

March 15, 1949.

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2,464,371

TELEGRAPH SWITCHING SYSTEM

Filed Aug. 14, 1944

2 Sheets-Sheet 1

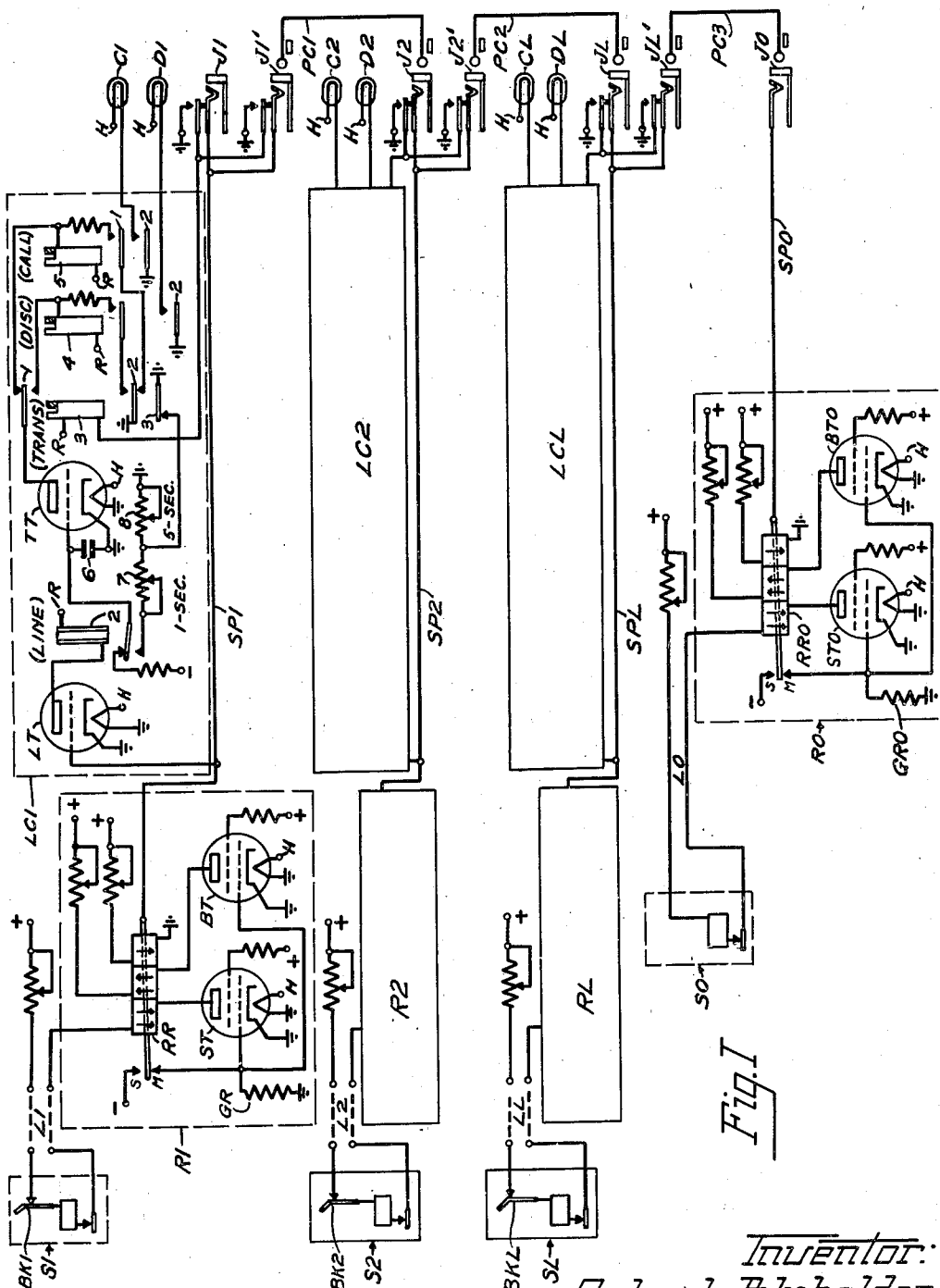


Fig. 1

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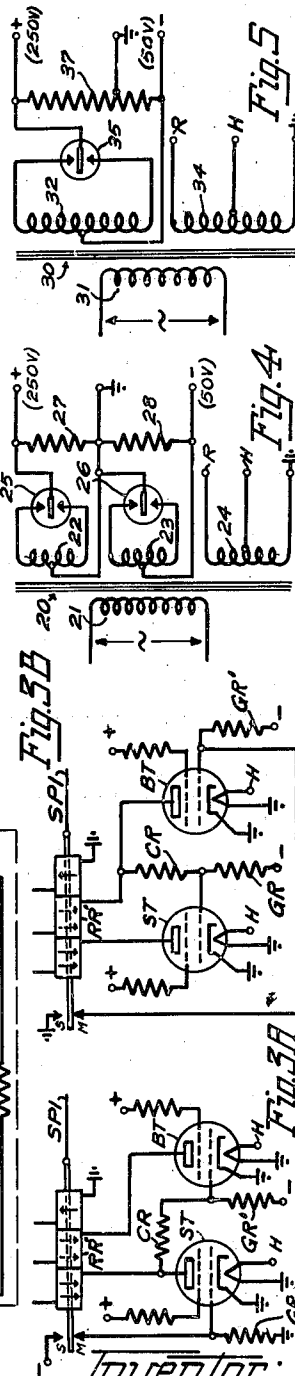
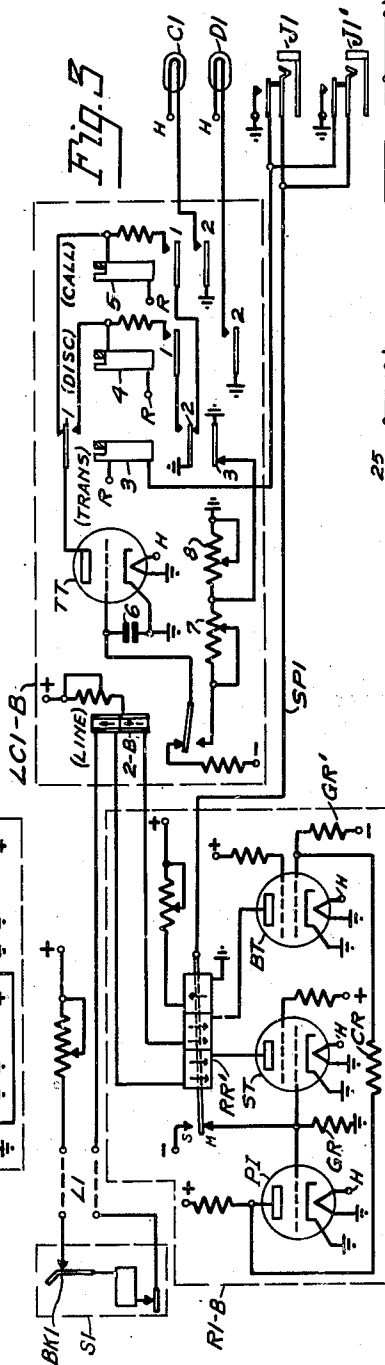
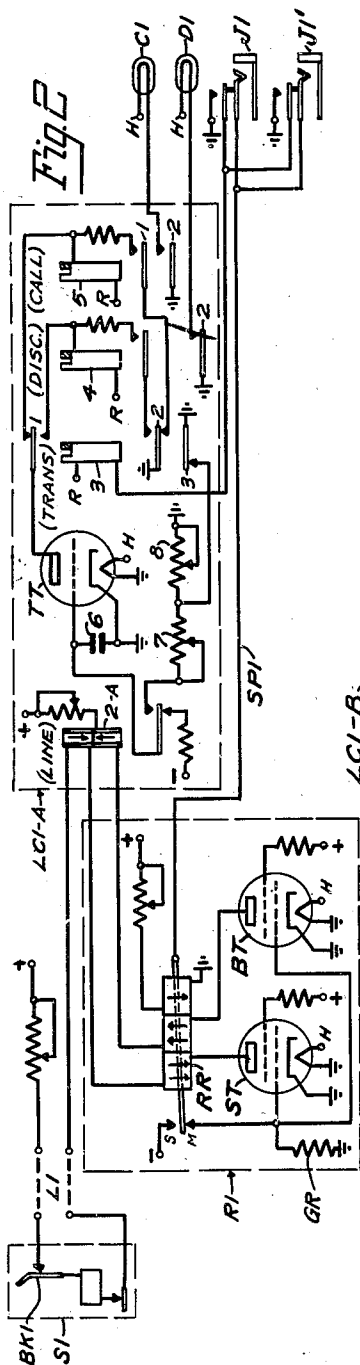
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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TELEGRAPH SWITCHING SYSTEM

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Application August 14, 1944, Serial No. 549,339

9 Claims. (Cl. 178—2)

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This invention relates to telegraph switching systems. Its general object is to provide a telegraph switching system affording improved features of operation.

GENERAL DESCRIPTION

The invention is illustrated as embodied in a telegraph switching system employing the so-called hub repeating arrangement wherein two or more lines may be interconnected through a common "hub" conductor having individual "spoke" conductors for the respective interconnected lines, and in which a two-way telegraph repeater is interposed between each individual line and its associated spoke conductor. In the hub repeating system as previously used, each repeater includes a receiving relay controlled over its associated line to transmit signals over its spoke to the common hub, and a sending relay controlled over the common hub by way of the associated spoke to transmit signals to the line. In each repeater, the local spoke conductor is connected to the inductive winding of the associated sending relay so long as the receiving relay is in its normal (marking) position, and is disconnected from such winding and transferred to a source of spacing current when the armature of the receiving relay leaves its marking contact and engages its spacing contact. Thereupon, spacing current flows over the associated spoke conductor to the common hub, and thence over the spoke conductors of the interconnected repeaters to the windings of the sending relay of each. Patent 2,056,277 issued to F. S. Kinkead et al. October 6, 1936, shows a system operating as above outlined. Patent 2,069,223 issued to G. C. Cummings February 2, 1937, provides special arrangements for minimizing the detrimental sparking and heating which occurs at the spacing contact of the receiving relay in a repeater transmitting over the hub system to a number of interconnected lines. Patent 2,077,917 issued to G. C. Cummings April 20, 1937, provides a hub-interconnecting repeater for interconnecting two hub systems to reduce injury to the spacing contact of the receiving relay of a transmitting repeater.

In view of the foregoing, it is a specific object of the invention to provide a telegraph repeating system in which a large number of lines may be interconnected in a hub system without overloading the spacing contact of the receiving relay of a transmitting repeater. This object is attained in the present disclosure by replacing the sending relay of each repeater by a vacuum tube whose

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control grid occupies the circuit position occupied heretofore by the winding of the sending relay. Since the control grid of a vacuum tube, when properly biased, draws no current, the only load on the spacing contact is represented by the grid resistor at each receiving repeater. Besides being of very high resistance, a grid resistor is, or may be, substantially non-inductive. Consequently, the required current flow per line is greatly reduced and is by way of a substantially non-inductive circuit. Both of these effects combine to reduce the tendency to injure the spacing contact of the receiving relay in the transmitting repeater.

A further object is to provide a telegraph switching system in which the lines have ordinary appearances at the switchboard and in which reliable provisions are made for signalling the switchboard operator over any line when connection or disconnection is desired.

Other objects and features of the invention, more or less incidental to the foregoing, will appear hereinafter.

THE DRAWINGS

The accompanying drawings, comprising Figs. 1 to 5, show sufficient of the apparatus incorporated in a system embodying the invention to enable the invention to be understood.

Fig. 1 shows one embodiment of the invention; Fig. 2 shows a modification of the equipment associated with line L1 of Fig. 1;

Fig. 3 shows a second modification of such equipment;

Figs. 3A and 3B show modifications of Fig. 3; Fig. 4 shows a power-supply unit suitable for the system of Figs. 1 and 2; and

Fig. 5 shows a simplified power-supply arrangement for use in the system of Figs. 3, 3A, and 3B.

FIGURE 1

Fig. 1 shows three subscriber lines of a system including any desired number of such lines; first and second lines L1 and L2, and the last line LL. These lines serve stations S1, S2, and SL respectively, shown diagrammatically as teletypewriter stations. The illustrated lines are provided with similar two-way repeaters R1, R2, and RL respectively, repeater R1 being shown in full. Spoke conductors SP1, SP2, and SPL connect the illustrated repeaters respectively with their switchboard jacks, J1, J2, and JL, with which the jacks J1', J2', and JL', are respectively multiplied, enabling patching cords such as PC1, PC2, and PC3 to be used to interconnect the spoke con-

ductors in any desired arrangement of pairs and hubs.

Each repeater contains a receiving relay, such as RR of repeater R1. The receiving relay RR may be of any desired form of polarized relay, being illustrated as of the type in which the polarized armature passes axially through the winding space. Such a relay may be adjusted to assume a neutral position with no current flowing through any of its three windings. The armature of relay RR is normally held in marking position (against contact M) by the right-hand or marking winding, energized in a circuit including the positive pole of the current supply and the associated regulating resistor. The right-hand or marking winding may be eliminated if relay RR is biased to marking position, such as magnetically or by spring action. The circuit of line L1 includes the two conductors thereof in series with the equipment at station S1. It may be considered as originating at the positive pole of the current-supply source, and the normal current-flow thereover is controlled by the associated adjustable resistor. The return path for line current is through the left-hand or line winding of receiving relay RR, and the plate of sending tube ST, to ground through the grounded cathode element thereof. Assuming that the three windings of relay RR are equivalent, the line current is preferably regulated to be about double the current in the right-hand or marking winding, and is in such a direction through the line winding as to assist the marking winding in holding the armature of the relay in marking condition, as is indicated by the fact that the vertical arrows on the windings in question are directed downwardly.

The magnetic effect of the current through the left-hand or line winding of receiving relay RR is neutralized by the opposed current flow of substantially equal strength through middle or balance winding of the relay. The balance winding is included in what may be termed an artificial-line circuit, which includes the associated adjustable resistor connected between such winding and the positive pole of the supply source. The return path for the artificial line is through the plate of the balance tube BT, to ground through the grounded cathode element thereof.

Each of the tubes ST and BT is indicated as a tetrode, having its control and screen grids in the usual relative positions. Each screen grid is supplied with positive potential from the supply source through the associated individual resistor. The control grids of tubes ST and BT are both connected to the marking contact M of receiving relay RR, and are normally supplied with ground potential through the associated grid resistor GR, permitting a normal flow of current through both. A tube such as the commercially available 6L6 beam-power tube is satisfactory at ST and BT, using a positive supply potential of 250 volts, for example.

Lines L1 to LL are provided with line circuits LC1 to LCL respectively, of which the line circuit LC1 is shown in full. Line circuit LC1 is controlled over the associated spoke conductor SP1 through the grid of line tube LT. Tube LT, as well as the other triodes shown herein, may be of the commercially available 6C5 type, using the same positive supply potential as the sending and balance tubes.

The purpose of line circuit LC1 is to light call lamp C1 at the switchboard responsive to a prolonged opening of line L1 (as by break key BK1)

in excess of one second, for example, and to light the disconnect lamp D1 responsive to a break in the associated line in excess of five seconds, for example, at a time when a connection with the line exists through the switchboard. Line circuit LC1 includes line relay 2, normally operated through the plate-cathode circuit of line tube LT by half-wave-rectified current from relay terminal R, supplied with alternating current of commercial frequency and suitable voltage, as by secondary winding 24 of the power-supply transformer 20 (Fig. 4). Relay 2 may be rendered slow-restoring and substantially non-inductive by the usual copper sleeve surrounding its magnetic core and lying beneath its winding, as is intended to be illustrated conventionally. Relay 2 is arranged to control the potential of the grid of timing tube TT by normally maintaining a cut-off bias on such grid, across condenser 6, and by discharging this biasing potential through resistor 7 for a one-second delay, and through resistors 7 and 8 for a five-second delay. As will hereinafter appear, timing tube TT controls one or another of the call and disconnect relays 5 and 4, according to the operated or restored condition of transfer relay 3, controlled from either of the associated jacks J1 and J1'. Relays 3 to 5 are supplied with current from the associated relay terminals R, supplied through the above-mentioned secondary winding 24 (Fig. 4). Each such relay is preferably a shaded-pole relay which remains operated steadily when energized by alternating, pulsating, or direct current.

The switchboard operator is supplied with a telegraph station SO, also illustrated as a typewriter station, controlled over the operator's line LO. This line terminates in the operator's repeater RO, exactly similar to repeater R1. Repeater RO is connected with the operator's switchboard jack JO by the spoke conductor SPO.

FIGURE 2

In Fig. 2, the equipment of line L1 of Fig. 1 is modified by replacing line tube LT and relay 2 of line circuit LC1 by relay 2-A of line circuit LC1-A. Line circuit LC1-A is arranged to respond only to breaks occurring in the associated line and is independent of control over the common hub by way of the associated spoke conductor SP1, as will appear hereinafter. For this purpose, relay 2-A is a double-wound differential relay, having one winding in series with line L1 and the other winding in series with the artificial or balance line of the repeater R1. In the arrangement of Fig. 2, the transmission of a disconnect signal from a connected line causes the lighting of the disconnect lamp associated with that line only, whereas in Fig. 1 the disconnect lamps light at all interconnected lines responsive to a disconnect break at any one of them.

FIGURE 3

Fig. 3 shows a further modification of the equipment of line L1 (Fig. 1), illustrating what may be termed a uniform-current system. The arrangement in Fig. 3 is such that current flows alternately in the subscriber line and in the associated artificial or balance line, thereby simplifying the power-supply requirements, in addition to halving the simultaneous or demand current for the several natural and artificial lines, as will be explained more in detail hereinafter. Fig. 3 employs the additional tube PI, used as a phase-inverter triode effective to transmit a potential of the opposite sign to the control grid of balance

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tube BT when a potential of a given sign is impressed on the control grid of the sending tube ST.

FIGURES 3A AND 3B

Fig. 3A is a direct modification of Fig. 3 wherein sending tube ST is employed also as a phase-inverter tube with respect to balance tube BT, rendering the use of the separate phase-inverter tube PI of Fig. 3 unnecessary.

Fig. 3B is similar to Fig. 3A, except that balance tube BT is used as the phase inverter instead of tube ST.

FIGURE 4

Fig. 4 shows a power-supply arrangement suitable for the system of Figs. 1 and 2 with its widely varying demands for plate current. Power is supplied through transformer 20, having primary winding 21 connected to a suitable source of commercial power. Secondary winding 22, having its mid-point grounded, supplies alternating potential to rectifier 25, through which the desired plate-supply and screen supply voltage is delivered to the associated positive output terminal. A stabilizing resistor 27 may be bridged between the positive output terminal and the common ground lead, as illustrated. Secondary winding 23 supplies alternating potential which is rectified by rectifier 26 to supply a negative biasing potential to the associated negative output lead. 28 is a stabilizing resistor for the biasing potential.

Secondary winding 24 has its lower terminal grounded, and the upper terminal brought out to terminal point R, used to supply operating potential to indicated ones of the relays of the line circuits such as LC1. An intermediate tap of transformer 24 is connected to terminal H to supply heater current to the heater elements of the several vacuum tubes, and to supply lighting current for signal lamps such as C1 and D1.

FIGURE 5

Fig. 5 shows a simplified modification of the power-supply arrangement of Fig. 4 suitable for use with the system of Figs. 3 and 3A, but which would very likely be unsatisfactory for the system of Figs. 1 and 2 because of their widely varying demands for plate current. The arrangement of Fig. 5 is generally similar to the arrangement of Fig. 4, except that winding 23 and the associated rectifier 26 are eliminated. Instead, the stabilizing resistor 37 of Fig. 5 is tapped near one end, and that tap is grounded, thus providing both a positive source of plate current and a negative source of biasing current from the same transformer winding 32 and rectifier 35.

Windings 31 and 34 of transformer 30 correspond respectively to windings 21 and 24 of transformer 20.

DETAILED DESCRIPTION

The disclosure having been described generally, a detailed description of the operation of the system will now be given.

A. FIGURE 1

The system of Fig. 1 will be considered first.

A1. Calling the operator

Assuming that the subscriber at substation S1 (Fig. 1) desires a connection, he opens the associated line L1, as by break key BK1, for an interval somewhat in excess of one second, and then

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recloses the line. When the line is opened, the flow of line current ceases, deenergizing the left-hand or line winding of receiving relay RR. Thereupon, relay RR operates its armature from engagement with its marking contact M into engagement with its spacing contact S, by virtue of the fact that the more powerful current in the middle or balance winding then overcomes the current in the right-hand or marking winding. Spacing current from the negative biasing terminal of the power-supply arrangement of Fig. 4, is thereby impressed on the associated spoke conductor SP1.

Since spoke conductor SP1 is normally disconnected at the jacks J1 and J1', the placing of the negative spacing potential thereon has no effect except in the line circuit LC1, where it blocks current flow through line tube LT. The normally operated line relay 2 thereupon restores, disconnecting the grid of timer tube TT (and the upper terminal of timing condenser 6) from the source of biasing potential and connects it through the adjustable one-second resistor 7, and contacts 3 of transfer relay 3, to ground. At the end of about one second, the normal negative charge of grid condenser 6 is sufficiently dissipated through resistor 7 to render the control grid of timing tube TT sufficiently positive to enable plate current of relay-operating value to flow therethrough. Call relay 5 thereupon operates in a circuit from ground, through the cathode and plate of tube TT, armature 1 of transfer relay 3 and its back contact, and thence through the winding of call relay 5 to relay terminal R, supplied with alternating potential by way of terminal R of Fig. 4. The current which flows through relay 5 at this time is pulsating because of the half-wave rectifying action of tube TT. Upon operating, relay 5 closes a local self-locking circuit at its contacts 1, to ground through the back contact of armature 2 of transfer relay 3. This self-locking circuit may include the illustrated current-limiting resistor. At its contacts 2, relay 5 closes a lighting circuit for call lamp C1.

When the circuit of line L1 is reclosed, the resumption of current flow through the line winding of receiving relay RR again neutralizes the effect of current flow through the balance winding of the relay, permitting the right-hand or bias winding of the relay to return the armature from spacing position to marking position. When this occurs, positive (ground) potential, obtained through grid resistor GR in the repeater R1 is again applied to the grid of line tube LT in line circuit LC1, whereupon current flow is resumed through tube LT and line relay 2. Relay 2 thereupon reoperates and disconnects the grid of timing tube TT from ground (cathode) potential by way of resistor 7 and transfers it to negative biasing potential. When this occurs, condenser 6 again charges to a negative value and the grid of tube TT becomes negative, terminating the flow of plate current therethrough. The resistor included in the lead extending to the front contact of relay 2 is to prevent momentary lowering of the biasing potential on the common supply lead by a sudden inrush of charging current to condenser 6. The cessation of the flow of plate current through tube TT does not cause call relay 5 to restore because of the above-noted self-locking circuit of relay 5 through its contacts 1. Only alternating current now flows through the winding of relay 5, but this relay is able to remain operated steadily when supplied only with alternating current, as previously noted,

A2. Answering

Upon noting the lighted condition of call lamp C1, the operator may insert one plug of an idle patching cord, such as PC3, into the jack J1 (or the jack J1'), and insert the other plug of such patching cord into the operator's jack JO. By this operation, spoke conductor SP1 is connected electrically with spoke conductor SPO, the concerned single-conductor patching cord serving as the common hub between the two spokes. With the repeaters R1 and R0 both in marking condition, both spokes are at ground potential, wherefore there is no immediate interchange of current over the interconnection.

As a result of the insertion of a connecting plug into either of the jacks J1 or J1', the upper contacts of such jack connect ground to the lower terminal of transfer relay 3, operating relay 3 in an obvious circuit. Armature 1 of relay 3 disconnects the plate of tube TT from call relay 5 and transfers it to relay 4. Armature 2 of relay 3 disconnects ground from the self-locking circuit of call relay 5 and prepares a self-locking circuit for disconnect relay 4. Call relay 5 now restores, thereby extinguishing call lamp C1. Armature 3 of transfer relay 3 removes the shunt normally existing around resistor 3 so as to increase the effective discharge time of grid condenser 6 from about one second to about five seconds, thereby insuring that no likely combination of telegraph signals nor a "break-in" signal will result in a premature operation of disconnect relay 4.

Having thus interconnected operator line LO with the calling subscriber line L1, the operator may now type out the usual challenge at the operator station SO to inform the subscriber at station S1 that he is in connection with the operator, the word "operator," for example. By this operation, line LO is opened and closed, as required. Each time the line is opened, the cessation of current in the line winding of repeating relay RRO causes the armature of such relay to move from its illustrated marking position into engagement with its spacing contact, thereby impressing negative potential on spoke conductor SPO. Each time line current is resumed in the line LO, the armature of relay RRO is reoperated from spacing position to marking position, thereby disconnecting the negative spacing potential and reconnecting conductor SPO to the grids of tubes STO and BTO. At the end of the instant sending operation, relay RRO comes to rest in its illustrated marking position, in readiness for the receipt of instructions from the calling subscriber.

Each time negative spacing potential is placed on conductor SPO as above noted, such potential is transmitted through jack JO and the patching cord in use (PC3), to spoke conductor SP1, by way of jack J1 or J1'. With the armature of relay RR in marking condition, each application of spacing current to conductor SP1 results in the application of a negative biasing potential to the grids of tubes ST and BT, causing a cessation of current through both tubes and consequently through the associated subscriber line and the artificial line. When this occurs, the armature of relay RR is unaffected because it is still held in marking position by current flow through its right-hand or biasing winding. The resulting cessation of current flow over the subscriber line causes the usual response at the

calling station S1, whereat the operator's challenge message is typed.

A3. Interconnecting

The subscriber at substation S1 may now type out the desired instructions to the operator. It may be assumed that the calling subscriber desires that his line be interconnected with lines L2 and LL. In this event, the operator may telegraphically interconnect line L2 with line L1 through jacks J1' and J2, and a cord such as PC1, and may then employ a patching cord such as PC2 to interconnect line L2 with line LL through jacks J2' and JL. The concerned patching cords now comprise the hub of the interconnected system, the spokes being SP1, SP2, SPL, and SPO. It will be understood of course that as many, or as few, lines as desired may be interconnected with the calling line by using the above procedure.

Having made the interconnection, the operator may signal the subscriber at substation S1 to proceed, as by typing a word such as "start," at station SO, resulting in the transmission of the corresponding combination of spacing and marking signals over spoke conductor SPO, and thence by way of patching cord PC3, to spoke conductor SP1. At this time spoke conductors SP2 and SPL are obviously energized by the spacing signals, giving the same response at all interconnected subscriber lines. The response at repeater R1 is as described hereinbefore, the current flow being stopped in each of the tubes ST and BT for the duration of each negative spacing signal.

Having transmitted the proceed signal, the operator may withdraw from the interconnection by removing the plugs of patching cord PC3 from jacks J1 and JO.

A4. Intercommunication

The interconnected stations S1, S2, and SL may now intercommunicate as desired. On transmission from station S1, receiving relay RR operates to spacing position on each interruption of line L1 and returns to marking position on each reclosure of the line, thereby transmitting negative spacing signals over spoke conductor SP1 and thence over the interconnecting hub (including the patching cords) to the interconnected spoke conductors SP2 and SPL. It will be apparent that a very large number of lines may be thus interconnected for effective intercommunication without overloading the spacing contact of any of the relays such as RR, because the only load imposed on such spacing contact is that represented by the current flow through the grid resistors of the repeaters such as R2 and RL, corresponding to grid resistor GR of the repeater R1. In practice, this grid resistor may be on the order of 100,000 ohms, or higher, up to a substantial fraction of a megohm, as it needs only to pass sufficient current to insure the quick resumption of positive potential on the control grids of the associated tubes such as ST and BT upon disconnection of negative spacing potential from the interconnected spoke and hub conductors.

During message transmission, line tube LT in each line circuit responds by terminating the current flow through the associated line relay 2 for each spacing signal, and by reestablishing current flow therethrough for each marking signal. For the most part, the spacing signals are too short for a slow-restoring relay of the nature of relay 2 to respond.

During transmission, the subscriber at any station may "break in" on the transmitting station by opening the break key thereat, such as BK1, for about one or two seconds. It may be assumed that station S1 is the transmitting station and that station S2 is the break-in station. Opening of line L2 causes the repeater R2 to transmit spacing potential over SP2 to the repeaters interconnected therewith. This transmission is begun immediately if the break occurs during marking condition. If the break occurs during spacing condition, the receiving relay in repeater R2 does not respond until the existing spacing condition is terminated.

In the repeater R1, no current can flow through either the subscriber line or the artificial line during the time the negative marking potential resulting from the break-in operation is impressed on the control grids of tubes ST and BT, wherefore the apparatus at the transmitting station S1 temporarily ceases to function, thereby informing the subscriber of the break. He is expected to cease transmission to permit his line L1 to remain closed for the receipt of a message from the break-in station.

When the break key BK2 at the break-in station S2 is subsequently reclosed, the consequent resumption of current flow over line L2 causes the repeater R2 to remove spacing potential from the interconnected hub system, enabling transmission to proceed thereover from any station.

During transmission of the break-in spacing signal over the hub system, line relays 2 may be restored in all line circuits, and start the timing operation of each of the associated timer tubes TT, but this does not cause disconnect signalling of the operator, for in the connected condition of any line, the associated transfer relay 3 is in operated condition to increase the length of the timing operation to about five seconds by including the associated resistor 8 in circuit with timing resistor 7, as previously noted.

A5. Disconnect Signalling

The subscriber at any interconnected station can signal the operator at any time to request that the entire connection be taken down or that his line be disconnected from the other line, or lines, of the interconnected group. Disconnect signalling is accomplished by opening the break key such as BK1 at station S1 for an interval exceeding the disconnect timing interval, assumed herein to be five seconds. Opening of the line causes spacing potential to be placed on the associated spoke conductor, whence it passes through the hub system to the other spoke conductors, causing a response at the line circuit of all connected lines. In the line circuit LC1, the disconnect spacing potential on conductor SP1 causes line tube LT to restore line relay 2. Relay 2 disconnects the upper terminal of timing condenser 6 and the grid of timing tube TT from negative charging potential and transfers them to ground through resistors 7 and 8 in series (contacts 2 of transfer relay 3 are open at this time because relay 3 is operated through the upper contacts of J1 or J1'). At the end of about five seconds, condenser 6 is discharged sufficiently to permit an operative flow of current through timing tube TT, whereupon relay 4 operates in a circuit from the associated alternating current terminal R, the winding of relay 4, front contact of armature 1 of relay 3 and the said armature, plate of tube TT, and thence to ground through the

grounded cathode of such tube. At its contacts 2, relay 4 closes a lighting circuit for disconnect lamp D1, while at its contacts 1 it closes a self-locking circuit to ground through the front contact of armature 2 of transfer relay 3. Accordingly, relay 4 remains operated following reclosure of the break key at the signalling station and the consequent reoperation of line relay 2 and cessation of current flow through timing tube TT.

Since the same line-circuit operation occurs at each interconnected line (each of the concerned disconnect lamps such as D1, D2 and DL becomes lighted at about the same time), it may be necessary for the operator to inquire which station requires disconnection, or whether all stations require disconnection. This may be accomplished by interconnecting the operator's equipment with the interconnected hub system as by way of patching cord PC3 and jacks J1' and JO. Upon learning what is required, the operator may temporarily take down the entire interconnection to restore the line circuits, and then reestablish such portion of it as may be desired.

Upon removal of the plug from jack J1', transfer relay 3 restores, disconnecting and restoring disconnect relay 4 to extinguish lamp D1. Similar results occur at the other line circuits.

B. FIGURE 2

As previously noted, Fig. 2 shows a modification of the equipment associated with line L1 of Fig. 1 in that differential line relay 2-A replaces line tube LT and line relay 2. One winding of relay 2-A is in series with the associated subscriber line L1, and one winding is in series with the artificial line. Normally, relay 2-A is not operated because the opposed windings are of substantially equal strength, but it is operated (by current flow through its lower winding alone) when current flows in the artificial line at a time when no current is flowing in the associated subscriber line. This condition obtains only when the associated station S1 is transmitting. It does not obtain when station S1 is receiving, for at that time tubes ST and BT are both blocked, to prevent current flow through both lines, subscriber and artificial. It may be noted that, since line relay 2-A is normally restored instead of normally operated, the negative biasing potential is connected to the back contact of the relay armature, and the connection to timing resistors 7 and 8 is brought to the front contact of such armature. In the arrangement of Fig. 2, when one station of an interconnected pair or group transmits a disconnect signal (a prolonged line break) such signal operates on no line circuit LC1-A except the associated one, and consequently results in the lighting of the disconnect lamp, such as D1, only at the station transmitting the disconnect signal. Except as noted, the line circuit LC1-A is exactly similar to the line circuit LC1 (Fig. 1), and operation and restoration of relay 2-A produces results as hereinbefore described for restoration and operation of line relay 2. When a disconnect signal is received, it suffices for the operator to disconnect the line over which it was received, it being unnecessary to disturb the connections to the remaining lines.

C. FIGURE 3

As previously noted, Fig. 3 shows a further modification of the equipment of line 1 (Fig. 1). Line circuit LC1-B is exactly similar to line cir-

cuit LC1-A, except that the two windings of line relay 2-B are connected in aiding relationship rather than in opposed relationship, because operating current flows through only one line (subscriber or artificial) at a time in Fig. 3.

Repeater R1-B is generally similar to repeater R1 of Figs. 1 and 2, except that phase-inverter tube PI has been added, and the grid circuit of balance tube BT is controlled from the plate circuit of tube PI instead of in parallel with the control grid of sending tube ST. More in particular, the control grid of tube ST is connected to marking contact M of receiving relay RR', and is supplied with ground potential through grid resistor GR, as in Figs. 1 and 2. The position occupied in Figs. 1 and 2 by the control grid of balance tube BT is occupied in Fig. 3 by the grid of phase-inverter PI. Accordingly, current is normally flowing in the plate-cathode circuit of tube ST and in the plate-cathode circuit of tube PI. Balance tube BT in Fig. 3 has its control grid normally supplied with negative biasing potential through grid resistor GR', wherefore current flow is normally blocked through the plate-cathode circuit of balance tube BT to provide a condition of no current in the associated artificial line (including the middle winding of relay RR', the lower winding of line relay 2-B, and the associated adjustable resistor). It will be noted that the connecting resistor CR is interconnected between the plate of phase inverter PI and the control grid of balance tube BT. Accordingly, current flows continuously from the positive plate of tube PI to the negative control grid of balance tube BT. With no signal being received over conductor SP1 at the repeater R1-B, however, the flow of current through resistor CR is very small because the positive voltage maintained on the right-hand terminal of resistor CR is very low with tube PI in its normal conducting condition. Under this condition, the grid resistor GR' is of such value that it accepts all of the current passing through control resistor CR and still maintains the potential of the control grid of tube BT sufficiently negative to substantially block the flow of current through tube BT and associated artificial line.

When transmission occurs from station S1 (either to signal the switchboard operator or to transmit signals to one or more interconnected stations), the opening of line L1 terminates the flow of current therein and through the left-hand winding of relay RR'. Since current is normally not flowing in the artificial line, the only current flow remaining through the winding of relay RR' is the normal current flow through the right-hand or bias winding thereof. The current flow through this winding is in such a direction as to cause the armature of relay RR' to move from marking position to spacing position. At this time, the current flow through tube PI is not affected, wherefore tube BT remains unaffected.

When the associated line L1 is reclosed, the resultant resumption of current flow thereover and through the left-hand winding of receiving relay RR' causes the armature of such relay to return from its spacing contact to its marking contact, thereby terminating the transmission of spacing potential over the associated spoke conductor SP1.

With receiving relay RR' in its illustrated marking position, receipt of spacing potential over conductor SP1 from another station causes the control grid of tube ST and the grid of phase-

inverter triode PI to become negative, thereby terminating the flow of plate current in both tubes. Tube ST directly terminates the current flow in the associated line L1, as a spacing signal to station S1. As a result of cessation of current flow through the plate-cathode circuit of phase-inverter PI, the plate element thereof tends to assume the full positive potential of the supply source, thereby increasing the flow of current from this positive source through control resistor CR to the grid of balance tube BT. As a result, the potential drop across grid resistor GR' is increased sufficiently that the grid terminal thereof assumes a relatively positive (or cathode) potential, rendering the plate-cathode circuit of balance tube BT conducting, whereupon current flows through the artificial line including the middle winding of relay RR' and the lower winding of line relay 2-B. The cessation of current flow in the plate circuit of tube ST and the starting of the flow of current through the plate circuit of tube BT occur substantially simultaneously, wherefore there is no open interval, when current is flowing through neither. Since the current normally flowing through the left-hand winding of relay RR' is replaced by a substantially equal current flow through the middle winding thereof, and in the same effective direction, the armature of relay RR' remains in engagement with its marking contact throughout the received marking signal.

When the negative spacing signal on the associated spoke conductor SP1 is terminated, current flow through tubes PI and ST is resumed. Current flow through the plate-cathode circuit of tube BT is terminated as a result of the lowering of the positive plate potential at tube PI and the consequent lessening of current flow (in a positive sense) through the resistor CR to the control grid of tube BT. Upon the above-noted resumption of normal marking conditions in the repeater R1-B, the armature of relay RR' is held in marking position by current flow through the left-hand winding thereof instead of by current through the middle winding thereof.

In the line circuit LC1-B, line relay 2-B is normally held in operated condition by current flow through the upper winding thereof, in series with line L1. The front contact of the armature of relay 2-B maintains a negative potential on the grid of the associated tube TT and maintains timing condenser 6 in charged condition. During the reception of a spacing signal at the repeater R1-B, the cessation of current flow in the upper winding of line relay 2-B is accompanied by the establishment of the current flow through the lower winding thereof, in circuit with tube BT and the middle winding of relay RR'. Consequently, line relay 2-B remains operated during the reception of spacing signals at the repeater R1-B and their transmission over line L1 to station S1. On the other hand, with the repeater R1-B in its normal marking condition, the opening of line L1 at station S1 pursuant to signal transmission causes a cessation of current flow through the upper winding of relay 2-B with no compensating current flow in the lower winding thereof, under which condition relay 2-B is currentless for the duration of the transmitted spacing signal. Being of the same type of slow-restoring relay as noted for relays 2 and 2-A (Figs. 1 and 2), relay 2-B may not respond to normal transmission. It does however respond to the comparatively prolonged line breaks at break key

BK1 of station S1, as when the associated line is opened for a period somewhat in excess of one second to signal the operator by a lighting of the associated call lamp C1, or is opened for an interval slightly in excess of five seconds to signal the operator by a lighting of the disconnect lamp D1 at a time when a plug is in either of the jacks J1 and J1'.

D. FIGURE 3A

As previously noted, Fig. 3A shows a modification of the repeater R1-B of Fig. 3, wherein the phase-inverter tube PI is eliminated and its phase-inverting function taken over by sending tube ST, which then becomes a dual-purpose tube.

In Fig. 3A, the armature of relay RR' is normally held at rest in marking position by current flow over the associated subscriber line (not shown in Fig. 3A) through the left-hand winding of the relay and through sending tube ST. Current flow through the plate of tube BT and consequently through the associated artificial line (including the middle winding of relay RR') is normally prevented by the negative bias imposed on the control grid of balance tube BT through grid resistor GR'. Control resistor CR is connected between the plate of tube ST and the grid of tube BT, wherefore flow of current from the normally positive plate of tube ST through resistor CR to the control grid of tube BT tends to impose a positive potential on the control grid of tube BT. As noted in connection with Fig. 3, the flow of current through resistor CR is normally ineffective to overcome the negative bias on the control grid of tube BT, because of the normal low positive potential on the right-hand terminal of resistor CR with the repeater in its normal marking condition.

In Fig. 3A, the transmission of signals from the associated subscriber lines does not cause current flow through the plate circuit of the tube BT, because opening of the line disconnects the source of positive potential from the plate of tube ST, permitting full negative potential to reach the control grid of tube BT through grid resistor GR'.

With the repeater of Fig. 3A in normal marking condition, the reception of a negative spacing signal over spoke conductor SP1 renders the control grid of sending tube ST negative, terminating the current flow through the tube and over the associated line. When this occurs, the plate of tube ST assumes full positive potential, increasing the current flow through control resistor CR sufficiently to render the control grid of tube BT positive. As a result, plate current now flows through the tube BT and through the associated artificial line, including the middle winding of relay RR'. Current flow through this middle winding is effective to maintain relay RR' in its illustrated marking position. When the negative spacing potential is subsequently removed from spoke conductor SP1, the control grid of tube ST resumes its normal negative potential, impressed through grid resistor GR, whereupon the flow of plate current through tube ST is resumed. The resultant lowering of the positive potential on the plate of tube ST reduces the current flow through control resistor CR sufficiently to permit negative blocking potential to be resumed at the control grid of balance tube BT. As a result, current flow through the artificial line, including the middle winding of relay

RR', is terminated substantially simultaneously with the resumption of current flow through the subscriber line. Relay RR' is thereby held continuously in marking condition. In Fig. 3A, the comparatively slight current flow through control resistor CR upon the reception of a spacing signal over conductor SP1 and its transmission to the associated subscriber line by sending tube ST, is obtained over the subscriber line, wherefore the line current is not altogether brought to zero. In practice, this small current will have practically no effect on the operation of the equipment at the subscriber station when suitable values are chosen for the negative biasing potential, grid resistor GR', and control resistor CR.

E. FIGURE 3B

As previously noted, Fig. 3B shows a direct modification of the arrangement in Fig. 3A. In the arrangement in Fig. 3B, the current for charging the control resistor CR is obtained from the artificial line rather than from the subscriber line, thereby overcoming any tendency such as that above noted to interfere with the response of the equipment at the associated subscriber station.

In Fig. 3B, the arrangement is such that received spacing signals pass first to the balance tube BT, which acts also as a phase-inverter tube to cause such signals to pass in inverted sign to the sending tube ST, through which such signals are transmitted to the associated subscriber line. Because the phase-inverting means is interposed between spoke conductor SP1 and sending tube ST, the spacing potential employed in a system using the repeater modification of 3B is a ground, or cathode, potential, indicated in Fig. 3B as ground connected to the spacing terminal S of relay RR'. The normal, marking potential on conductor SP1 is the negative blocking potential impressed thereon locally through grid resistor GR'. This negative potential normally blocks current flow through the plate of tube BT, wherefore the potential of the plate of this tube is normally substantially the full positive potential of the current-supply source. The control grid of sending tube ST is supplied with a negative biasing potential through grid resistor GR, but this negative biasing potential is normally overcome by the current flow in a positive sense, supplied to the control grid of tube ST through the control resistor CR, from the highly positive plate of the normally blocked balance tube BT. As a result, normally the only current flowing through the balance line (including the middle winding of relay RR') is the relatively slight current drawn by control resistor CR, while full line current is normally flowing through the plate circuit of tube ST and the left-hand winding of relay RR'. This flow of line current maintains the armature of relay RR' in its marking position against the influence of the weaker right-hand, bias winding.

When the associated line is opened for signal transmission, the resulting cessation of current flow through the left-hand winding of relay RR' causes the armature of the relay to move from marking position to spacing position, whereupon the normally negative potential of spoke conductor SP1 is altered to ground potential as a spacing signal. When the associated line is reclosed, the resulting resumption of current flow through the tube ST and the left-hand winding of relay RR' causes the armature of the relay to move

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from its grounded spacing contact into engagement with its negative marking contact, terminating the spacing signal.

With the repeater arrangement of Fig. 3B in its normal marking condition, the application of a spacing ground potential to spoke conductor SPI by another similar repeater results in an altering of the potential of the control grid of tube BT from its normally negative condition to ground condition, whereupon full current flows through the plate circuit of tube BT and over the associated artificial line, including the middle winding of relay RR'. The establishment of this condition so lowers the normally high potential on the plate of balance tube BT that the reduced flow of current in a positive sense through control resistor CR to the control grid of tube ST permits such control grid to assume a negative blocking potential. As a result, the flow of current over the associated line, including the left-hand winding of relay RR', is terminated, but relay RR' is held in marking condition during this interval by the substitute flow of current through the middle winding thereof.

When the spacing ground potential is removed from spoke conductor SPI, the control grid of tube BT resumes its normal negative blocking potential, terminating the flow of plate current through tube BT and reducing the flow of current through the artificial line to the minute charging current passing through control resistor CR. The resultant raising of the positive potential on the plate of tube BT causes resumption of the normal flow of current in a positive sense through control resistor CR to the control grid of tube ST, causing resumption of the flow of plate current through the later tube and over the associated line. Relay RR' is again held in marking position by current flow through its left-hand winding in the absence of the flow of substantial current through the middle winding thereof.

I claim:

1. In a telegraph repeating system, a plurality of telegraph lines and a local interconnecting line, two-way telegraph repeaters interposed respectively between said telegraph lines and said local line, any repeater including means controlled over the associated telegraph line for impressing successive impulses of potential on said local line, a first means in each other repeater responsive electrostatically to each such impulse to impose a signal condition directly on the associated telegraph line, and a second means in each said other repeater responsive electrostatically to each last-named impulse to disable the repeater from responding to the imposed signal condition.

2. In a telegraph repeating system, a plurality of telegraph lines and a local interconnecting line, two-way telegraph repeaters interposed respectively between said telegraph lines and said local line, any repeater including means controlled over the associated telegraph line for impressing successive impulses of potential on said local line, and first and second means in each other repeater separately responsive electrostatically to each such impulse, said first means responding to impose a signal condition directly on the associated telegraph line, said second means responding to directly disable the repeater from responding to the first means.

3. In a two-way repeater for telegraphically interconnecting a first telegraph line with a second telegraph line, a relay and a vacuum tube connected in series with the first line, a connection from the control grid of said vacuum tube

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to the second line enabling the current flow over the first line to be controlled according to the potential on the second line, and contacts controlled by said relay for disconnecting said control grid from the second line and for substituting a signal potential.

4. In a two-way repeater for telegraphically interconnecting a first telegraph line with a second telegraph line, a vacuum tube connected in series with the first line, a connection from the control grid of said vacuum tube to the second line enabling the current flow over the first line to be controlled according to the potential on the second line, and means controlled over the first line for disconnecting said control grid from the second line and for substituting a signal potential.

5. In a telegraph system, a first line and a second line, sending means controllable from the first line to send signals therefrom to the second line, a sending tube in series with the first line having a control grid controllable from the second line to send signals therefrom to the first line, and means including a second tube also having a control grid controllable from the second line to prevent said sending means from responding to the last-named signals.

6. In a telegraph system, a first line and a second line, a receiving relay controllable from the first line to send signals therefrom to the second line, said relay including a line winding in series with the first line, a sending tube also in series with the first line having a control grid controllable from the second line to send signals therefrom to the first line, a balance line including a balance winding of said relay, and a balance tube in series with said balance line having a control grid controllable from the second line to send signals therefrom to the balance line to prevent said receiving relay from responding to the signals sent by said sending tube.

7. In a telegraph system, a first line having a balance line associated therewith, a second line, a receiving relay controllable from the first line to send signals therefrom to the second line, said relay including a line winding in series with the first line and a balance winding in series with the balance line, two tubes in series with the first and balance lines respectively, each tube having a control grid controllable by signals on the second line to send signals to the associated line, the signals sent to the balance line preventing said receiving relay from responding to the signals sent to the first line, a common current source for energizing the first line and the balance line, and means for inverting the phase of the signals at one control grid with respect to the signals at the other to alternate the demands of the two concerned lines for current from the common source.

8. In a telegraph system, a first line having a balance line associated therewith, a second line, a receiving relay controllable from the first line to send signals therefrom to the second line, said relay including a line winding in series with the first line and a balance winding in series with the balance line, and tube means controlling current flow over the first line and over the balance line, said tube means including control-grid means controllable by signals on the second line to send signals to the first line and to the balance line, the signals sent to the balance line preventing said receiving relay from responding to the signals sent to the first line.

9. In a telegraph system, a first line having a balance line associated therewith, a second line,

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a receiving relay controllable from the first line to send signals therefrom to the second line, said relay including a line winding in series with the first line and a balance winding in series with the balance line, tube means controlling current flow over the first line and over the balance line, said tube means including control-grid means controllable by signals on the second line to send signals to the first line and to the balance line, the signals sent to the balance line preventing said receiving relay from responding to the signals sent to the first line, a common current source for energizing the first line and the balance line, and means for inverting the phase of the signals sent to one such line with respect to the signals sent to the other to alternate the demands of such lines for current from the common source.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,252,629	Hanley -----	Aug. 12, 1941
2,321,618	Potts -----	June 15, 1943
2,347,813	Cummings -----	May 2, 1944

FOREIGN PATENTS

Number	Country	Date
385,414	Great Britain -----	Dec. 29, 1942