Aug. 11, 1936. G. R. EATON 2,050,292

TELEPHONE REPEATER SYSTEM

Filed July 15, 1933 4 Sheets-Sheet 1

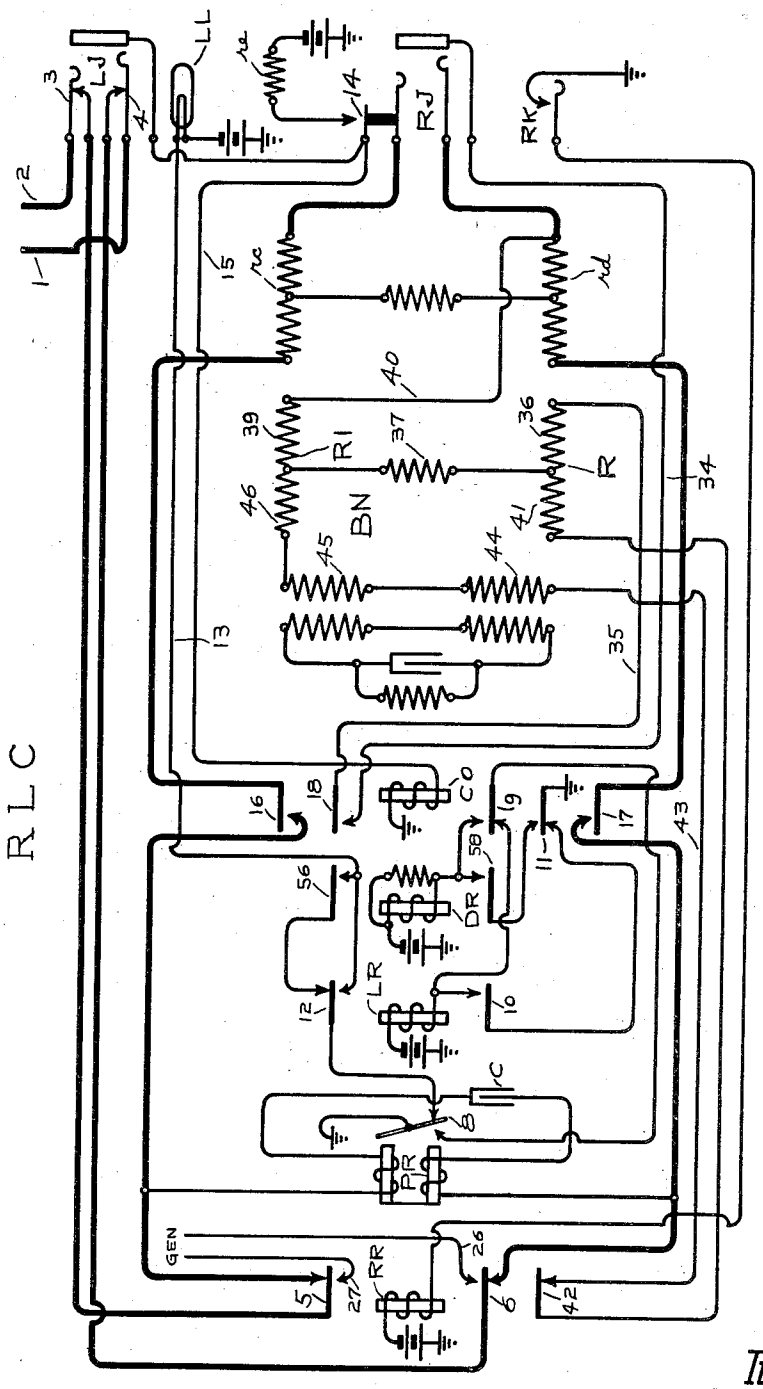


Fig. 1

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TELEPHONE REPEATER SYSTEM

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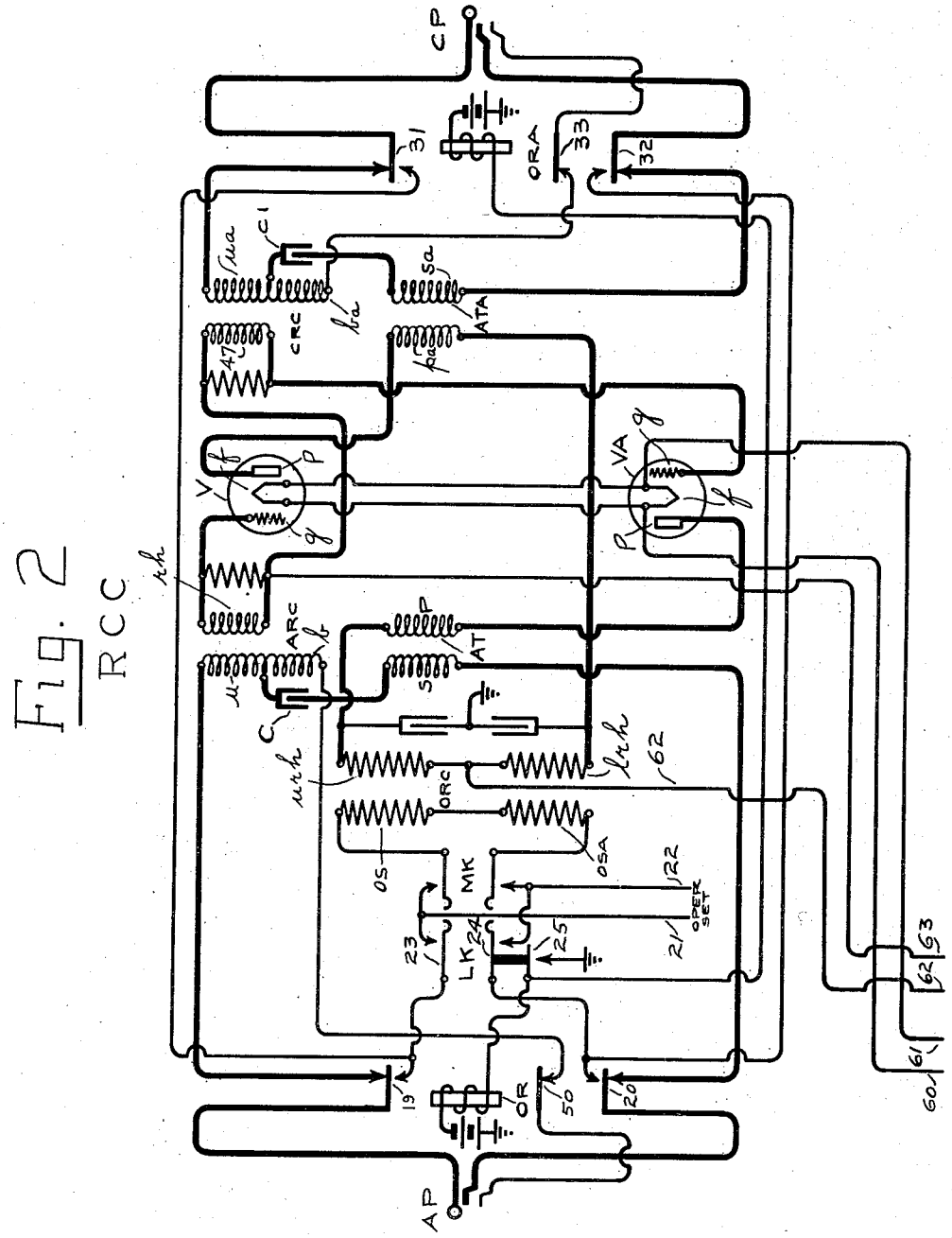


Fig. 2
RCC

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TELEPHONE REPEATER SYSTEM

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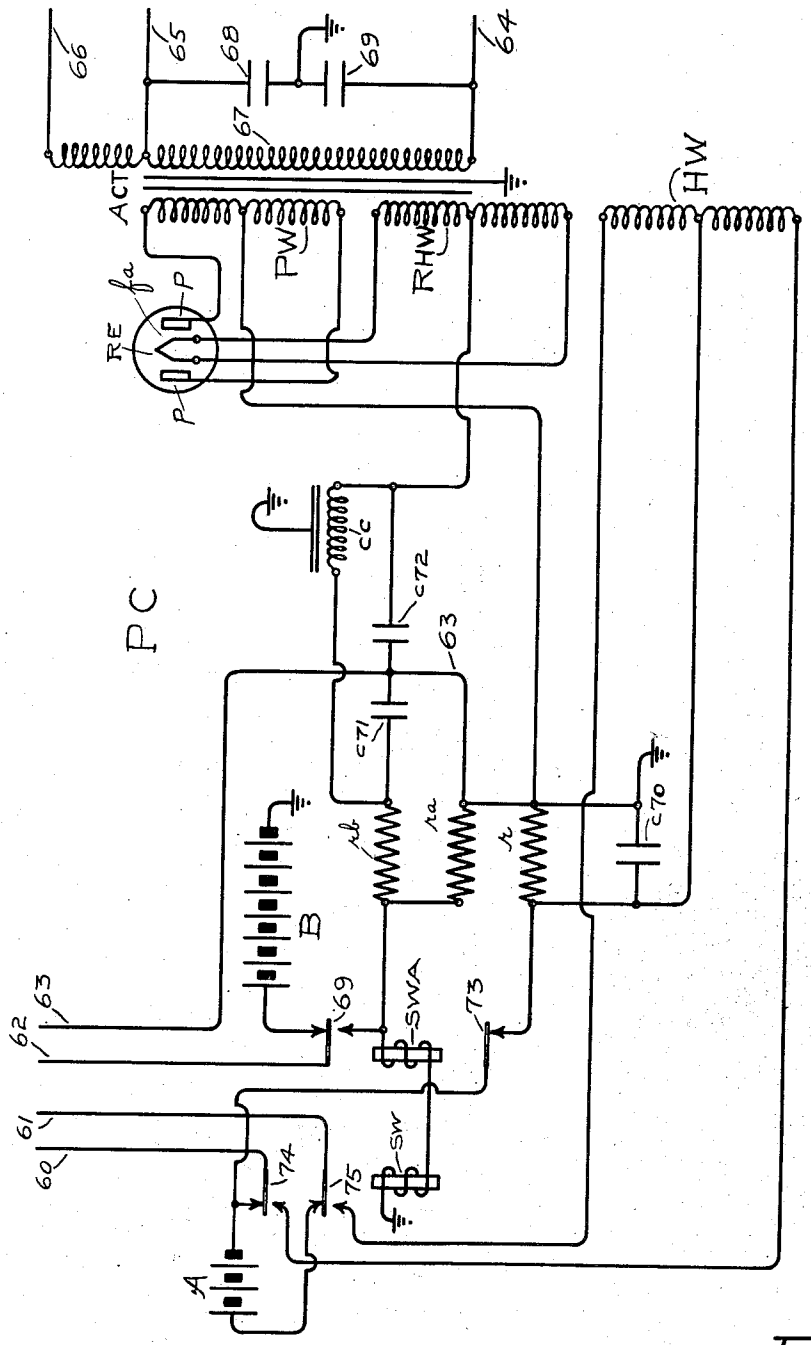


Fig. 3

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TELEPHONE REPEATER SYSTEM

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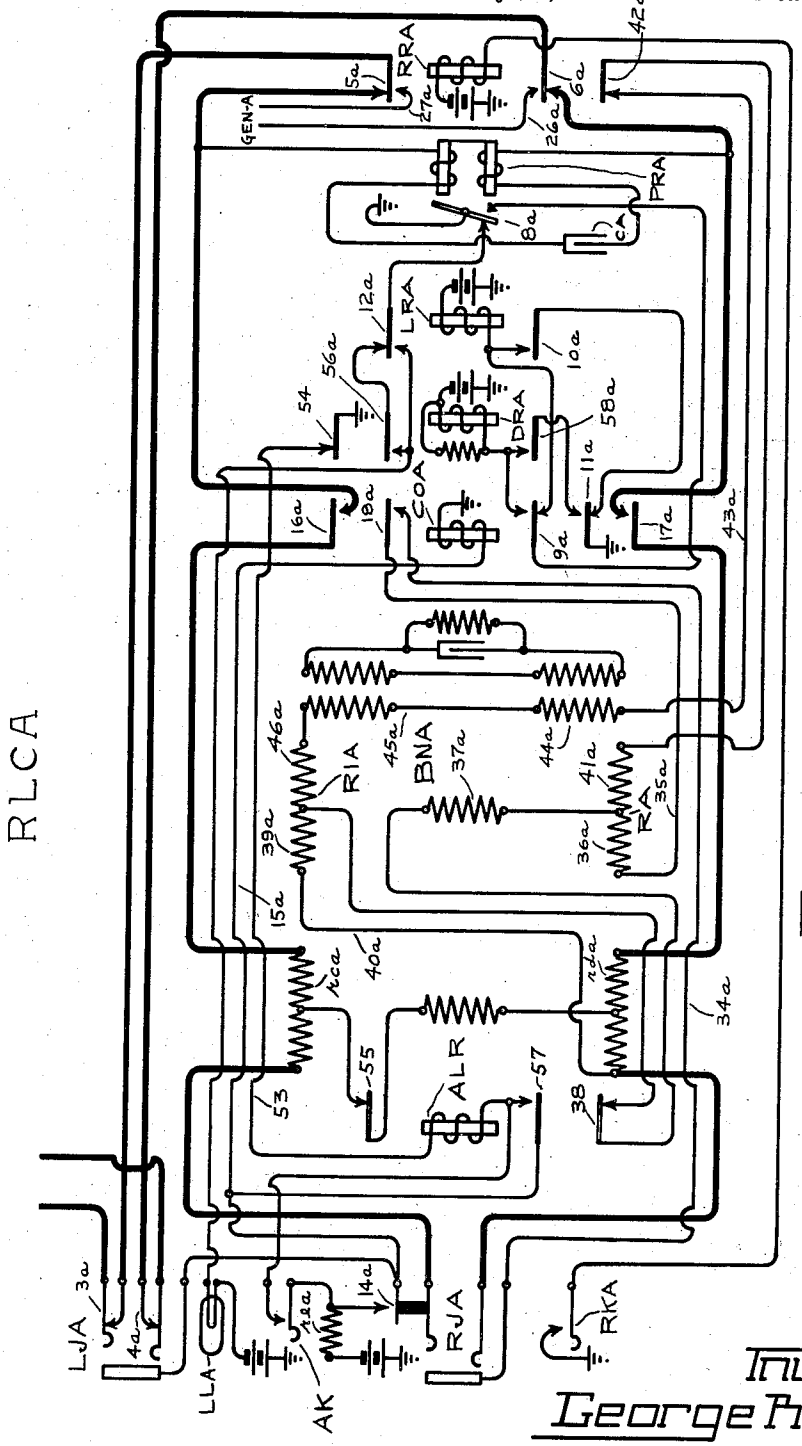


Fig. 4

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UNITED STATES PATENT OFFICE

2,050,292

TELEPHONE REPEATER SYSTEM

George R. Eaton, Oak Park, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill., a corporation of Illinois

Application July 15, 1933, Serial No. 680,521

18 Claims. (Cl. 179—170)

This invention relates to telephone systems and more particularly to two way repeating of telephonic currents.

An object of the invention is to produce an improved system of two way transmission of electrical energy over long distance lines. Such lines are of very high attenuation and amplifiers or repeaters are necessary to amplify the transmitted currents sufficiently to properly operate the receiving devices associated therewith. Due to the variable characteristics of long distance lines it has been found necessary, in order to insure proper operation of the associated repeater, to provide a network or artificial balancing line for association with each line. Suitable signaling and switching means are usually supplied in the link circuit used for connecting such lines.

A feature of my invention is the inclusion in the line circuit associated with the long distance lines of signaling means and switching means for said lines.

Another feature is the association of a balancing line or network with each line or with a group of lines of similar characteristics.

A further feature is the provision of means for normally disconnecting the artificial line or network from the long distance line when the same is idle.

Still another feature is the association with such a line circuit of a two-way repeater system of a novel and improved type.

Other features will become apparent upon a further perusal of the specification and together with the features pointed out, will be explained fully hereinafter, reference being had to the accompanying drawings comprising Fig. 1 to Fig. 4 inclusive in which

Fig. 1 is a circuit arrangement of a repeater line circuit of my invention;

Fig. 2 shows the repeater cord circuit;

Fig. 3 is a circuit drawing of the power supply circuit associated with the repeater of my invention; and

Fig. 4 is a modification of Fig. 1.

In the drawings a repeater line circuit RLC, in Fig. 1, which extends by means of conductors 1 and 2 to a distant station (not shown) terminates in a local jack LJ at a central exchange. The line circuit RLC is provided with the usual line and disconnect signal or lamp LL, which may be any type of indicator, a repeater jack RJ, a ringing key RK, a ringing relay RR, line relay LR, cutoff relay CO, and disconnect relay DR. An artificial balancing network BN comprising coils R and RI is provided for the line circuit RLC and may be individual to a line or means may be provided for switching the artificial line in circuit with any one of a plurality of lines having similar characteristics.

Fig. 2 shows a two-way repeater cord circuit RCC comprising two one way vacuum tube repeaters V and VA, an answering plug AP and a calling plug CP. An answering repeating coil ARC is interposed between the plug AP and vacuum tube V while a calling repeater coil CRC is interposed between the calling plug CP and tube VA. Audio transformers AT and ATA are associated respectively with the output circuit of the tube repeaters VA and V. An operator's repeating coil ORC is connected in the output circuit of both of the tube repeaters V and VA and enables the operator to monitor or supervise the connection thru a monitor's key MK. Operator's relays OR and ORA are energized when the listening key LK is thrown to connect the operator's set to the connected lines without the connection of the repeaters V and VA in the circuit.

The power circuit PC disclosed in Fig. 3 consists of an alternating current transformer ACT, a rectifier tube RE, resistances *r*, *ra* and *rb*, choke coil *cc*, switching relays SW and SWA and batteries A and B.

In the modified line circuit RLCA shown in Fig. 4 the apparatus similar to that shown in Fig. 1 is marked with similar reference characters with an "A" or "*a*" added. Additional apparatus not shown in Fig. 1 comprises an artificial line relay ALR and a key AK for initially operating the relay ALR.

The invention may be more easily comprehended by a description of the operation of the illustrated system. Signaling current from the distant station flows over conductors 1 and 2, closed contacts 3 and 4 of local jack LJ, normal contacts 5 and 6 of ringing relay RR, upper and lower windings of relay PR and condenser *c*. Relay PR operates and closes alternate contact 8 during the flow of ringing current thereby establishing an energizing circuit for the line relay LR. This circuit can be traced from grounded battery thru the winding of relay LR, normal contact 9 of CO, alternate contact 8 of PR to ground. The relay LR energizes and locks itself up thru its alternate contact 10 and normal contact 11 of relay CO. After the cessation of the flow of ringing current the relay PR restores its contact 8 to normal and establishes a circuit for the line lamp LL or other indicator which is illuminated by current flowing from grounded battery thru the lamp LL, conductor 13, alternate

contact 12 of relay LR, normal contact 8 of relay PR to ground.

The operator noting the display of the indicator LL, inserts the answering plug of a regular local cord circuit (not shown) into the local jack LJ to connect her to the calling party in the usual manner. Upon being informed the desired party is located at a distant exchange the operator withdraws the plug from the local jack LJ and inserts the answering plug AP of a repeater cord circuit such as RCC into repeater jack RJ thereby operating the cut-off relay CO over a circuit extending from battery, alternate contact 14 of jack RJ, conductor 15, and winding of CO to ground. Relay CO energizes and interrupts the locking circuit of LR at contact 11 and closes the talking circuit at contacts 16 and 17 thru to the cord circuit. Relay LR releases its contact 12 and thereby extinguishes the line lamp LL. A branch circuit closed at alternate contact 14 of RJ places a battery potential upon the sleeve of jack LJ and any other jacks connected in multiple therewith to indicate a busy condition should any operator attempt to insert a plug of another repeater cord therein. The closing of alternate contact 18 completes the circuit thru the artificial line. If the operator does not have all the necessary information to complete the call she next throws the listening key LK which causes the operation of relays OR and ORA over obvious circuits to ground at alternate contact 25 of LK. Relay OR closes its alternate contacts 19 and 20 thereby connecting the operator associated with leads 21 and 22 in a conversational circuit with the distant station. This circuit can be traced from lead 21, alternate contact 23 of LK, alternate contact 19 of OR, tip contacts of AP and RJ, resistance *rc* of the artificial line network, alternate contact 16 of CO, normal contact 5 of RR, normal closed contact 3 of LJ, conductor 2 to the distant station and back over conductor 1, normal contact 4 of LJ, normal contacts 6 of RR, 17 of CO, resistance *rb*, ring contacts of RJ and AP, alternate contacts 20 of OR and 24 of LK, lead 22 to the operator's set.

The operator ascertains the connection desired and assuming that the wanted line is associated with the line circuit RLCA of Fig. 4 inserts the calling plug CP into jack RJA which energizes relay COA by current flowing from grounded battery, resistance *rea*, alternate contact 14*a*, conductor 15*a*, winding of COA to ground. Relay COA disconnects the line relay LRA from the line at alternate contact 9*a* and closes the balancing line circuit at contact 18*a*. The attendant next operates the ringing key RKA which establishes an obvious energizing circuit for ringing relay RRA which closes alternate contacts 5*a* and 6*a* to connect the generator leads 26*a* and 27*a* to the called line. Signaling current is supplied over the leads 26 and 27 until the key RKA is released. As soon as the party at the distant end responds the operator restores the listening key LK and the conversational circuit thru the repeater system is established.

Voice currents from the calling line flow over the conductor 1, normal contacts 4 and 6 and the lower heavily marked conductors to jacks RJ and AP, normal contact 20 of OR, secondary winding *s* of the transformer AT, condenser C, mid-point of the left hand winding of repeating coil ARC, upper winding *u* of ARC and the upper heavily marked conductors to conductor 2 and over the line. Current passing thru coil *u* of ARC causes a flow of induced current thru the right hand winding *rh* of ARC which is impressed upon the grid *g* of the repeater V and transmitted to the plate *p* and over the heavily marked conductor to primary winding *pa* of ATA, lower right hand winding *lrh* of operator's repeating coil ORC, conductor 62 to a source of current in Fig. 4. Current is induced in the secondary *sa* of ATA which current flows thru condenser C1 to the mid-point of the right hand winding of CRC and thence in parallel, one path extending thru the upper winding *ua* of CRC, normal contact 31 of ORA, tip contacts of CP and RJA, resistance *rca*, alternate contact 16*a* of COA, normal contact 5*a* of RRA, normal contact 3*a* of LJA, out over the line and back thru normal contacts 4*a* and 6*a*, alternate contact 17*a* of COA, resistance *rda*, ring contacts of RJA and CP, normal contact 32 of ORA to *sa*; the other path extending thru the bottom winding *ba* of CRC, normal contact 33 of ORA, sleeve contacts of CP and RJA, conductor 34, alternate contact 18*a* of COA, condenser 35*a*, left hand winding 36*a* of resistance RA to the mid-point of RA where it divides and part flows thru resistance 37*a*, normal contact 38 of ALR, to the mid-point of resistance R1A and part flows thru resistance 41*a*, normal contact 42*a* of RRA, conductor 43*a*, resistances 44*a*, 45*a*, and 46*a*, to the mid-point of R1A where it joins the first path and both flow thru resistance 39*a*, conductor 40*a* to the heavily marked conductor and back to *sa*. The parallel paths pass respectively thru the physical line to the distant station and thru the balancing network BNA which is so constructed as to have the same characteristics as has the physical line. The flow of current thru upper winding *ua* and bottom winding *ba* is equal in each case and due to the construction of CRC neutralize each other and prevent any current being induced in the left hand winding 47 of CRC and setting up voice currents in the repeater VA.

Voice currents originating at the called line pass thru the line circuit RLCA over the heavily marked conductors thru the tip and ring contacts of CP, normal contacts 31 and 32 of ORA, winding *sa* of ATA, condenser C1 and upper winding *ua* of CRC. Current flowing thru *ua* induces a flow of current thru winding 47 which is impressed upon the grid *g* of repeater VA and thence flows from plate *p* of VA, thru the primary winding *p* of AT and upper right hand winding *urh* of ORC and conductor 62 to a source of plate current.

Induced current flows thru the secondary *s* of AT, condenser C to the mid-point of the left hand winding of ARC where it divides equally and flows over parallel paths having identical characteristics. One-half flows thru upper winding *u* of ARC, the heavily marked conductor thru the tip contacts of AP and RJ, resistance *rc*, alternate contact 16 of CO, normal contacts 5 and 3, over the long line to the distant station and back on conductor 1, normal contacts 4 and 6, alternate contact 17, resistance *rd*, ring contacts of RJ and AP, normal contact 20 of OR, to the secondary *s* of AT. The other half of the current flows thru the lower winding *b* of ARC, normal contact 50 of OR, sleeve contacts of AP and RJ, conductor 34, alternate contact 18 of CO, conductor 35, resistance 36, where it divides and one part flows thru resistance 37 to the mid-point of R1 and the other part flows thru resistance 41, normal contact 42 of RR, resistances 44, 45, and 46 to the mid-point of R1 where the paths meet and pass thru resistance 39, conductor 40, where

it joins the first mentioned path and returns to the secondary *s* of AT. The current flowing in the windings *u* and *b* of ARC neutralize each other and consequently no flow of current is set up in the secondary *rh* of ARC.

Should the operator desire to listen in on the connection for monitoring purposes she operates the monitoring key MK which connects the operator's set by its contacts **51** and **52**, over conductors **21** and **22**, to the secondary windings *os* and *osa* where induced current from the conversational circuit is flowing. If the connection is not operating properly the operator may operate the key AK of RLCA which operates the relay ALR by current flowing from battery thru resistance *rea*, operated key AK, the winding of ALR, conductor **53**, normal contact **54** of DRA. Relay ALR interrupts the circuit between coils *rca* and *rda* at contact **55**, and opens the circuit of the balancing network BNA at alternate contact **38** thereby permitting a gain over the physical line with improved clarity of reception of the transmitted message. The closure of alternate contact **57** of ALR establishes a branch circuit for the relay COA which may be traced from battery, resistance *rea*, alternate contact **57** of ALR, conductor **15***a*, thru the winding of COA to ground.

Upon the cessation of the conversation, signaling current may be impressed upon the line circuits at the distant stations causing the operation of the disconnect signals shown as lamps LL and LLA in the following manner. The signaling current operates PR as before explained which closes alternate contact **8** to energize the disconnect relay DR by current flowing from grounded battery thru the winding of DR, alternate contact **9** of CO, to ground at **8** of PR. Disconnect relay DR closes a locking circuit for itself thru alternate contacts **58** and **11** and an operating circuit for disconnect lamp LL or other signal thru alternate contact **56**. The operator noticing the lighted lamp LL withdraws the plug AP from RJ which interrupts the energizing circuit of cut off relay CO which restores contact **11** to normal to deenergize DR which extinguishes disconnect lamp LL and thereby restores all the apparatus to normal. The lamp LLA of RLCA is lighted in a similar manner and the plug CP is withdrawn from the jack RJA. However, in this case the cut-off relay COA is not deenergized as the branch circuit thru alternate contact **57** of ALR is still closed. The restoration of AK interrupts the energizing circuit of ALR which restores relay COA to normal by opening contact **57** with the subsequent restoration of disconnect relay DRA and the extinguishment of the disconnect lamp LLA which places the apparatus in condition for another call.

Current for the repeater tubes V and VA is supplied by the power circuit PC of Fig. 3 thru conductors **60**, **61**, **62**, and **63**. The current used is normally supplied by a source of alternating current such as is ordinarily used for lighting purposes over conductors **64** and **65** or **64** and **66**, depending upon the voltage of the line, to the primary winding **67** of a transformer ACT. Condensers **68** and **69** having their mid-point grounded are connected across the conductors **64** and **65** to filter out any high frequency current which may be present on the AC line. The secondary of ACT is divided into three portions HW, RHW and PW; the coil HW supplies heating current to the filaments *f* and *f* of the repeaters V and VA over conductors **60** and **61**; the rectifier heater winding RHW supplies heating current to the filament *fa* of the rectifier tube RE and the winding PW supplies current to the plate elements *p* of the rectifier RE.

The plate current for V and VA has one pole connected to the mid-point of RHW which is the positive pole, and then thru a choke coil *cc*, resistance *rb* to provide the proper potential, alternate contacts **69** of switching relay SWA which is normally operated, over conductor **62** to the plates *p* and *p* of V and VA. The negative side of the plate current is from the mid-point of PW, conductor **63** to the grids *g* of V and VA, and thru V and VA to the plates *p*. The grids *g* are kept negative to the cathodes or filaments *f* by a resistance *r* which is connected between ground and the mid-point of winding HW. A condenser *c***70** is connected across the resistance *r*, and condensers *c***71** and *c***72** are for filtering out any undesirable hum or other noises. A portion of the plate current passes thru the relays SWA and SW and maintains them operated as long as plate current is passing thru conductor **62**. Relay SWA closes alternate contact **69** to complete the plate current circuit and opens contact **73**. Relay SW closes alternate contacts **74** and **75** which connect the ends of HW to conductors **60** and **61** to supply heating current to *f* and *f*.

If the rectifier RE or the source of alternating current fails the relays SW and SWA deenergize and restore their contacts to normal. The restoration of contacts **74** and **75** connect the conductors **60** and **61** to the positive and negative terminals of an emergency battery A which supplies heating current to the filaments *f*. Contact **69** disconnects positive plate current conductor **62** from the winding RHW and connects it to emergency battery "B" which thereafter supplies plate current to *p* and *p* of V and VA. The closure of contact **73** of SWA maintains the negative bias on the grids *g* by connecting the negative pole of battery A to ground thru resistance *r*. Upon the resumption of a flow of current thru the rectifier RE the relays SW and SWA operate to disconnect the emergency batteries A and B from the supply conductors **60**, **61**, and **62**.

While I have described my invention in certain particular embodiments, I desire that it be understood that modifications and alterations may be made and that I intend no limitations upon my invention other than those imposed by the scope of the appended claims.

Having described my invention, what I claim as new and desire to secure by United States Letters Patent is:

1. In a telephone system a transmission line, a jack in which said line terminates, a primary relay associated with said line and arranged to be operated by signaling current thereover, a line relay, a cut-off relay, an energizing circuit for said cut-off relay, a contact associated with a jack controlling said circuit for said cut-off relay, a circuit for said line relay controlled by said primary relay and said cut-off relay, an indicator for said line, and a circuit for said indicator including contacts of said line relay and said primary relay.

2. In a telephone system, a transmission line, a jack for said line, a primary relay associated with said line and arranged to be actuated by signaling current thereover, a line relay for said line, a cut-off relay, an energizing circuit for said cut-off relay, a contact associated with a jack controlling said circuit for said cut-off relay, a circuit for said line relay including a front contact of said primary relay and a back contact

of said cut-off relay, an indicator for said line, and a circuit for said indicator including a front contact of said line relay and a back contact of said primary relay.

3. In a telephone system, a transmission line, a jack in which said line terminates, a primary relay associated with said line and arranged to be actuated by signaling current thereover, a disconnect relay for said line, a cut-off relay, an energizing circuit for said cut-off relay, a contact associated with a jack controlling said circuit for said cut-off relay, a circuit for said disconnect relay including a contact of said cut-off relay and a contact of said primary relay, an indicator for said line, and a circuit for said indicator including a contact of said disconnect relay and a contact of said primary relay.

4. In a telephone system, a transmission line, a jack in which said line terminates, a primary relay associated with said line and arranged to be actuated by signaling current thereover, a line relay for said line, a cut-off relay, a circuit for said line relay extending thru a contact of said primary relay and a contact of said cut-off relay, an indicator for said line, a circuit for said indicator including a contact of said line relay and a contact of said primary relay, a circuit for said cut-off relay, and means actuated incident to inserting a plug in said jack for completing said cut-off relay circuit.

5. In a telephone system, a transmission line, a jack in which said lines terminates, a primary relay associated with said line and arranged to be actuated by signaling current thereover, a line relay for said line, a cut-off relay, a circuit for said line relay extending thru a front contact of said primary relay and a back contact of said cut-off relay, a locking circuit for said line relay including a back contact of said cut-off relay, an indicator for said line, a circuit for said indicator including a front contact of said line relay and a back contact of said primary relay, a circuit for said cut-off relay, and means actuated incident to inserting a plug in said jack for closing said cut-off relay circuit.

6. In a telephone system, a transmission line, a jack in which said line terminates, a primary relay associated with said line and arranged to be actuated by signaling current thereover, a disconnect relay for said line, a cut-off relay for said line, a circuit for said disconnect relay including a contact of said primary relay and a contact of said cut-off relay, an indicator for said line, a circuit for said indicator including a contact of said disconnect relay and a contact of said primary relay, a circuit for said cut-off relay, and means for completing said circuit actuated incident to inserting a plug in said jack.

7. In a telephone system a transmission line, a jack in which said line terminates, a primary relay associated with said line arranged to be actuated by signaling current thereover, a disconnect relay, a cut-off relay, a circuit for said disconnect relay including a front contact of said cut-off relay and a front contact of said primary relay, an indicator for said line, a circuit for said indicator including a front contact of said disconnect relay and a back contact of said primary relay, a circuit for said cut-off relay, and means for completing said cut-off relay circuit incident to inserting a plug in said jack.

8. In a telephone system, a transmission line, a jack in which said line terminates, a primary relay associated with said line and arranged to be actuated by signaling current thereover, a line relay for said line, a cut-off relay, a circuit for said relay including a back contact of said cut-off relay and a front contact of said primary relay, an indicator for said line, a circuit for said indicator including a front contact of said line relay and a back contact of said primary relay, a disconnect relay, a circuit for said disconnect relay including a front contact of said cut-off relay and a front contact of said primary relay, a circuit for said signaling device including a front contact of said disconnect relay and back contact of said line relay and a back contact of said primary relay, a circuit for said cut-off relay, and means for completing said circuit incident to inserting a plug in said jack.

9. In a telephone system, a transmission line, a jack in which said line terminates, a ringing relay for said line, a circuit for said ringing relay, a key for completing said circuit, a ringing generator, leads from said generator terminating in front contacts of said relay, and back contacts for said relay for cutting off said jack from said transmission line upon actuation of said key.

10. In a telephone system a transmission line, a jack in which said line terminates, a primary relay associated with said line and arranged to be operated by signaling current thereover, a line relay, a cut-off relay, a circuit for said line relay controlled by said primary relay and said cut-off relay, an indicator for said line, a circuit for said indicator including contacts of said line relay and said primary relay, and a locking circuit for said line relay closed at its own front contact and a back contact of said cut-off relay.

11. In a telephone system, a transmission line, a jack for said line, a primary relay associated with said line and arranged to be actuated by signaling current thereover, a line relay for said line, a cut-off relay, a circuit for said line relay including a front contact of said primary relay and a back contact of said cut-off relay, an indicator for said line, a circuit for said indicator including a front contact of said line relay and a back contact of said primary relay, and a locking circuit for said line relay controlled by said cut-off relay.

12. In a telephone system, a transmission line, a jack in which said line terminates, a primary relay associated with said line and arranged to be actuated by signaling current thereover, a disconnect relay for said line, a cut-off relay, a circuit for said disconnect relay including a contact of said cut-off relay and a contact of said primary relay, an indicator for said line, a circuit for said indicator including a contact of said disconnect relay and a contact of said primary relay, and a locking circuit for said disconnect relay controlled by said cut-off relay.

13. In a telephone system, a transmission line, a jack in which said line terminates, a primary relay associated with said line and arranged to be actuated by signaling current thereover, a line relay for said line, a cut-off relay, a circuit for said line relay extending thru a contact of said primary relay and a contact of said cut-off relay, an indicator for said line, a circuit for said indicator including a contact of said line relay and a contact of said primary relay, a circuit for said cut-off relay, means actuated incident to inserting a plug in said jack for completing said cut-off relay circuit, and a locking circuit for said line relay controlled by said cut-off relay.

14. In a telephone system, a transmission line, a jack in which said line terminates, a primary

relay associated with said line and arranged to be actuated by signaling current thereover, a disconnect relay for said line, a cut-off relay for said line, a circuit for said disconnect relay including a contact of said primary relay and a contact of said cut-off relay, an indicator for said line, a circuit for said indicator including a contact of said disconnect relay and a contact of said primary relay, a circuit for said cut-off relay, means for completing said circuit actuated incident to inserting a plug in said jack, and a locking circuit for said disconnect relay controlled by said cut-off relay.

15. In a telephone system a transmission line, a jack in which said line terminates, a primary relay associated with said line arranged to be actuated by signaling current thereover, a disconnect relay, a cut-off relay, a circuit for said disconnect relay including a front contact of said cut-off relay and a front contact of said primary relay, an indicator for said line, a circuit for said indicator including a front contact of said disconnect relay and a back contact of said primary relay, a circuit for said cut-off relay, means for completing said cut-off relay circuit incident to inserting a plug in said jack, and a locking circuit for said disconnect relay controlled by cut-off relay.

16. A telephone system comprising a plurality of lines, a link circuit for interconnecting said lines, a voice current repeater in said link circuit, a balancing network associated with one of said lines having characteristics similar to those of the said line, a three-conductor contact switch for connecting said link circuit to said line, a talking circuit extending thru two of the contacts of said switch, and a circuit joining said balancing network to said link circuit and repeater including two contacts only of said switch.

17. A telephone system comprising a plurality of lines, a link circuit for interconnecting said lines, a voice current repeater in said link circuit, a balancing network associated with one of said lines having characteristics similar to those of the said line, a three-conductor switch for connecting said link circuit to said line, a two-wire talking circuit extending thru two of the contacts of said switch, and a circuit joining said balancing network to said line and link circuit and repeater including one of said pair of talking contacts and the third contact of said switch.

18. A telephone system comprising a plurality of lines, a cord circuit for interconnecting said lines, a voice current repeater in said cord circuit, a balancing network associated with one of said lines having characteristics similar to those of the said line, a three-conductor plug and jack for connecting said cord circuit to said line, a two-wire talking circuit extending thru two of the contacts of said plug and jack in series and a circuit joining said balancing network to said line and cord circuit repeater including one only of the talking contacts of said pair and the third contact of said plug and jack.

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