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## (54) Stereo/telephone change-over transmitter/receiver

(57) When a stereo receiver connected to a personal computer and a telephone contained in the personal computer are to be used, separate voice terminal devices must be used, which is inconvenient. A stereo/telephone change-over transmitter/receiver comprises first and second receivers 1a and 2 that can be connected to a stereo unit 4a, a transmitter 1b mounted close to said first receiver 1a, a transmitter/receiver circuit 4b which is a telephone to which said transmitter and the second receiver can be connected, and a switching means 4c which, when listening to the stereo, connects said stereo unit and said first and second receivers together and, when talking over the telephone, connects said transmitter and said second receiver together.

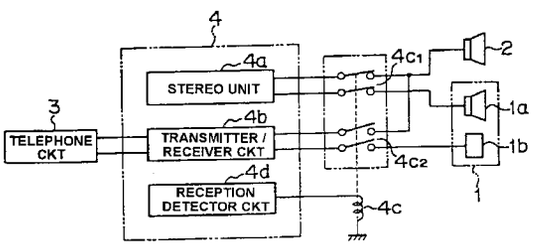



*Fig. 1*

EP 0 869 696 A1

## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

The present invention relates to a stereo/telephone change-over transmitter/receiver with which the stereo sound can be heard through receivers such as right and left headphones or earphones when listening to a stereo program, and with which the voice can be picked up by a transmitter which is a microphone when talking over a telephone, the voice from the receiver closer to the transmitter being suppressed but the voice from the other receiver only being picked up, so that clear communication can be realized over the telephone.

#### Prior Art

Personal computers have, in recent years, been placed in the market in very large quantities as represented by the words "one unit in every family". Accompanying this trend, computers have been developed having multiple functions, enabling compact disks and TV channels to be watched, permitting the telephone circuits to he connected so that communications by personal computer and communications by facsimile can be accomplished, and offering a function of the telephone.

When a person receives a telephone call while he is listening to the sound of a compact disk or a TV using a computer through a stereo receiver such as earphones or headphones, the person removes the stereo receiver from the ears, holds the handset of the telephone by hand, and puts it to his ear to talk. That is, the person must remove the stereo receiver, hold the handset of the telephone located at another place, and must talk over the telephone.

To solve this problem, contrivance has been made so that a person can listen to the stereo using two receives by utilizing a hands-free-type transmitter/receiver (receiver and transmitter are fabricated as a single unit) designed for the portable telephones that are placed in the market. According to this contrivance, the person listens to the stereo using two receivers. When talking over the telephone, the person is allowed to talk using a hands-free-type transmitter/receiver. Namely, the person can talk hands-free without the need of removing the stereo receiver while he is at work.

When talking using the transmitter/receiver of the above-mentioned hands-free type, however, the voice of talk leaks from the receiver and enters into the transmitter giving rise to the occurrence of howling, which makes it difficult to communicate messages with another person.

Besides, since the transmitter/receiver is worn near the ears, the volume of voice is less picked up in front of the mouth, and amplification of the voice using an amplifier to compensate for the volume of voice is liable to pick up ambient noise and ambient reverberation. It therefore becomes necessary to use a transmitter which is short and has sharp directivity, as well as an ambient noise suppressing circuit.

### SUMMARY OF THE INVENTION

The present invention is to solve the above-mentioned problem and its object is to provide a stereo/telephone change-over transmitter/receiver with which a person is allowed to listen to the stereo using two receivers upon switching over the switching means and, when using the telephone, is allowed to hear the talk using a receiver which has not been fabricated integrally with the transmitter. Accordingly, a sufficient distance is maintained between the transmitter and the receiver, and highly clear communication can be realized without quite accompanied by howling.

The stereo/telephone change-over transmitter/receiver of the present invention was proposed to accomplish the above-mentioned object, and comprises first and second receivers that can be connected to a stereo unit, a transmitter mounted close to said first receiver, a transmitter/receiver circuit which is a telephone to which said transmitter and the second receiver can be connected, and a switching means which, when listening to the stereo, connects said stereo unit and said first and second receivers together and, when talking over the telephone, connects said transmitter and said second receiver together.

It is desired that said switching means is constituted by a reception detector circuit which effects the change over when a ringing is received from said transmitter/receiver circuit. It is further desired that said transmitter has a bidirectional microphone that is formed integrally with said receiver and is held nearly at the central portion of a cavity, and is stuffed with a sound-absorbing material at both ends thereof, or has two unidirectional microphones held at both ends of said cavity.

According to the present invention, furthermore, an ambient noise suppressing circuit is connected to said transmitter, said ambient noise suppressing circuit comprising a gain controller which inputs AC output, a band-pass amplifier which permits the passage of a particular frequency band only in the AC output from said transmitter, and a peak-holding circuit which includes a peak detector for taking out the output corresponding to a peak value in the AC output that has passed through said band-pass amplifier and a holding circuit for holding the output level of said peak detector from being attenuated for a predetermined period of holding time, and the gain of said gain controller is controlled depending upon the output signal level of said peak-holding circuit.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating an embodiment of the present invention;

Fig. 2 is a sectional view of an earphone with transmitter used in the embodiment of the present invention;

Fig. 3 is a diagram illustrating the whole constitution of an earphone-type receiver;

Fig. 4 is a diagram illustrating the whole constitution of a headphone-type receiver;

Fig. 5 is a block diagram of a transmitter/receiver circuit;

Fig. 6 is a diagram of frequency characteristics of a band-pass amplifier;

Fig. 7 is a diagram of frequency characteristics showing formants of Japanese vowels (utterance of voice);

Fig. 8 is a diagram illustrating a gain controller by using an analog multiplier; and

Fig. 9 is a diagram of gain characteristics of a gain controller relative to the amplitude of the output of the transmitter.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will now be described in connection with a personal computer 4 shown in Fig. 1 which is connected to a telephone circuit 3 as well as to a transmitter/receiver 1 and to a second receiver 2 that will be described later.

The personal computer 4 includes the above-mentioned stereo unit 4a, a transmitter/receiver circuit 4b for connecting the telephone circuit 3 to the personal computer 4, and a reception detector circuit 4d which detects a ringing from the telephone circuit 3 and controls a relay 4c that has normally-closed contacts 4c1 of two circuits and normally-open contacts 4c2 of two circuits.

To the personal computer 4 are connected a second receiver 2 comprising an earphone only, and a hands-free-type transmitter/receiver 1 in which are fabricated, as a unitary structure, a first receiver 1a which is a speaker for listening to the reproduced stereo sound or talking over the telephone and a transmitter 1b which is a microphone.

The hands-free-type transmitter/receiver 1 will now be described in conjunction with Fig. 2, wherein reference numeral 11 denotes a case made of a synthetic resin having nearly an L-shape. A swollen member 11a of a size that fits to the inlet of the external auditory miatus is detachably attached to the case 11 on the side of the receiver, which is the short-piece side of the L-shape. In the swollen member 11a are formed a hollow chamber 11b and a sound-emitting portion 11c. It is desired that the case 11 is formed of a plastic material such as ABS resin as a unitary structure.

The case 11 further has a vertically elongated cavity lid with its both ends open being formed on the side of the transmitter, which is the long-piece side of the case 11, and a transmitter 1b is contained nearly at the central portion of the cavity 11d, the transmitter 1b being a microphone of the type of electret having bidirectivity or being two unidirectional microphones with their backs fitted to each other. A mesh 12 is attached to the upper and lower openings of the cavity 11d, and the cavity is stuffed with a sound-absorbing material 13 between the transmitter 1b and the mesh 12.

A first receiver 1a which is an electromagnetic type speaker is contained in the cavity 11b of the swollen member 11a, and the sound from the first receiver 1a is emitted through a sound hole only formed in the sound-emitting portion 11c.

Reference numeral 14 denotes connection cords from the transmitter 1b and the receiver 1a, and are bundled into one and are guided to an external unit running on the outer side of the cavity 11d. The connection cord from the second receiver 2 is bundled into one on the way of the connection code 14.

A small and highly sensitive electret microphone is best suited as the transmitter 1b. Since the connection cords 14 generate contact noise, it is desired to use the microphone of the back-electret type since it picks up little vibration that is directly conducted.

Described below is the operation of the above-mentioned transmitter/receiver 1.

First, the swollen member 11a of the case 11 is inserted in a concha and is fitted thereto. In this state, the sound-emitting portion 11c has been so shaped as will not completely close the external auditory miatus. Therefore, a person wearing the voice terminal device does not feel that his ear is closed but is permitted to hear external sound, and there is no problem from the standpoint of safety. Besides, little voice leaks from the sound-emitting portion 11c.

When voice signals are input as electric signals to the receiver 1a from the connection cords 14 in the above-mentioned state, a voice is emitted from the receiver 1a. The voice emitted from the receiver 1a is further emitted into the external auditory miatus through the sound hole in the sound-emitting portion 11c.

On the other hand, the voice of a person wearing the device is transmitted to the transmitter 1b through the meshes 12 at the openings and through the sound-absorbing material 13, and is converted through the transmitter 1b into electric signals which are then output through the connection cords 14.

Here, however, the cavity 11d is so close to the mouth of the person wearing the device, a delay develops between the voice level input through one end of the cavity 11d and the voice level input through the other end by the length of the cavity 11d. Accordingly, the voice level of the person wearing the device output from the transmitter 1b is not so much decreased.

On the other hand, external noise from sources more distant than the mouth reach the meshes 12 at

both ends on nearly the same level and in phase. Therefore, the noise is cut by the subtraction function of the bidirectional transmitter.

When the noise sources are remote like those of ambient noise, therefore, the sound waves of noise are input to both surfaces of the transmitter 1b in phase and are canceled by each other. As for the voice of a person wearing the device, on the other hand, the lower side of the transmitter 1b is close to the mouth. Therefore, a louder voice is input from the lower side of the transmitter 1b than from the upper side of the transmitter 1b; i.e., the voice is picked up maintaining sufficient sensitivity even though it is subtracted to some extent.

A lead wire to the first receiver 1a and a lead wire from the transmitter 1b are guided to a lead wire-holding portion 11e running through a lead wire-insertion pipe (not shown) formed on the side surface of the case 11, and are guided to an external unit from the lead wire-holding portion 11e being bundled into one.

Fig. 3 illustrates an example where the transmitter/receiver 1 is worn in one ear, and a stereo receiver 2 of the earphone type is worn in the other ear, and Fig. 4 illustrates an example where the above-mentioned transmitter is fitted to one receiver 1a between the two receivers 1a and 2 of the headphone type. Reference numeral 6 denotes a jack to be inserted in a plug such as of a personal computer or the like, and 5a denotes a box in which is incorporated an ambient noise suppressing circuit 5 that will be described later.

The whole operation will now be described with reference to Figs. 1 to 5.

When listening to a stereo program such as music using the stereo unit 4a, the normally closed contacts 4c1 are closed as shown in Fig. 1 and the normally open contacts 4c2 are opened. Therefore, the listener is allowed to listen to a stereo music using the receivers 1a and 2.

In this state, when a ringing is input to the transmitter/receiver circuit 4b from the telephone circuit 3, the reception detector circuit 4d detects the ringing and supplies a current to the relay coil 4c. Therefore, the normally closed contacts 4c1 are opened and the normally open contacts 4c2 are closed, and the voice of talk from the transmitter/receiver circuit 4b is sent to the receiver 2 through one of the normally open contacts 4c2. The voice from the transmitter 1b is sent to the transmitter/receiver circuit 4b through the other normally open contact 4c2, and the person is allowed to talk.

At this moment, the receiver 1a fabricated integrally with the transmitter 1b is cut off from the transmitter/receiver circuit 4b. Besides, a sufficiently large distance is maintained between the receiver 2 and the transmitter 1b. Therefore, the voice from the receiver 1a does not hinder the talk over the telephone, or no howling is caused to the transmitter 1b; i.e., clear communication is maintained. The listener who has noticed a call received by the transmitter/receiver circuit 4b may change over the switch by hand to talk, instead of relying upon the reception detector circuit 4d.

Since the transmitter 1b is more than 10 cm away from the mouth, the sound volume decreases by more than 10 dB, and the sound must be amplified to compensate for the drop of volume. Accordingly, if a nondirective microphone is used, the ambient sound is picked up by more than 10 dB compared with the system which picks up the sound in front of the mouth. An environment where a computer is used is full of noise such as background music and noise resulting from the operation of keyboard. Besides, reverberation in the room is emphasized. Accordingly, noise around the transmitter 1b must substantially be suppressed.

Besides, the transmitter connected to the transmitter/receiver circuit contained in the personal computer 4 converts the voice of a person who is talking and the ambient noise into electric signals which are then output. Moreover, the receiver adds part of the signals from the transmitter to the signals transmitted from another person, so that they are converted into voice. That is, the person who is talking feels easy when he confirms the voice uttered by him through the receiver. For this purpose, the transmission signals are partly added to the reception signals.

In talking in a noisy environment, therefore, it becomes very difficult to listen to another person's talk since the ambient noise from the transmitter of the person who is talking is added to the signals from another person. Moreover, noise during when the person is talking is transmitted to another person who then may feel very offensive to listen to. Besides, it becomes difficult for the person who is talking to recognize his own voice, and the talk may be hindered.

According to the present invention, therefore, the transmitter 1b is constituted by containing a bidirectional microphone in a pipe which is longer than 4 cm as shown in Fig. 2. Moreover, the ambient noise suppressing circuit 5 fabricated in the form of an IC as shown in Fig. 5 is connected to the transmitter 1b, and time zones in which the ambient noise only is transmitted are selectively taken out to control the gain for transmission, in order to greatly improve the practical SN ratio for transmitting the talk.

The following two items can be quoted as important assignments for accomplishing the improvement; i.e.,

(1) Voiced section and voiceless section are discriminated and detected easily and faithfully; and
(2) A ratio of transmission gain is large between the voiced section and the voiceless section (section of ambient noise only).

In order to satisfy the above-mentioned assignments, it is desired to employ a circuit of Fig. 5 as the transmitter/receiver circuit.

In Fig. 5, reference numeral 1b denotes the above-mentioned transmitter for outputting the voice of a per-

son who is talking as AC signals, 51 denotes a band-pass amplifier for passing the sound of 0.2 to 1 KHz or of 0.2 to 2 KHz, 52 denotes a peak-holding circuit comprising a peak detector 52a for detecting a peak value of the sound that has passed through the band-pass amplifier 51 and a holding circuit 52b for holding the peak value detected by the peak detector 52a, and reference numeral 53 denotes a gain controller for controlling the gain from the transmitter 1b relying upon the output from the peak-holding circuit 52.

In order to pick up characteristic frequency region of conversation, a band-pass amplifier 51 having characteristics as shown in Fig. 6 is used for discriminating and detecting voiced section and voiceless section, which is the above-mentioned important assignment (1). The band-pass amplifier 51 will have a pass band of 0.2 to 1 KHz or 0.2 to 2 KHz.

This is because, most of the human conversation comprises language voice, and most of the time and energy of language voice is occupied by vowels. As shown in Fig. 7, vowels (Japanese language) are synthetic sounds of specific frequency spectra called first, second and third formants. Among them, the first and second formants occupy most of the energy.

The first formant is distributed over about 0.2 to 1 KHz, and the second formant is distributed over about 0.75 to 2 KHz. Therefore, if the pass band of the band-pass amplifier 51 is set to be 0.2 to 2 KHz, the first and second formants of vowels can be selectively picked up. If the pass band is set to be 0.2 to 1 KHz, the first formant having the greatest energy can be selectively picked up.

The ambient noise contains much components of a low-frequency band (50 to 150 Hz) such as of sound of revolution of cars and electric cars as well as components of a high-frequency band (2 KHz or higher) such as frictional sound. Therefore, the pass band of the band-pass amplifier set to be 0.2 to 2 KHz or 0.2 to 1 KHz is very effective in discriminating and picking up voice uttered in the conversation.

Next, continuous and smooth control is realized by using a gain controller as means for varying the transmission gain for the voiced section and the voiceless section without creating the feeling of incompatibility, which is the above-mentioned important assignment (2), the controller being capable of controlling the gain depending upon the peak-holding value output by the band-pass amplifier 51.

As the gain controller 53, there can be suitably used an analog multiplier circuit which outputs the multiplied result of a gain control signal and an AC output from the transmitter 1b. For example, a circuit shown in Fig. 8 outputs,

$$V_0 = K(X_1 - K_2)(Y_1 - Y_2) = K \cdot V_1 \cdot Vc$$

where $V_1$ is an AC output of the transmitter, Vc is a gain control signal, $V_0$ is a control output, K is a proportional constant, and gain G is K • Vc.

Since Vc is a peak-holding value (= amplitude), the relationship between the amplitude and the output of the gain controller is a proportional relationship as shown in Fig. 9. It is also allowable to use an FET multiplier (utilizing a change in the channel resistance of FET) in place of the above-mentioned analog multiplier.

Next, the time for holding the voiced section may hold the vowels which occupy most of the language voice. By taking into consideration the fact that the lower limit of spectrum of the first formant of a vowel is about 200 Hz, the longest period Tm of the vowel is considered to be about 5 msec. Therefore, the peak-holding circuit 52 may set the holding time Th to hold a peak value of the 5-msec period waveform for a predetermined period of time.

As described above, when the gain control circuit 53 is controlled by the output of the peak-holding circuit 52 for which the holding time Th is set (see Fig. 9), the gain during the conversation varies in proportion to the loudness of voice of the person who is talking and, hence, the voice is not interrupted. Since the peak-holding circuit 52 rises very quickly, a high gain is obtained from the start of conversation, i.e., the sound can be produced in sufficient amounts.

The time Tf until the output of the peak-holding circuit 52 of this embodiment is attenuated by 99%, which can be regarded to be outside the holding range, can be expressed by Tf = 13Th. From this relation, the time Tf is shorter than one second, and this time of attenuation is short enough for the practical conversation. When the talk is finished, therefore, the peak-holding circuit 52 attenuates within a sufficiently short period of time following the peak value of the operation of the voiceless section making it possible to quickly suppress the ambient noise.

When the holding time in the peak-holding circuit 52 is defined to be the time in which the attenuation factor from the peak value is not larger than 30%, this holding time can be set to be 5 to 65 milliseconds when the peak detector 52a is of the type of unidirectional detection and is set to be 2.5 to 32.5 milliseconds when the peak detector 52a is of the type of bidirectional detection. This makes it possible to prevent the talk from unnaturally terminating, which stems from a too short holding time, and to prevent the output of talk from staying large for extended periods of time and hence to prevent a drop of the ambient noise suppressing effect, which stems from a too long holding time.

In other words, when the holding time is set to be 1 to 13 times as long as the time period of 5 milliseconds which corresponds to a minimum frequency (200 Hz) of the first formant of a vowel which is the greatest element of talk energy, the gain after the end of talk can be quickly decreased yet without impairing the transmission of smooth talk, which is practically the best control operation. When the peak detector is of the bidirectional detection type, the peak is detected within one-half

period compared to that of the unidirectional detection type. Therefore, the optimum holding time will be from 1 to 13 times as long as 2.5 milliseconds.

According to the present invention, as described above, listening to a stereo program and talking over the telephone can be instantaneously changed over using a switching means. In a multi-media terminal equipment such as personal computer having a telephone function and a CD player, therefore, there is no need to change over the hands-free transmitter/receiver and the stereo receiver every time when the function is changed over such as talking over the telephone and using the multi-functional voice terminal like listening to a stereo program.

Besides, when talking over the telephone, the receiver that is fabricated integrally with the transmitter is disconnected, and the other receiver and the transmitter are used to communicate bidirectionally. Therefore, voice does not enter into the transmitter from th receiver, howling is avoided, and clear telephone conversation can be realized.

Moreover, the transmitter/receiver circuit of the telephone is equipped with the ambient noise suppressing circuit so that the user is allowed to talk easily, and ambient noise is suppressed for the telephone signals. Therefore, the user is allowed to communicate clearly even in a noisy environment, and clear communication over the telephone is realized.

## Claims

1. A stereo/telephone change-over transmitter/receiver comprising first and second receivers that can be connected to a stereo unit, a transmitter mounted close to said first receiver, a transmitter/receiver circuit which is a telephone to which said transmitter and the second receiver can be connected, and a switching means which, when listening to the stereo, connects said stereo unit and said first and second receivers together and, when talking over the telephone, connects said transmitter and said second receiver together.

2. A stereo/telephone change-over transmitter/receiver according to claim 1, wherein said switching means is constituted by a reception detector circuit which effects the change over when a ringing is received from said transmitter/receiver circuit.

3. A stereo/telephone change-over transmitter/receiver according to claim 1, wherein said transmitter has a bidirectional microphone that is formed integrally with said receiver and is held nearly at the central portion of a cavity, and is stuffed with a sound-absorbing material at both ends thereof, or has two unidirectional microphones held at both ends of said cavity.

4. A stereo/telephone change-over transmitter/receiver according to claim 1, wherein an ambient noise suppressing circuit is connected to said transmitter, said ambient noise suppressing circuit comprising a gain controller which inputs AC output, a band-pass amplifier which permits the passage of a particular frequency band only in the AC output from said transmitter, and a peak-holding circuit which includes a peak detector for taking out the output corresponding to a peak value in the AC output that has passed through said band-pass amplifier and a holding circuit for holding the output level of said peak detector from being attenuated for a predetermined period of holding time, and the gain of said gain controller is controlled depending upon the output signal level of said peak-holding circuit.

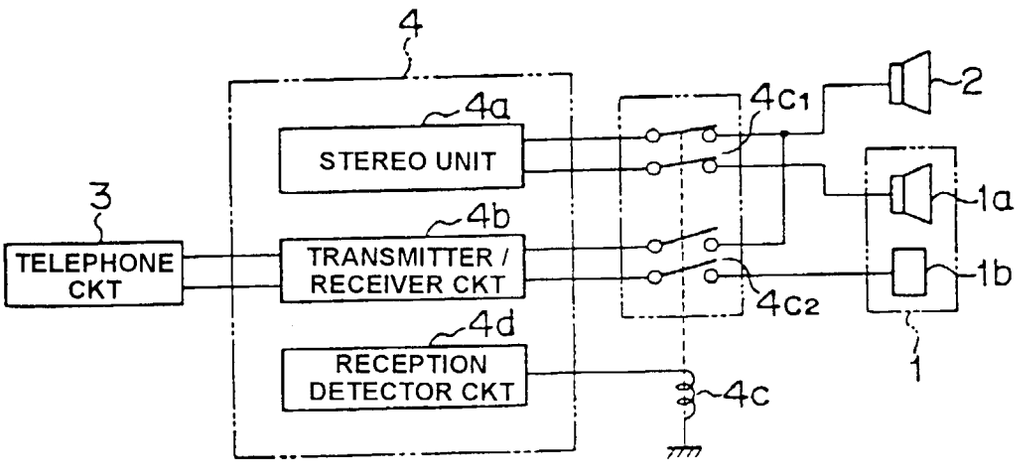

4
4a
STEREO UNIT
3
TELEPHONE CKT
4b
TRANSMITTER / RECEIVER CKT
4d
RECEPTION DETECTOR CKT
4c1
4c2
4c
2
1a
1b
1

*Fig. 1*

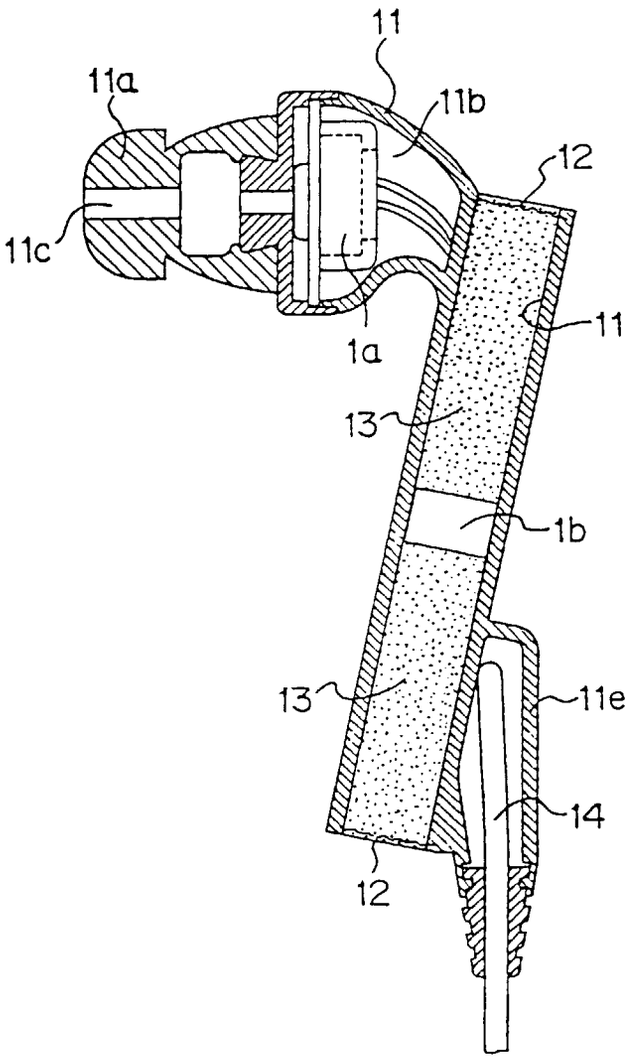



*Fig. 2*

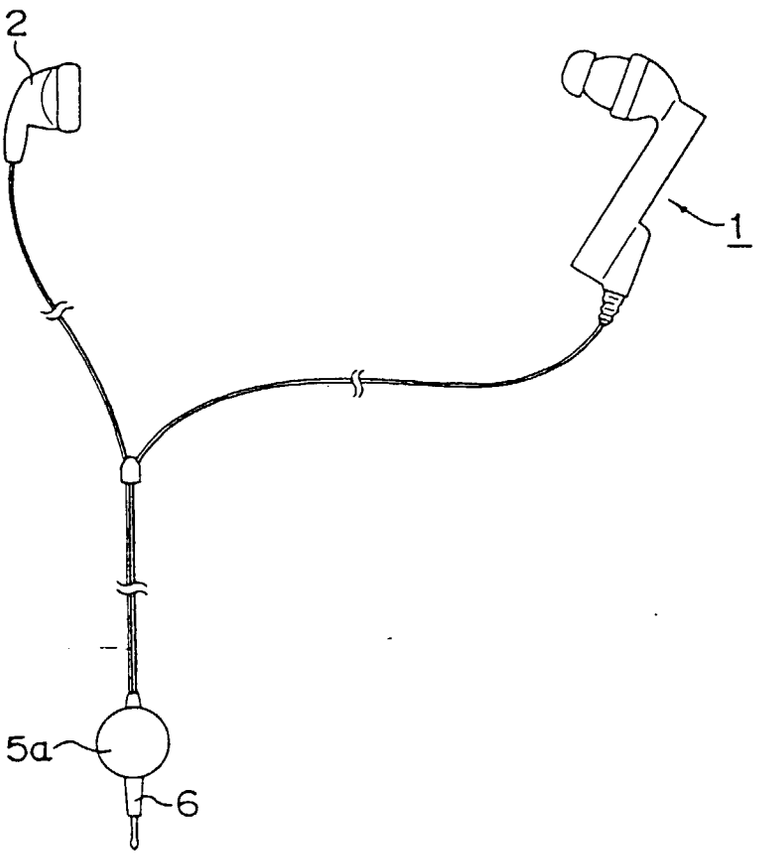



*Fig. 3*

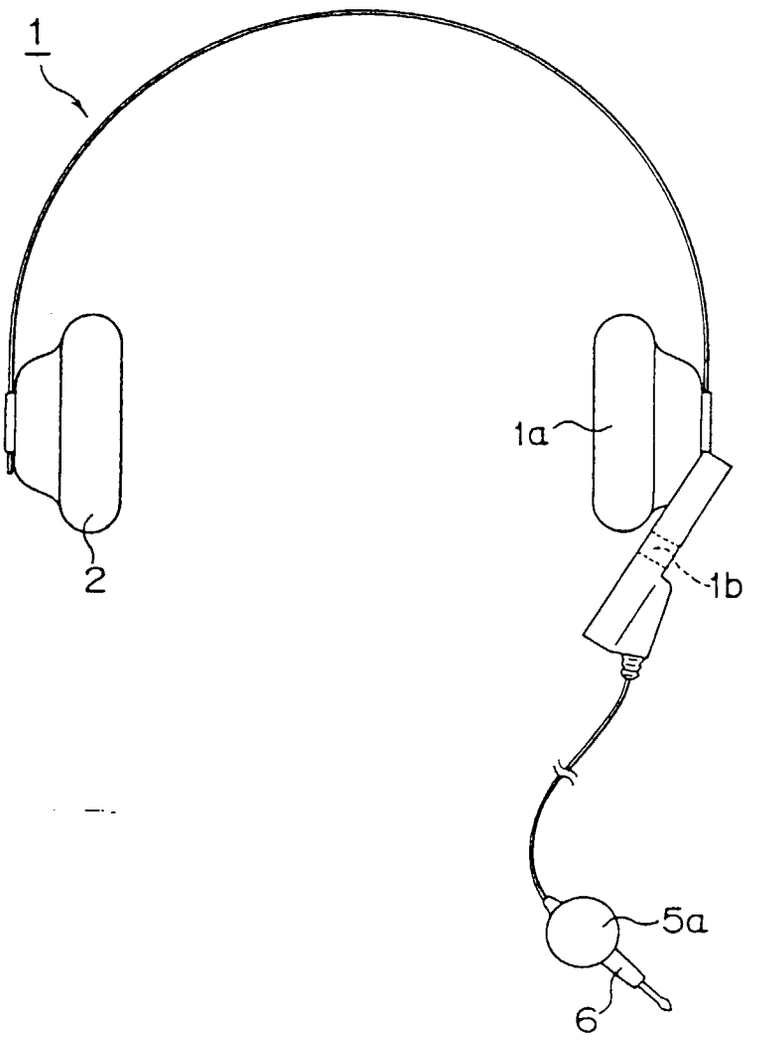



*Fig. 4*

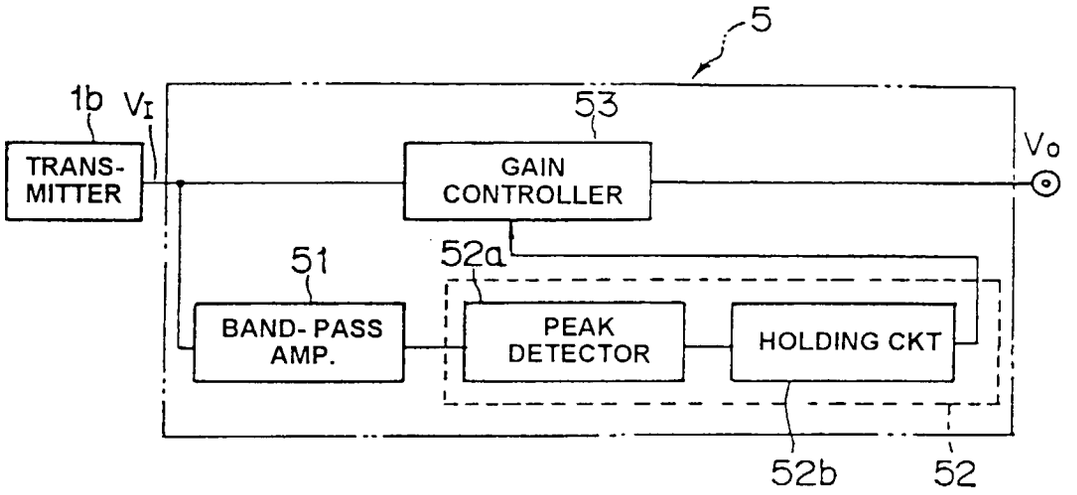

5
1b
$V_I$
53
TRANS-
MITTER
GAIN
CONTROLLER
$V_O$
51
52a
BAND-PASS
AMP.
PEAK
DETECTOR
HOLDING CKT
52b
52

*Fig. 5*

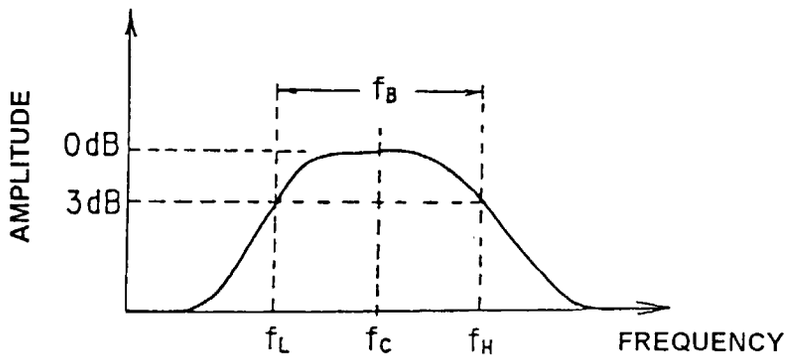

AMPLITUDE
0dB
3dB
$f_B$
$f_L$
$f_C$
$f_H$
FREQUENCY

*Fig. 6*

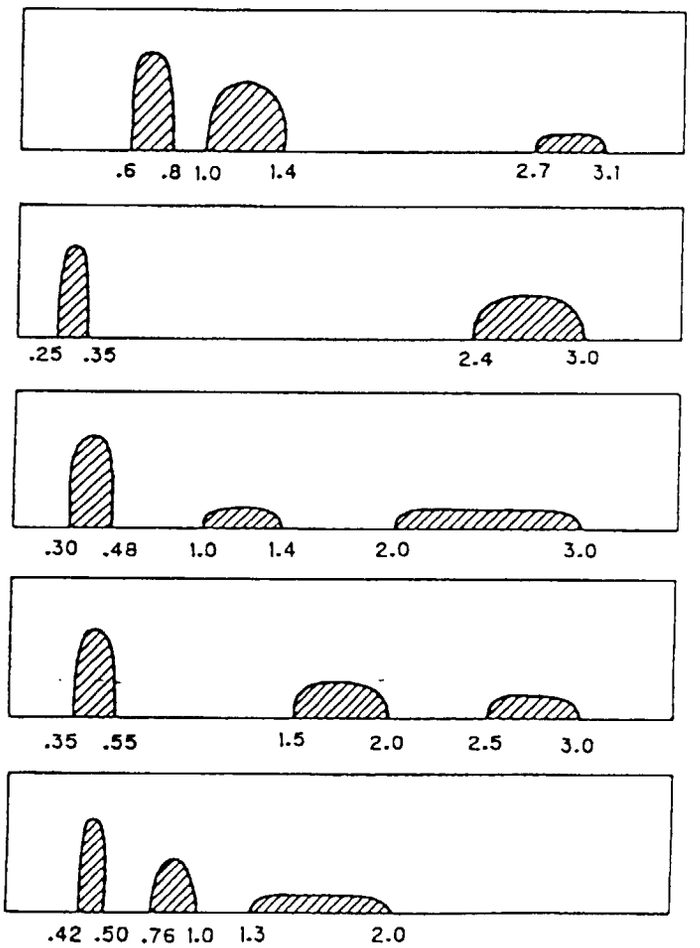
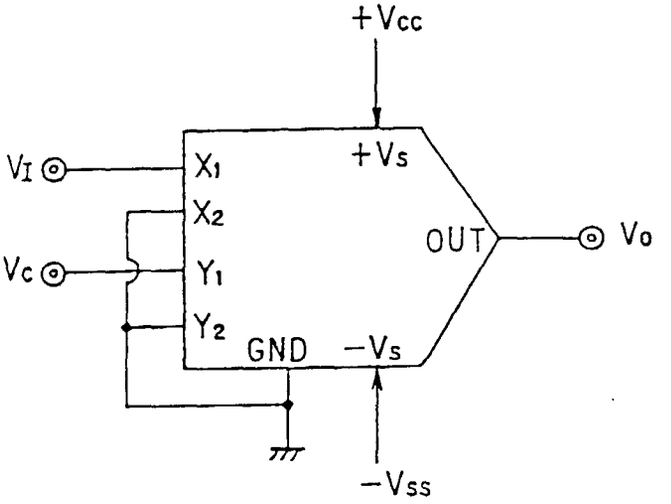

.6 .8 1.0 1.4 2.7 3.1
.25 .35 2.4 3.0
.30 .48 1.0 1.4 2.0 3.0
.35 .55 1.5 2.0 2.5 3.0
.42 .50 .76 1.0 1.3 2.0
FREQUENCY (KHz)

*Fig. 7*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VI
X1
+Vs
X2
OUT
Vo
Vc
Y1
Y2
GND
−Vs
−Vss

Fig. 8

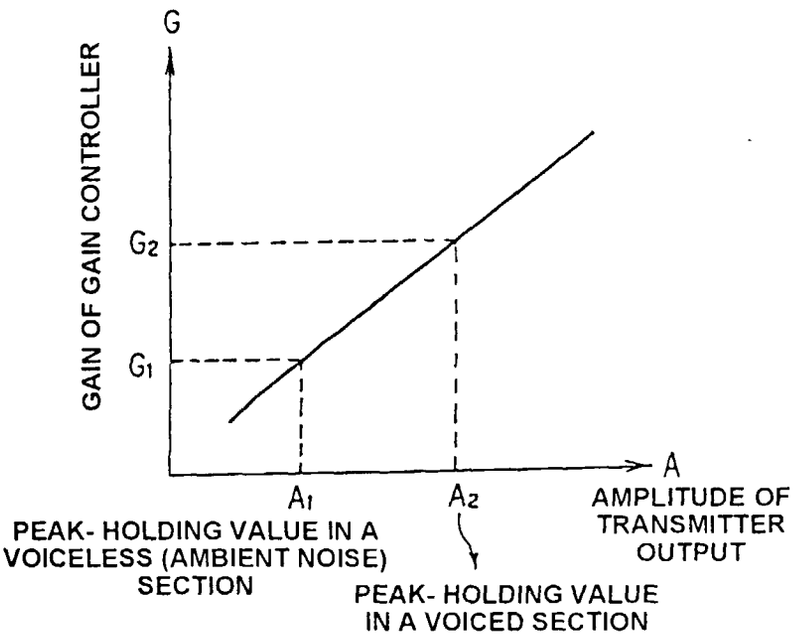
G
GAIN OF GAIN CONTROLLER
G2
G1
A
A1
A2
AMPLITUDE OF TRANSMITTER OUTPUT
PEAK- HOLDING VALUE IN A VOICELESS (AMBIENT NOISE) SECTION
PEAK- HOLDING VALUE IN A VOICED SECTION

Fig. 9

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number
EP 97 10 5555

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
|---|---|---|---|
| Y | JP 08 079 353 A (HITACHI) 22 March 1996<br>& PATENT ABSTRACTS OF JAPAN<br>vol. 96, no. 7, 31 July 1996<br>& JP 08 079353 A (HITACHI), 22 March 1996,<br>* abstract * | 1,2 | H04R1/10<br>H04R3/00 |
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| A | US 5 448 637 A (YAMAGUCHI ET AL.)<br>* column 1, line 8-13 *<br>* column 4, line 62 - column 5, line 50 *<br>* column 6, line 1 - column 8, line 52 *<br>* column 8, line 62 - column 9, line 64 * | 1,3,4 | |
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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 9 September 1997 | Zanti, P |

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