. This circuit may be traced from battery 104 through the make contact and armature of relay 102, through the break contact of filament jack 105, through fuse 106, variable resistance 107, resistance 108 and the filament of tube 103 to ground. When plug 109 is inserted into the testing jack associated with the leg of an inverse netural telegraph repeater concentration group, such as jacks 201, 202 or 203 of Fig. 2, ground is connected through the winding of the testing relay, such as 204, 205 or 206 of Fig. 2 to the sleeve of the testing jack and the circuit extends from this point through the sleeve of plug 109, through the bottom winding of relay 110, through resistance 111, through the top outer armature and break contact of relay 112, through the top winding of relay 110 to battery. This operates relay 110. The operation of relay 110 connects ground through its bottom outermost front contact and armature to supplement the ground from key 101. The operation of relay 110 supplies ground through its bottom innermost armature and front contact for future use in connection with the starting of teletypewriter and telegraph circuits which cooperate with the trouble indicator cord circuit but which will not be described in detail in connection with the operation of this circuit. The operation of relay 110 also closes the plate supply circuit of tube 103. This circuit may be traced from plate battery 113 through resistance 114, the winding of relay 115, through the bottom middle front contact and armature of relay 110, through the top back contact and armature of relay 116, through resistance 117 and induction coil 118 to the plate of tube 103.

When a space signal is transmitted toward the hub of the inverse neutral concentration group circuit through the leg to which the circuit herein is connected, the tip of the test resistance, such as 207, 208 or 209 of Fig. 2 and the tip of the concentration test jack as well as the tip of plug 109 are grounded. The potential of the tip of the plug, therefore, is more positive than the potential of the ring of the plug connected to the other end of the test resistance in the same leg of the concentration jack circuit. A circuit may be traced from the tip of the plug through the top outer armature and back contact of relay 119 through the top outer armature and back contact of relay 120, through the bottom back contact and armature of relay 112 to point 121 where it is connected to two copper-oxide rectifiers or varistors, as they are otherwise known, 122 and 123, in parallel. Varistor 122 is connected so that it presents a low impedance to current of this polarity. The ring circuit may be traced from the ring of plug 109 through the top break contact and armature of key 127, through the bottom inner break contact and armature of relay 112 to point 128. When the tip of plug 109 is more positive than the ring of plug 109, current will flow from point 121 through varistor 122 and through a three-branch parallel circuit comprising varistor 124 and the low resistance coils 125 and 126, forming the primary of the transformer 139, to point 128. Current flows through the coils 125 and 126 in such a direction as to induce a

potential in coil 140 which makes the grid of tube 103 sufficiently positive with respect to the cathodes of tube 103 so that current will flow in the plate circuit of tube 103.

If the space signal is coming from the other legs of the concentration group, the ring of plug 109 will be more positive than the tip of plug 109 and very little current will flow through the transformer primary windings due to the high impedance presented under this condition by the varistor unit 122. For this condition tube 103 will not ionize.

When current flows in the plate circuit of tube 103, relay 115 operates. The operation of relay 115 closes a circuit from battery through the bottom armature and front contact of relay 115 and the filament of lamp 129 to ground, lighting lamp 129. The operation of relay 115 also closes a circuit from battery through winding of relay 116 and the top front contact and armature of relay 115, through the winding of relay 130 to ground operating relay 130. The operation of relay 130 closes a circuit from ground through the source of alternating potential 131, winding of buzzer 132, resistance 133, through the armature and front contact of relay 130, back to ground. This operates buzzer 132. Relay 116 does not operate in series with relay 130, which is of high resistance.

Restoring the circuit to normal

Following the reception of a trouble indication or the possible lighting of lamp 129 when plug 109 is inserted in the testing jack, the circuit may be restored to normal for the reception of a further hit by momentarily operating the unlock alarm key 134. The momentary operation of key 134 short-circuits the winding of relay 130. Relay 130 releases. This in turn breaks the buzzer circuit. Momentary operation of key 134 also provides a direct ground which permits relay 116 to operate. The operation of relay 116 opens the plate battery supply for tube 103. Tube 103 deionizes. Relay 115 releases when the plate battery circuit is opened. The release of relay 115 in turn releases relay 116. The release of relay 116 by opening its bottom contacts extinguishes lamp 129. The circuit is now ready for the reception of a second space signal.

Transmission indication

The space signal which operated the indicator may have been a telegraph transmission signal from the associated inverse neutral circuit branch instead of a hit. In this case, immediately after the momentary operation of key 134 the circuit will reoperate and if key 134 is held operated, lamp 129 will flash irregularly.

The manner in which the lamp is flashed is as follows: The first spacing pulse causes the tube 103 to function in the manner described above. When relay 115 operates to light lamp 129 it simultaneously closes the circuit for the operation of relay 116. If key 134 is held operated relay 116 operates. Relay 116 in operating closes a circuit for the continued operation of lamp 129 at its bottom armature and front contact. The operation of relay 116 also opens the plate circuit of the tube. This releases relay 115 which in turn opens the circuit through the winding of relay 116. Relay 116 is designed so that it acts slowly. It does not release before lamp 129 is flashed. With relays 115 and 116 restored to normal, and key 134 maintained operated, the cycle may be repeated.

Disabling the circuit without disconnecting

If by the operations described in the two preceding sections the circuit is found to be responding to telegraph signals coming in on the branch of the inverse neutral concentration group to which the trouble indicator cord circuit herein is connected, further responses of the indicator circuit herein may be prevented by operating the disconnect alarm key 127. This opens the circuit heretofore traced through the ring conductor to one side of the input coils of the transformer. The operation of key 127 further connects ground through its bottom armature and front contact. In the event that relay 115 was operated when key 127 was operated, relay 116 will operate.

Connecting attendant's set

The circuit herein is arranged so that it may be connected to a manual telegraph set or to an attendant's teletypewriter set so that manual telegraph signals or teletypewriter signals may be transmitted or received through the trouble indicator circuit to the inverse neutral concentration group to which the trouble indicator cord circuit herein is connected through plug 109. If it is desired to connect a manual telegraph set to the trouble indicator cord circuit herein, key 141 is operated. When key 141 is operated ground is connected through the armature and front contact of key 141 and the winding of relay 120 to battery operating relay 120. This breaks the connection of the tip circuit heretofore traced to the input coil of the transformer and extends the tip instead into an attendant's manual telegraph set circuit (indicated by a rectangular box) so that the attendant may transmit and receive manual telegraph signals to and from the connected circuit over conductors 144 and 145. The object of disconnecting the circuit through the primary of the transformer when the trouble indicator cord circuit herein is connected to either of the associated telegraph transmitting or receiving facilities, is to prevent the false operation of the indicator circuit on signals sent from the attendant's set.

The operation of key 142 connects ground through the armature and make contact of key 142, through the winding of relay 119 to battery. This connects the trouble indicator cord circuit herein to an attendant's teletypewriter set (indicated by a rectangular box) through conductors 147 and 148 so that teletypewriter signals may be transmitted or received. The operation of relay 119 also disconnects the tip conductor of the trouble indicator cord circuit from the input windings of the transformer for the same reason as described above in connection with the operation of relay 120.

Removing a leg in trouble

If operation of the trouble indicator cord circuit herein indicates that the branch of the inverse neutral concentration group to which it has been connected is in trouble, the leg associated with the branch may be disconnected from the concentration group by operating key 149. The operation of key 149 closes a circuit from ground through the bottom armature and front contact of key 149 and through the winding of relay 112 to battery, operating relay 112. This breaks the circuit through the tip conductor at the bottom outer armature and break contact of relay 112. The operation of relay 112 will also connect an artificial leg consisting of resistances 150, 151,

152 and 153 and of condensers 154 and 155 to the ring of the indicator cord circuit. The operation of relay 112 will also connect the varistor and transformer circuit across resistance 152 in the artificial leg in the proper direction to respond to signals from the hub. The operation of relay 112 also reduces the resistance in the sleeve circuit of the cord by disconnecting the top winding of relay 110 from the sleeve connection and connecting the sleeve to battery through the top outer armature and front contact of relay 112.

The object of reducing the sleeve resistance is to permit the operation of the testing relay such as 204, 205 or 206 in Fig. 2 in the concentration jack circuit which disconnects the corresponding leg circuit. The operation of key 149 also connects ground through its top armature and front contact for operating relay 116 in the event that relay 115 responds to a signal. Thus lamp 129 will flash on any transmission which is taking place on the concentration group circuit.

If the operator wishes to communicate on the leg of the inverse neutral circuit which has been split off from the inverse neutral concentration group, it may be done by operating key 141 or 142 to connect the attendant's manual telegraph set circuit or the attendant's teletypewriter set circuit to the split-off leg through the tip of the trouble indicator cord circuit herein.

Apparatus functions

Condensers 156, 157, 158, 159 and 160 and resistances 161 and 162 are to prevent false operation due to interference. Resistance 162 is of the order of one megohm.

Fuse 106 is intended to protect resistances 107 and 108 from overheating in the event of accidental ground.

Resistance 163 and condenser 164 provide shock protection on the sleeve of the cord.

The three copper-oxide rectifiers, or varistors as they are otherwise known, 122, 123 and 124, as is well known, have the property of presenting a low resistance to current in one direction and a high resistance to current in the opposite direction. Each of these varistors is a single copper-oxide unit and must be protected against excessive voltage applied in the direction opposite to which it is intended that current shall be passed as, if excessive voltage in the opposite direction is applied, the unit will break down. In order, therefore, to protect against breakdown, it is arranged so that each unit, on which potentials in the reverse direction might be applied to cause breakdown, is shunted by a varistor arranged in the direction to present a low resistance to currents of the polarity which might cause damage.

After key 149 has been operated so as to disconnect the branch of the circuit with which the trouble indicator cord circuit herein has been functioning, there is a momentary interval, when key 149 is restored to normal while the branch of the inverse neutral concentration group is being reconnected into the group during which it is possible that the full 48 volts may be impressed from the group circuit on the tip or ring of the circuit herein. In order to prevent the breakdown of varistor 122 if an excessive reverse potential were to be impressed upon it, the circuit through the primary windings of the transformer and through the varistor 122 in the reverse direction is shunted by varistor 123 arranged in the proper direction to prevent the breakdown of varistor 122. The manner in which practically the full 48-volt potential may be impressed from the group circuit on the single copper-oxide rectifier unit 122 in the indicator circuit may be understood from the following.

It will be assumed that plug 109 has been connected to jack 203 and that key 149, relay 112 and relay 206 are all in the operated condition, so as to cut the branch with which relay 205 is associated off from the hub. The attendant restores key 149 to normal to reconnect the branch to the hub. The restoration of key 149 to normal disconnects ground at the bottom armature and front contact of key 149 from the circuit extending through the winding of relay 112. Relay 112 releases. This reestablishes the circuit which may be traced from the tip of jack 203 through the tip of plug 109, top outer armatures and back contacts of relay 119 and relay 120, bottom outer back contact and armature of relay 112, the single copper-oxide rectifier unit 122, primary windings 125 and 126 of transformer 139 in parallel, bottom inner armature and back contact of relay 112, top armature and back contact of key 127 and the ring of plug 109 to the ring of jack 203.

Normally, that is while relay 206 is released, the test resistance 209 is connected in shunt with the circuit just traced, across the tip and ring of jack 203 through the top contacts of relay 206. Relay 206 is operated while the branch with which it is associated is disconnected from the hub. Relay 206 has been operated due to the reduced resistance of the sleeve circuit in Fig. 1 heretofore traced. While relay 112 was operated, direct battery was connected to the sleeve circuit at the top outer front contact and armature of relay 112. When relay 112 releases, the alternate high resistance path through the top outer back contact of relay 112 and the top winding of relay 110 is reestablished. This reduces the current through the bottom winding of relay 206 and relay 206 releases. During the interval while relay 206 is releasing, however, before the low valued test resistance 209 is reconnected in shunt across the tip and ring of plug 109 of the indicator circuit, an excessive potential, sufficient to break down the single unit copper-oxide rectifier 122, may be applied in a direction, the reverse of the low resistance direction, across rectifier 122. If one of the circuits which has remained connected into the hub is transmitting while the reconnected branch is in the marking condition, a direct ground connected to the hub by the circuit which is transmitting will be connected to the ring of the indicator circuit through the ring of jack 203. Battery of 48 volts will be connected through the bottom winding of relay 221 and the marking contact and armature of the sending relay in the reconnected branch to the tip of the indicator circuit through the tip of jack 203. Due to the fact that the resistance in the high resistance direction through rectifier 221 is very high relative to the combined resistance of the other elements in the circuit, practically the whole 48 volts would be applied across the rectifier 122 in the reverse or high resistance direction which would break down the rectifier if it were not protected. Rectifier 123 is connected so as to form a low resistance shunt for rectifier 122 to protect it against breakdown from excessive reverse voltage. In the same manner varistors 123 and 124 are arranged to protect varistor 123 from an excessive back potential. Varistor 124 which is connected in shunt with the primary windings of the trans-

former both of which windings are of low resistance protects them from excessive current.

What is claimed is:

1. In a telegraph system, a telegraph trouble indicator circuit, means in said circuit for observing non-standard electrical conditions, a group of intercommunicating telegraph circuits, means for operatively interconnecting said indicator circuit and said group and means in said indicator circuit for controlling the disconnection from said group of a particular telegraph circuit on which a non-standard condition occurs.

2. In a telegraph system, a telegraph trouble indicator circuit, means in said circuit for observing non-standard electrical conditions, a group of intercommunicating telegraph circuits, means for interconnecting said indicator circuit and said group, telegraph means connected to said indicator circuit for communicating through said indicator circuit to said group, and means for restricting said communication to one circuit of said group.

3. In a telegraph system, a telegraph trouble indicator circuit, means in said circuit for observing non-standard electrical conditions, a group of intercommunicating telegraph circuits, means for interconnecting said indicator circuit and said group, telegraph means connected to said indicator circuit for communicating simultaneously with all of said intercommunicating circuits and means for excluding from such communication a circuit in said group on which trouble is indicated.

4. In a telegraph system, a telegraph trouble indicator circuit, means in said circuit for observing non-standard electrical conditions, a group of telegraph circuits interconnected by means of individual telegraph repeaters to a common neutral electrical point, means for interconnecting said indicator circuit and said group, and means in said indicator circuit for controlling the disconnection of an observed circuit in said group from said group.

5. A system in accordance with claim 4, and means in said indicator circuit for observing transmission on the circuits remaining in said group after the disconnection of said observed circuit without the necessity for disconnecting said indicator circuit from a connection in its original means of access to said observed circuit.

6. In combination in a telegraph system, an inverse neutral telegraph repeater concentration group, a branch connecting a repeater in said group to the hub of said concentration, a resistance in series in said branch, a trouble indicator circuit, means for connecting said indicator circuit across said resistance, and means in said indicator circuit responsive to a potential drop across said resistance in one direction only for indicating a non-standard electrical condition arising on a circuit connected to said hub through said branch.

7. In combination in a telegraph system, an inverse neutral telegraph repeater concentration group, a branch connecting a repeater in said group to the hub of said concentration group, a resistance in series in said branch, a trouble indicator circuit, means for connecting said circuit across said resistance, and a copper-oxide rectifier in said circuit for discriminating between potential drops in reverse directions across said resistance.

8. In a teletypewriter switching system, a plurality of telegraph circuits connected in an inverse neutral telegraph repeater concentration group through a common hub point, a trouble indicator circuit, means in said concentration group and in said indicator circuit for interconnecting said group and said indicator, a telegraph signal transmitting and receiving circuit, means in said indicator circuit for extending said indicator circuit to said telegraph circuit so that communication signals may be transmitted or received through said indicator circuit to and from said concentration group.

9. In a telegraph system, a trouble indicator circuit, means in said circuit for connecting said circuit to an operable telegraph path comprising a plurality of branches, means in said indicator circuit for discriminating between communication signals and signals caused by trouble conditions on one of said branches, means in said indicator circuit for controlling the disconnection of a branch found to be causing trouble and means in said indicator circuit for establishing a circuit for simulating said disconnected branch.

10. In a telegraph system, in combination, a plurality of telegraph circuits associated together in an inverse neutral telegraph repeater concentration group, a trouble indicator cord circuit conditioned to interconnect with said concentration group, means in said indicator circuit for indicating the transmission of normal communication signals through said concentration group, means in said indicator circuit for indicating the transmission of false signals caused by trouble through said concentration group, means in said indicator circuit for identifying the branch of said concentration group on which said false signals originate, and means in said indicator circuit for disconnecting the particular telegraph circuit on which said trouble arises.

11. In a telegraph system, a telegraph circuit, means connected to said circuit for communicating over said circuit in a first direction at a first time, lumped impedance means connected to said circuit for developing a potential to operate an indicator when signals are transmitted over said circuit in a second direction at said first time, a copper-oxide rectifier connected to said impedance means for detecting signals transmitted over said circuit in said second direction at said first time and an indicator, connected to said rectifier, responsive to said signal.

12. In a telegraph system, a telegraph trouble indicator circuit, means in said circuit for connecting said circuit to a telegraph communication circuit, means in said circuit for observing non-standard signals transmitted over said communication circuit while said circuits are interconnected and means in said testing circuit for establishing in said testing circuit an artificial branch of said communication circuit.

13. In a telegraph system, a telegraph trouble indicator circuit, means in said circuit for establishing in said circuit an artificial branch of a telegraph communications circuit and means also in said circuit for testing said branch to identify false signals in said communications circuit.

14. In a telegraph system, an inverse neutral telegraph repeater hub circuit comprising a plurality of branches, a hit indicator circuit, a branch in said indicator circuit extending through a lumped resistance to battery of the same polarity and magnitude as that in which the various branches of said hub circuit are terminated, means in said circuits for interconnecting said branch to the hub of said hub circuit and means in said indicator circuit cooperating with

said resistance for observing non-standard conditions in said hub circuit.

15. In a telegraph system, a testing circuit, a first rectifier, a control means and indicator means, all in said circuit, means in said circuit for passing current of a particular polarity through said rectifier and said control means to operate said indicator to indicate an abnormal condition and a second rectifier in said circuit, connected in shunt with said first rectifier, to protect said first rectifier against damage from excessive reverse potential.

16. In a telegraph system, a direct current telegraph communication circuit, a telegraph testing circuit, an indicating device in said testing circuit, means for interconnecting said circuits, a first element in said testing circuit presenting resistances of substantially different magnitudes to direct current of different polarities, said element being susceptible of injury from voltages within the normal operating range and of a particular polarity, means in said circuits for impressing voltage of said particular polarity on said element and a second element in said testing circuit, substantially identical with said first element, shunting said first element and poled to present a low resistance to voltage of said particular polarity to protect said first element.

17. In a telegraph system, a direct current telegraph communication circuit, a telegraph testing circuit, means for interconnecting said circuits, means in said testing circuit for indicating an abnormal condition in said communication circuit and a pair of independent rectifiers in said testing circuit arranged to afford mutual protection against reverse potential.

18. In a telegraph system, a telegraph testing circuit, a transformer winding connected to an indicator, both in said testing circuit, means in said testing circuit for operating said indicator to indicate an abnormal operating condition impressed on said circuit, a rectifier network consisting of three copper-oxide rectifiers only directly interconnected each to the other in said circuit, means in said network for passing substantial current of one polarity only to said winding, means in said network for protecting said winding against excessive current and means in said network for mutually protecting said three rectifier elements from potential applied in any direction on any of said rectifiers.

TOLA A. MARSHALL.