No. 850,079. PATENTED APR. 9, 1907.

N. G. WARTH.

TELEPHONE REPEATER SYSTEM.

APPLICATION FILED FEB. 5, 1907.

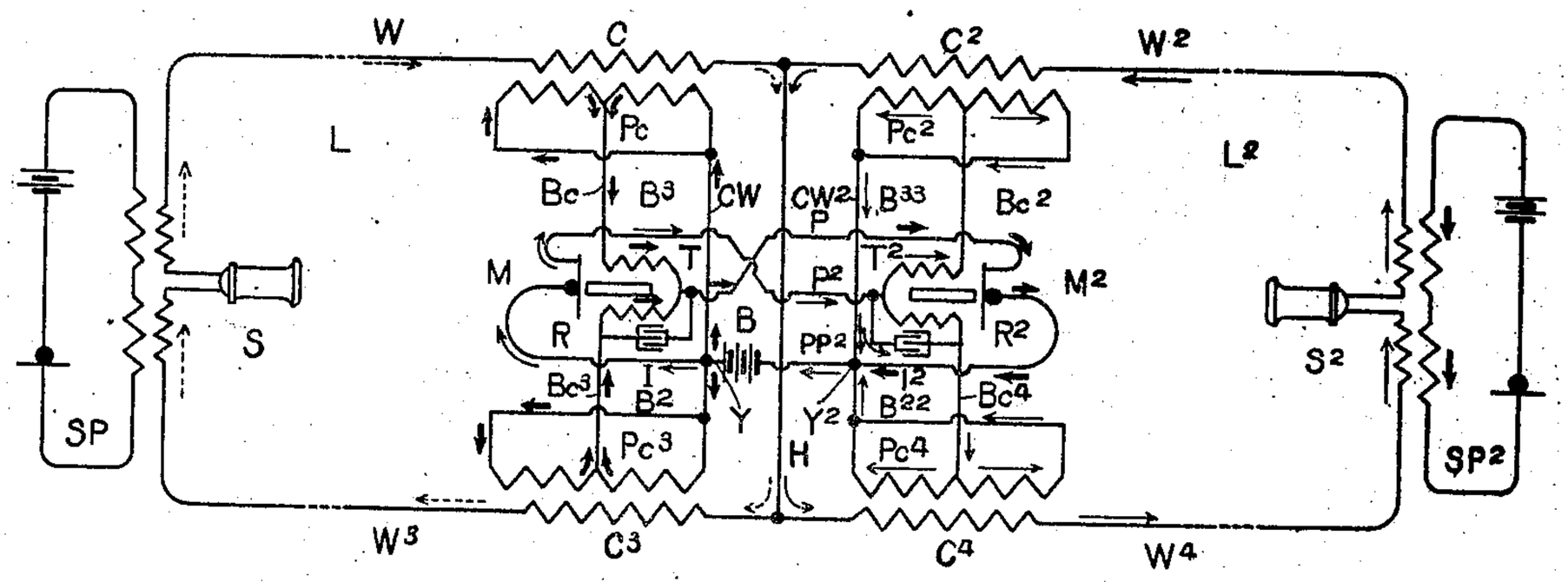

FIG. 1.

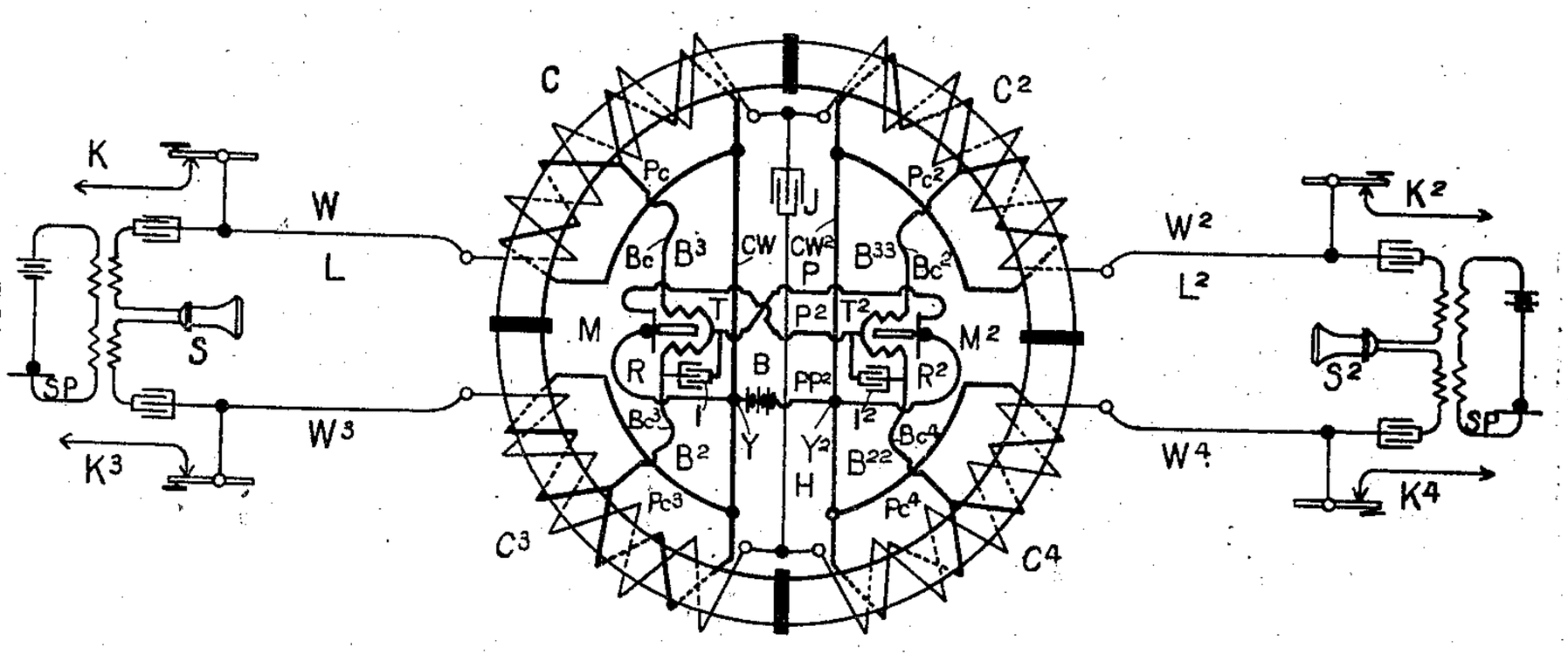

FIG. 2.

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UNITED STATES PATENT OFFICE.

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TELEPHONE-REPEATER SYSTEM.

No. 850,079. Specification of Letters Patent. Patented April 9, 1907.

Application filed February 5, 1907. Serial No. 355,800.

To all whom it may concern:

Be it known that I, NATHANIEL G. WARTH, a citizen of the United States, residing at Columbus, in the county of Franklin and State of Ohio, have invented a certain new and useful Improvement in Telephone-Repeater Systems, of which the following is a specification.

This invention relates to improvements in telephone current-repeaters or reciprocal relay-reinforcers and in systems for their operation of the general character illustrated in my patent of the United States No. 845,282, dated February 26, 1907, and comprises in part the generic features of the invention covered by said patent and additional features in circuits and apparatus and combinations thereof for securing new and beneficial results.

In my system referred to and in the system of Herbert E. Shreeve, illustrated in Patents Nos. 791,655 and 791,656, dated June 6, 1905, and No. 835,037, dated November 6, 1906, the transmission from the repeater is effected bidirectionally at all times, the currents developed at the repeater being divided and transmitted to the connected two circuits simultaneously. This condition results in the dissipation of the current set up in the section of circuit then transmitting, and which current if directed into the section of circuit then receiving will increase the volume of current transmitted to the receiving-telephone and will also be beneficial to the repeater service by avoiding conditions of current interference and distortion in the transmissions through the circuits connected.

The object of my invention is to provide means to accomplish these beneficial features, and, further, to secure complete singleness of action in the repeater apparatus, and consequent fidelity to the initial currents, by avoiding backward or reacting transmission and consequent confusion of effects in the repeater apparatus when two or more repeaters are included in a circuit, thus providing a pure quality and augmented volume of telephonic long-distance through-transmission.

The invention consists, essentially, in the association of two repeater instrumentalities, forming a double or twin repeater apparatus, and with auxiliary apparatus and local circuits connecting them for operation in combination with the line-circuits, whereby the initial currents are received and relayed unidirectionally.

The present system of repeater apparatus, local circuits, repeating induction-coil, and the association of them with the line-circuits comprises features from each of my systems referred to combined with the additional repeater and connections and modification of local circuits and coil-windings to secure the improved results. The twin repeaters are maintained in constantly-balanced local circuits to prevent the local self-action termed "howling" or "singing," which in other systems because of unstable balancing or absence of balance is frequently developed, interfering with their service.

Where the exigencies of service require or cause two or more repeaters of the bidirectional type to be included in tandem in a circuit they react upon each other and reproduce a sort of composite of the new impulses from the sending-station and the return impulses from the next repeater, resulting in a confused or blended transmission of the telephonic waves, which at times is wholly inarticulate or unintelligible. My arrangement of apparatus and circuits results in a system which not only avoids this detrimental condition for transmission to extreme distances, but provides for the operation of several circuits together by repeaters and secures the benefits of the improved quality of transmission due to the absence of reactive currents and interfering effects, as set forth in my patent hereinbefore referred to.

The drawings herewith are diagrammatic illustrations of the invention, showing two line-circuits and a reciprocal unidirectional twin repeater in each instance. Additional line-circuits and additional repeaters would be represented merely by a duplication of the arrangement.

In the drawings, Figure 1 illustrates a compound circuit composed of two circuit-sections associated with a twin telephone-repeater. Fig. 2 represents a like twin repeater-circuit adapted to the conditions of a special form of composite repeating induction-coil.

In Fig. 1 the two telephonic circuits or circuit-sections L L^2 are composed of line conductors W W^2 on one side and line conductors W^3 W^4 on the other side of the circuit associated with a twin repeater apparatus R R^2 for through repeated transmission be-

tween terminal telephones S and S². The circuit-sections are divided at the intermediate or repeater station or stations by the bridge conductor H, providing an individualized condition for each circuit-section. The twin repeaters R R² each comprise a receiving electromagnetic element T and T², respectively, and a transmitting variable resistance element M and M², respectively, the said elements respectively being mechanically associated in repeater relation and the twin repeaters R R² being electrically associated in double twin or divided local circuits B² B³ and B²² B³³, respectively. Each of said local circuits is divided by a bridge which is utilized to divide the circuit in its association with its receiver to balance said receiver locally against operation by the local repeating transmitter-currents. The bridge conductor P is connected to the middle terminal of receiver T, which is connected by its outer terminals to bridging conductors Bc and Bc³, said bridges being connected at their outer terminals to the middle terminals of the local windings Pc and Pc³, respectively. Bridge conductor P is common to the bridges Bc and Bc³ and contains the transmitter element M² of repeater R² and battery B and terminates at junction Y with the common conductor CW, leading to the local windings Pc and Pc³. The bridge conductor P² for the other local circuit is connected to the middle terminal of receiver T², which is connected by its outer terminals to bridging conductors Bc² and Bc⁴, said bridges being connected at their outer ends to the middle terminals of the local windings Pc² and Pc⁴, respectively. Bridge conductor P² is common to the bridges Bc² and Bc⁴ and contains the transmitter element M of repeater R and battery B and terminates at junction Y² with the common conductor CW², leading to the local windings Pc² and Pc⁴. The portion PP² of these bridges between junctions Y and Y², together with the battery B, are common to both divided local circuits. The circuits and apparatus above enumerated comprise all the essentials for a complete telephonic system for long-distance communication requiring repeater service from one or several successive repeaters. In this view, Fig. 1, the repeating induction-coil secondary windings are disposed as follows: Windings C and C³ are in the L circuit, one being connected in each conductor and producing a coöperative flow, and windings C² and C⁴ are in the L² circuit, one being connected in each conductor and producing a coöperative flow. The two primary windings associated with each secondary have their two outside terminals connected to their respective common conductors CW and CW² and have their two inside terminals connected to their respective bridge conductors Bc, Bc³, Bc², and Bc⁴, so that though split to conform to the bridge and balancing requirements the flow of current therein is always coöperative. The flow of the several currents is conventionally indicated as follows: the initial currents in the main circuit and the induced repeating-currents therefrom by long solid arrows, primary or battery currents by short solid arrows, and the reproduced or repeated currents by dotted arrows. An initial transforming line-current being set up at the terminal telephone S² in circuit-section L² would at the repeater-station traverse the repeating induction-coil secondary windings C² C⁴ and the low-resistance bridge connection H and would induce a like current (also indicated, as stated, by long solid arrows) in the split local windings relatively associated. The flow from windings Pc² traverses the common conductor CW² to junction Y², and the flow from windings Pc⁴ traverses the same common conductor to the same junction and there unites with the other current and flows through conductor PP², battery B, thence through transmitter M and conductor P² to the middle terminal of receiver T², where it divides, one division energizing receiver T² by traversing one of its windings and the other division passing through the shunting-condenser I². Each division thence returns to its respective winding through the bridge conductors Bc² and Bc⁴, respectively. As the flow of current through the other winding of receiver T² would be differential and neutralizing in effect, this being an alternating current, it will select the shunting-condenser I² for its path and leave the receiver-winding on that side unenergized. The energization of receiver T² causes the actuation of its repeating-transmitter M², which latter varies correspondingly the resistances of the twin primary circuits B² and B³, said circuits being associated with circuit-section L as follows: The variation of resistance stated produces a current impulse from battery B, flowing from its positive pole to the junction Y, where, dividing, one division traverses the common conductor CW and the parallel windings Pc³ to their middle terminals, from whence it traverses along bridge Bc³ to and through one winding of receiver T, while the other division traverses common conductor CW and the parallel windings Pc to their middle terminals and thence along bridge Bc to and through the other winding of receiver T, where they again unite. The divided currents flow differentially in the two receiver-windings and produce a neutral effect therein. From the middle terminal of the receiver T the current flows through the common bridge conductor P and transmitter M² to junction Y², thence through the common bridging conductor PP² to the negative pole of the battery, completing the circuit. The pulsation in windings Pc and Pc³ induces a facsimile current pulsation, though

of increased potential, by means of the high-wound secondaries into circuit-section L, whereby the current pulsation (see the dotted arrows) is transmitted to and operates the terminal telephone S, thus completing the cycle of initial transmission, repetition, and retransmission. It will be understood that the reciprocal of these current-flows and effects occurs with each change in the direction of transmission or use of the line and also that with additional repeaters in a through-circuit the conditions, effects, and results would be duplicated at each repeater, but of course with a natural loss of acuteness or quality in the transmission.

The differential flow of the battery-currents in the windings of both the receivers, which being located in the local circuits, and thus not subject to any disturbance of their maintained balances by unbalanced main-circuit conditions, is the means for avoiding the local self-action or howling effect at all times. The separation or division of the main-circuit sections by the lower resistance bridge and the location of the repeater secondary windings therein to operate each individually is the means for avoiding the usual reactive echo-like effects other than the reaction due to backward repeated transmission from a second repeater, to which latter condition the present invention is more particularly directed.

In Fig. 2 is illustrated, as before stated, the adaptation of my twin unidirectional repeater system to the conditions of a special form of composite repeating induction-coil. In said view the secondary windings C, C^2, C^3, and C^4 may be differentially connected throughout to secure the advantages of a neutral core effect for composite through-transmission on each side of the circuit for telegraphic service between telegraphic instruments K and K^2 and between similar instruments K^3 and K^4. This condition is also advantageous to prevent unusual operation of the repeaters from slow-acting ringing-currents, which usually flow in the telephonic circuit proper. The sectional separation of the secondary windings to create separate fields for the telephonic effects for each circuit-section is an advantage in the use of a coil having a single core, as it avoids the effects of direct induction between any two circuit-sections. It will be appreciated that the coil and associated apparatus as illustrated in this view is not relative as to size, but is so proportioned to simplify the illustration of the electrical circuits and connections. The circuits and the current-flows in this view are essentially the same as those in Fig. 1 and need not, therefore, be indicated.

For the establishment of an initial magnetic field in the receivers T and T^2 for their sensitization I prefer to employ a permanent magnet, as is usual with an ordinary receiving magneto-telephone.

The present system may be operated in connection with various superposed circuits and their currents and also with flexible cord-circuit and other necessary auxiliary arrangements.

Modifications of this invention as illustrated herein may be made without departing from the intent and scope thereof.

What I claim, and desire to secure by Letters Patent, is—

1. In a telephone-repeater system, the combination with a compound telephone-circuit and its telephones, of a twin telephone-repeater having twin local circuits, means connecting the twin repeater with the compound telephone-circuit inductively and to operate unidirectionally and reciprocally, the secondary windings of said inductive connection being included in the said compound circuit in separated divisions thereof, the primary windings of said inductive connection being included in the local twin circuits with said twin repeater, each twin local circuit with its respective receiver element of said twin repeater being mutually inductively associated with the secondary windings in one of the compound-circuit sections, and the receiver being active to the inward currents from such inductive association, twin local-battery and transmitter circuits embraced in said local twin circuits, and associated with the transmitter elements, so that each will operate the opposite or twin primary windings and produce a neutral state in their associated receiver elements, whereby, with associated means, the inward currents from one section of the compound circuit will operate its individually-associated receiver element, which, by actuating its mechanically-associated transmitter element, varies the battery-current associated therewith and sets up a coöperative flow in the opposite twin primary windings and a differential flow in their receiver-windings, and induces the reproduced facsimile currents into the associated compound-circuit section and prevents local self-action of the receiver.

2. In a telephone-repeater system, the combination with a compound telephone-circuit and its telephones, of a twin telephone-repeater, means for connecting the same therewith inductively, balanced local circuits for said twin repeater and in circuit with said repeater, whereby the receiving elements of said twin repeater are rendered active to inward-induced telephonic impulses, but inactive to the renewed outward telephonic impulses from the transmitting elements of said twin repeater, for the purpose of providing retransmission of renewed power without interfering effects from local action in the twin-repeater apparatus.

3. In a telephone-repeater system, the

combination with a twin repeater comprising two repeater units, each having a receiver element and a transmitter element united in repeater relation and a main-line circuit divided at the repeater-station and containing a telephone in each terminal section, of induction-coil windings in each line-section operating individually therewith for both the inward and the outward currents for the repeaters, and associated induction-coil windings having in circuit therewith the four elements of the repeaters with the receiving elements balanced against operation by the transmitting elements and associated local battery, the induction-coil windings operating with the line for the repeaters inductively and maintaining the aforesaid balance in the receiver elements.

4. The combination in a telephone-repeater system of a twin-repeater apparatus, comprising two units, each having a receiver element and a transmitter element united in repeater relation, a main-line circuit having telephones in circuit, induction-coil windings in said line-circuit for the repeater, and associated induction-coil windings having in circuit therewith both the receiving and transmitting elements of the repeaters which are operated inductively with said main-line circuit.

5. In a telephone-repeater system including a repeater-station, the combination of a twin-repeater apparatus comprising two units, each having a receiver element and a transmitter element united in repeater relation, a main-line circuit divided at the repeater-station and containing suitable telephones, induction-coil windings in each line-section that operate for both the inward and the outward currents for the repeaters, and associated induction-coil windings having in circuit therewith both elements of the repeaters which are operated inductively with said line-sections.

6. In a telephone-repeater system, the combination of a twin-repeater apparatus comprising two units, each having a receiver element associated with a transmitting element and united in repeater relation, divided local circuits for such elements, the division being such that currents energizing either receiver element will not affect the associated receiver element, means for operating each receiver element inductively and individually with a line-section so that the inward currents in either line-section will energize its respective repeater and the resulting repeating-currents set up will be inductively transmitted to the associated line-section.

7. The combination in a telephone-repeater system, of a telephonic main-line circuit having sending and receiving stations, and a repeater-station at an intermediate point, a unidirectional-repeater apparatus at said repeater-station, and a repeating induction-coil inductively associating said main circuit and the said unidirectional-repeater apparatus for mutual operation.

8. In a reciprocal unidirectional repeater system, the combination of a main-line circuit with transmitting and receiving telephones, a unidirectional repeater at an intermediate point, and means inductively associating said main circuit and said unidirectional-repeater apparatus to prevent self-action in same.

9. In a telephone-repeater system, the combination of a main telephone-circuit divided into circuit-sections, twin repeaters and local circuits, substantially as described, associated inductively with the said main-circuit sections, and means controlled by said twin repeaters for reciprocally relaying the telephonic transmission, said relayed transmission being in one direction from each transmitter.

10. The combination in a twin-telephone-repeater system, of twin receivers and transmitters associated in repeater relation, a repeating induction-coil having plural windings both secondary and primary, a transmitting-line having a section on each side of a repeater-station, and means for balancing and operating the twin receivers of said twin repeaters and connecting them in circuit with the primary windings of said coil whereby they are rendered insensitive to the local currents, but are sensitive to the inducing-currents from their respectively associated line-circuits and corresponding secondary windings.

11. In a telephone-repeater system, the combination of main and local circuits, each of which is divided to prevent the initial telephonic currents in said main circuit from being transmitted directly beyond or across the repeater, a twin-repeater apparatus comprising twin receivers and transmitters, substantially as specified, associated in repeater relation, and a repeating induction-coil, the secondary windings of which are in the main circuit and the local windings of which are in circuit with the said repeater apparatus.

12. In a reciprocal unidirectional reinforcing telephone-repeater system, the combination of a compound through telephone-circuit comprising a plurality of main-line sections extending between telephone-stations at a distance, a plurality of repeater-stations dividing said main line, twin-unidirectional-repeater apparatus, substantially as described, at each repeater-station, repeating induction-coils at the repeater-stations, individual secondary windings of same in each main-line section at each repeater-station, with primary windings of said repeating-coils associated with the twin repeaters, a local circuit containing a balanced repeater-receiver for the primary windings associated inductively with each line-section, a bridge for

each of said local circuits, having in circuit therewith the repeater-transmitter of its associated twin receiver, and a source of current-supply, whereby the currents set up by either transmitter are caused to induce like currents into the adjoining main-line circuit.

13. In a telephone-repeater system, the combination of a twin-repeater apparatus including twin receivers and transmitters, substantially as described, a main telephonic circuit, a bridge dividing said circuit, a repeating induction-coil having its secondary in said circuit, windings of said secondary being included in said circuit on each side of said bridge, local circuits containing balancing-bridges for the twin receivers and transmitters of said twin-repeater apparatus, said local circuits being balanced on each side of their respective bridges, and each containing primary windings of said coil associated with respective secondary windings thereof, each of said local balancing-bridges containing a repeater-transmitter and a battery, and each of said transmitters being actuated by the receiver in its twin opposite local circuit, each receiver having one winding shunted by a condenser, the said balancing means together with the said condensers causing the receivers to remain insensitive to their operating transmitter-currents, but sensitive and operative to the induced currents from their respective main-line sections.

14. The combination in a telephone-repeater system, of a transmission-line extending between transmitting and receiving telephones thereon and twin-repeater apparatus associated with said transmission-line for unidirectionally repeating the transmitted telephonic currents from one terminal telephone to the other, said twin-repeater apparatus comprising two electromagnetic receivers, each having associated in repeater relation with it a variable-resistance transmitter and a local battery, repeating induction-coil primary and secondary windings interposed between said twin-repeater apparatus and said transmission-line, the said line being divided or compounded into two sections at each repeater-station, the division into sections preventing direct transmission past a repeater and compelling the repeated currents to be effective only toward the receiving end of the compound circuit, each of the twin receivers being in circuit with the said primary windings of said repeating induction-coil secondary windings, and subject to direct inductive influence from the currents of one section of said compound circuit, each of the twin transmitters being in circuit with its opposed twin receiver and the primary windings in circuit therewith, and also being in circuit with said local battery, means for rendering each transmitter sensitive or active by its own receiver and for setting up currents in its said opposed receiver and associated primary windings, whereby the opposed receiver is rendered inert and the repeated currents are rendered inductively active for transmission to the associated or receiving section of line, and whereby the reciprocal of such effects is secured with each change in the direction of transmission.

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