

H. E. SHREEVE.
TELEPHONE CURRENT REINFORCER OR RELAY.

APPLICATION FILED FEB. 28, 1905.

2 SHEETS—SHEET 1.

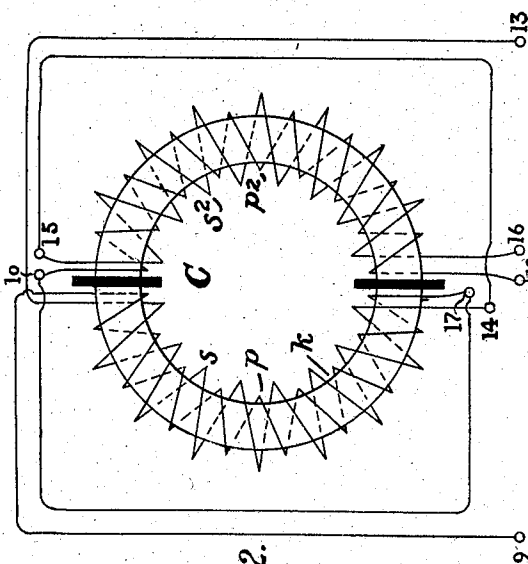
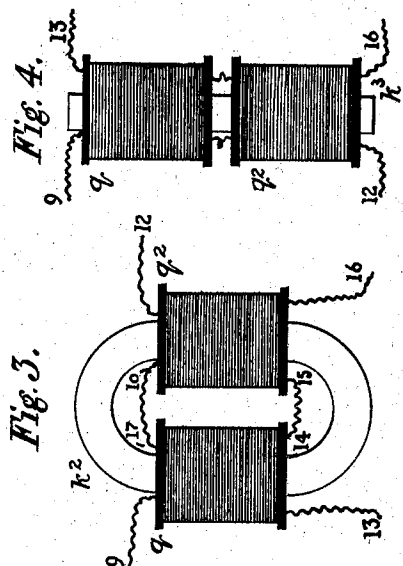


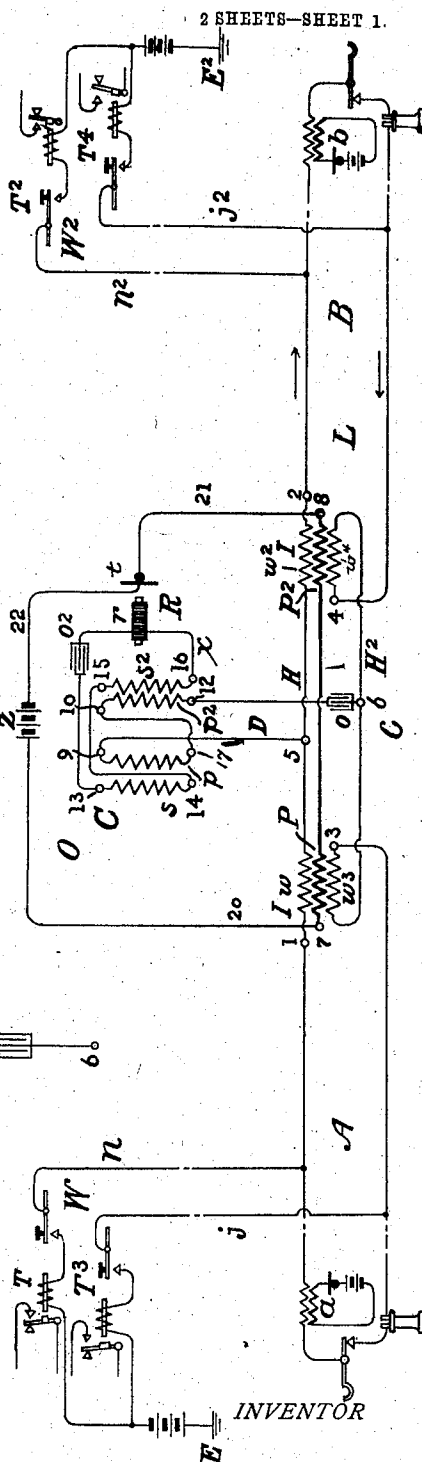
Fig. 1.

Fig. 2.

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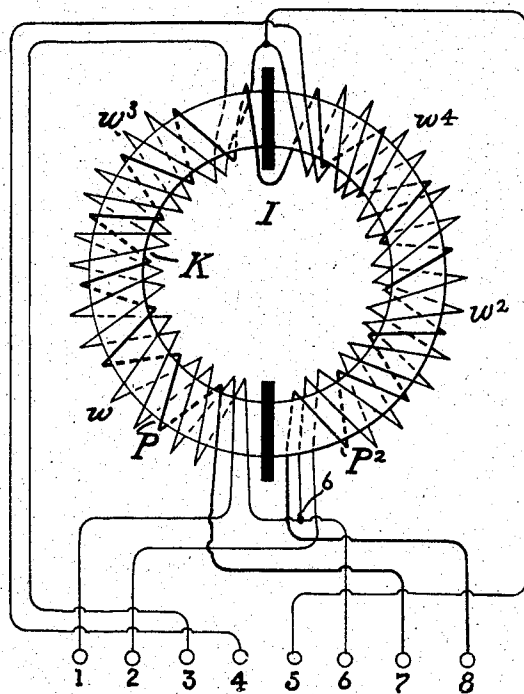


Fig. 5.

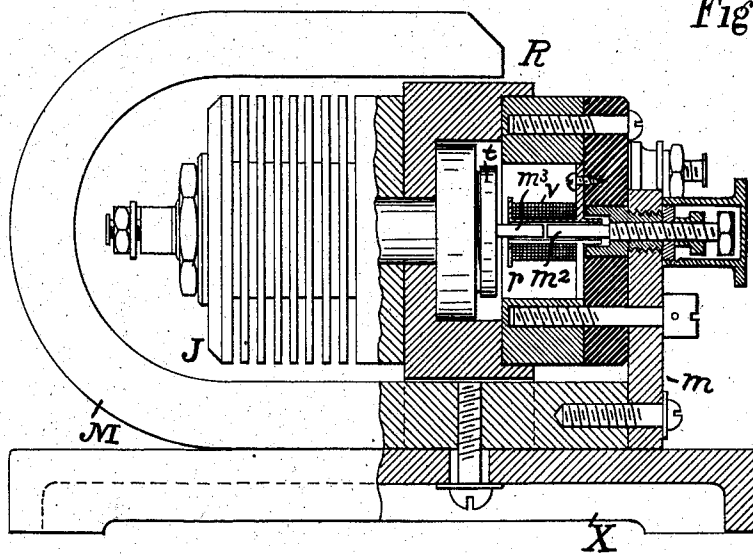


Fig. 6.

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UNITED STATES PATENT OFFICE.

HERBERT E. SHREEVE, OF NEWTON, MASSACHUSETTS, ASSIGNOR TO
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TELEPHONE-CURRENT REINFORCER OR RELAY.

SPECIFICATION forming part of Letters Patent No. 791,656, dated June 6, 1905.

Application filed February 28, 1905. Serial No. 247,691.

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-Current Reinforcers or Relays, of which the following is a specification.

This invention relates to means for reinforcing or strengthening the electrical currents concerned in telephonic transmission, and more particularly is directed toward a circuit for a telephone-current-reinforcing apparatus, which in its employment effectually prevents the receiving medium of said apparatus from being responsive to undesired currents in neighboring circuits or traversing portions of its own circuit when such portions are serving also as conductors of other circuits, and protects the said reinforcing apparatus from disturbance accruing from such undesired currents.

In a pending application for Letters Patent of the United States, Serial No. 215,811, filed by me July 8, 1904, I have described and claimed reinforcing and renewing apparatus for telephone circuits and currents which has been put into practical use. The invention of the present case is in some respects specific to the generic invention of my said prior application.

Many long telephone-lines are now operated as "composite" circuits, the line-wires coupled at their ends serving as the two conductors of the metallic telephone-circuit, while provided with ground-terminal extensions and appropriate appliances and instruments. The said two conductors severally constitute separate earth-completed telegraphic circuits, and in operating my reinforcing apparatus in association with the telephone-circuits of such composited lines and with such relay-circuit arrangements as prior to the present invention were accessible (those, for example, set forth by patents No. 340,707, issued to Edison April 27, 1886, and No. 542,619, granted to Arnold July 16, 1895,) it has been found that the current emissions and intermissions engaged in producing the

telegraphic signals in the two telegraphic circuits composed of the same conductors act adversely upon the receiving medium of the said reinforcing apparatus and seriously interfere with its normal operation and with the telephonic transmission dependent thereon. Under these circumstances the present invention has been conceived and worked out as a means for connecting the telephone-current-reinforcing apparatus with the main circuit-conductors in such manner that the said apparatus shall be made irresponsive to the relatively low frequency telegraphic currents without material impairment of its responsiveness to the higher-frequency telephonic currents. In other words, by this invention the telegraphic and other undesired currents of relatively low frequency are, as it were, strained out and prevented from disturbing or in any way affecting the repeating mechanism, which yet remains sufficiently efficient and in a high degree responsive to the legitimate working currents of the telephone-circuit.

The invention mainly consists in combining the compound telephone-circuit or the united circuits or circuit-sections which form the through-line of communication and a relay or reinforcing mechanism with a repeating induction-coil of small mutual inductance or such a coil having its primary winding bridged between the main circuit-conductors and its secondary joined up in circuit with the electromagnetic receiving medium of the reinforcing apparatus.

It further consists in the same combination of devices and circuits, the special requirements of the repeating induction-coil being met by having its primary winding disposed or connected over the two halves of the common iron core differentially or in magnetically-opposing half-windings, while the secondary is correspondingly arranged so that the currents induced in its halves shall coincide in direction. Practically, therefore, though both windings are arranged differentially and though the two divisions of the primary do exert opposite magnetizing influences upon the core, the secondary is so correspondingly

wound or connected merely for the purpose of causing the induced currents developed separately in its half-windings to be of such direction that in the circuit they shall not oppose each other, but shall coincide in electromagnetic effect.

It consists also in an induction-coil characterized by such peculiar construction and in the complete circuit arrangement, all of which will be particularly pointed out in the claims at the close of this specification.

In the drawings which accompany this specification, Figure 1 is a diagram of a compound metallic telephonic circuit arranged for composite transmission, together with an associated telephone current reinforcing or repeating mechanism having electrical connections arranged in accordance with the present invention. Fig. 2 is a diagram illustrating the electrical arrangement of the windings of the repeating induction-coil, which constitutes an important and characteristic part of the invention. Figs. 3 and 4 represent alternative forms of the said repeating induction-coil, which, while dissimilar in external form, are identical in electrical arrangement. Fig. 5 is a diagram of the electrically-divided induction-coil associated with the transmitting-electrodes of the repeating, amplifying, or reinforcing apparatus; and Fig. 6 is a side elevation, partly in vertical section, of a practically efficient type of the said reinforcing apparatus.

In Fig. 1, L is a complete line of telephonic communication extending between terminal stations *a* and *b*. It may be a line complete in itself or in a well-understood manner may be formed of two normally separate circuits whose adjoining ends enter the same intermediate station *c* and are there switched together. In either case the portions on the two sides of the said intermediate station may be regarded as separate circuit-sections A and B. At the intermediate station *c* is placed any suitable reinforcing apparatus R, so organized and so connected with the two main-circuit sections that its receiving medium *r* is or may be responsive to the operation of the transmitter at either terminal station, according as either at any particular moment may be transmitting, and that its transmitting medium or electrodes *t* shall in such case be actuated by the said receiving medium *r* and shall operate to repeat the message with current renewed and amplified from the battery *z* through the electrically-divided transmitter induction-coil I upon the second circuit-section for the operation of the receiving-telephone of the terminal station which at such moment is receiving. The reinforcing apparatus is thus arranged to work reciprocally, and when the direction of transmission is reversed the entire cycle of operation is also reversed, but in mode continues as before. As will be seen, the receiving medium

r of the reinforcer is connected with the main circuit by a bridge connection D, extending from the point 5 on conductor H to the point 6 on conductor H², a condenser *o* being included in said bridge. The transmitting-electrodes *t* of the reinforcing apparatus are in a local repeating-circuit O, which also includes the battery *z* and the two parts P P² of the primary winding of the electrically-divided transmitter induction-coil I, all in series. This local circuit is easily traceable from one pole of battery *z* to the other by way of conductor 20 to terminal 7 of induction-coil I, through the half-primary P, the second half P² thereof, terminal 8 of said induction-coil, conductor 21, transmitting medium *t*, and conductor 22. The secondary winding of the coil I is electrically divided, as shown, into four substantially equal parts *w*, *w*², *w*³, and *w*⁴, so that one-half thereof shall be in each of the two main conductors H H² and so also that the portion assigned to each main conductor shall be half in the circuit-section A on one side of the bridge connection D and half in the circuit-section B on the other side of said bridge connection. It is to be further noted that the consecutive arrangement of these electrically-separated parts of the secondary winding is such that they will act at all times in the main circuit coöperatively. Thus though all of the quarter-windings may be wound over the common core with helices of like direction the working current, it is obvious, will at any instant be of opposed direction in the two main conductors, as indicated by the arrows. For this reason the coil and main-line connections, which, with the quarter-windings *w* and *w*², are made at their outer terminals 1 and 2, are with the remaining quarter-windings *w*³ and *w*⁴ made at the inner terminals 3 and 4, respectively. Although thus shown in the diagram as a divided induction-coil, it is to be understood that this is indicative of the electrical arrangement only and that the entire coil may conveniently be formed as a single and complete appliance, as shown in Fig. 5. The coil I, represented in this figure, has a substantially circular and closed-circuit iron core K, upon which the primary is wound in coöperative serial half-sections P P² over the two halves of the core, respectively, while two of the several quarter-secondaries *w* *w*³ are wound over one half of the core and the remaining two, *w*² and *w*⁴, over the other. The terminals of this coil 1, 2, 3, 4, 5, 6, 7, and 8 correspond with those of the diagram in Fig. 1, the numerals 7 and 8 representing the terminals of the complete primaries, 1 and 2 representing the outer terminals of the quarter-windings *w* and *w*², 3 and 4 the inner terminals of quarter-windings *w*³ and *w*⁴, and 5 and 6 the joined remaining terminals of *w* *w*² and *w*³ and *w*⁴, respectively, and also the points of attachment of the bridge connection D.

It does not appear that Fig. 6 requires any

extended description. The figure shows the complete reinforcing apparatus R, the same being substantially similar in essential respects to that described in my pending application, previously mentioned as bearing Serial No. 215,811 and as having been filed on July 8, 1904. In this apparatus, mounted on a suitable base X, t is the transmitting medium, consisting of the usual hollow button with front and rear contact-transmitting electrodes and granular carbon held between them, the back electrode being rigid and supported in a metal block connected with a scored heat-radiating mass J, while the forward electrode is attached to an edge-clamped mica disk and has fastened to its center the small vibratory iron core m^3 . A field-magnet M, with its polar extension m , a fixed iron core m^2 , secured thereto, the coil v , and the said vibratory core m^3 collectively constitute the receiving medium r , and the vibratory motion exercised upon the transmitting medium through the varying attractions brought to bear upon the vibratory core m^3 by the variations of magnetism developed under the varying voice-currents circulating in the coil produce the amplification of the working current desired for the second or receiving part of the line.

Referring again to Fig. 1, the two main conductors H H^2 of the circuit L are at their terminals provided with telegraphic earth-circuit extensions. The main conductor H, in addition to serving as one side of the metallic telephone-circuit L, constitutes the line of a grounded telegraphic circuit whose terminal branches n n^2 at W W^2 , respectively, are grounded at E E^2 and include suitable telegraph instruments T T^2 . Similarly, line H^2 has terminal earth branches j j^2 , which contain telegraph instruments T³ T⁴. This is a usual arrangement for long-distance-telephone lines.

To the end that the reinforcing telephone apparatus R shall not be disturbed or interfered with by any trespassing currents, and particularly by the emissions and intermissions of the currents concerned in the operation of either telegraph-line, I not only include the condenser o , as already stated, but also remove the actuating-coil of the reinforcing-apparatus receiving medium r from direct conductive association with the bridge connection D, placing it in the secondary circuit of a repeating induction-coil C of small mutual inductance, whose primary winding, peculiarly arranged, is placed in the bridge connection.

As clearly shown in Figs. 1 and 2, the repeating induction-coil C consists of an iron core k , over which are wound two helices. One of these—that which under ordinary conditions acts as the primary winding—is wound in two differential or magnetically-opposing like portions p and p^2 over the two halves or substantially equal or similar portions of the core k

and is so associated with the bridge connection D as to sustain such required magnetically-opposed relation. The other winding, s , serving as the secondary, is also wound in two portions associated with the two portions of the primary, respectively, and although correspondingly wound or connected, so as to be apparently also differential, are obviously thus arranged so that the current at any moment induced in its two parts shall not be of opposing direction, but shall in the circuit be of coinciding direction and adapted to exercise coöperative and complementary magnetic effects. The secondary half-windings are connected serially in a short circuit x , which also includes the magnet-coil of the receiving medium, and a condenser o^2 , the said condenser, together with the bridge-connection condenser o , aiding in the general result of preventing the adverse operation of trespassing currents and also acting to sharpen the quality of the retransmission. It is found that the repeating induction-coil C, constructed and connected in this manner, has a very low efficiency to the currents of the telegraphic circuits, which are of relatively low frequency, while at the same time its efficiency in respect to the high-frequency telephonic currents is reduced, but to a very slight extent. This has been experimentally ascertained and is assumed to be attributable to the different action of the two classes of current upon the core. The telegraphic current impulses are sufficiently slow to permit the core to act as a whole, and, as a consequence, being acted upon in its two halves simultaneously and oppositely it remains, so far as the said telegraphic currents are concerned, null or in a practically zero magnetic state; but with the incomparably quicker telephonic current impulses each portion of the core is acted upon individually or independently and by its own portion of the coil alone and is thereby enabled to act effectively, in association with the primary-coil portions, upon the corresponding portions of the secondary winding, developing vigorous operating pulsations in the secondary as a whole and in the receiving medium coil with which the said secondary is connected in the local circuit x .

In Fig. 2 the reference characters indicating the circuit - terminals correspond with those of the diagram Fig. 1. Thus 9 and 12 are the terminals of the primary winding to be attached to the conductors of the bridge D, while 17 and 10, the remaining terminals of the two portions p and p^2 thereof, are to be joined to one another. In the same way 13 and 16 are the ultimate terminals of the secondary winding, while 14 and 15 are the remaining terminals of its two portions s s^2 , and these are joined together.

In coils of the form of Fig. 2 which have been actually operated as described herein good results have been attained when the two

windings have been wound with the same number of turns, but with insulated copper wire of slightly different size, so that the resistance of both, though the turns of the outer winding are larger, shall be the same. Thus it has been found to work well with the inner or primary winding in direct conductive circuit with the bridge-conductors formed of one thousand turns of No. 28 copper wire, the outer or secondary winding having likewise one thousand turns, but of No. 27 copper wire, the resistance of each winding under such conditions being 22.5 ohms.

While the repeating induction-coil C shaped generally as shown in Fig. 2 and as thus far described, is satisfactory and is contributive toward good results, toroidal or ring-formed cores are by no means essential; nor, indeed, is it necessary that the core shall constitute a complete magnetic circuit.

The forms of coil illustrated by Figs. 3 and 4 may, if desired, be alternately employed. In Fig. 3 the iron core k^3 , though magnetically continuous, is ovoid in form, one half of the primary and secondary conductors wound together in a spool q being arranged to surround one side of the core, while the remaining halves in the spool q^2 similarly encircle the other half of said core. In Fig. 4 the core k^3 is bar-formed or cylindrical, and the joint halves of the two windings composing the spools q q^2 are wound over separate end portions of said core. The several coil-terminals in both Figs. 3 and 4 are indicated by reference characters corresponding to those which indicate the coil-terminals of the form shown in Fig. 2.

Having now fully described the invention, the features and combinations claimed as new are—

1. In a system for the reinforcement or renewal of telephone-currents, the combination of a main telephone-circuit; and a relay apparatus associated therewith comprising a receiving-magnet and transmitting-electrodes actuated thereby, to receive telephonic impulses from one circuit or part circuit and to amplify and retransmit said impulses in another circuit or part circuit; with an induction-coil of small mutual inductance interposed between said main circuit and relay apparatus, one winding of said induction-coil being bridged or branched between the main-circuit conductors, and the other joined up in circuit with the receiving medium of said relay apparatus; substantially as set forth.

2. The combination of a main telephone-circuit; and a relay or reinforcing apparatus associated therewith and comprising a receiving medium, and transmitting-electrodes actuated thereby; with a repeating induction-coil interposed between said main circuit and reinforcing apparatus, having its primary winding wound or connected over the core in two differential or magnetically-opposing equal por-

tions bridged between the main-circuit conductors and its secondary winding connected up in circuit with the receiving medium of said reinforcing apparatus; substantially as specified.

3. The combination of a main telephone-circuit; and a reinforcing or relay apparatus associated therewith and comprising a receiving-magnet and transmitting-electrodes actuated thereby; with a repeating induction-coil interposed between said main circuit and reinforcing apparatus, having its windings divided electrically into two substantially equal portions disposed differentially over the common iron core, the primary winding being bridged between the main-circuit conductors, and the secondary winding being connected in serial circuit with the receiving medium of said reinforcing apparatus; substantially as specified.

4. The combination of a main telephone-circuit; and a relay or reinforcing apparatus associated therewith and comprising a receiving medium and transmitting-electrodes actuated thereby; with a repeating induction-coil interposed between said main circuit and reinforcing apparatus, and consisting of an iron core having a primary winding in two substantially equal magnetically opposing portions wound over different portions of said core, and a secondary winding correspondingly disposed; the said primary winding being connected in bridge between the main-circuit conductors, and the said secondary winding in circuit with said reinforcing-apparatus receiving medium; substantially as specified.

5. In a system of composite telephony and telegraphy the combination substantially as hereinbefore described of a metallic main telephone-circuit whose two conductors severally constitute telegraphic circuits; and a telephonic relay apparatus associated therewith and comprising a receiving-magnet and transmitting-electrodes; of a repeating induction-coil interposed between said main circuit and relay apparatus, and having its primary and secondary windings joined up in circuit with a bridge between the conductors of said main circuit, and with the receiving-magnet of said relay apparatus respectively, the said primary winding being formed in halves wound or connected differentially or opposingly over corresponding halves of the core; and the said secondary winding being correspondingly wound or connected so that the currents induced in its separate portions shall be of coincident and coöperative direction; substantially as set forth.

6. In a telephone-current-reinforcing system, the combination of a main telephone-circuit; a bridge connection including a condenser between the conductors thereof; a relay apparatus comprising a receiving-magnet, and transmitting - electrodes operated thereby; a local circuit containing the winding of said receiving-magnet and a second condenser; and

a repeating induction-coil interposed between said main circuit and relay apparatus, having a primary winding in two equal divisions wound or connected differentially or in opposition over corresponding halves of a magnetic core, and a secondary winding correspondingly wound or connected, the said primary and secondary windings being connected in the said bridge and receiving-magnet local circuit respectively; substantially as described.

7. In a system of composite telephony and telegraphy, the combination of the two conductors of a metallic main telephone-circuit severally constituting telegraphic circuits; a bridge connection including a condenser extending between said conductors; a relay apparatus for the telephone-circuit comprising a receiving-magnet and transmitting-electrodes actuated thereby; a local circuit containing the winding of said receiving-magnet and a second condenser; and a repeating induction-coil interposed between said main circuit and relay apparatus, having a primary winding of substantially equal opposing helices wound over corresponding halves of the iron core, and a correspondingly-disposed secondary winding also wound over said core, the said primary winding being joined up in said bridge connection, and the secondary winding in the said receiving-magnet local circuit; substantially as set forth.

8. In a telephone-current-reinforcing system, the combination of a main telephone-circuit; a bridge connection including a condenser extending between the conductors of said circuit, and dividing the same into two sections; a relay apparatus comprising a receiving-magnet, and transmitting-electrodes operated thereby adapted to receive telephonic impulses from either circuit-section and to amplify and retransmit them over the other; a

local receiving-circuit for said relay apparatus containing the winding of said receiving-magnet and a second condenser; a local transmitting-circuit for said relay apparatus including a battery and said transmitting-electrodes; a repeating induction-coil having its primary wound or connected in opposing half-windings over corresponding portions of its core and included in said bridge connection, and its secondary formed in corresponding half-windings coöperatively connected in the said local receiving-circuit; and a retransmitting induction-coil having a continuous primary winding included in the said local transmitting-circuit, and a secondary divided electrically into four similar sections connected coöperatively in the said main circuit, one in each of the two conductors thereof on both sides of said bridge connection; substantially as described.

9. The combination with two telephone-circuits; and a repeating induction-coil consisting of an iron core, a primary winding wound in two substantially equal differential or electromagnetically opposing portions over corresponding halves of said core, and a secondary winding in two like equal portions correspondingly wound or connected; the said primary being in conductive relation with both telephone-circuits to prevent the inductive passage between said circuits of low-frequency trespassing currents while freely permitting the inductive passage of the high-frequency telephone-currents; substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 25th day of February, 1905.

HERBERT E. SHREEVE.

Witnesses:

GEO. WILLIS PIERCE,
JOSEPH A. GATELY.