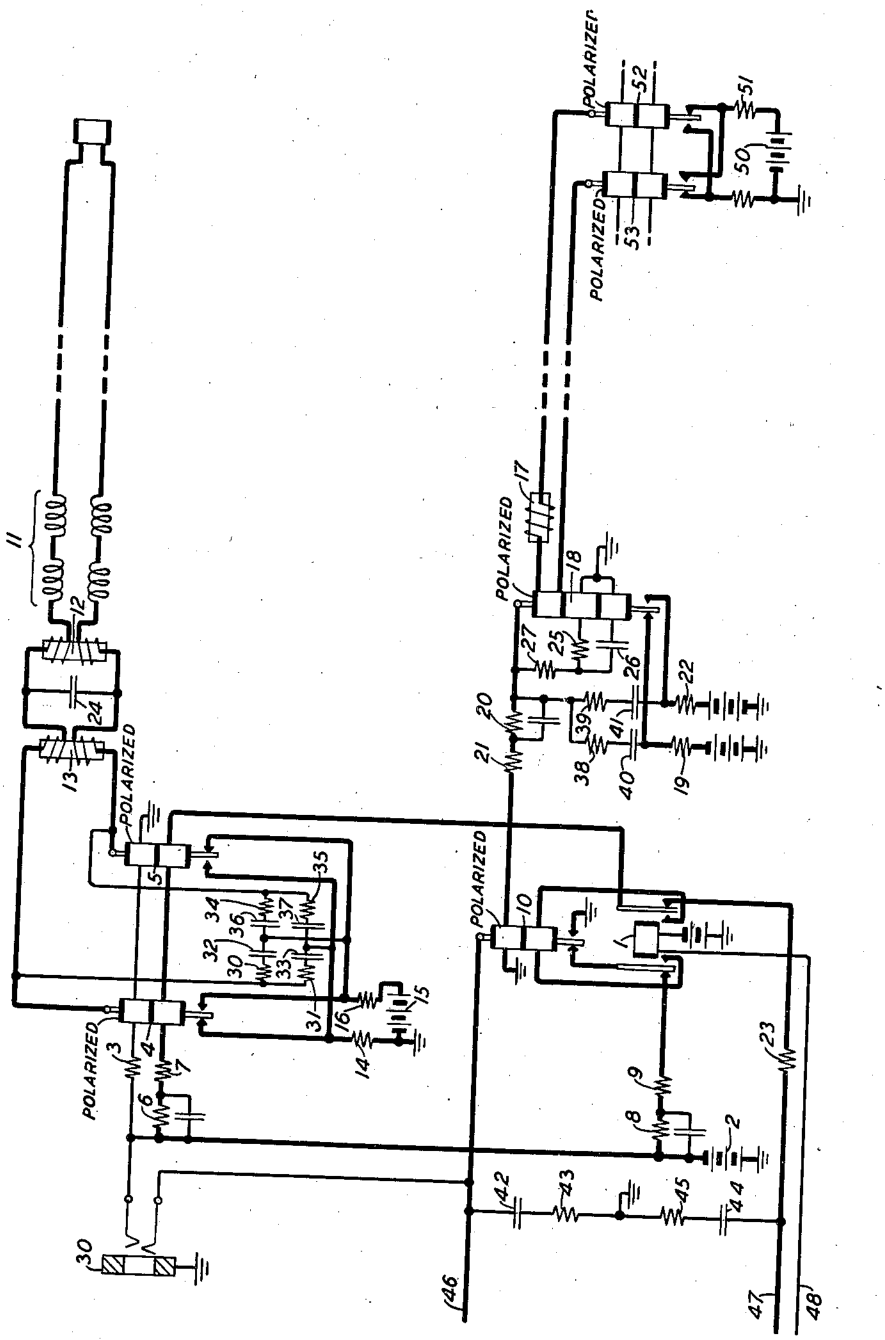
Oct. 21, 1941. R. B. HEARN 2,259,637

TELEGRAPH REPEATER

Filed June 26, 1940 3 Sheets-Sheet 1

FIG. 1



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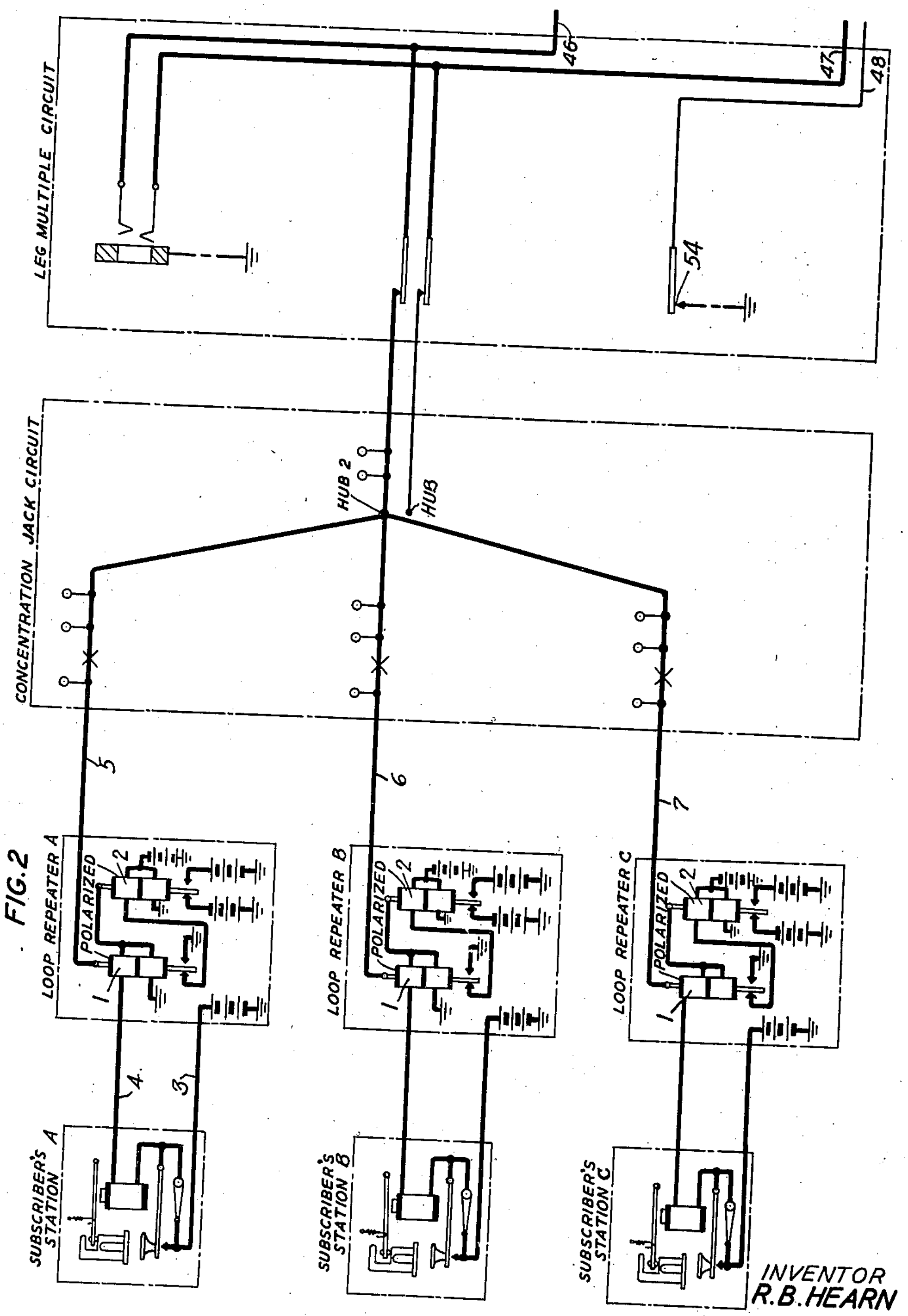
TELEGRAPH REPEATER

Filed June 26, 1940

3 Sheets-Sheet 2

FIG. 2



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TELEGRAPH REPEATER

Filed June 26, 1940 3 Sheets-Sheet 3

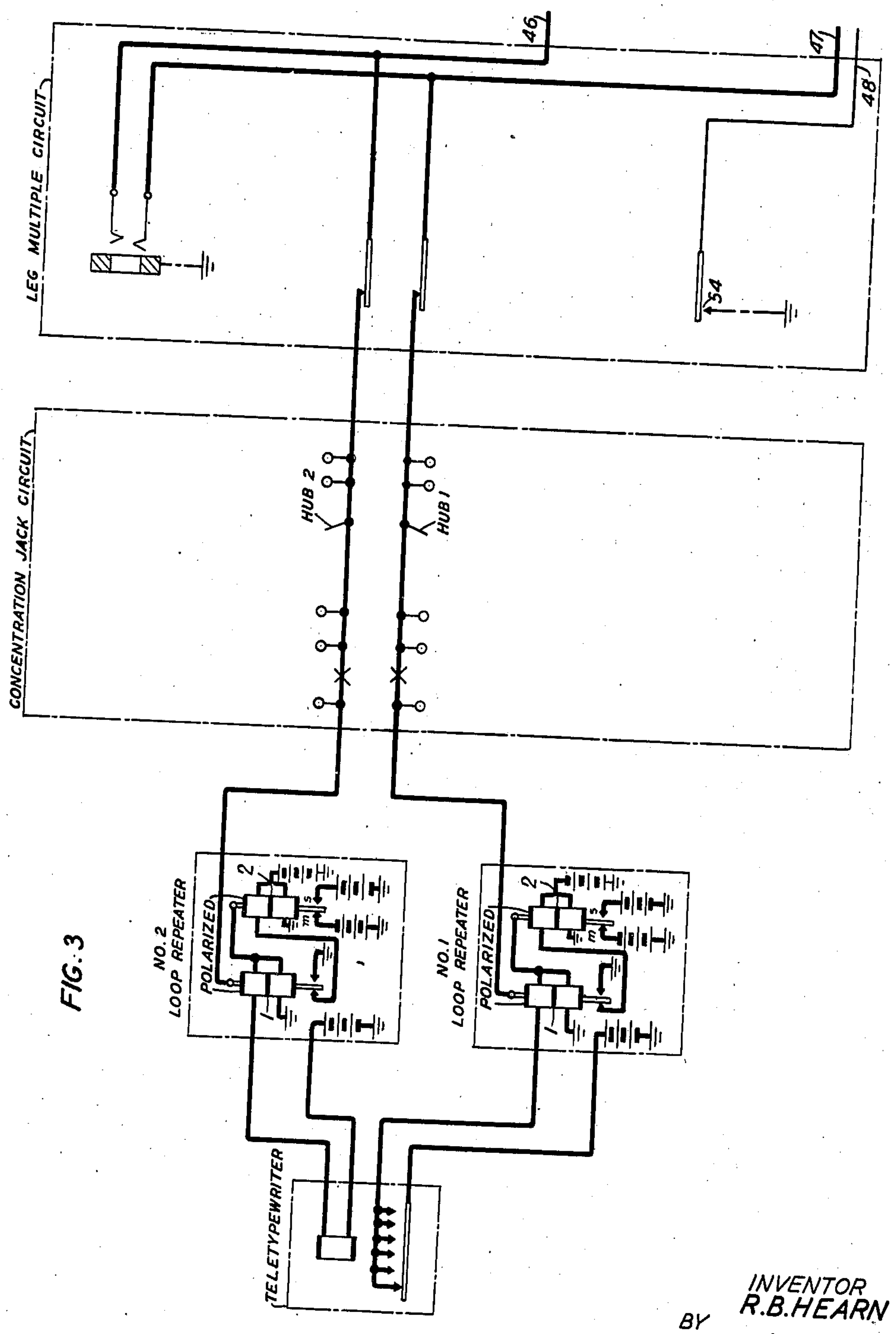

FIG. 3

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UNITED STATES PATENT OFFICE

2,259,637

TELEGRAPH REPEATER

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Application June 26, 1940, Serial No. 342,431

11 Claims. (Cl. 178—73)

This invention is a new telegraph repeater and, particularly, a terminal telegraph repeater for use in interconnecting a four-wire telegraph circuit with inverse neutral circuits or "hub" circuits, as they are known in the art.

An object of the invention herein is the provision of an improved telegraph terminal repeater for use in interconnecting a four-wire telegraph circuit with inverse neutral telegraph circuits.

A further object of the invention herein is the provision of a terminal repeater which may, at a first time, interconnect a four-wire telegraph circuit and a group of telegraph circuits associated together to form a single hub circuit, to provide half duplex operation between the inverse neutral circuit and the four-wire circuit and which terminal repeater may be conditioned so as to serve at a second time between the four-wire circuit and two groups of telegraph circuits associated together in two hub circuits, to provide full duplex operation between the inverse neutral circuits and the four-wire circuit.

By full duplex operation, in this application, is meant simultaneous two-way communication only. It does not mean simultaneous two-way communication over a single wire. It is not possible to transmit in two directions simultaneously through the hub of a single inverse neutral repeater concentration.

As is well understood by those skilled in the telegraph art, when a group of circuits are associated through a single hub in an inverse neutral repeater concentration, while the marking condition prevails, all legs radiating from a hub are terminated in battery of the same polarity and magnitude. No current flows in any of the legs for this condition. In order to transmit a spacing signal, ground is connected to the leg associated with the particular station which is sending. Current thereupon flows from negative battery in each of the spokes or legs of the hub which is at the time receiving, toward the common hub point and through said point, to ground on the single sending leg. A receiving relay is thereupon operated in each branch which is receiving, transmitting a spacing signal to its respective facility.

In order to provide simultaneous two-way communication in inverse neutral telegraph repeater systems, it is necessary to provide two separate independent hubs. Each party associated in such a system when simultaneous two-way communication is provided, must have access to two separate hubs through two separate inverse neutral repeaters.

In the inverse neutral repeater system disclosed herein, means are provided for interconnecting an inverse neutral repeater concentration group, which is established at a first telegraph central terminal, through a four-wire telegraph trunk circuit, to a distant telegraph terminal. The four-wire telegraph trunk is equipped with a special inverse neutral repeater to enable it to be connected to the inverse neutral concentration at the first telegraph central terminal. The four-wire telegraph trunk disclosed herein is arranged also so that it may be connected either to a single hub at the first telegraph terminal, or to two separate hubs at the first telegraph terminal. When the trunk is connected to the single hub at the first telegraph terminal, any party joined to the hub at the first telegraph terminal may transmit simultaneously to all other parties connected into the hub at the first telegraph terminal as well as to the party or parties that may be connected at the distant central terminal by means of the transmitting loop of the four-wire trunk which extends to the distant central terminal. Similarly any party joined to the trunk at the distant telegraph terminal, may, at another time, transmit from the distant terminal over the other loop of the four-wire trunk, through the single hub at the first telegraph central terminal to all parties connected to the single hub at the first telegraph central terminal. This is what shall be called one-way or half-duplex operation in this application.

For simultaneous two-way communication, it is necessary to provide two separate hubs at the first telegraph central terminal, one for transmitting and one for receiving. The four-wire trunk circuit which is disclosed herein is arranged so that it may be connected to a single hub for half-duplex operation or to two hubs for simultaneous two-way operation. Whether the four-wire trunk is connected to one hub or to two hubs at the first telegraph central terminal, all of its four wires, two of which are arranged to form a transmitting loop and the other two a receiving loop, are required in each form of operation. Simultaneous two-way communication through two inverse neutral repeater concentration hubs and the four-wire trunk circuit will be called full duplex operation in this application.

A feature of this invention is its arrangement so that the side of the repeater arranged for connection to the inverse neutral circuits may connect to either one group of telegraph circuits associated together in one inverse neutral concentration circuit or two groups of telegraph circuits associated together in two inverse neutral concentration circuits for half duplex operation or for full duplex operation, respectively.

A further feature of this invention is a switching arrangement, which functions when the repeater herein is connected to a single hub concentration, for conditioning the repeater herein to operate as a half duplex repeater and which switching arrangement functions, when the repeater herein is connected to two hub concentrations, for conditioning the repeater herein to operate as a full duplex repeater.

A further feature of the invention is an arrangement for reversing a battery connected in series in the two conductors serving as the transmitting circuit on the four-wire side of the repeater for the transmission of marking and spacing signals.

A further feature of the invention is the use of an auxiliary receiving relay, controlled by the receiving relay in the two receiving conductors in the four-wire side of the circuit, which auxiliary receiving relay operates to connect alternately to the hub point battery of the same polarity as is connected to each hub leg as a marking signal and ground as a spacing signal.

A further feature of this invention is an arrangement wherein the switching device, which operates when the repeater herein is conditioned for half duplex operation, extends the transmitting path from the inverse neutral circuit through a winding on the auxiliary receiving relay, so that the auxiliary receiving relay may be controlled, in response to a break signal from the inverse neutral circuit to stop the transmission of signals from the four-wire side of the circuit into the inverse neutral circuit.

These and other features of the invention will be made apparent from the detailed description of the invention hereinafter when read with reference to the associated drawings.

Fig. 1 shows a terminal repeater of the invention herein designed to connect inverse neutral telegraph circuits arranged at its left to a four-wire telegraph circuit.

Fig. 2 shows the manner in which the repeater per Fig. 1 is interconnected through a hub concentration to provide half duplex service.

Fig. 3 shows the manner in which the repeater per Fig. 1 is interconnected through two hubs to provide full duplex service.

The concentration jack circuit and the leg multiple circuit, shown in Figs. 2 and 3, are indicated only schematically. They are not shown in complete detail as they are not a part of this invention and an understanding of their operation is not necessary to an understanding of the present invention. The various telegraph legs are arranged into hub groups by means of the concentration jack circuits. The concentration jack circuits and the leg multiple circuit provide means for flexibly connecting the repeater of Fig. 1 to various hub concentrations as required. It is to be understood that the repeater per Fig. 1 may be terminated in the jack shown in the leg multiple circuit, frim which jack it may be flexibly connected as required to an inverse neutral or hub concentration, or the repeater per Fig. 1 may be associated with one or more inverse neutral concentrations through the concentration jack circuit as indicated.

Inverse neutral or hub repeaters are described in detail in Patents 2,056,277, F. S. Kinkead et al., October 3, 1936; 2,069,251, F. S. Kinkead, February 2, 1937; and 2,069,224, G. C. Cummings, February 2, 1937.

As described in these patents inverse neutral repeaters are joined in a common point from which the legs of the various connecting circuits radiate. For the marking condition all legs are terminated in battery of the same polarity and same potential. For the spacing condition ground is connected to a particular leg to operate a receiving relay in each of the other legs in the same inverse neutral concentration simultaneously. Each group of repeaters associated through a single hub, as is well understood, is capable of transmitting in one direction only at any one time. That is to say, any one station associated in the hub may transmit signals through the hub point to all of the other stations simultaneously. When full duplex service is provided it is necessary to provide two different hub circuits, one for transmitting and one for receiving. The circuit of the present invention is designed so that it may function either on a half duplex or on a full duplex basis.

Full Duplex Operation

Refer to Figs. 1 and 3.

In order to provide full duplex service it is necessary to provide two separate hub circuits, as indicated in Fig. 1 and Fig. 3. The three leads **46, 47** and **48** extending from the repeater herein toward the left of the drawing per Fig. 1 into the box marked "Leg multiple circuit" are arranged so that half duplex service or full duplex service may be provided by means of the repeater of the invention herein.

When half duplex service is provided, as indicated when Fig. 1 is connected to Fig. 2, only one hub circuit is required to be connected to the left-hand side of the repeater herein. For full duplex operation, as indicated when Fig. 1 is connected to Fig. 3, a hub repeater is connected to both of the main transmitting conductors extending to the left of Fig. 1. When half duplex service is provided only one of the main transmitting conductors extending to the left of the figure performs any function and it is connected to a single hub concentration. The purpose of the third lead extending to the left of the figure is to condition the circuit herein for full duplex or half duplex operation. When half duplex operation is required ground is connected from relay contacts in the leg multiple circuit to the lead extending through the winding of relay **1**. This disconnects the lower transmission lead **47** which functions only when full duplex service is required and conditions the circuit herein for half duplex operation.

It is to be understood that the circuit herein extends to hub repeaters through switching circuits to facilitate the connection of the circuit of the invention herein with the other hub repeaters, but since these switching circuits form no part of the present invention they will not be shown in detail. It should be understood, however, that for the marking condition for full duplex operation each of the main transmitting leads is connected to the common point of a hub circuit. From the common hub point the circuit extends to the legs of another repeater. The transmitting leg of each repeater connects to the receiving leg of the other repeater. Provision is made for connecting additional legs to either hub, if required.

For full duplex operation since both main transmitting leads 46 and 47 extending to the left of Fig. 1 are required, relay 1, Fig. 1, is to remain in the unoperated condition as shown. Therefore, the circuit extending from battery through the winding of relay 1 over conductor 48 to the left of Fig. 1 into Fig. 3 is open for this condition through the operation of a relay in the leg multiple circuit (not shown) which disconnects ground from conductor 48.

A circuit may be traced from battery 2, Fig. 1, through resistance 3 and the top windings of relays 4 and 5 to ground. This circuit provides biasing current to hold the armatures of relays 4 and 5 in their marking positions as indicated. A circuit may also be traced from battery 2 through resistances 6 and 7, through the bottom windings of relays 4 and 5, through the right-hand armature and break contact of relay 1, through resistance 23 and the bottom main transmitting lead 47 toward the left of Fig. 1 into Fig. 3 where it is connected through a leg multiple circuit and a concentration jack circuit in Fig. 3 to hub point 1, from which it extends through the armature and marking contact of relay 1 in the teletypewriter station transmitting loop repeater and through the top winding of loop repeater relay 2 to negative battery. Since each one of the leads connected to the hub terminates in battery of the same polarity as that of battery 2 in Fig. 1, no current will flow through the bottom windings of relays 4 and 5, so that the current through the top or biasing winding will be unopposed for the marking condition.

A circuit may also be traced from battery 2, Fig. 1, through resistances 8 and 9, through the left-hand break contact and armature of relay 1, through the left-hand or marking contact and armature of relay 10 and over the top main transmitting lead 46 toward the left of Fig. 1 into Fig. 3. Lead 46 is connected in the same manner as 47 to a hub point, hub 2, from which it extends also to negative battery, in loop repeater 2, which is connected to the receiving loop of a teletypewriter station circuit. Therefore, no current will flow in this path for the marking condition.

A circuit may also be traced from the positive terminal of the battery 15, through resistance 16, through the right-hand or marking contact and armature of relay 5, through the bottom windings of induction coils 13 and 12 and the bottom windings of repeating coil 11, over the lower lead of the top pair of conductors extending to the right of Fig. 1, which are the transmitting leads of the four-wire circuit, through the receiving device at the distant terminal and thence returning over the top lead through the top winding of repeating coil 11 and the top windings of induction coils 12 and 13, through the armature and left-hand or marking contact of relay 4, through resistance 14, to the negative terminal of battery 15 which is grounded. If ground is connected from loop repeater 1 to hub circuit 1, to which the bottom main transmitting conductor 47 is connected, current will flow through the bottom windings of relays 4 and 5. The effect of this current preponderates over the effect of the current flowing in the top or biasing windings of relays 4 and 5 and the armatures of these relays are actuated to engage their spacing contacts. When the armatures of relays 4 and 5 are thus operated, the connections of battery 15 are reversed so that ground, instead of being connected to the top conductor extending to the right of the figure, is connected to the bottom conductor, and positive battery, instead of being connected to the bottom conductor, is connected to the top conductor. This reversal of battery transmits a spacing signal to the distant terminal.

Signals from the distant station are received over the lower pair of conductors extending to the right of Fig. 1. The path may be traced from ground through battery 50, resistance 51, right-hand contact and armature of relay 52, over the top conductor of this pair through the winding of induction coil 17, the top winding of relay 18, through the bottom conductor of the pair and through the armature and left-hand contact of relay 53, back to ground at the distant station. The effect of current for marking and spacing signals in the path just traced is to actuate the armature of relay 18 between its opposing marking and spacing contacts. The circuit through the bottom windings of relay 18 will be described in detail hereunder.

For full duplex operation, as has been described, relay 1 is in the position shown. The circuit through the bottom winding of relay 10 is, therefore, open at the right- and left-hand make contacts of relay 1. When the armature of relay 18 is on its left-hand or marking contact, a circuit may be traced from negative battery through resistance 19, the left-hand or marking contact and armature of relay 18, through resistances 20 and 21 and the top winding of relay 10 to ground. This maintains the armature of relay 10 in engagement with its left-hand or marking contact. When the armature of relay 18 is actuated to engage its right-hand or spacing contact, positive battery through resistance 22 is substituted for negative battery through resistance 19 and the armature of relay 10 is actuated to engage its right-hand or spacing contact. When the armature of relay 10 is actuated to engage its spacing contact, ground is connected to the armature of relay 10 and a spacing signal is transmitted over conductor 46 into the leg associated in the hub 2 circuit. As the armature of relay 10 is actuated between its marking and spacing contacts, marking and spacing signals will be transmitted into these circuits forming the receiving hub circuit.

It should be apparent from the above that for the full duplex condition two hub circuits are connected to the left-hand side of Fig. 1. Signals from one hub circuit, hub 1, which serves as the transmitting hub, reverse the connections of battery 15 to transmit signals over the top pair of conductors extending toward the right of Fig. 1 to the distant station. Signals received from the distant station operate relay 18, which in turn operates relay 10, which alternately connects negative battery and ground to hub point 2, which is the receiving hub. The transmitting and receiving circuits are independent. Signals may be transmitted from one hub circuit connected at the left to the distant station connected at the right of Fig. 1, while signals are being received from the distant station and impressed upon the receiving hub circuit without interference. The circuit of Fig. 1, therefore, will function as a full duplex circuit in conjunction with two connected hub circuits.

Half Duplex Operation

Refer to Figs. 1 and 2.

When the circuit of this invention is to function as half duplex repeater, ground is connected in the leg multiple circuit of Fig. 2 to conductor 48 through the contacts 54 of a relay in the leg multiple circuit. A circuit may then be traced from ground through contacts 54, through conductor 48 from Fig. 2 into Fig. 1, through the winding of relay 1 to battery, operating relay 1. This breaks the circuit extending from hub 1 through the bottom transmitting conductor 47 and resistance 23, at the right-hand break contact of relay 1. As has been explained above, when the circuit per Fig. 1 functions half duplex, it is connected to but one hub circuit. This is indicated as hub circuit 2, which is connected to conductor 46. Conductor 47 serves no purpose in half duplex operation. When relay 1 is operated, a circuit may be traced from hub 2 through conductor 46, through the armature and left-hand or marking contact of relay 10, which relay is operated, through the left-hand armature and left-hand make contact of relay 1, through the bottom winding of relay 10, through the right-hand make contact and armature of relay 1, through the bottom windings of relays 5 and 4, through resistances 7 and 6 and through battery 2 to ground. In Fig. 2, three subscribers' station circuits, each including a transmitting key and a telegraph sounder, are connected by means of individual loop circuits, individual inverse neutral telegraph repeaters and individual legs to hub 2. The circuits are shown in the marking condition. All three of these circuits are identical. The circuit connecting the subscriber's station A, in the upper left-hand corner of Fig. 2 to hub 2, may be traced from positive battery in the top rectangle, marked loop repeater A, through the lower loop conductor 3, through the transmitting key contacts, or the switch shunting them, at subscriber's station A, the winding of the receiving magnet, the top loop conductor 4, the top winding of receiving relay 1 in loop repeater A and through the armature and left-hand or spacing contact of transmitting relay 2 to negative battery. Attention is called to the fact that the opposite ends of this loop, when the armature of relay 2 is in engagement with its left-hand or marking contact, are connected to batteries arranged in series-aiding relationship. The effect of current flowing through the top winding of relay 1 for this condition tends to actuate the armature of relay 1 to engage with its left-hand or marking contact as shown. This effect preponderates over the effect of current flowing from negative battery, connected to the left-hand or mark-contact of relay 2, through the armature of relay 2 and the bottom winding of relay 1, to ground, tending to actuate the armature of relay 1 to engage with its right-hand or spacing contact, and the armature of relay 1 is maintained in engagement with its left-hand or marking contact. The armature of relay 2 in loop repeater A, is held in engagement during the marking condition, with its left-hand contact, by the effect of current flowing from negative battery through the bottom winding of relay 2 to ground. The effect of this current is unopposed, as no current flows through the top winding of relay 2 during marking. The path through the top winding of relay 2 extends from negative battery through the top winding of relay 2, through the left-hand or marking contact and armature of relay 1 in loop repeater A, over conductor 5 and through a concentration jack circuit, indicated schematically by small circles joined to conductor 5, to hub 2.

Subscriber's station B, shown at the left center of Fig. 2 and subscriber's station C shown at the lower left of Fig. 2 are each joined to the hub 2 in the same manner as is subscriber's station A. For the marking condition leg 6, joining hub 2 with loop repeater B and leg 7 joining hub 2 with loop repeater C are each terminated in negative battery connected to the top winding of its respective relay 2 in loop repeater B and loop repeater C, respectively. It has been shown that leg 46 which joins hub 2 with the inverse neutral repeater of the four-wire trunk circuit per Fig. 1 is also terminated in negative battery 2 in Fig. 1.

For the marking condition, therefore, for half-duplex operation, under which arrangement Fig. 1 and Fig. 2 are interconnected, all legs rediating from the single hub which is used, in this case hub 2, are terminated in negative battery of the same magnitude so that no current is transmitted through any of the legs such as 5, 6, 7 or 46 comprising the hub circuit.

If a spacing signal is to be transmitted from any one leg to all of the other legs, ground is connected to the one leg which is to transmit and current flows from negative battery connected to the ends of each of the other legs, toward and through hub 2, to the single ground connection on the transmitting leg. Thus, if a spacing signal is to be transmitted from subscriber's station A, the subscriber's loop is opened. To do this, first the switch shunting the transmitting key is opened, so that the transmitting key takes control of the loop. When the transmitting key is opened, the loop is broken. The top winding of relay 1 in loop repeater A is deenergized. The armature of relay 1 is actuated so as to engage its right-hand or spacing contact which connects ground to leg conductor 5. A sending relay, relay 2, in each of the other station legs is energized as a result of this operation. A pair of sending relays, relays 4 and 5, in the trunk are operated to transmit a spacing signal to the distant central terminal. In the case of the station loops, the effect of current flowing from negative battery through the top winding of relay 2 of repeater B as well as through the top winding of relay 2 of loop repeater C, which effect tends to actuate the armatures of each of these relays to engage with their respective right-hand or spacing contacts, preponderates over the effect of the current through the bottom winding of each relay 2 and the armature of each of these relays is actuated so as to engage with its right-hand or spacing contact. This connects battery of the same polarity and magnitude to each end of the loop of station B and station C. As a result of this, current ceases to flow in each loop and the receiving magnet at each station is deenergized resulting in a spacing signal at each station.

In the case of the four-wire trunk connected to hub 2 by means of conductor 46, the effect of current through the bottom winding of relays 4 and 5 preponderates over the effect of current through the top windings tending to hold the armatures of relays 4 and 5 on their marking contacts, as shown, and the armatures of relays 4 and 5 will be actuated to engage with their other or spacing contacts. This reverses the connections of battery 15 to the top or transmitting loop of Fig. 1 and results in the transmission of a spacing signal to the distant central terminal.

It has been described that the effect of current flowing through the top winding of relay 10, from battery through resistance 19, is to tend to hold the armature of relay 10 in engagement with its left-hand or marking contact. When signals are received from the hub circuit during half duplex operation, as described above, no current will pass through the bottom winding of relay 10 for the marking condition. The effect of current flowing for the spacing condition is to augment the effect of current flowing through the top winding of relay 10, so that the armature of relay 10 will be maintained in engagement with its left-hand or marking contact, as shown, while signals are being received from the hub circuit connected at the left of Fig. 1.

When signals are received from the distant terminal at the right, relay 18 will be actuated as described above under "Full duplex operation." For the marking condition, both sides of the bottom winding of relay 10 are connected to negative battery, namely, battery 2 and negative battery connected from the loop repeater to each of the legs radiating from the hub circuit. The bottom winding of relay 10 will therefore be deenergized. Relay 10 will, therefore, follow relay 18. For the marking condition of relay 10, negative battery 2 will be connected through resistances 6 and 7 and the bottom windings of relays 4 and 5, through the right-hand make contact and armature of relay 1, through the lower winding of relay 10 and the left-hand make contact and armature of relay 1 to the left-hand contact and armature of relay 10 and over lead 46 to hub 2. For the spacing condition, ground will be connected through the right-hand contact and armature of relay 10 over lead 46 to hub 2. All of the receiving relays in the various legs connected to hub 2 will be actuated in response to the operation of relay 10.

From the above, it should be apparent that, for half duplex operation, a single hub circuit is connected to the repeater per Fig. 1. When signals are transmitted from the hub, battery 15 will be reversed, through the operation of relays 4 and 5, to transmit the signals to the distant station at the right. Signals received from the distant station will actuate relay 18, which will in turn actuate relay 10, which will connect negative battery and ground to conductor 46 extending to the left of Fig. 1, to actuate receiving relays on the various legs of hub circuit 2.

If, during half duplex operation, it is desired to break while the circuit per Fig. 1 is receiving signals from the distant terminal connected to the right of Fig. 1, any station connected through a leg into the hub at the left of Fig. 1 may actuate a relay connected individually in its respective leg, so as to transmit a spacing signal from the hub toward Fig. 1. Ground will be thereupon connected from the loop repeater associated with the particular station. Current flowing through the bottom winding of relay 10 in response to this ground will maintain the armature of relay 10 in engagement with its left-hand or marking contact, as soon as it has been operated to engage that contact in response to the next marking signal received from the distant terminal connected to the right of Fig. 1, and current flowing through the bottom windings of relays 4 and 5 in response to the spacing signal from the hub, when relay 10 is held on marking, will actuate the armatures of relays 4 and 5 so as to transmit a spacing signal to the distant terminal at the right. If signals are being transmitted from the hub circuit connected at the left of Fig. 1 to the distant terminal connected at the right of Fig. 1 and the receiver at the right wishes to break, a spacing signal is impressed through the bottom pair of conductors extending to the right of Fig. 1. In response to this, the armature of relay 18 will be actuated to engage its right-hand or spacing contact. As soon as the next marking signal is transmitted from the hub circuit, since no current will be flowing through the bottom winding of relay 10, the armature of relay 10 will be actuated to engage its right-hand or spacing contact. The armature of relay 10 will be maintained in this position since the path through the bottom winding of relay 10 is broken and the spacing current from the spacing contact of relay 18 will continue its effect of holding the armature of relay 10 in engagement with its spacing contact. While this condition prevails, the path extending from the hub circuit through the bottom windings of relays 4 and 5 remains open at the left-hand armature and contact of relay 10, so that no signals may be transmitted from the hub circuit to the distant terminal at the right. Meanwhile the ground connected to the armature of relay 10 will maintain all of the legs connected to the hub circuit in the spacing condition as a breaking signal.

Vibrating Circuit

The wave shape of the signals received from the distant terminal through the top winding of relay 18 is usually very much rounded in character and would result in considerable distortion were it not for the use of the vibrating circuit, which is connected through the two bottom windings of relay 18.

The vibrating circuit consists of two branches. One branch extends from ground through the middle winding of relay 18 and resistance 25, through resistance 27 to the armature of relay 18. The second branch extends from ground through the bottom winding of relay 18 and condenser 26 through resistance 27 to the same armature. When the armature of relay 18 is in engagement with its left-hand or marking contact, the circuit is extended through resistance 19 and negative battery to ground. When the armature of relay 18 is in engagement with its right-hand or spacing contact the circuit is extended through resistance 22 and positive battery to ground.

The circuit is arranged so that when no current is traversing the top winding of relay 18, the armature of relay 18 will vibrate continuously at a frequency fixed by the values of the inductance capacitance and resistance in the circuit and also by the adjustment of the relay itself. This vibrating circuit accelerates the action of the relay and results in retransmitting the signals received from the distant terminal connected to the right-hand side of Fig. 1 to the hub circuit connected to the left-hand side of Fig. 1 with a minimum of distortion. The vibrating circuit is so arranged that the current through the middle winding of relay 18 is in a direction to move the armature from the contact to which it is held by the current in the top winding of the relay. When a reversal of current takes place at the distant end of the line and the line current falls to a point where the ampere turns of the line windings are less than the ampere turns of the middle vibrating winding, the armature moves to the opposite contact. During the travel time a discharge current from condenser **26** through the bottom and middle windings in series aiding tends to accelerate the action. When the armature engages the opposite contact, the charge on condenser **26**, which is in series with the bottom winding, is reversed. Since the bottom winding is poled opposite to the middle winding the charging current causes the contact just made to remain closed until the current in the top winding builds up sufficiently to maintain the contact closure. At the same time the current in the opposing middle winding is also building up. When the charging current dies down and the currents in the top winding and the middle winding have been established, the current in the middle winding is again in such a direction as to move the armature to the opposite contact when the line current loses control of the relay. The above operation takes place each time a contact is made.

Other Miscellaneous Features Included in Circuit

A—Monitoring

Provision is made for lining up the circuit with a special test circuit. The function of jack **30** is to enable the test circuit to be connected to the circuit herein. This testing circuit forms no part of this invention and its operation is not therefore described.

B—Noise killers

Noise killers are connected to the transmitting circuit extending from the circuit herein to the distant terminal to the right. It consists of repeating coil **11**, induction coils **12** and **13** and condenser **24**. The purpose of this noise killer circuit is to suppress telegraph thump on the telephone circuit operated over the same pair of cable conductors. Condenser **24** is shown connected between coils **12** and **13**. The position of this condenser may be changed, depending upon the degree to which noise must be suppressed. At times it may be connected in shunt between the two transmitting conductors, between coil **12** and repeating coil **11** instead of between coils **12** and **13**.

A noise killer may be connected in the circuit incoming from the distant terminal connected to the right of Fig. 1. Coil **17** is used for this purpose. Its function is to reduce telegraph thump caused by induction of the vibrating circuit current into the receiving end of the incoming circuit through the windings of relay **18**.

C—Contact protection

Contact protection is provided across the contacts of relays **4**, **5** and **18** to reduce contact erosion. The contact protection for relay **4** consists of resistances **30** and **31** and condensers **32** and **33**. The contact protection for relay **5** consists of resistances **34** and **35** and condensers **36** and **37**. The contact protection for relay **18** consists of resistances **38** and **39** and condensers **40** and **41**.

D—Leg circuit wave shapers

Wave shapers are connected with the legs extending to the two hub circuits connected to the left-hand end of Fig. 1. The function of the wave shapers is to compensate for the armature travel time of the relays transmitting to the leg circuits. The wave shaper for the top conductor consists of condenser **42** and resistance **43**. The wave shaper for the bottom conductor consists of condenser **44** and resistance **45**.

What is claimed is:

1. In a telegraph system, a repeater circuit, means in said circuit for operably interconnecting a single group of telegraph circuits arranged in a single inverse neutral concentration to a four-wire telegraph circuit at a first time, means in said circuits for operating said circuits on a half duplex basis at said first time, means in said repeater for operably interconnecting two groups of telegraph circuits arranged in two inverse neutral concentrations to a four-wire telegraph circuit at a second time, and means in said circuits for transmitting a separate communication through each of said two concentrations simultaneously at said second time.

2. A system in accordance with claim 1 including relay means for switching said repeater from half duplex operation through one concentration, to simultaneous separate communications through said two concentrations.

3. A system in accordance with claim 1, including breaking means for use while the system is conditioned for half duplex operation.

4. A system in accordance with claim 1 including a relay in said repeater having a winding in series in a conductor connected to the hub of one of said inverse neutral concentrations.

5. A system in accordance with claim 1, including an individual winding on each of two relays, said windings being connected in series in a conductor connected to the hub point of one of said inverse neutral concentrations.

6. A system in accordance with claim 1, having a winding on a relay in said repeater in series in a conductor extending to the hub of one of said inverse neutral circuits, and an armature on a second relay in said repeater, said armature being connected in series in the conductor connected to the hub of the other of said inverse neutral concentrations.

7. A system in accordance with claim 1, including a first two wires of said four-wire circuit arranged for transmitting from an inverse neutral circuit and a second two wires of said four-wire circuit arranged for transmission toward an inverse neutral circuit, and means for reversing the polarity of a battery connected in series in said first two wires for the transmission of marking and spacing signals from said inverse neutral circuit.

8. A system in accordance with claim 1, having a winding of a receiving relay in series with two conductors of the four-wire circuit, said relay being conditioned to transmit polar telegraph signals through a winding on an auxiliary receiving relay, said auxiliary relay being conditioned to impress inverse neutral telegraph circuits on one of said inverse neutral concentrations.

9. In a system in accordance with claim 1, an auxiliary receiving relay in said repeater responsive to a primary receiving relay in the two receiving conductors of said four-wire circuit, said auxiliary receiving relay being conditioned to impress inverse neutral signals on an inverse neutral concentration, and breaking means connected to said auxiliary receiving relay under control of either the four-wire circuit or another inverse neutral circuit in said concentration when either is in the receiving condition, to stop further transmission from an associated transmitting station.

10. In a telegraph system, a telegraph repeater for interconnecting inverse neutral telegraph circuits to a four-wire telegraph circuit, and means in said repeater for transmitting two separate communications between said inverse neutral circuits and said four-wire circuit simultaneously.

11. In a telegraph system, a telegraph repeater, means in said repeater for repeating inverse neutral telegraph signals from a first inverse neutral telegraph circuit concentration into two transmitting conductors of a four-wire telegraph circuit, and means also in said repeater for repeating telegraph signals from two receiving conductors of said four-wire circuit into said first inverse neutral telegraph circuit concentration on a half duplex basis or into a second inverse neutral telegraph circuit concentration during simultaneous two-way communication.

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