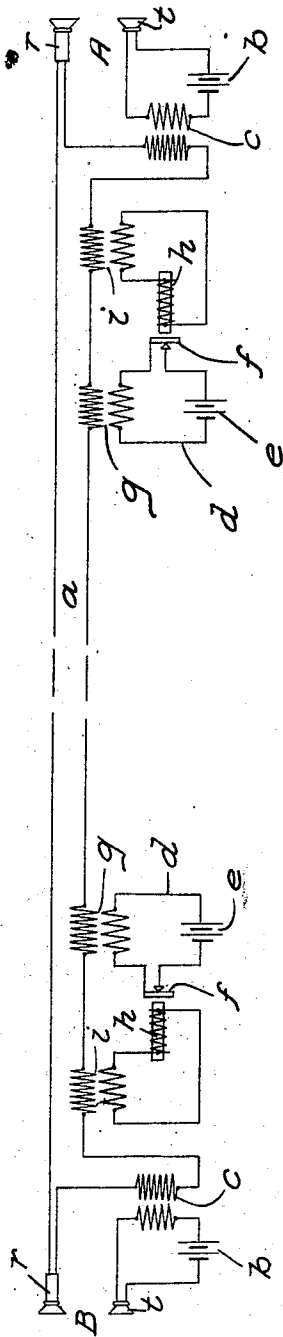


C. D. LANNING.
 SYSTEM FOR THE TRANSMISSION OF ELECTRICAL ENERGY.
 APPLICATION FILED JUNE 2, 1911.

1,053,098.

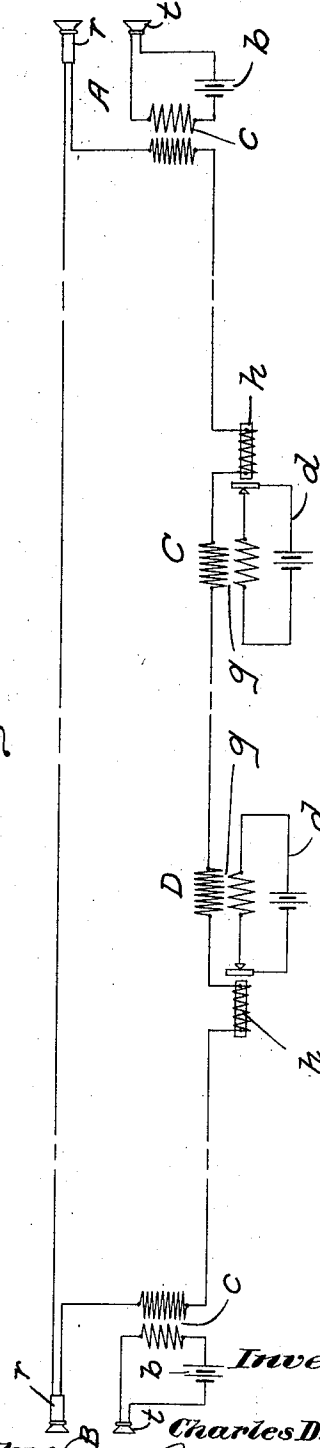
Patented Feb. 11, 1913.

Fig. 1.



Witnesses:
 Robert H. Kammler.
 Horace A. Crossman.

Fig. 2.



Inventor:
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 by *Henry D. Smith* Attorney

UNITED STATES PATENT OFFICE.

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SYSTEM FOR THE TRANSMISSION OF ELECTRICAL ENERGY.

1,053,098.

Specification of Letters Patent.

Patented Feb. 11, 1913.

Original application filed December 26, 1905, Serial No. 293,216. Divided and this application filed June 2, 1911. Serial No. 630,811.

To all whom it may concern:

Be it known that I, CHARLES D. LANNING, a citizen of the United States, and a resident of Boston, county of Suffolk, State of Massachusetts, (whose post-office address is 95 Milk street, Boston, Massachusetts,) have invented an Improvement in Systems for the Transmission of Electrical Energy, of which the following description, in connection with the accompanying drawings, is a specification, like characters on the drawings representing like parts.

My invention relates to methods for reinforcing an electrical current on a conductor by the action of said current upon another current and the impressing or superposing upon said first mentioned current of a third current set up or controlled by said second current; and my improved method has reference particularly but not exclusively to the reinforcing of telephonic alternating currents.

This application is a division of my prior copending application Serial No. 293,216, filed December 26, 1905.

For the purpose of describing the aforesaid improved method I have in the annexed drawings indicated apparatus that may be employed.

In these drawings: Figure 1 is a diagrammatic representation of circuit connections in a telephone system, with apparatus for the practise of the method. Fig. 2 is a similar view of telephonic apparatus with the connecting circuits differently arranged.

Referring to these drawings and particularly to Fig. 1, *a* represents a circuit intended for the transmission of electrical energy. In this particular instance I will describe the same as a telephonic circuit connecting the separated stations A, B, which are each adapted both for the transmission and receipt of telephonic voice-created currents. For this purpose each station is provided with the usual receiver *r*, transmitter *t*, battery *b* and induction coil *c*. At each station, and as represented in Fig. 1 adjacent thereto, there is located reinforcing repeating means at R for impressing upon the line circuit current undulations proportional to those generated in the transmitting circuit of the station which may be intensified in amount. The means herein illustrated comprises a local circuit *d*, the latter including

a battery *e* and some means for varying the energy of said local or repeating circuit, such for example, as the variable resistance medium *f*, located in the repeating circuit which is here conventionally shown, but which may be of any ordinary or usual construction. The local circuit is associated with the line circuit so as to impress its current variations upon the line circuit, such association in the illustrated system being through the medium of the induction coil *g*. The variable resistance medium *f* is subject to the controlling influence of the electro-magnet *h*, the latter being in series with the secondary of the induction coil *i*, the primary of which is connected in line and in series with the secondary of the induction coil *g*.

With the connection shown the current undulations generated in the transmitter *t* and impressed upon the line circuit are inductively reproduced in the coil of the electro-magnet *h*, causing the variable resistance *f* to impress similar and harmonious undulations upon the local circuit *d*, as will be well understood. The undulations of the local circuit are in turn impressed upon the main circuit to reinforce the original impulses through the medium of the induction coil *g*.

It is to be understood that the repeating agency employed may be any means adapted to receive telephone currents and reproduce therefrom currents harmonious therewith, the invention being limited neither to the employment of a variable resistance medium nor any other one particular agency for the purpose.

It will be observed that the current undulations transmitted in either direction from one station to the other are effective in causing intensified but harmonious undulations to be cumulatively impressed upon the line circuit.

In Fig. 2 I have shown an application of this invention to a system embodying widely separated stations where it is desired to introduce one or more repeating stations C, D, at intervals to step up or reinforce the weakened energy line undulations reaching the repeating station. Each repeater station has a local or repeating circuit *d*, similar to that already described, and inductively related to the line through the in-

duction coil *g*. There is also provided a similar magnet *h*, adapted to be energized by the line undulations, but herein shown as directly included in the line circuit, instead of inductively associated therewith as before.

It will be observed that the single repeating circuit at each station is in operative relation to the line for intensifying the energy undulations transmitted from either station, this being accomplished by cumulatively and harmoniously adding the undulations of the repeating circuit to those of the line, no matter in what direction transmission takes place.

This discussion of the apparatus described in said drawings and its operation clearly discloses my improved method of reinforcing the current entirely by series action of a conductor carrying the current upon related apparatus and the harmonious reimpression by such related apparatus upon the line and by series action thereon of another current which is added to the original line current by synchronous and harmonious impression thereon. The broad object of this method is to secure the reinforcement of telephone currents by closed circuit arrangements without resorting to what are known in the art as "bridged" or "reciprocally arranged" repeating instruments. In "bridged" arrangements while the new current set up by the repeating or reinforcing instrumentalities is theoretically added to the original line current, all line currents are divided among the different circuit portions formed by the "bridged" connection in the line and consequently the full line energy does not reach the distant terminal receiving instrument although it is for the purpose of strengthening the action of such instrument that the current is reinforced. Moreover in all such "bridged" arrangements, with which I am familiar, artificial resistances or other elements are interposed in the circuits (that is, elements having no necessary connection with the direct current reinforcing operation) and all current effects upon the line are thereby weakened. Still further it is generally necessary with such "bridged" arrangements to provide means whereby the different line portions may be adjustably brought into an electrically balanced relation as the circuit connections from time to time, affected by the reinforcing station, vary the length or electrical qualities of the different circuit portions. In closed circuit reinforcing arrangements involving "reciprocally arranged" repeating instrumentalities (that is, duplicate repeater arrangements, each section of the line being independent of the other except as related through the repeating devices and each section of the line having connected therein the receiving ele-

ment of one repeater, of which the transmitting element is connected into the other line section, and the transmitting element of the other repeater of which the receiving element is connected to the other line section) the action is substantially a pure relaying action similar to what takes place in a two-way telegraphic repeater; that is, there is no cumulating of the repeater-caused current upon the original line current; and in such forms there is in general a tendency to a strong reactive singing in the line unless at least artificial balancing or neutralizing elements are introduced into line connections.

By the use of my invention as herein disclosed provision is made for synchronously and harmoniously reinforcing a telephone line current by means of repeater circuits serially related to the line, said repeater circuits including appropriate receiving elements and appropriate transmitting elements magnetically independent each of the other. Both synchronous and harmonious action of the repeater circuits on the line is necessary for uniform and most successful operation.

Lack of synchronism results from mechanical or electromagnetic lag in repeater circuits as related to associated line circuits;—and the effect of such lack of synchronism is to distort the form of the line current wave so that a double-peaked wave may result from a single peaked wave originally impressed upon the line, thus producing self-continuing or reactive operation of the whole circuit arrangement. This is the characteristic fault of such arrangements as shown in the patent to Gilliland, #247,631, September 27, 1881, and similar arrangements;—and is present in bridged forms of repeater circuits such as are shown in patents to Arnold, #542,618 and 542,619, and analogous arrangements. Reaction in such forms results from mechanical and electro-magnetic lag factors between the excitation of the repeating instrumentalities by the line and the resulting excitation of the line by the repeating instrumentalities, with subsequent renewed excitation of the repeater. It is analogous to the reaction produced by holding a commercial telephone receiver closely opposite a related transmitter in which relation frequently a continuous reactive "singing" of the receiver is heard. This is produced by the lag in the passage through the air of the vibration set up by the receiver diaphragm, which vibration is primarily caused by the original movement of the transmitter diaphragm. The electric impulse flows at the assigned speed of electric current conductor flow but the air wave moves at a relatively slow speed, so that each receiver diaphragm movement causes a subsequent movement of the

transmitter diaphragm. Where a telephone receiver and transmitter are operatively connected or related electrically each to the other as in closed-repeater circuits the conditions of lag causing reaction are closely analogous to those just discussed.

By "harmonious" action of the repeater circuits and instrumentalities on the line, as distinguished from "synchronous" action, I have reference to two factors. The first is the relation of the wave form received by the repeater circuits from the line and the wave form re-impressed on the latter by the former. These obviously should be the same;—which means, when alternating line currents are employed, that the same phase (positive or negative) received by the repeater circuits from the line should be re-impressed by them on the line. This it will be apparent (disregarding internal connections in the repeater circuits, that is, connections therein other than those to the main line) is accomplished by properly arranging the terminal connections of the repeater circuits to the line. Each set of repeater circuits should be so connected to the line that the line wave form impressed on the repeater-receiver shall be re-impressed by the repeater-transmitter on the line. If this is not done, obviously distortion and change of wave form on the line will or may result, with consequent double-peaked wave forms in place of single-peaked wave forms; and, since the line and the repeater instrumentalities are in electrical connection, self-excitation or "reaction" will be produced, with a "singing" of the line. This is a characteristic fault of bridged forms of repeater circuits, and results therein from the fact that the various portions of the circuit formed by the bridge necessarily have, under varying operating conditions and unless means are provided for artificially balancing the same, various and different components of resistance, capacity and inductance, which produce change of the wave form as originally impressed on the line. The serial connection herein disclosed avoids these factors because the unitary condition of the transmitting line is not disturbed. A second factor relating to "harmonious" circuiting has to do with the internal connection in the repeater circuits. Assuming as constituent elements of the repeating instrumentalities an initially magnetized receiving element, responding differentially to the phases of an alternating current (constituting therefore, as does the commercial receiver when used with alternating currents, a true "polarized" device) and a local direct current varied in value by such receiving device and in turn operating to vary or produce a line current that finally reacts on the repeater-receiver, it is important that the connection of the circuit carrying the

local current to the repeater-receiver-governed current-varying means affecting such local current shall be such that any current impression put on the line by the repeater will produce in the said local current the change necessary to produce said last mentioned current impression. To make this clear, if the repeater local-current varying-device is a variable resistance microphone acted upon by an armature in the field of an initially magnetized electro-magnet adapted to be energized by the main line, then not only must the terminal connections of the line and the repeater circuits be "harmonious," but the connections of the local circuit to said current-varying device must be such that any given direction of movement of the said armature shall produce an immediate local direct-current effect (and consequent line current effect) that, ultimately, reacting on the said magnet through the line, will produce the same direction of movement of said armature. If this is not done a condition is produced analogous to that existing in the interrupter of induction coils; that is, each change of movement by the armature tends, through the connections and magnetic arrangement, to produce an opposite movement thereof, and reactive "singing" of the line will result.

It will be evident from the foregoing that in the serially connected repeater or reinforcing circuits and instrumentalities that I have disclosed I have provided means whereby a transmitter line may be kept in the normal, unitary connection from terminal to terminal and telephone currents thereon reinforced by harmonious connection and synchronous action, so that the disturbing and variable factors present in "bridged" or "reciprocally" arranged repeaters are avoided. The action of the line on the repeater and of the repeater on the line is obviously best had through undivided circuits.

I do not herein claim the apparatus for carrying out the described method, such apparatus being claimed in another copending application.

Where in the claims I refer to the repeater-receiver element and the repeater-transmitter element as being magnetically independent each of the other what I mean is such construction that the coils or windings of one do not act upon the coils or windings of the other in any except the desired manner, so that they are free from operative interference. This in general means (since the coils necessarily have magnetic cores) that the magnetic cores of the respective elements are separate from each other, whereby the magnetic flux set up by the receiving instrument is not directly operative upon the transmitting element, the latter being designed to be controlled by an independently created magnetic flux.

Claims:

1. The method of reinforcing a varying current which consists in setting up by the series action of a conductor carrying said current variations of a second current harmonious with the variations of said first mentioned current; in creating by the action of said second current a third varying current harmonious in its variations with the variations of said second current; and in impressing said third mentioned current serially upon said first mentioned current synchronously and harmoniously with the variations thereof; and which consists further in maintaining the said action of said first mentioned varying current on said second current and the said action of said third mentioned current on said first mentioned current each magnetically independent of the other.

2. The method of reinforcing an alternating current which consists in setting up by the series action of a conductor carrying said current variations of a second current harmonious with the variations of said first mentioned current; in creating by the action of said second current a third varying current harmonious in its variations with the variations of said second current; and in impressing said third mentioned current serially upon said first mentioned current synchronously and harmoniously with the variations thereof; and which consists further in maintaining the said action of said first mentioned varying current on said second current and the said action of said third mentioned current on said first mentioned

current each magnetically independent of the other.

3. The method of reinforcing alternating telephone currents on a line which consists in setting up by the series action of variations of current flow in said line an undulatory direct current harmonious with the waveform of said alternating current; in setting up by the undulations of said direct current a second alternating current, and in impressing said second alternating current on said line by series action thereon, synchronously and harmoniously with said first mentioned alternating current; and which consists further in maintaining said two series actions magnetically independent of each other.

4. The method of reinforcing alternating telephone currents on a line which consists in setting up by the series action of said line a second alternating current harmonious in its wave form with said first mentioned alternating current; and in impressing said second alternating current on said line by series action thereon synchronously and harmoniously with said first mentioned alternating current; and which consists further in maintaining said two series actions magnetically independent of each other.

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

CHARLES D. LANNING.

Witnesses:

EVERETT S. EMERY,
ROBERT H. KAMMLER.