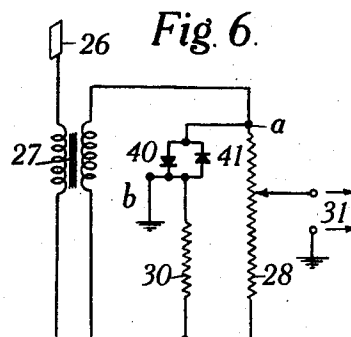
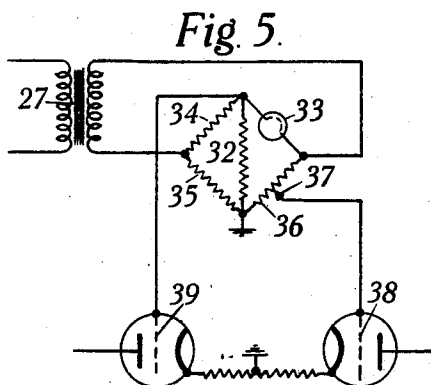
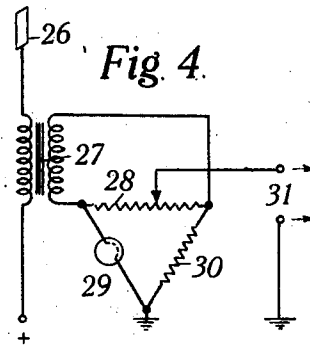
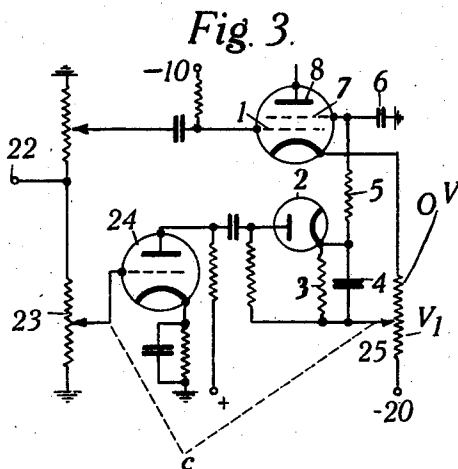
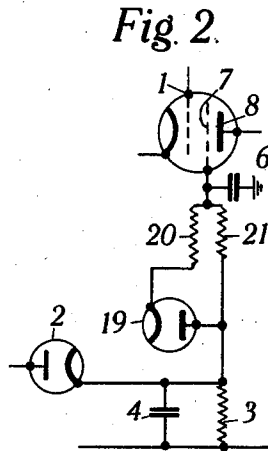
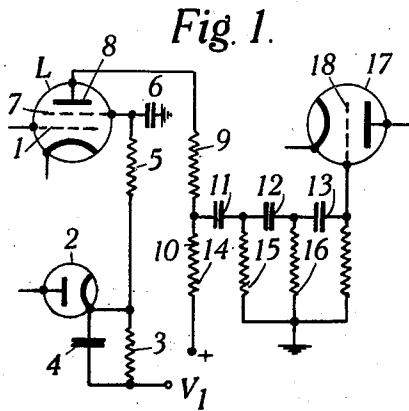


Oct. 29, 1940.

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 DEVICE EMPLOYED IN THE CONVERSION OF ELECTRICAL
 ENERGY INTO ACOUSTIC ENERGY AND VICE VERSA
 Filed June 17, 1937

2,219,729

2 Sheets-Sheet 1



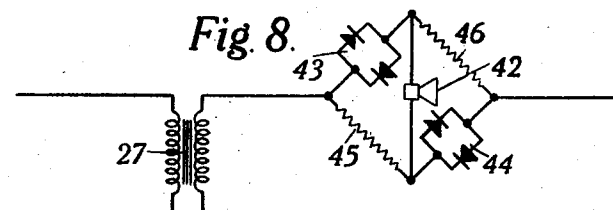
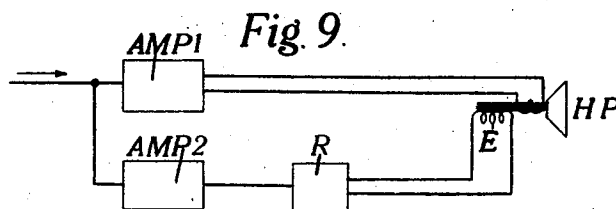
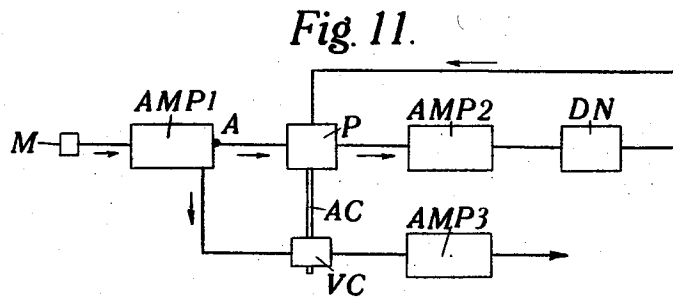
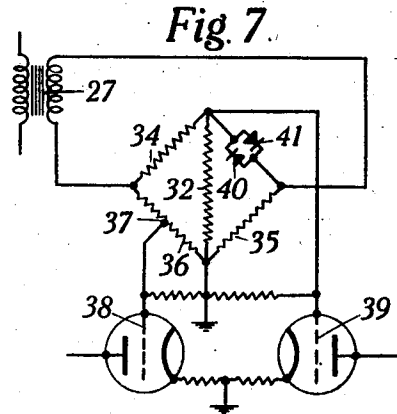
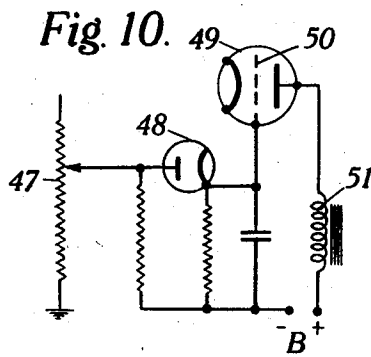
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,219,729

DEVICE EMPLOYED IN THE CONVERSION OF
ELECTRICAL ENERGY INTO ACOUSTIC
ENERGY AND VICE VERSA

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International Standard Electric Corporation,
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5 Claims. (Cl. 179—171)

The present invention relates to improvements in devices employed in the conversion of electrical energy into acoustic energy.

The present invention particularly relates to devices for increasing the contrasts in the electrical reproduction of sounds, for example, of music.

It is known that in consequence of the limitations of amplitude imposed in electrical or mechanical transmissions connecting an initial microphone to a final loud speaker, very large variations in the level of the musical sounds must be considerably reduced at the transmission, for example, by means of a potentiometric control normally effected by hand.

At the time of the reproduction of the sounds transmitted either after a direct transmission or after mechanical recording, it is thus desirable to re-establish these variations of level of the sounds in order to obtain as far as possible satisfactory reproduction. That is to say, it is important to re-establish the contrasts of the sounds to be reproduced and to increase the contrasts of the sounds actually transmitted. One object of the invention is consequently to control automatically in a predetermined manner the different levels of the musical sounds in a reproduction of sounds transmitted by any transmission channel, such as by radio or over wires.

In certain cases it may be preferable to exaggerate or to reduce the sonorous contrasts in a transmission which has been "smoothed" in transmission.

The invention provides in accordance with certain of its characteristics, means for obtaining and automatically controlling the effects to be obtained.

One feature of the invention is to provide circuits with variable gain permitting the control of the level of a transmission.

Another feature of the invention consists in the use of the change of phase in a device in the form of a bridge associated with a valve in order to obtain a predetermined control of the sound contrasts.

In accordance with one feature of the invention means are provided to obtain different speeds of operation of the device for increasing sound contrasts according to whether the sudden change of volume is an increase or a reduction.

In accordance with other features of the invention, variations of resistance of the potentiometers or heated resistances or non-linear re-

sistances are also employed for the same purpose.

Still another feature of the invention consists in the use of the magnetic field produced by the energising winding of an electrodynamic loud speaker.

Finally, a feature of the invention consists in an arrangement of a quick-acting potentiometer, driven by a motor and acting in conjunction with an amplifier and level detector of the signals transmitted in one line of the transmission.

The invention will be better understood by means of the following description based on the attached drawings in which the various figures represent contrast-amplifier circuits employing features of the invention.

The arrangement of Fig. 1 employs the properties of a valve with two or more grids;

Fig. 2 shows a circuit adapted for obtaining different speeds of operation according to the increase or reduction of the level of the signals received;

The arrangement of Fig. 3 employs the properties of a variable amplification valve;

The arrangement of Fig. 4 employs the variation of resistance of metal wires with the temperature;

The arrangement of Fig. 5 employs the change of phase in the diagonal of a Wheatstone bridge at its point of equilibrium;

The arrangements of Figs. 6, 7 and 8 employ the variations of resistances provided by dry contact rectifiers or the like;

The arrangements of Figs. 9 and 10 make use of variations of the magnetic field of an electrodynamic loud speaker; and finally

The arrangement of Fig. 11 employs a quick acting potentiometer, acting in conjunction with an amplifier and a transmission level detector.

Referring to Fig. 1, which represents a circuit of a variable amplification valve L, with for example, two grids a signal to be amplified is applied on the one hand to the grid 1, and on the other hand also to an auxiliary amplifier (not shown) the amplified potentials of which are applied to the plate of a diode 2, the cathode of which is connected through a resistance 3, shunted by a condenser 4, to a point of suitable and fixed potential V_1 .

The potential of the cathode of the diode 2 follows variations of the level of the signal, and this potential is applied through a resistance 5 to the grid 7 of the variable amplification valve L, this grid being on the other hand connected to earth

over a condenser 6. The connection between the plate 8 and the following valve 17 is preferably made by the well-known means of a resistance-capacity coupling. The time constant of the circuit comprising resistance 5 and capacity 6 must be sufficient, otherwise a sudden increase of the potential of the grid 7 produces a sudden increase of the plate current, that is, sudden drop of the mean potential of the plate 8. If this plate is directly connected by a condenser to the grid of the next valve 17, the mean potential of which is fixed by a resistance of high value, the drop of potential of the plate 8 causes a drop of potential of the grid 18, which is thereby brought to a rather negative potential and thus entirely cuts off the operation of the valve 17. The time constant of the circuit 5—6 can hardly be less than 0.2 second for example. The result is that the sudden changes of sound volumes are not suddenly amplified to the value to which they would otherwise be; generally speaking, the amplification of the contrasts depends upon their duration.

The result is a distortion of the sounds for example, of music. In order that the time constant of the circuit 5—6 may be considerably reduced, the capacity connecting the plate 8 to the grid 18 is connected not to the plate itself, but to a suitable point of the loading resistance, said resistance being divided into two parts 9 and 10, the part 10 being small with respect to the part 9. The variations of the potential applied to the coupling capacity are reduced in the ratio of the valves of the resistance 10, and 9 plus 10. In order that the grid 18 may not be subjected to variations of mean potential under the influence of sudden changes of volume, it is necessary in short, that the very low frequencies of the order of 10 periods per second for example should not be transmitted to it. Moreover, in order that the response of the amplifier may be good, it is necessary for low frequencies, 30 periods per second for example, to be transmitted to it without great attenuation. The connection between the plate 8 and the grid 18 may be effected by suitable means such as high pass filter carried out economically for example by means of the capacities 11, 12, 13 and resistances 14, 15, 16.

A good reproduction of the sudden increase of volume giving good reproduction of changes in mood, as in reproduction of music, is often desirable. This requires a low time constant of the circuit 5—6, and the result is that the sudden reductions of volume are also very rapid. This produces an effect similar to that produced in a room which is very much damped acoustically and this effect may be considered unpleasant.

In accordance with the invention, means is provided for obtaining different speeds of operation according to whether the sudden change of volume is an increase or a reduction.

Referring to Fig. 2 it will be seen that the resistance 5 is replaced by the diode 19 and two resistances 20 and 21.

When the volume increases, the potential of the cathode of the diode 2 is raised, the current easily passes through the diode 19 which only offers it a negligible resistance, and it is the resistance 20, which is relatively low with respect to 21, which provides the slight delay necessary.

When the volume reduces, the direction is reversed and the diode 19 is opposed to the passage of the current which must pass through the high value resistance 21, thus producing slow operation of the system.

In another circuit employing the properties of a valve with variable amplification, the variable potential of the auxiliary grid 7 (Fig. 3) is obtained by rectifying by means of the diode 2, the signal applied at 22 obtained from a potentiometer 23, and amplified by a valve 24.

In the absence of a signal, the potential V_1 of the auxiliary grid 7 is obtained by means of a potentiometer 25.

The potentiometers 23 and 25 are mechanically coupled as indicated by the broken line C of Fig. 3.

By manipulating the tapping on the potentiometer 25 so as to render point V_1 more and more negative, the threshold of the signal level at which the signal no longer passes is adjusted.

When the potentiometer 23 is adjusted, so as to obtain little or no increase of the contrasts, it is seen that all the signals, even the weak ones, may be equally amplified, thus the potential V_1 is adjusted to a relatively low absolute value—10 volts for example.

When, on the other hand, the potentiometer 23 is adjusted so as to obtain the full effect of the circuit, it is well to bring V_1 to a higher absolute value, for example—15 volts, so as completely to cut off the very weak signals such as parasitic noises, and to prevent overloading the following amplifier.

The two potentiometers 23 and 25 are mechanically connected to each other so that the two variations described above are obtained simultaneously by a single adjusting operation.

In the circuit which is shown in Fig. 4, the transformer 27 is connected in the circuit of the plate 26 of a suitable amplifying valve.

The secondary winding of the transformer 27 is connected on the one hand to a potentiometer 28, and on the other hand to a suitable lighting lamp 29 and to a fixed resistance 30. The potentiometer slide is connected to one output terminal.

For a determined level of the signal, the lamp 29 assumes a particular temperature and resistance, and it is possible to balance the Wheatstone bridge formed by the resistances 28 and 30 and the lamp, in such a way that the signal transmitted to the output terminals is nil.

For values of the signal level different from that which gives equilibrium, a potential appears between the terminals of the output circuit 31 which increases as the level of the signal departs from the level which gives the equilibrium.

In particular, if the bridge is balanced for the lowest signal level background noise will be eliminated and the useful signals will be amplified to an increasing extent the stronger they are.

It is also possible to employ, in order to control the contrasts, the change of phase which is produced in the diagonal of a Wheatstone bridge at the moment when the latter passes through its condition of equilibrium. Fig. 5 shows a circuit of this type.

The junction point of the resistances 36 and 37 is connected to a grid 38 of a symmetrical amplifier, the other grid 39 is connected to the ungrounded extremity of the diagonal 32. When the bridge is in equilibrium, which is produced for a certain signal level which gives the lamp 33 a suitable resistance, the grid 39 receives no signal and the grid 38 operates alone.

For weaker signals, the voltage applied to the grid 39 is in phase agreement with that which is applied to the grid 38 which means that the

effects due to the two grids are subtracted in the final amplifier.

For stronger signals the voltage applied to the grid 39 is in phase opposition to that which is applied to grid 38, which causes the effects to be added in the final amplifier.

By suitably adjusting the values of the resistances, it is possible to make the total effect nil for very weak signals, and maximum for very strong signals.

Another arrangement employing features of the invention is shown in Fig. 6 in which the properties of metal oxide contact rectifiers are employed in order to obtain a variable resistance. It is known that such devices offer a resistance which increases when the current which passes through them diminishes.

Referring to Fig. 6, 40 and 41 represent dry rectifiers preferably associated in a full-wave rectification arrangement in order to reduce the capacity effect, and connected in such a way that between points *a* and *b* they offer a resistance dependent upon the value of the current, but not upon the direction thereof.

A potentiometer 28 and resistance 30 are connected as shown in the drawings.

For a certain value of the signal level, the apparent resistance of 40-41 assumes a certain value and it is possible to adjust the slide of the potentiometer 28 in such a way that the equilibrium of the bridge is obtained, which has the effect that no potential appears on the output terminals 31. For weaker or stronger signals, the bridge is unbalanced and the potential which appears at 31 increases the more the level of the signal differs from that which gives equilibrium.

Variable resistances comprising dry rectifiers of any kind can also be employed in a circuit similar to that which is shown in Fig. 5 and give the same results, that is, operation of the two valves of a symmetrical amplifier connected after the circuit, in push-pull for strong signals, in opposition for weak signals. Such a circuit is shown in Fig. 7, in which 40-41 represents the dry rectifiers, the other elements of the circuit having the same reference as in Fig. 5. The operation of the circuit of Fig. 7 is similar to that of Fig. 5, the resistance of the elements 40-41 then depending upon the intensity of the current which passes through them, but not on its direction.

The variable resistances offered by the dry rectifiers may also be employed in a bridge circuit similar to that shown in Fig. 8.

The secondary winding of the output transformer 27 feeds the loud speaker 42 through resistances 45 and 46 and metal rectifiers 43-44. These various members are connected as indicated in Fig. 8.

The elements 43 and 44 are composed in such a way that their resistance is relatively low with respect to the impedance of the loud speaker 42 for current values corresponding to high sound volumes.

On the other hand, their resistance increases and becomes high with respect to the impedance 42 for very low volumes.

The fixed resistances 45 and 46 have relatively high values of the same order of magnitude as the resistances of the rectifiers 43 and 44 for very weak signals.

The result is that when the signals are weak, the current passing through the loud speaker 42 is nil or very weak. In proportion as the signals increase the resistance of the contacts 43 and 44 diminish, the bridge is more and more unbalanced,

and the loud speaker is traversed by a stronger and stronger current.

It is clear that in consequence of the unbalance of the bridge, the current passing through the loud speaker increases more quickly than the potential supplied by the transformer, whence there results an increase of the contrasts.

It is also possible to employ, in order to increase the sound contrasts, the variation of the magnetic field produced by the energization winding in the air-gap of an electrodynamic loud speaker.

This result is obtained either by feeding the energisation winding with the signal itself, suitably amplified and rectified, or by controlling the energisation current by means of the variations in the level of the signal.

The first device is shown schematically in Fig. 9. The signals are applied at the same time to different amplifiers, an ordinary low frequency amplifier AMP1, producing a modulated current which is transmitted in the moving coil of the loud speaker HP, and an amplifier AMP2, which is also a low frequency amplifier, but which is distinguished from the first by the fact that the distortion introduced in the signal is only of quite secondary importance as far as it is concerned. The modulated current produced by the amplifier AMP2 is rectified by a rectifier R and employed in the energisation winding of the loud-speaker HP.

The second arrangement is shown in Fig. 10. The signal, suitably amplified and controlled by means of the potentiometer 47, is rectified by means of a diode 48, and the resulting potential is applied to the grid 50 of a three-electrode valve 49, in the plate circuit of which is inserted the energisation coil 51 of the loud speaker. In the absence of the signal, the grid 50 is brought to a negative point—B which reduces the current through coil 51 and valve 49 to a very low value. When a signal is applied to 47, the potential of 50 rises and the current through 51 is increased.

The invention also relates to a method of automatic control of the level of the signal sent in a transmission line, the level of the signal after the control being joined to the level of the signal before control by whatever law has been arbitrarily chosen.

Fig. 11 shows an embodiment of this method. A quick-acting potentiometer P, actuated by motor and acting in conjunction with an amplifier AMP2 and a level detector DN, co-operates with the said members in such a way that the angular position of the shaft AC of the potentiometer differs at any moment from a position of origin, by an angle in exact proportion to the level of the signal at the point A of the output of the first amplifier AMP1, directly connected to the microphone M.

The orientation of the shaft AC being a simple function of the level at A, it will be easily understood that it is sufficient to actuate by means of this shaft AC a volume control device VC, connected between the two amplifiers AMP1 and AMP3 and control said device in accordance with whatever law be desired, in order that the level of the signal to be amplified in the transmission line may be any desired function of the level of the signal at A.

While this method may obviously serve to increase the contrasts it can also supply an automatic control of the diminution of the contrasts, which diminution is necessitated by the conditions of transmission of the signals.

It is obvious that if the contrasts are controlled

on the one hand, upon transmission, in accordance with a predetermined law by an automatic process, then developed on the other hand upon reception, in accordance with a law complementary to the preceding one by an equally automatic method, the original contrasts are restored in the terminal loud speaker or established so as to produce the desired sound effects.

It is clear that the devices described have only been so described by way of example and that various modifications may be made without departing from the limits of the invention.

It is clear that the arrangement described can also be employed to separate the desired sounds more clearly from the parasitic noises (background noise, cross-talk, etc.) rather than to re-establish the contrasts themselves in the wanted sounds transmitted.

It is also clear that the devices which have been described as relating to the automatic increase of the contrasts in receiving devices may be applied to control the volume of the sounds for microphonic recording, in order to permit a choice of the law of contraction or diminution of the contrasts which may then be re-established upon reproduction.

What is claimed is:

1. A wave transmission device for compressing or expanding the volume of signals, comprising a Wheatstone bridge one arm of which comprises a power dependent resistance adapted to be heated by the signal currents, said bridge being so adjusted that it is in equilibrium for a predetermined signal level, means being provided for utilizing the change in phase produced across a diagonal of said bridge when the signal level increases or decreases for controlling the output of a succeeding thermionic amplifier.

2. A wave transmission device according to claim 1 in which said bridge is associated with a pair of symmetrically-arranged thermionic valves the input electrodes of one of which are connected

across the said bridge diagonal, and the input electrodes of the other of which are connected across one of the resistance arms or a portion thereof.

3. A wave transmission device for compressing or expanding the volume of signals, comprising a Wheatstone bridge, one arm of which comprises a non-linear conducting means adapted to be effected by the signal currents, said bridge being so adjusted that it is in equilibrium for a predetermined signal level, and means for utilizing the change in phase produced across a diagonal of said bridge when the signal level increases or decreases for controlling the output of a succeeding amplifier.

4. A wave transmission device for compressing or expanding the volume of signals, comprising a Wheatstone bridge, one arm of which comprises a non-linear conducting device adapted to be effected by signal currents, said bridge being so adjusted that it is in equilibrium for a predetermined signal level, and means for utilizing the change in phase produced across a diagonal of said bridge, comprising a pair of symmetrically arranged thermionic valves, circuit connections for one of said valves arranged across said bridge diagonal, and an input circuit for the other of said valves arranged across at least a portion of the resistance of one of said arms of said bridge, and adjustable means to balance the bridge for any predetermined level of input signal.

5. A wave transmission device for compressing or expanding the volume of signals, comprising a Wheatstone bridge, one arm of which comprises parallel connected pairs of oppositely poled dry contact rectifiers, said bridge being so adjusted that it is in equilibrium for a predetermined signal level, and means for utilizing the change in phase produced across a diagonal of said bridge when the signal level increases or decreases for controlling the output of a succeeding amplifier.

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