No. 812,718. PATENTED FEB. 13, 1906.

A. J. P. BERTSCHY.

TELEPHONIC REPEATING SYSTEM.

APPLICATION FILED JUNE 4, 1904.

3 SHEETS—SHEET 1.

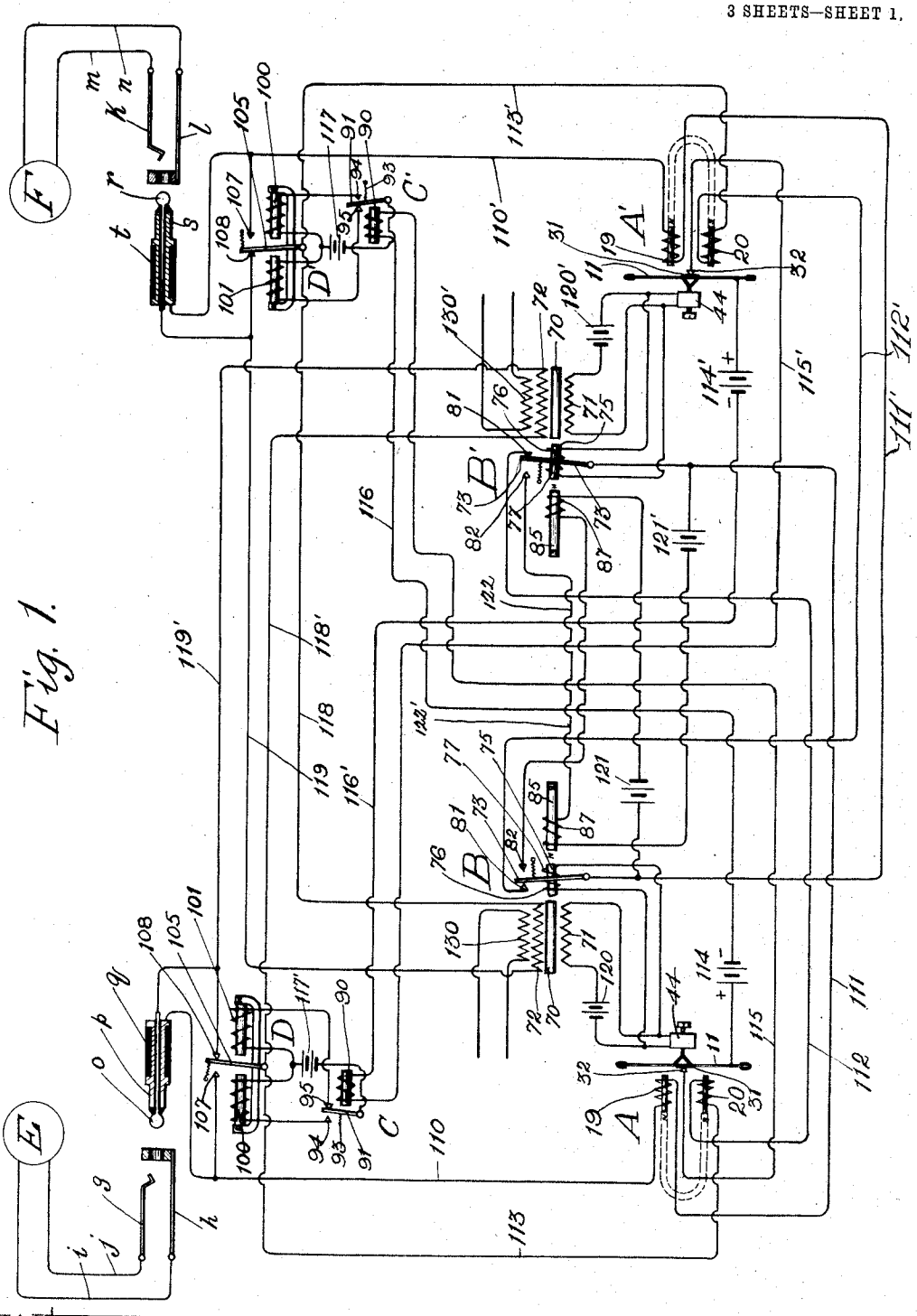

Fig. 1.

Witnesses:

Arthur H. Boettcher,

John Stahr

Inventor

Adolph J.P. Bertschy

By Lynn A. Williams

Attorney

No. 812,718. PATENTED FEB. 13, 1906.

A. J. P. BERTSCHY.

TELEPHONIC REPEATING SYSTEM.

APPLICATION FILED JUNE 4, 1904.

3 SHEETS—SHEET 2.

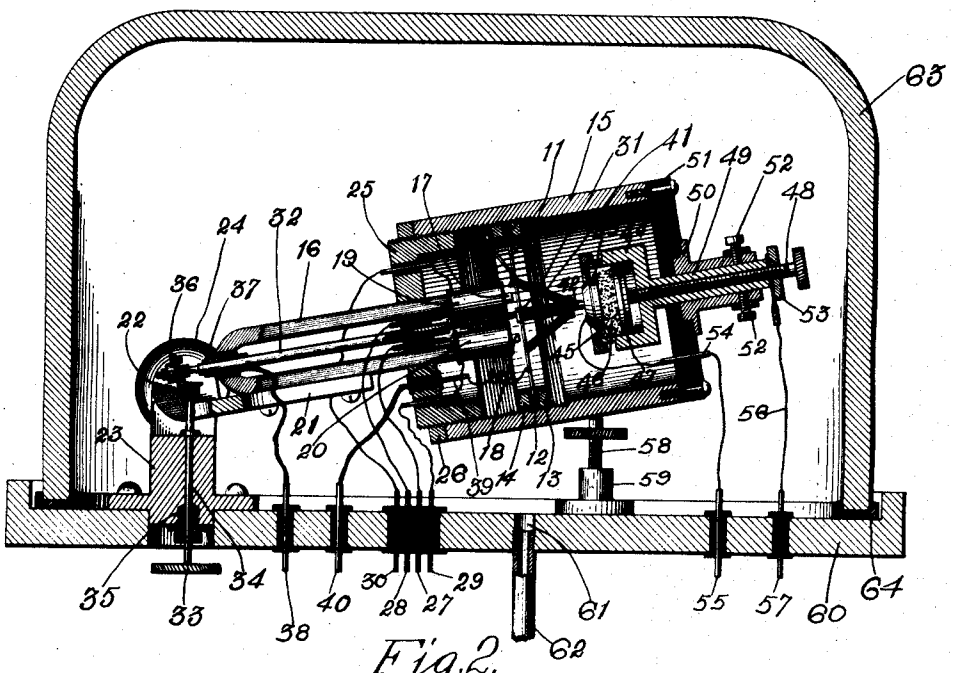

Fig. 2.

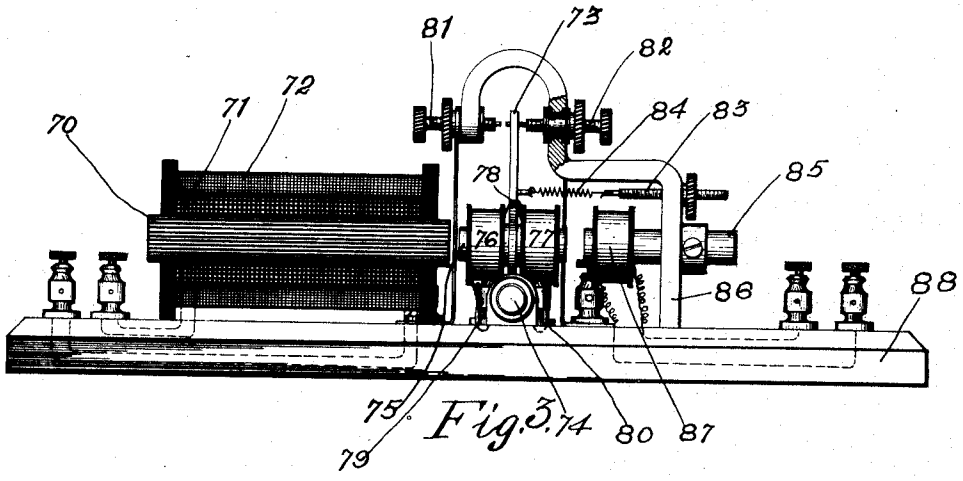

Fig. 3.

Witnesses:
John Stahr.
Arthur H. Boettcher.

Inventor
Adolph J. P. Bertschy
By Lynn A. Williams
Attorney.

No. 812,718. PATENTED FEB. 13, 1906.

A. J. P. BERTSCHY.

TELEPHONIC REPEATING SYSTEM.

APPLICATION FILED JUNE 4, 1904.

3 SHEETS—SHEET 3.

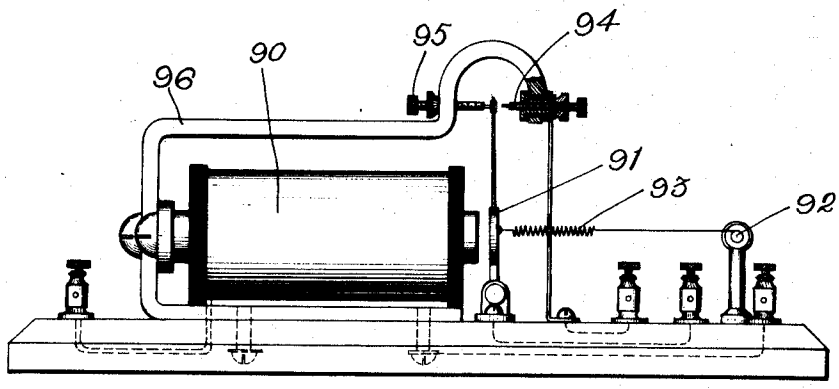

Fig. 4.

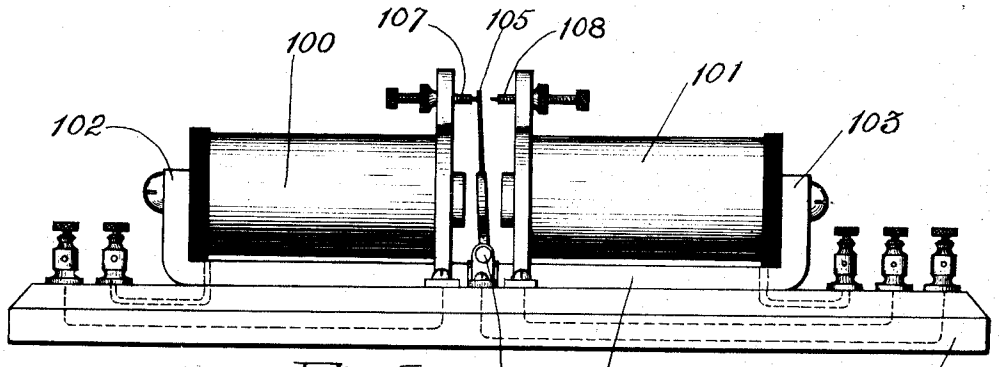

Fig. 5.

Witnesses:

Arthur H. Boettcher,

John Stahr.

Inventor

Adolph J. P. Bertschy

By Lynn A. Williams

Attorney

UNITED STATES PATENT OFFICE.

ADOLPH J. P. BERTSCHY, OF WOODSTOCK, ILLINOIS, ASSIGNOR OF ONE-FOURTH TO CHARLES H. DONNELLY, OF WOODSTOCK, ILLINOIS.

TELEPHONIC REPEATING SYSTEM.

No. 812,718. Specification of Letters Patent. Patented Feb. 13, 1906.

Application filed June 4, 1904. Serial No. 211,147.

To all whom it may concern:

Be it known that I, ADOLPH J. P. BERTSCHY, a citizen of the United States, residing at Woodstock, in the county of McHenry and State of Illinois, have invented a certain new and useful Improvement in Telephonic Repeating Systems, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to variable-current repeaters, and is particularly useful as an intensifying-repeater for telephonic purposes.

As is well known to those skilled in the art, the transmission of alternating or pulsating telephonic voice-currents to a great distance is accompanied by a considerable attenuation of the current-waves, which so far reduces the intensity of the vibrations at the receiving end as to render the long-distance transmission of telephonic voice-currents a matter of extreme difficulty. It has heretofore been the practice to repeat telegraphic currents by means of relays, a relay being connected in one circuit so as to be controlled by the currents flowing in this circuit and the armature of the relay controlling, by means of suitable contacts, the currents flowing in a second circuit extending beyond the first. By means of a relay of this character it is possible to control a comparatively strong current in a second circuit by means of comparatively feeble currents in the first circuit. It has heretofore been proposed to repeat telephonic voice-currents in a manner somewhat similar. It has, for instance, been proposed to mechanically associate a telephone-receiver and a telephone-transmitter and to connect the receiver-coils at the extremity of one telephonic circuit, the receiver-coils serving to actuate, by means of variations of current flowing therein, the resistance-varying members of the associated transmitter, the transmitter serving to initiate telephonic current-waves in a second transmission-circuit extending beyond the terminal of the first transmission-line. While such combined receivers and transmitters of the prior art have not been suitably constructed for the purpose, they have also been subject to the very serious objection that they provide for the transmission of voice-currents in one direction only. It has been attempted from time to time to provide systems in which the voice-currents could be transmitted over a single pair of conductors in both directions, this of course being a well-known commercial requirement. Great difficulty has been experienced in making a two-way repeater, for the reason that no automatic switch has been devised which would bring about the circuit changes required when the transmitting-station desired to become the receiving-station. It has been attempted to associate two relays with the line-circuits in such a manner that no interference would occur. The great and thus far insurmountable difficulty in connection with such systems of the prior art has been that the two relays when associated with the same pair of lines would almost invariably set up a singing sound, due to the mutual action between the two. A slight vibration of the diaphragm of one relay would produce changes in the current in the local circuit which would act upon the diaphragm of the other relay, producing another change of current, which would in turn react upon the first relay. This action is in many respects analogous to that produced in many telephone-circuits by holding the receiver of a telephone set in front of the mouthpiece of a microphone-transmitter. The shrieking noise set up when this adjustment is made is due to the fact that the sound-waves set up by the receiver-diaphragm act upon the transmitter-diaphragm, which in turn causes currents to flow through the receiver-coil, causing its diaphragm to vibrate still more strongly, and thus in turn again to set up further vibrations in the transmitter-diaphragm. My invention provides means for overcoming these difficulties heretofore experienced, the invention residing partially in the construction of the repeater and other mechanism employed and partially in the circuit arrangements by means of which automatic switches serve to provide for the transmission of voice-currents in either direction without interference, which will produce the shrieking or howling above described.

My invention will be clearly understood by reference to the accompanying drawings, in which—

Figure 1 illustrates diagrammatically the apparatus and circuit connections employed. Fig. 2 illustrates the telephonic relay. Fig. 3 illustrates a combined induction-coil and electromagnetic switching device. Fig. 4 illustrates a double-contact relay, which is

used in the preferred embodiment of my invention; and Fig. 5 illustrates a polarized relay, which is used in bringing about certain desired circuit changes.

I shall first explain the various pieces of apparatus employed and then describe the manner of their coöperation by means of Fig. 1.

Referring now more particularly to Fig. 2, I shall describe in detail the telephonic repeater, which forms a part of my invention. Broadly stated, this figure shows the combination of a telephone-receiver with a microphone-transmitter; but the construction of my invention embodies many points of novelty and value. A diaphragm 11, preferably of ferrotype iron, is common to the receiver and transmitter portions of the telephonic relay or repeater. This diaphragm is provided with a soft-rubber gasket 12, clamped between the two clamping-rings 13 and 14, these rings being screwed into the threaded end of the cylindrical metal shell 15, whereby the position of the diaphragm may be adjusted within the shell. The permanent horseshoe-magnet 16 is provided with soft-iron pole-pieces 17 and 18, upon which are wound the receiver magnet-coils 19 and 20, the pole-pieces being near the receiver side of the soft-iron diaphragm 11. The permanent magnet 16 is secured to a table 21, this table being pivoted at 22 to a suitable standard 23, the thumb-screw 24 serving to clamp the table in position. The receiver is attached to the end plate 25 of the chamber which incloses the repeater mechanism proper. By turning the shell 15 upon this end plate the distance between the pole-pieces 17 and 18 and the diaphragm 11 may be adjusted, the locking-ring 26 serving to clamp the parts in adjustment. The receiver-coils are not connected together, as is generally done; but the inner ends of the coils are connected through the insulated leading-in studs, with the terminals 27 and 28. The outer terminals of the coils are connected by way of suitable leading-in studs with the terminals 29 and 30. Upon the face of the diaphragm 11 is soldered a platinum contact-piece 31. This contact-piece normally makes connection with the platinum contact-point of an adjustable contact-screw 32, the position of this screw being regulated by the geared connection with the thumb-wheel 33. The spindle 34, associated with this thumb-wheel, extends through a packing-gland 35 and the standard 23 to a pin-wheel 36, splined upon the contact-screw 32, but insulated therefrom. The contact-screw 32 is electrically connected, by means of the metal bearing 37 and a suitable conductor, with a terminal 38, while the contact 31 is connected by way of the diaphragm itself, a suitable conductor, and the leading-in stud 39 with the terminal 40. A suitable bracket 41, of insulating material—such as, for instance, hard rubber—is attached to the diaphragm 11 a slight distance from the center, and into the hub of this bracket is screw-threaded the stem 42, connected with the movable electrode 43 of the microphone-transmitter button. This button comprises a chamber 44, to the front or open end of which is clamped the auxiliary mica diaphragm 45, this diaphragm permitting the movement of the movable electrode 43 with reference to the chamber and at the same time retaining the comminuted material—such, for instance, as the carbon granules 46—within the chamber. The fixed electrode 47 is carried upon a screw-threaded stem 48, extending to the outside of the inclosing case 15. The transmitter-button as a whole is carried upon the stem 49, this stem being adjustable within the standard 50, which is secured to the hard-rubber end plate 51 of the large cylindrical chamber. The set-screws 52, together with their lock-nuts, permit the adjustment of the granule-chamber and serve to clamp the stem 49 in position. The stem 48 permits the relative adjustment of the fixed and movable electrodes, the lock-nut 53 serving to clamp the parts in permanent adjustment. The movable electrode is electrically connected, by way of the stud 54, with the terminal 55, while the conductor 56 electrically connects the fixed electrode 47 to the terminal 57. The thumb-screw 58 serves to regulate the inclination of the repeater, as I have found that the apparatus is more sensitive when in an inclined position than when in a horizontal position. The repeater as a whole is mounted, by means of the standard 23 and the base 59 for the thumb-screw 58, upon a suitable platen 60, through which there is an opening 61, the pipe 62 registering with this opening and being connected with a vacuum-pump, by means of which the air may be withdrawn from the chamber formed within the bell glass or cover 63, resting upon a suitable gasket 64 upon the platen 60. This cover may be formed of iron, if desired, to prevent the effect of outside magnetic disturbances.

In Fig. 3 I have illustrated an induction-coil comprising the core 70, of soft-iron wires, upon which are wound the primary winding 71 of coarse turns of wire and the secondary winding 72, consisting of a large number of turns of fine wire. At one end of the core 70 an armature 73 is mounted within the trunnions 74. To the armature is fastened a short electromagnet-core 75, upon which the coils 76 and 77 are wound, these coils being connected together at 78 and with the terminals 79 and 80. The conductors leading to the coils 76 and 77 are extremely flexible, so that they will not interfere with the movement of the coils and their core with the armature 73. The armature is provided with platinum contact-points at its upper end, these contact-points serving to make con-

nection alternately with the contact-points of the insulated and adjustable contact-screws 81 and 82. An adjustable screw 83 serves to regulate the tension of the retracting-spring 84. A permanent magnet 85 is adjustably mounted within the frame 86 and upon its front end carries an electromagnet-coil 87. The various electrical terminals and contacts are connected with suitable binding-posts, as shown, the entire mechanism being mounted upon a suitable base-plate 88.

In Fig. 4 I have illustrated a double-contact relay, comprising an ordinary electromagnet 90 and an armature 91, this armature being extremely light, as shown. An adjustable screw 92 regulates the tension of the retracting-spring 93, the armature serving normally to make electrical connection with the back contact-screw 94, but when attracted, due to the energization of the electromagnet 90, to make contact with the contact-screw 95, this contact-screw being connected directly with the frame 96. The electrical connections with the various binding-posts are indicated in the figure.

In Fig. 5 I have shown a polarized double-contact relay comprising electromagnets 100 and 101, these magnets being mounted between the poles 102 and 103 of a permanent magnet 104. The armature 105 is mounted in suitable trunnions 106 and vibrates between the electrical contact-screws 107 and 108. Suitable binding-posts mounted upon the base 109 are provided for the purpose of making the required electrical connections with the coils and contacts. The construction of all these relays should be made extremely delicate, the trunnions being provided with hardened-steel journals and jeweled bearings in order that the adjustment may be perfected and the movement of the armatures accompanied with the least possible friction, the reason for this being that the movements of the armatures must take place with extreme rapidity, as will hereinafter more fully appear.

I shall refer now more particularly to Fig. 1, in which the circuit connections of these various pieces of apparatus are shown, the parts of the apparatus diagrammatically shown in Fig. 1 corresponding with the apparatus shown in Figs. 2 to 5, inclusive. These parts diagrammatically illustrated in Fig. 1 are provided with the same reference characters as those illustrated in the figures, more fully showing the precise mechanical construction employed. At A and A′ are illustrated telephonic repeaters or relays, such as shown in detail in Fig. 2. At B B′ are shown induction-coils and electromagnetic armature mechanism, such as shown in Fig. 3. The relays marked C and C′ in Fig. 1 are like that shown in Fig. 4, and the relays D and D′ of Fig. 1 are of the type shown in Fig. 5.

In Fig. 1 I have illustrated subscribers' substations at E and F, the substation E being connected with the spring-jack terminals *g* and *h* by means of the telephone-line limbs *j* and *i*. The substation F is connected with the spring-jack terminals *k* and *l* by means of the line-limbs *m* and *n*. Between the spring-jack terminals of the line to station E and the spring-jack terminals of the line to station F is interposed the repeating mechanism which constitutes my invention. The repeating outfit is connected between the terminals *o* and *p* of the plug *q* and the terminals *r* and *s* of the plug *t*.

It may be stated in general that the repeating apparatus which is employed in transmitting telephonic voice-currents in one direction is duplicated by similar apparatus employed in transmitting voice-currents in the opposite direction. Switching mechanism is provided which serves to open the circuit connections required for transmission in one direction when transmission is being carried on in the other direction, and my invention contemplates the use of a double series of safeguards to prevent simultaneous connection of the repeating apparatus in such a manner as would permit interference and shrieking due to undesirable cooperation of the two repeating-relays employed.

I shall now trace the circuits employed in the operation of the repeating system. There is a permanent connection by means of the conductor 110 between the sleeve-contact *p* of plug *q* and the coil 19 of the repeating-relay A. The circuit through this coil and its mate 20 is traced normally from coil 19, through the terminal 28, (shown on Fig. 2,) through the conductor 111 (shown on Fig. 1) to the armature 73 of the electromagnetic switching device B′, the front contact 81 of this relay, the conductor 112, the receiver-coil 20 of the repeater A, and thence through conductor 113, armature 105 of the polarized relay D and its normal contact 108 to the tip-contact *o* of the plug *q*. The voice-currents entering the repeating system from the line from station E traverse this circuit, thereby setting in vibration the diaphragm 11 of the repeater A. The diaphragm normally makes connection by means of its platinum contact 31 (shown on Fig. 2) with the contact-screw 32. The following circuit may be traced normally through these contacts: from the positive pole of the battery 114 to diaphragm 11, contact 32, through conductor 115 to the electromagnet 90 of relay C′, and thence through conductor 116 back to the negative pole of the battery 114. Current passing through this circuit normally closes a circuit from the local battery 117 through the armature 91 of relay C′, its front contact 95, and through the electromagnet-winding 101 of relay D′ to the other side of the battery.

The armature 105 of the relay D′ is thereby maintained normally in connection with its contact 108.

The voice-currents set up at substation E may be in the nature of variations of an otherwise steady current flowing through the coils 19 and 20. When, therefore, the diaphragm is set in vibration by means of the variable currents passing through the coils 19 and 20, the current traversing the local circuit through the coil 90 of the relay C′ is interrupted on account of the breaks in the circuit introduced between the contact-points 31 and 32 on the face of the repeater-diaphragm 11. The retracting-spring 93 is of sufficient tension to retract the armature 91 from its front contact 95, and as the interruptions in the circuit through the coil 90 are of great frequency the armature 91 is retained in electrical connection with its back contact 94 during the period in which the diaphragm 11 of the repeater A is vibrating due to passage of voice-currents coming in from station E. The retraction of the armature 93 from the front contact 95 serves to break the circuit previously traced through the electromagnet-coil 101 of the relay D′, and the connection of the armature 93 with back contact 94 closes a similar local circuit through the electromagnet 100 of the polarized relay D′, whereupon the armature 105 is attracted to make connection with its alternate contact 107. This movement of the armature 105 serves a double purpose—first, to break a circuit which could otherwise be traced from the tip-contact *r* of the plug *t* through the contact 108, the armature 105, conductor 113′, and thence through the receiver-coils of repeater A′ back to the sleeve-contact *s* of the plug *t*. This circuit is similar to that already described for the other side of the repeating system and is the one which would serve to actuate the diaphragm 11 of the repeater A′ in receiving voice-currents from station F. The interruption of this circuit by means of the break introduced between the armature 105 and the contact 108 serves to prevent the passage of currents through the coils 19 and 20 of the repeater A′ during the time in which the repeater A is in operation for the transmission of voice-currents from the line from substation E to the line to substation F. Furthermore, the connection of the armature 105 with the contact 107 closes the secondary circuit of the induction-coil of the instrument B to the line F. This circuit may be traced as follows: from the secondary coil 72 of the induction-coil at B, through conductor 118 to armature 105, thence to contact 107, sleeve-contact *s* of plug *t*, and after passing through the line to station F, to tip-contact *r* of the plug *t*, and thence through conductor 119 back to the other side of the secondary 72. As will now be explained, it is the currents from this secondary 72 of the induction-coil B that are transmitted to the station F. The primary coil 71, inductively related to the secondary coil 72 of the instrument B, is connected through a local battery 120 with the electrodes of the transmitter-button 44 of the repeater A. The vibrations of the diaphragm 11, due to voice-currents coming in from station E and traversing the coils 19 and 20, cause variations in the resistance of the granules between the electrodes of the button 44, whereupon similar voice-currents are set up in the primary winding 71, thereby inducing similar voice-currents but of higher intensity in the secondary coil 72, and these voice-currents are transmitted through the circuit already described to station F.

If desired, a second repeating system may be connected at station F, this second repeater serving to intensify and repeat the voice-currents to the third station, and so on indefinitely.

In shunt of the transmitter-button are connected the electromagnet-coils 76 and 77 of the instrument B, these coils all wound upon a core 75, as shown in Fig. 3, the whole being mounted with the armature 73. A certain current flows normally through the primary winding 71, thereby polarizing the soft-iron core 70 of the induction-coil, and a certain current flows also through the electromagnet-coils 76 and 77, whereupon the armature 73 remains normally in electrical connection with the contact 81. When the granules within the transmitter-button 44 are compressed, there is a consequent decrease in the resistance, whereupon the transmitter-button serves to shunt an increased proportion of the current from the electromagnet-coils 76 and 77, and there will also be a slight increase in current through the coil 71. This increase in current in the coil 71, however, is not sufficient to overcome demagnetization of armature 73 and the attraction of said armature by the permanent magnet 85. The armature therefor is drawn into engagement with contact 82. This movement of the armature 73 of the instrument B serves two purposes—first, to break the connection between the contact 81 and the armature 73, a circuit through these contacts being required for the operation of the diaphragm 11 of repeater A′, due to voice-currents traversing the associated coils 19 and 20. In other words, when the diaphragm 11 of the repeater A is set in operation the armature 73 of the instrument B at once breaks its connection with the contact 81, thereby preventing the operation of the repeater A′. Thus when the repeater A is in operation there are two breaks in the circuit through the coils 19 and 20 of the repeater A′ to prevent the operation of this repeater, one of these breaks being made between the contact 108 and the armature 105 of the polarized re-

lay D′ and the other break being that made between the armature 73 and its contact 81 of the instrument B. When the armature 73 makes connection with its back contact 82, a local circuit is closed from the local battery 121 through the electromagnet-coil 87 of the electromagnetic device B′ and thence through conductor 122 to contact 82 of the instrument B. Current flowing through this circuit is in such a direction as to depolarize the permanent magnet 85 of the instrument B′, whereupon the attraction for the core 75, associated with the armature 73 of the instrument B′, is decreased to such an extent as to absolutely insure the armature 73 of instrument B′ making connection with its contact 81. It will be remembered that this circuit is absolutely essential for the operation of the repeater A, as the circuit through its coils 19 and 20 was traced through a connection between this armature 73 and its contact 81 of instrument B′. When a person at station E has ceased talking, the normal current is caused to flow through the coils 19 and 20 of repeater A, (this current being of a zero value, if so desired, and in this case the voice-currents serve to depolarize the permanent magnet 16 of the repeater.) Variations in the resistance of the transmitter-button 44 are therefore discontinued, whereupon a steady current of increased value flows through the coils 76 and 77 of the instrument B and the armature 73 is attracted to make connection with its normal contact 81. The diaphragm 11 makes an uninterrupted electrical connection with its contact-screw 32, whereupon a circuit for uninterrupted currents is closed through the electromagnet 90 of the relay C′, the armature 91 being thereupon attracted to make connection with the contact 95, which closes a local circuit through the winding 101 of the relay D′, whereupon the armature 105 is attracted to engage the contact 108, thereby restoring the instruments to their normal condition.

As heretofore pointed out, the subscriber at station F cannot cause the operation of his repeater A′ during the time in which the repeater A is in operation, due to voice-currents coming in from station E; but with the cessation of voice-currents coming in from station E the apparatus is restored to its normal condition such that a subscriber at station F may cause the operation of the repeater A′ to intensify and transmit the telephonic voice-currents to station E. The apparatus employed for this purpose is a duplication of that just described in connection with transmission in the opposite direction, and its operation is the same; but I shall describe briefly the circuits employed for such transmission. The voice-currents coming in from station F pass from the sleeve-contact *s* of the plug *t* through conductor 110′, the coils 19 and 20 of the repeater A′ by way of the circuit afforded between the connected contact 81 and the associated armature 73 of the instrument B. Currents pass from the coil 20 to the tip-contact *r* by way of the conductor 113′, the armature 105 of polarized relay D′, and the contact 108. These voice-currents traversing the coils 19 and 20 of the repeater A′ set in vibration the associated diaphragm 11, thereby breaking the otherwise completed circuit through the diaphragm 11 and the associated contact-screw 32 of the repeater A′, the current through this circuit normally flowing through the electromagnet 90 of the relay C by way of conductor 115′, the battery 114′, and the conductor 116′. The deënergization of the electromagnet 90 of the relay C causes the retraction of the associated armature 91 to break the local circuit through the coil 101 of the polarized relay D and to close the circuit through the electromagnet 100 of this relay, thereby causing the attraction of the armature 105 to break the connection with the contact 108 and to make connection with the alternate contact 107. It will be remembered that the circuit previously traced from station E to repeater A included a connection between the contact 108 and the armature 105. The breaking of this connection upon the actuation of the repeater A′ for transmission in the opposite direction prevents the subscriber at station E and the repeater A itself from interfering with the transmission from station F to station E. The closure of the connection between contact 107 and armature 105 provides a circuit from the secondary winding 72 of the instrument B′ through conductor 118′, armature 105, contact 107, sleeve-contact *p* of the plug *q*, and thence to station E, the return-circuit being traced through the contact *o* of the plug *q* and conductor 119′ to the other side of the secondary 72 of instrument B′. Thus the vibrations of the diaphragm 11 of the repeater A′ caused by voice-currents coming in from station F when producing variations in the resistance of the associated transmitter-button 44 may cause an intensification and repetition of the voice-currents to station E on accountof the inductive relation between the secondary coil 72 of the instrument B′ and the associated primary coil 71, which is connected with the electrodes of the button 44 of the repeater A′. The local circuit for primary coil 71 of instrument B includes a source of current 120′, this battery supplying current also to the coils 76 and 77 of the instrument B′, as already described in connection with the instrument B. The compression of the granules within the button 44 of the repeater A′ causes a decrease in the resistance thereof, whereupon the coils 76 and 77 of instrument B′ are deprived of a portion of their current, thereby causing a movement of the armature 73 to break connection with the normal contact 81 (this con-

nection being essential for the operation of the repeater A) and making connection with the alternate contact 82, this connection serving to depolarize the permanent magnet 85 of the instrument B in the manner already described, thereby insuring the maintenance of the connection between the armature 73 and the front contact 81 of the instrument B, (this connection being essential for the operation of the repeater A′.)

At 130 and 130′ I have shown tertiary induction-coil windings, to which an operator's telephone set may be connected for the purpose of supervision. Any suitable system of supervisory or other signals may be associated with the cord-circuit to which the repeating system is connected, these signals being employed in the well-known manner for affording control of the connections. Under certain conditions I have found it desirable to place certain of the relays in addition to the repeating-relays A and A′ in vacuum-chambers—such, for instance, as that shown in Fig. 2. Such a provision permits the more prompt and rapid movements required of the armature mechanism.

Most of the parts diagrammatically illustrated in Fig. 1 are mechanically constructed as shown in Figs. 2 to 5, inclusive, and where such correspondence exists the same reference characters are applied to the parts of Fig. 1 as in Figs. 2 to 5, inclusive. The sources of current and conductors shown in Fig. 1 are duplicated for transmission in both directions, and these duplicate parts are provided with similar reference characters, except that in one case the reference characters are provided with a suitable index.

It will be seen that by means of my invention telephonic voice-currents may be repeated and intensified in both directions over a single transmission-circuit, the transmission being effective without interference and without the loss of clearness, but with increased intensity, whereby telephonic transmission may be carried on to great distances and through obstacles—such, for instance, as submarine cables—which heretofore have offered a considerable obstruction to the transmission of telephonic currents.

While I have herein shown and described a preferred embodiment of my invention, it will be understood by those skilled in the art that many modifications and changes may be made without departing from the spirit thereof. I do not wish, therefore, to limit myself to the precise construction herein set forth; but,

Having described my invention, I claim as new and desire to secure by Letters Patent—

1. In a telephonic repeating system, the combination with two transmission-lines terminating at a repeating-station, of a repeating-relay for each line, each comprising suitable receiving-coils, a transmitter and a common vibratory diaphragm, a transformer associated with each repeating-relay, the primary circuit of each transformer being controlled by the transmitter of the associated repeating-relay, an electromagnetic switching device for each repeating-relay, each having an actuating-winding connected in shunt of the transmitter thereof, each of said switching devices serving normally to maintain the closure of a break in the circuit of the receiving-coils of the other repeating-relay but when actuated due to the actuation of the associated transmitter to open the break in said receiver-circuit, each of said switching devices serving also when actuated to close a local circuit through an electromagnetic safety device associated with the other switching device, thereby insuring the maintenance of its normal circuit connections, and an auxiliary switching device associated with the diaphragm of each repeating-relay and each maintaining normally a closed circuit through associated electromagnetic switching mechanism, said electromagnetic switching mechanism serving normally to maintain an electrical connection between the receiving-coils of the other repeating-relay and its transmission-line and to maintain a break in an otherwise completed circuit containing this other transmission-line and the secondary coil of the transformer associated with that relay which controls the given switching mechanism, but serving when deënergized due to the opening of the circuit at said auxiliary switching mechanism upon the vibration of the associated relay-diaphragm to close the circuit connection between said transmission-line and the secondary coil of said transformer and to open the circuit connection between the same transmission-line and the receiving-coils of its repeating-relay.

2. In a telephone repeating system, the combination with an electromagnet connected in a receiving-circuit, of a transmitter for controlling currents in the sending-circuit, a vibratory diaphragm common to said electromagnet and said transmitter, and an auxiliary switching device controlled by said diaphragm to cause the closure of a break in the sending-circuit.

3. In a telephonic repeating system, the combination with an electromagnet connected in a receiving-circuit, of a transmitter for controlling currents in the sending-circuit, a vibratory diaphragm common to said electromagnet and said transmitter, normally closed switch-contacts associated with said diaphragm, an electromagnetic switching device controlled by said switch-contacts, and means whereby the vibration of said diaphragm causes a break in the connection between said switch-contacts to deënergize said electromagnetic switching device, said switching device serving normally to main-

tain a break in the sending-circuit but upon deënergization to cause the closure of said break in the sending-circuit.

4. In a telephone repeating system, the combination with electromagnetic receiving-coils connected in a receiving-circuit, of a transmitter for controlling currents in the sending-circuit, a vibratory diaphragm common to said electromagnetic receiving-coils and said transmitter, a relay having one electromagnet adapted upon energization to cause the associated armature to assume one of its alternative positions, and a second electromagnet adapted upon energization to cause the armature to assume the other of its alternative positions, the armature remaining in the position which it has assumed due to the energization of either electromagnet until the other electromagnet is energized, a second relay adapted upon energization to cause a closure of the circuit through the first electromagnet of the first said relay, and upon deenergization to cause the closure of a local circuit through the second electromagnet of the first said relay, and auxiliary switch-contacts associated with said diaphragm, said switch-contacts serving normally to maintain the closure of a circuit through the second said relay, but upon the vibration of said diaphragm to interrupt the circuit through said relay, the energization of the second electromagnet of the first said relay serving to close a break in the continuity of the sending-circuit.

5. In a telephone repeating system, the combination with electromagnetic receiving-coils connected in a receiving-circuit, of a transmitter for controlling currents in the sending-circuit, a vibratory diaphragm common to said electromagnetic receiving-coils and said transmitter, a relay having one electromagnet adapted upon energization to cause the associated armature to assume one of its alternative positions, and a second electromagnet adapted upon energization to cause the armature to assume the other of its alternative positions, a second relay adapted upon energization to cause a closure of the circuit through the first electromagnet of the first said relay and upon deenergization to cause the closure of a local circuit through the second electromagnet of the first said relay, and auxiliary switch-contacts associated with said diaphragm, said switch-contacts serving normally to maintain the closure of a circuit through the second said relay but upon the vibration of said diaphragm to interrupt the circuit through said relay, the energization of the second electromagnet of the first said relay serving to close a break in the continuity of the sending-circuit.

6. In a telephonic repeating system, the combination with two transmission-lines leading to a repeating-station, of a repeating-relay for each line, each relay having its receiving-coils normally connected with one line and its transmitter adapted for the control of voice-currents in the other line, and electromagnetic switching mechanism controlled by said repeating-relays, whereby the actuation of one of said relays serves to open the circuit through the receiving-coils of the other relay.

7. In a telephonic repeating-station, the combination with two transmission-lines leading to a repeating-station, of a repeating-relay for each line, each relay having its receiving-coils normally connected with one line and its transmitter adapted for the control of voice-currents in the other line, and electromagnetic switching mechanism controlled by said repeating-relays, whereby the actuation of one of said relays serves to open the circuit through the receiving-coils of the other relay and to close the transmitting-circuit of the first-named relay.

8. In a telephonic repeating system, the combination with two transmission-lines leading to a repeating-station, of a repeating-relay for each line, each relay having its receiving-coils normally connected with its line and its transmitter adapted for the control of voice-currents in the other line, and switching mechanism controlled by said repeating-relays, whereby the actuation of one of said relays serves to cause a plurality of breaks in the circuit through the receiving-coils of the other relay.

9. In a telephonic repeating system, the combination with two transmission-lines leading to a repeating-station, of a repeating-relay for each line, each relay having its receiving-coils normally connected with its line and its transmitter adapted for the control of voice-currents in the other line, and switching mechanism controlled by said repeating-relays, whereby the actuation of one of said relays serves to cause a plurality of breaks in the circuit through the receiving-coils of the other relay and to close the transmitting-circuit of the first-named relay.

10. In a telephonic repeating system, the combination with two transmission-lines leading to a repeating-station, of a repeating-relay for each line, each relay having its receiving-coils connected with its line and its transmitter adapted to control inductively the currents in the other line, and an electromagnetic switching device connected in shunt of said transmitter and serving upon partial deënergization due to a decrease in resistance in the transmitter to break the circuit through the receiving-coils of the other relay.

11. In a telephonic repeating system, the combination with two transmission-lines leading to a repeating-station, of a repeating-relay for each line, each relay having its receiving-coils connected with its line and its transmitter adapted to control inductively the cur-

rents in the other line, an electromagnetic switching device connected in shunt of said transmitter and serving upon partial deënergization due to a decrease in resistance in the transmitter to break the circuit through the receiving-coils of the other relay, and auxiliary switch-contacts controlled by the vibration of the diaphragm of each repeating-relay, said switch-contacts serving to control the transmitting-circuit of the first-named relay.

12. In a telephonic repeating system, the combination with a pair of transmission-lines terminating at a repeating-station, of a repeating-relay for each line, an induction-coil for each repeating-relay, the circuit for the primary coil of each induction-coil being controlled by the transmitter of one of said repeating-relays and the secondary coil of each induction-coil being adapted for connection with one of said transmission-lines but normally disconnected therefrom, and means whereby the passage of telephonic voice-currents from one line to its repeating-relay causes a connection of the secondary coil of the associated induction-coil with the other transmission-line.

13. In a telephonic repeating system, the combination with a pair of transmission-lines terminating at a repeating-station, of a repeating-relay for each line, an induction-coil for each repeating-relay, the circuit for the primary coil of each induction-coil being controlled by the transmitter of one of said repeating-relays, the secondary coil of each induction-coil being adapted for connection with one of said transmission-lines but normally disconnected therefrom, and means whereby the passage of telephonic voice-currents from one line to its repeating-relay causes a connection of the secondary coil of the associated induction-coil with the other transmission-line and causes a break in the connection between this other transmission-line and the receiving-coils of its repeating-relay.

14. In a telephonic repeating system, the combination with a pair of transmission-lines terminating at a repeating-station, of a repeating-relay for each line, an induction-coil for each repeating-relay, the circuit for the primary coil of each induction-coil being controlled by the transmitter of one of said repeating-relays, the secondary coil of each induction-coil being adapted for connection with one of said transmission-lines but normally disconnected therefrom, and means whereby the passage of telephonic voice-currents from one line to its repeating-relay causes a connection of the secondary coil of the associated induction-coil with the other transmission-line, and causes a double break in the circuit of the receiving-coils associated with this other transmission-line.

15. In a telephonic repeating system, the combination with a pair of repeating-relays each consisting of a receiver and a transmitter part, of means jointly controlled by said receiver and transmitter part for causing the actuation of one relay to render the other relay inoperative.

16. In a telephonic repeating system, the combination with a pair of repeating-relays, each comprising a transmitter portion and a receiver portion and a vibratory member common to both, of switching means associated with said vibratory member, and an electrical circuit controlled by said switching means, whereby the vibration of the vibratory member of one repeating-relay renders the other relay inoperative.

17. In a telephonic repeating system, the combination with a pair of repeating-relays, each comprising a transmitter portion and a receiver portion and a vibratory member common to both, of normally closed switch-contacts associated with said vibratory member, and means whereby the vibration of said vibratory member due to voice-currents traversing the associated receiver portion causes the actuation of said switch-contacts to cause a break in the receiver-circuit of the other repeating-relay.

18. In a telephonic repeating system, the combination with a pair of repeating-relays, each comprising a transmitter portion and a receiver portion and a vibratory member common to both, of normally closed switch-contacts associated with said vibratory members and means whereby the vibration of said vibratory member due to currents traversing the associated receiver portion causes an actuation of said switch-contacts to close the transmission-circuit for the associated transmitter.

19. In a telephonic repeating system, the combination with a pair of repeating-relays, each comprising a transmitter portion and a receiver portion and a vibratory member common to both, of normally closed switch-contacts associated with said vibratory member, and means whereby the vibration of said vibratory member due to currents traversing the associated receiver portion causes an actuation of said switch-contacts to close the transmission-circuit for the associated transmitter and to cause a break in the receiver-circuit of the other repeating-relay.

20. In a telephonic repeating system, the combination with two telephone transmission-circuits, of a repeating-relay for each circuit adapted to repeat into the other circuit, each relay consisting of a receiver and a transmitter part, and electromagnetic means jointly controlled by the receiver and transmitter parts whereby the actuation of one repeater destroys the connection between the other repeater and its transmission-circuit.

21. In a telephone repeating system, the combination with a pair of transmission-lines

terminating at a repeating-station, of a repeating-relay for each line consisting of a receiver and a transmitter part and having its receiving-coils normally connected in circuit with its line, and electromagnetic means jointly controlled by the receiving and transmitting parts whereby the passage of voice-currents through the receiving-coils of one repeating-relay causes a disconnection of the receiving-coils of the other repeating-relay from its transmission-line.

22. In a telephone repeating system, the combination with a pair of transmission-lines terminating at a repeating-station, of a repeating-relay for each line consisting of a receiver and a transmitter part and having its receiving-coils normally connected in circuit with its line, and electromagnetic means jointly controlled by the receiving and transmitting parts whereby the passage of voice-currents through the receiving-coils of one repeating-relay causes a disconnection of the receiving-coils of the other repeating-relay from its transmission-line and causes a connection of the transmitting-circuit of the first said relay with the transmission-line from which the receiving-coils of the other relay are disconnected.

23. In a telephonic repeating system, the combination with two transmission-lines leading to a repeating-station, of a repeating-relay for each line, each relay consisting of a receiving and a transmitting part and having its receiver-coils normally connected with its line, and electromagnetic switching mechanism jointly controlled by the receiving and transmitting parts whereby the actuation of one of said relays serves to open a circuit through the receiver-coils of the other relay.

24. In a telephonic repeating system, the combination with a pair of transmission-lines terminating at a repeating-station, of a repeating-relay for each line, transformer means for inductively transferring telephonic voice-currents from one line to the other, the primary currents through said transformer means being controlled by said repeating-relays, the secondary windings of said transformer means being adapted for connection with said transmission-lines but normally disconnected therefrom, and means whereby the passage of telephonic voice-currents from one line to its repeating-relay causes the closure of a telephonic circuit including said transformer means from the transmitter portion of said repeating-relay to the other transmission-line.

25. In a telephonic repeating system, the combination with a pair of transmission-lines terminating at a repeating-station, of a repeating-relay for each line, transformer means for inductively transferring telephonic voice-currents from one line to the other, the primary currents through said transformer means being controlled by said repeating-relays, the secondary windings of said transformer means being adapted for connection with said transmission-lines but normally disconnected therefrom, and means whereby the passage of telephonic voice-currents from one line to its repeating-relay causes the closure of a telephonic circuit including said transformer means from the transmitter portion of said repeating-relay to the other transmission-line and causes a break in the connection between this other transmission-line and the receiving-coils of its repeating-relay.

26. In a telephonic repeating system, the combination with a pair of transmission-lines terminating at a repeating-station, of a repeating-relay for each line, transformer means for inductively transmitting telephonic voice-currents from one line to the other, the primary currents through said transformer means being controlled by said repeating-relays, the secondary windings of said transformer means being adapted for connection with said transmission-lines but normally disconnected therefrom, and means whereby the passage of telephonic voice-currents from either line to its repeating-relay causes the closure of a circuit from the secondary windings of said transformer means to the other transmission-line.

27. In a telephonic repeating system, the combination with a pair of transmission-lines terminating at a repeating-station, of a repeating-relay for each line, transformer means for inductively transmitting telephonic voice-currents from one line to the other, the primary currents through said transformer means being controlled by said repeating-relays, the secondary windings of said transformer means being adapted for connection with said transmission-lines but normally disconnected therefrom, and means whereby the passage of telephonic voice-currents from either line to its repeating-relay causes the closure of a circuit from the secondary windings of said transformer means to the other transmission-line and causes a break in the connection between this other transmission-line and the receiving-coils of its repeating-relay.

In witness whereof I hereunto subscribe my name this 23d day of May, A. D. 1904.

ADOLPH J. P. BERTSCHY.

Witnesses:
LYNN A. WILLIAMS,
ARTHUR H. BOETTCHER.