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TELEPHONE LINES

Filed Sept. 19, 1927

Fig. 1

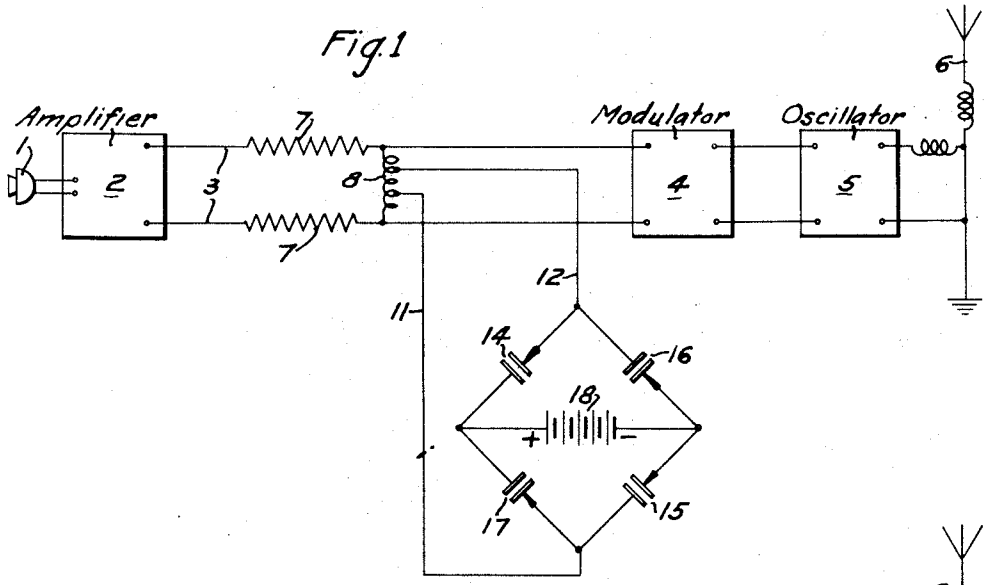
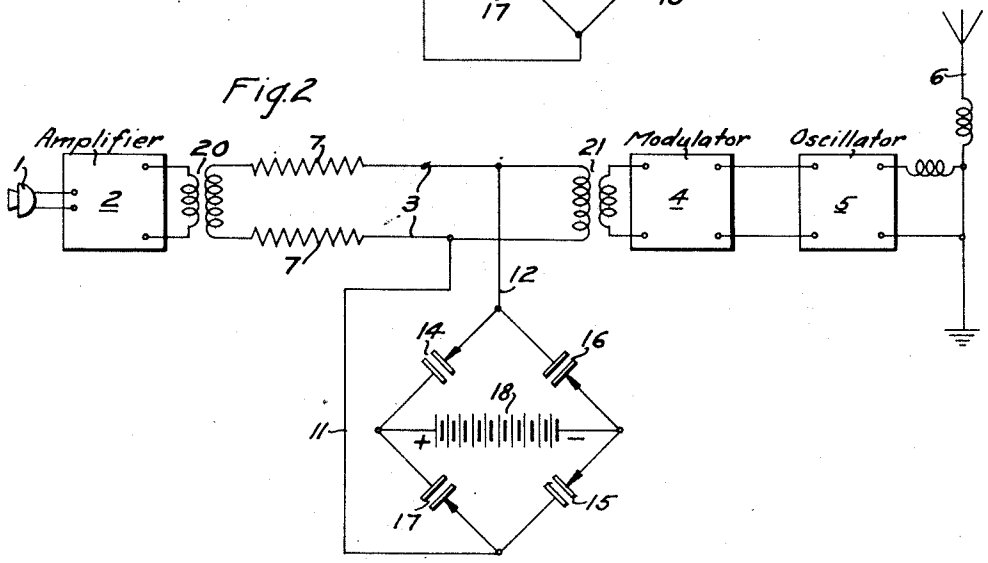


Fig. 2



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TELEPHONE LINES

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This invention relates to telephone lines and is particularly applicable to the connections between a radio transmitting studio and the radio sending station.

The variation of current or of voltage caused by the voice is small. Much amplification is, therefore, necessary before the variation may be effectively impressed upon the output of a powerful radio sending station. Most amplifying devices have a characteristic, certain portions of which are curved and only a small fraction of which is a straight line. In order to avoid distortion in the broadcasted signal, it is necessary that the amplifiers be operated on that portion of the characteristic which is straight.

Consequently, amplifiers are selected which are capable of delivering a much greater power than the intended operation of the system requires them to deliver. If, through any accident, the circuit, which is intended to carry the voice current experiences a greater variation of current or of voltage than normal operation causes, this greater variation is magnified by the amplifiers. The circumstance that the amplifiers are capable of delivering a much greater power than that they normally deliver enables this magnification to produce a very great change in the current or the voltage at the broadcasting station. Such great changes may cause serious damage.

It is, therefore, important that voltages produced at the studio in excess of a certain limit shall not arrive at the sending station.

Efforts have been made to avoid excess voltage at the sending station by inserting in the line from the studio to the station a voltage-limiting device. Such efforts have heretofore been accompanied by the undesirable result that they absorbed the energy corresponding to certain elements of the modulation to a greater extent than that corresponding to other elements, with the result that the quality of the sound in the received signals was distorted.

It is an object of this invention to provide a voltage-limiting device which may be inserted between the studio and the broadcasting station without producing the disadvantage present in devices heretofore proposed. This device may be located at any convenient point in the audio circuit if, for any reason, it is not put in the line connecting the studio and the station.

It is a further object of this invention to provide, across the line connecting the studio to the broadcasting station, a shunt which shall be practically non-conducting until the voltage on the line reaches a certain value and shall be highly conducting for voltages above that value.

It is a further object of this invention to so fix the value of the voltage at which the shunt shall become conducting that it is above the voltages at which distortion is necessarily present and below the voltage at which any danger to the apparatus is present.

It is a further object of this invention to obtain advantage, from the circumstance that the change in voltage which causes the shunt to change from conducting to non-conducting, although very small, is finite.

Other objects of the invention and details of the construction will be readily understood from the following description and the accompanying drawings, in which:

Figure 1 is a diagram of circuits and apparatus embodying the invention; and

Fig. 2 is a similar diagram showing a modification.

The microphone 1 is located in the studio or at the point where the sound, which is to be broadcasted, originates. An amplifier or a succession of amplifiers, accompanied, if necessary, by a filter, is inserted, as indicated at 2, between the microphone 1 and the line 3.

The line 3 extends to the modulator 4. Any usual or suitable amplifier or combination of amplifiers and filters may be provided between the line 3 and the modulator 4 for producing, at the modulator, a sufficient voltage to control the transmission set. By this means, the effect of the line, both on the strength and on the quality of the signal, is corrected.

The rectangle 5 represents the usual radio-frequency generator for imparting to the antenna 6 energy capable of being radiated therefrom. Either the amplitude or the fre-

quency of the oscillations radiated may be controlled by the modulator 4. The radiations delivered from the antenna 6 are then modulated in accordance with the sound impressed upon the microphone 1.

Two resistors 7 are included in the line 3. If the line is long enough, the resistors may be the resistance of the line itself, but if not, local resistance may be added to the line. A shunt comprising an inductor 8, is placed across the line between the resistors 7 and the modulator 4.

The inductor may constitute an auto transformer, and the leads 11 and 12 from two points upon the inductor 8 will have impressed upon them a voltage smaller than the line voltage. The voltage-limiting device is inserted between the leads 11 and 12.

The essential feature of the voltage-limiting device is a rectifier, associated with a biasing battery. All familiar rectifiers, including mercury-arc devices and hot-cathode vacuum tubes, are adapted for use with this invention but I prefer the copper-oxide rectifier. This is conventionally represented upon the drawing by a combination of the usual symbols for a rectifier and for a condenser in order to indicate that the device has both a rectifier action and a condenser action.

Some benefits may be obtained by a single rectifier in series with a battery, but, in order that like limits may be placed upon the line voltage in each direction, two such rectifiers should be used. Two batteries may then be used, if desired, but I prefer a combination in which a single battery is used.

Various expedients for using a single battery to bias two rectifiers are contemplated, but the one which I prefer includes four rectifiers arranged in the form of a Wheatstone bridge.

As illustrated in Fig. 1, the rectifiers 14 and 15 are so placed that their conductive direction is from the lead 12 toward the lead 11, while rectifiers 16 and 17 are so placed that their conductive direction is from the lead 11 toward the lead 12. A path, conductive from the lead 12 to the lead 11, may be traced through rectifier 14, across battery 18, and through rectifier 15 to the lead 11. This path extends through the battery from the positive to the negative pole.

A path, conductive from the lead 11 to the lead 12, may be traced from the lead 11 through the rectifier 17, across the battery 18, and through the rectifier 16 to the lead 12. It will be seen that, although this connection is from the lead 11, while the connection first traced is from the lead 12, both connections extend through the battery 18 in the same direction. The electromotive force of the battery is in the direction in which the two paths just traced are nonconductive.

The structure illustrated in Fig. 2 requires a higher potential on the line than that shown in Fig. 1. This is provided by a step-up transformer 20 between the output of the amplifier 2 and the line 3. For the return to the normal-voltage level, a step-down transformer 21 is inserted between the line 3 and the modulator 4.

The resistors 7 have been shown in the high-potential line 3. The effect of these resistors may, however, be obtained by including the corresponding resistance in the primary of the transformer 20 or in the leads from the amplifier 2 to the transformer 20. Although, therefore, I have spoken of the line 3 as extending from the studio to the broadcasting station, it will be clear that, the geographically long line may be between the amplifier 2 and the transformer 20, if preferred. The line 3 will then be of a short length only.

In the operation of the device, potentials of voice frequency are impressed upon the line 3 by the amplifier 2 and the resulting current in the line 3 controls the modulator 4. Even though the input of the modulator be a voltage-responsive device, some current must be used in operating it and this current will produce some drop over the resistors 7. The voltage applied to the ends of the inductor 8 is less than the voltage delivered by the amplifier 2, by the magnitude of this drop.

As the voltage across the inductor 8 changes, the voltage across the leads 11 and 12 changes. Whenever the potential of the lead 12 exceeds the potential of the lead 11 by more than the potential of the battery 18, a conductive path is established from the lead 12 through the rectifier 14, the battery 18 and the rectifier 15 to the lead 11. If the difference in voltage between leads exceeds the battery voltage by only a very small amount, the rectifiers will not be of as low resistance as if the said excess be of a somewhat greater amount. The change of the path from nonconductive to conductive character, while not absolutely abrupt, requires only a very small excess of impressed voltage over the biasing voltage of the battery 18.

When the connection between the lead 12 and the lead 11 is conductive, it is, in effect, a short circuit about a portion of the inductor 8. This inductor will, therefore, now act as a transformer having a short-circuited secondary, that is, it will, in effect, place a short circuit across the line 3 between the resistors 7 and the modulator 4.

The voltage impressed by the amplifier 2 will now cause a larger current and this will result in a larger drop in the resistors 7. The drop will be of such size that the voltage impressed upon the modulator 4 is substantially equal to that voltage at which the path from the lead 12 to the lead 11 becomes conductive, multiplied by the voltage-ratio of the auto-transformer.

Similarly, when the voltage of the lead 11 exceeds the voltage of the lead 12, a path is established through rectifier 17, battery 18 and rectifier 16, which path will be of low resistance when the difference in voltage between leads 11 and 12 exceeds the voltage of the battery 18 by even a small amount. The voltage impressed across the leads 11 and 12, therefore, no matter in which direction, will cause the inductor 8 to act as a short circuit, and thereby cause the drop in resistors 7 to bring the potential impressed upon the modulator 4 down to a point fixed by the voltage of the battery 18, whenever the voltage impressed across the inductor 8 exceeds that corresponding to that of the biasing battery.

The correspondence between the biasing voltage of the battery 18 and the voltage impressed upon the inductor 8 is determined by the points at which the leads 11 and 12 are connected to the inductor. The inductor is, in effect, a step-down transformer. In order, therefore, to impress across the leads 11 and 12 a sufficient voltage to render the rectifiers conductive, the voltage impressed across the inductor 8 must be sufficient to produce the required voltage on the leads 11 and 12 after it has been reduced by the transformer action. It is thus possible, with a low-voltage battery at 18, to fix a fairly high voltage for the limit which the voltage impressed upon the modulator 4 will not exceed.

Normally, the line 3 is operated at a voltage which will not render the rectifiers conductive. If, through any accident, such, for example, as a mechanical shock to the microphone 1, a voltage in excess of that normally present is impressed on the line 3, a corresponding, but smaller, increase in the voltage impressed across the leads 11 and 12 results. The effect of the step-down action of the autotransformer 8 is, therefore, to require a greater percentage change in the voltage upon the line to cause the safety device to act.

In Fig. 2, this disadvantage is overcome, but a larger biasing battery is necessary. When, in the modification shown in Fig. 2, the amplifier 2 delivers an unusually large voltage, the set-up transformer 20 causes the change in voltage upon the line 3 to be greater than the change in voltage at the amplifier 2. The same number of volts is required by the voltage-limiting device to produce the change from conductive to non-conductive condition, but this change is now a smaller percentage of the voltage normally present. The action of the modification shown in Fig. 2 is, therefore, much sharper than that of the modification shown in Fig. 1.

In the form shown in Fig. 1 there is a step-down transformer 8. In the form shown in Fig. 2 there is a step-up transformer 20. Obviously, an intermediate form may be provided in which the voltage is neither stepped up nor down. Such a form may be produced by omitting the transformers. The leads 11 and 12 would then be connected directly to the line 3, as they are in Fig. 2. The line 3 would be directly connected to the amplifier, as in Fig. 1 and also directly connected to the modulator 4, as in Fig. 1.

Although I have specifically illustrated only two modifications, it will be clear that they represent only two aspects of one continuous application of the transformer principle. Many other modifications of the proposed invention will be apparent to those skilled in the art without specific description of them. For example, instead of the four rectifiers illustrated, two rectifiers may be made to suffice by connecting the biasing battery between the junction of the rectifiers and midpoint of a transformer-secondary. Therefore, I do not intend the specific description of the systems illustrated to be considered a limitation. No limitations except those required by the prior art or stated in the accompanying claims are intended.

I claim as my invention:

1. In a radio system, a source of signal current, a modulator, a line connecting said source to said modulator, said line including a resistor, and a shunt across said line between said resistor and said modulator, said shunt including a plurality of asymmetrically conductive members arranged in a Wheatstone bridge and a source of potential in a diagonal of said bridge.

2. In a radio system, a modulator, a source of signal-representative voltage, means for impressing on said modulator a voltage derived from said source and means, cooperating with said impresisng means, for causing the voltage impressed upon the modulator to be less than the value corresponding to the voltage of said source, said cooperating means including an asymmetric resistance having a curved voltage-current characteristic at voltages near its critical voltage and a biasing battery, whereby, when the voltage of said source is below a limit determined by the voltage of said biasing battery said cooperating means will be ineffective, and when the voltage of said source exceeds said limit said cooperating means will be effective, the effectiveness increasing at a nonproportional rate with increase of said excess.

3. In a voltage-control device, a source of current, a load, a line connecting said source to said load, said line including impedance, and a shunt across said line between said impedance and said load, said shunt including a plurality of asymmetrically conductive members arranged in a Wheatstone bridge and a source of potential in a diagonal of said bridge.

4. In a voltage-control device, a source of current, a load, a line connecting said source to said load, said line including impedance,

a transformer connected across said line between said impedance and said load, a variable impedance device comprising a plurality of asymmetrically conductive members arranged in a Wheatstone bridge, and a source of potential in a diagonal of said bridge, the output of said transformer being connected across the other diagonal of said bridge.

In testimony whereof, I have hereunto subscribed my name this 10th day of September, 1927.

CARROL J. BURNSIDE.