

April 29, 1958

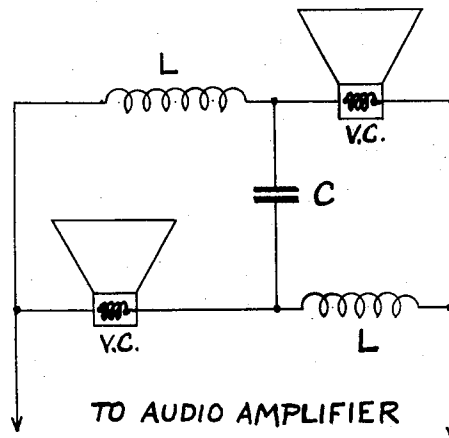
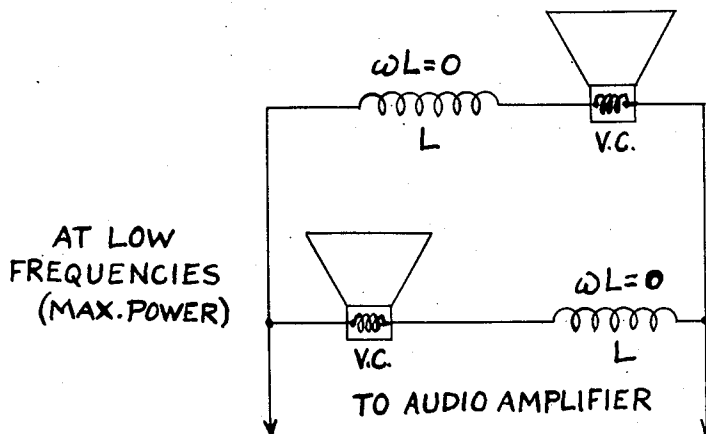
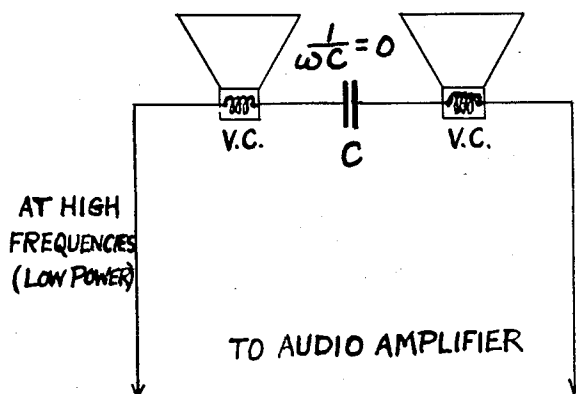
S. E. LEVY

2,832,828

LOUDSPEAKER CIRCUITRY

Filed Sept. 26, 1955

3 Sheets-Sheet 1



INVENTOR.
S. E. Levy
BY Robb & Robb
Attorneys.

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S. E. LEVY

2,832,828

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3 Sheets-Sheet 2

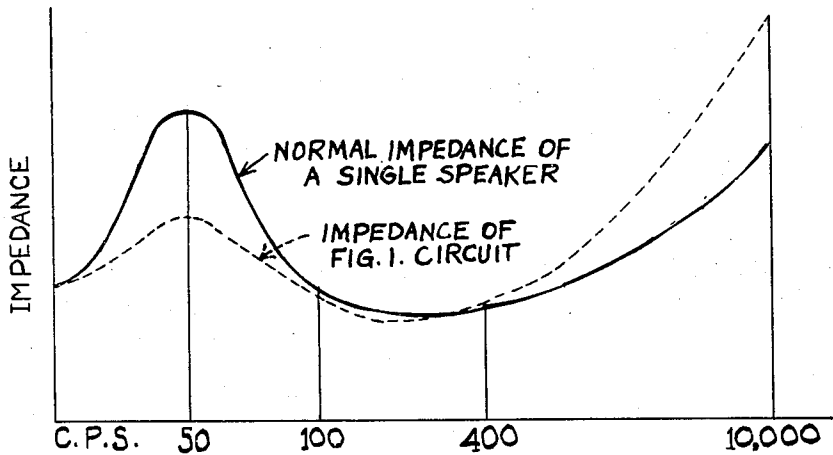


Fig. 4

AT INTERMEDIATE
FREQUENCIES

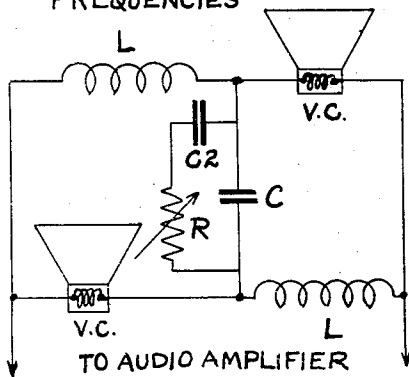


Fig. 5

AT INTERMEDIATE
FREQUENCIES

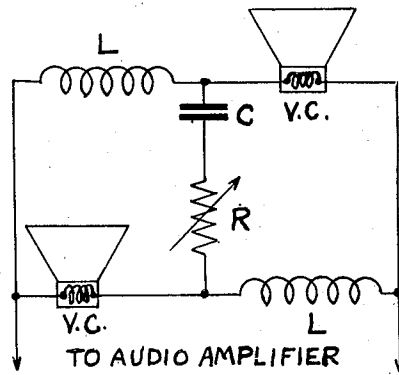


Fig. 6

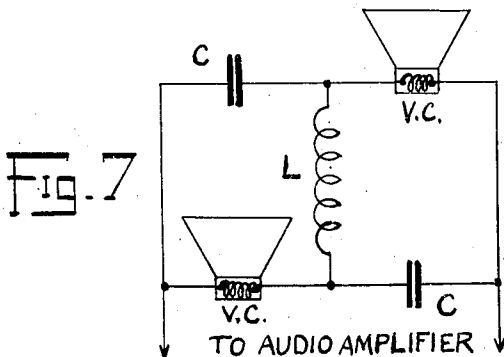


Fig. 7

INVENTOR.

S. E. Levy
BY Robert Robb
Attorneys.

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3 Sheets-Sheet 3

AT LOW FREQUENCIES
(MIN. POWER)

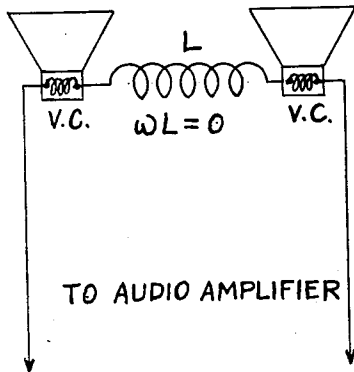


Fig. 8

AT HIGH FREQUENCIES
(MAX. POWER)

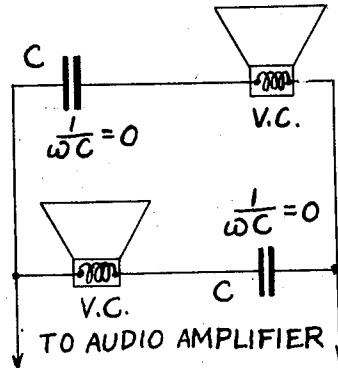


Fig. 9

L.F. AT MAX.
H.F. AT MIN.

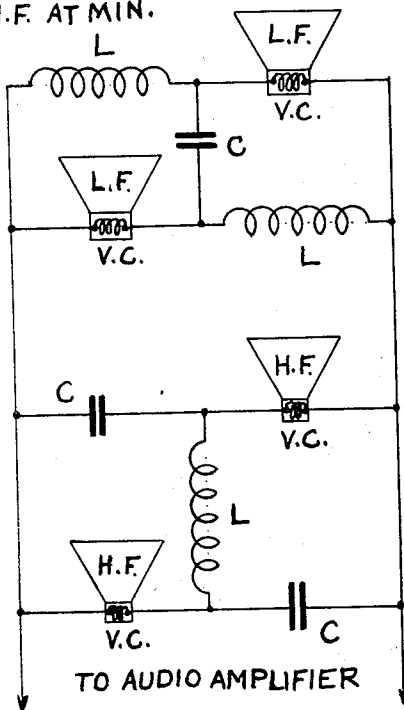


Fig. 10

INVENTOR.
S. E. Levy
BY Robb & Robb
Attorneys.

1

2,832,828

LOUDSPEAKER CIRCUITRY

Sidney E. Levy, White Plains, N. Y., assignor of one-half to Arthur Blumenfeld, New York, N. Y.

Application September 26, 1955, Serial No. 536,622

6 Claims. (Cl. 179—1)

The present invention relates to loudspeaker circuitry, and more particularly to means for varying the impedance of a loudspeaker circuit as a function of the applied frequency.

I have found that it is possible by the use of loudspeakers and various component circuitries to vary the loudspeaker input power from the amplifier to equalize the response of the loudspeaker as may be desired. If preferred, the loudspeaker may, therefore, draw more power from the amplifier at low frequencies, and less power at high frequencies, or vice versa, thus creating a certain balance of sound between the low registers and the high overtones.

The fundamental response of a loudspeaker is usually characterized by a sharp increase in electrical impedance at the frequency of resonance. This usually occurs, in the case of conventional cone speakers, at some low frequency point, usually below 100 cycles. Since most amplifiers for loudspeakers are of the constant voltage output type, that is, incorporating large orders of negative feedback, resulting in low internal generator impedance, the voltage output of such amplifiers then becomes independent of the load impedance. Thus, at the frequency of speaker resonance, where the impedance is high, an amplifier delivering a constant voltage for any given input will deliver less power to the speaker in such frequency zones. Since, by elementary Ohm's law, the power absorbed by a load is proportional to

$$\frac{E^2}{Z}$$

where E is the voltage across the load, and Z is its electrical impedance, the power will fall off in proportion to the increase in Z. The present invention, therefore, contemplates various loudspeaker circuits having inductances and capacitors in such arrangement as to (1) provide for an increase of power input to the speaker in the resonant zone; (2) shift the tonal balance in a predetermined and preferred manner, wherein low frequencies may receive the maximum power and high frequencies the minimum power; or (3) wherein high frequencies may receive maximum power and low frequencies receive minimum power; or (4) wherein the power input to the speaker is controlled in the middle or intermediate frequency zone to balance the power input at the low and high frequency regions.

In the accompanying drawings:

Fig. 1 shows one typical illustrative loudspeaker circuit according to the present invention;

Fig. 2 diagrammatically represents the effect of the circuit of Fig. 1 at low frequencies, with maximum power being drawn by the loudspeaker circuit from the amplifier;

Fig. 3 diagrammatically represents the effect of the circuit of Fig. 1 at high frequencies, with low power being drawn by the loudspeaker circuit from the amplifier;

Fig. 4 graphically represents the impedance vs. frequency characteristics according to the circuit of Fig. 1, with the solid curve illustrating the normal impedance of

2

a single speaker and the dotted curve illustrating the impedance of the speaker network circuit;

Fig. 5 illustrates a modified form of the circuit of Fig. 1 embodying a variable resistor in series with a capacitor and shunted across the main network capacitor so as to modify the transition frequency between the low and high frequencies and thus alter the impedance of the main capacitor C at some intermediate frequency range;

Fig. 6 is an alternative modification of the circuit of Fig. 5, said alternative circuit also causing the transition range to be shifted and modified between the high and low frequencies where desired;

Fig. 7 illustrates another modification of the circuit of Fig. 1, which produces the reverse effect of the circuit of Fig. 1;

Fig. 8 diagrammatically represents the effect of the circuit of Fig. 7 in producing a high impedance in the circuit at low frequencies by effectively putting the inductance in series with the speakers and thus causing the circuit to draw minimum power from the amplifier;

Fig. 9 diagrammatically illustrates the circuit of Fig. 7 at high frequencies which have the effect of putting the speaker elements in parallel, thus drawing maximum power from the amplifier; and

Fig. 10 shows another modified loudspeaker circuit wherein maximum power is diverted to the low frequency speaker components of the network only at low frequencies, while permitting maximum power to be diverted to the high frequency components of the network in the presence of high frequency signals.

Like reference characters designate corresponding parts in the several figures of the drawings and in the following description, and it is to be further understood that the invention as illustrated and described herein is applicable to either two or more separate loudspeakers in the speaker circuit or network, or to a single loudspeaker having two or more voice coils or windings on the same moving system or diaphragm assembly to impart vibrating movements to the diaphragm responsive to sound wave signals to be reproduced by the speaker. For convenience of illustration and explanation, separate speakers, each having a single voice coil winding designated V. C., are depicted in Figs. 1 to 3 inclusive and 5 to 11 inclusive.

Referring first to Figs. 1 to 3 inclusive, L represents the inductive components and C represents the capacitive components of the loudspeaker network or circuit, which components have reactances which vary with frequency. In the circuit illustrated in Fig. 1, the speakers are in parallel, and at low frequencies, the inductive reactances of the inductances L in the individual branches become very low, and the effect of the circuit corresponds to that of the circuit illustrated in Fig. 2, resulting in the drawing of maximum power from the amplifier to which the loudspeaker circuit or network is adapted to be connected in the conventional manner. At high frequencies, the reactance of the components reverse themselves, and the voice coils V. C. of the two speakers become in effect connected in series as illustrated in Fig. 3, thus presenting a relatively higher impedance in the circuit which is four times greater than that of the circuit of Fig. 2, and thus drawing less power (one-quarter the amount of power) from the amplifier. This results in an impedance vs. frequency characteristic as graphically illustrated in Fig. 4, wherein the solid curve represents the normal impedance of a single speaker, and the dotted curve represents the impedance resulting from the use of a speaker network circuit as disclosed in Fig. 1.

Summarizing the foregoing, it will be understood that in a circuit corresponding to Fig. 1, the voice coils of the loudspeaker elements assume a parallel relation in the presence of low frequencies, and assume a series relation in the

presence of high frequencies, this transition being smooth and automatic and depending upon the frequency or frequencies present in the audible signals received from the amplifier to which the speaker network or circuit is connected.

Referring to Fig. 5, the circuit of this view represents a modification of the circuit of Fig. 1 by incorporating a variable resistor R and a capacitor C2, these latter components serving to modify the transition frequency at any appropriate point intermediate the high and low frequencies. The principal effect of this modified circuit is to cause an alteration of the impedance of the capacitor C at some intermediate frequency range, or to maintain it at a constant value until the impedance of C approaches or is less than R.

Fig. 6 represents a modification of the circuit of Fig. 5, and in this latter modification, a variable resistor R is arranged in series with a single capacitor C, and these elements are bridged across the two branch circuits between the inductance L and the voice coil V. C. of each branch circuit. Thus, the effect of the circuit of Fig. 6 will result in a shifting and modification of the transition range in still another obvious manner as may be desired or preferred.

Referring next to Fig. 7, this circuit produces an effect which is the reverse of the effect of the circuit of Fig. 1, and at low frequencies, the speaker voice coils V. C. are effectively in series with each other and with the inductance L, thus producing a high impedance and drawing minimum power from the amplifier, as diagrammatically represented in Fig. 8. By the same token, in the presence of high frequencies, the voice coils V. C. are effectively in parallel, with each voice coil in series with a capacitor C in separate branch circuits, thus drawing maximum power from the amplifier, as diagrammatically illustrated in Fig. 9. The impedance of the inductance components L is negligible at low frequencies and large at high frequencies, while the reactance of the capacitors C is negligible at high frequencies and large at low frequencies. Therefore, at each end of the frequency spectrum, only the actual voice coil of the speaker is effective in establishing the final net impedance. On the other hand, at some intermediate frequency range, the reactances of the capacitors and inductances assume equal values so that a mean average net impedance results.

Referring to Fig. 10, this view diagrammatically illustrates a circuit which utilizes two low frequency reproducers, respectively designated L. F. and commonly referred to as "Woofers," and two high frequency reproducers respectively designated H. F. and commonly known as "Tweeters," the same being arranged in parallel and in a circuit combining the circuit of Fig. 1 as one branch, and the circuit of Fig. 7 as the other branch, with the low frequency reproducers disposed in the first-mentioned branch and the high frequency reproducers disposed in the last-mentioned branch. In this modified arrangement, maximum power is diverted into the low frequency speakers only during low frequency signals impressed upon the input of the speaker network from the output of the amplifier, while maximum power is delivered to the high frequency reproducers in the presence of high frequency signals.

Although the fundamental resonance of a loudspeaker usually exists at that frequency at which the speaker is most

sensitive, in practical operation of the speaker, this sensitivity is offset acoustically to a large extent by the fact that the speaker impedance has increased by many times at the resonance frequency. Thus, when such a speaker is fed from an amplifier having constant voltage characteristics, the speaker will receive a minimum of power from the amplifier at this frequency. This result is usually additionally associated with a further characteristic, namely, the falling off of sound absorption by the atmosphere due to lack of air radiation resistance, and these two factors generally result in completely insufficient sound output at and near the zone of resonance.

The present invention which is typified by the various circuit arrangements described in the foregoing and illustrated in the drawings, more particularly concerns itself with a solution of these problems by permitting the speaker to draw more power at the resonance frequency than would otherwise be the case, and thus offsetting to some extent, at least, the losses due to the two factors mentioned above.

While the specific details of the invention have been herein shown and described, the invention is not confined thereto as changes and alterations may be made without departing from the spirit thereof as defined in the appended claims.

I claim:

1. A loudspeaker circuit for use with amplifiers of the constant voltage output type, comprising a plurality of voice coils, each having an impedance element of like characteristics connected in series therewith, with one voice coil and its series impedance element connected in parallel with the other voice coil and its like series impedance element and with the voice coils and the like impedance elements of the respective branches of the parallel circuit arranged in reverse order, and another impedance element of opposite characteristics connected in shunt between the junction of one of the voice coils and its series impedance element and the junction of the like impedance element with the other voice coil, whereby at predetermined zones in the frequency band a predetermined power input will be achieved.

2. A loudspeaker circuit as defined in claim 1, wherein the impedance elements of like and opposite characteristics are inductances and capacitors, respectively.

3. A loudspeaker circuit as defined in claim 1, wherein the impedance elements of like and opposite characteristics are capacitors and inductances, respectively.

4. A loudspeaker circuit as defined in claim 1, wherein a resistor and an impedance element also of opposite characteristics are connected in series with each other and together are connected in parallel with the shunt impedance element.

5. A loudspeaker circuit as defined in claim 1, wherein a resistor is connected in series with the shunt impedance element.

6. A loudspeaker circuit as defined in claim 1, combined with a second circuit corresponding thereto and connected in parallel therewith but having the impedance elements thereof reversed in relation to those of the first circuit.

References Cited in the file of this patent

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