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(54) Microphone apparatus.

(57) A microphone apparatus using a non-directional microphone and a directional microphone equalizes the pressure and vibration responses of the directional microphone located near a sound source to respective counterparts of the non-directional microphone, and processes signals to cancel acoustic noise and vibration noise generated from the sound source near the microphones. This microphone apparatus, when built in an appliance having an acoustic noise and vibration source within it, reduces acoustic noise, vibration noise, and wind noise, to prevent reduction of the S/N ratio at the time of sound pick up, enabling best-quality sound recording.

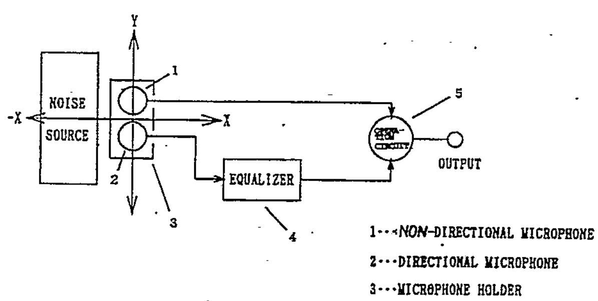

Fig. 1

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MICROPHONE APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a microphone apparatus to be built in an appliance having an acoustic noise and/or vibration source within it.

2. Description of the Prior Art

Sound pick up using a microphone is accompanied by the deterioration of the quality of audio signals due to acoustic noise (undesired sounds), vibration noise caused by the mechanical vibration given to the microphone, and wind noise by wind. In such an appliance as video camera and radio-integrated cassette tape-recorder in particular, built-in mechanical systems generate acoustic noise and vibration. When the appliance contains any directional or non-directional microphones, the S/N ratio(signal-to-noise ratio) at the time of sound pick up is reduced due to the following factors:

- Location of the microphone close to the acoustic noise or vibration source increases the absolute level of acoustic noise or vibration applied to the microphone.
- Location of the microphone close to the acoustic noise source enhances the pressure sensitivity of the directional microphone in its front and rear due to the proximity effect, allowing the microphone to receive more influence of the acoustic noise generated by the mechanical system.
- A directional microphone receives more influence of vibration than a non-directional microphone.
- A directional microphone receives more influence of wind than a non-directional microphone.
- A non-directional microphone cannot remove acoustic noise by directivity.

A microphone system which reduces vibration noise has already been disclosed in the Japanese Patent Publication No. 54-8295 (1 979). This microphone system is so constructed that two microphone units made by attaching a diaphragm to an electroconductive frame under tense conditions are fitted to two windows located opposite in a case and these diaphragms are connected in series.

The two diaphragms of the microphone system constructed in this way vibrate in phase with sound pressure and out of phase with mechanical vibration. This microphone system, therefore, reduces vibration noise by offsetting mechanical vibration as well as has a pressure sensitivity twice as high as a single microphone unit.

The conventional microphone system mentioned above is, however, unable to reduce the influence of the acoustic noise generated by a mechanical system in an appliance with a built-in microphone.

SUMMARY OF THE INVENTION

An object of this invention is to provide a microphone apparatus which can reduce wind noise as well as acoustic noise and vibration noise generated by a mechanical system in an appliance with a built-in microphone, thereby preventing a reduction in the S/N ratio at the time of sound pick up.

In order to achieve the above object, a microphone apparatus of this invention comprises a non-directional microphone located near a noise source, a directional microphone located adjacent to the non-directional microphone with their main axes parallel with each other, a microphone holder for fixing thereto the non-directional microphone and the directional microphone to transmit an equal amount of vibration to the two microphones, an equalizer for filtering an output signal of the directional microphone to equalize a pressure response of the directional microphone in a certain direction of the noise source located close to the directional microphone to a pressure response of the non-directional microphone, and an operation unit for mixing an output signal of the non-directional microphone and an output signal of the equalizer so that acoustic noise and vibration noise are canceled.

Due to the above construction, the microphone apparatus of this invention can reduce acoustic noise and vibration noise generated by a mechanical system in an appliance with a built-in microphone, thereby preventing reduction of the S/N ratio at the time of sound pick up.

Preferably, for more effective reduction of vibration noise, the surface density of a diaphragm can be established so as to equalize the pressure response of the directional microphone, located near the sound source, in a certain direction of the noise source to the vibration response.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 shows a block diagram of a microphone apparatus of this invention in an embodiment.

Fig. 2a shows a pressure response of a non-directional microphone in Fig. 1, placed 1 meter apart from the sound source.

Fig. 2b show a pressure response of a non-directional microphone in Fig. 1, placed 2 centimeters apart from the sound source.

Fig. 3a shows a pressure response of an output of an equalizer in Fig. 1 when the microphone is placed 1 meter apart from the sound source.

Fig. 3b shows a pressure response of an output of an equalizer in Fig. 1 when the microphone is placed 2 centimeters apart from the sound source.

Fig. 4 shows a vibration response of a non-directional microphone in Fig. 1.

Fig. 5 shows a vibration response of an output of an equalizer in Fig. 1.

Fig. 6a shows a pressure response of the Fig. 1 microphone apparatus placed 1 meter apart from the sound source.

Fig. 6b shows a pressure response of the Fig. 1 microphone apparatus placed 2 centimeters apart from the sound source.

Fig. 7 shows a vibration response of the Fig. 1 microphone apparatus.

Fig. 8 shows a frequency response of an equalizer in Fig. 1 when a uni-directional microphone is used as the directional microphone.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of this invention are explained below with reference to drawings.

Fig. 1 shows a schematic block diagram of a microphone apparatus in an embodiment of this invention. In the following explanation, both the acoustic noise source and the vibration source mean the mechanical systems housed in an appliance with a built-in microphone. Meanwhile, the X direction shown in Fig. 1 is referred to as the front direction, the -X direction as the rear direction, and the Y direction as the side direction. In Fig. 1, 1 is a non-directional microphone so arranged that it is located near the noise source and the noise source is positioned in the direction of the microphone's main axis, 2 is a directional microphone arranged to be located adjacent to and parallel with the non-directional microphone 1 (here, a bi-directional microphone is used as the directional microphone 2), 3 is a microphone holder to fix the non-directional microphone 1 and the directional microphone 2 so that an equal amount of vibration may be transmitted from the vibration source to the two microphone, 4 is an equalizer which, by filtering an output signal of the directional microphone 2, equalizes the pressure response of the directional microphone 2, if located near the sound source, in the rear direction to the pressure response of the non-directional microphone 1 (specifically, the equalizer 4 may be an amplifier to adjust the gain when a bi-directional microphone is used as the directional microphone 2 or an equalizer having a frequency response as shown in Fig. 8 when a uni-directional microphone is used), and 5 is an operation circuit which mixes an output signal of the non-directional microphone 1 and an output signal of the equalizer 4 so that acoustic noise and vibration noise are canceled (specifically, the operation circuit 5 may be a subtractor when the output signals of the non-directional microphone 1 and the equalizer 4 in response to the sound pressure in the rear direction are in phase with each other or an adder when they have opposite phases to each other). The surface density of the diaphragm of the directional microphone is so established that the pressure response of the microphone, if located near the sound source, in the rear direction is equalized to the vibration response of the microphone as the vibration sensitivity of a microphone is proportional to the surface density of a diaphragm.

The operation of the microphone apparatus constructed in the above manner is explained below.

Fig. 2a and Fig. 2b show pressure responses of the non-directional microphone 1 in the Fig. 1 microphone apparatus placed 1 meter and 2 centimeters apart from the sound source respectively. As clear from these figures, the pressure sensitivity of the non-directional microphone 1 shows a flat response independent of the distance from the sound source.

Fig. 3a and Fig. 3b show pressure responses of the output signal of the equalizer 4 in the Fig. 1 microphone apparatus placed 1 meter and 2 centimeters apart from the sound source respectively. In Fig. 3a and Fig. 3b, phases of the output signals in response to the sound pressures in the front and rear directions are reverse to each other. The pressure sensitivities in the front and rear directions of the directional microphone 2 decrease with decreasing frequencies when the sound source is distant from the microphone. apparatus but increase in the low-frequency region when the sound source is located near the apparatus (proximity effect). Accordingly, the output signal of the directional microphone 2 is filtered by the equalizer 4 so that the pressure sensitivity in the rear direction of the directional microphone 2 in the microphone apparatus located near the sound source may be equalized to that of the non-directional microphone 1. As a result, as seen in Fig. 3b, the output signal of the equalizer 4 in response to the sound pressure in the rear direction of the directional microphone 2 shows an almost equal level to the output signal of the non-directional microphone 1. In contrast, when the sound source is distant from the microphone apparatus, the output signal of the equalizer 4 shows a lower level than that of the output signal of the non-directional microphone 1.

The operation circuit 5 in Fig. 1 cancels the output signal of the equalizer 4 with that of the non-directional microphone 1 in the microphone apparatus located near the sound source in response to the sound pressure in the rear direction. More specifically, as the operation circuit 5, a subtractor is used when the phases of the output signals of the non-directional microphone 1 and the equalizer 4 in response to the sound pressure in the rear direction are in phase each other, and an adder is used when they are reverse to each other. Fig. 6a and Fig. 6b show pressure responses of the Fig. 1 microphone apparatus placed 1 meter and 2 centimeters apart from the sound source respectively. The directivity of the Fig. 1 microphone apparatus takes a uni-directional characteristic in the higher frequency region than about 1 KHz and a non-directional characteristic in the lower frequency region than about 1 KHz when the sound source is distant from the microphone apparatus. The non-directional characteristic taken in the low-frequency region leads to the reduction in wind noise. Contrary to this, the directional characteristic becomes uni-directional over a wide frequency range when the sound source is located near the microphone apparatus. Consequently, by arranging the microphone apparatus so that it is located near the acoustic noise source positioned in the rear direction, the acoustic noise generated from the acoustic noise source can be canceled to prevent the reduction of the S/N ratio at the time of sound pick up.

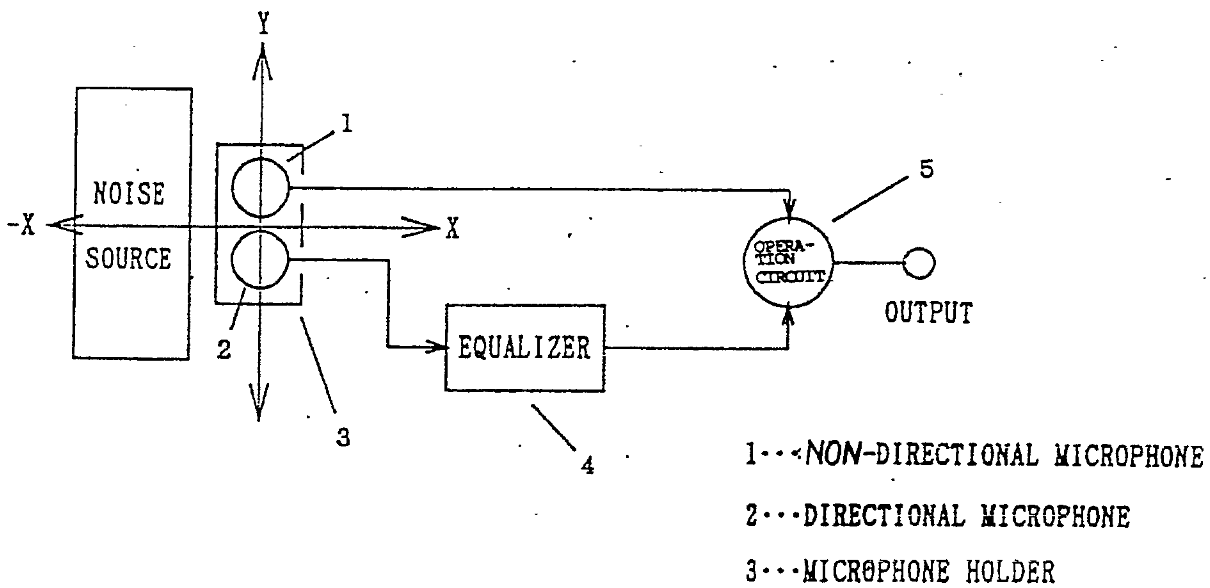
Fig. 4 shows a vibration response of the non-directional microphone 1 in the Fig. 1 microphone apparatus. Fig. 5 shows a vibration response of the output signal of the equalizer 4 in the Fig. 1 microphone apparatus, and Fig. 7 illustrates a vibration response of the Fig. 1 microphone apparatus. As seen in these figures, the output signal of the equalizer 4 in response to vibration takes the same frequency characteristic as that of the non-directional microphone 1. Therefore, as in the case of the sound pressure in the rear direction of the microphone apparatus located near the sound source, the vibration noise can be canceled, thereby preventing the reduction in the S/N ratio at the time of sound pick up.

Meanwhile, when a uni-directional microphone is used as the directional microphone 2 in the Fig. 1 microphone apparatus, the effect similar to the above can be obtained by giving the frequency response as shown in Fig. 8 to the equalizer 4.

Claims

1. A microphone apparatus comprising:
a non-directional microphone located near a noise source; a directional microphone located adjacent to said non-directional microphone so that its main axis is parallel with that of said non-directional microphone;
a microphone holder for fixing said non-directional and directional microphones so that an equal vibration is transmitted to said two microphones;
an equalizer for filtering an output signal of said directional microphone to equalize a pressure response of said directional microphone, if located near a sound source, in a certain direction of the noise source to a pressure response of said non-directional microphone; and an operation unit for processing an output signal of said non-directional microphone and an output signal of said equalizer so as to reduce acoustic noise and vibration noise.

2. A microphone apparatus according to Claim 1, wherein a surface density of a diaphragm of said directional microphone is so established that the pressure response in a rear direction of said microphone when located near the sound source takes substantially the same as a vibration response of said microphone.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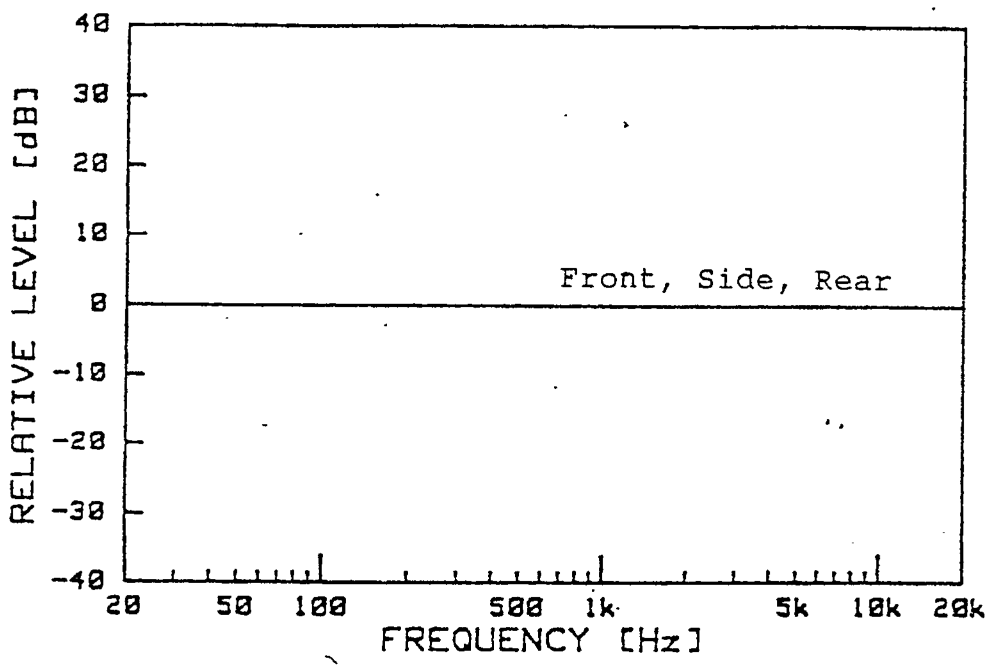
2···DIRECTIONAL MICROPHONE
3···MICROPHONE HOLDER

Fig. 1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FREQUENCY [Hz]

Fig. 2a

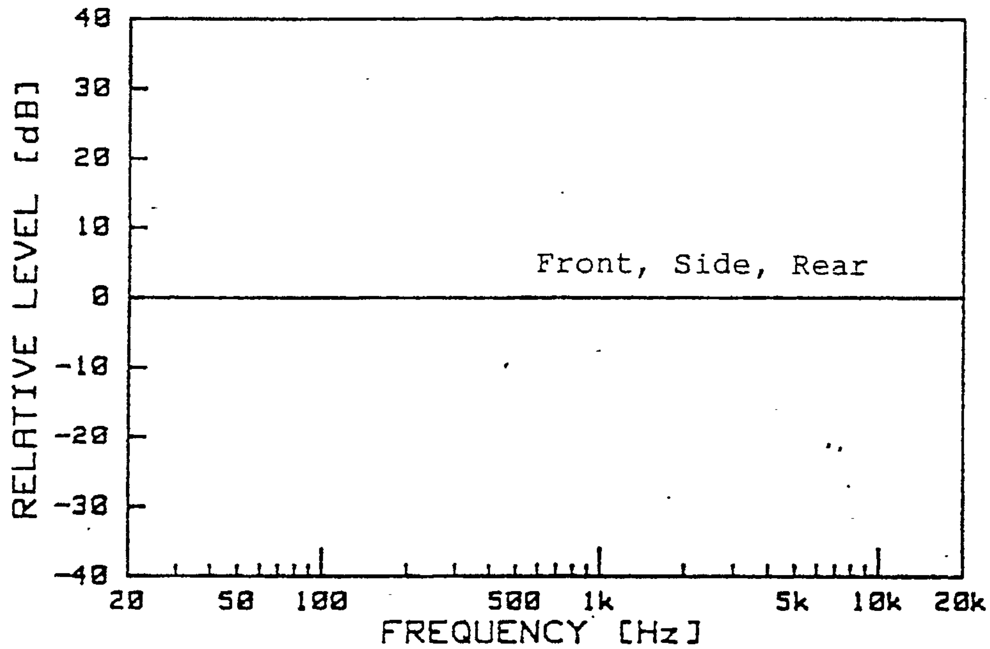
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Fig. 2b

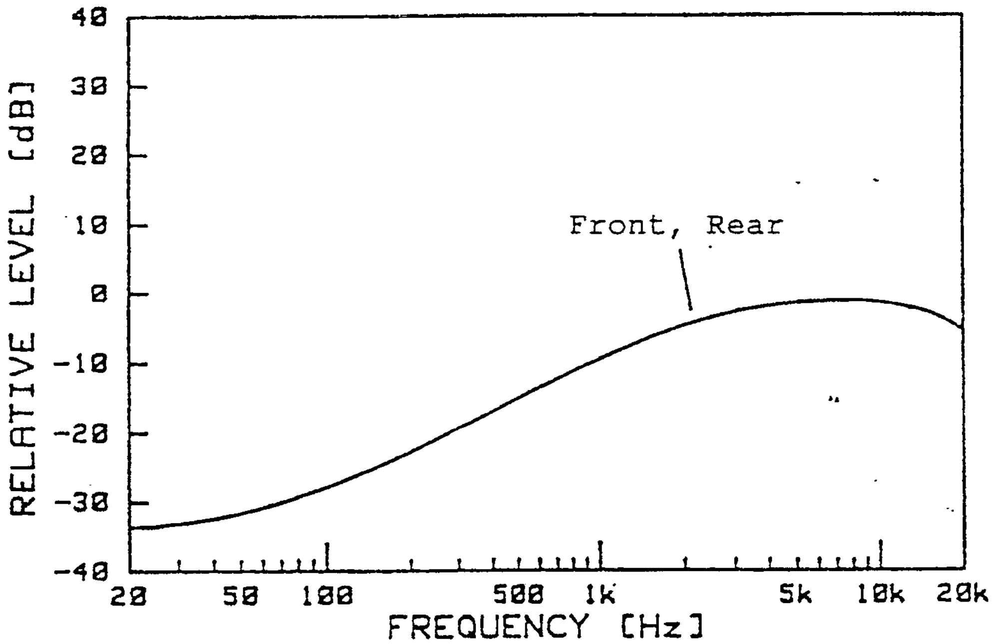
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Fig. 3a

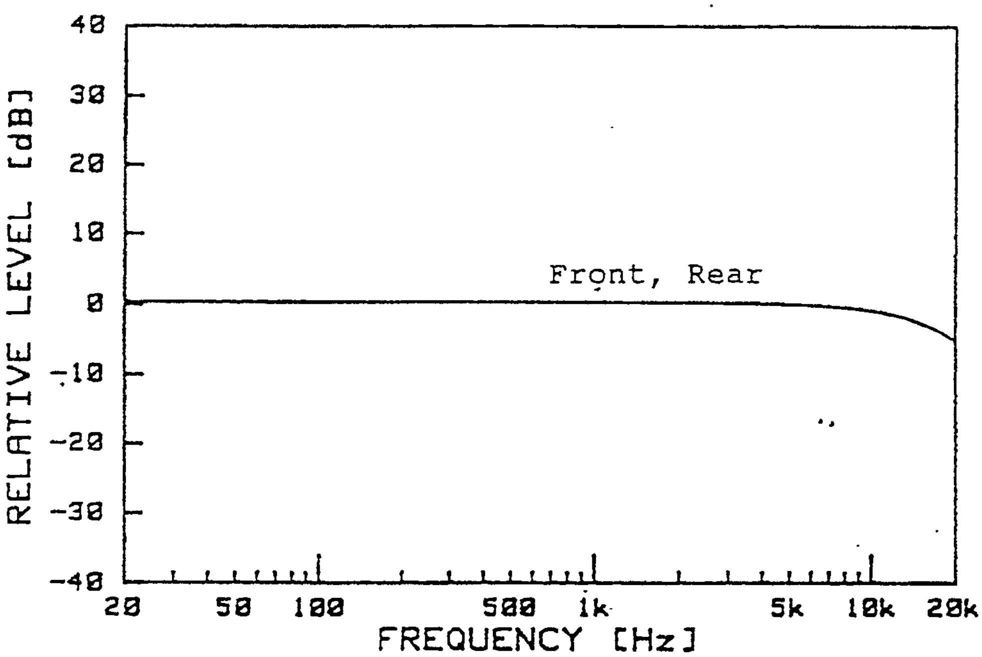
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Fig. 3b

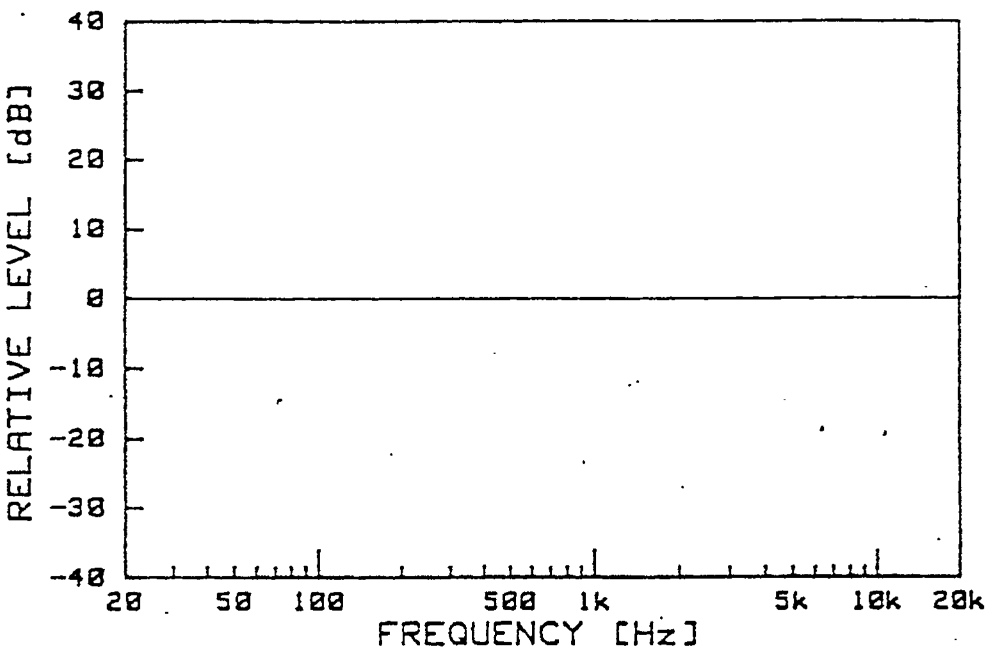
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Fig. 4

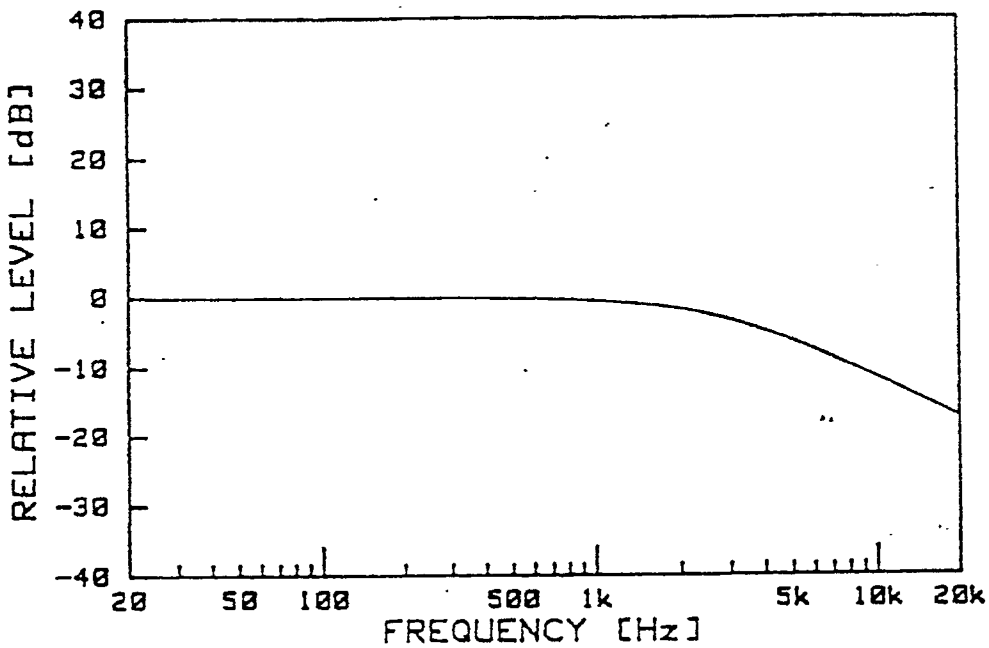
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Fig. 5

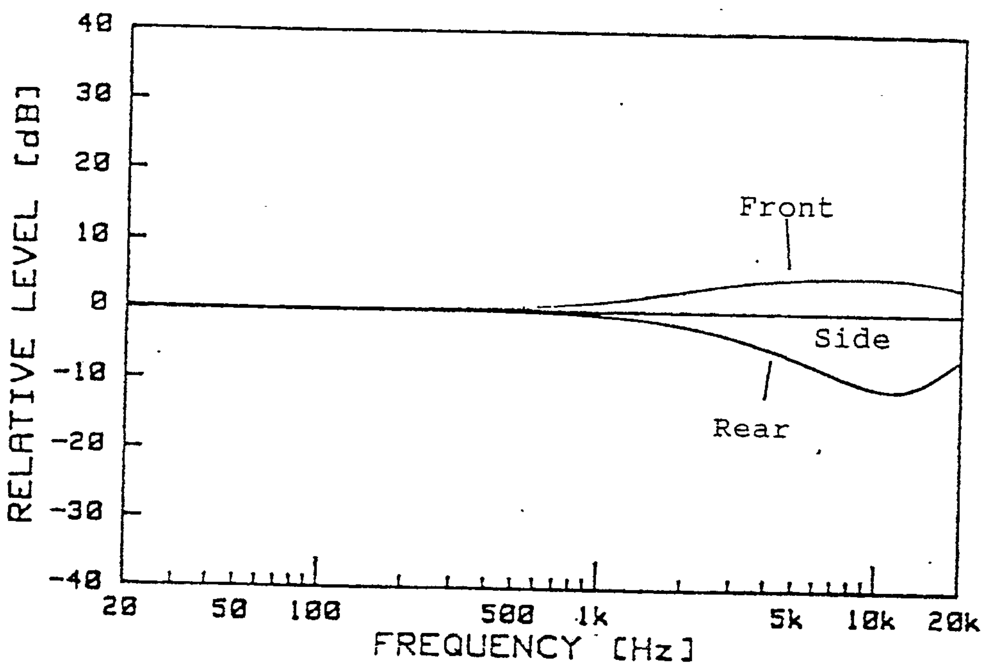
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Fig. 6a

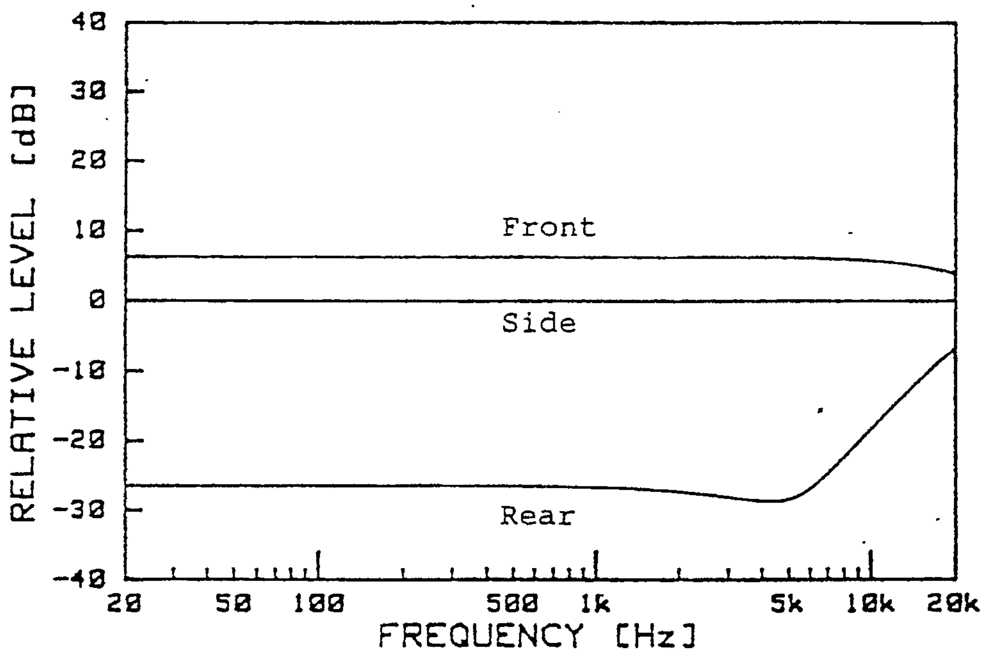
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Fig. 6b

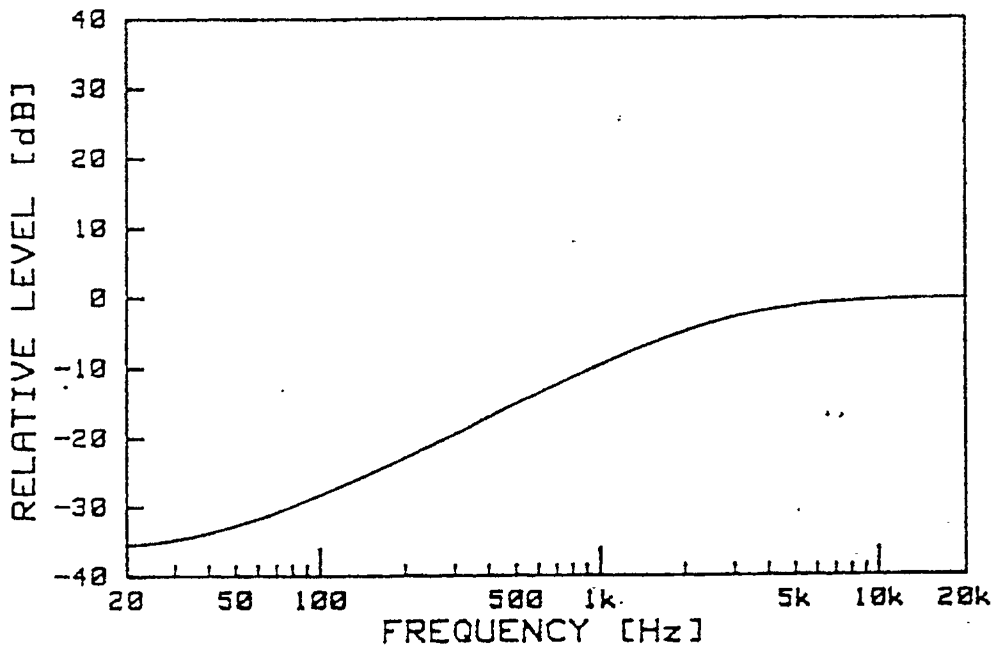

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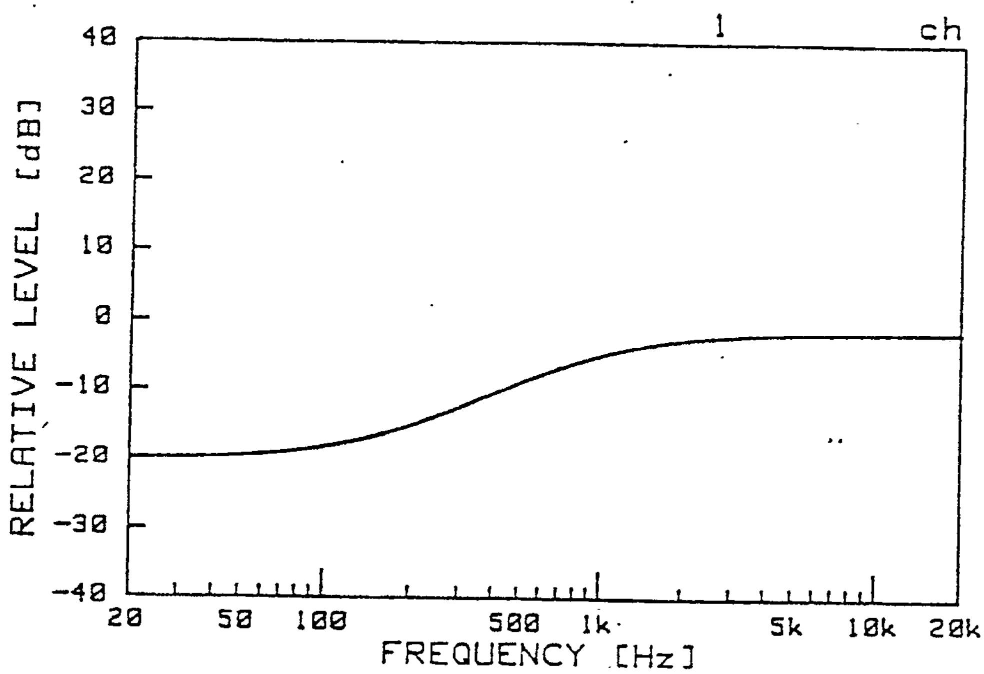
Fig. 7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FREQUENCY [Hz]

Fig. 8