

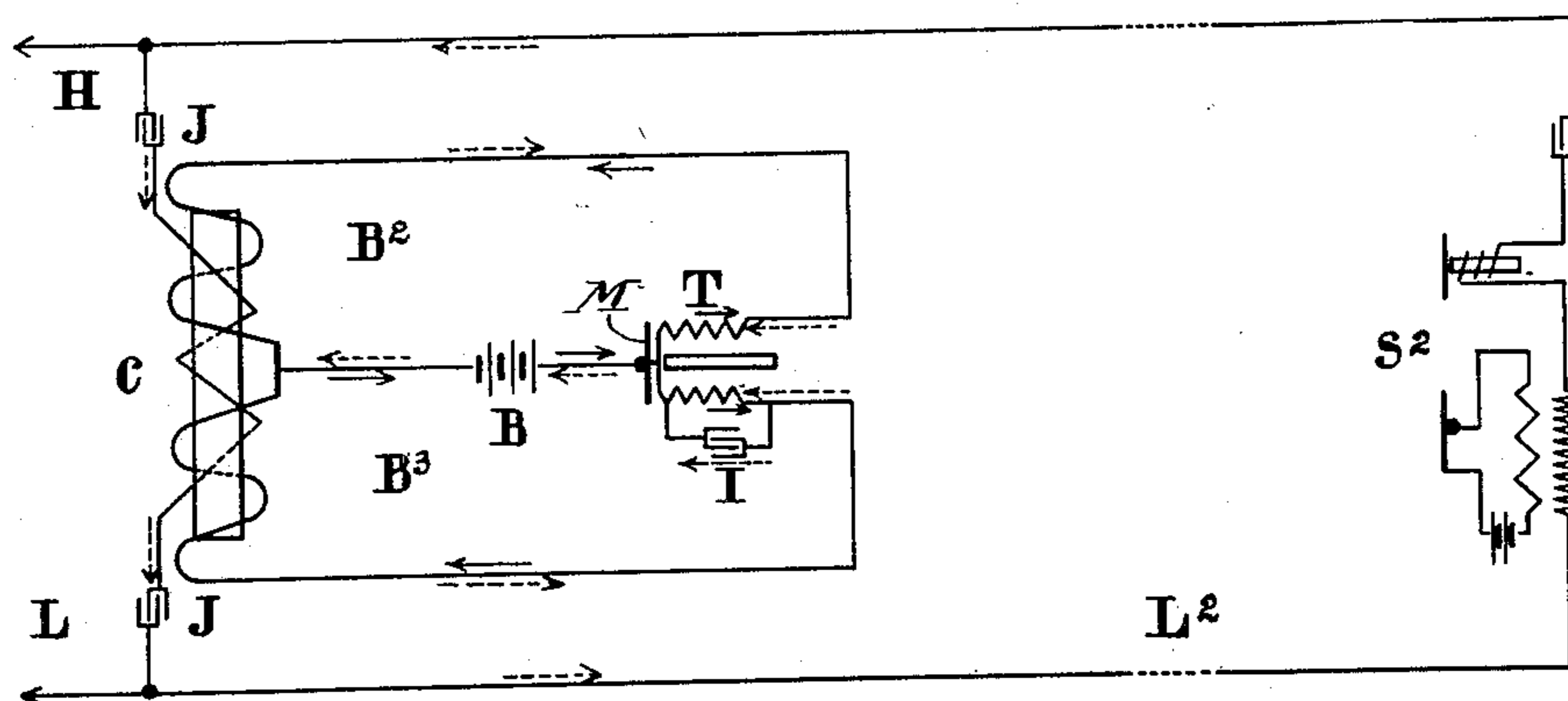
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N. G. WARTH.

TELEPHONIC CURRENT REINFORCER OR REPEATER SYSTEM.

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UNITED STATES PATENT OFFICE.

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TELEPHONIC-CURRENT REINFORCER OR REPEATER SYSTEM.

No. 845,282.

Specification of Letters Patent.

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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 certain new and useful Improvements in Telephonic-Current Reinforcer or Repeater Systems; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to improvements in telephone-current repeaters or relay-reinforcers of the general character illustrated in the following patents, to wit: Nos. 542,657 and 542,658 to Richards, Nos. 542,618, 542,619, and 542,913 to Arnold, and Nos. 791,655 and 791,656 to Shreeve.

This invention has for its chief objects the provision of a thoroughly practicable repeater system for use in connection with repeater apparatus in which the receiving element is locally maintained in a positive balance or neutral state regardless of any unbalanced condition in the line-circuit or sections of circuit connected.

By my present arrangement the receiver is made sensitive or responsive to the inducing-currents from the lines, but irresponsive and insensitive to its own transmitter currents or effects. I provide apparatus and circuit arrangement whereby the reproduced retransmitted currents are maintained in practically a distortionless form and not interfered with, confused, or mutilated by the originating currents reacting upon the repeater nor penetrating injuriously into the receiving side of the system, and, further, a simplified apparatus and circuit system of a preferred form in which the receiver and transmitter elements of the repeater proper are included in a combination local or primary circuit, and also apparatus and circuit arrangements in connection with the aforesaid conditions to effect a flexible use of the same telephonically and to also enable signals and telegraphic or composite service to be operated over the same wires without mutual interference as freely as is usual with no repeater in the circuit.

All automatic or electromechanical reciprocal telephone-repeaters adapted to retransmit with renewed energy an attenuated voice-current have heretofore, when at all practical or commercial, been extremely

delicate and very sensitive to line troubles or imperfect conditions of circuit, apparatus, and currents not in good balance. Hence with the apparatus heretofore in use great care has been necessary in the selection of well-balanced induction-coils and repeating-coils to secure perfect balancing of current effects in the location, installation, and handling of the same, and particularly as to the condition and handling of the circuits there-to connected. Each wire of the pair has had to be balanced with its mate and each circuit or section of the circuit with its other side. These conditions have been so exacting that to prevent the apparatus from setting up the local action which causes what is commonly called "howling" the American Telephone and Telegraph Company, now utilizing the only practicable telephone-repeater apparatus, has found it necessary to install the repeaters midway in or between long sections of circuit at stations, which if not midway the circuits or sections of same have had to be balanced artificially or specially to bring about an approximate midway location or balance. The apparatus has thus been applied specially to a given circuit arranged to meet these peculiar and more or less difficult conditions.

The confusing interfering reacting effects referred to above and which cause distorted or mutilated retransmission, and which it is one of my chief objects to prevent, are the actions upon the receiver of the repeater produced by the counter-currents set up by electromagnetic coils in the preceding forms of telephonic repeaters, which coils are either directly in the line-circuit at the repeater-station or are coils otherwise associated with the repeater apparatus which are energized by the original currents simultaneously with the repeater-receiver, and which, in discharging electromagnetically, create counter or reactive currents similar in form to but out of phase with the original currents. In general these detrimental, echo-like, extra, or reaction currents are neither in the direction nor in time or step with the retransmitted currents and in proportion to their strength have power to oppose, and thus to reduce or to improperly accentuate or to blur the retransmitted or renewed currents, resulting in a degraded transmission. When the original currents are transmitted across the repeater into the associated line-circuit or section of line-cir-

cuit; or such reaction currents are set up even in the local repeater-circuit and can strongly react upon the repeater, imperfect and lower transmitting efficiency is the result.

The local action which causes howling, referred to above, is also inherent in all previous forms of telephonic repeaters, for the reason that the receiver element has always heretofore been associated with or connected in the line-circuit or section of line-circuit in such manner as to upset the "balance" created in or for the receiver coil or coils, which balance is designed to prevent the receiver from responding to its own transmitter or retransmitted currents. Such a balanced or neutral condition of the receiver to its own repeater action must be essentially positive, and should not be dependent for normal action upon the nice or exacting electrical conditions of circuit hereinbefore mentioned, where, should the line become "grounded," "short-circuited," "crossed" with another circuit, or otherwise "unbalanced," even when the repeater is placed in a midway location or balance on the through-circuit, the repeater will set up the local "howl," producing interfering effect. In the later forms of repeaters or repeater systems, or those in which neutralizing effects have been attempted, this condition also has not been overcome, and any "line trouble" or unbalanced condition which ordinarily would not cause the line to be withdrawn from service causes the repeaters to become "noisy" and necessitates their disconnection from the line until it is restored to its previous good condition.

An unbalanced line or line-section causes an unequal flow of the differential equalizing repeated currents from the line-circuits through the coils operating the receiver-transmitter, letting the current in one direction through the controlling-coils affect the receiver to operate it, which in turn actuates the transmitter in its normal manner, sending out an impulse to the line-circuit, and this impulse, due to the unbalanced condition, reacts upon the system, setting up a continuous vibrant musical tone having the fundamental pitch of the armature whether the latter be in the form of a diaphragm or in the form of a plunger, or otherwise.

In describing this invention reference will be had to the drawing which accompanies and forms a part of this specification. Said drawing is a diagrammatic representation of my repeater for securing the improved results hereinbefore described, the repeater being shown in simple bridged relation to a through-circuit, and the receiver-transmitter elements and associated auxiliary apparatus included, together with the primary of the repeating induction-coil contained in the bridge in a combination primary circuit.

The drawing shows my preferred arrangement. It can be installed for use in connection with ordinary switchboard service irrespective of lengths of circuit or circuit-sections connected for repeater purposes and regardless of line-balances with reference to their affecting the repeater or the repeater affecting them in an adverse manner. It will be understood that modifications or equivalents of this form of the system and apparatus arrangements can be made without departing from the scope and intent of this invention. In this preferred arrangement the line-wires are devoid of coils, being connected straight through, thus providing a clear and unobstructed circuit for "composited" or "phantomed" currents, as well as for the talking-currents, the bridged connection H, with its induction-coil C secondary, (and condensers J when necessary for composite work,) being the medium for receiving from and transmitting to the line-circuit the telephonic or talking currents. The primary of the line-induction coil C is split or divided and is coöperatively connected into the split primary circuit B² B³ containing the battery B, transmitter M, receiver T, and condenser I, which latter is connected around one coil of the receiver. The receiver element has two windings that are differently acted upon by the battery-current, which flows simultaneously through them and produces a neutral magnetic state. As the flow of current from the half B³ of the induction-coil C primary is caused to return through the battery B branch or leg of the primary circuit the receiver would also be neutral to the incoming alternating currents from the line. Hence I shunt the receiver-coil, say, on the side B³, with the condenser I to preserve its sensitivity to these currents.

The action or operation is indicated conventionally by the arrows, which show the flow of both the primary and the secondary currents, the former by the solid and the latter by the broken arrows. A current pulsation from originating-station S² arriving at the bridge H with its low-impedance secondary coil C is practically all shunted through the bridge and acting inductively upon the primary windings cause a current-flow therein which is divided or split at the junction of the split primary coil, and the half B² of the current energizes its winding of the receiver, the other receiver-coil remaining unenergized. The incoming or induced currents from the line operate the receiver T. These currents, being set up in the two primary halves of the induction-coil C, are caused to flow coöperatively from the junction with the battery B, branch outwardly to and through the two outside legs of the local circuit (see the broken arrows) to and through the B² side of winding receiver T and through the condenser I on the B³ side of the

receiver T, respectively, combining at the juncture with the transmitter M, thence flowing through said transmitter, battery B, and the battery B branch of the circuit back to the aforesaid junction of the split primary winding with the battery B branch, thus completing the circuits and compelling the operation of receiver T by the energized coil on the B² side. The operation of the receiver element T actuates the transmitter element M to vary its resistance and set up the consequent primary current effects from battery B in the two halves B² B³ of the primary circuit. As the flow of this battery-current is differential or opposed through the two windings of the receiver element T (see the solid arrows) and coöperative in the primary windings of the repeating-coil C, the current divides at the junction-points, as it did in the case of the receiving-current described above, the actions being similar except that both coils of the receiver element T are energized by this current. Hence the receiver element T is neutral or inactive, and the primary of coil C is active, as in the other case, and transforms the reproduced reinforced currents which are transmitted both ways on the line-circuit from the secondary of coil C in the bridge. By reason of my elimination of coils from the line-circuit proper in this arrangement very clear and desirable conditions of circuit with repeater service are provided for the talking-currents, as well as for the various forms of "composite," "simplex," and "phantom-circuit" transmission. No interfering reactive-current effects are set up, as there is in circuit only the line-repeating induction-coil, and this is in the bridge. With very long circuits should any of the original currents penetrate beyond the repeater into the receiving side of the circuit they are of insufficient power to reach the distant station or receiver. The coil C because it acts without creating a lagging-current cannot produce any reacting interference with the retransmitted currents.

My invention as embodied in the above-described arrangement is so adaptable to general service conditions that it may be installed not only in fixed relation to a circuit, as is the present practice for extending the distance or power of transmission, but may be installed to be utilized or operated by the line-operators to great advantage and in a very flexible way with reference to various circuit conditions desirable to be connected together for repeater service and will relieve the operators from taking and repeating messages, as is frequently done. The retransmission will have greater purity and volume than heretofore, as the full action of the repeated currents will pass to the lines, because there is no balancing apparatus or artificial circuit conditions nor line-coils to absorb a portion of the renewed currents.

In the above-described apparatus I prefer to employ in connection with the receiving element of the repeater a permanent magnet for creating its residual or initial magnetic field for sensitization.

It will be appreciated from the foregoing description that the primary or repeating transmitter-currents operate at all times and under all conditions of line-balance to create a neutralizing or unresponsive local effect upon the repeating-receiver, the repeater apparatus operating to reproduce only such transforming-current effects as may be flowing in the line-circuit, and thus in turn causing the transmitter to furnish reinforced currents of such effects only, and thereby preventing local action or howling and reactive effects upon the repeater from reinduced or out-of-phase currents.

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

1. A telephone repeater system comprising two lines, or two sections forming a through-circuit, and their terminal telephones, an induction-coil joining said lines or sections at an intermediate point with a telephone-repeater, said repeater embodying a telephonic receiver and transmitter in repeater relation; the juncture between the circuit and the repeater being wholly inductive and operative for both the received currents and the reproduced currents, and connected in bridged relation to the through-circuit; the secondary being bridged in the circuit and the primary being connected in the repeater auxiliary circuit, said auxiliary circuit being divided and also containing a battery, the receiver-transmitter, and means for rendering the receiver inert to its transmitter-currents and sensitive to the received currents from the line.

2. The combination in a relay for telephone-currents, of a receiver and transmitter in relay relation, a battery for supplying the relaying-currents, means for rendering the receiver operative only by the induced currents from the line, all in inductive bridged relation to the line, said inductive relation being common for the receiving and transmitting currents, and means to prevent reactive currents from affecting the repeater.

3. In a telephone repeater system, a repeater apparatus, a main-line circuit connected through without repeating or induction coils being included therein for the repeater, a bridge across said line, an induction-coil in said bridge, the repeater being connected to the line by means of the secondary of the induction-coil, the repeater receiving and transmitting elements being in circuit with the primary of said coil.

4. In a telephone-repeater, twin local circuits embracing a current-supply, and a transmitter in repeater relation to a receiver, together with means for operating the re-

ceiver from and the transmitter to the line inductively.

5. In a telephone-repeater, a primary or local circuit including the following elements, to wit: the primary of an induction-coil, a source of current, and a transmitter and a receiver, in repeater relation.

6. The combination in a telephone repeater system of two lines or line-sections terminating at the repeater-station, transmitting and receiving telephones in the circuit at the transmitting and receiving stations on said lines, a bridge across the line at the repeater-terminals, an induction-coil winding in said bridge, a condenser included in the bridge with said winding, the primary windings of said induction-coil differentially wound, a split combination local and primary circuit for said primary windings, the third or middle branch of said circuit connected to the center of the winding, a battery and the transmitter included in the middle branch or conductor, a split wound receiver in the circuit, with its middle terminals connected to the middle conductor and with its two remaining terminals connected one each to the two remaining conductors of the combination circuit to complete the same, a condenser connected around one of the two receiver-windings to act as a shunt to same for the received impulses, the battery impulses flowing through the receiver-windings in opposition to effect neutrality in said receiver to said battery impulses, the split battery-current flowing coöperatively in the two halves of the primary of the induction-coil and inducing the renewed impulses into the secondary circuit, the transmitter being in such mechanical relation to the receiver as to be actuated thereby.

7. In a telephone system, a repeater, a long-distance metallic circuit with no retarding apparatus, such as repeating or induction coils in such circuit, but having a bridge or connection between the two wires of said circuit inductively associated with the repeater, said bridge containing a winding of an induction-coil, and said bridge and winding serving as the means for receiving from and transmitting to said line the currents relayed or received and the reproduced retransmitted currents respectively from the repeater connected inductively therewith.

8. In a telephone repeater system, the combination of the two main telephone-circuits or two sections of a circuit, an associated local repeater-circuit inductively connected with the said main circuits or circuit-sections, a receiving electromagnet in said local circuit, together with a source of current and a variable-resistance medium controlled by the electromagnet, means for rendering the electromagnet insensitive to the retransmitting-currents, and an induction-coil connected between the local and main

circuits constituting the medium for receiving from and sending to the line-circuits both the weak incoming and the reinforced outgoing currents respectively, substantially as described.

9. In a telephone repeater system containing two sections of transmitting-line, an instrument-circuit local thereto and at an intermediate station thereon, means within said local circuit for establishing an electrical balance for the repeater independent of the line balance and for the purpose of preventing the creation of reactive effects that disturb the transmission or distort the form of the originating current, said means constituting a part of said instrument-circuit and connected with the transmitting-line, and an induction-coil apparatus in said connection, said induction-coil apparatus being common to both sections of the line.

10. In a telephone repeater system, a combined receiver-transmitter repeating apparatus, a main circuit with transmitting and receiving apparatus at distant points requiring reinforcing operating-currents at a repeating-station, a repeating local circuit inductively connected with said main circuit and containing a source of current and the circuits of the combined receiver-transmitter repeating apparatus.

11. In a telephone-repeater, a twin local circuit containing current-supply, receiving and transmitting elements in repeater relation, together with common means adapted to inductively operate with the line for both the received and retransmitted currents.

12. In a telephone repeater system, a line inductively connected with a repeater in a local repeater-circuit, a receiver and transmitter in repeater relation, means for preventing said receiver from being responsive to its actuated transmitter effects, common means for the received and retransmitted currents to be relayed from and to the line respectively, means for energizing the transmitter, together with means for avoiding reacting or blurring efforts in the renewed currents.

13. The combination of a main telephone-circuit, and a reinforcing or relay apparatus associated therewith, said relay comprising a receiver and a transmitter in repeater relation, the receiver adapted to be acted on differentially, a repeating induction-coil interposed between said main circuit and reinforcing apparatus, said coil having its secondary winding in operative connection to the main circuit and its primary winding being split and the two halves differentially wound with reference to each other and connected in circuit with both the receiver and transmitter elements, together with the battery for energizing the transmitter, the receiver element having two windings through which the battery-current flows differentially

to produce neutrality of the receiver to the transmitter variations in the local circuit, the receiver element having one winding shunted with a condenser to render it sensitive to the
5 received impulses, and all the currents flowing through the split primary of the repeating induction-coil coöperatively and said coil acting to transmit inductively both the incoming and outgoing currents for the relay.
10 14. A telephone repeater system embodying secondary and primary portions, the secondary portion consisting of the line-circuit having a bridged connection, a repeating induction-coil, the bridged connection including the secondary of the repeating induction-
15 coil, and a condenser, the primary portion of

said system consisting of the primary of the induction-coil in local circuit with a battery, a repeater receiver-transmitter, and means to render the system sensitive to induced re- 20 ceived currents from the line but insensitive to its local self-action, the inductive effects between the repeater and the line-circuit being wholly transmitted through the said repeating induction-coil.

In testimony whereof I affix my signature
25 in presence of two witnesses.

NATHANIEL G. WARTH.

Witnesses:

SAMUEL W. LATHAM,
ALICE B. COOK.