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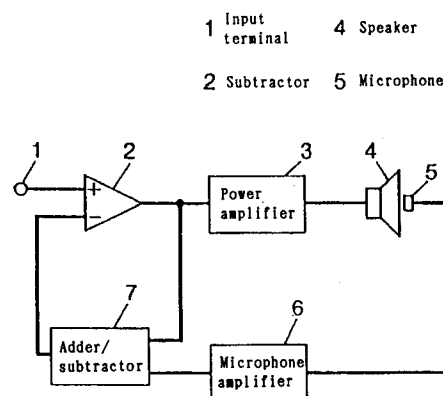
(57) The invention presents means for applying negative feedback more powerfully and stably than before over a frequency range as wide as possible, in the constitution for detecting a reproduced sound of a speaker used in various acoustic appliances by a microphone, and applying a negative feedback to an input signal of the speaker by the detected signal, and correcting the reproduced signal by improving the reproduction frequency characteristic and other characteristic of the speaker.

A fundamental constitution of an acoustic reproducing apparatus of the invention comprises a subtractor having an input terminal, a power amplifier for amplifying the output signal of this subtractor, a speaker for reproducing the output signal of the power amplifier, a microphone for detecting the acoustic output signal radiated from the speaker, a microphone amplifier for amplifying the acoustic output signal detected by the microphone, and an adder/subtractor for adding or subtracting the output signal of the microphone amplifier and the input signal of the power amplifier, wherein the output signal of the adder/subtractor is connected to the subtractor to compose a negative feedback circuit.

Or, in an acoustic reproducing circuit using a speaker box incorporating a passive radiator, a microphone is disposed in the front side of the magnetic circuit of the speaker for reproducing the output signal of the power amplifier or speaker rear enclosed acoustic space, or in the enclosed acoustic

space with the passive radiator of the speaker front side, and the output signal of the microphone is added or subtracted with the input signal of the power amplifier in the adder/subtractor in the fundamental constitution above, and the signal is subtracted from the input signal in the subtractor, thereby composing a negative feedback circuit.

Fig. 1



Field of the Invention

The present invention relates to an acoustic reproducing apparatus for a reproduced sound from a speaker used in various acoustic appliances by a microphone, feeding back negatively to the input signal to the speaker by this detected signal to improve the reproduction frequency characteristic, distortion factor and other characteristics of the speaker, and correcting the reproduced sound.

Background of the Invention

In an acoustic reproducing apparatus, in order to improve a reproduced sound from a speaker, it has been attempted to detect the reproduced sound by a microphone, feed back negatively to the input signal of the speaker by this detected signal to improve the reproduction frequency characteristic, distortion factor and other characteristics of the speaker, and correct the reproduced sound. A prior example of this kind of acoustic reproducing apparatus is described below by reference to drawings.

Fig. 57 is a block diagram showing a constitution of an acoustic reproducing apparatus using a negative feedback circuit of a prior art. A signal is fed from an input terminal 50, and is supplied from a positive input terminal of a subtractor 51, and its output is amplified in power in a power amplifier 52, and the signal is applied to a speaker 53. The acoustic signal issued from the speaker 53 is detected by a microphone 54, and this signal is amplified in a microphone amplifier 55, and its output signal is passed through a filter 56 and is connected to a negative input terminal of the subtractor 51, thereby forming a negative feedback loop.

Fig. 58 is a block diagram showing a constitution in which the speaker 53 of the acoustic reproducing apparatus shown in Fig. 57 is incorporated into a speaker box 58 using a passive radiator 57, wherein a signal fed into the input terminal 50 is passed into the subtractor 51 through the positive input terminal, and is amplified in power in the power amplifier 52, and the output signal from the power amplifier 52 is reproduced by the speaker 53 coupled inside the speaker box 58. At the rear side of the speaker 53, an enclosed acoustic space 58A is formed, and further an enclosed acoustic space 58B is also formed at the front side of the speaker 53, and by the passive radiator 57 coupled between the enclosed acoustic space 58B and the opening of the speaker box 58, an acoustic output is radiated into the front space of the speaker box 58, and the acoustic output signal radiated from the passive radiator 57 is detected by the microphone 54, this detected sig-

nal is amplified by the microphone amplifier 55, and its output signal is passed through a filter 56 and connected to the negative input terminal of the subtractor 51, thereby forming a negative feedback loop.

In such conventional constitution, however, the phase difference between the electric signal entering the speaker 53 and the acoustic signal radiated from the speaker 53 is disturbed as shown in Fig. 59, and it is negative feedback around phase difference of 0 degree, but it is positive feedback around +180 degrees or -180 degrees, and this is a very unstable negative feedback system, and it was a problem that a sufficient negative feedback could not be applied.

Besides, when the band is limited by the filter 56 in order to keep allowance for oscillation, improvement of characteristics by negative feedback is limited only to a certain frequency band, and the acoustic output characteristics could not be improved sufficiently.

In the constitution using the passive radiator 57 shown in Fig. 58, meanwhile, same as shown in Fig. 59, the phase difference between the electric signal entering the speaker 53 and the acoustic signal radiated from the passive radiator 57 varies significantly from +180 degrees to -180 degrees, and stable negative feedback is not obtained, and same as in the case of Fig. 57, further, the microphone 54 detects also the acoustic signal incoming noise aside from the acoustic signal radiated from the passive radiator 57, and a sufficient signal-to-noise ratio (S/N ratio) cannot be maintained, and if attempted to keep the S/N ratio by removing high frequency components by passing through the filter 56 or the like, a sufficient S/N ratio could not be attained.

The invention is intended to solve these conventional problems and present an acoustic reproducing apparatus capable of improving the performance stably.

SUMMARY OF THE INVENTION

It is a first object of the invention to correct a reproduced sound by detecting a reproduced sound from a speaker used in various acoustic appliances, and apply negative feedback to the input signal of the speaker by this detected signal, thereby improving the reproduction frequency characteristic and other characteristic, distortion factor and of the speaker.

It is a second object of the invention to present means for applying negative feedback more powerfully and stably than before over a wide frequency range in achieving the first object.

To achieve the objects, a basic constitution of the acoustic reproducing apparatus of the invention

comprises a subtractor connected to an input terminal, a power amplifier for amplifying the output signal of the subtractor, a speaker for reproducing the output signal of the power amplifier, a microphone for detecting the acoustic output signal radiated from the speaker, a microphone amplifier for amplifying the acoustic output signal detected by the microphone, and an adder/subtractor for adding or subtracting the output signal of the microphone amplifier and the input or output signal of the power amplifier, wherein the output signal of the adder/subtractor is connected to the subtractor to compose a negative feedback circuit.

Moreover, a filter may be inserted between the output of microphone amplifier and adder/subtractor, the output of microphone amplifier or filter is divided into two and added to two adders/subtractors, or it is also possible to modify to insert a high pass filter only in one of them, or to modify to connect another subtractor to the output of the subtractor connected to the input terminal, or it is possible to compose by further combining this modified circuit.

The installation place of the microphone may have various positions around the speaker, and it may be determined according to the required detection characteristic.

In an acoustic reproducing apparatus using a speaker box incorporating a passive radiator, a microphone is disposed in an enclosed acoustic space at the front side of the magnetic circuit of the speaker for reproducing the output signal of the power amplifier or at the rear side of the speaker, or in an enclosed space between the speaker front side and passive radiator, and the output signal of the microphone is fed into the adder/subtractor to be added or subtracted with the input signal or the output signal of the power amplifier, and the signal is subtracted from the input terminal in the subtractor to compose a negative feedback circuit.

In the constitution using the passive radiator, too, the output of the microphone amplifier may be divided into two, and it may be modified same as the modifications of the basic constitution above. At this time, instead of the filter, a phase shift circuit is added, or other modifications may be possible. Or, using two microphones, the addition and subtraction method of the outputs may be also varied, and these modifications can be combined.

Being thus constituted, the invention performs negative feedback by adding or subtracting the phase difference of the electric signal entered in the speaker and the acoustic output signal radiated from the speaker in the adder/subtractor, making it hard to cause oscillation (howling) due to positive feedback due to phase shifts and is hence capable of applying a negative feedback over a wide frequency range, powerfully and stably.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing an acoustic reproducing apparatus according to embodiment 1 of the invention.

Fig. 2 is a block diagram showing an acoustic reproducing apparatus according to embodiment 2 of the invention.

Fig. 3 is a block diagram showing an acoustic reproducing apparatus according to embodiment 3 of the invention.

Fig. 4 is a block diagram showing an acoustic reproducing apparatus according to embodiment 4 of the invention.

Fig. 5 is a block diagram showing an acoustic reproducing apparatus according to embodiment 5 of the invention.

Fig. 6 is a block diagram showing an acoustic reproducing apparatus according to embodiment 6 of the invention.

Fig. 7 is a block diagram showing an acoustic reproducing apparatus according to embodiment 7 of the invention.

Fig. 8 is a block diagram showing an acoustic reproducing apparatus according to embodiment 8 of the invention.

Fig. 9 is a block diagram showing an acoustic reproducing apparatus according to embodiment 9 of the invention.

Fig. 10 is a block diagram showing an acoustic reproducing apparatus according to embodiment 10 of the invention.

Fig. 11 is a block diagram showing an acoustic reproducing apparatus according to embodiment 11 of the invention.

Fig. 12 is a block diagram showing an acoustic reproducing apparatus according to embodiment 12 of the invention.

Fig. 13 is a block diagram showing an acoustic reproducing apparatus according to embodiment 13 of the invention.

Fig. 14 is a block diagram showing an acoustic reproducing apparatus according to embodiment 14 of the invention.

Fig. 15 is a block diagram showing an acoustic reproducing apparatus according to embodiment 15 of the invention.

Fig. 16 is a block diagram showing an acoustic reproducing apparatus according to embodiment 16 of the invention.

Fig. 17 is a block diagram showing an acoustic reproducing apparatus according to embodiment 17 of the invention.

Fig. 18 is a block diagram showing an acoustic reproducing apparatus according to embodiment 18 of the invention.

Fig. 19 is a block diagram showing an acoustic reproducing apparatus according to embodiment 19 of the invention.

19 of the invention.

Fig. 20 is a block diagram showing an acoustic reproducing apparatus according to embodiment 20 of the invention.

Fig. 21 is a block diagram showing a basic constitution of an acoustic reproducing apparatus according to embodiment 21 of the invention.

Fig. 22 is a specific block diagram showing the acoustic reproducing apparatus according to embodiment 21 of the invention.

Fig. 23 is a block diagram showing a basic constitution of an acoustic reproducing apparatus according to embodiment 22 of the invention.

Fig. 24 is a specific block diagram showing the acoustic reproducing apparatus according to embodiment 22 of the invention.

Fig. 25 is a block diagram showing an acoustic reproducing apparatus according to embodiment 23 of the invention.

Fig. 26 is a block diagram showing an acoustic reproducing apparatus according to embodiment 24 of the invention.

Fig. 27 is a semi-sectional view showing the configuration of speaker and microphone of acoustic reproducing apparatus according to embodiments 25 to 30.

Fig. 28 is a characteristic diagram showing the speaker frequency characteristic in embodiment 1.

Fig. 29 is a characteristic diagram showing the frequency characteristic and phase characteristic of the power amplifier in embodiment 1.

Fig. 30 is a characteristic diagram showing the frequency characteristic and phase characteristic of the filter in embodiment 3.

Fig. 31 is a block diagram showing an acoustic reproducing apparatus according to embodiment 31 of the invention.

Fig. 32 is a semi-sectional block diagram showing the speaker in the same embodiment.

Fig. 33 is a frequency characteristic diagram of input signal of the acoustic reproducing apparatus in the same embodiment.

Fig. 34 is a acoustic frequency characteristic diagram of acoustic output signal when the acoustic output of the passive radiator is controlled in the acoustic reproducing apparatus in the same embodiment.

Fig. 35 is a acoustic frequency characteristic diagram of acoustic output signal when the acoustic output of the passive radiator is not controlled.

Fig. 36 is an acoustic signal waveform diagram when the passive radiator is controlled in the acoustic reproducing apparatus in the same embodiment.

Fig. 37 is an acoustic signal waveform diagram when the passive radiator is not controlled in the same acoustic reproducing apparatus.

Fig. 38 is a block diagram showing an acoustic reproducing apparatus according to embodiment 32 of the invention.

Fig. 39 is a block diagram showing an acoustic reproducing apparatus according to embodiment 33 of the invention.

Fig. 40 is a block diagram showing an acoustic reproducing apparatus according to embodiment 34 of the invention.

Fig. 41 is a block diagram showing an acoustic reproducing apparatus according to embodiment 35 of the invention.

Fig. 42 is a block diagram showing an acoustic reproducing apparatus according to embodiment 36 of the invention.

Fig. 43 is a block diagram showing an acoustic reproducing apparatus according to embodiment 37 of the invention.

Fig. 44 is a characteristic diagram showing the frequency characteristic and phase characteristic of the microphone output of the acoustic reproducing apparatus in embodiment 37.

Fig. 45 is a block diagram showing an acoustic reproducing apparatus according to embodiment 38 of the invention.

Fig. 46 is a block diagram showing an acoustic reproducing apparatus according to embodiment 39 of the invention.

Fig. 47 is a block diagram showing a modified acoustic reproducing apparatus of embodiment 39 of the invention.

Fig. 48 is a block diagram showing an acoustic reproducing apparatus according to embodiment 40 of the invention.

Fig. 49 is a block diagram showing a modified acoustic reproducing apparatus of embodiment 40.

Fig. 50 is a block diagram showing an acoustic reproducing apparatus according to embodiment 41 of the invention.

Fig. 51 is a block diagram showing an acoustic reproducing apparatus according to embodiment 42 of the invention.

Fig. 52 is a block diagram showing a modified acoustic reproducing apparatus of embodiment 42 of the invention.

Fig. 53 is a block diagram showing an acoustic reproducing apparatus according to embodiment 43 of the invention.

Fig. 54 is a block diagram showing a modified acoustic reproducing apparatus of embodiment 43 of the invention.

Fig. 55 is a block diagram showing an acoustic reproducing apparatus according to embodiment 44 of the invention.

Fig. 56 is a block diagram showing an acoustic reproducing apparatus according to embodiment 45 of the invention.

Fig. 57 is a block diagram showing a constitution of an acoustic reproducing apparatus of a prior art.

Fig. 58 is a block diagram showing the constitution of an acoustic reproducing apparatus using a passive radiator in a prior art.

Fig. 59 is a characteristic diagram showing the acoustic reproduction frequency characteristic and phase characteristic in a prior art.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Embodiment 1

A first embodiment of the invention is described below by reference to the accompanying drawing.

Fig. 1 is a block diagram showing the constitution of acoustic reproducing apparatus of the first embodiment of the invention. In Fig. 1, a signal entering from an input terminal 1 is fed into a positive input terminal of a subtractor 2, and the output signal of the subtractor 2 is fed into a power amplifier 3 and is amplified. A speaker 4 is connected at the output side of the power amplifier 3, and an acoustic output from the speaker 4 is radiated. This acoustic output is detected by a microphone 5.

The signal detected by the microphone 5 is amplified by a microphone amplifier 6, and its output signal and the output signal of the subtractor 2 are subtracted or added in an adder/subtractor 7. The output signal of the adder/subtractor 7 is fed into a negative input terminal of the subtractor 2, and a negative feedback circuit is composed. The adder/subtractor 7 is used as an adder when the output of the subtractor 2 is in positive phase to the output of the microphone amplifier 6 receiving the acoustic output signal of the speaker 4.

The adder/subtractor 7 is used as a subtractor when the output of the subtractor 2 is in reverse phase to the output of the microphone amplifier 6 receiving the acoustic output signal of the speaker 4.

Further explaining the adder/subtractor 7, the phase relation varies with the phase relation and connection polarity of the inputs and outputs of the power amplifier 3, microphone 5 and microphone amplifier 6, and the phase characteristic to the frequency varies depending on the location of the microphone 5. It also varies with the combination of the filter and phase shift circuit as mentioned below, and whether the adder/subtractor 7 is used as adder or subtractor should be determined at the time of composing the circuit, which holds true also in the following embodiments.

If used as the adder, when the input signal is -180 degrees, it is subtracted actually, but such operation is not shown herein.

The transmission function of the circuit for composing the acoustic reproducing apparatus in the first embodiment is expressed as follows, supposing the transmission function (degree of amplification) of the power amplifier 3 to be A, the degree of amplification of the adder/subtractor 7 and subtractor 2 to be 1 each, the transmission function of the acoustic system including the speaker 4, microphone 5 and microphone amplifier 6 to be T(S), the input voltage of input terminal 1 to be Vin, and the output voltage of power amplifier 3 to be Vout:

$$V_{out}/V_{in} = A/(2 + A \cdot T(S))$$

In such relation, if A is sufficiently large, it follows that

$$V_{out}/V_{in} \approx 1/T(S)$$

and the transmission characteristic of the acoustic system including speaker 4 and the others becomes a reverse characteristic of the transmission function of the acoustic system including the speaker 4, microphone 5 and microphone amplifier 6. Actually, however, since oscillation (howling) occurs, the magnitude of A is limited, and generally when

$$|2 + A \cdot T(S)| > 1$$

the feedback is negative, and when

$$|2 + A \cdot T(S)| < 1$$

the feedback is positive. In positive feedback, oscillation (howling) occurs, and this range cannot be used, and therefore, in the following embodiments, it is attempted not to operate the system in such range by various means.

As a conventional example, the transmission function of the circuit in the block diagram shown in Fig. 58 may be expressed as follows in the same manner as above,

$$V_{out}/V_{in} = A/(1 + A \cdot T(S))$$

and comparing it with the transmission function of the invention, evidently, it is known possible to increase the negative feedback amount more than in the prior art.

Fig. 28 compares the frequency characteristic of the speaker 4 corrected according to the embodiment with the uncorrected cases. Fig. 29 shows the output voltage characteristic relative to

the frequency and the phase characteristic relative to the frequency of the power amplifier 3 corrected according to the embodiment.

Incidentally, the position of the microphone 5 in the embodiment is located above the center pole of center of the lower plate 35 of the speaker 4 as shown in code 5e in Fig. 27 as specifically described in the following embodiments, and as shown in Fig. 28 it is known that the characteristic in the medium range (700 Hz to 1.5 kHz) for inducing edge resonance of the speaker 4 is improved.

Embodiment 2

A second embodiment of the invention is described by reference to the drawing.

Fig. 2 is a block diagram showing the constitution of the acoustic reproducing apparatus in the second embodiment. As one of the input signals to the adder/subtractor 7, the signal from the output terminal of the power amplifier 3 is connected, and the other constitution is same as in Embodiment 1.

The transmission function of this circuit is

$$V_{out}/V_{in} = A/(1 + A + A \cdot T(S))$$

and the negative feedback amount can be increased from the prior art same as in Embodiment 1.

Embodiment 3

A third embodiment of the invention is described by reference to the drawing.

Fig. 3 is a block diagram showing the constitution of the acoustic reproducing apparatus in the third embodiment. In addition to the constitution of the first embodiment, a filter 8 is inserted between the microphone amplifier 6 and adder/subtractor 7, and the other constitution is same as in Embodiment 1.

Fig. 30 shows the characteristic of the filter 8, and the degree of amplification rises as becoming higher in frequency range. The phase characteristic of this filter has a phase advancement of about 60 degrees at 1.5 kHz.

Generally, the phase characteristic of a speaker is delayed toward -180 degrees from the frequency band exceeding the piston motion range (about 800 Hz) as shown in Fig. 59, and the phase characteristic is disturbed in the split resonance region. However, edge resonance also occurs near the maximum frequency of piston motion, and fluctuations are significant depending on the speaker, and therefore both amplitude and phase may be unstable at the time of negative feedback. it is hence intended to maintain a phase allowance by

inserting the filter 8 having such phase advancing characteristic as mentioned above into the output side of the microphone amplifier 6.

Nevertheless, since the frequency characteristic of the filter 8 is also raised toward the high frequency range, in the place where the speaker frequency characteristic acoustically declines as becoming higher in frequency range, for example, at positions of codes 5e, 5f, 5g, 5h in Fig. 27 showing the microphone locations explained in detail below, by installing microphones 5 and correcting the phase with the filter 8 having above phase advancing characteristic, the band allowed to apply negative feedback stably can be expanded.

Embodiment 4

A fourth embodiment of the invention is described by reference to the drawing.

Fig. 4 is a block diagram showing the constitution of the acoustic reproducing apparatus in the fourth embodiment. In addition to the constitution in Fig. 2 of the second embodiment, a filter 8 is inserted between the microphone amplifier 6 and adder/subtractor 7, and the other constitution is same as in Embodiment 2.

In this embodiment, by the filter 8 having the phase advancing characteristic as shown in Fig. 30, the stability of the negative feedback system can be enhanced same as in Embodiment 3, and detailed description is omitted.

Embodiment 5

A fifth embodiment of the invention is described by reference to the drawing.

Fig. 5 is a block diagram showing the constitution of the acoustic reproducing apparatus in the fifth embodiment. In this embodiment, in addition to the constitution of the first embodiment in Fig. 1, a high pass filter 11 and a second adder/subtractor 10 are added, in which the output signal of the microphone amplifier 6 and input signal of the power amplifier 3 are passes through the high pass filter 11 and fed into the second adder/subtractor 10, and the output signal added or subtracted in the second adder/subtractor 10 is connected so as to be negatively fed back to the subtractor 9.

The transmission function of the circuit is, supposing the first adder/subtractor 7 to be a subtractor and the second adder/subtractor 10 to be an adder, and the transmission characteristic of the high pass filter 11 to be $T(F)$, expressed as follows:

$$V_{out}/V_{in} = A/(2 + A \cdot T(S) + T(F) - A \cdot T(S) \cdot T(F))$$

and from this transmission function, assuming now $T(F)$ to be a primary high pass filter, and in the

case of frequency band for cutting off the signal, it is $T(F) \equiv 0$ and the transmission function is

$$V_{out}/V_{in} \equiv A/(2 + A \cdot T(S))$$

and the transmission function is same as in Embodiment 1. Furthermore, when $T(F)$ is a frequency band for passing a signal, it becomes $T(F) \equiv 1$, and the transmission function is

$$V_{out}/V_{in} \equiv A/3$$

In this circuit configuration, hence, the same negative feedback as in Embodiment 1 is applied in the frequency cut-off band of the transmission function $T(F)$ of the high pass filter 11, and when $T(F)$ is passing frequency band, the degree of amplitude is constant regardless of the transmission function of the acoustic system including speaker 4 and the others.

In this circuit, for example, if the split resonance or the like of the speaker 4 depends on the high frequency range and phase rotation is violent so that howling cannot be avoided, by further negatively feeding back parallel the band limited by $T(F)$, it is irrelevant to transmission function of the acoustic system including speaker 4 and the others, and howling can be prevented.

Herein, the first adder/subtractor 7 is used as subtractor and second adder/subtractor 10 as adder, but, depending on the condition, the first adder/subtractor 7 may be operated as adder, and the second adder/subtractor 10 as subtractor.

Embodiment 6

A sixth embodiment of the invention is described by reference to the drawing.

Fig. 6 is a block diagram showing the constitution of the acoustic reproducing apparatus in the sixth embodiment. What differs from Embodiment 5 is that one input terminal of the first adder/subtractor 7 is connected to the output terminal of the power amplifier 3.

In this circuit, too, same as in Embodiment 5, using the first adder/subtractor 7 as subtractor and the second adder/subtractor 10 as adder, and supposing the transmission function of the high pass filter 11 to be $T(F)$, the transmission function is expressed as follows:

$$V_{out}/V_{in} = A/(1 + A + A \cdot T(S) + A \cdot T(F) - A \cdot T(S) \cdot T(F))$$

In the case of frequency band for the filter 11 cutting off the signal, that is, $T(F) \equiv 0$, it follows that

$$V_{out}/V_{in} = A/(1 + A + A \cdot T(S))$$

or in the case of frequency band for the filter 11 passing through the signal, that is, $T(F) \equiv 1$, it follows that

$$V_{out}/V_{in} = A/(1 + 2A)$$

and it eliminates the dependence of the transmission characteristic $T(S)$ of the acoustic system including speaker 4 and others only in the passing band of $T(F)$ relative to Embodiment 2.

Herein, the first adder/subtractor 7 is used as subtractor and second adder/subtractor 10 as adder, but, depending on the condition, the first adder/subtractor 7 may be operated as adder, and the second adder/subtractor 10 as subtractor.

Embodiment 7

A seventh embodiment of the invention is described by reference to the drawing.

Fig. 7 is a block diagram showing the constitution of the acoustic reproducing apparatus in the seventh embodiment. A filter 8 hiving in the degree of amplitude along with elevation in frequency range as shown in Fig. 30 used in Embodiment 3 is connected to the output of the microphone amplifier 6 in the circuit in Embodiment 5 in Fig. 5, and the first adder/subtractor 7 and high pass filter 11 are connected to the output of this filter 8, and the other constitution is same as in Embodiment 5.

By this filter 8, in this embodiment, the stability of negative feedback system can be enhanced same as in Embodiment 3, and detailed description is omitted.

Embodiment 8

An eighth embodiment of the invention is described by reference to the drawing.

Fig. 8 is a block diagram showing the constitution of the acoustic reproducing apparatus in the eighth embodiment. The filter 8 used in Embodiment 3 is connected to the output of the microphone amplifier 6 of Embodiment 6 in Fig. 6, and the first adder/subtractor 7 and high pass filter 11 are serially connected to the output of this filter 8, and the other constitution is same as in Embodiment 6.

By this filter 8, in this embodiment, the stability of negative feedback system can be enhanced same as in Embodiment 3, and detailed description is omitted.

Embodiment 9

A ninth embodiment of the invention is described by reference to the drawing.

Fig. 9 is a block diagram showing the constitution of the acoustic reproducing apparatus in the ninth embodiment. An input terminal 1 is connected to a positive input terminal of a first subtractor 12, an output terminal of the first subtractor 12 is connected to a positive input terminal of a second subtractor 13, an output terminal of the second subtractor 13 is connected to an input terminal of a power amplifier 3, the output of the power amplifier 3 is given to the speaker 4, the acoustic output of the speaker 4 is received by the microphone 5, and its output is fed into a microphone amplifier 6. The output of the microphone amplifier 6 is connected to the negative input terminal of the second subtractor 13, and the output terminal of the second subtractor 13 is connected to the negative input terminal of the first subtractor 12.

In this constitution, the input signal of the power amplifier 3 is subtracted from the input signal in the first subtractor 12, and the output signal of the microphone amplifier 6 is subtracted from the output signal of the first subtractor 12 in the second subtractor 13, and its output signal is fed as input signal to the power amplifier 3.

The transmission function of this circuit is

$$V_{out}/V_{in} = A/(2 + A \cdot T(S))$$

and the same transmission characteristic as in Embodiment 1 is obtained, and this transmission characteristic is same as in Embodiment 1 and detail description is omitted.

Embodiment 10

A tenth embodiment of the invention is described by reference to the drawing.

Fig. 10 is a block diagram showing the constitution of the acoustic reproducing apparatus in the tenth embodiment. What the embodiment differs from Embodiment 9 is that the output of the power amplifier 3 is connected to the negative input terminal of the first subtractor 12 connecting the input terminal 1, and the other constitution is same as in Embodiment 9, and the output signal of the power amplifier 3 is subtracted from the input signal in the first subtractor 12, and the output signal of the microphone amplifier 6 is subtracted from the output signal of the first subtractor 12 in the second subtractor 13, and its output signal is fed as input signal to the power amplifier 3.

The transmission function of this circuit is

$$V_{out}/V_{in} = A/(1 + A + A \cdot T(S))$$

and the same transmission characteristic as in Embodiment 2 is obtained, and detail description is omitted.

Embodiment 11

An eleventh embodiment of the invention is described by reference to the drawing.

Fig. 11 is a block diagram showing the constitution of the acoustic reproducing apparatus in the eleventh embodiment, and in addition to the constitution of Embodiment 9, in this embodiment, the filter 8 used in Embodiment 3 is inserted between the output of the microphone amplifier 6 and negative input terminal of the second subtractor 13, and the other constitution is same as in Embodiment 9.

By the filter 8, in this embodiment, the stability of the negative feedback system can be enhanced same as in Embodiment 3, and explanation of detail is omitted.

Embodiment 12

A twelfth embodiment of the invention is described by reference to the drawing.

Fig. 12 is a block diagram showing the constitution of the acoustic reproducing apparatus in the twelfth embodiment. In addition to the constitution of Embodiment 10, in this embodiment, the filter 8 used in Embodiment 3 is inserted between the microphone amplifier 6 and negative input terminal of the second subtractor 13, and the other constitution is same as in Embodiment 10.

By the filter 8, in this embodiment, the stability of the negative feedback system can be enhanced same as in Embodiment 3, and explanation of detail is omitted.

Embodiment 13

A thirteenth embodiment of the invention is described by reference to the drawing.

Fig. 13 is a block diagram showing the constitution of the acoustic reproducing apparatus in the thirteenth embodiment. In addition to the constitution of Embodiment 9, in this embodiment, an adder/subtractor 7 is provided between the microphone amplifier 6 and negative input terminal of the second subtractor 13, and the output signal of the second subtractor 13 is branched and connected to one input terminal of the adder/subtractor 7, and in this constitution, the output signal of microphone amplifier 6 and output signal of second subtractor 13 are added or subtracted in the adder/subtractor 7, and its output signal is connected to the negative input terminal of the second subtractor 13, output of the first subtractor 12 is connected in series to the front stage of the second subtractor 13, and the output signal of the second subtractor 13 is fed into the negative input terminal of the first subtractor 12.

The transmission function of this circuit is

$$V_{out}/V_{in} = A/(3 + A \cdot T(S))$$

and hence, according to the embodiment, the negative feedback amount may be further increased more than in the circuit described in Embodiment 1.

Embodiment 14

A fourteenth embodiment of the invention is described by reference to the drawing.

Fig. 14 is a block diagram showing the constitution of the acoustic reproducing apparatus in the fourteenth embodiment. What the embodiment differs from Embodiment 13 is that the output signal of the power amplifier 3 is connected to the input of the adder/subtractor 7 and negative input terminal of the first subtractor 12, and the other

constitution is same as in Embodiment 13.

The transmission function of this circuit is

$$V_{out}/V_{in} = A/(2 + A + A \cdot T(S))$$

and hence, according to the embodiment, the negative feedback amount may be further increased more than in the circuit described in Embodiment 2.

Embodiment 15

A fifteenth embodiment of the invention is described by reference to the drawing.

Fig. 15 is a block diagram showing the constitution of the acoustic reproducing apparatus in the fifteenth embodiment. In addition to the constitution of Embodiment 13, in this embodiment, the filter 8 used in Embodiment 3 is inserted between the output of the microphone amplifier 6 and one input of the adder/subtractor 7, and the other

constitution is same as in Embodiment 13. By constituting with the filter 8, in this embodiment, the stability of the negative feedback system can be enhanced same as in Embodiment 3, and explanation of detail is omitted.

Embodiment 16

A sixteenth embodiment of the invention is described by reference to the drawing.

Fig. 16 is a block diagram showing the constitution of the acoustic reproducing apparatus in the sixteenth embodiment. In addition to the constitution of Embodiment 14, in this embodiment, the filter 8 used in Embodiment 3 is inserted between the output of the microphone amplifier 6 and one input of the adder/subtractor 7, and the other

constitution is same as in Embodiment 14. By constituting with the filter 8, in this embodiment, the stability of the negative feedback system can be enhanced same as in Embodiment 3, and explanation of detail is omitted.

Embodiment 17

A seventeenth embodiment of the invention is described by reference to the drawing.

Fig. 17 is a block diagram showing the constitution of the acoustic reproducing apparatus in the seventeenth embodiment. In this embodiment, instead of the subtractor 2 provided in the input unit in Embodiment 1, a second subtractor 13 is used, and the output terminal of the first subtractor 12 is connected to a positive input terminal of the second subtractor 13, an input terminal 1 for signal input is connected to the positive input terminal of the first subtractor 12, and the output signal of the power amplifier 3 is connected to its negative input terminal.

In this constitution, the output signal of microphone amplifier 6 and input signal of power amplifier 3 are added or subtracted in the adder/subtractor 7, and the output signal of the adder/subtractor 7 is subtracted from the output signal of the first subtractor 12 in the second subtractor 13, and further the output signal of the power amplifier 3 is subtracted from the input signal in the first subtractor 12, and hence the transmission function of this circuit is

$$V_{out}/V_{in} = A/(2 + A + A \cdot T(S))$$

and this transmission function is same as in Embodiment 14, and description of its detail is omitted.

Embodiment 18

An eighteenth embodiment of the invention is described by reference to the drawing.

Fig. 18 is a block diagram showing the constitution of the acoustic reproducing apparatus in the eighteenth embodiment. In this embodiment, instead of the subtractor 2 provided in the input unit in Embodiment 2, a second subtractor 13 is used, and the output terminal of the first subtractor 12 is connected to a positive input terminal of the second subtractor 13, an input terminal 1 for signal input is connected to the positive input terminal of the first subtractor 12, and the output signal of the second subtractor 13 is connected to negative input terminal of the first subtractor 12.

In this constitution, the output signal of power amplifier 3 and output signal of microphone amplifier 6 are added or subtracted in the ad-

der/subtractor 7, and the output signal of the adder/subtractor 7 is subtracted from the output signal of the first subtractor 12 in the second subtractor 13, and further the output signal of the second subtractor 13 is subtracted from the input signal in the first subtractor 12, and hence the transmission function of this circuit is

$$V_{out}/V_{in} = A/(2 + A + A \cdot T(S))$$

and this transmission function is same as in Embodiment 14, and description of its detail is omitted.

Embodiment 19

A nineteenth embodiment of the invention is described by reference to the drawing.

Fig. 19 is a block diagram showing the constitution of the acoustic reproducing apparatus in the nineteenth embodiment. In addition to the constitution of Embodiment 17, in this embodiment, the filter 8 used in Embodiment 3 is inserted between the output of the microphone amplifier 6 and one input of the adder/subtractor 7, and the other constitution is same as in Embodiment 17.

By constituting with the filter 8, in this embodiment, the stability of the negative feedback system can be enhanced same as in Embodiment 3, and explanation of detail is omitted.

Embodiment 20

A twentieth embodiment of the invention is described by reference to the drawing.

Fig. 20 is a block diagram showing the constitution of the acoustic reproducing apparatus in the twentieth embodiment. In addition to the constitution of Embodiment 18, in this embodiment, the filter 8 used in Embodiment 3 is inserted between the output of the microphone amplifier 6 and one input of the adder/subtractor 7, and the other constitution is same as in Embodiment 18.

By constituting with the filter 8, in this embodiment, the stability of the negative feedback system can be enhanced same as in Embodiment 3, and explanation of detail is omitted.

Embodiment 21

A twenty-first embodiment of the invention is described by reference to the drawings.

Fig. 21 is a block diagram showing the constitution of the acoustic reproducing apparatus in the twenty-first embodiment, and Fig. 22 is a further specific block diagram.

Fig. 21 shows a basic block diagram for applying an acoustic negative feedback by using a plu-

ality each of speakers and microphones and one power amplifier 3.

Usually, the characteristic of filters 14a, 14b, 14c which divide the bands of speakers 4a, 4b, 4c, and the characteristic of filters 16a, 16b, 16c which are connected to outputs of negative feedback circuits 15a, 15b, 15c are used in combination.

The negative feedback circuits 15a, 15b, 15c herein may be composed of any circuit designed to add or subtract the input of power amplifier 3 and output of microphone amplifier 6 (or output through filter) as disclosed in Embodiments 1 through 20.

Fig. 22 shows the circuit structure in Fig. 21 more specifically, and a two-way speaker system is constituted herein, and a low pass circuit is composed of a coil 18 and a high pass circuit a capacitor 19, which are respectively connected to a bass speaker 4d and a treble speaker 4e. The outputs of microphones 5a, 5b corresponding to the speakers are amplified in microphone amplifiers 6a, 6b, added or subtracted with output signals of subtractors 2a, 2b connected to one of inputs thereof in adders/subtractors 7a, 7b, and connected to negative input terminals of the subtractors 2a, 2b.

The outputs of the subtractors 2a, 2b are passed through filters 16e, 16d, and added and fed into a power amplifier 3. At this time, the filters 16e, 16d have the same characteristic as the low pass circuit of the coil 18 of the output filter of the power amplifier 3 and the high pass circuit of the capacitor 19, and suppress interference between the speakers 4d, 4d due to the microphones 5a, 5b.

In this constitution, a negative feedback can be applied to a multi-way speaker system.

Embodiment 22

A twenty-second embodiment of the invention is described by reference to the drawings.

Fig. 23 is a block diagram showing the constitution of the acoustic reproducing apparatus in the twenty-second embodiment, and Fig. 24 is a block diagram showing its specific constitution. In Fig. 23, microphones 5a to 5c are used as many as the number (three in this embodiment) of speakers 4a to 4c, and a negative feedback circuit 20 is provided to feed back negatively to one subtractor after adding or subtracting process by disposing filters at outputs of the microphones 5a to 5c.

In a more specific configuration in Fig. 24 (a two-way system is explained for the sake of simplicity), a coil 18 of low pass circuit (filter) and a capacitor 19 of high pass circuit (filter) are connected to the output of the power amplifier 3, and are further connected to a bass speaker 4d and a

treble speaker 4e respectively. Their acoustic outputs are detected by microphones 5a, 5b, amplified by microphone amplifiers 6a, 6b, passed through filters 8a, 8b, fed into adders/subtractors 7a, 7b, and added or subtracted with the output signal of the subtractor 2, and the outputs are connected to a negative input terminal of the subtractor 2.

For this circuit configuration, all constitutions of negative feedback circuits in Embodiments 1 to 20 are usable, and it is possible to compose with a relatively smaller number of parts than in Embodiment 21, while a negative feedback can be applied to a multi-way speaker.

Embodiment 23

A twenty-third embodiment of the invention is described by reference to the drawings.

Fig. 25 is a block diagram showing the constitution of the acoustic reproducing apparatus in the twenty-third embodiment. In this embodiment, the acoustic reproducing apparatus possessing a tone adjusting function is composed of a negative feedback circuit and a voltage control amplifier, and it is optimum in the case of presence of limitation in the dynamic range of the system, for example, acoustic reproducing apparatus for mobile audio system or hall acoustic system.

As shown in Fig. 25, the signal entered from an input terminal 1 passes through a voltage control amplifier 21, a tone adjusting filter 22 (for example, a graphic equalizer), and a negative feedback circuit 23, and is fed into a power amplifier 3. This negative feedback circuit 23 may be composed of any circuit designed to add or subtract the input signal of the power amplifier 3 and output of the microphone amplifier 6 (or a filter output) as disclosed in Embodiments 1 to 22.

Generally, by applying acoustic negative feedback or changing frequency characteristic by tone adjusting filter, the dynamic range lacks in a high level portion of input signal, and the output of the power amplifier may be clipped, but in this embodiment, in order to solve this problem, the input voltage of the power amplifier 3 is detected by a level detector 24, and by setting an input voltage (output voltage of the negative feedback circuit 23) not to cause to clip the output of the power amplifier 3, when an input voltage exceeding the set voltage is detected, it is converted into a DC voltage in an AC/DC converter 25, and the degree of amplification of the voltage control amplifier 21 is lowered by this voltage.

By using thus constituted circuit of the embodiment, the clip of the power amplifier 3 can be limited to a minimum regardless of the adjusting state of the frequency characteristic of the acoustic adjusting filter 22 or the state of negative feedback

system.

Embodiment 24

A twenty-fourth embodiment of the invention is described by reference to the drawings.

Fig. 26 is a block diagram showing the constitution of the acoustic reproducing apparatus in the twenty-fourth embodiment, and in this embodiment, when the constitution of the power amplifier 3 used in Embodiments 1 to 23 is different, that is, in a mobile audio system, when a power amplifier 26 is connected in BTL (balanced transformer-less) structure, and a DC voltage of about half of the supply (battery) voltage is applied between its output terminal and the ground, only a DC component is picked up from the output of the power amplifier 26, and is used as a power source for a microphone 27.

When the supply voltage is, for example, 14 V, a DC voltage of about 7 V is applied between the output terminal (positive output, negative output) of the BTL-connected power amplifier 26 and the ground, and AC signals are adding in reverse phase to each other on the basis of this voltage. By adding these two signals in resistors 28, 29, AC components in reverse phase to each other are removed, and only DC components (about 7 V) can be taken out. A capacitor 30 composes a low pass filter together with the resistors 28, 29, and the DC voltage is stabilized.

As the microphone 27, generally, an electret condenser microphone is used, and a field effect transistor is built in a microphone capsule, and a register 31 is for bias register of the field effect transistor, and a microphone output signal is taken out from one end 32 at the microphone 27 side of the register 31.

Generally, when using this acoustic reproducing apparatus for mobile use, a shield wire is used for prevention of induced noise as the connection cord of the microphone 27, but in the constitution of the embodiment it is possible to lower the output resistance of the microphone 27, and if the connection cord is a single wire, it is less susceptible to noise effect.

Embodiment 25

Examples described in Embodiments 25 to 30 below relate to changes of configuration of microphone explained in the foregoing Embodiments 1 to 24, and, to begin with, a twenty-fifth embodiment of the invention is described below by reference to the drawing.

Fig. 27 shows the speaker for the acoustic reproducing apparatus of Embodiments 25 to 30, and in the twenty-fifth embodiment, specifically, the

microphone 5d for detecting acoustic output signals is disposed on the front side of a dust cap 34 coupled in the middle of a diaphragm 33.

By disposing the microphone 5d in this area, the frequency characteristic can be detected over an almost entire frequency range generated from the speaker.

Embodiment 26

A twenty-sixth embodiment of the invention is described below by reference to the drawing.

In the twenty-sixth embodiment, the microphone 5e for detecting acoustic output signals in Fig. 27 is disposed before the center pole of a lower plate 35 for composing a magnetic circuit.

By disposing the microphone 5e in this area, the characteristic is such that signals are detected from low frequency range to the limit value of piston motion, while higher frequency components attenuate.

Embodiment 27

A twenty-seventh embodiment of the invention is described below by reference to the drawing.

In the twenty-seventh embodiment, the microphone 5f for detecting acoustic output signals in Fig. 27 is disposed in lower part (rear part in the position being installed in speaker box) of a central hole of the lower plate 35.

By disposing the microphone 5f in this area, same as in Embodiment 26, the characteristic is such that the resonance (peak) of the central hole of the lower plate 35 appears in the high frequency range, while higher frequency components attenuate.

Embodiment 28

A twenty-eighth embodiment of the invention is described below by reference to the drawing.

In the twenty-eighth embodiment, the microphone 5g for detecting acoustic output signals in Fig. 27 is disposed between the center pole of the lower plate 35 for composing a magnetic circuit and a magnet 36.

When the microphone 5g is disposed in this area, nearly the same characteristic as in Embodiment 26 is obtained.

Embodiment 29

A twenty-ninth embodiment of the invention is described below by reference to the drawing.

In the twenty-ninth embodiment, the microphone 5h for detecting acoustic output signals in Fig. 27 is disposed between the lower side of a

suspension 38 for supporting a voice coil 40 and a frame 39 (or an upper plate 37).

When the microphone 5h is disposed in this area, the characteristic is similar to that of Embodiment 25, that is, high frequency range attenuates smoothly while detecting almost all frequency range of the acoustic output issued by the speaker.

Embodiment 30

A thirtieth embodiment of the invention is described below by reference to the drawing.

In the thirtieth embodiment, the microphone 5i for detecting acoustic output signals in Fig. 27 is disposed between the diaphragm 33 and frame 39.

When the microphone 5i is disposed in this area, the characteristic nearly similar to that of Embodiment 25 is obtained.

Embodiment 31

A thirty-first embodiment of the invention is described by reference to the drawing.

Fig. 31 is a block diagram showing the constitution of the acoustic reproducing apparatus in the thirty-first embodiment. In the diagram, the signal entering from an input terminal 1 is fed into a positive input terminal of a subtractor 2, and an output signal of the subtractor 2 is fed into a power amplifier 3 and is amplified. A speaker 42 is connected at the output side of the power amplifier 3, and an acoustic output is radiated from the speaker 42. This acoustic output is detected by a microphone 5.

The signal detected by the microphone 5 is amplified by a microphone amplifier 6, and its output signal and the output signal of the subtractor 2 are subtracted or added in an adder/subtractor 7. The output signal of the adder/subtractor 7 is fed into a negative input terminal of the subtractor 2, thereby composing a negative feedback circuit. Thus constituted negative feedback circuit is same as Embodiment 1 electrically.

Herein, a speaker box 41 forms enclosed spaces 41A, 41B communicating in the longitudinal direction, and the speaker 42 is coupled to the enclosed space 41A at the rear chamber side, and a passive radiator 43 is coupled to the enclosed space 41B at the front chamber side, and the passive radiator 43 is driven through the air in the enclosed space 41B by driving of the speaker 42, thereby reproducing acoustically.

Fig. 32 is a semi-sectional view showing only one side from the central line axis-symmetrical of the sectional view of the speaker 42 coupled to the speaker box 41. The microphone 5 is disposed in the central front part of the magnetic circuit 42A of the speaker 42, and an acoustic output signal gen-

erated in a space enclosed by a voice coil 42B and dust cap 42C is detected, and it is composed to apply a negative feedback by using the detected acoustic signal.

In thus constituted acoustic reproducing apparatus of the embodiment, as shown in Fig. 31, the input signal amplified in the power amplifier 3 through the subtractor 2 from the input terminal 1 is reproduced by the speaker 42 shown in Fig. 32, and the acoustic output signal radiated from the speaker 42 is detected by a microphone 5, and the output signal of the microphone 5 is amplified in the microphone amplifier 6, and the output signal of the microphone amplifier 6 and the output signal of the subtractor 2 connected to the input terminal 1 are added or subtracted in the adder/subtractor 7, and fed into the negative input terminal of the subtractor 2.

The transmission function of this circuit is expressed as follows, supposing the transmission function of the acoustic system comprising the speaker 42, microphone 5 and microphone amplifier 6 to be $T(S)$, the transmission function of the power amplifier 3 to be A (constant), the degree of amplitude of the adder/subtractor 7 and subtractor 2 to be 1, the input voltage to be V_{in} , and output voltage of the power amplifier 3 to be V_{out} :

$$V_{out}/V_{in} = A/(2 + A \cdot T(S))$$

Expressed similarly, the transmission function in the block diagram of the acoustic reproducing apparatus of the prior art explained in Fig. 58 was as follows as mentioned above.

$$V_{out}/V_{in} = A/(1 + A \cdot T(S))$$

That is, since the frequency characteristic of the microphone 5 is nearly flat, $T(S)$ is a transmission function of acoustic system composed of speaker 42, passive radiator 43, and front and rear enclosed spaces 41A, 41B, and when the phase difference of the signal delivered from the power amplifier 3 by resonance (low frequency range resonance) composed of the speaker 42, passive radiator 43 and enclosed spaces 41A, 41B, and the output signal of the microphone 5 is changed by 180 degrees to the plus or minus side (the phase is inverted), $T(S)$ is minus 1, and supposing the degree of amplitude A of the power amplifier 3 to be 1, the denominator is 0 and oscillation occurs in the circuit of the prior art, but the transmission function is 1 in the circuit of the embodiment, and it is known possible to keep stability of the negative feedback in the same condition.

Besides, the position of the microphone 5 is very large in sound pressure, and incoming noise is substantially attenuated by the passive radiator

43, and hence a high S/N ratio is obtained.

Fig. 33, Fig. 34, and Fig. 35 respectively show the frequency characteristic of the input signal of the acoustic reproducing apparatus of the embodiment, the frequency characteristic by control of the acoustic output of the passive radiator 43 by negative feedback circuit, and the frequency characteristic without control of the acoustic output of the passive radiator 43, and it is known that the characteristic by negative feedback in Fig. 34 is closer to the input original signal shown in Fig. 33.

Fig. 36 shows an acoustic signal waveform radiated from the passive radiator 43 when 60 Hz tone burst waves (10 waves ON, 1 wave OFF) are entered in the case of control of acoustic output of the passive radiator 43 by the negative feedback circuit in Fig. 31. Fig. 37 shows an acoustic signal waveform without such control. Comparing them and taking note of the 1-wave OFF portion, it is known that the signal waveform with control of acoustic output is decreased in level as compared with the signal waveform without control. It proves that the rise and fall characteristics of the passive radiator 43 are improved by the control.

Embodiment 32

A thirty-second embodiment of the invention is described by reference to the drawing. Fig. 38 is a block diagram showing the constitution of the acoustic reproducing apparatus in the embodiment. A phase shift circuit 45 is inserted between the microphone amplifier 6 and adder/subtractor 7 of Embodiment 31, and the other constitution is same as in Embodiment 31 in Fig. 31.

In such constitution, by controlling the phase of negative feedback signal in the negative feedback frequency band, the tone and frequency characteristic of the system can be stably improved same as in Embodiment 31.

Embodiment 33

A thirty-third embodiment of the invention is described by reference to the drawing. Fig. 39 is a block diagram showing the constitution of the acoustic reproducing apparatus in the embodiment. A filter 44 and a phase shift circuit 45 are serially inserted between the microphone amplifier 6 and adder/subtractor 7 of Embodiment 31, and the other constitution is same as in Embodiment 31 in Fig. 31.

In such constitution, by controlling the band and phase of negative feedback, the tone and frequency characteristic of the system can be stably improved same as in Embodiment 31.

Embodiment 34

A thirty-fourth embodiment of the invention is described by reference to the drawing. Fig. 40 is a block diagram showing the constitution of the acoustic reproducing apparatus in the embodiment. The output of the microphone amplifier 6 in Embodiment 31 is branched into two, and the branched outputs are fed into a first filter 46A and a second filter 46B mutually different in characteristic. The output of the first filter 46A and the output of the second filter 46B passing through an inverting circuit 47 are fed into an adder 48, and the output of the adder 48 is fed into the adder/subtractor 7, and the other constitution is same as in Embodiment 31 in Fig. 31.

In such constitution, the tone and frequency characteristic of the system are proved same as in Embodiment 31, while the degree of freedom for control for that purpose can be extended.

Embodiment 35

A thirty-fifth embodiment of the invention is described by reference to the drawing. Fig. 41 is a block diagram showing the constitution of the acoustic reproducing apparatus in the embodiment. In this embodiment, instead of the inverting circuit 47 in Embodiment 34 shown in Fig. 40, a phase shift circuit 45 is used, and the other constitution is same as in Embodiment 34 in Fig. 40.

In such constitution, the degree of freedom for control for improving the tone and frequency characteristic of the system can be extended same as in Embodiment 34.

Embodiment 36

A thirty-sixth embodiment of the invention is described by reference to the drawing. Fig. 42 is a block diagram showing the constitution of the acoustic reproducing apparatus in the embodiment. In this embodiment, the location of the microphone 5 shown in Embodiment 31 in Fig. 31 is disposed within the rear side enclosed space 41A of the speaker 42, and the other constitution is same as in Embodiment 31.

In thus constituted acoustic reproducing apparatus of the embodiment, the output signal of a power amplifier 3 is connected to the speaker 42, and the speaker 42 is driven to cause a pressure change in the front enclosed space 41B. At this time, in the rear enclosed space 41A of the speaker 42, a pressure change different in phase from the front enclosed space 41B occurs, and the pressure change in the rear enclosed space 41A is detected by the microphone 5, and in this constitution, therefore, the pressure change in the rear

enclosed space 41A reaches the maximum at the frequency where the speaker 42 and passive radiator 43 resonate in phase, and becomes the minimum when the speaker 42 and passive radiator 43 resonate in reverse phase.

Therefore, when the speaker 42 and passive radiator 43 resonate in phase, the transient characteristic can be improved.

Embodiment 37

A thirty-seventh embodiment of the invention is described by reference to the drawing. Fig. 43 is a block diagram showing the constitution of the acoustic reproducing apparatus in the embodiment. In this embodiment, the location of the microphone 5 shown in Embodiment 31 in Fig. 31 is disposed in the front side enclosed space 41B of the speaker 42, and the other constitution is same as in Embodiment 31.

In thus constituted acoustic reproducing apparatus of the embodiment, the signal entering from an input terminal 1 is fed into a positive input terminal of a subtractor 2, and the output of the subtractor 2 is amplified in a power amplifier 3, and the speaker 42 is driven by its signal. The pressure change of this speaker 42 is transmitted to the air in the front enclosed space 41B of the speaker 42, and the pressure change in this enclosed space 41B is transmitted to a passive radiator 43, and an acoustic output is radiated outside by the vibration of the passive radiator 43.

The pressure change of the front enclosed space 41B of the speaker 42 for vibrating the passive radiator 43 is detected by the microphone 5. The detected signal is amplified by the microphone amplifier 6, the output of the microphone amplifier 6 and the output signal of the subtractor 2 connected to the input terminal 1 are fed into an adder/subtractor 7 to be subtracted or added in the adder/subtractor 7. The output signal of the adder/subtractor 7 is connected to a negative input terminal of the subtractor 2, and a negative feedback circuit is constituted.

The adder/subtractor 7 is used as an adder when the output signal of the microphone 5 is in phase with the input signal of the input terminal 1, and as a subtractor when in reverse phase. In this case, the transmission function of the entire system can be expressed as follows:

$$V_{out}/V_{in} = A/(2 + A/T(S))$$

where A is the degree of amplification of the power amplifier 3, T(S) is the transmission function comprising the speaker 42, microphone 5 and microphone amplifier 6, V_{in} is an input voltage, and V_{out} is an output voltage of the power amplifier 3.

In this transmission function, supposing the degree of amplitude A of the power amplifier 3 to be 1, and the transmission function T(S) comprising the speaker 42, microphone 5 and microphone amplifier 6 also to be 1, when a negative feedback of a stationary in-phase signal is considered, we obtain

$$V_{out}/V_{in} = 1/3$$

and when the negative feedback signal before rise of the speaker 42 is 0, the transmission function is

$$V_{out}/V_{in} = 1/2$$

and hence until the speaker 42 begins to operate, the power amplifier 3 supplies a high power of about 3.6 dB to the speaker 42.

In case a reverse-phase signal is fed back, the transmission function is

$$V_{out}/V_{in} = 1$$

and it is known that oscillation (howling) does not occur.

When it is compared with the transmission function of general single negative feedback loop of

$$V_{out}/V_{in} = A/(1 + A/T(S))$$

the output power difference of the power amplifier 3 before and after start of operation of the speaker 42 is 6 dB, but if a reverse-phase signal is fed back, it follows that

$$V_{out}/V_{in} = \infty$$

and hence it is known that oscillation (howling) occurs in the case of a general single negative feedback loop.

Fig. 44 shows the output frequency characteristic of the microphone 5 in the front enclosed space 41B of the speaker 42 of the acoustic reproducing apparatus of the embodiment, in which two resonance peaks f_{01} and f_{02} are present, and the phase makes one revolution between them. It is also known that the sound pressure is decreased in the phase inverting portion between f_{01} and f_{02} .

Hence, by applying a negative feedback to be in phase between f_{01} and f_{02} , it is known that improvement of transient characteristic at resonance frequency and increase of sound pressure in the sound pressure decreasing portion between f_{01} and f_{02} are realized.

When the negative feedback is controlled in the acoustic reproducing apparatus of the embodiment and when not controlled, the tone burst output waveform (10 waves ON, 1 wave OFF) has the

characteristic same as shown in Fig. 36 and Fig. 37, respectively, and when controlled, the output is evidently stopped in 1-wave OFF time.

Embodiment 38

A thirty-eighth embodiment of the invention is described by reference to the drawing. Fig. 45 is a block diagram showing the constitution of the acoustic reproducing apparatus in the embodiment. In this embodiment, two microphones for detecting the acoustic output signal radiated from the speaker 42 are disposed in the speaker box, with the first microphone 5A disposed at the front side of a magnetic circuit of the speaker 42, and the second microphone 5B in the rear enclosed space 41A of the speaker box 41.

The output signals of the two microphones 5A, 5B are respectively connected to first and second microphone amplifiers 6A, 6B, and the output signals of the first and second microphone amplifiers 6A, 6B are fed into a second adder/subtractor 7B, and the output signal of the second adder/subtractor 7B and the output of a subtractor 2 are fed into a first adder/subtractor 7A, and the output signal of the first adder/subtractor 7A is connected to a negative input terminal of the subtractor 2, thereby constituting a negative feedback circuit.

By thus constituting, for example, when the second adder/subtractor 7B is used as a subtractor, the in-phase portion of low frequency (below f_{01}) shown in Fig. 44, and negative feedback signals of over 500 Hz totally inverted in phase can be decreased, and in the reproduced band of over f_{01} in Fig. 44, it is known stable if the negative feedback amount is increased.

Or, by using the second adder/subtractor 7B as an adder, and adding such a signal as to cause the output signals of the first and second microphone amplifiers 6A, 6B to be in reverse phase to the input signals, and further adding the output signal of the second adder/subtractor 7B by the first adder/subtractor 7A, signals for low frequency range reproduction cutting off high frequency components can be produced, and it is possible to present a system having the degree of freedom for controlling the tone and frequency characteristic of the speaker system higher than in the foregoing embodiments.

Embodiment 39

A thirty-ninth embodiment of the invention is described by reference to the drawings. Fig. 46 and Fig. 47 are block diagrams showing the constitution of the acoustic reproducing apparatus in the embodiment. In the embodiment shown in Fig.

46, a filter 44 is connected to the output of the second microphone amplifier 6B for amplifying the output signal of the second microphone 5B installed in the rear enclosed space 41A of the speaker box 41 in Embodiment 38 in Fig. 45, and the output signal of this filter 44 and the output signal of the first microphone amplifier 6A connected to the first microphone 5A installed in the front side of the magnetic circuit of the speaker 42 are fed into the second adder/subtractor 7B.

In a modified embodiment shown in Fig. 47, a filter 44 is connected to the output signal of the first microphone amplifier 6A, and the output signal of this filter 44 and the output signal of the second microphone amplifier 6B are fed into the second adder/subtractor 7B, and in Fig. 46 and Fig. 47 the other constitution is same as in Embodiment 38 in Fig. 45.

In such constitution, at a frequency causing positive feedback with one microphone, by giving another microphone signal, the positive feedback amount can be decreased. With one microphone, moreover, in a band where negative feedback cannot be applied as the phase deviation to input signal is 90 degrees, by applying an output signal from other microphone, negative feedback can be applied, and thus the degree of freedom of control is further increased, and so that the tone and frequency characteristic of the speaker system can be created more precisely.

Embodiment 40

A fortieth embodiment of the invention is described by reference to the drawings. Fig. 48 and Fig. 49 are block diagrams showing the constitution of the acoustic reproducing apparatus in the embodiment. In this constitution, a phase shift circuit 45 is used instead of the filter 44 in Embodiment 39 shown in Fig. 46 and Fig. 47, and in the embodiment shown in Fig. 48, the phase shift circuit 45 is connected to the output of the second microphone amplifier 6B, and the output signal of the phase shift circuit 45 and the output signal of the first microphone amplifier 6A are fed into the second adder/subtractor 7B.

In a modified embodiment shown in Fig. 49, the phase shift circuit 45 is connected to the output signal of the first microphone amplifier 6A, and the output signal of the phase shift circuit 45 and the output signal of the second microphone amplifier 6B are fed into the second adder/subtractor 7B, and in Fig. 48 and Fig. 49 the other constitution is same as in Embodiment 39 in Fig. 46 and Fig. 47.

In such constitution, the band over f_{01} shown in Fig. 44 is inverted by the phase shift circuit 45, and when the second adder/subtractor 7B is used as a subtractor, it is possible to decrease signals less

than f_{01} where the phase of output signals of the first microphone amplifier 6A and second microphone amplifier 6B are in phase with input signals, and signals in medium and high frequency range where both output signals of the first microphone amplifier 6A and second microphone amplifier 6B are in reverse phase to input signals, so that the negative feedback signals having the band limited in the reproducing band of the speaker system can be created.

Incidentally, if the output signals of the first and second microphone amplifiers 6A, 6B are in reverse phase in a band desired for negative feedback control and negative feedback signals decrease, the phase of the negative feedback signal can be matched by using the phase shift circuit 45 for inverting the phase at a frequency point where the phase is reverse, so that the decrease of negative feedback signals can be prevented.

Embodiment 41

A forty-first embodiment of the invention is described by reference to the drawing. Fig. 50 is a block diagram showing the constitution of the acoustic reproducing apparatus in the embodiment. In this embodiment, in addition to the constitution of Embodiment 38 explained in Fig. 45, the output of the first microphone amplifier 6A is fed to a first filter 44A, the output signal of the second microphone amplifier 6B is fed to a second filter 44B, and the output signal of the first filter 44A and the output signal of the second filter 44B are connected to the second adder/subtractor 7B, and the other constitution is same as in Embodiment 38.

By thus constituting, band limitation is applied to the output signals of the two microphones 5A, 5B, and only the band in which the output signals of the microphones 5A, 5B are in phase with input signals is picked up, and the second adder/subtractor 7B is used as an adder, or the band in which the signal of one microphone is in phase with the input signal is picked up, and the band in which the input signal of the other microphone is in reverse phase to the input signal is picked up, and the second adder/subtractor 7B is used as a subtractor, and therefore as compared with the case of one microphone, a deeper negative feedback can be applied, or negative feedback can be applied in a wider band.

Embodiment 42

A forty-second embodiment of the invention is described by reference to the drawings. Fig. 51 and Fig. 52 are block diagrams showing the constitution of the acoustic reproducing apparatus in the embodiment. In the embodiment shown in Fig.

51, in addition to the constitution of Embodiment 38 explained in Fig. 45, the output signal of the first microphone amplifier 6A is fed into the filter 44, and the output signal of the second microphone amplifier 6B is fed into the phase shift circuit 45, and moreover the output signal of the filter 44 and the output signal of the phase shift circuit 45 are connected to the second adder/subtractor 7B, and the other constitution is same as in Embodiment 38.

In a modified embodiment shown in Fig. 52, in addition to the constitution of Embodiment 38 explained in Fig. 45, the output signal of the first microphone amplifier 6A is fed into the phase shift circuit 45, and the output signal of the second microphone amplifier 6B is fed into the filter 44, and moreover the output signal of the filter 44 and the output signal of the phase shift circuit 45 are connected to the second adder/subtractor 7B, and the other constitution is same as in Embodiment 38.

In such constitution, negative feedback control is effected by using the output signal of the microphone connected to the phase shift circuit 45 side as the main signal, and furthermore at a frequency desired to increase the negative feedback amount, or at a frequency desired to decrease the negative feedback amount, by processing another microphone signal in the filter 44 and adding or subtracting in the second adder/subtractor 7B, the frequency range of negative feedback and negative feedback amount can be controlled, so that the range for controlling the tone and frequency characteristic of the system can be expanded.

Embodiment 43

A forty-third embodiment of the invention is described by reference to the drawings. Fig. 53 and Fig. 54 are block diagrams showing the constitution of the acoustic reproducing apparatus in the embodiment. In the embodiment shown in Fig. 53, in addition to the constitution of Embodiment 38 explained in Fig. 45, the output signal of the first microphone amplifier 6A is fed into the a first filter 44A, and the output signal of the first filter 44A is fed into the phase shift circuit 45, and moreover the output signal of the phase shift circuit 45, and the output signal of the second microphone amplifier 6B passing through a second filter 44B are connected to the second adder/subtractor 7B, and the other constitution is same as in Embodiment 38.

In a modified embodiment shown in Fig. 54, in addition to the constitution of Embodiment 38 explained in Fig. 45, the output signal of the second microphone amplifier 6B is fed into the phase shift circuit 45 through the second filter 44B, and the

output signal of the phase shift circuit 45, and the output signal of the first microphone amplifier 6A passing through the first filter 44A are connected to the second adder/subtractor 7B, and the other constitution is same as in Embodiment 38.

In such constitution, as for the output signal of the microphone connected to the phase shift circuit 45 side, by expanding the passing band more than the band shown in Embodiment 41, and using the phase shift circuit inverted in phase at the band of positive feedback, a stable negative feedback is realized in a wider frequency band, so that the range for controlling the tone and frequency characteristic of the system can be expanded.

Embodiment 44

A forty-fourth embodiment of the invention is described by reference to the drawing. Fig. 55 is a block diagram showing the constitution of the acoustic reproducing apparatus of the embodiment. In this embodiment, a second microphone 5B is disposed in a front enclosed space 41B of a speaker 42, and a first microphone 5A is disposed in a space (front side of magnetic circuit) composed by the pole piece central part and dust cap of the speaker 42, and the other constitution is same as in Embodiment 38 in Fig. 45.

By thus constituting, the operating state of the diaphragm of the speaker 42, and the pressure of the enclosed space 41B for driving a passive radiator 43 can be detected. In this case, the transient characteristic is improved by applying a negative feedback by the first microphone 5A at the rise of action of the speaker 42, and if the passive radiator 43 is not put in action despite start of action of the speaker 42, the internal pressure of the front enclosed space 41B is raised, and this information is detected by the second microphone 5B.

By using this information of the second microphone 5B as positive feedback, the pressure in the front enclosed space 41B of the speaker 42 is further heightened, and the rise time of the passive radiator 43 may be much shortened. Thus, the transient characteristic can be greatly improved.

Embodiment 45

A forty-fifth embodiment of the invention is described by reference to the drawing. Fig. 56 is a block diagram showing the constitution of the acoustic reproducing apparatus of the embodiment. In this embodiment, a first microphone 5A for pressure detection is disposed in a rear enclosed space 41A of a speaker 42, and a second microphone 5B is disposed in a front enclosed space 41B of the speaker 42.

The first and second microphones 5A and 5B are respectively connected to first and second microphone amplifiers 6A and 6B, and the output signals of the first and second microphone amplifiers 6A and 6B are connected to a second adder/subtractor 7B, and the output signal of the second adder/subtractor 7B and the output signal of a subtractor 2 are connected to a first adder/subtractor 7A, and the other constitution is same as in Embodiment 44 explained by reference to Fig. 55.

By thus constituting, the pressure change of vibration of the speaker 42 and passive radiator 43 in phase is detected by the first microphone 5A, and the pressure change of vibration in reverse phase is detected by the second microphone 5B, so that pressure changes in all resonances can be detected.

Moreover, by using the second adder/subtractor 7B as the adder, the feedback can be canceled in the frequency band where the phase is reverse in the rear enclosed space 41A and front enclosed space 41B of the speaker 42, and the output sound pressure below the minimum resonance frequency can be elevated.

Or, by using the second adder/subtractor 7B as a subtractor, it is also possible to apply a deeper negative feedback when the speaker 42 and passive radiator 43 resonate in reverse phase, and the negative feedback to such resonance of the speaker system may be applied more precisely.

In these embodiments of the acoustic reproducing apparatus of the invention, the negative feedback may be applied deeply or stably, and the merits of negative feedback may be fully utilized, and the acoustic characteristic of the speaker and its surrounding can be improved, so that an excellent characteristic may be obtained.

In the acoustic reproducing apparatus using a speaker box incorporating a passive radiator, having enclosed spaces coupled before and after the speaker, the acoustic characteristic of the speaker system having the passive radiator coupled in the front enclosed space of the speaker may be notably improved, and moreover since the detection signal of the microphone is used as the reference, the acoustic characteristic is corrected automatically if the characteristic of the speaker or passive radiator is changed, and the contribution of these outstanding effects is magnificent.

These embodiments may be executed individually, or constituent elements of two or more embodiments may be properly combined for achieving the purpose of the invention. Besides, minor parts may be modified within the scope and true spirit of the invention.

Claims

1. An acoustic reproducing apparatus comprising a subtractor having an input terminal, a power amplifier for amplifying the output signal of the subtractor, a speaker for reproducing the output signal of the power amplifier, a microphone for detecting the acoustic output signal radiated from the speaker, a microphone amplifier for amplifying the acoustic output signal detected by the microphone, and an adder/subtractor for adding or subtracting the output signal of the microphone amplifier and the input signal of the power amplifier, wherein the output signal of the adder/subtractor is connected to the subtractor to compose a negative feedback circuit.
2. An acoustic reproducing apparatus of claim 1, wherein the adder/subtractor is to add or subtract the output signal of the microphone amplifier and output signal of the power amplifier.
3. An acoustic reproducing apparatus of claim 1, wherein a filter is disposed between the microphone amplifier and the adder/subtractor.
4. An acoustic reproducing apparatus of claim 2, wherein a filter is disposed between the microphone amplifier and the adder/subtractor.
5. An acoustic reproducing apparatus comprising a subtractor having an input terminal, a power amplifier for amplifying the output signal of the subtractor, a speaker for reproducing the output signal of the power amplifier, a microphone for detecting the acoustic output signal radiated from the speaker, a microphone amplifier for amplifying the acoustic output signal detected by the microphone, a first adder/subtractor for adding or subtracting the output signal of the microphone amplifier and input signal of the power amplifier, and a second adder/subtractor for subtracting the output signal of the microphone amplifier passing through a high pass filter and the input signal of the power amplifier when the first adder/subtractor acts to add, or adding when the first adder/subtractor acts to subtract, wherein the output signals of the first and second adders/subtractors are connected to the subtractor to compose a negative feedback circuit.
6. An acoustic reproducing apparatus of claim 5, wherein the first adder/subtractor adds or subtracts the output signal of the microphone amplifier and the output signal of the power amplifier, and the second adder/subtractor re-

- ceives the output signal of the microphone amplifier passing through the high pass filter and the output of the power amplifier, and subtracts them when the first adder/subtractor acts to add, and adds when the first adder/subtractor acts to subtract.
7. An acoustic reproducing apparatus of claim 5, wherein a filter is provided at the output side of the microphone amplifier, so that the output signal of the microphone amplifier may pass through this filter and be entered in the first adder/subtractor and high pass filter. 10
 8. An acoustic reproducing apparatus of claim 6, wherein a filter is provided at the output side of the microphone amplifier, so that the output signal of the microphone amplifier may pass through this filter and be entered in the first adder/subtractor and high pass filter. 15 20
 9. An acoustic reproducing apparatus comprising a first subtractor having an input terminal, a second subtractor connected in series to the output side of the first subtractor for branching its output and connecting to the minus terminal of the first subtractor, a power amplifier for amplifying the output signal of the second subtractor, a speaker for reproducing the output signal of the power amplifier, a microphone for detecting the acoustic output signal radiated from the speaker, and a microphone amplifier for amplifying the acoustic output signal detected by the microphone, wherein the output signal of the microphone amplifier is connected to the second subtractor to compose a negative feedback circuit. 25 30 35
 10. An acoustic reproducing apparatus of claim 9, wherein the signal connected to the minus terminal of the first subtractor is an output signal of the power amplifier. 40
 11. An acoustic reproducing apparatus of claim 9, wherein a filter is provided between the output of the microphone amplifier and the minus terminal of the second subtractor. 45
 12. An acoustic reproducing apparatus of claim 7 or 10, wherein a filter is provided between the output of the microphone amplifier and the minus terminal of the second subtractor. 50
 13. An acoustic reproducing apparatus of claim 9, wherein an adder/subtractor is provided between the microphone amplifier and the minus terminal of the second subtractor, and the output signal of the second subtractor is branched and connected to the other input terminal of this adder/subtractor. 55
 14. An acoustic reproducing apparatus of claim 10, wherein an adder/subtractor is provided between the microphone amplifier and the minus terminal of the second subtractor, and the output signal of the power amplifier is branched and connected to the other input terminal of the adder/subtractor.
 15. An acoustic reproducing apparatus of claim 13, wherein a filter is provided between the output of the microphone amplifier and the input of the adder/subtractor.
 16. An acoustic reproducing apparatus of claim 14, wherein a filter is provided between the output of the microphone amplifier and the input of the adder/subtractor.
 17. An acoustic reproducing apparatus comprising a first subtractor having an input terminal, a second subtractor connected in series to the output side of the first subtractor, a power amplifier for amplifying the output signal of the second subtractor and branching the amplified output signal and connecting to the minus terminal of the first subtractor, a speaker for reproducing the output signal of the power amplifier, a microphone for detecting the acoustic output signal radiated from the speaker, a microphone amplifier for amplifying the acoustic output signal detected by the microphone, and an adder/subtractor for adding or subtracting the output signal of the microphone amplifier and input signal of the power amplifier, wherein the output signal of the adder/subtractor is connected to the second subtractor to compose a negative feedback circuit.
 18. An acoustic reproducing apparatus of claim 17, wherein the signal connected to the minus terminal of the first subtractor is an input signal of the power amplifier, and the adder/subtractor adds or subtracts the output signal of the microphone amplifier and the output signal of the power amplifier.
 19. An acoustic reproducing apparatus of claim 17, wherein a filter is provided between the microphone amplifier and the adder/subtractor.
 20. An acoustic reproducing apparatus of claim 18, wherein a filter is provided between the microphone amplifier and the adder/subtractor.

21. An acoustic reproducing apparatus comprising plural negative feedback circuits having input terminals, plural filters connected to output sides of the plural negative feedback circuits respectively, an adder for adding the signals passing through these plural filters, a power amplifier for amplifying the output signal of the adder, plural speakers for reproducing the output signal of the power amplifier through a passive filter respectively, and plural microphones for detecting the acoustic output signals radiated from the plural speakers respectively, wherein the respective acoustic output signals detected by the plural microphones are connected to the corresponding plural negative feedback circuits.
22. An acoustic reproducing apparatus comprising a subtractor having an input terminal, a power amplifier for amplifying the output signal of the subtractor, plural speakers for reproducing the output signal of the power amplifier through a passive filter respectively, plural microphones for detecting the acoustic output signals radiated from the plural speakers respectively, plural microphone amplifiers for amplifying the acoustic output signals detected by the plural microphones respectively, and plural adders/subtractors for adding or subtracting the output signals of microphone amplifiers passing through a filter connected at the output side of the plural microphone amplifiers and the output signal of the subtractor, wherein the outputs of the plural adders/subtractors are connected to the subtractor to compose a negative feedback circuit.
23. An acoustic reproducing apparatus comprising a power amplifier for amplifying an input signal, a speaker for reproducing the output signal of the power amplifier, a microphone for detecting the acoustic output signal radiated from the speaker, a microphone amplifier for amplifying the acoustic output signal detected by the microphone, a negative feedback circuit for negatively feeding back the output signal of the microphone amplifier into an input signal, a detector being connected to the output side of the negative feedback circuit for detecting the signal input voltage entered in the power amplifier, a converter for converting the input signal voltage detected by the detector into a DC voltage, a voltage control amplifier for amplifying the input signal depending on the converted DC voltage, and a tone adjusting filter connected to the output side of the voltage control amplifier, wherein the signal passing through the tone adjusting filter is connected to the negative feedback circuit.
24. An acoustic reproducing apparatus of any one of claims 1 to 23, wherein the power amplifier for amplifying the input signal is BTL-connected, and only the output of DC component is picked up from the output signal of the power amplifier, and the picked-up DC voltage is connected as the power source of the microphone.
25. An acoustic reproducing apparatus of any one of claims 1 to 24, wherein the microphone for detecting the acoustic output signal radiated from the speaker is disposed at the front side of the speaker diaphragm.
26. An acoustic reproducing apparatus of any one of claims 1 to 24, wherein the microphone for detecting the acoustic output signal radiated from the speaker is disposed at the front side of the central part of magnetic circuit of the speaker.
27. An acoustic reproducing apparatus of any one of claims 1 to 24, wherein the microphone for detecting the acoustic output signal radiated from the speaker is disposed at the final end of a penetration hole provided in the central part of magnetic circuit of the speaker.
28. An acoustic reproducing apparatus of any one of claims 1 to 24, wherein the microphone for detecting the acoustic output signal radiated from the speaker is disposed inside the magnetic circuit of the speaker.
29. An acoustic reproducing apparatus of any one of claims 1 to 24, wherein the microphone for detecting the acoustic output signal radiated from the speaker is disposed between the speaker magnetic circuit and the damper.
30. An acoustic reproducing apparatus of any one of claims 1 to 24, wherein the microphone for detecting the acoustic output signal radiated from the speaker is disposed between the speaker frame inside and the diaphragm.
31. An acoustic reproducing apparatus comprising a speaker box internally coupling a speaker for reproducing an output signal of a subtractor having an input terminal through a power amplifier, forming enclosed spaces before and after the speaker, and coupling a passive radiator in the opening of the front side enclosed space of the speaker, a microphone disposed at the front side of a magnetic circuit of the speaker for detecting the acoustic output sig-

- nal radiated from the speaker, a microphone amplifier for amplifying the acoustic output signal detected by the microphone, and an adder/subtractor for adding or subtracting the output signal of the microphone amplifier and input signal of the power amplifier, wherein the output signal of the adder/subtractor is connected to the subtractor to compose a negative feedback circuit.
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32. An acoustic reproducing apparatus of claim 31, wherein a phase shift circuit is disposed between the microphone amplifier and adder/subtractor.
33. An acoustic reproducing apparatus of claim 31, wherein a filter and phase shift circuit is provided in series between the microphone amplifier and adder/subtractor.
34. An acoustic reproducing apparatus of claim 31, wherein the output of the microphone amplifier is branched and connected to a first filter and a second filter differing in the characteristic, the output of the first filter, and the output of the second filter passing through an inverting circuit are connected to an adder, and the output of the adder is connected to the adder/subtractor.
35. An acoustic reproducing apparatus of claim 31, wherein the output of the microphone amplifier is branched and connected to a first filter and a second filter differing in the characteristic, the output of the first filter, and the output of the second filter passing through a phase shift circuit are connected to an adder, and the output of the adder is connected to the adder/subtractor.
36. An acoustic reproducing apparatus of claim 31, wherein a microphone for detecting the acoustic output signal radiated from the speaker is disposed in the rear enclosed space of the speaker.
37. An acoustic reproducing apparatus of claim 31, wherein a microphone for detecting the acoustic output signal radiated from the speaker is disposed in the front enclosed space of the speaker.
38. An acoustic reproducing apparatus comprising a speaker box internally coupling a speaker for reproducing an output signal of a subtractor having an input terminal through a power amplifier, forming enclosed spaces before and after the speaker, and coupling a passive radiator in the opening of the front side enclosed space of the speaker, first and second microphones disposed at the front side of the magnetic circuit of the speaker and in the rear enclosed space of the speaker for detecting the acoustic output signal radiated from the speaker, first and second microphone amplifiers for amplifying the acoustic output signals detected by the first and second microphones respectively, a second adder/subtractor for adding or subtracting the output signals of the first and second microphone amplifiers, and a first adder/subtractor for adding or subtracting the output signal of the second adder/subtractor and the input signal of the power amplifier, wherein the output signal of the first adder/subtractor is connected to the subtractor to compose a negative feedback circuit.
39. An acoustic reproducing apparatus of claim 38, wherein a filter is provided between either one of the first microphone amplifier and second microphone amplifier, and the second adder/subtractor.
40. An acoustic reproducing apparatus of claim 38, wherein a phase shift circuit is provided between either one of the first microphone amplifier and second microphone amplifier, and the second adder/subtractor.
41. An acoustic reproducing apparatus of claim 38, wherein filters are provided among the first microphone amplifier, second microphone amplifier, and the second adder/subtractor.
42. An acoustic reproducing apparatus of claim 38, wherein a filter is provided either between the first microphone amplifier and the second adder/subtractor, or between the second microphone amplifier and the second adder/subtractor, and a phase shift circuit is provided in the other pair.
43. An acoustic reproducing apparatus of claim 38, wherein a filter and a phase shift circuit are provided either between the first microphone amplifier and the second adder/subtractor, or between the second microphone amplifier and the second adder/subtractor, and a filter is provided in the other pair.
44. An acoustic reproducing apparatus of claim 38, wherein the second microphone is disposed in the front enclosed space of the speaker.
45. An acoustic reproducing apparatus of claim 38, wherein the first microphone is disposed in the

rear enclosed space of the speaker, and the second microphone is disposed in the front enclosed space of the speaker.

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Fig. 1

- | | | | |
|---|----------------|---|------------|
| 1 | Input terminal | 4 | Speaker |
| 2 | Subtractor | 5 | Microphone |

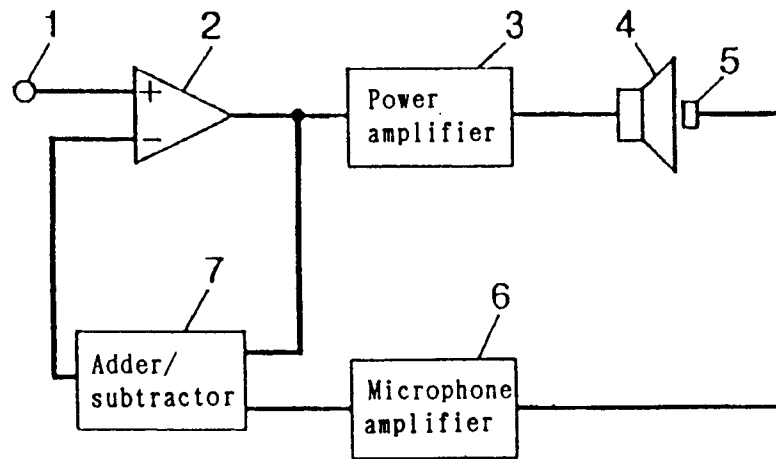


Fig. 2

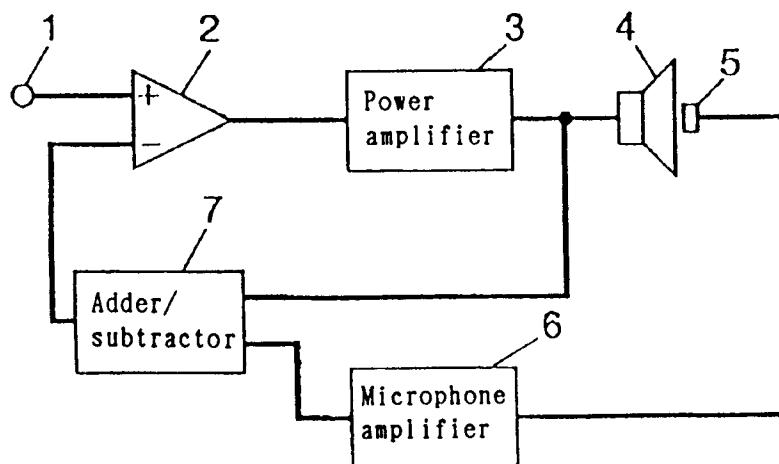


Fig. 3

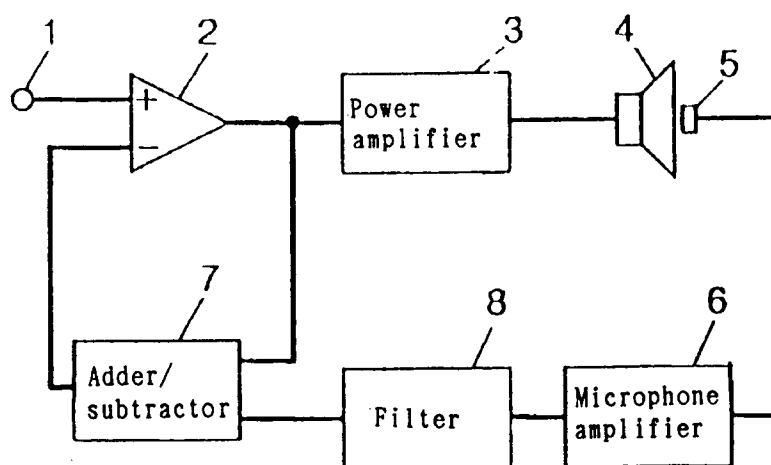


Fig. 4

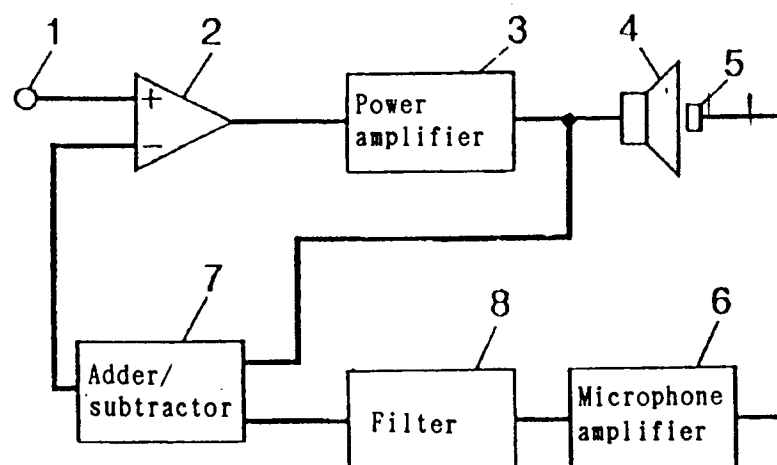


Fig. 5

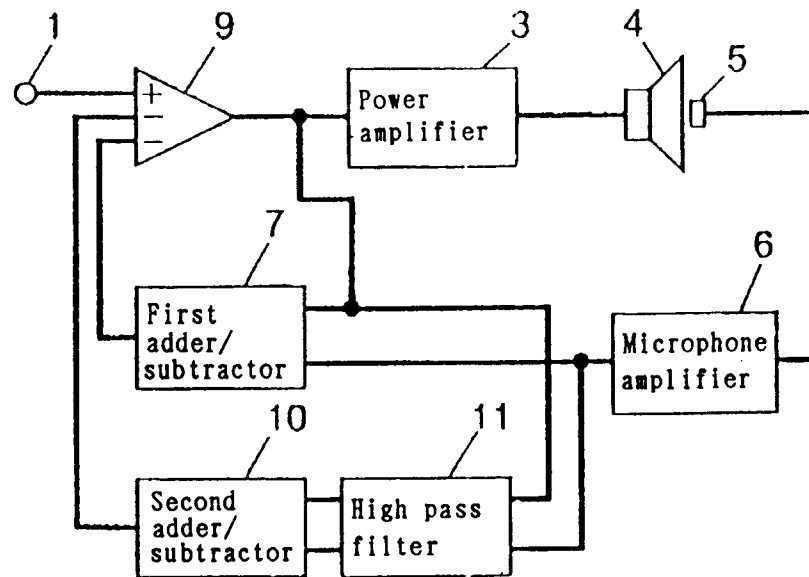


Fig. 6

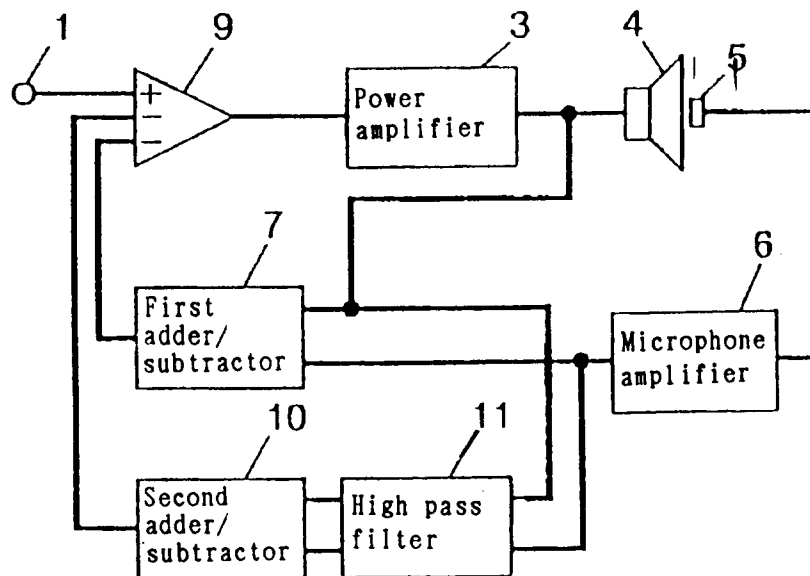


Fig. 7

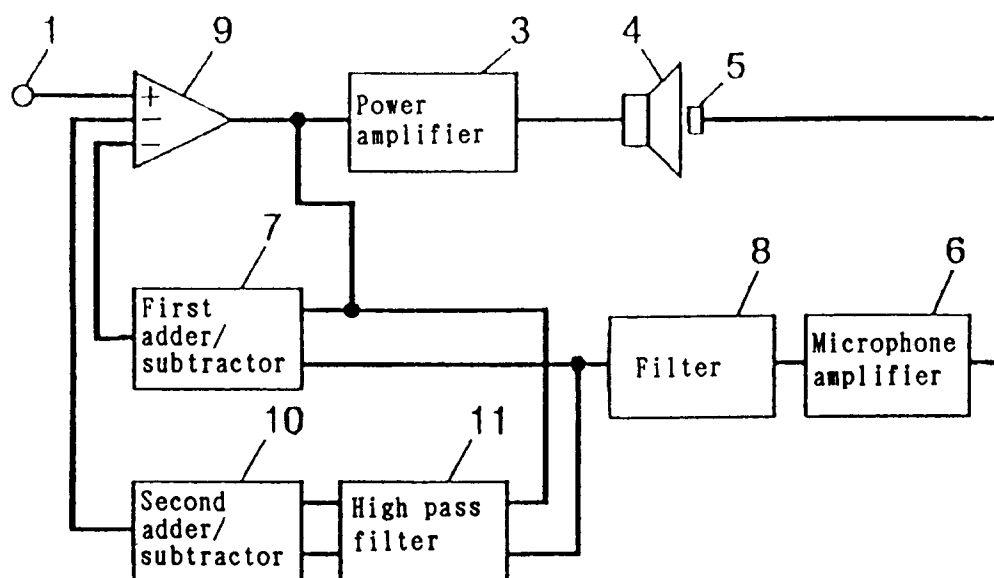


Fig. 8

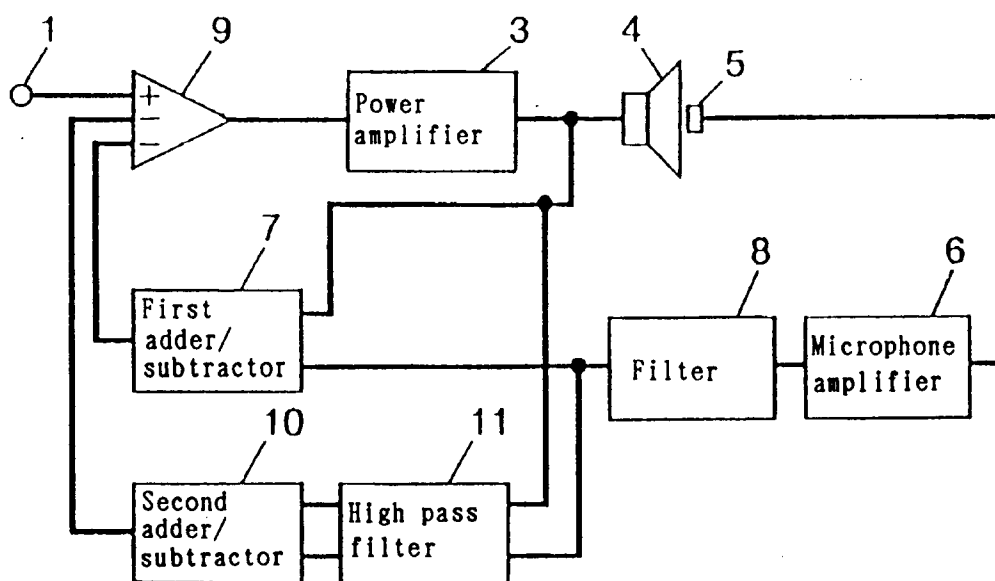


Fig. 9

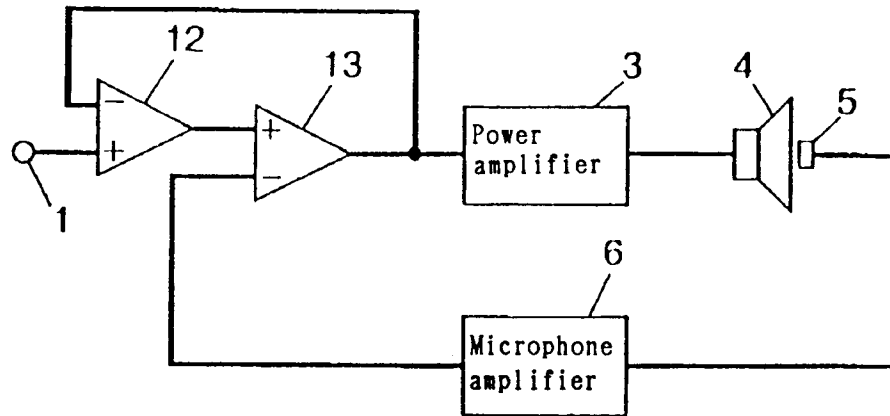


Fig. 10

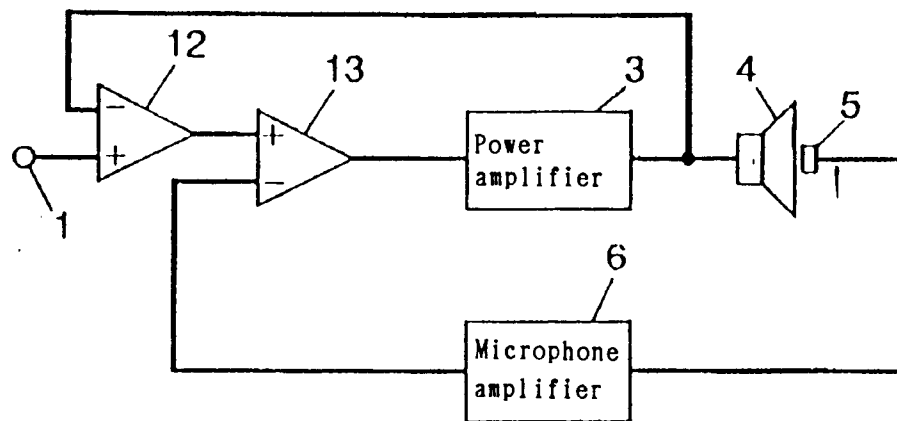


Fig. 11

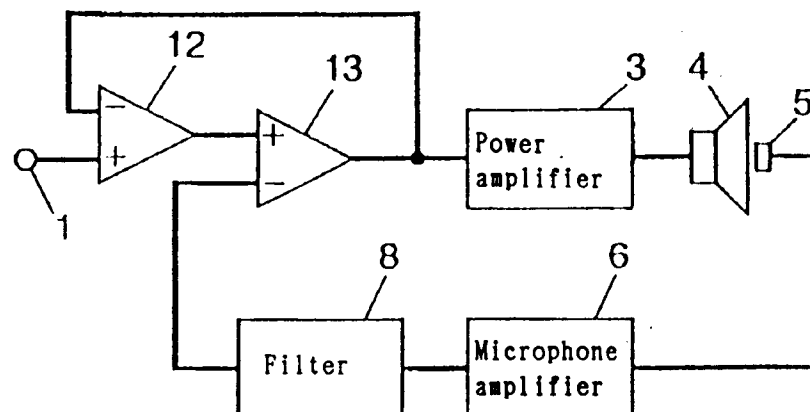


Fig. 12

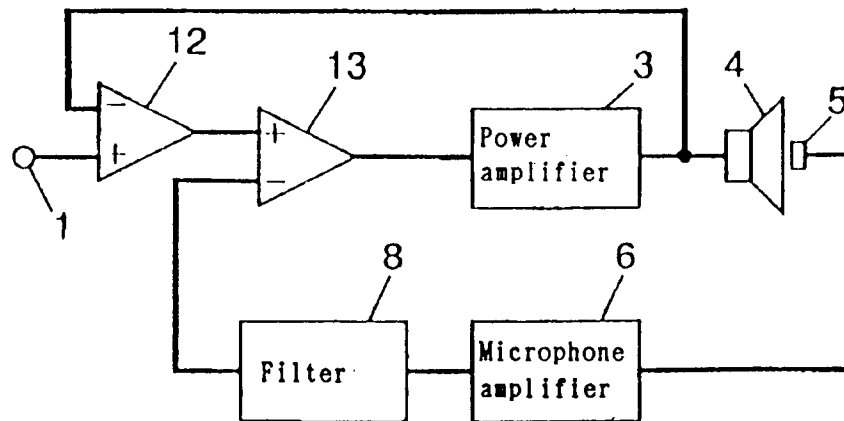


Fig. 13

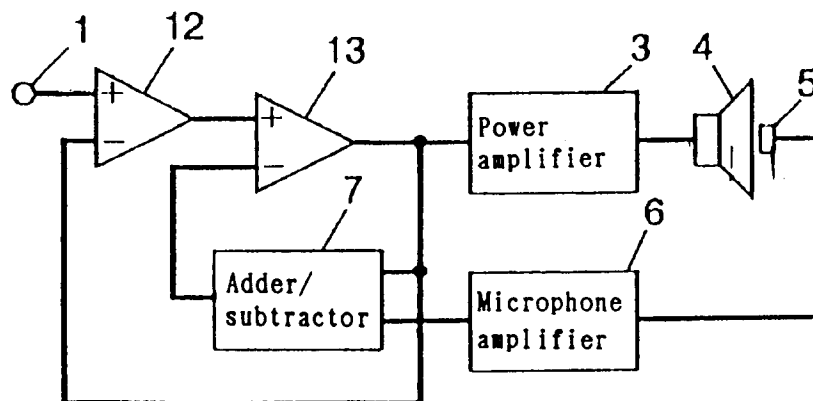


Fig. 14

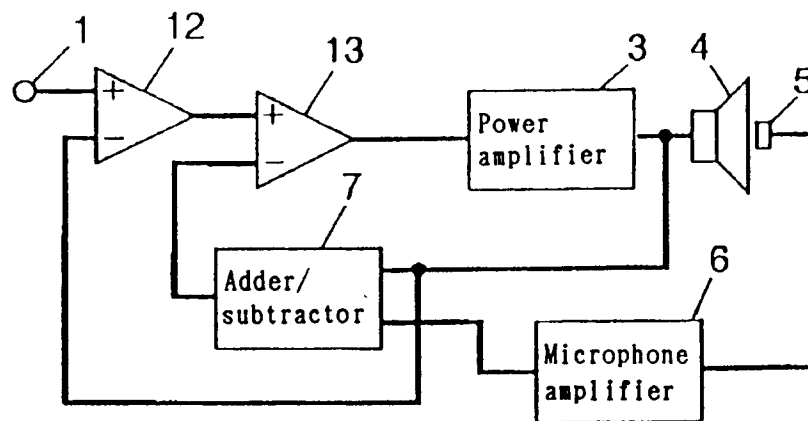


Fig. 15

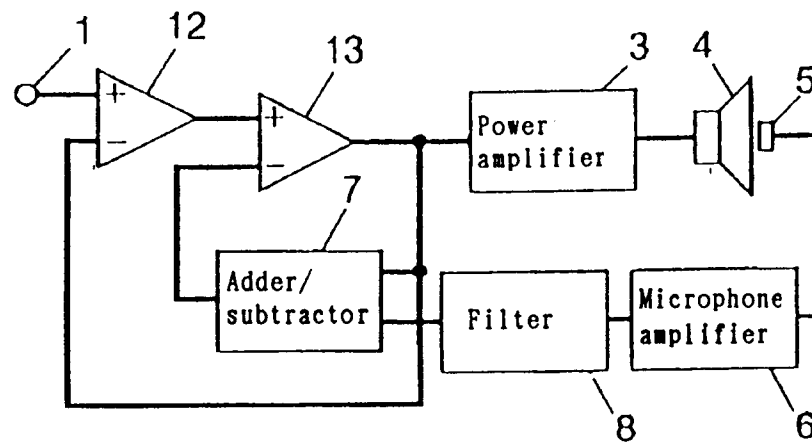


Fig. 16

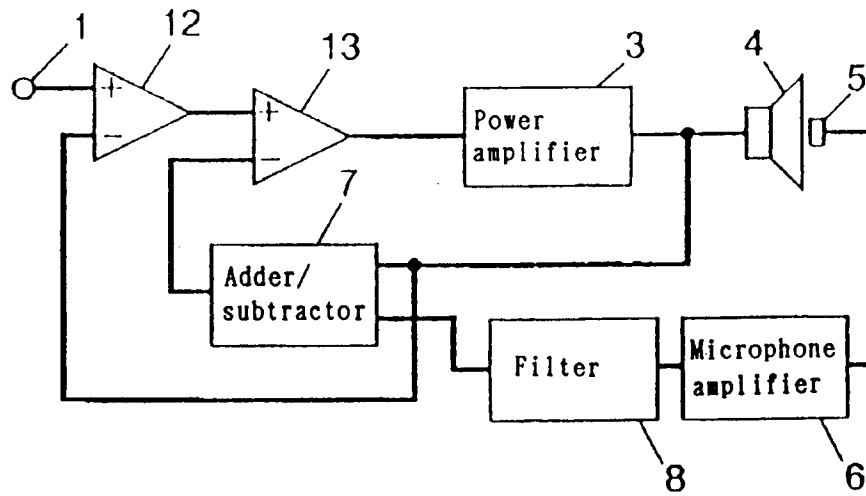


Fig. 17

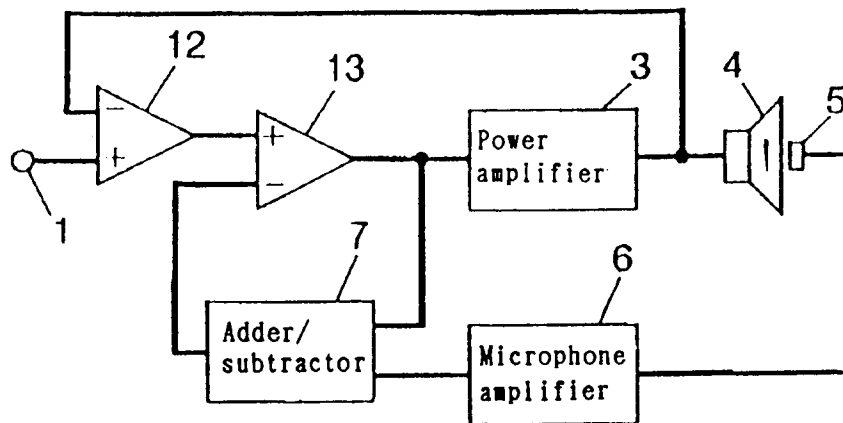


Fig. 18

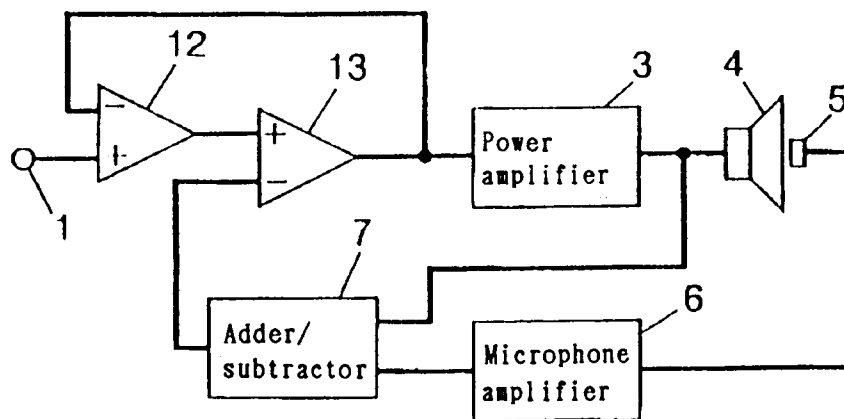


Fig. 19

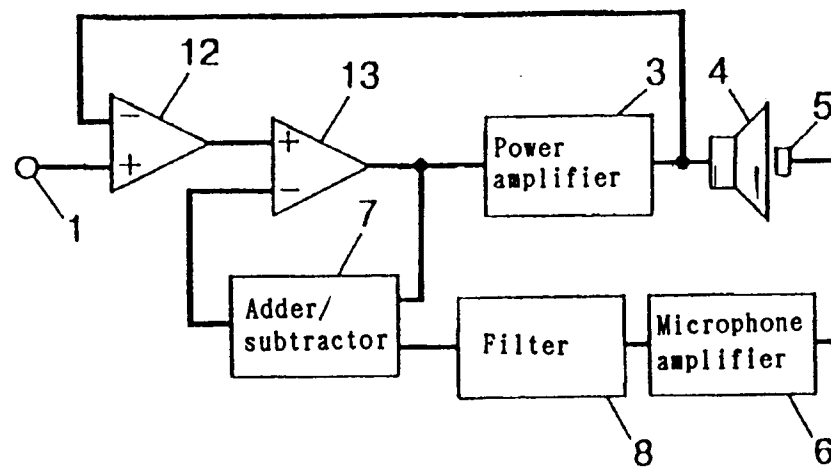


Fig. 20

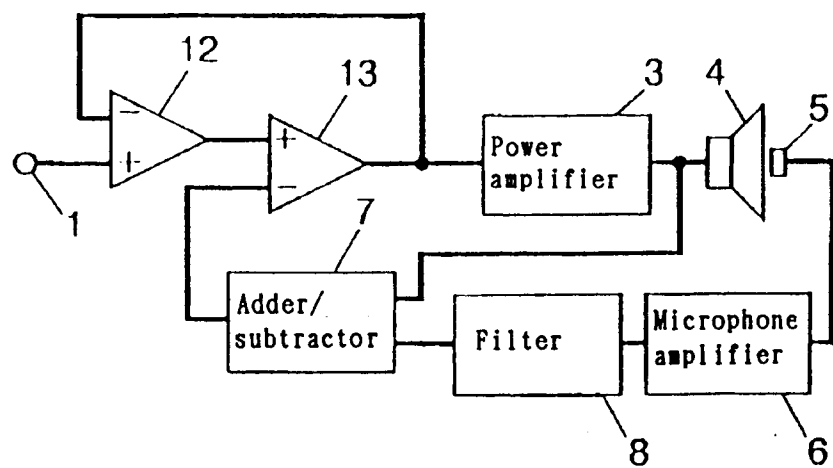


Fig. 21

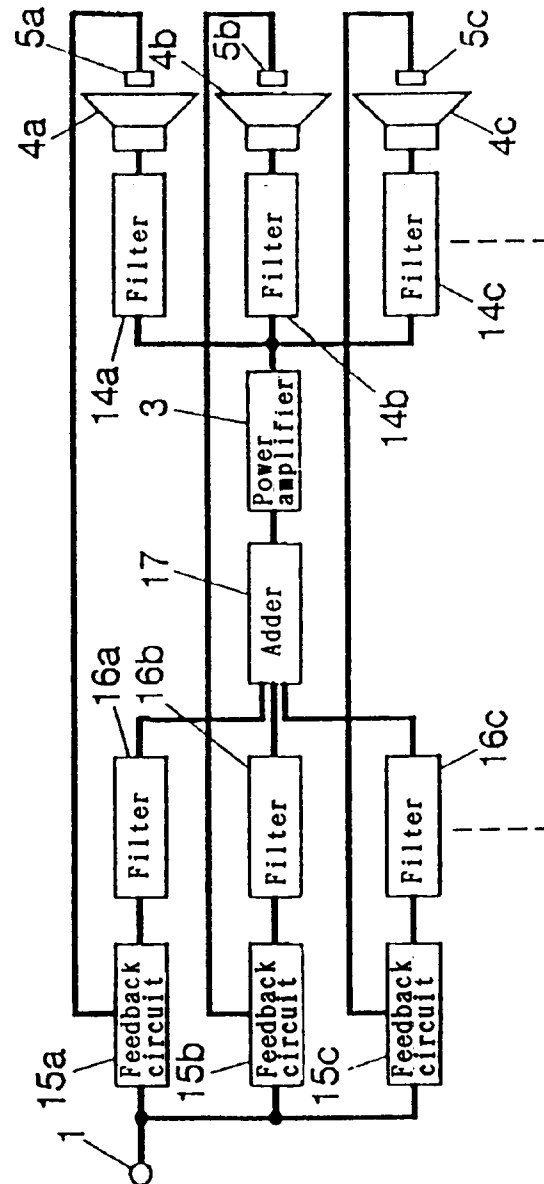


Fig. 22

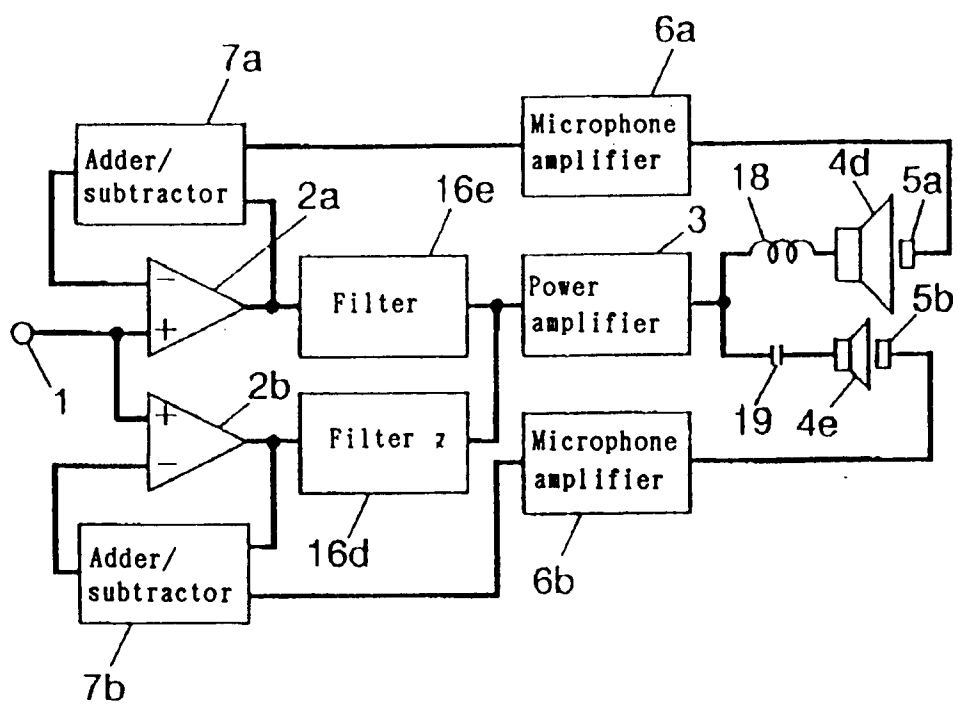


Fig. 23

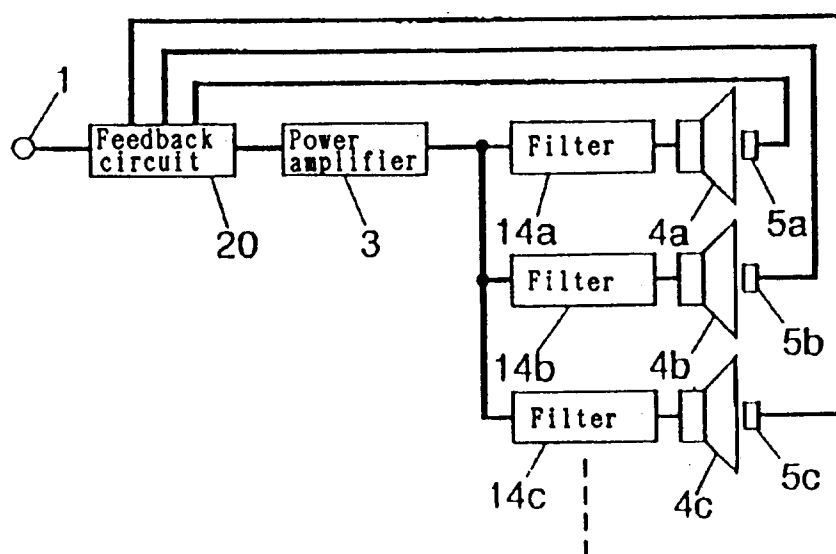


Fig. 24

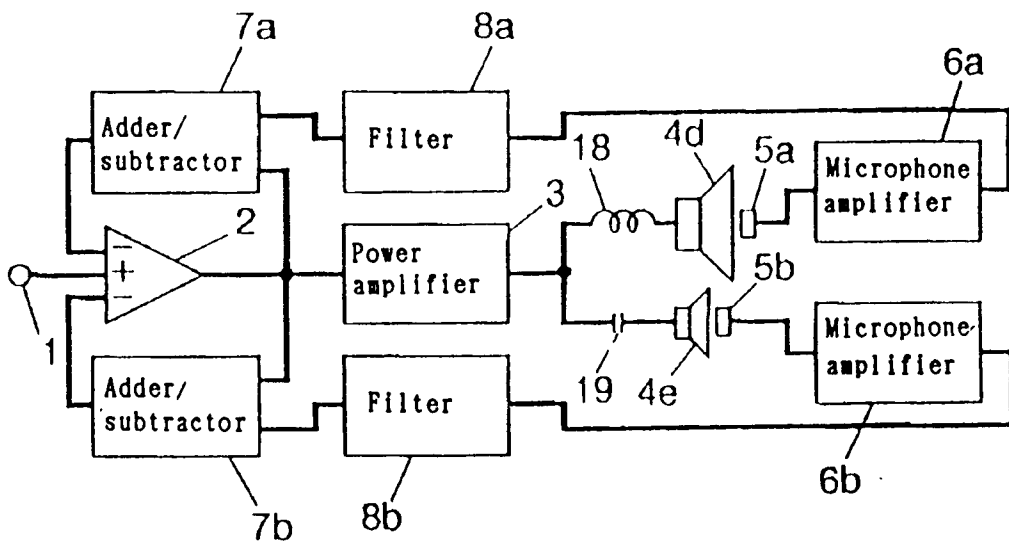


Fig. 25

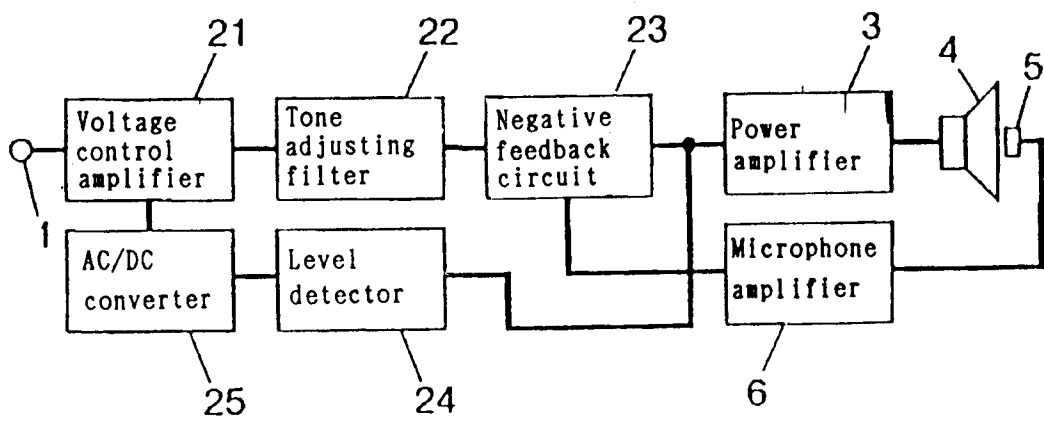


Fig. 26

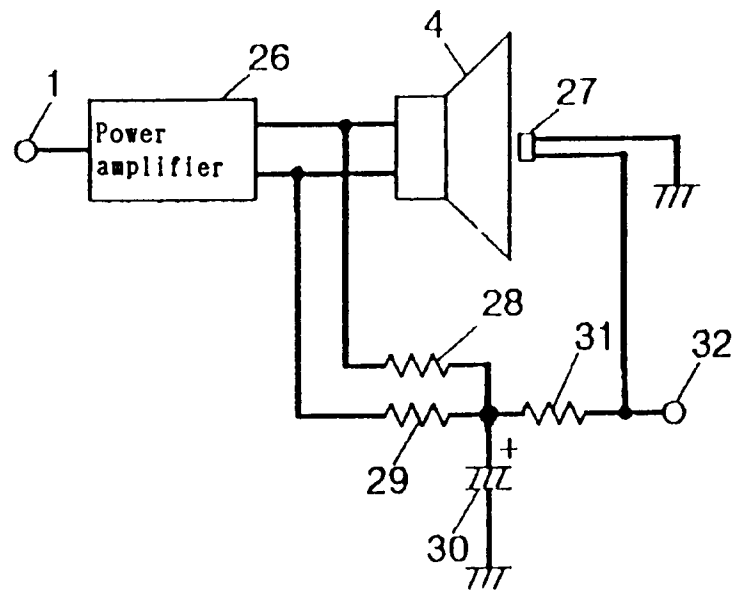


Fig. 27

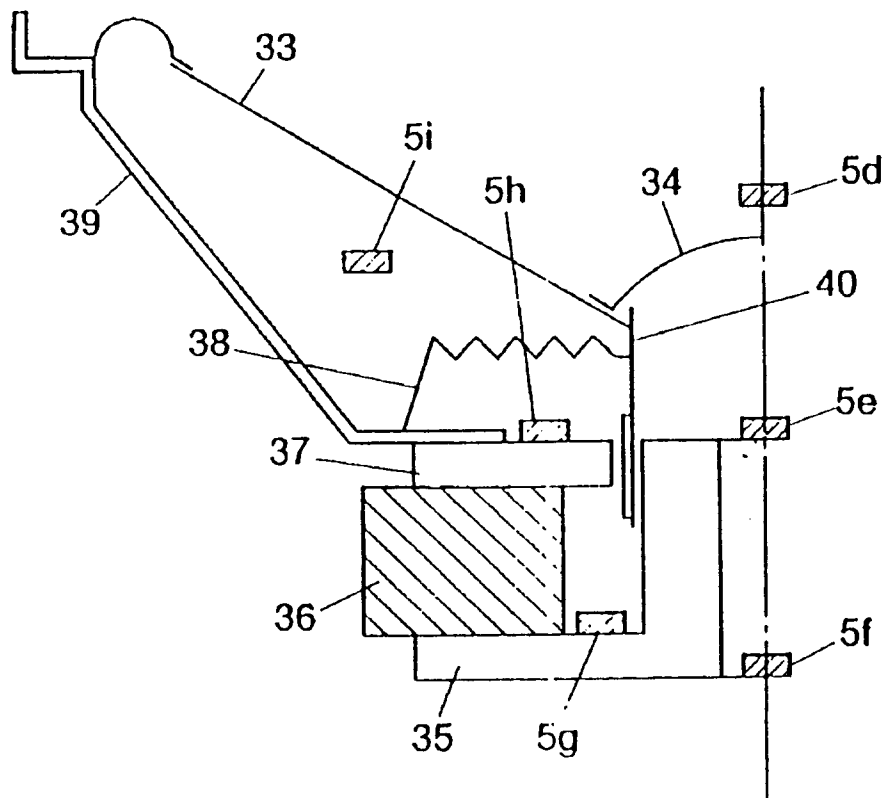


Fig. 28

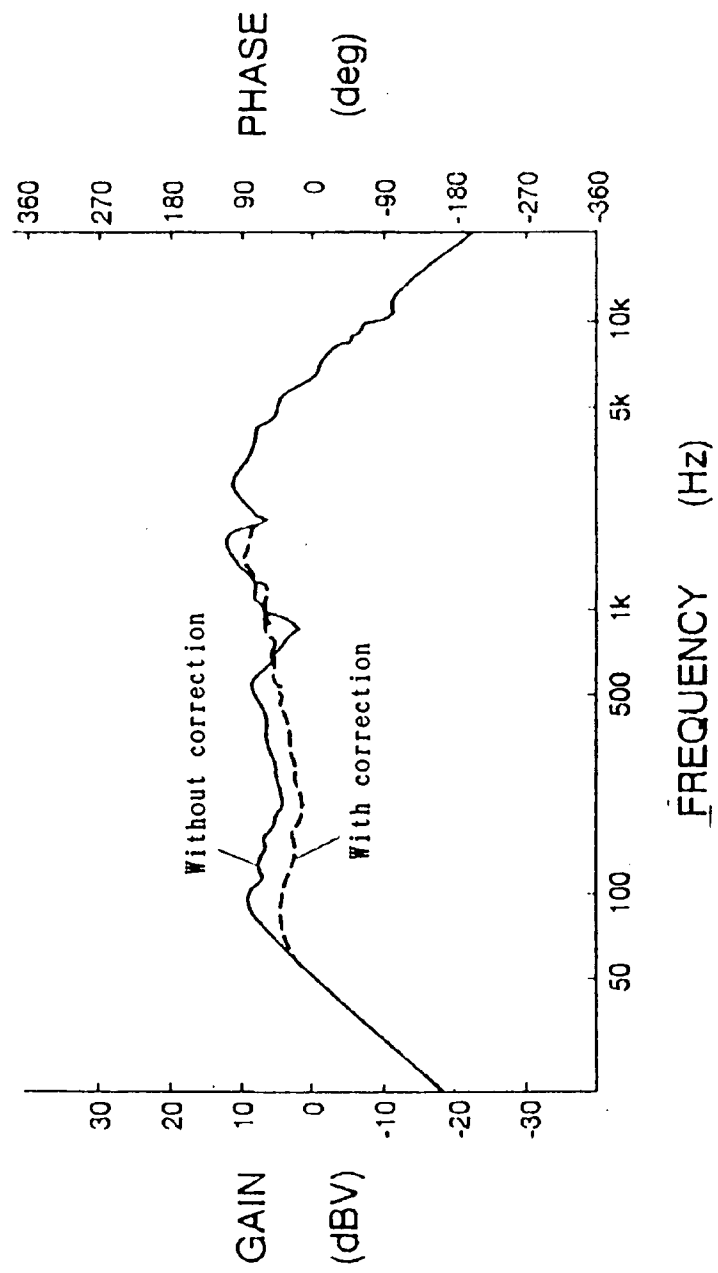


Fig. 29

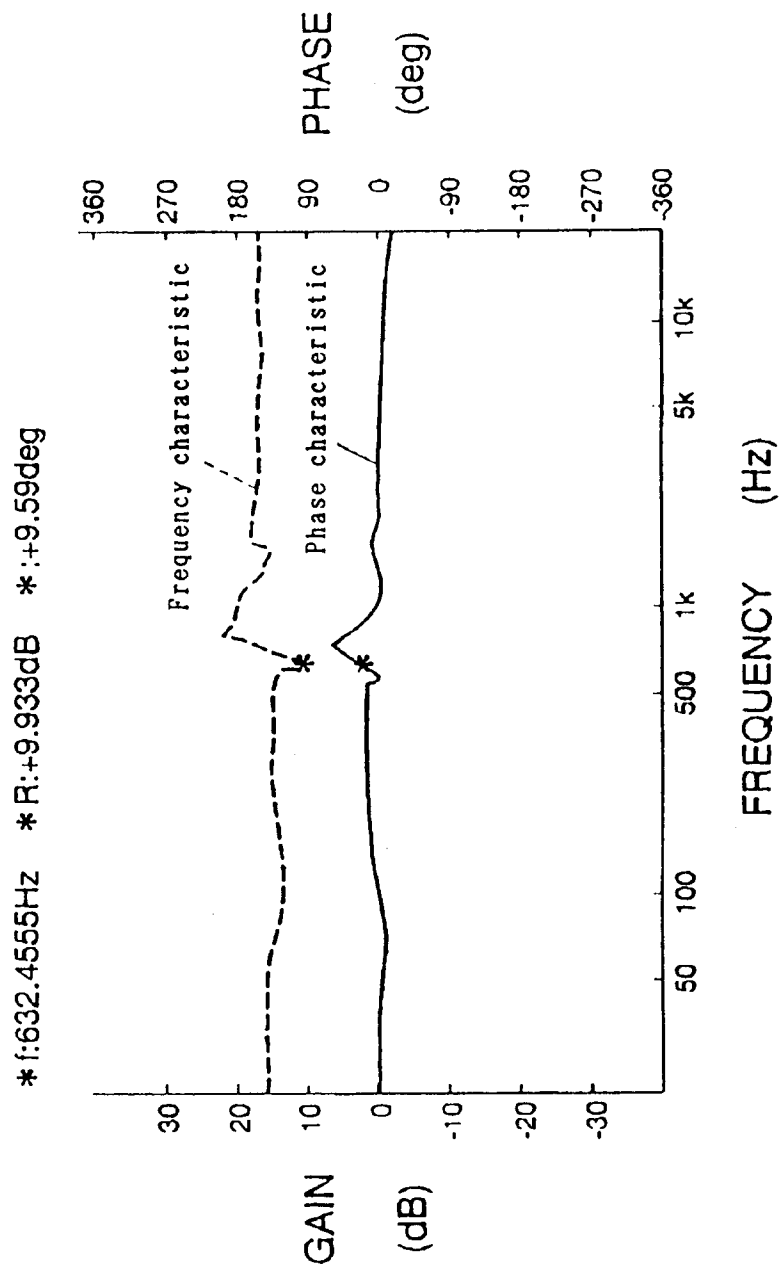


Fig. 30

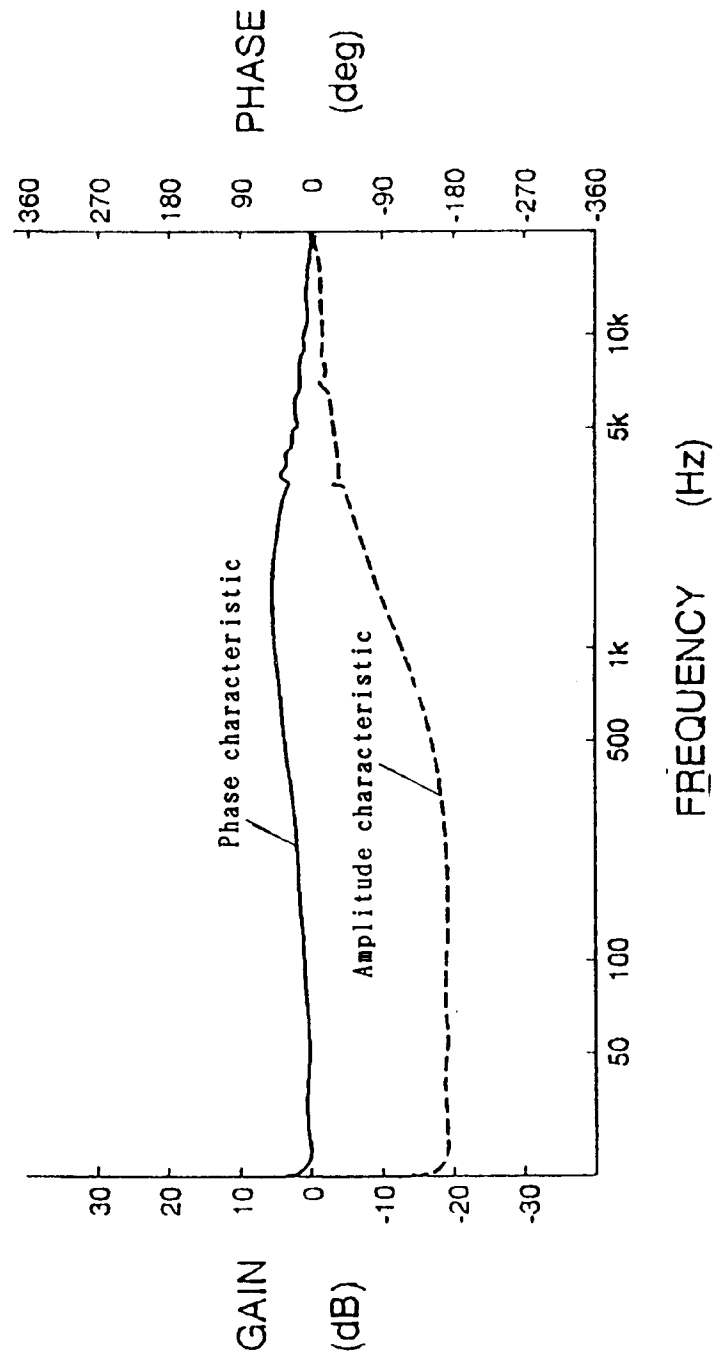


Fig. 31

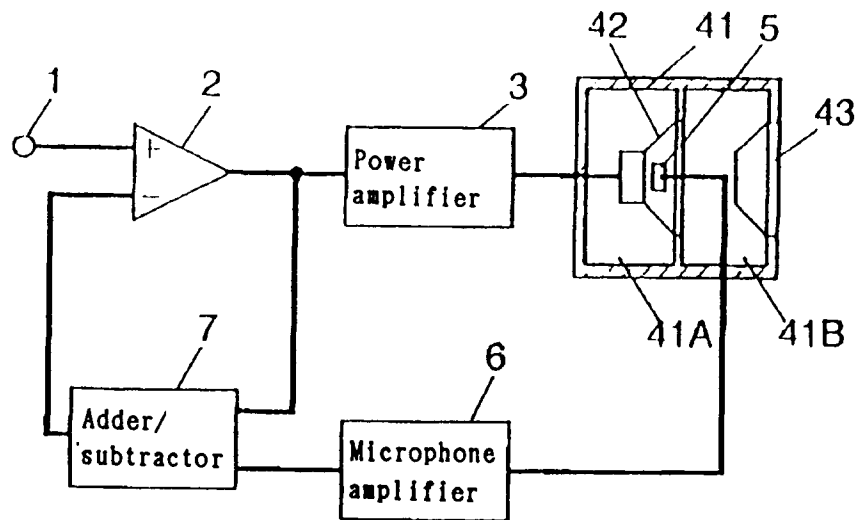


Fig. 32

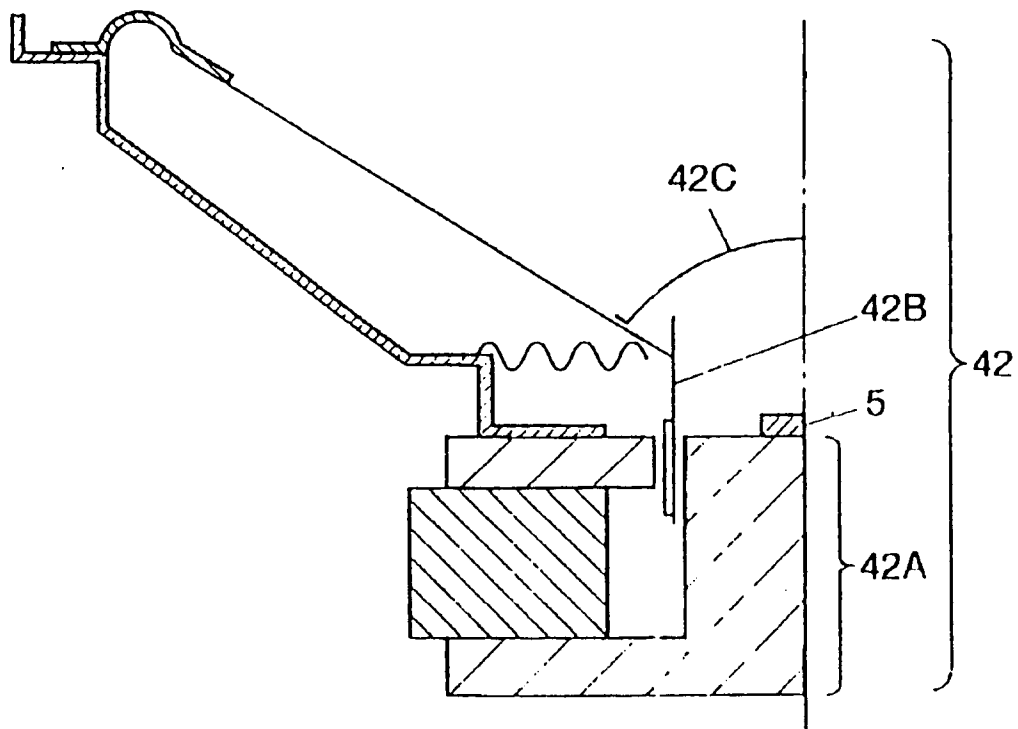


Fig. 33

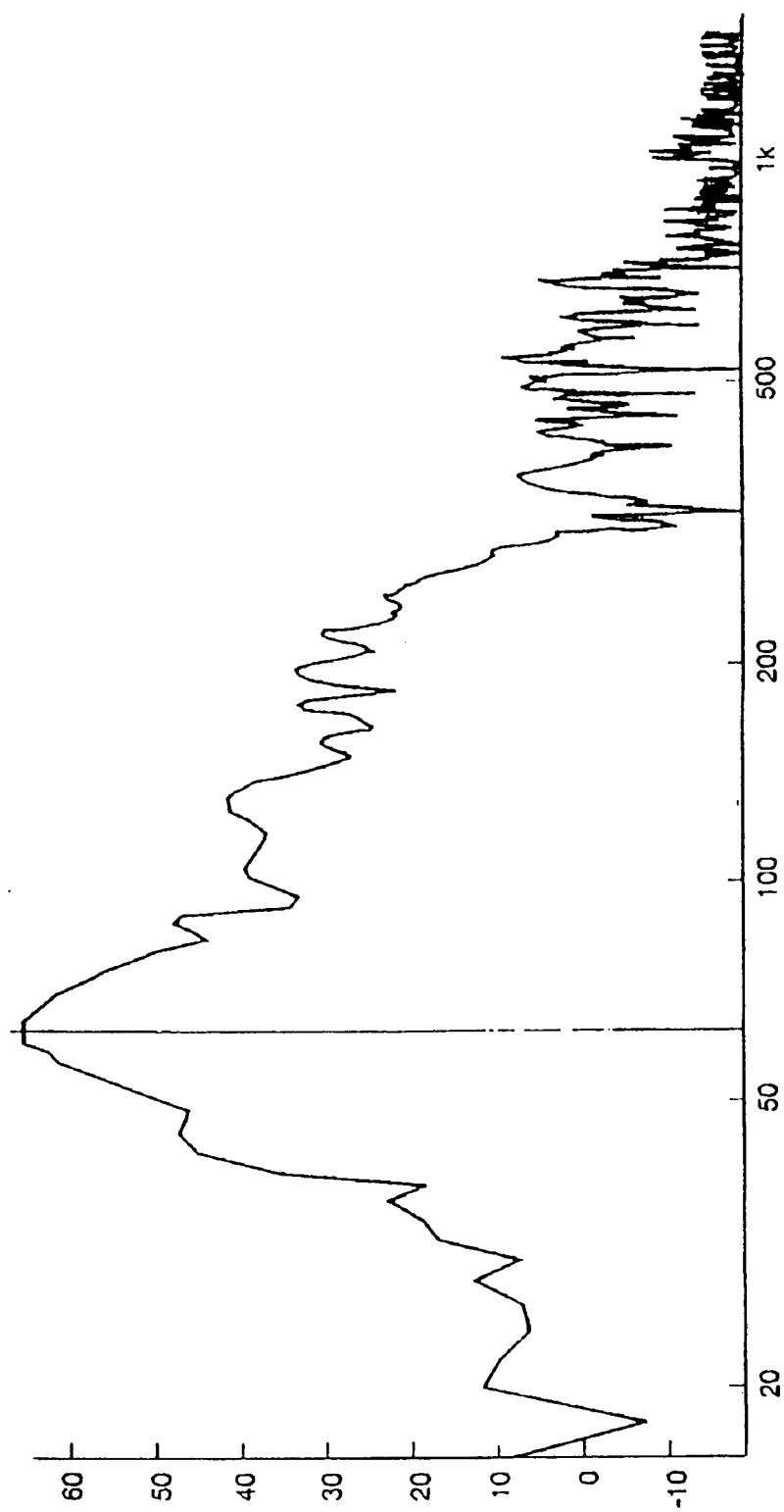


Fig. 34

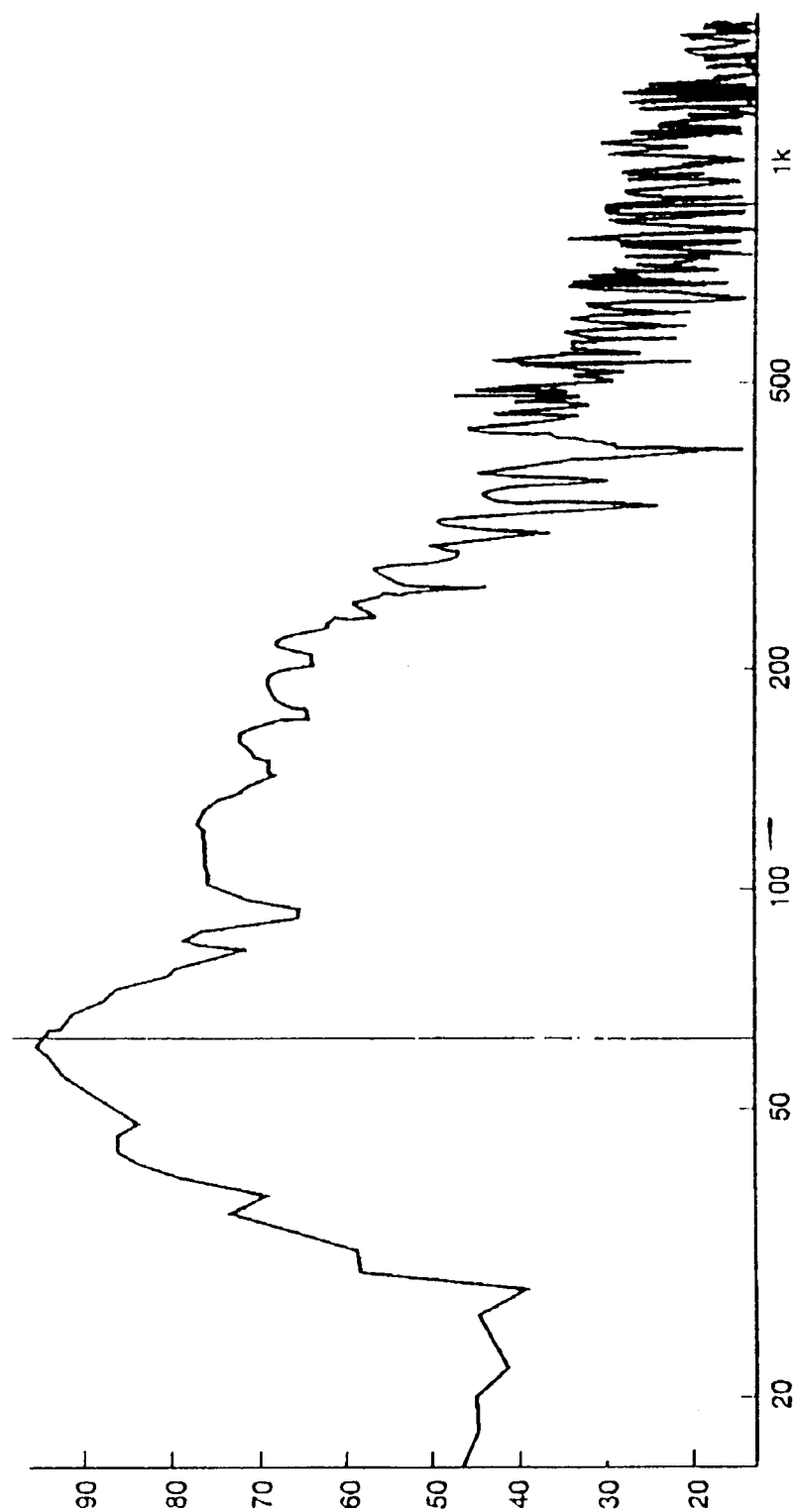


Fig. 35

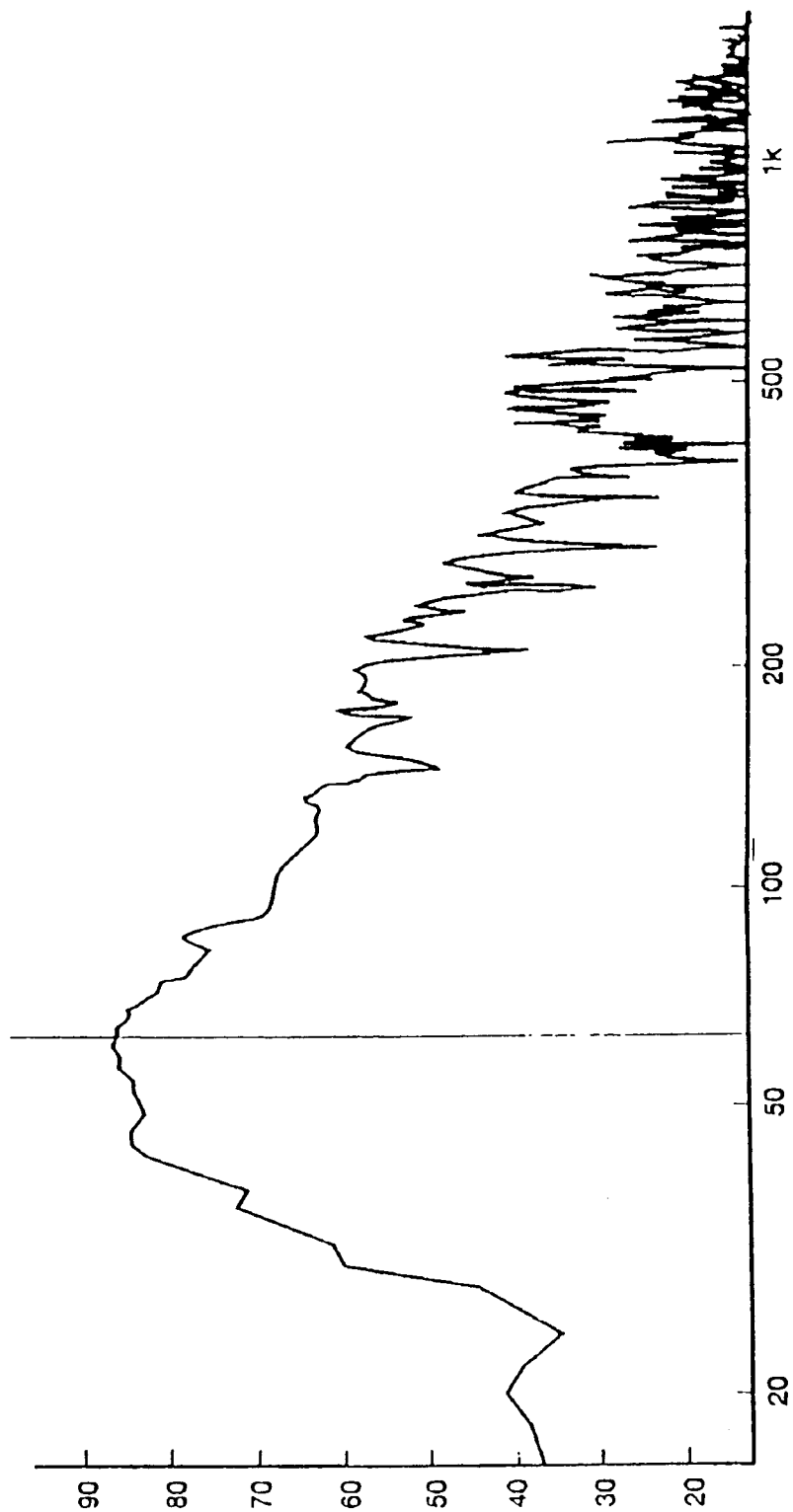


Fig. 36

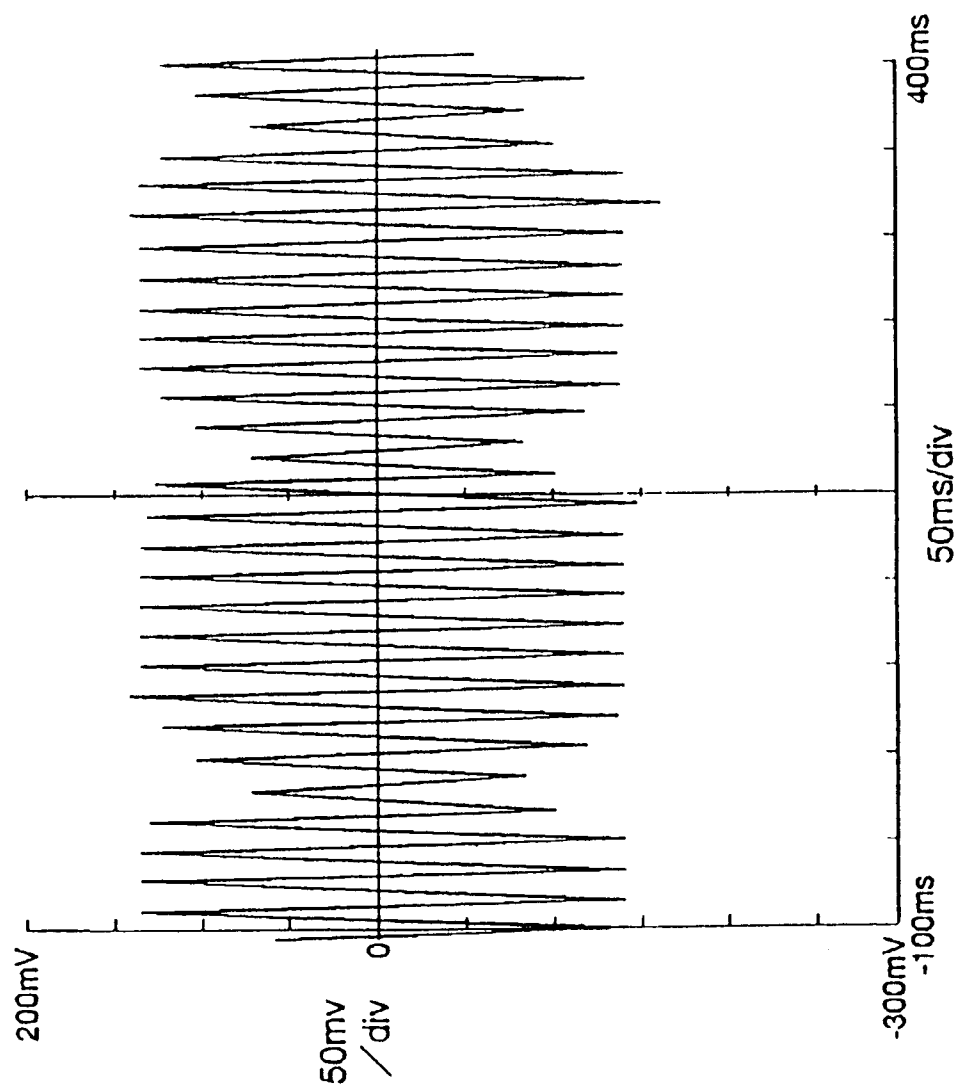


Fig. 37

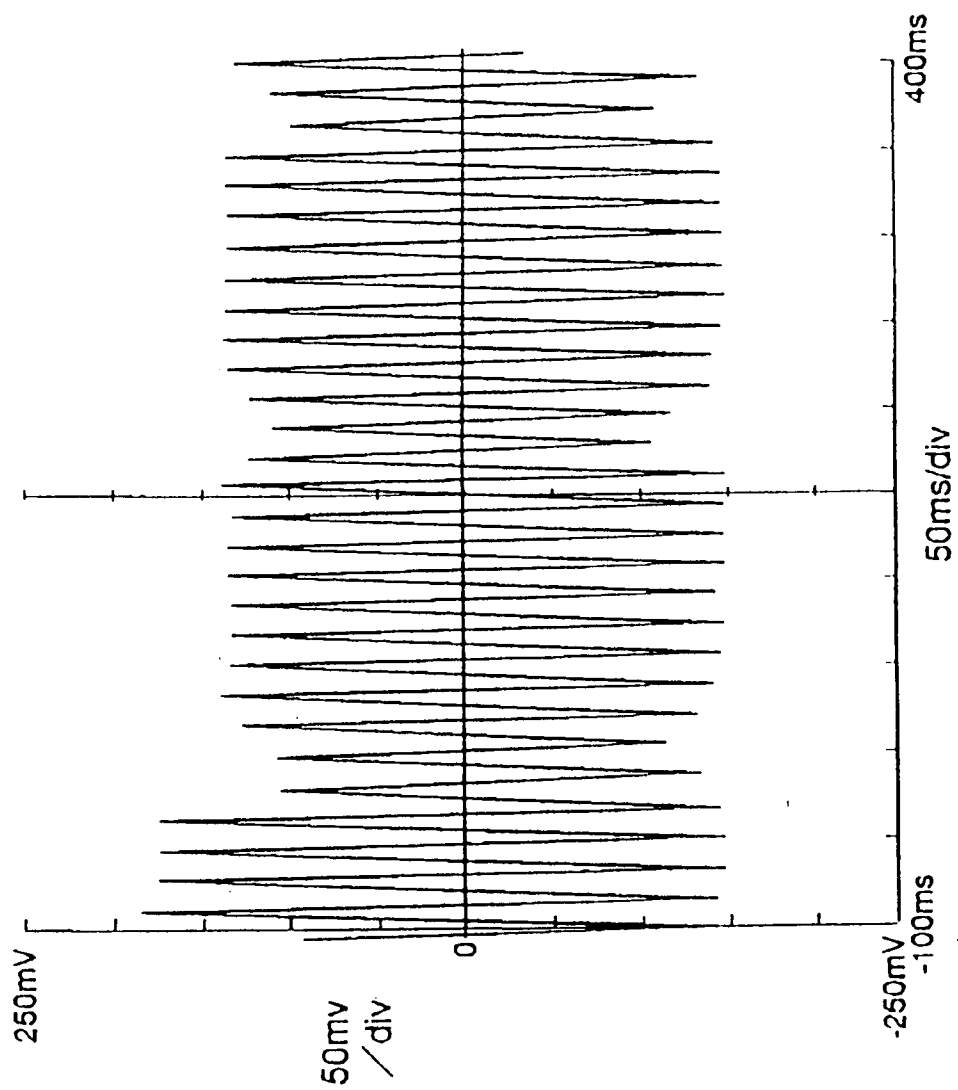


Fig. 38

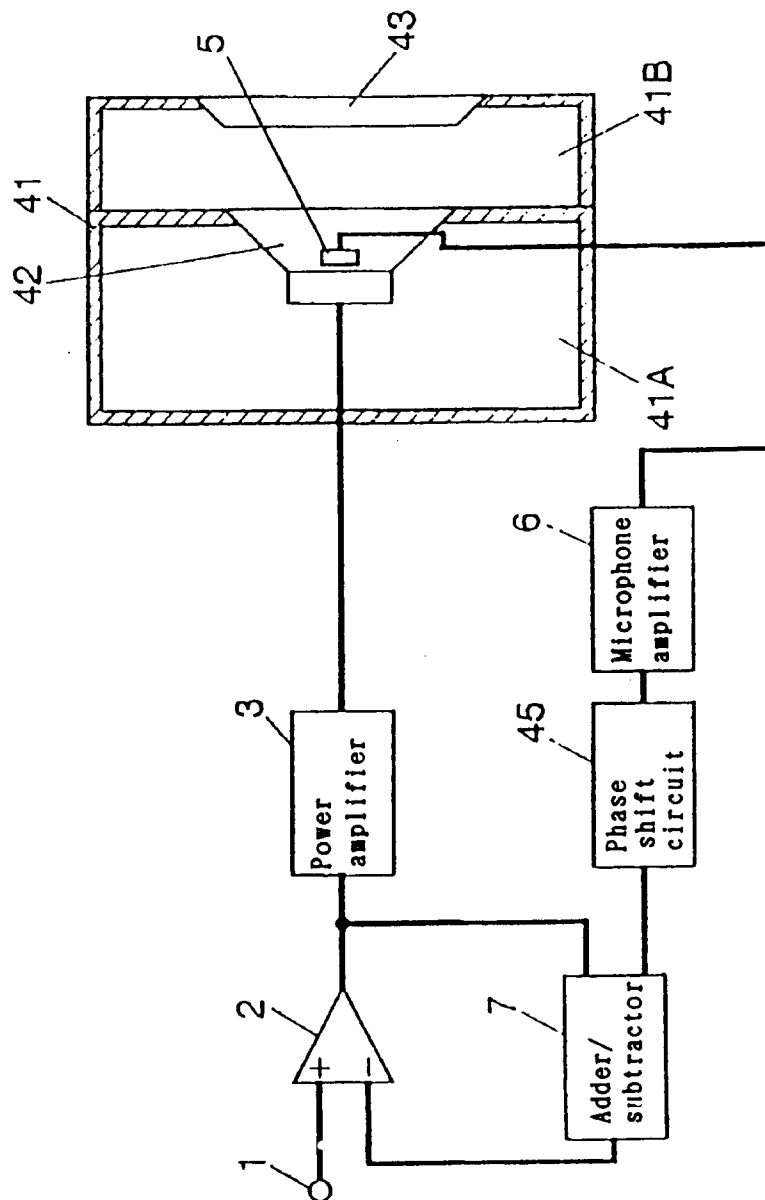


Fig. 39

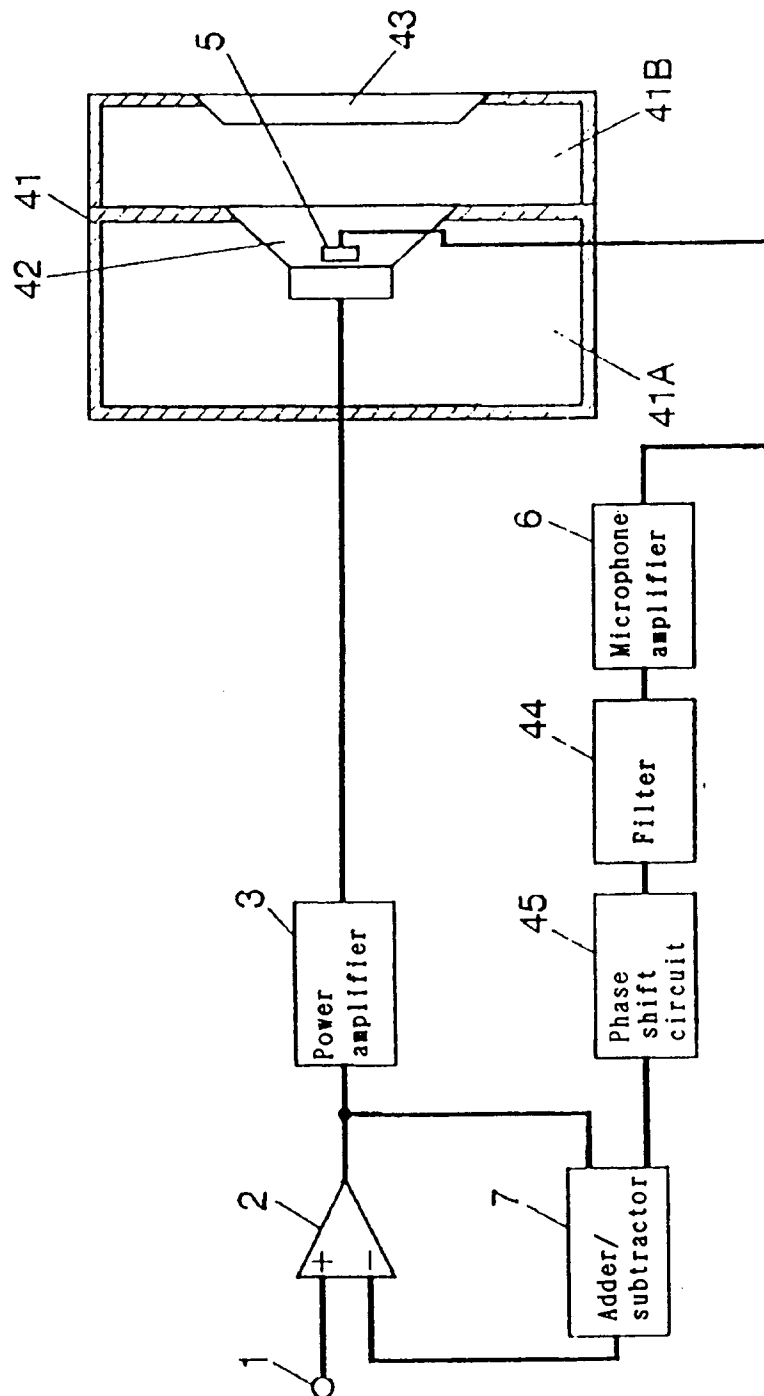


Fig. 40

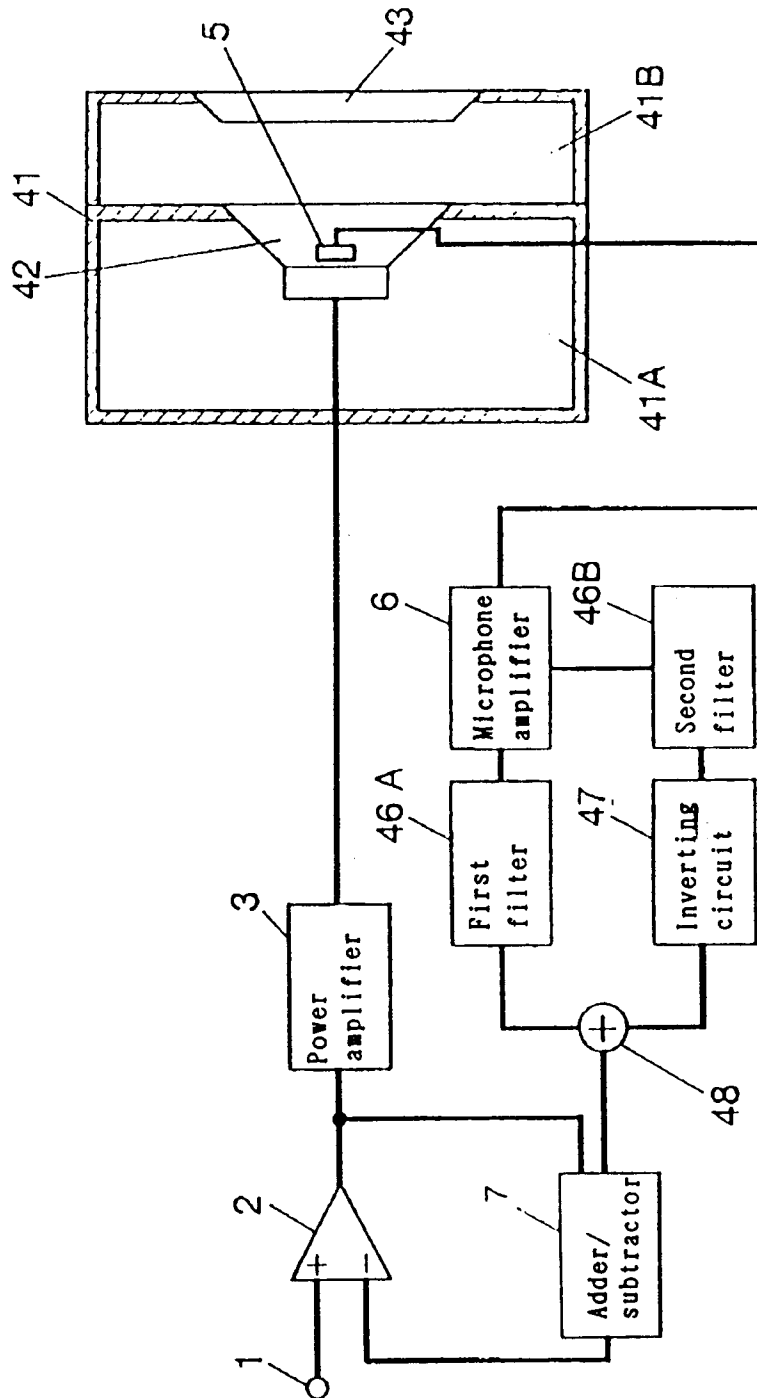


Fig. 41

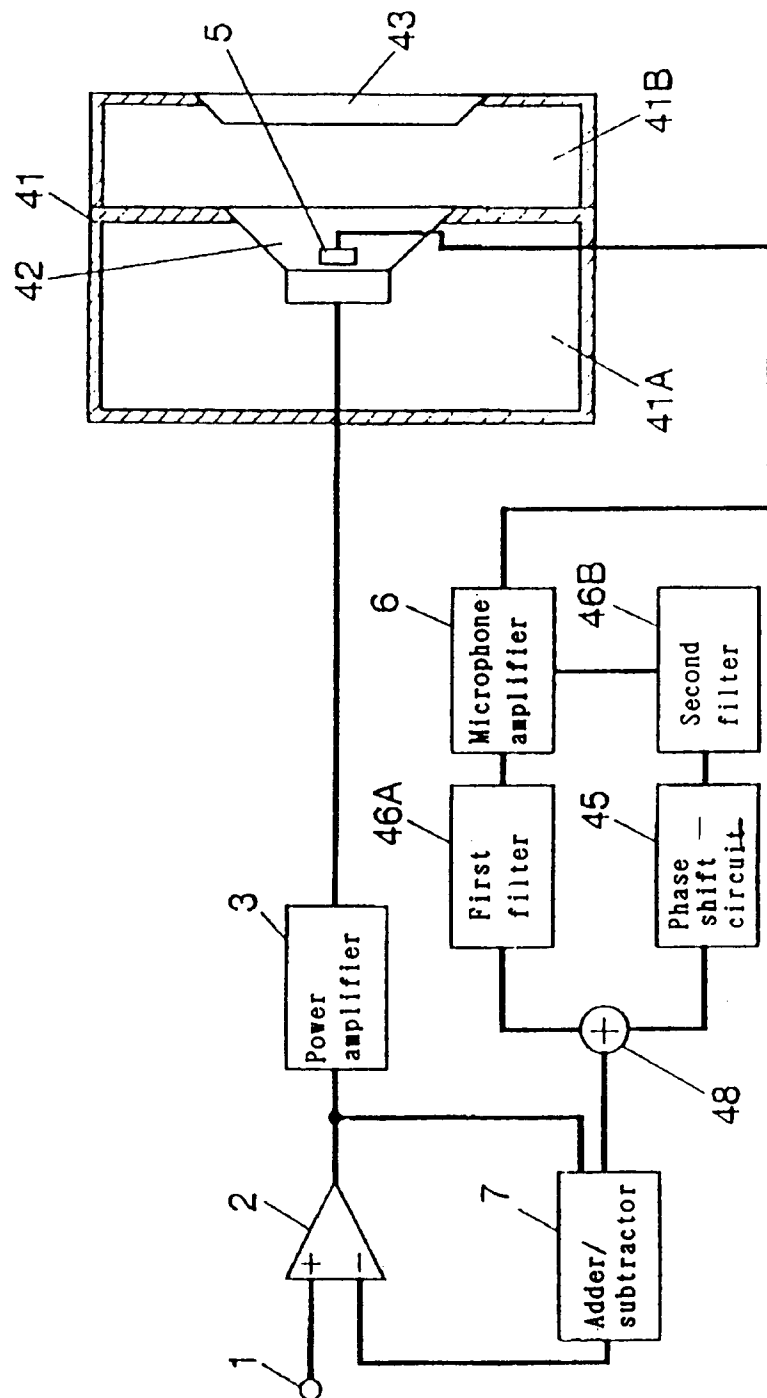


Fig. 42

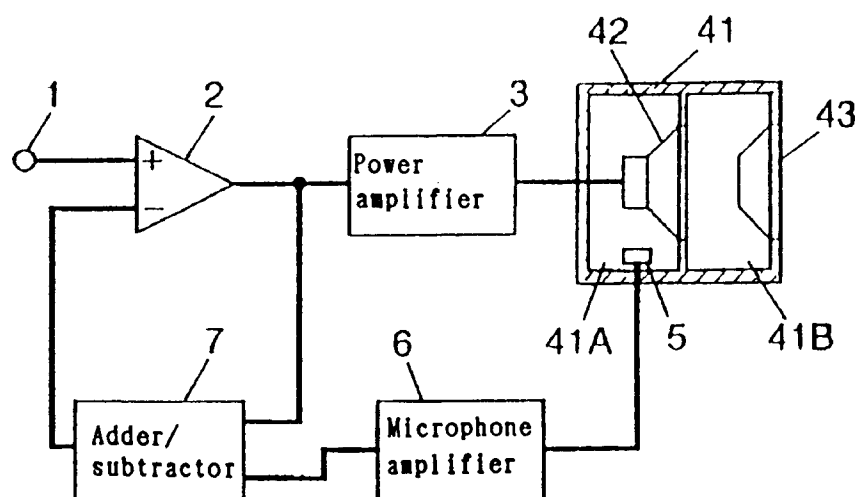


Fig. 43

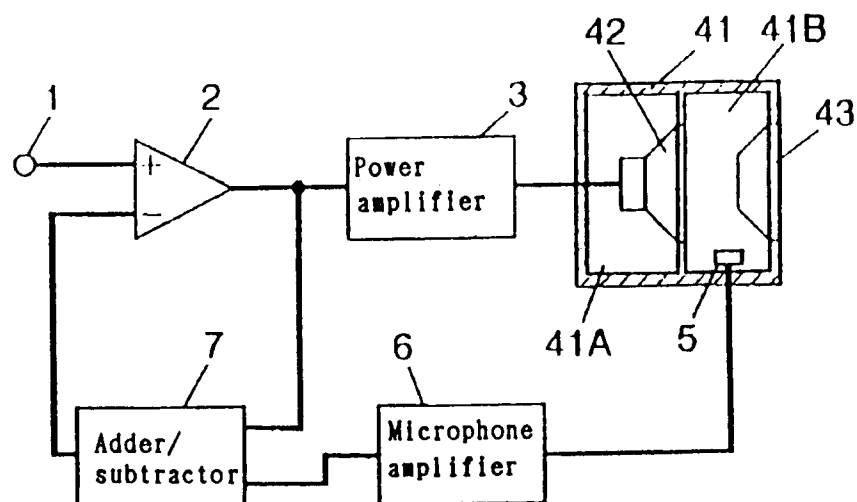


Fig. 44

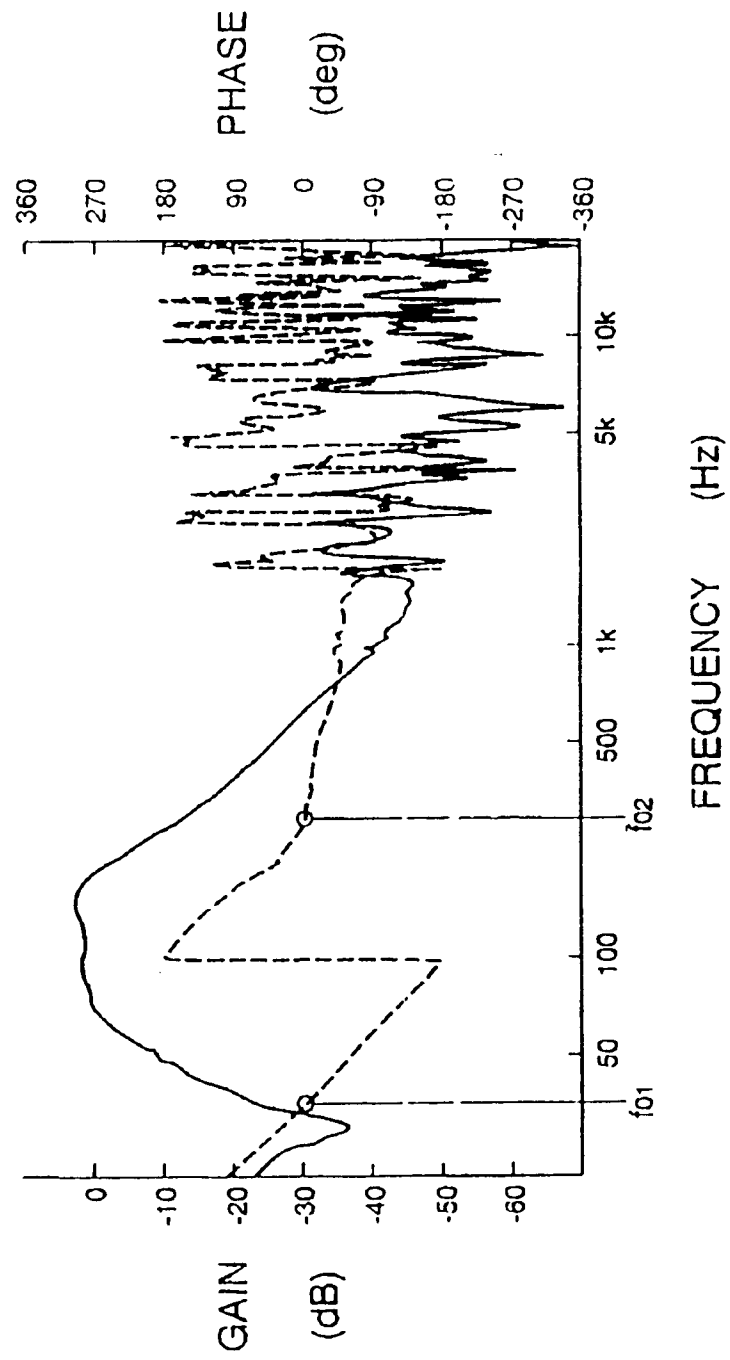


Fig. 45

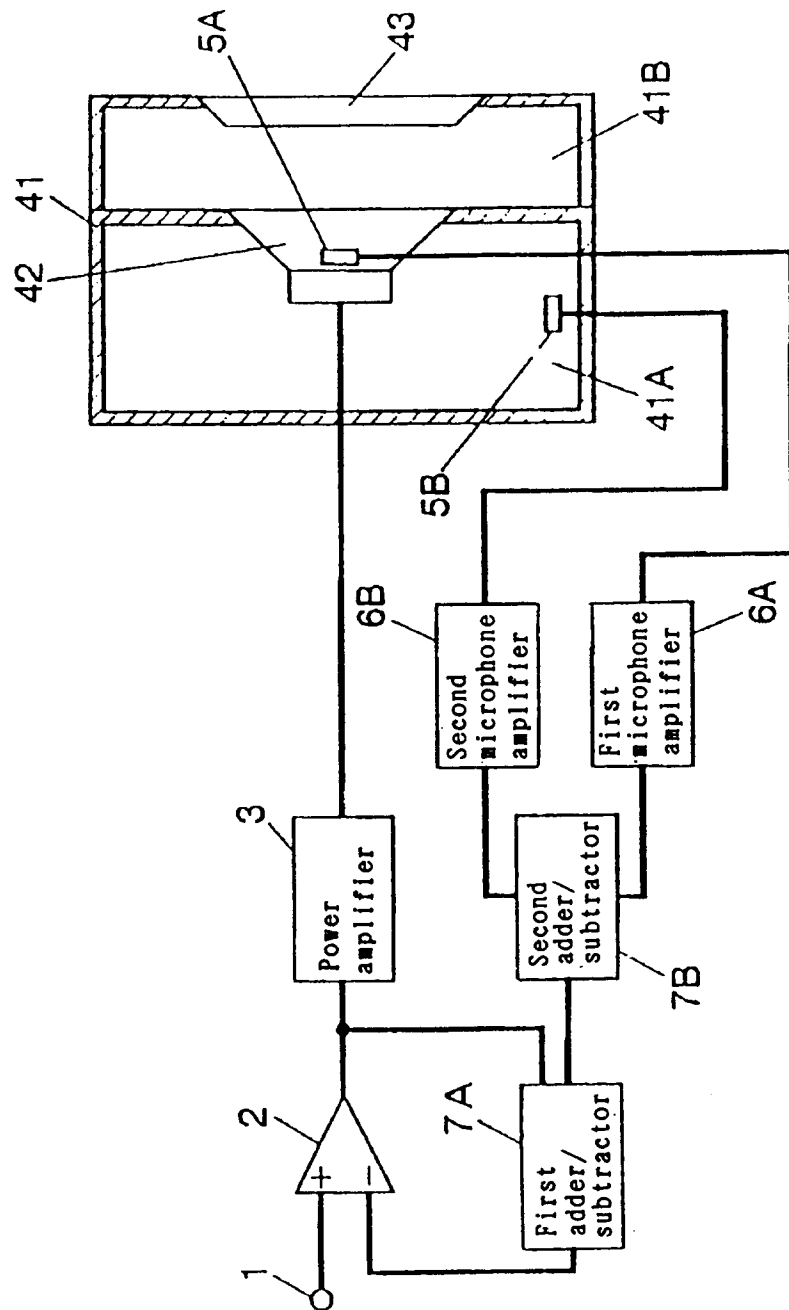


Fig. 46

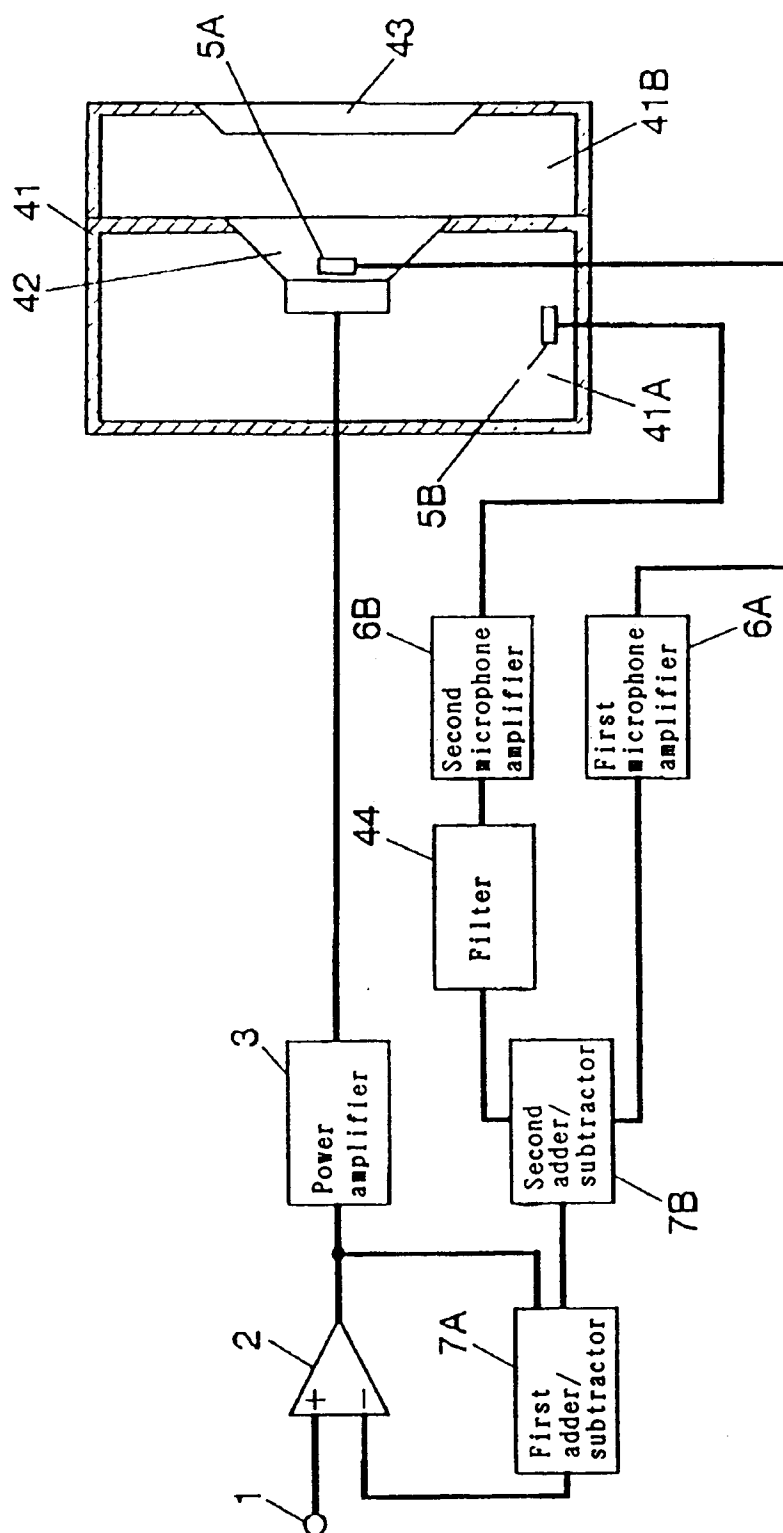


Fig. 47

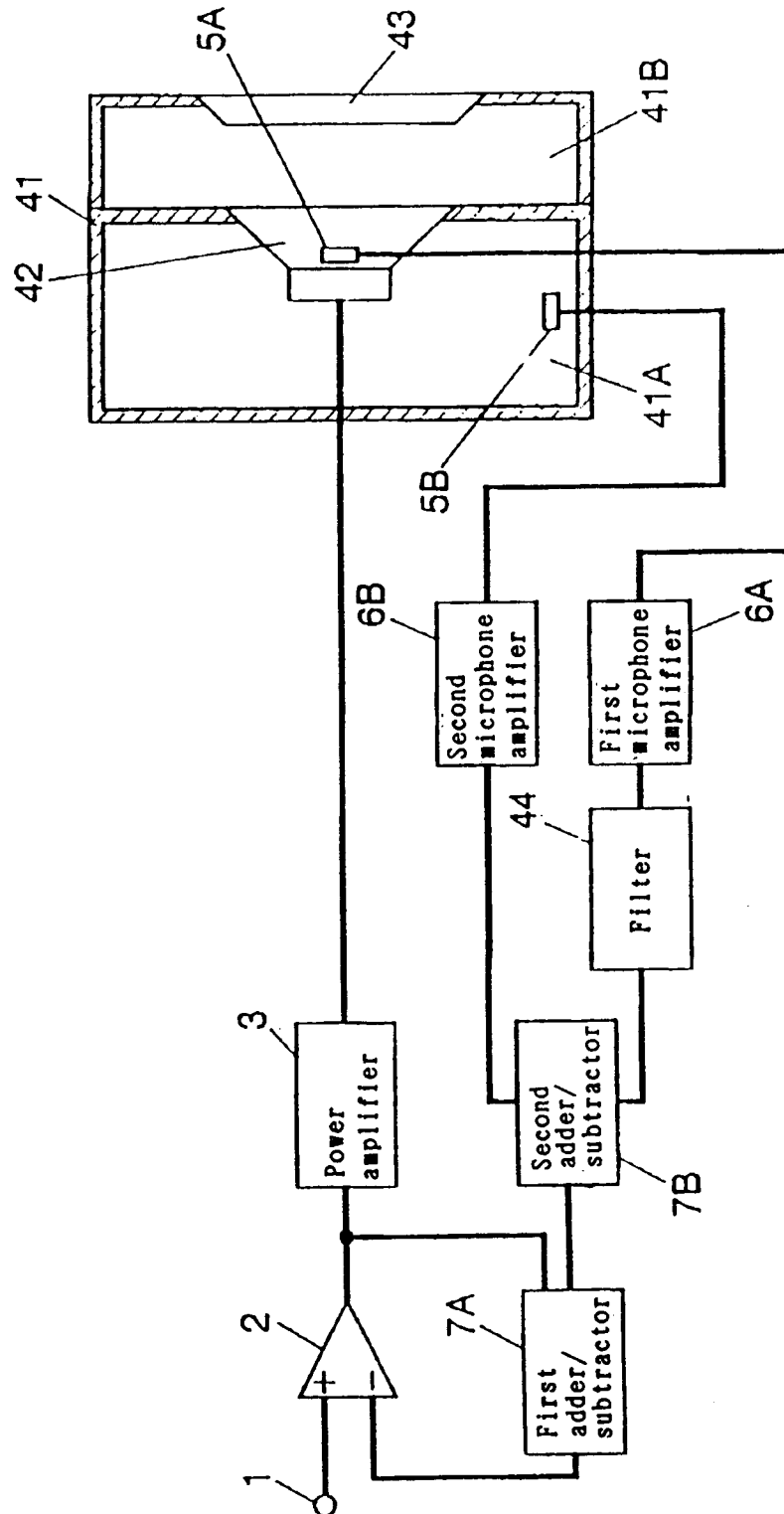


Fig. 48

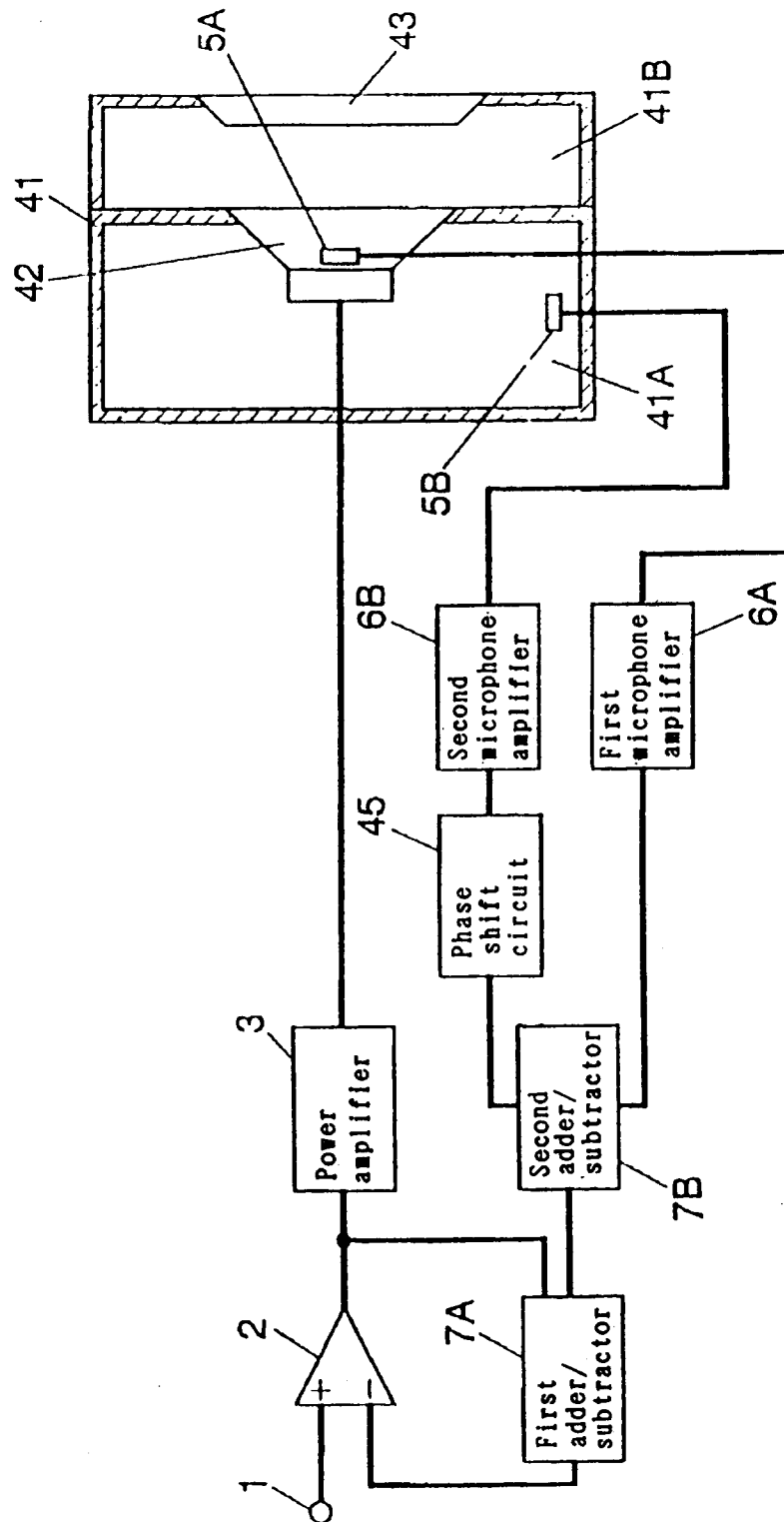


Fig. 49

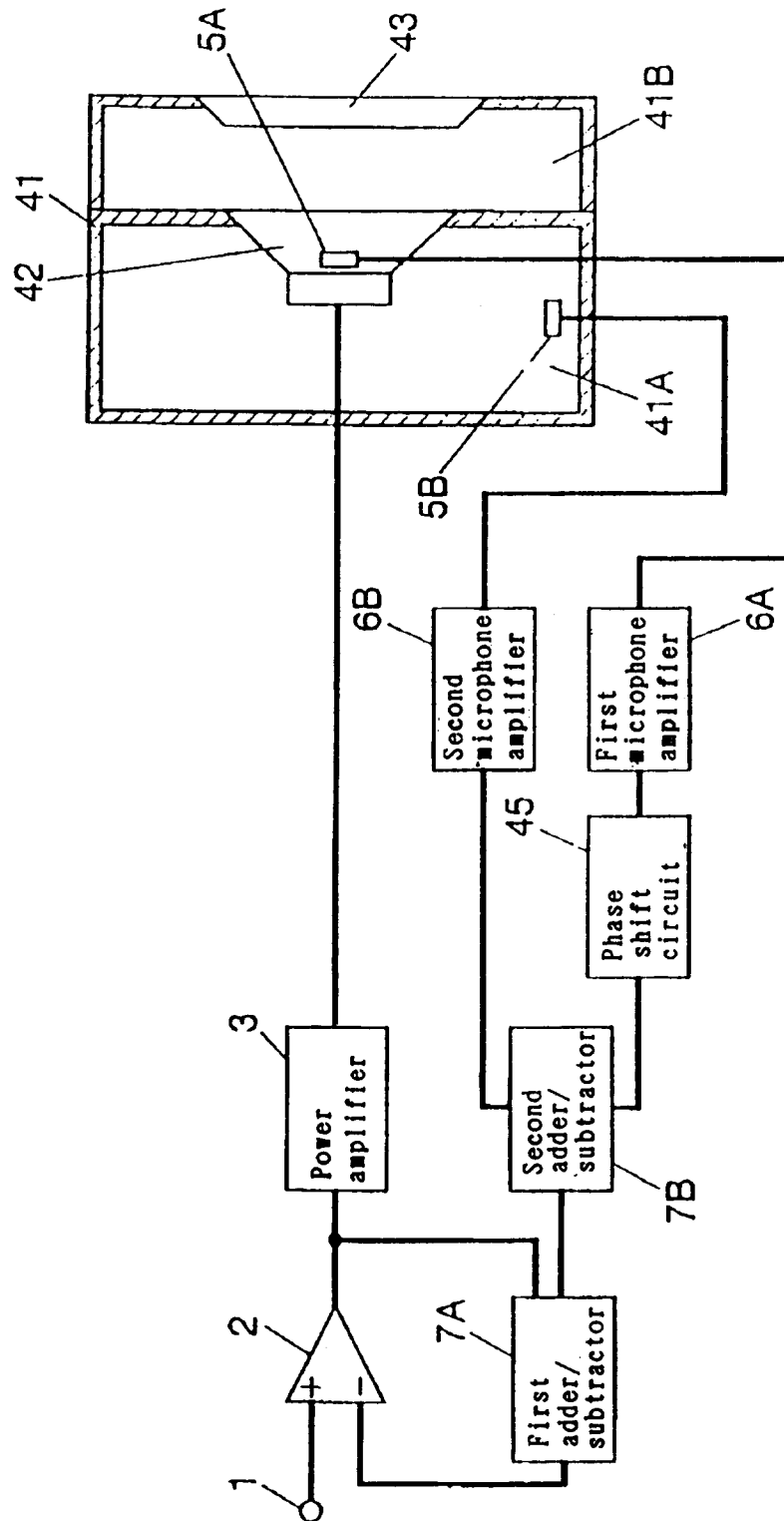


Fig. 50

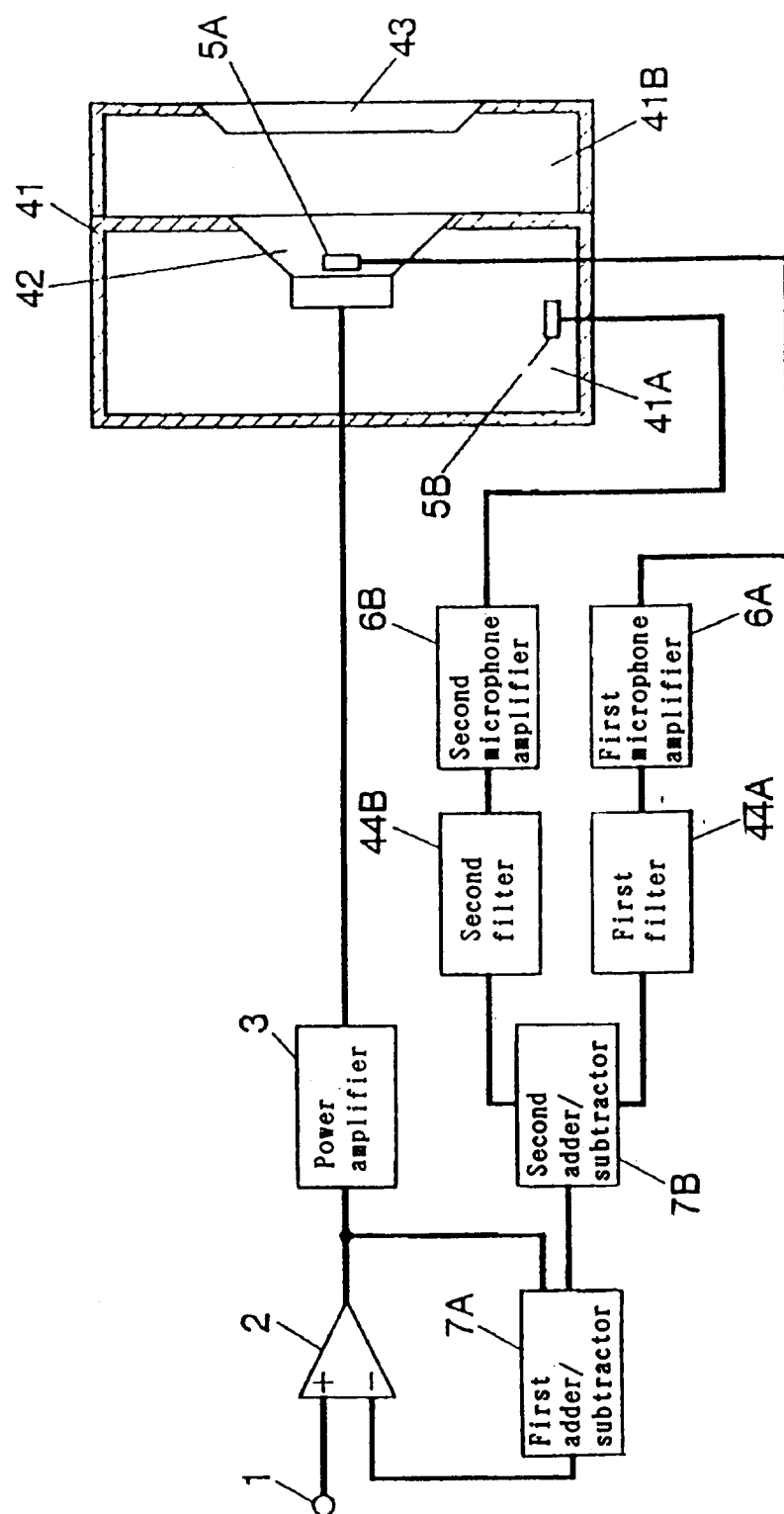


Fig. 51

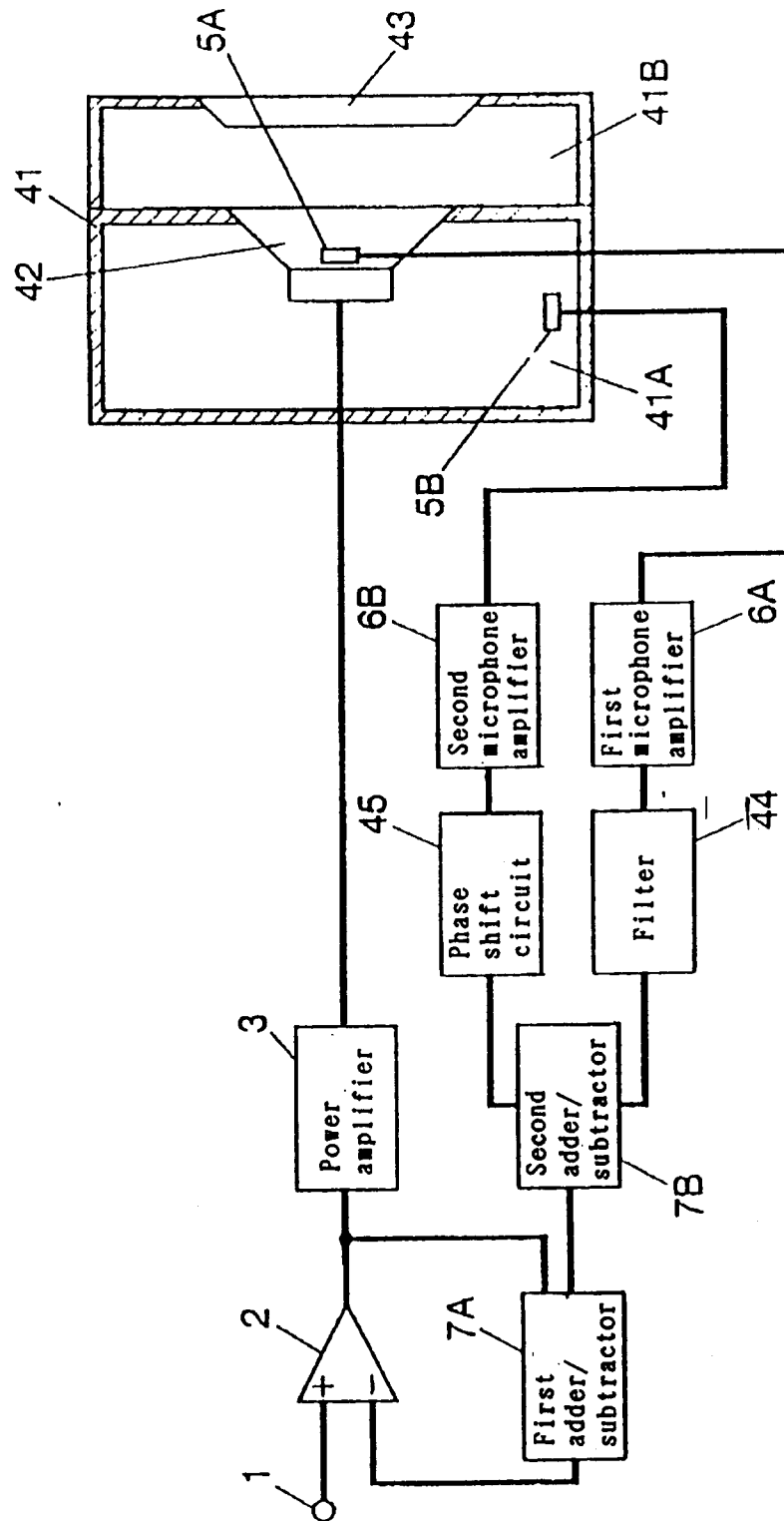


Fig. 52

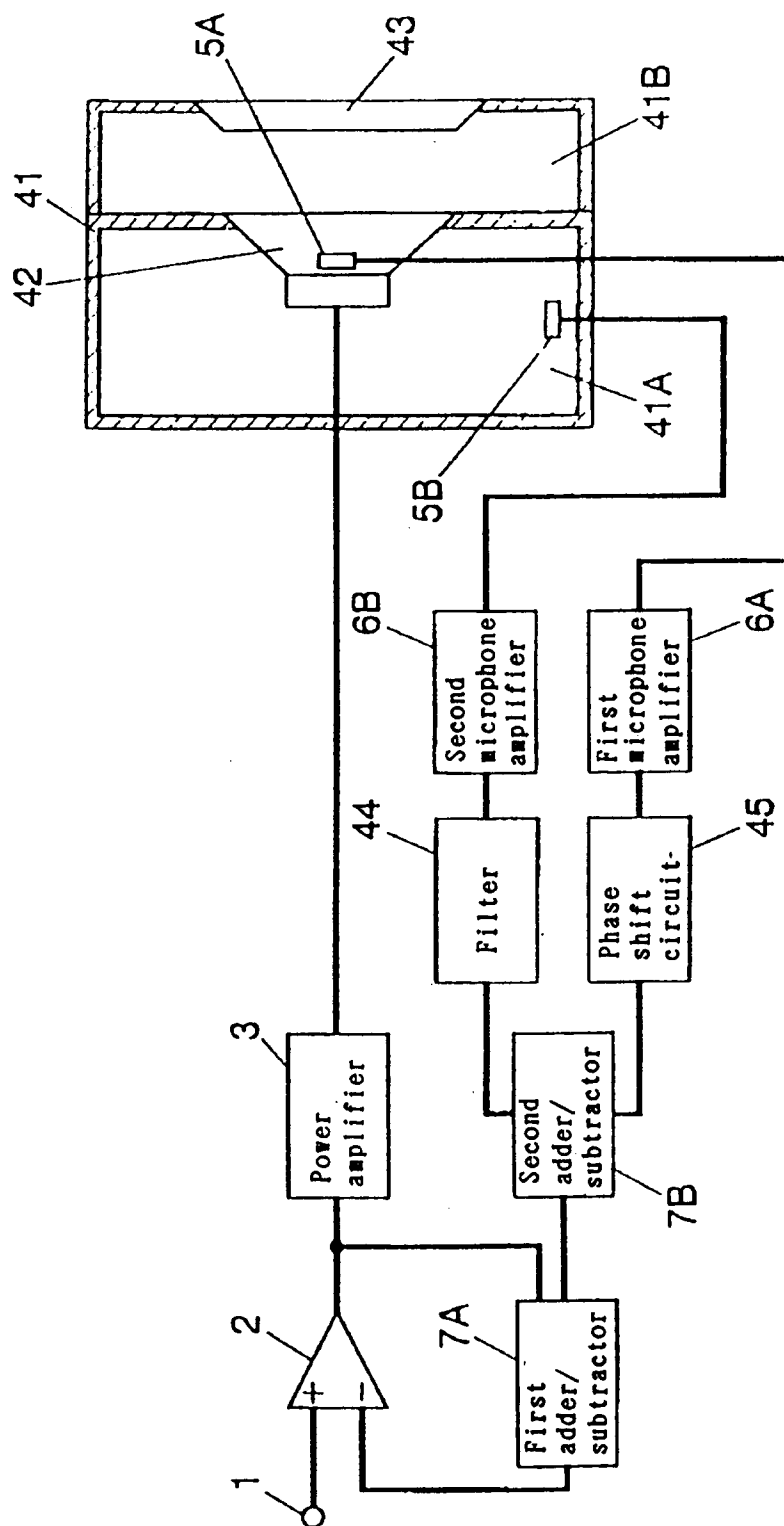


Fig. 53

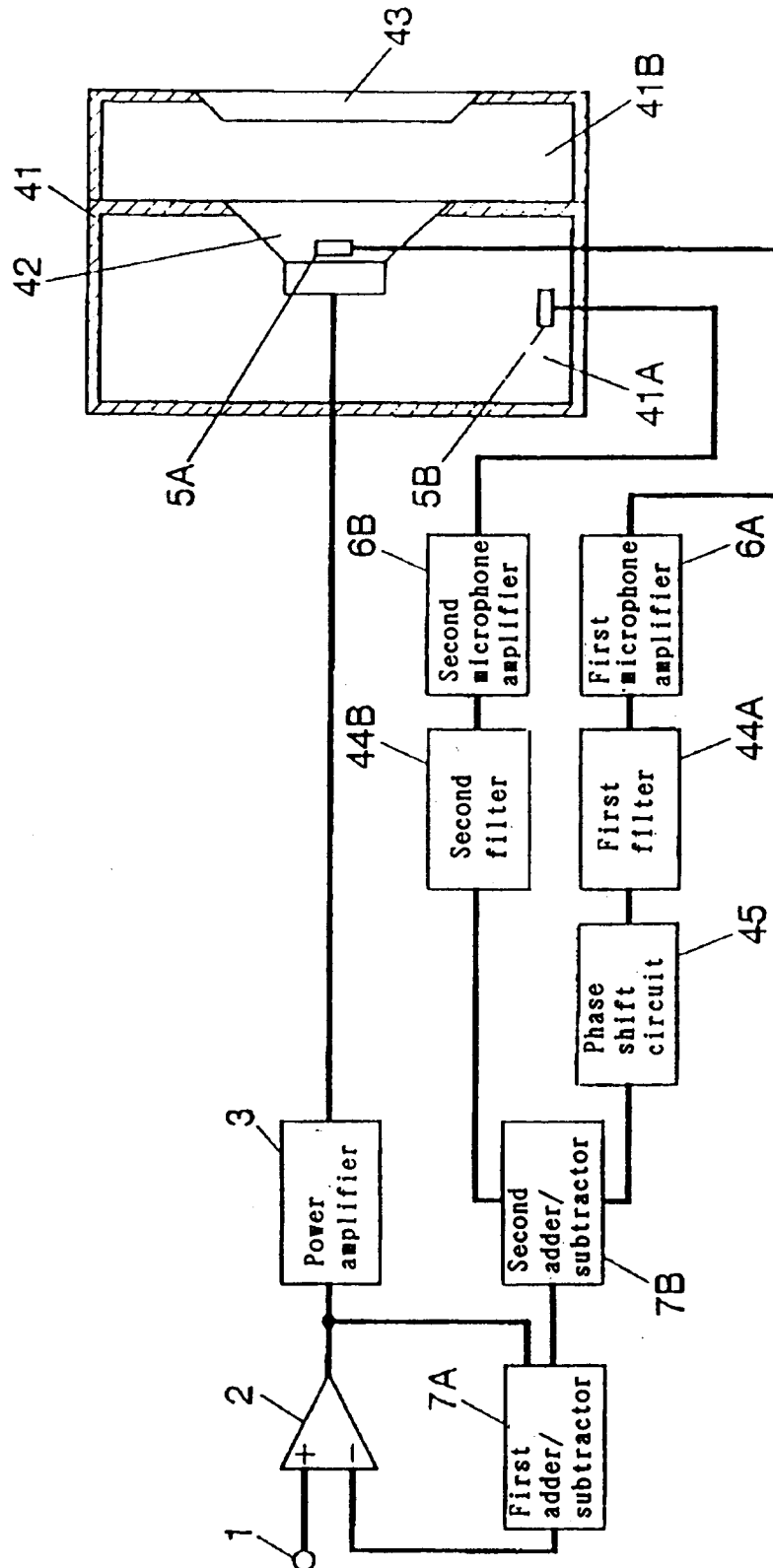


Fig. 54

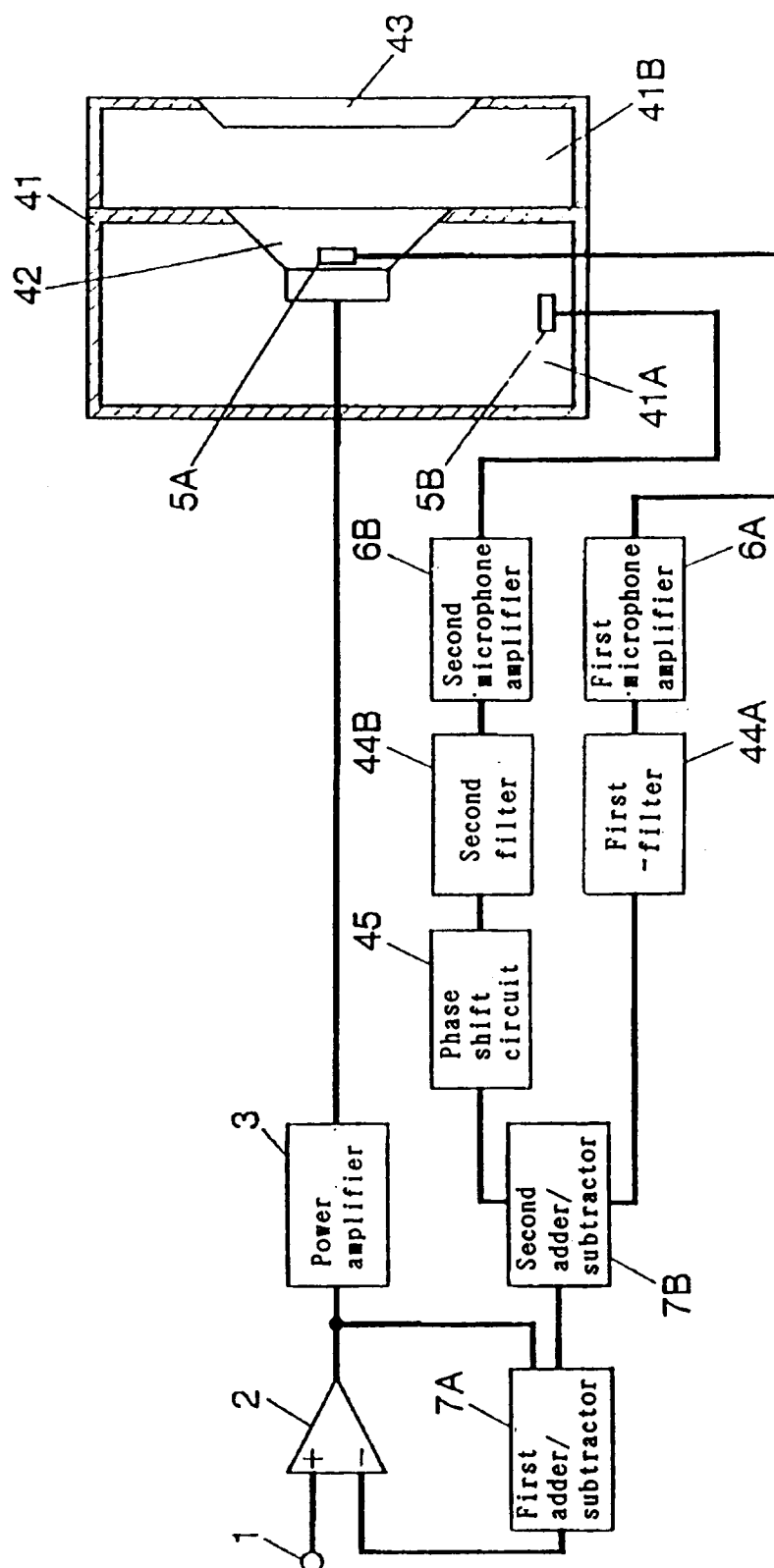


Fig. 55

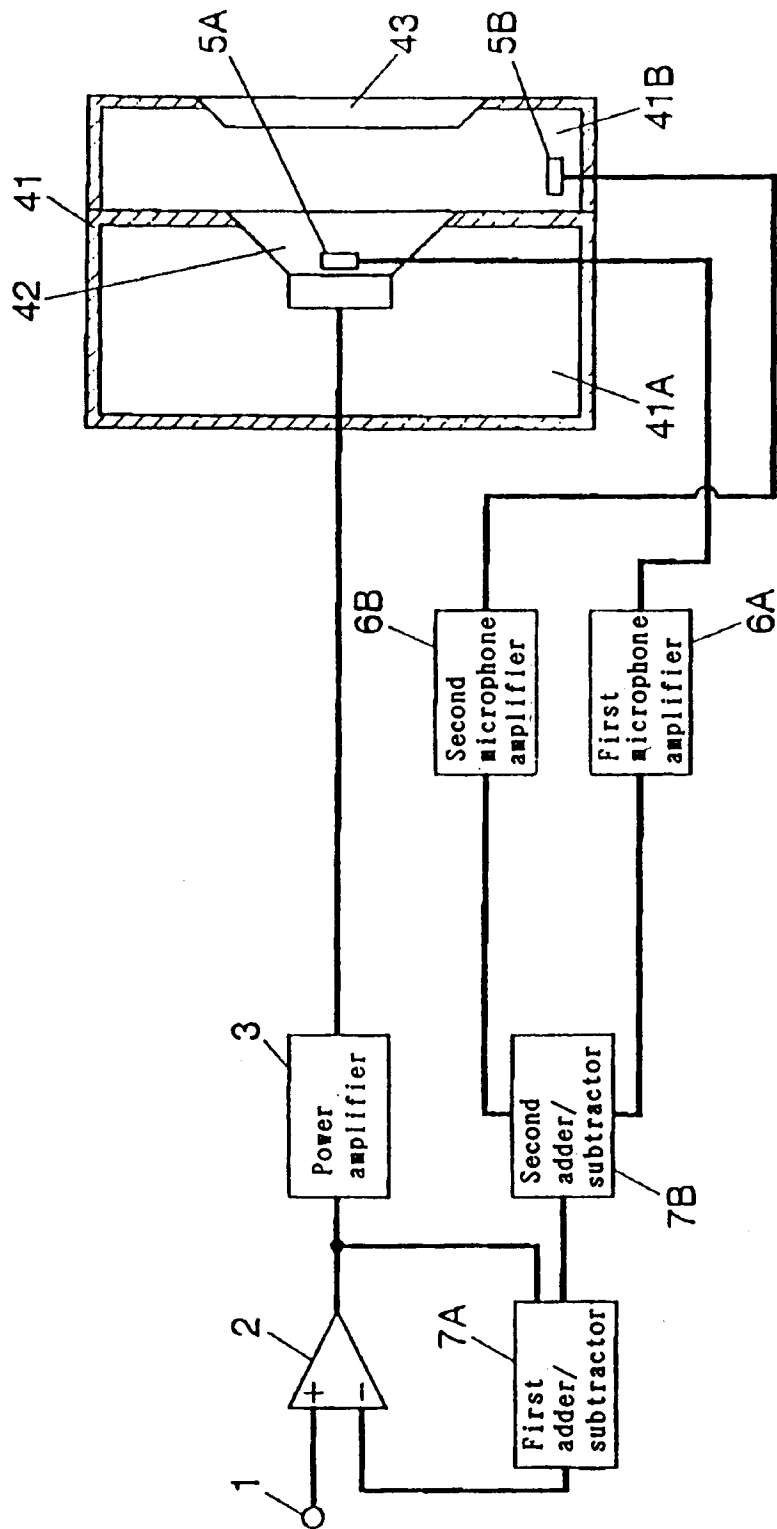


Fig. 56

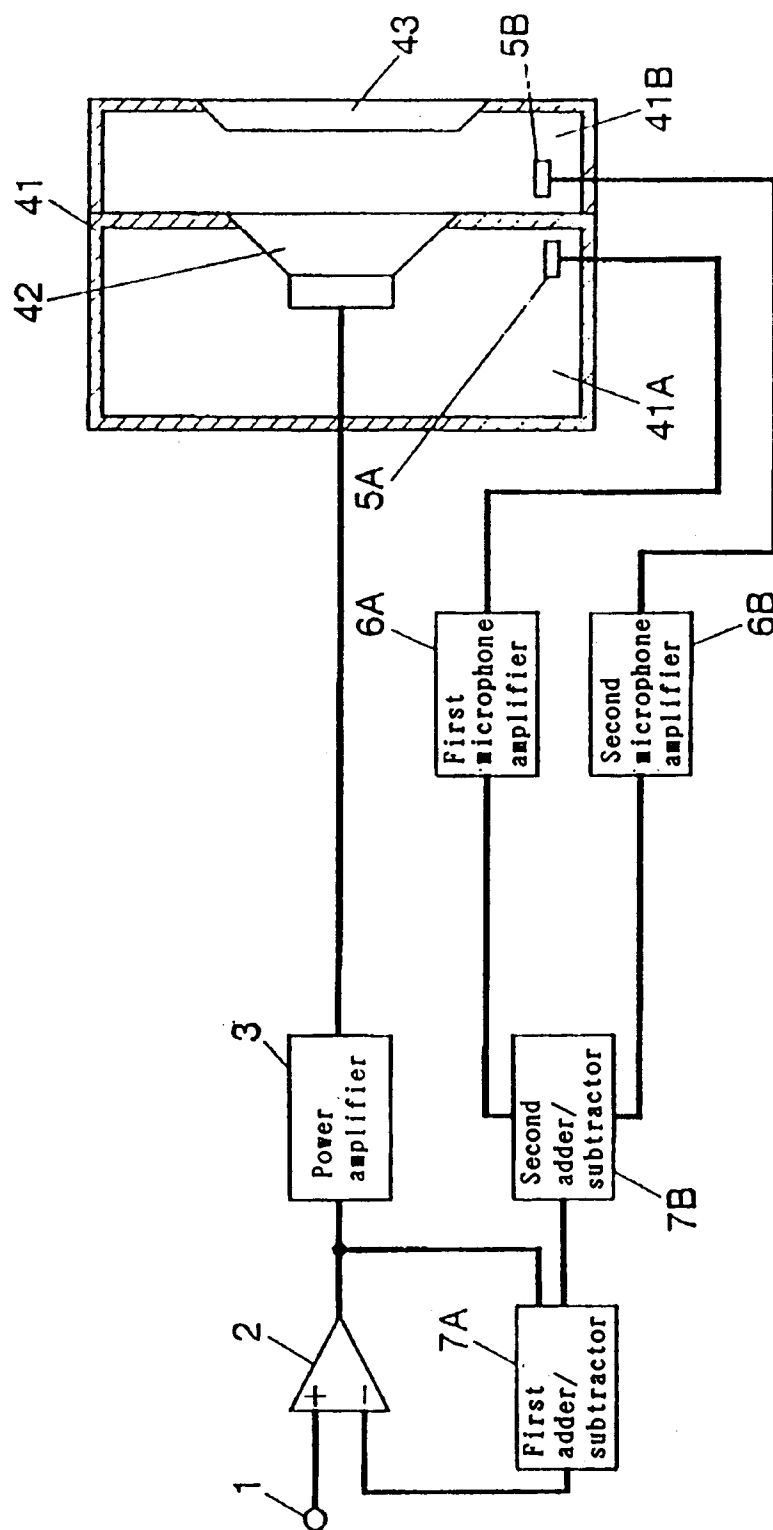


Fig. 57

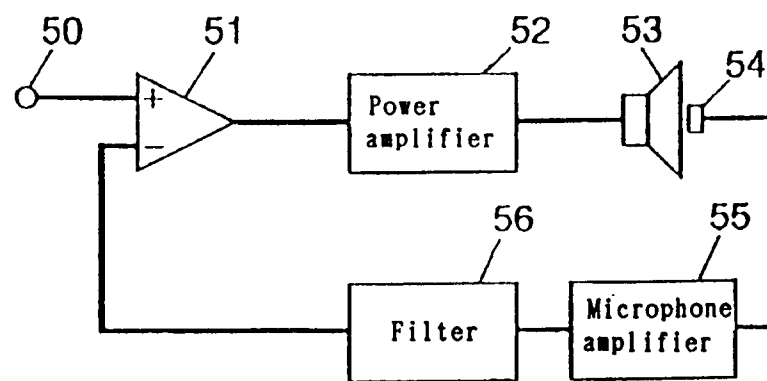


Fig. 58

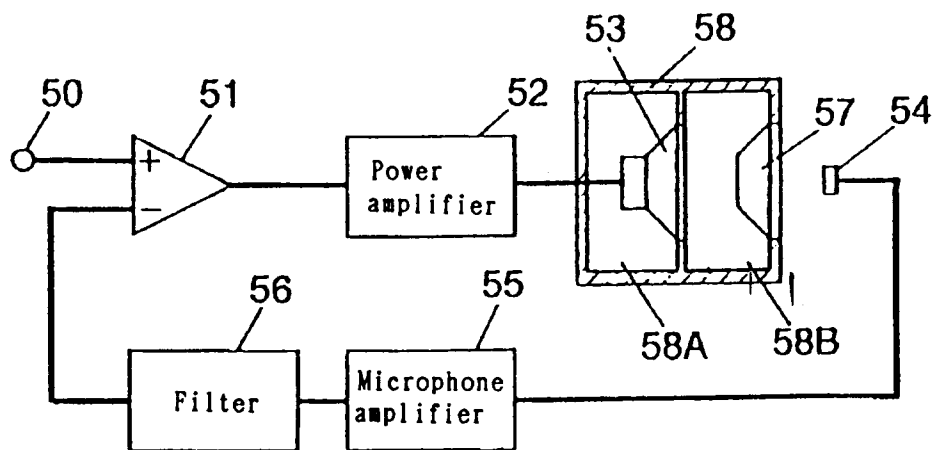


Fig. 59

