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H. E. SHREEVE.

TELEPHONE REPEATER CIRCUIT.

APPLICATION FILED MAY 4, 1906.

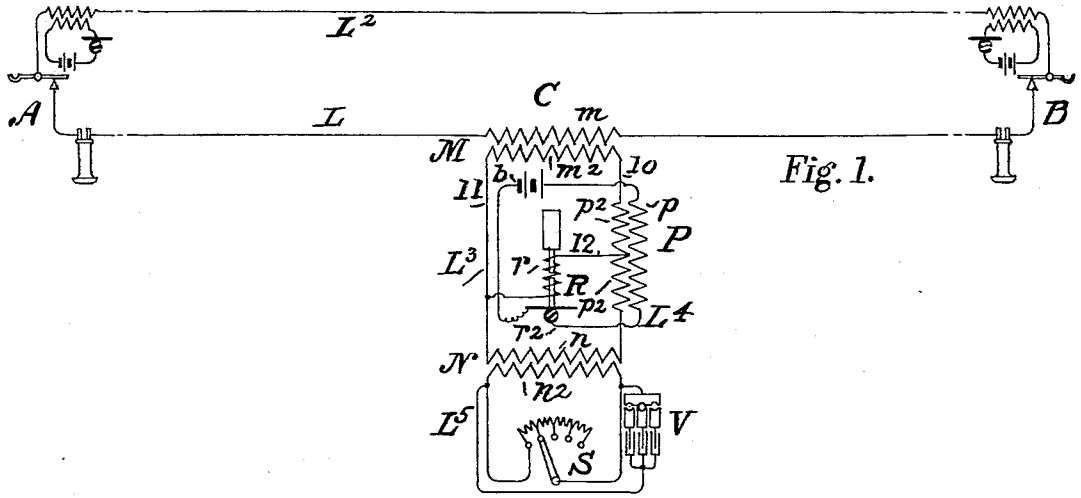

Fig. 1.

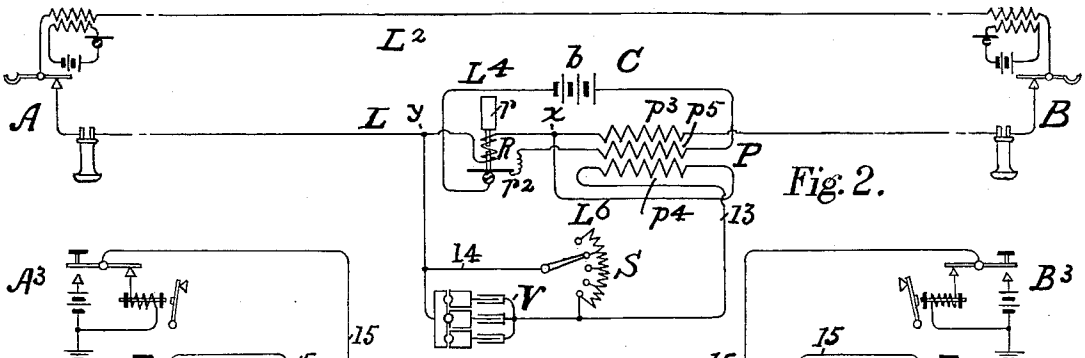

Fig. 2.

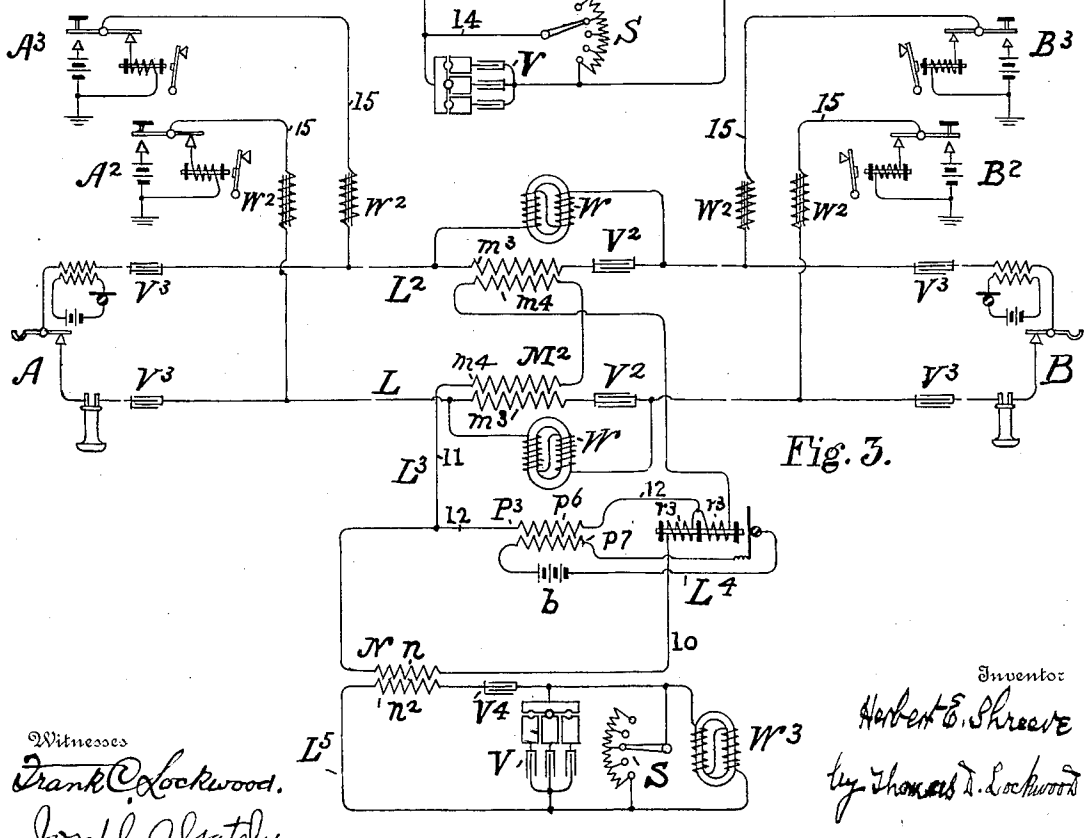

Fig. 3.

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TELEPHONE REPEATER-CIRCUIT.

No. 863,230. Specification of Letters Patent. Patented Aug. 13, 1907.

Application filed May 4, 1906. Serial No. 315,232.

To all whom it may concern:

Be it known that I, HERBERT E. SHREEVE, residing at Newton, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Telephone Repeater-Circuits, of which the following is a specification.

The present invention concerns such systems for the reinforcement or renewal of telephone-currents as are described, for example, in Patents Nos. 542,618 and 542,619 to Arnold, dated July 16, 1895, and my Patent No. 791,655, dated June 6, 1905, in which the relay or repeating apparatus has its receiving element located in a connection bridged across the line between transmitting-stations. The repeating induction-coil of the system is so associated with the transmitting-circuit and bridge-connection that the receiving element responds freely to telephone-currents impressed upon it by said transmitting-circuit, and when the latter is properly balanced as to its electrical properties upon the opposite sides of the bridge connection the receiving element is neutral with respect to the reinforcing-currents which the transmitting element throws upon the line. In systems of this character, however, a difficulty is encountered which prevents the attaining of equal efficiency in the renewal of the current transmitted in opposite directions over the line. This arises from the fact that the receiving element is a polarized device, and to insure equally effective operation under the influence of currents generated upon both sides of its bridge some definite relation must be established between the polarity of the receiver and the direction of the operating current otherwise the condition created might sometimes oppose rather than reinforce such operating-current. Moreover, telephone-lines of less than a certain length are liable to present a fluctuating impedance. This arises from the fact that the varying impedance of terminal stations is apparent throughout the transmitting-circuit until it is offset by the capacity of a sufficient amount of line, when the circuit-impedance may become substantially a constant as far as such apparatus as is now under consideration is concerned. This limits the application of the previously-mentioned reinforcing system, since with shorter lines it becomes difficult to maintain the electrical balance upon opposite sides of the bridge-connection necessary to secure the neutral condition without which the receiving element of the relay is liable to "sing."

The chief objects of this invention are to provide a system in which approximately equal current reinforcement is attained for transmission in both directions, and which is not dependent for its proper operation upon the balance of the transmitting-circuit upon opposite sides of the relay apparatus. To achieve these ends all the elements of said relay apparatus have been removed from their bridged relation to the line and at least one of them connected serially with the transmitting-stations; and means are associated with the relay apparatus for securing a balance of resistance and capacity with regard to the transmitting-circuit as a whole.

Reference may be had to the accompanying drawings in which

Figure 1 is a diagrammatic view of one embodiment of my improved system applied to a telephone-line; Fig. 2 illustrates in the same manner another form of the invention; and Fig. 3 shows diagrammatically still another arrangement in connection with a composite telephone and telegraph-circuit.

Similar characters indicate like parts throughout the several figures of the drawings.

In Fig. 1, L and L^2 designate the opposite sides of what is here shown as a metallic telephone-circuit or main line connecting stations A and B, these stations being provided with the usual or any convenient form of telephone apparatus. At some intermediate point is a station C at which is located a repeating or current-reinforcing apparatus. This need not be midway between the terminal or transmitting and receiving stations, but at such relative distance from them as the conditions peculiar to each installation demand.

Included in the line at the station C is one winding m of a transmitting induction-coil M which, for the sake of simplicity and clearness, is shown in the limb L, though, as will appear later, it may be in sections contained in both limbs. This induction-coil may be considered as a portion of the reinforcing apparatus which, in the present instance, comprises a circuit L^3 having no conductive relation with the transmitting-circuit but which is associated therewith inductively by the associate winding m^2 of the coil M. Between conductors 10 and 11 of the reinforcing circuit, which join the winding m^2 with a winding n of an induction-coil N, to be later described, is a bridge-connection 12. In this bridge is the receiving element r of a relay or repeater R which may be of any suitable type, for example, that disclosed in my said Patent No. 791,655, dated June 6, 1905. The transmitting element r^2 of the relay is contained in a local circuit L^4, which is also to be considered as an element of the reinforcing-circuit, together with some such source of electrical energy as a battery b and the primary winding p of an induction-coil P. The secondary winding of this coil is included in the conductor 10 of the circuit L^3, and is symmetrically divided into sections p^2 p^2 which are connected to one another at one extremity of the bridge 12.

Associated with the reinforcing-circuit, in the pres-

ent instance inductively, is a balancing-circuit L^5 in which is the winding n^2 of the coil N. This circuit L^5 constitutes an artificial line presenting substantially the same electrical properties as the main line. To readily secure and maintain such similarity the circuit L^5 includes a suitable adjustable resistance S in series with the winding n^2 and an adjustable condenser or capacity-varying means V in parallel or shunt relation to such resistance.

In the operation of the system, telephone-currents generated at either of the stations A or B flow through the main line and the winding m of the coil M. A portion of the current induced in the winding m^2 contained in the reinforcing-circuit passes through the bridge 12 and receiving element r of the relay and operates the transmitting element r^2, resulting in a variation in the resistance of the latter and consequently in the current put upon the local circuit L^4 by the battery b. This current in the winding p induces like current in the same direction in the sections p^2 and therefore in the circuit L^3, which adds itself to that already present and acts inductively through the coil M to augment the talking-current in the main line. It is evident that to prevent the reinforcing-current from reacting upon the receiving element and causing the apparatus to "sing", said receiving element must be rendered neutral to the energy generated in the relay. This necessitates the maintaining of an equal potential at the opposite extremities of the bridge 12 and an equality in the current through the sections p^2 of the secondary of coil P. To attain these conditions the opposite sides of the reinforcing-circuit with respect to the bridge are balanced electrically, the energy converted through the coil N between the reinforcing-circuit L^3 and the balancing-circuit L^5 being equal to that exchanged between said reinforcing-circuit and the main line through the coil M. This follows because the induction-coils M and N are similar and act between symmetrical halves of one circuit and two circuits which are equivalent to one another, this latter condition being attained by varying the resistance and capacity of the circuit L^5 until it corresponds to that of the line. In this manner the desired neutrality of the receiving element to the reinforcing-current is secured and reactive disturbances are eliminated. On account of the serial connection of the reinforcing apparatus with the line and its transmitting-stations a constant current relation may be preserved, and the difficulty as to the polarity of the receiving element is obviated. At the same time the necessity for maintaining an adjustment between the varying electrical conditions of portions of the line is done away with, since here only a balance for the entire line is required. This enables the apparatus to be located much nearer one of the transmitting-stations than has been possible before.

In Fig. 2 of the drawings an arrangement of the system has been illustrated in which a conductive relation exists between the transmitting and reinforcing-circuits, and also between the latter and its balancing-circuit. Here, a winding of the repeating induction-coil P has one section p^3 of its divided secondary winding connected in series with the receiving element r of the relay R in the limb L of the line at the station C, said station being situated as before between the stations A and B. The other section p^4 of the secondary is connected in a circuit L^6 constituting both the reinforcing and balancing-circuits, and of which a portion of the main line containing the receiving element between the points x and y forms a part. Of this circuit a conductor 13 extends from the point x between the winding p^3 and the receiving element r, back to the line upon the opposite side of the receiving element at y. As just stated, it includes the section p^4 of the secondary of coil P, and also contains the adjustable condenser V. In parallel with the condenser in a conductor 14 is the adjustable resistance S. The transmitting element is, as in the form previously described, connected in a local circuit L^4 with the battery b and the primary p^5 of the repeating induction-coil. In this embodiment of the invention, a portion of the current transmitted from either of the stations A or B flows through the receiving element of the relay. This operates the transmitting element as in the arrangement of Fig. 1, and causes the primary winding p^5 of the coil P to induce current in the sections p^3 and p^4. By oppositely winding or oppositely connecting these sections, the latter being here shown, these currents are added to one another to increase the talking-current flowing through the line and the circuit L^6. At the points x and y these reinforcing-currents in the sections p^3 and p^4 will oppose one another and, when the resistance and capacity of the artificial line furnished by the circuit L^6 have been adjusted by means of the devices S and V to equal those of the main line, they will be balanced and will not react upon the receiving element.

Fig. 3 shows still a third embodiment of the invention in connection with a composite telephone and telegraph line. The telephone-stations A and B are connected by the line conductors L and L^2 as before, but in addition each limb of the line provides with conductors 15 grounded telegraph circuits connecting stations A^2 B^2 and A^3 B^3, each having appropriate sending and receiving-instruments. At the intermediate station C is the reinforcing-circuit L^3 associated with the line and with the balancing-circuit L^5, by induction-coils M^2 and N as described in connection with Fig. 1, except that the coil M^2 is shown as being provided with a section m^3 included in each side of the line and each as having an associate winding m^4 in the reinforcing-circuit. The latter windings are oppositely connected to secure the proper direction of induced current and serve to balance the limbs of the main line to prevent the introduction of inductive disturbances from lack of symmetry. To avoid interference with telephonic transmission by the currents employed in telegraphing, each of the coil sections m^3 has in series with it a condenser V^2, each of these pairs of elements being shunted by a suitable impedance-coil W. At each telephone-station A and B similar condensers V^3 are inserted between the telephone-instruments and the connection of the telegraph-branches 15, and these branch conductors include impedance-coils W^2. The condensers and impedance-coils operate in a manner well known, the former giving relatively free passage to the high-frequency telephone-currents and excluding the slower telegraph-currents, while the latter present a much greater efficiency to currents of low periodicity. Thus, paths are furnished for the telegraph-currents without impairing telephonic transmission. To maintain the correct balance of the

system a coil W^3 is placed in the balancing-circuit L^5, it offering the same amount of impedance as the coils W W in series, while a condenser V^4 having one half the capacity of each of the condensers V^2 furnishes the equivalent of said condensers V^2 V^2 in series. In connection with this composite system a further modification of the reinforcing-circuit has been illustrated, though it is to be understood that it is equally applicable to a simple telephone-circuit, and that the forms hereinbefore described may be used with a composite circuit. In this case the divided winding is that of the receiving element, the sections being designated by the characters r^3 r^3. These sections are symmetrical and are connected in the conductor 10 upon the opposite sides of the bridge 12. This bridge now includes the secondary winding p^6 of the induction-coil P^3, the primary p^7 being in the local circuit L^4, as in the arrangements of Figs. 1 and 2. The currents induced from the main line in the reinforcing-circuit act upon both sections of the reinforcing element similarly to actuate the transmitting element. The reinforcing-current induced in the winding p^6, by means of the variations of current caused by the transmitting element in the winding p^7, passes in opposite directions through the windings of the repeating-element r^3, producing the desired neutral condition as regards the energy generated in the relay. It will be seen that the relay-current in the reinforcing-circuit upon the side of the bridge-connection toward the transmitting induction-coil is such as to reinforce the line current, while upon the side toward the balancing-circuit it opposes that induced in the line, but this latter condition does not lessen the efficiency of the system, since its effect is exerted only upon the artificial line.

While the various embodiments of the invention which have been disclosed differ as to detail, it will be evident that they have in common the principle of placing all the elements of the reinforcing apparatus in other than a bridged relation to the main line and balancing said apparatus by an artificial line having electrical properties similar to those of the main line.

I claim:

1. A current-reinforcing system comprising a main line provided with transmitting and receiving stations, intermediate repeating apparatus including a receiving element and having all its main circuit elements in series with the transmitting and receiving stations, and means for preventing the energy generated in the repeating apparatus from reacting upon the receiving element thereof.

2. A current-reinforcing system comprising a main line provided with terminal station telephones, relay apparatus having an element provided with a winding in the main line in series with the terminal stations, and an artificial line associated with the relay apparatus and possessing electrical properties similar to those of the main line.

3. A current-reinforcing system comprising a continuous main line provided with transmitting and receiving stations, relay apparatus having an element provided with a winding in the main line in series with said stations, and an artificial line associated with the relay apparatus containing resistance-varying means and capacity-varying means.

4. A telephone system comprising a transmitting-circuit, means for reinforcing current therein, and balancing means possessing electrical properties similar to those of said transmitting-circuit and associated with the reinforcing means to balance the latter with relation to the transmitting-circuit.

5. A system for the reinforcement of telephone-currents comprising a transmitting-circuit, connecting terminal station telephones, a reinforcing-circuit, a balancing-circuit associated with the reinforcing-circuit and possessing electrical properties similar to those of said transmitting circuit, and means for varying said electrical properties to effect a balance of the reinforcing-circuit with relation to the transmitting-circuit, substantially as described.

6. The combination with a main telephone-circuit connecting terminal telephone-station apparatus, of a reinforcing-circuit including an element having a winding connected in said main circuit in series with the telephone apparatus, and a balancing-circuit associated with the reinforcing-circuit.

7. A telephone current reinforcing system comprising a main telephone circuit connecting terminal station telephone apparatus, a reinforcing circuit, and a balancing circuit, the said main, reinforcing and balancing circuits being all in inductive relation only with one another.

8. In a telephone system, the combination with a main circuit, of means for transmitting telephone and telegraph-currents therethrough, a circuit including reinforcing means for telephone-currents and an element having a winding connected in the main circuit in series with the telephone-current transmitting means; a condenser also included in the main circuit, a retardation-coil shunted about the winding of the reinforcing element and the condenser, and a balancing-circuit for the reinforcing-circuit, said balancing-circuit containing a condenser and retardation-coil the electrical properties of which bear some definite relation to those associated with the main circuit.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses, this second day of May 1906.

HERBERT E. SHREEVE.

Witnesses:

SYLVANUS H. COBB,

GEO. WILLIS PIERCE.