C. A. KRUCKOW.

TELEPHONE REPEATER CIRCUIT.

APPLICATION FILED JUNE 10, 1907.

990,365.

Patented Apr. 25, 1911.

Fig. 1.

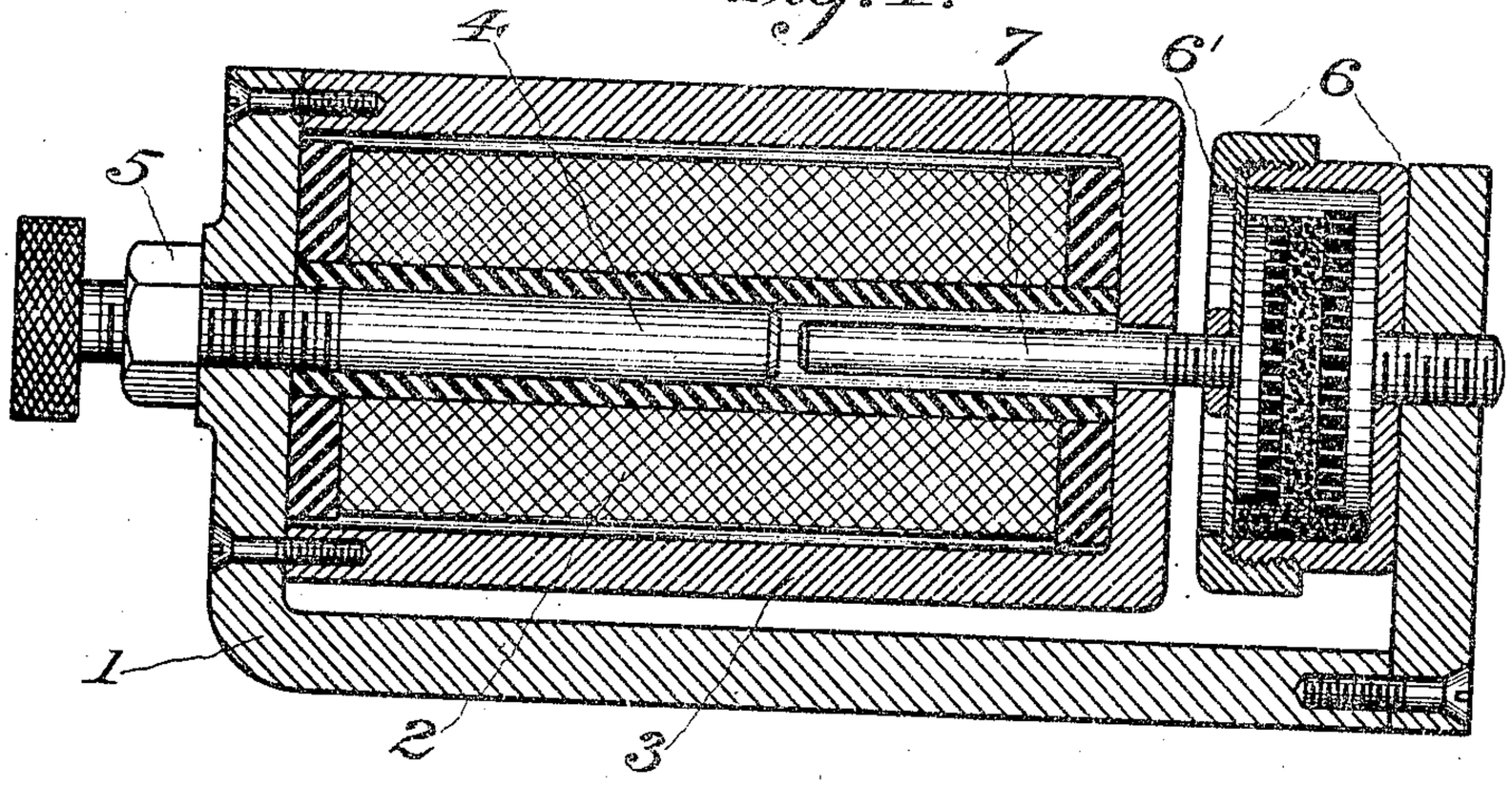
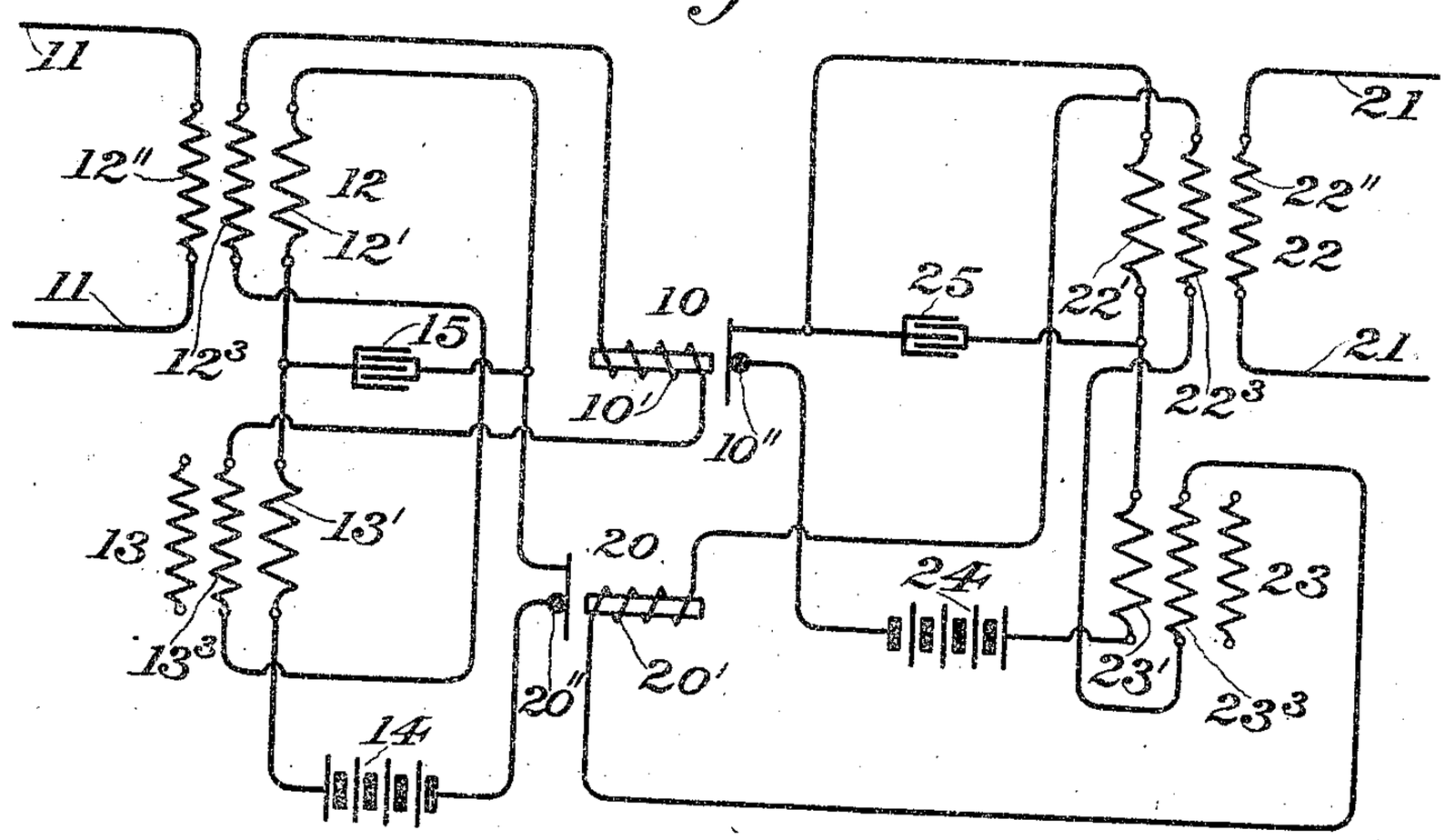


Fig. 2.



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UNITED STATES PATENT OFFICE.

CARL AUGUST KRUCKOW, OF HALLE-ON-THE-SAALE, GERMANY, ASSIGNOR OF ONE-HALF TO McMEEN & MILLER, OF CHICAGO, ILLINOIS, A COPARTNERSHIP.

TELEPHONE REPEATER-CIRCUIT.

990,365. Specification of Letters Patent. Patented Apr. 25, 1911.

Application filed June 10, 1907. Serial No. 378,231.

To all whom it may concern:

Be it known that I, CARL AUGUST KRUCKOW, a subject of the Emperor of Germany, residing at Halle-on-the-Saale, Germany, have invented a new and useful Improvement in Telephone Repeater-Circuits, of which the following is a specification.

My invention pertains to circuits for telephone repeaters, rather than to any mechanical devices which have been designed or which may be designed, the mechanical requirements for my circuit consisting of (first) a mechanism adapted on its receiving side to accept speech currents, and adapted on its transmitting side to vary a resistance in response to the accepted speech currents, and (second) an aggregation of induction coils, condensers and batteries of ordinary types of apparatus or of such specialized types as may be readily appreciated from the following description.

The repeater installations hitherto known for long distance lines suffer from defects chiefly as follows: 1. They disturb the balance in the two branches of the line. 2. The alternating currents generated by the repeater distribute themselves equally in both directions upon the long distance lines connected for the purpose of transmission. 3. The talking currents generated by the microphone of the first station may pass over the whole circuit to the second station; the currents generated by the repeater superimpose themselves upon the former ones and thus produce difference of phase and similar disturbances.

In the installation presented by Shreeve in United States Patent 791,656, June 6, 1905, the first defect has been eliminated, but the two others remain. The speech currents coming from either station may pass over the whole circuit to the other station and have superimposed upon them the currents generated by the repeater. In the system proposed by me, I believe I have overcome all these defects.

This description is accompanied by two figures, of which—

Figure 1 shows in rather diagrammatic form the mechanical repeating device disclosed by Shreeve in United States Patent 791,655, June 6, 1905, and Fig. 2 shows my improved repeater circuits utilizing two of the devices of Fig. 1.

It is of course understood that the device of Shreeve is shown in Fig. 1 and is referred to in Fig. 2 because it is adapted to the requirements of my circuits, but not because my circuits involve any requirements limiting them solely to the Shreeve device.

In Fig. 1, 1 is a permanent magnet; 2 is a helix of wire wound upon a spool and supported upon the magnet 1 by the case 3 which is attached by screws passing through the magnet. The helix 3 is wound upon the hollow non-magnetic core and an extension pole piece 4, attached adjustably to the magnet 1 by screw threads and provided with the lock nut 5, forms a terminal for the magnet 1 lying within the helix 2 and approximately near the center of the helix. Upon the other end of the magnet 1 is supported the granular carbon cell 6, the diaphragm 6′ of this cell carries an electrode to which is attached a soft iron rod 7 which extends into the tubular core of the helix 2 and which approaches the pole piece 4. The part 7 is mechanically free from the core or shell of the helix 2 but is under the considerable magnetic pull from the pole piece 4, due to the permanent magnetism of the magnet 1. This magnetic pull places a tension upon the diaphragm 6′. In placing the device in operation the incoming line circuit is connected with the helix 2 and the carbon cell 6 is connected in series with a battery and an induction coil primary, the induction coil secondary being taken to the line upon which the repeater currents are to be sent out. The operation is that speech waves in the helix 2 will vary the attraction between the parts 4 and 7, resulting in a movement of the part 7 and a consequent variation in resistance of the carbon cell 6, which will vary the current from the battery, flowing through the primary of the induction coil, to reproduce in the secondary currents essentially duplicating the speech currents received. This action is well understood, and I have illustrated only the mechanical device of Fig. 1.

In Fig. 2 I present my repeater circuit with two devices of Fig. 1 shown at 10 and 20 respectively. The circuit of Fig. 1 represents a line 11 which may be hereinafter referred to as the first line, and a line 21 which may be hereinafter referred to as the second line. The first line 11 is associated with an induction coil 12 having three windings, a primary 12′, a secondary 12″ and an

additonal winding or tertiary 12^3, the line 11 being connected with the winding 12″. In similar manner the second line 21 is associated with the induction coil 22 by connection with its secondary winding 22″. Two additional induction coils 13 and 23 are provided, one associated secondarily with each of the two lines. The naming of the windings 12′ 12″ 12^3 is arbitrary and some thoughts and formulæ appear in more symmetrical form when 12^3 is named the secondary and 12″ the tertiary winding, in view of the fact that 13″ and 23″ are not used and may be dispensed with, leaving 13^3 and 23^3 the true secondaries of inductoriums 13 and 23; because not involved in circuits, the third windings of those inductoriums are not labeled in the figure.

For convenience in the practical application of my circuit, I make the four induction coils mechanically alike. Batteries are shown at 14 and 24 and condensers at 15 and 25. The condensers are preferably of very small capacity, as their function is the absorption of very small oscillations and if of abnormally large capacity they exercise a harmful rather than a beneficial effect. In the repeaters 10 and 20, 10′ and 20′ are the receiving helices and 10″ 20″ are the associated carbon cells.

The inductive relations of the windings upon the induction coil cores are, as is the usual practice, assumed to be such that, with the primary current flowing downward, an increase in the primary current will induce a secondary current flowing upward in both of the other windings of the coil.

If we follow the speech currents from line 11 we shall find that the transmission proceeds from 12″ as a primary to 12^3, the induced currents of 12^3 flowing through 10′ and 13^3, thus producing in 10 a variation of the resistance of 10″ which varies the current from battery 24 through primary winding 22′, the variation in the current of 22′ producing in 22″ speech currents which are transmitted over the line 21. The circuit of Fig. 2 is symmetrical, and speech currents received from line 21 are repeated into line 11 in a manner symmetrical with the paths just traced.

In the above transmission divers local currents and potentials were generated. The originally received speech currents in 12″ produced some oscillations in the winding 12′, and the current from 12^3 through 10′ and 13^3 produce from 13^3 some oscillations in the circuit 13′. The oscillations in 12′ and 13′ oppose each other with some difference of phase, and the presence of the small condenser 15 quiets this primary circuit disturbance. The speech waves of 12″ pass therefore in comparatively pure form to the helix 10′ and are mechanically transmitted to the carbon cell 10″. Variation in the carbon cell 10″ causes fluctuations in windings 22′ and 23′ which induce potentials in 22^3 and 23^3, but inasmuch as these two windings are connected in opposition to each other, current will not flow in the circuit containing 22^3, 23^3, 20′, hence there will be no speech waves transmitted from 20′ to 20″ and the primary circuit containing elements 20″, 14, 13′, 12′ and 15 will not be disturbed by any reactionary effect attendant upon the speech currents in winding 12″ which might be likened to side tone in the ordinary telephone substation circuit. It will be seen, therefore, that all local or reactionary currents are neutralized or annulled and that speech currents received by the winding 12″ are transmitted through the linking device of induction coils, batteries and mechanical repeaters, and are transmitted to the line 21 solely and free from phase complications.

To recapitulate: I provide a repeater circuit comprising two devices of the type now generally known by the name of repeater, the two repeaters in my circuit being oppositely directed and neutrally connected each with respect to the other; this repeater circuit links together the lines or the portions or parts of the line over which transmission is to be effected. The limitation of the repeater alone without a specialized circuit lies in its adaptability to repeat or transmit in one direction only. The special circuit of my device provides a separate repeater for repeating in each direction and provides neutralizing means whereby the repeater not active is restrained from deleterious effect upon the operating elements of the system.

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

1. In a telephone repeater circuit, a symmetrical inductive link each half of said link comprising the following elements:—two induction coils; a circuit containing in series a winding of each of said induction coils, a battery, and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing in series a winding of each of said induction coils and an inductive helix controlling the variable resistance of the other half.

2. In a telephone repeater circuit, a symmetrical inductive link having two repeating devices, each half of said link comprising the following elements:—two induction coils; a circuit containing in series a winding of each of said induction coils, a battery and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing in series a winding of each of said induction coils and an inductive helix controlling the variable resistance of the other half.

3. In a telephone repeater circuit, a symmetrical inductive link each half of which comprises the following elements:—two induction coils; a circuit containing in series a primary winding of each of said induction coils, a battery, and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing in series a winding of each of said induction coils and an inductive helix controlling the variable resistance of the other half, said winding being connected in opposition with reference to potentials resulting from currents from said battery.

4. In a telephone repeater circuit, a symmetrical inductive link having two repeaters and each half of which comprises the following elements: two induction coils; a circuit containing in series a primary winding of each of said induction coils, a battery, and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing in series a winding of each of said induction coils and an inductive helix controlling the variable resistance of the other half, said winding being connected in opposition with reference to potentials resulting from currents from said battery.

5. In a telephone repeater circuit, a symmetrical inductive link having two repeaters and each half of which comprises the following elements: two induction coils; a circuit containing in series a primary winding of each of said induction coils, a battery, and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing in series a winding of each of said induction coils and an inductive helix controlling the variable resistance of the other half, said windings being connected in opposition with reference to potentials resulting from currents from said battery; and a line circuit of two parts, each part directly connected to the terminals of a third winding of one of the induction coils of each of said halves, respectively.

6. In a telephone repeater circuit, a symmetrical inductive link having two repeaters and each half of which comprises the following elements: two induction coils; a circuit containing in series a primary winding of each of said induction coils, a battery, and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing in series a winding of each of said induction coils and an inductive helix controlling the variable resistance of the other half, said winding being connected in opposition with reference to potentials resulting from currents from said battery; a line circuit directly connected to the terminals of a third winding of one of the induction coils; and a condenser connected as a shunt around the primary winding of the last mentioned induction coil.

7. In a telephone repeater circuit, a symmetrical inductive link connecting two conductively isolated portions of a telephone line and comprising four induction coils, two of said induction coils pertaining to each line portion; two windings for one of said coils; a primary, a secondary and a tertiary winding for one of said coils, said secondary being connected to its line portion and said tertiary and a corresponding winding of its associated coil being connected in opposition.

8. In a telephone repeater circuit, a symmetrical inductive link connecting two conductively isolated portions of a telephone line and comprising four induction coils, two of said induction coils pertaining to each line portion; two windings for one of said coils; a primary, a secondary and a tertiary winding for one of said coils, said secondary being connected to its line portion and said tertiary and a corresponding winding of its associated coil being connected in series with each other and with a receiver helix and in opposition to each other.

9. In a telephone repeater circuit, an inductive link having an inductive receiving circuit consisting of two secondaries and a repeater helix, the two secondaries being oppositely connected with reference to their respective primaries and one of said secondaries being inductively related to a winding associated with a telephone line, and whereby speech currents generated in one of said secondaries through its inductive relation with the telephone line may flow through both of said secondaries and through the repeater helix, and whereby potentials generated in said secondaries by a current through their respective primaries will oppose and neutralize and will not result in current through the repeater helix, substantially as described.

10. In a telephone repeater circuit, a transmitting circuit containing a variable resistance, a battery and two inductive primary coils, each of said primary coils having a secondary and said two secondaries being connected in opposition and in series with a repeater receiving helix, and one of said primary coils having an additional inductive winding associated with the telephone circuit over which transmission is desired, substantially as described.

11. In a telephone repeater circuit, a transmitting circuit containing a variable resistance, a battery and two inductive primary coils; secondary coils for each of said primary coils; and upon one of said primary coils an additional secondary coil said secondary coil being connected across the line over which transmission is to be effected.

12. In a telephone repeater circuit, two parts of a line; and a symmetrical inductive link connecting the same, each half of

said symmetrical link comprising the following elements: two induction coils; a circuit containing in series a winding of each of said induction coils, a battery and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing in series a winding of each of said induction coils, and an inductive helix controlling the variable resistance of the other half.

13. In a telephone repeater circuit, two parts of a line; two repeaters and a symmetrical inductive link of two halves, each half comprising the following elements: two induction coils; a circuit containing in series a primary winding of each of said induction coils, a battery and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing in series a winding of each of said induction coils, and an inductive helix controlling the variable resistance of the other half, the windings being in opposition upon said helix

14. In a repeater circuit, an inductive link of two halves, each half containing a receiving helix and a variable resistance, the helix of one half controlling the resistance of the other; each of said halves comprising a transmitting circuit, containing the variable resistance, a battery and two primary inductive windings; an inductive winding upon one of said primaries to which the line circuit is directly connected; and a receiving circuit containing a receiving helix and the secondaries of said primary windings, said secondaries being connected in opposition.

15. In a repeater circuit, an inductive link of two halves, each half containing a receiving helix and a variable resistance, the helix of one half controlling the resistance of the other; each of said halves comprising a transmitting circuit, containing the variable resistance, a battery and two primary inductive windings; a condenser as a shunt about one of said primary windings; and a receiving circuit containing a receiving helix and the secondaries of said primary windings, said secondaries being connected in opposition.

16. In a repeater circuit, an inductive link of two halves, each half containing a receiving helix and a variable resistance, the helix of one half controlling the resistance of the other; each of said halves comprising a transmitting circuit, containing the variable resistance, a battery and two primary inductive windings; a condenser as a shunt about one of said primary windings; an inductive winding upon one of said primaries to which the line circuit is directly connected; and a receiving circuit containing a receiving helix and the secondaries of said primary windings, said secondaries being connected in opposition.

17. In a repeater circuit, an inductive link of two halves, each half containing a receiving helix and a variable resistance, the helix of one half controlling the resistance of the other; each of said halves comprising a transmitting circuit, containing the variable resistance, a battery and two primary inductive windings; a small condenser as a shunt about one of said primary windings; and a receiving circuit containing a receiving helix and the secondaries of said primary windings, said secondaries being connected in opposition.

18. In a telephone repeater circuit, a symmetrical inductive link, each half of said link comprising the following elements: two induction coils; a circuit containing a winding of each of said induction coils, a battery, and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing a winding of each of said induction coils and an inductive helix controlling the variable resistance of the other half, said two circuits being inductively neutral each upon the other.

19. In a telephone repeater circuit, a symmetrical inductive link having two repeating devices, each half of said link comprising the following elements: two induction coils; a circuit containing a winding of each of said induction coils, a battery and a variable resistance controlled by the inductive helix of the other half; and a second circuit containing a winding of each of said induction coils and an inductive helix controlling the variable resistance of the other half, said two circuits being inductively neutral each upon the other.

20. In a telephone repeater circuit, a symmetrical inductive link, each half of said link comprising the following elements: two induction coils; a circuit containing a winding of each of said induction coils, a battery and a variable resistance controlled by the inductive helix of the other half; a second circuit containing a winding of each of said induction coils and an inductive helix controlling the variable resistance of the other half, said two circuits being inductively neutral each upon the other; and an additional winding upon one of said induction coils and associated with a telephone line.

21. In a telephone repeater circuit, a symmetrical inductive link each half of which comprises the following elements: a plurality of inductoriums; a circuit containing primary windings of inductoriums, a battery, and a variable resistance controlled by the receiving helix of the other half; and a second circuit containing windings of inductoriums and the receiving helix controlling the variable resistance of the other half, said circuits being connected inductively neutral upon each other.

22. In a telephone repeater circuit, a symmetrical inductive link having two repeaters and each half of which comprises the following elements: a plurality of inductoriums; a circuit containing primary windings of inductoriums; a battery and a variable resistance controlled by the receiving helix of the other half; and a second circuit containing windings of inductoriums and the receiving helix controlling the variable resistance of the other half, said circuits being connected inductively neutral upon each other.

23. In a telephone repeater circuit, a symmetrical inductive link each half of which comprises the following elements: a plurality of inductoriums; a circuit containing primary windings of inductoriums, a battery and a variable resistance controlled by the receiving helix of the other half; and a second circuit containing windings of inductoriums and the receiving helix controlling the variable resistance of the other half, said circuits being connected inductively neutral upon each other; and a line winding in an inductorium and inductively related to both of said circuits.

24. In a telephone repeater circuit, a transmitting circuit containing a variable resistance, a battery and two inductive primary coils; secondary coils for each of said primary coils; upon one of said primary coils an additional secondary coil to the terminals of which is directly connected the line over which transmission is to be effected; and a circuit including a receiving helix and the two first mentioned secondaries, the secondaries being so related inductively to said primaries as to produce no current in said receiving helix in response to the operation of the primaries.

25. In a telephone repeater circuit, a transmitting circuit containing a variable resistance, a battery and two inductive primary coils; secondary coils for each of said primary coils; upon one of said primary coils an additional secondary coil to the terminals of which is directly connected the line over which transmission is to be effected; and upon the same primary coil a condenser connected as a shunt.

26. In a telephone repeater circuit, a transmitting circuit containing a variable resistance, a battery and two inductive primary coils; secondary coils for each of said primary coils; upon one of said primary coils an additional secondary coil to the terminals of which is directly connected the line over which transmission is to be effected; and upon the same primary coil a small condenser connected as a shunt.

27. In a telephone repeater system, the combination with a line circuit and a primary circuit, of a repeating device having two windings, one of said windings being inductively connected with said line and primary circuits, and the other of said windings being inductively connected with the said primary circuit only.

28. In a telephone repeater, in combination, two independent line circuits associated for repeater service, two repeating devices, one for each respective line circuit, each repeating device comprising a receiver and a transmitter, a winding in each line circuit to control the respective repeating devices and actuating them by the inward or received currents, a balancing auxiliary or local circuit for each repeating device, differential means in each balancing auxiliary circuit for each repeating device controlled by the transmitter of the opposite repeating device, a primary circuit for each repeating device, and an induction coil with primary, tertiary and secondary windings for each line circuit inductively associating the respective primary, balancing and line circuits.

29. In a reciprocal telephone repeating system, the combination with two telephone lines or circuit sections of two repeating telephones, means for inductively associating and identifying the receiver of each repeater with a respective circuit section, and means for balancing each repeater locally to prevent reactive transmission, an individual local circuit for the transmitter of each repeater together with means for jointly inductively associating each said transmitter with the opposite line circuit section and with its receiver.

30. In a telephone repeater system, the combination with a main telephone-circuit, of a repeating device and a tertiary circuit in which the repeating device is connected and is directly inductively associated with said main-telephone-circuit, a primary or transmitter-circuit which is also directly inductively connected with the said main circuit and with the tertiary circuit, and means for an extra or auxiliary inductive connection directly between the tertiary and primary circuits, whereby the repeating device is prevented by differential current or magnetic effects from operation by the local or repeated currents, yet is operated by the received or initial main circuit currents.

Signed at Berlin, Germany, on the seventeenth day of May A. D. 1907, in the presence of two witnesses.

CARL AUGUST KRUCKOW.

Witnesses:
HENRY HASPER,
WOLDEMAR HAUPT.

Correction in Letters Patent No. 990,365.

It is hereby certified that in Letters Patent No. 990,365, granted April 25, 1911, upon the application of Carl August Kruckow, of Halle-on-the-Saale, Germany, for an improvement in "Telephone Repeater-Circuits," an error appears in the printed specification requiring correction as follows: Page 4, line 23, after the word "helix", the words *in response to control by said first circuit.* should be inserted and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of June, A. D., 1911.

[SEAL.]

C. C. BILLINGS,

Acting Commissioner of Patents.