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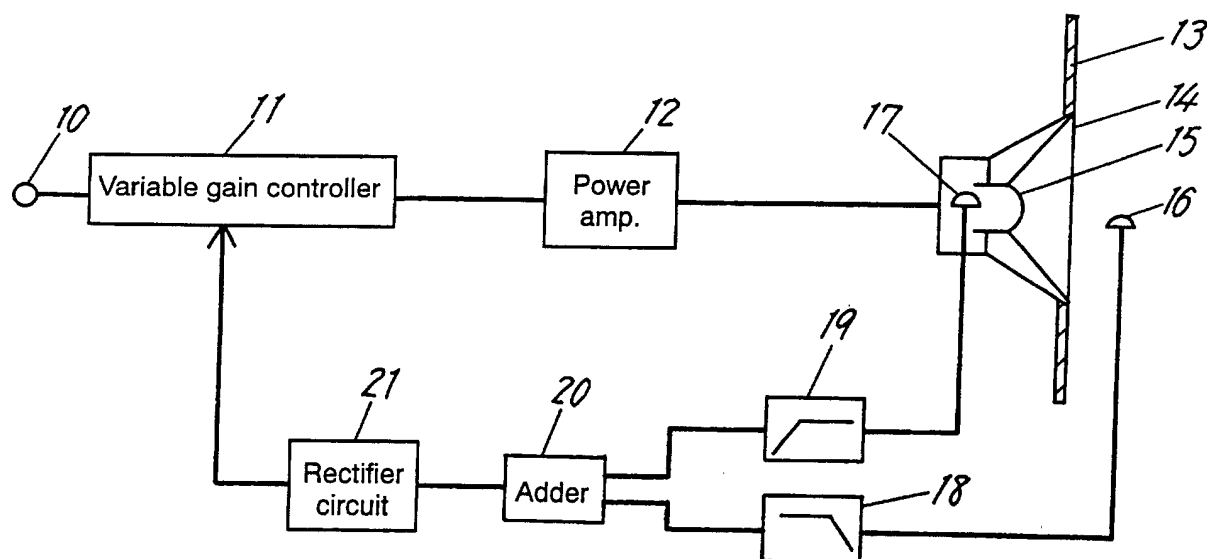
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(54) **SOUND-REPRODUCTION DEVICE**

(57) A sound reproduction apparatus that performs a better masking compensation, by precisely extracting the ambient noise from a composite sound which contains the ambient noise and the signal generated by a speaker, removing therefrom the signal generated from

the speaker. It comprises a first microphone (16) provided outside a dust cap (15) of a speaker unit (14), and a second microphone (17) provided inside a dust cap (15). An output signals from the microphones are filtered respectively and then added together, the added signal controls the strength of input signal.

FIG. 1



Description

TECHINICAL FIELD

[0001] The present invention relates to a sound reproduction apparatus that provides favorable reproduced signals in an environment of relatively high ambient noise.

BACKGROUND ART

[0002] FIG. 6 is block diagram of a conventional sound reproduction apparatus. Referring to FIG. 6, signals supplied to input terminal 1 is led, through a variable gain controller 2, to a power amplifier 3 for power amplification. Output signal from the power amplifier 3 is delivered to a speaker unit 4 mounted on a baffle 5 to be reproduced into sounds. Meanwhile, a microphone 6 placed at the vicinity of the speaker unit 4 collects a sum of the signals radiated from the speaker unit 4 and the noise in the neighborhood of the baffle 5.

[0003] Output signal from the microphone 6 is delivered, together with output signal of the power amplifier, to a subtracter 7. The subtracter 7 subtracts input signal components from the sum of the signals radiated from the speaker unit 4 and the ambient noise collected by the microphone 6, in order to extract the ambient noise components. Output signal of the subtracter 7, which is proportional to the ambient noise, is limited to a pass band by a low-pass filter 8. An output signal of the low-pass filter 8 is rectified from AC to DC by a rectifier 9 and then delivered to the variable gain controller 2 provided at the front stage of the power amplifier 3. Thus, degree of amplifying the input signals is automatically varied by the variable gain controller 2 in accordance with a degree of ambient noise around the speaker unit 4, so that signals radiated from the speaker unit 4 is not masked by the ambient noise.

[0004] In the conventional sound reproduction apparatus, however, there is a difference between the signal components radiated from the speaker unit 4 and the signal components delivered from the power amplifier 3. Therefore, the subtracter 7 can not totally remove the signal components radiated from the speaker unit 4, or, it is difficult to extract component of the ambient noise around the speaker unit 4. So, it is compelled to perform the control, using only a very limited pass band components of the noise.

DISCLOSURE OF THE INVENTION

[0005] The present invention aims to provide a sound reproduction apparatus that precisely removes signals radiated from a speaker unit and varies the gains in accordance with the ambient noise.

[0006] A sound reproduction apparatus of the present invention extracts ambient noise components using a first microphone provided outside the dust cap of a

speaker unit and a second microphone provided inside the dust cap of the speaker unit. With the above described arrangement, it can extract the ambient noise around the speaker unit precisely, and performs a natural compensation to the masking.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 shows block diagram of a sound reproduction apparatus in an example of the present invention.

[0008] FIG. 2 is an output characteristic of a second microphone in the sound reproduction apparatus of the present invention.

[0009] FIG. 3 is an output characteristic of a high-pass filter in the sound reproduction apparatus of the present invention.

[0010] FIG. 4 is an output characteristic of a first microphone in the sound reproduction apparatus of the present invention.

[0011] FIG. 5 is an output characteristic of a low-pass filter in the sound reproduction apparatus of the present invention.

[0012] FIG. 6 shows block diagram of a conventional sound reproduction apparatus.

BEST MODE FOR CARRYING OUT THE INVENTION

Example

[0013] FIG. 1 shows block diagram of a sound reproduction apparatus in an example of the present invention. Referring to FIG. 1, input signal supplied to an input terminal 10 is delivered to a variable gain controller 11, or control means, which is controlled by a signal generated in accordance with an ambient noise to be described later. Output of the variable gain controller 11 is delivered to a power amplifier 12, output signal of the power amplifier 12 is connected to a speaker unit 14 mounted on a baffle 13. Outside the dust cap of speaker unit 14, a first microphone 16 is provided for collecting sum of the signal radiated from speaker unit 14 and the ambient noise.

[0014] Inside the dust cap of speaker unit 14, a second microphone 17 is provided for collecting the signal in proportion to the sound radiation from speaker unit 14.

[0015] An output signal of the first microphone 16 after passing through a low-pass filter 18 and an output signal of the second microphone 17 after passing through a high-pass filter 19 are input together to an adder 20. Then, components of the signal radiated from the speaker unit 14 are removed, and only the noise components around the speaker unit 14 collected by the first microphone 16 can be extracted. Output of the adder 20, which being the noise components around speaker unit 14, is delivered to a rectifier 21, or conversion means, to be converted from AC signal to DC signal. By supplying output signal of the rectifier 21 to the variable

gain controller 11, the gains are automatically varied in accordance with the ambient noise around the speaker unit 14. Thus the masking is compensated in a more natural way.

[0016] In the following, description is made on a practical example.

[0017] FIG. 2 shows frequency and phase characteristics of output signal from the second microphone 17 relative to output signal of power amplifier 12. In FIG. 2, frequency at a phase characteristic 0° is 70Hz. A primary high-pass filter 19 of cut-off frequency 70Hz is set as a second filter for outputting a signal of certain specific pass band. Frequency and phase characteristic of output signal from the second microphone 17 after passing through the high-pass filter 19 are shown in FIG. 3. Frequency at the phase characteristic 0° is 95Hz.

[0018] FIG. 4 shows frequency and phase characteristic of output signal from the first microphone 16 in relation to the output signal of power amplifier 12. A primary low-pass filter 18 is set as a first filter outputting a signal of certain specific pass band so that phase characteristic is -180° at the frequency 95Hz. Frequency and phase characteristic of output signal from the first microphone 16 after passing through the primary low-pass filter 18 are shown in FIG. 5. As shown in FIG. 3 and FIG. 5, output signals from the first microphone 16 and the second microphone 17 have approximately the same band pass characteristic in the frequency and the phase characteristic, with the phase inverse to each other. By inputting these signals to the adder 20, signal components radiated from the speaker unit 14 are removed, only the noise components around the speaker unit 14 collected by the first microphone 16 can be extracted.

[0019] Although the first microphone 16 is provided somewhere outside the dust cap 15 in the present example, it may be attached and fixed instead on the outer surface of the dust cap 15. The latter configuration, which does not require any place for installing the first microphone 16 outside the speaker unit 14, reveals its advantageous in a case where a space available for installing the speaker unit 14 is limited. Also, the first microphone 16 may be provided somewhere opposing to the dust cap 15 with a certain predetermined clearance in between. In this case, signals reproduced by the speaker unit 14 and ambient noise may be collected together with a higher fidelity. Thus, the accuracy of extracting the noise components is improved for compensation of the masking.

[0020] Although the second microphone 17 is provided somewhere inside the dust cap 15 in the present example, it may be attached and fixed instead on the inner surface of the dust cap 15. The latter configuration, in which the place of second microphone 17 can be away from the inside of the speaker unit 14 where the temperature goes high during operation, is advantageous in that the second microphone 17 is protected from damage due to the heat. Also, the second microphone 17

may be provided opposing to the dust cap 15 with a certain predetermined clearance in between. In this case, signals reproduced by the speaker unit 14 may be collected with a higher fidelity. Thus, the accuracy of extracting the noise components is improved for compensation of the masking.

[0021] In the present example, the first microphone 16 and the second microphone 17 have been disposed, respectively, at the outside and at the inside of the dust cap 15. These microphones may be disposed instead on the axial line of the dust cap 15 opposing face to face with the dust cap 15 in the middle. In the above-described configuration, the first microphone 16 collects the signals reproduced by the speaker unit 14 containing the ambient noise, while the second microphone 17 collects the reproduced sound of the speaker unit 14 within the dust cap 15 at an improved accuracy without ill-affecting the sound quality of speaker unit 14 at all. It is advantageous in terms of the quality of reproduced sound and the accuracy of extracting the noise components. Thus, it leads to a higher accuracy in compensating the audio sound masking.

INDUSTRIAL APPLICABILITY

[0022] Output signals from the two microphones, disposed respectively at the outside and the inside of dust cap, are processed through filters for precisely extracting only the ambient noise around the speaker unit, with the signal components output from the speaker unit removed. The noise signal is converted by a rectifier circuit into DC component, and supplied to a variable gain control circuit provided at the input stage for automatically varying the gains in accordance with the ambient noise around the speaker unit. Thus the sound reproduction apparatus of the present invention provides reproduced sound that is not masked by the ambient noise.

Reference Numerals

[0023]

- 10 input terminal
- 11 variable gain amplifier
- 12 power amplifier
- 13 baffle
- 14 speaker unit
- 15 dust cap
- 16 first microphone
- 17 second microphone
- 18 low pass filter
- 19 high pass filter
- 20 adder
- 21 rectifier circuit

Claims**1.** A sound reproduction apparatus comprising:

a power amplifier for amplifying input signal; 5
 a speaker unit for reproducing output signal of
 the power amplifier, mounted on a baffle;
 a first microphone provided outside a dust cap
 of speaker unit;
 a second microphone provided inside the dust 10
 cap of speaker unit;
 a first filter that receives output signal of said
 first microphone containing ambient noise and
 reproduced signal of said speaker unit, and out-
 puts a signal of certain specific pass band; 15
 a second filter that receives output signal of
 said second microphone, and outputs a signal
 of certain specific pass band;
 an adder for adding output signals from said
 first filter and said second filter; 20
 conversion means for converting AC signal
 from the adder into DC signal; and
 control means provided at the input stage of
 said power amplifier, said control means auto-
 matically controlling the strength of said input 25
 signal in accordance with DC signal delivered
 from said conversion means so that the sound
 reproduced by said speaker unit is not masked
 by ambient noise around said speaker unit. 30

2. The sound reproduction apparatus of claim 1,
wherein the first filter is a primary low-pass filter.**3.** The sound reproduction apparatus recited in claim
1 or claim 2, wherein the second filter is a primary 35
high-pass filter.**4.** The sound reproduction apparatus of claim 1,
wherein the first microphone is attached and fixed
on a outer surface of the dust cap. 40**5.** The sound reproduction apparatus of claim 1,
wherein the second microphone is attached and
fixed on a inner surface of the dust cap. 45**6.** The sound reproduction apparatus of claim 1,
wherein the first microphone is disposed opposing
to the dust cap with a certain predetermined clear-
ance. 50**7.** The sound reproduction apparatus of claim 1,
wherein the second microphone is disposed oppos-
ing to the dust cap with a certain predetermined
clearance. 55**8.** The sound reproduction apparatus of claim 1,
wherein the first microphone and the second micro-
phone are disposed on the axial line of the dust cap

opposing face to face with the dust cap in the mid-
dle.

9. The sound reproduction apparatus of claim 1,
wherein the conversion means is a rectifier circuit.**10.** The sound reproduction apparatus of claim 1,
wherein the control means is a variable gain con-
troller which controls an amplification degree of the
input signal in accordance with the DC signal deliv-
ered from the conversion means.

FIG. 1

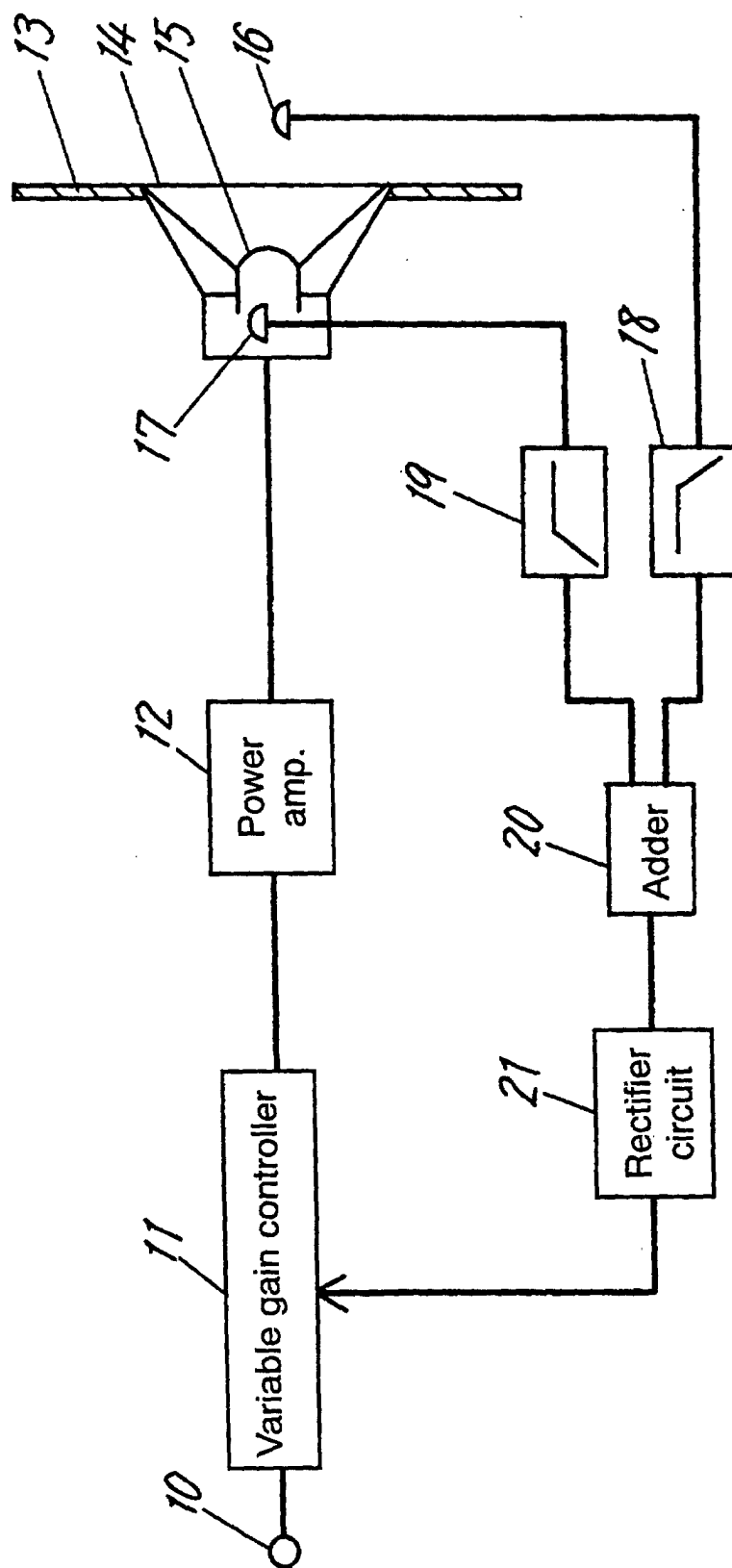


FIG. 2

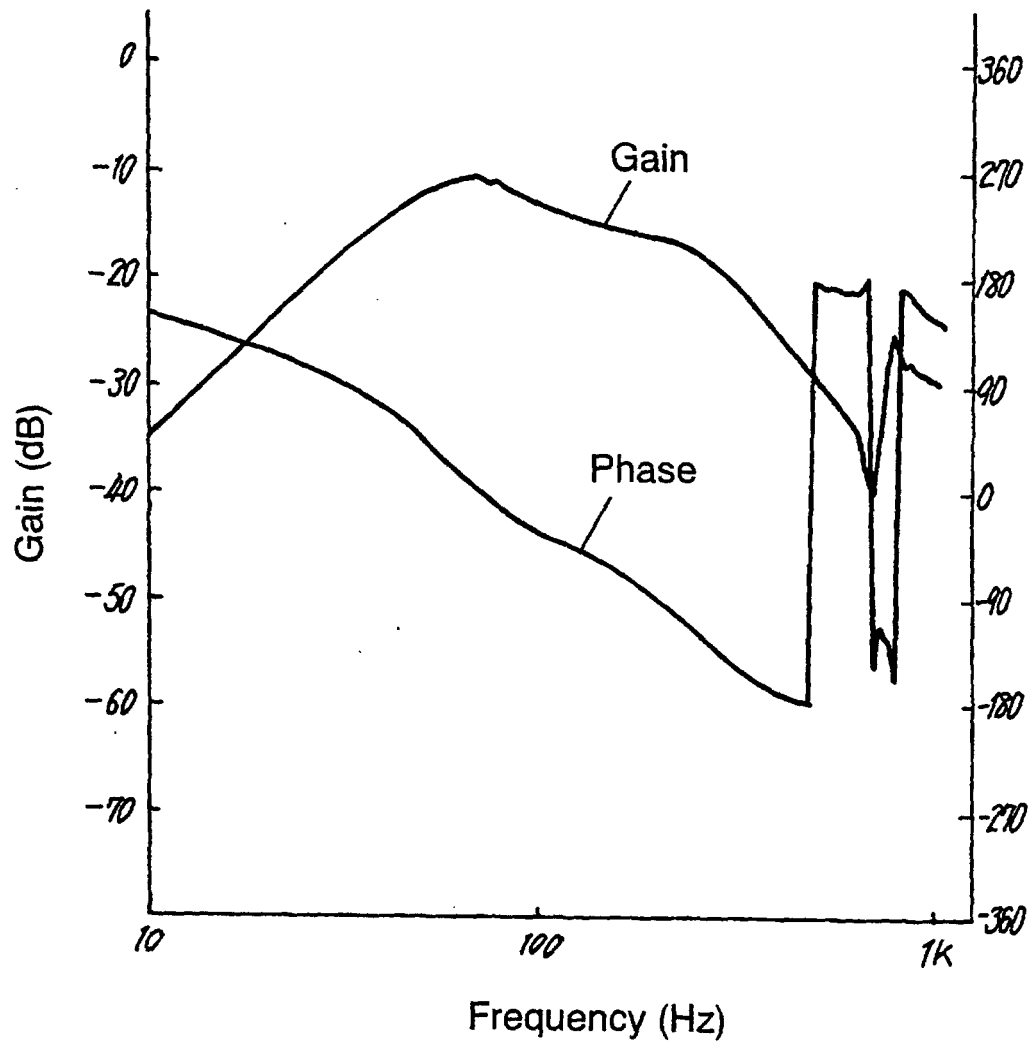


FIG.3

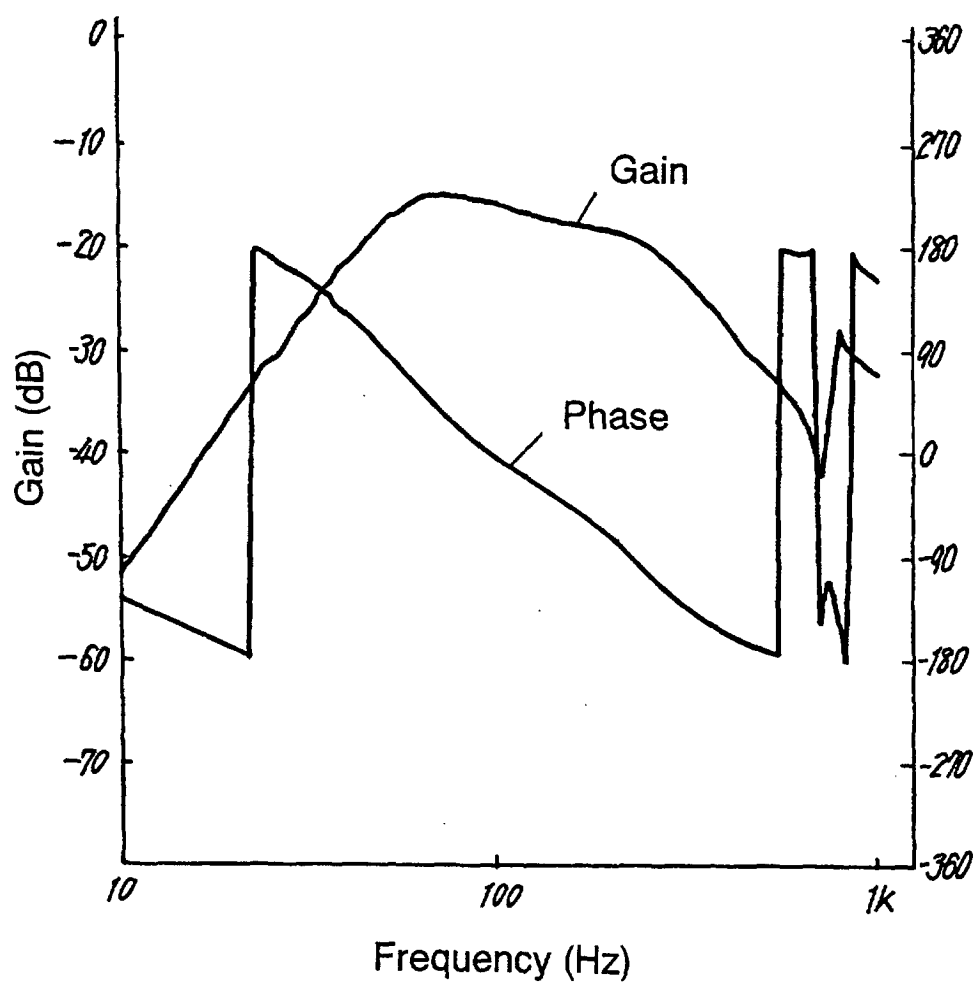


FIG. 4

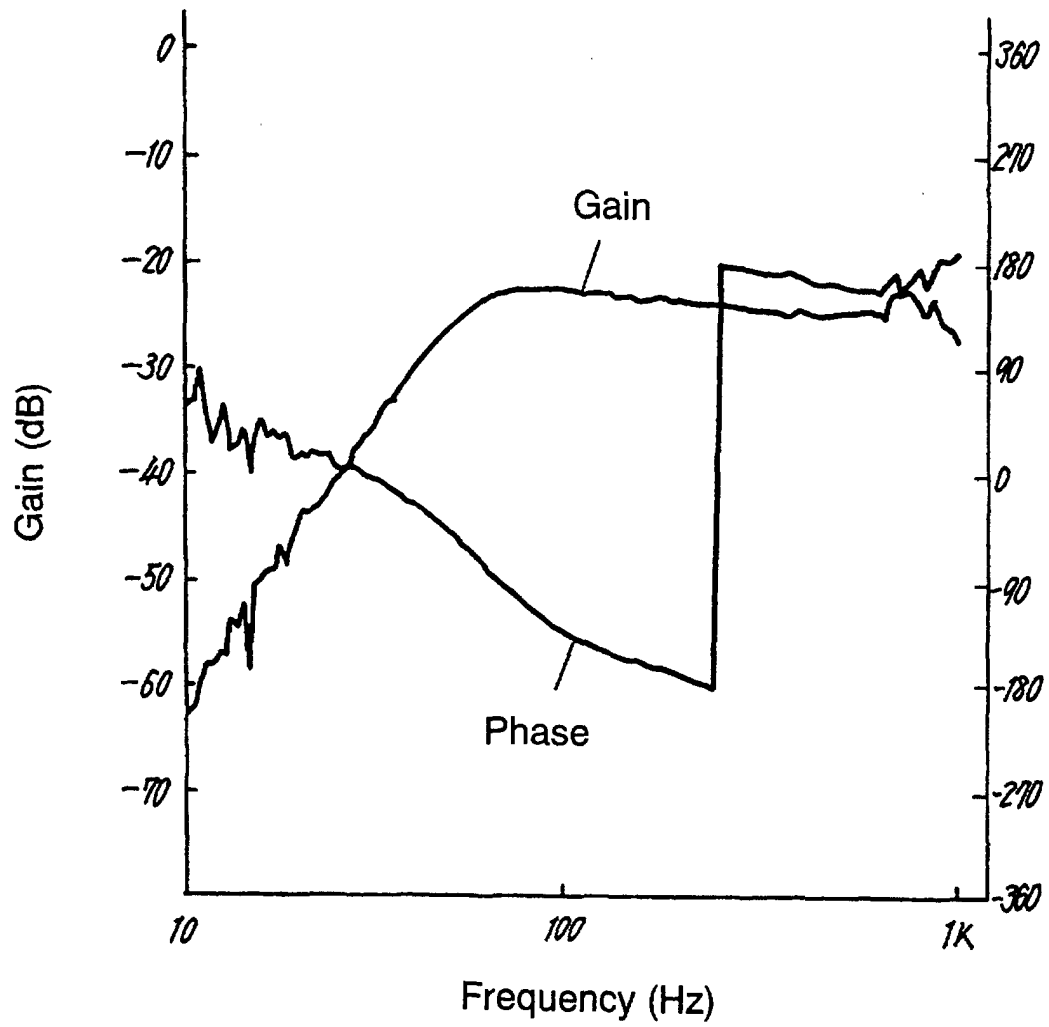


FIG. 5

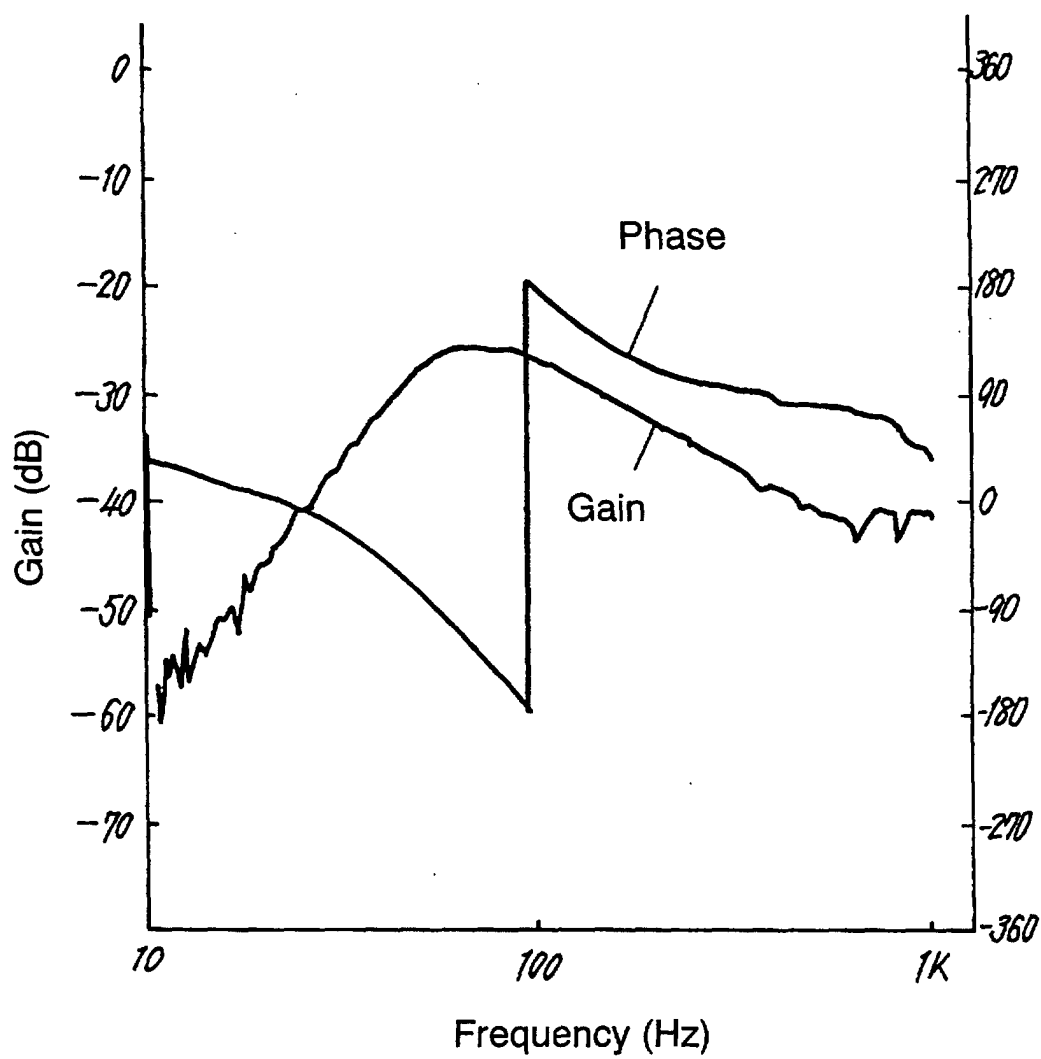
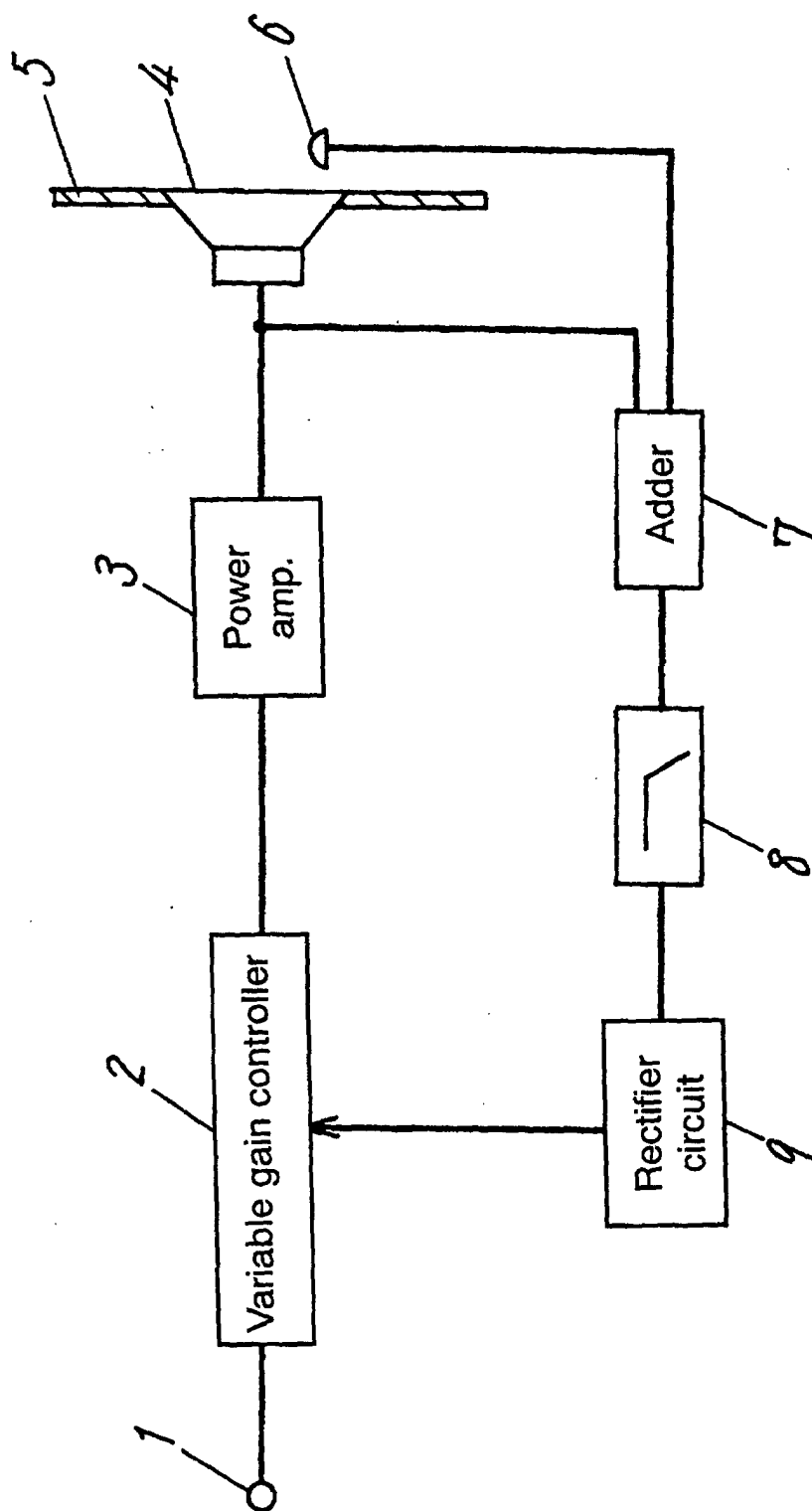


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP00/04652

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl.⁷ H04R3/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl.⁷ H04R3/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-1999

Kokai Jitsuyo Shinan Koho 1971-1999 Jitsuyo Shinan Toroku Koho 1996-1999

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 52-10001, B1 (TDK Corporation), 19 March, 1977 (19.03.77), Full text (Family: none)	1-10
A	JP, 58-63207, A (Matsushita Electric Ind. Co., Ltd.), 15 April, 1983 (15.04.83), Full text (Family: none)	1-10
A	JP, 10-56346, A (TOA Corp.), 24 February, 1998 (24.02.98), Full text (Family: none)	1-10

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
19 September, 2000 (19.09.00)Date of mailing of the international search report
03 October, 2000 (03.10.00)Name and mailing address of the ISA/
Japanese Patent Office

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