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OSCILLATION CONTROL DEVICE

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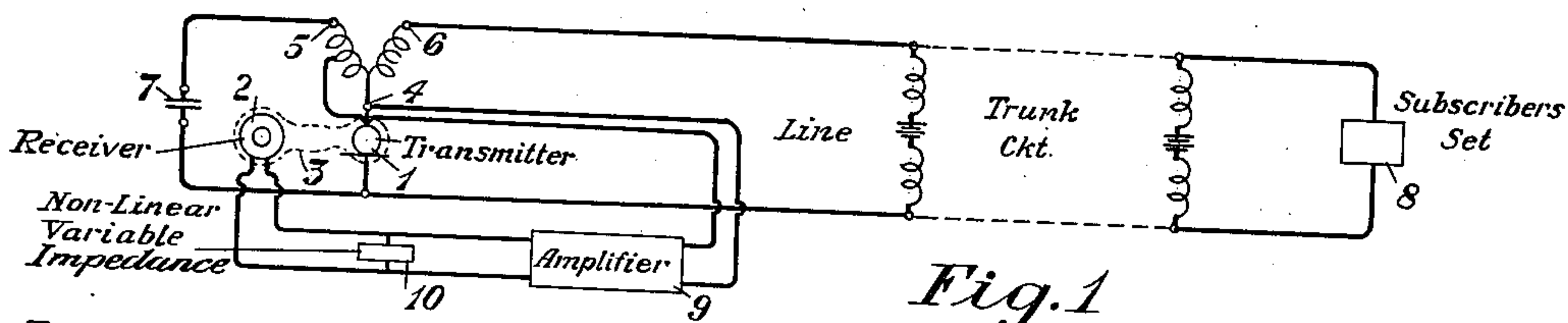


Fig. 1

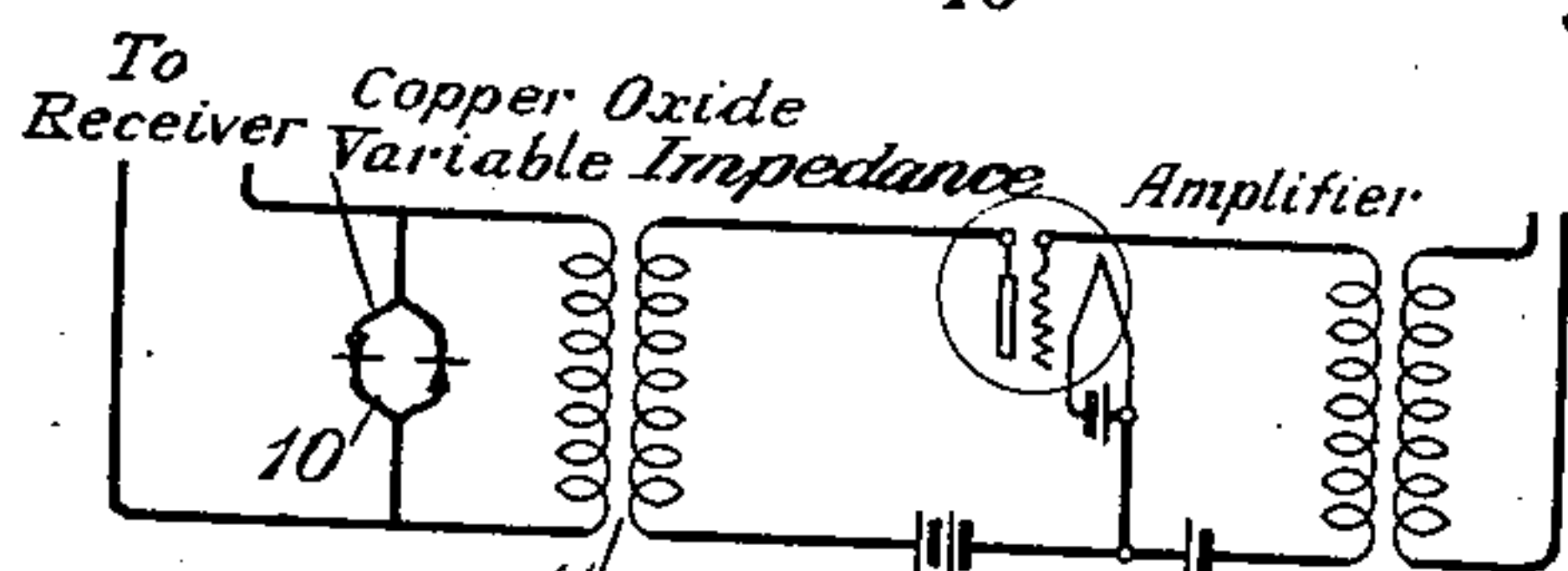


Fig. 1a

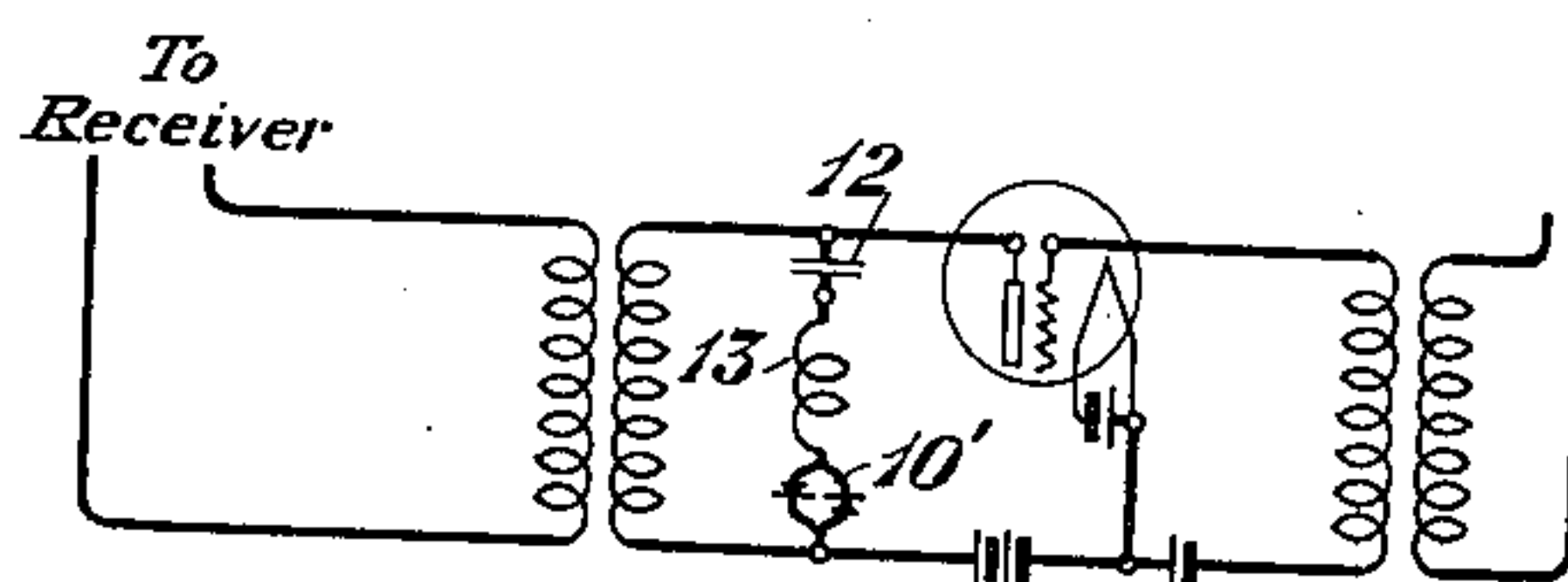


Fig. 1b

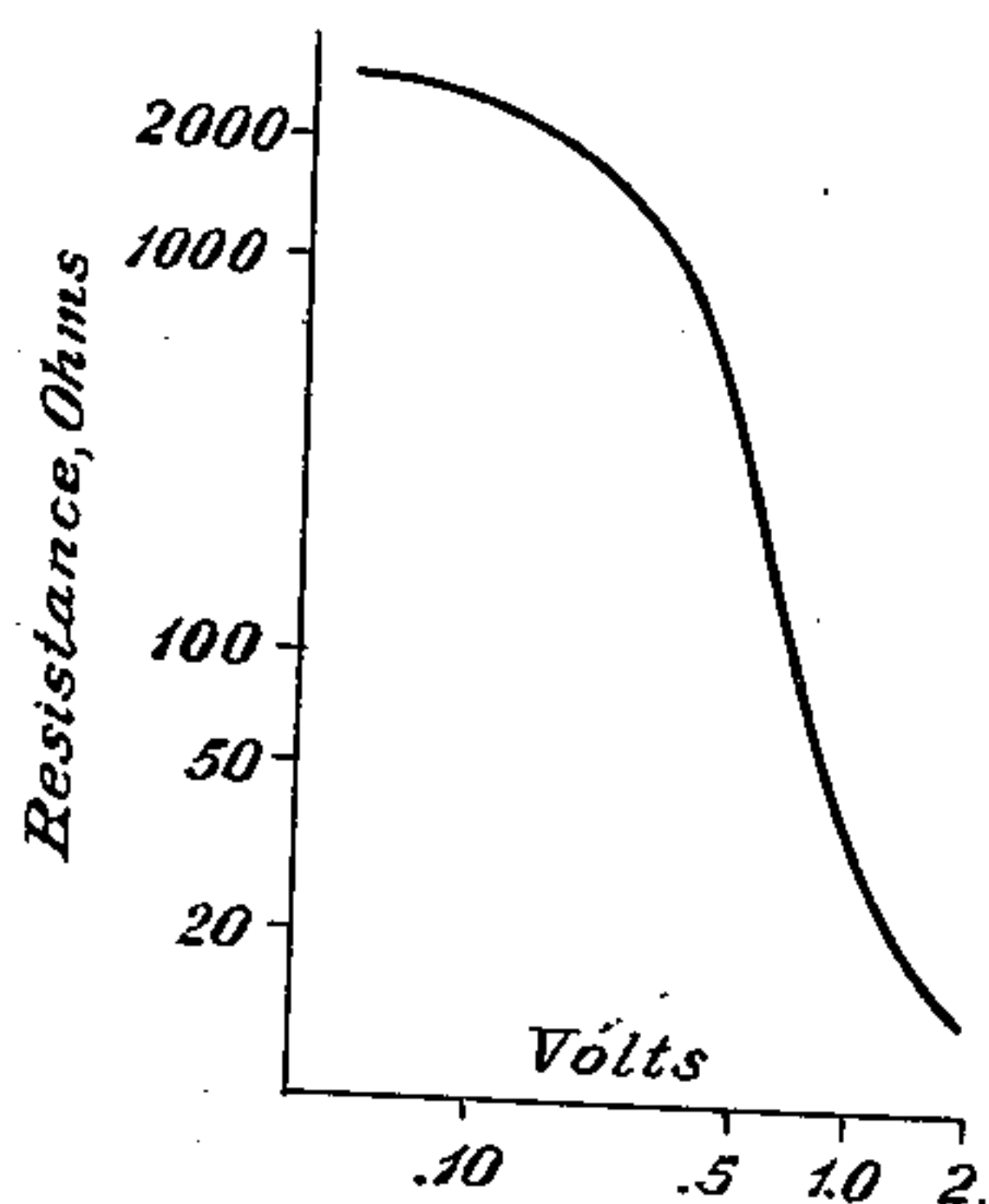


Fig. 1c

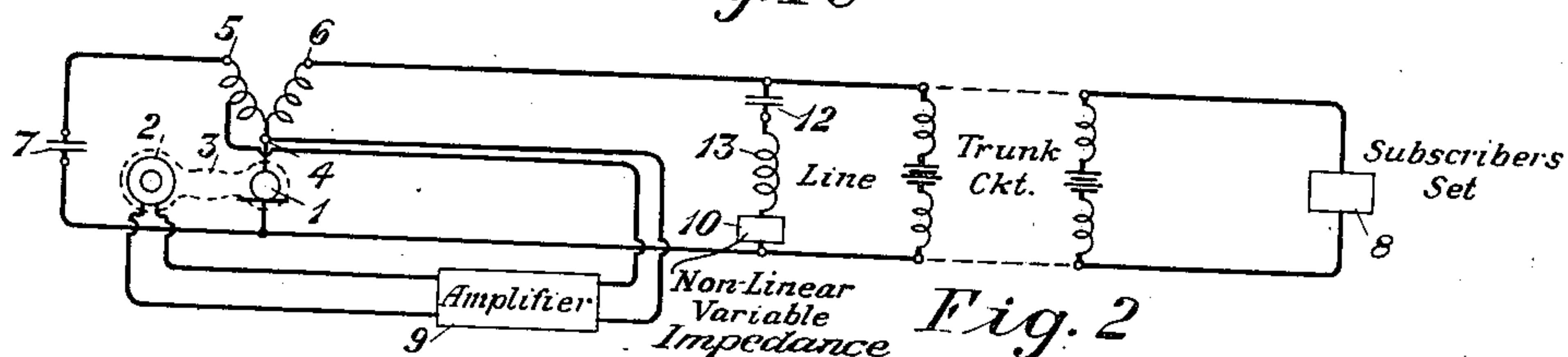


Fig. 2

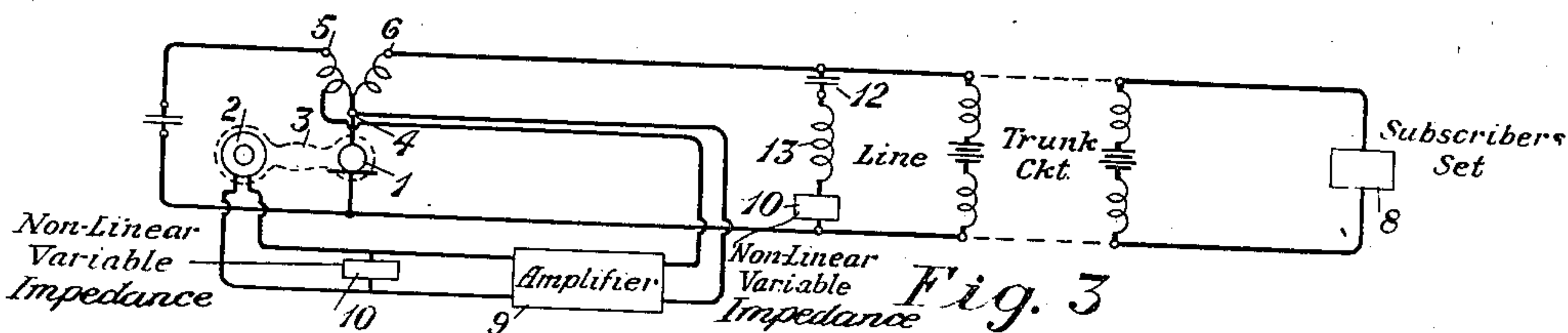


Fig. 3

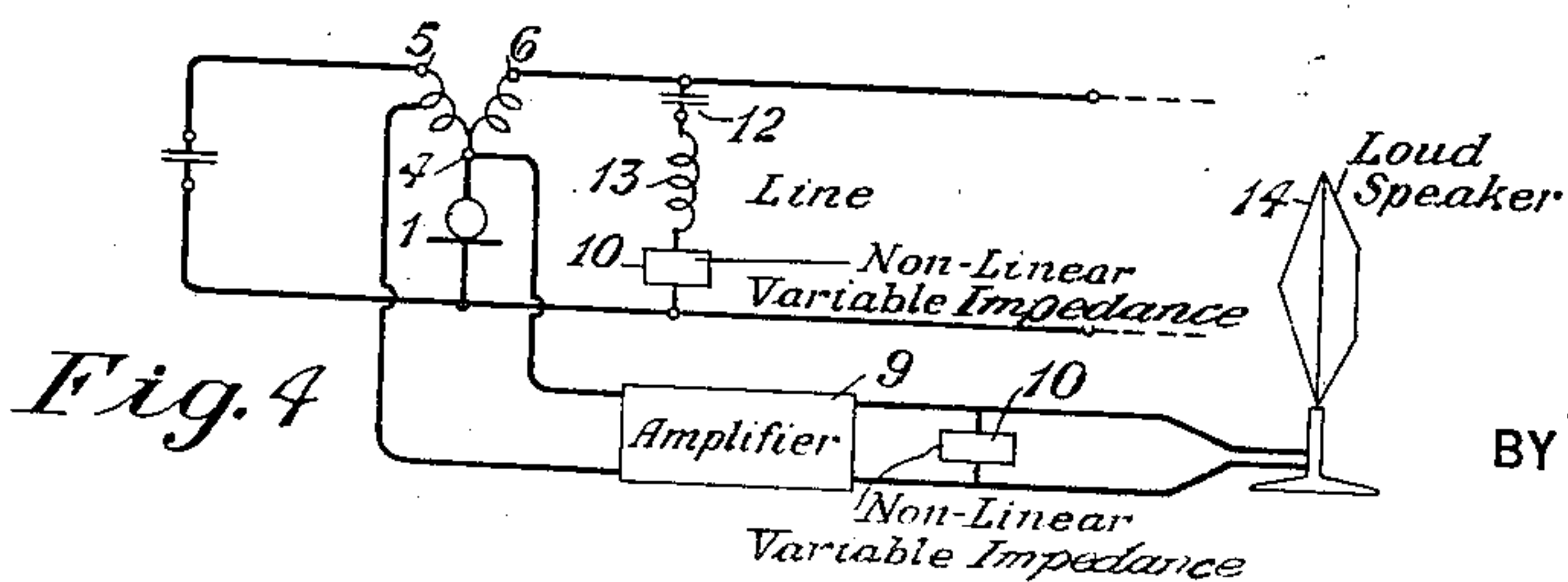


Fig. 4

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OSCILLATION CONTROL DEVICE

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7 Claims. (Cl. 179—81)

This invention relates to a system for controlling electrical oscillations and, particularly, to means for regulating the feed-back voltage in an oscillating circuit without affecting the fixed gains and losses in the circuit.

It is well known that in the operation of a circuit containing an amplifier, oscillations will be set up in that circuit, by virtue of some form of coupling between the output of the amplifying element and its input, whenever the loss between the output and input terminals of that amplifier is less than the gain effected by the amplifier. Those oscillations will build up in intensity until the load-carrying capacity of the amplifier is reached. While the form of the coupling between the output and the input of the amplifier may be electrical, mechanical or acoustical, the invention will be described in connection with circuits embodying the last two forms of coupling but it is to be understood it is equally applicable to a system employing the first-mentioned type of coupling.

One of the objects of this invention is to increase the net gain obtainable from an amplifier in a circuit susceptible to the production of oscillations without causing the setting up of oscillations. Another object of the invention is to effect a reduction in the intensity of the oscillation when it occurs.

Other objects of this invention will be apparent when the following description when read in connection with the attached drawing of which Figure 1 shows schematically the mode of application of the invention to a subscriber's telephone set in which an amplifier is employed to increase the intensity of the speech voltages received from the line. Since any agitation of the transmitter results also in a voltage across the line oscillation or "singing" may occur through the mechanical coupling furnished by the handset handle and the acoustic coupling through the air between the receiver and transmitter.

Figs. 1a and 1b show in greater detail, the form of amplifier and the mode of connecting thereto the regulating device; Fig. 1c is a graph showing a characteristic of one form of the regulating device employed in my invention; Figs. 2 and 3 show other modes of applying the regulating device to a subscriber's telephone circuit and Fig. 4 shows the employment of the invention in a system in which a loudspeaker serves as the receiving device, as in a two-way private address system, the coupling between the loudspeaker and microphone or transmitter being acoustic only.

In Fig. 1, 1 represents a telephone transmitter and 2 is a telephone receiver, which devices are

connected mechanically by the handle of a handset represented by the dotted lines indicated by 3. The transmitter 1 is connected to the junction of the windings 4—5 and 4—6 of the induction coil. A condenser 7 is connected between the other side of the transmitter 1 and terminal 5. Also, the line is connected between said other side of the transmitter 1 and the terminal 6. This line may be any type of telephone circuit having connected therewith some form of apparatus here designated a trunk circuit and subscriber's set. Bridged across a portion of the winding 4—5 is the circuit leading to the receiver 2. This circuit contains an amplifier 9 and a non-linear impedance device 10, the structure and function of which will be made clear hereinafter. Except for the amplifier and the non-linear impedance, the subscriber's circuit just described is a type of antisidetone circuit that is well known to those familiar with the art. The electrical variations produced by the transmitter 1, corresponding to the sound impressed thereon, will be transmitted to the line and also to the circuit 4—5—7, but, owing to the structure and proportioning of the circuit, such variations will be greatly reduced before reaching the receiver 2.

In order to increase the loudness of the received speech, an amplifier is connected in the receiver path between the winding 4—5 and the receiver 2. Since the receiver and transmitter are coupled mechanically through the handle 3 and are also coupled acoustically through the air, oscillations will be set up if the gain of the amplifier is increased to a certain value. I have found that, if a nonlinear variable impedance device, such as 10, is connected across the output of the amplifier, and that device is capable of introducing an increased bridged loss with increase of the output voltage of the said amplifier, the amplifier may be operated at a relatively high gain without going into an oscillating condition. A suitable type of non-linear device is a full-wave copper-oxide rectifier, the characteristic of which is shown in Fig. 1c. As shown by that characteristic curve, the alternating current impedance of a copper-oxide device falls rapidly and nonlinearly with increasing voltage. It is to be understood that those copper-oxide devices, as employed in this invention, do not rectify but merely serve as impedances which vary nonlinearly with applied voltage. Those devices, which are represented by 10' in Figs. 1a and 1b, may be connected either across the secondary of the output transformer 11, as shown in Fig. 1a, or in series with a condenser 12 and the in-

ductance 13 across the plate circuit of the amplifier, as shown in Fig. 1b. In the latter arrangement, the condenser 12 serves to prevent the flow of direct current through the copper-oxide element, which would render it inoperative. The inductance 13 neutralizes the effect of the condenser 12 and the combination tunes the path containing the copper-oxide device approximately to the natural period of the feedback circuit. This permits the non-linear device 10' to exercise the maximum control at the frequency at which oscillations occur. As mentioned before, the action of the non-linear element is to introduce a bridging loss which depends on the output voltage of the amplifier. The voltage required to overcome the other losses in the feedback path causes the non-linear device to decrease in resistance so that a further increase in voltage is required to induce oscillation. If the gain of the amplifier is progressively increased, a point will be reached where the loss caused by the non-linear device, together with the circuit losses between the output and the input, cannot be less than the gain of the amplifier. The circuit will then oscillate but the intensity will be limited by the non-linear element which will balance any increase by a corresponding increase in the bridging loss. While the non-linear device 10' has been shown connected to the output of the amplifier, either across the plate circuit or across the secondary of the output transformer, it is obvious that such device could be, if properly proportioned, connected across any part of feedback circuit as, for example, the input circuit of the amplifier. This would, of course, involve working upon lower voltages but the basic principle underlying the invention would remain unchanged.

Fig. 2 shows the use of the non-linear device, in the form shown in Fig. 1b, to maintain the line circuit effectively closed at all times and without producing a large bridging loss across said line that would impair transmission. The anti-sidetone form of circuit which is employed in illustrating all figures is essentially a Wheatstone bridge, one arm of which is the line circuit. As long as perfect balance is maintained between the line and the other arms of the bridge, the electrical variations produced by the transmitter will not affect the receiver so that the user of the telephone will not hear his own speech in the receiver and, furthermore, there is no possibility of oscillation or "singing" occurring. During the progress of a call there may be times when the subscriber's line is terminated in a very high impedance as, for instance, when the trunk is open. At such times, the balance of the Wheatstone bridge is destroyed and singing or sidetone would be perceived in the receiver 2, were it not for the presence of the non-linear device 10' across the line circuit. The manner in which this device functions to prevent those troubles is as follows: When the line is opened and the balance is momentarily destroyed, oscillations will tend to arise due to the feedback through the transmitter and receiver. However, the voltage thus generated across the line (and therefore across the bridged resonant circuit containing the non-linear device 10') tends to lower the resistance of that element (as shown by Fig. 1c) until a value is reached that is substantially equivalent to the impedance of the line, for example, 600 ohms. This automatically and substantially balances the Wheatstone bridge thereby suppressing the oscillations. Since a perfect balance is not ob-

tained in ordinary practice oscillations may be induced by a sufficient increase in the amplifier gain. When this occurs the intensity of the oscillation is not limited by the arrangement since the balance is not improved by exceeding the output voltage which is just sufficient to start the oscillation. However, by connecting a non-linear element as shown in Fig. 1 in addition to the element shown in Fig. 2 or with the arrangement shown in Figs. 3 and 4 an additional increase in gain may be obtained before oscillation occurs and when this gain is exceeded the intensity of the resulting oscillation is limited as described above.

It is desirable to point out that even though no oscillations are set up by the amplifier circuit and only the speech frequency voltages exist across the non-linear devices connected across the output of the amplifier and also across the line, the voltages may be high enough, particularly when the person using the equipment is talking, to lower the impedance of the element and to cause a transmission loss. This, however, is a benefit in that it reduces the volume of the sidetone and prevents uncomfortable speech levels from reaching the listener. For speech coming over the line, as from the distant subscriber's set, there is no loss except for currents of unusually high intensities which, of course, may be attenuated somewhat without impairing transmission.

Although this invention has been described in connection with a circuit in which the feedback has been established mechanically and acoustically, it is desired to point out that the invention is also applicable to a circuit in which the feedback may be either mechanical or acoustical or electrical, or a combination of those various modes of coupling. Furthermore, it is desired to point out that, while the invention has been described in connection with a subscriber's circuit employing a handset, it is applicable to other types of circuits as, for example, one in which a loudspeaker is employed for the reception and translation of the electrical variations representing the transmitted sound.

The arrangement shown in Fig. 4 represents the employment of the invention in a two-way private address system in which the sound of the received speech is produced by means of a loudspeaker instead of a telephone receiver, as in the other figures. The coupling between the loudspeaker and the microphone or transmitter of the arrangement shown in Fig. 4, is purely acoustic. The devices for controlling the feedback voltage in Fig. 4 function in the manner described in Fig. 3.

It is desired to point out that the term "amplifier" or "amplifying device" is used generically and is intended to cover not only vacuum tube or mechanical repeaters, but also to cover other devices capable of amplification, such as telephone transmitters.

While this invention has been disclosed as embodied in particular forms, it is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In an amplifying circuit, the combination with an amplifier having input and output circuits effectively coupled so that oscillations will be set up whenever the loss through the feedback path is less than the gain of the amplifier and a non-linear variable impedance device connected

across the output of the feedback path to effectively increase the loss through said path whenever the voltage increases across the said device thereby preventing the continuance of said oscillations.

2. In an amplifying circuit, the combination with an amplifier having input and output circuits effectively coupled so that oscillations will be set up whenever the loss through the feedback path is less than the gain of the amplifier and a non-linear variable impedance device connected across the feedback path to effectively increase the loss through said path whenever the voltage increases across the said device thereby preventing the continuance of said oscillations.

3. In an amplifying circuit, the combination with an amplifier having input and output circuits, the said circuits being effectively coupled, of a source of voltage connected to the input circuit, means connected to the output circuit responsive to the voltage applied to said input circuit as amplified by the amplifying element of said amplifier and a non-linear variable impedance device connected to the output of said amplifier, the said device having the characteristic of decreasing its impedance whenever the voltage applied across its terminals is increased thereby increasing the loss in the feedback path to prevent the creation of oscillations.

4. In a telephone system, the combination with a subscriber's circuit including a transmitter, a receiver and an induction coil, and a line connected to said circuit, the said circuit and said line constituting in effect a balanced Wheatstone bridge whereby electrical variations produced by said transmitter will produce substantially no effect upon said receiver so long as said line balances said bridge, and a non-linear variable impedance device connected to said line to effectively and automatically maintain the balance of said bridge whenever changes in the electrical characteristics of said line tend to destroy said balance.

5. In a telephone system, the combination with a subscriber's circuit including an induction coil, a transmitter and a receiver effectively coupled to each other, and a line connected to said circuit, the said circuit and said line forming a balanced Wheatstone bridge, whereby the electrical variations set up by said transmitter will produce substantially no effect upon said receiver so long as said line balances said bridge, a non-linear variable impedance device connected to said line to effectively maintain the balance of said bridge whenever changes in the electrical characteristics of said line tend to destroy said balance, an amplifier connected between said coil and said receiver and another device connected across the output of the amplifier to increase the loss whenever the feedback voltage of the amplifier increases.

6. In a telephone system, the combination with a line of a circuit connected thereto, the said circuit including an induction coil, a microphone and a sound producing device acoustically coupled to said microphone, the said circuit and said line forming a balanced Wheatstone bridge, a non-linear variable impedance device connected to said line to maintain the balance of said bridge when variations occur in the electrical characteristics of said line, an amplifier connected between the induction coil and the sound producing device and another non-linear variable impedance device connected to said amplifier to increase the loss through the feedback circuit whenever the feedback voltage of said amplifier increases.

7. The method of controlling the feedback voltage in an oscillation circuit without affecting the fixed gains or losses in the circuit which consists in increasing the gain in amplification until oscillations are set up, then increasing the loss in the feedback by decreasing the impedance non-linearly with increase in the feedback voltage.

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