

- [54] **HEADPHONE WITH CROSS FEEDING AMBIENCE CONTROL**
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- [73] Assignee: **Koss Corporation,** Milwaukee, Wis.
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- [51] Int. Cl.² **H04R 5/02**
- [58] Field of Search **179/1 GP, 156 R, 1 G, 182, 179/101; 325/486**

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[57] **ABSTRACT**
 A stereophonic headphone includes ambience control potentiometers connected in series with each audio transducer. A portion of the audio signal applied directly to each audio transducer is coupled to the ambience control potentiometer of the other audio transducer and is applied to the other audio transducer 180° out of phase. A mixing of the left and right audio channels is thus obtained and can be controlled by the listener to provide the desired binaural listening effect.

3 Claims, 3 Drawing Figures

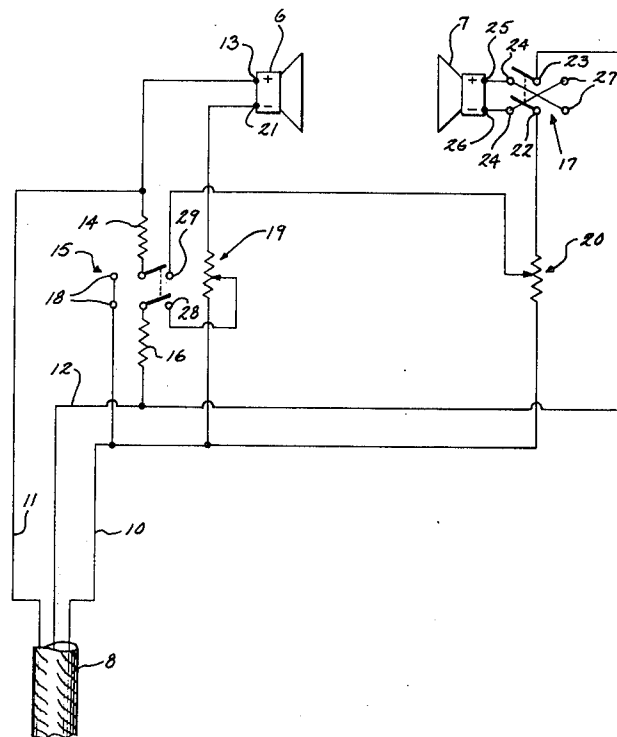


Fig. 1

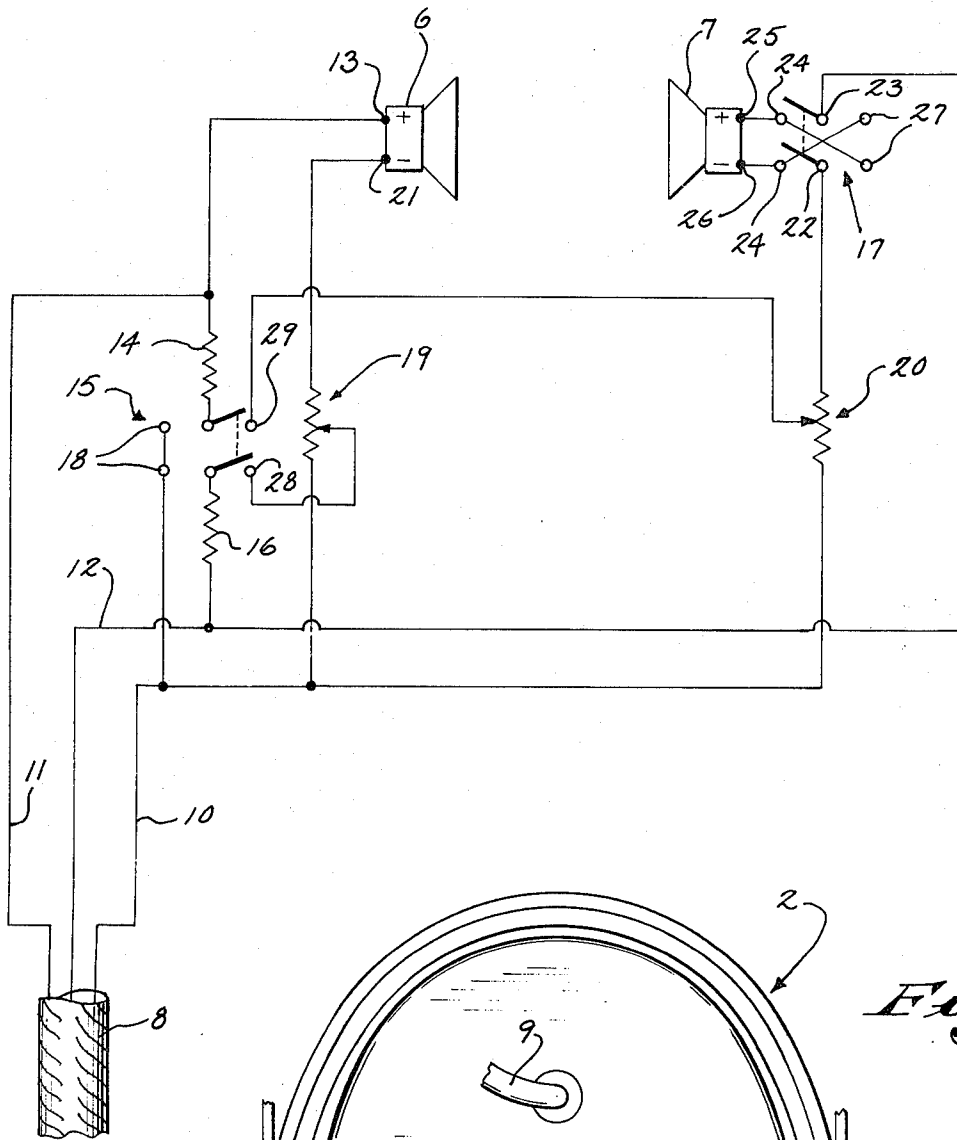
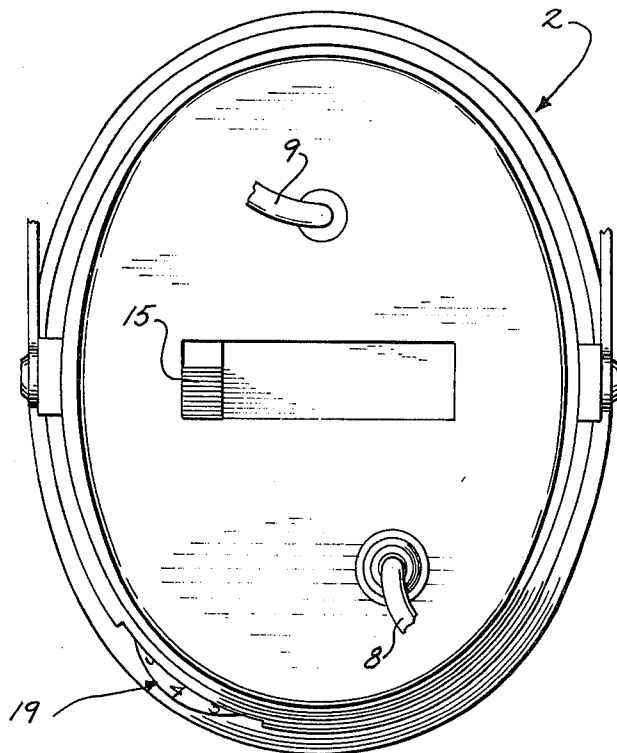


Fig. 3



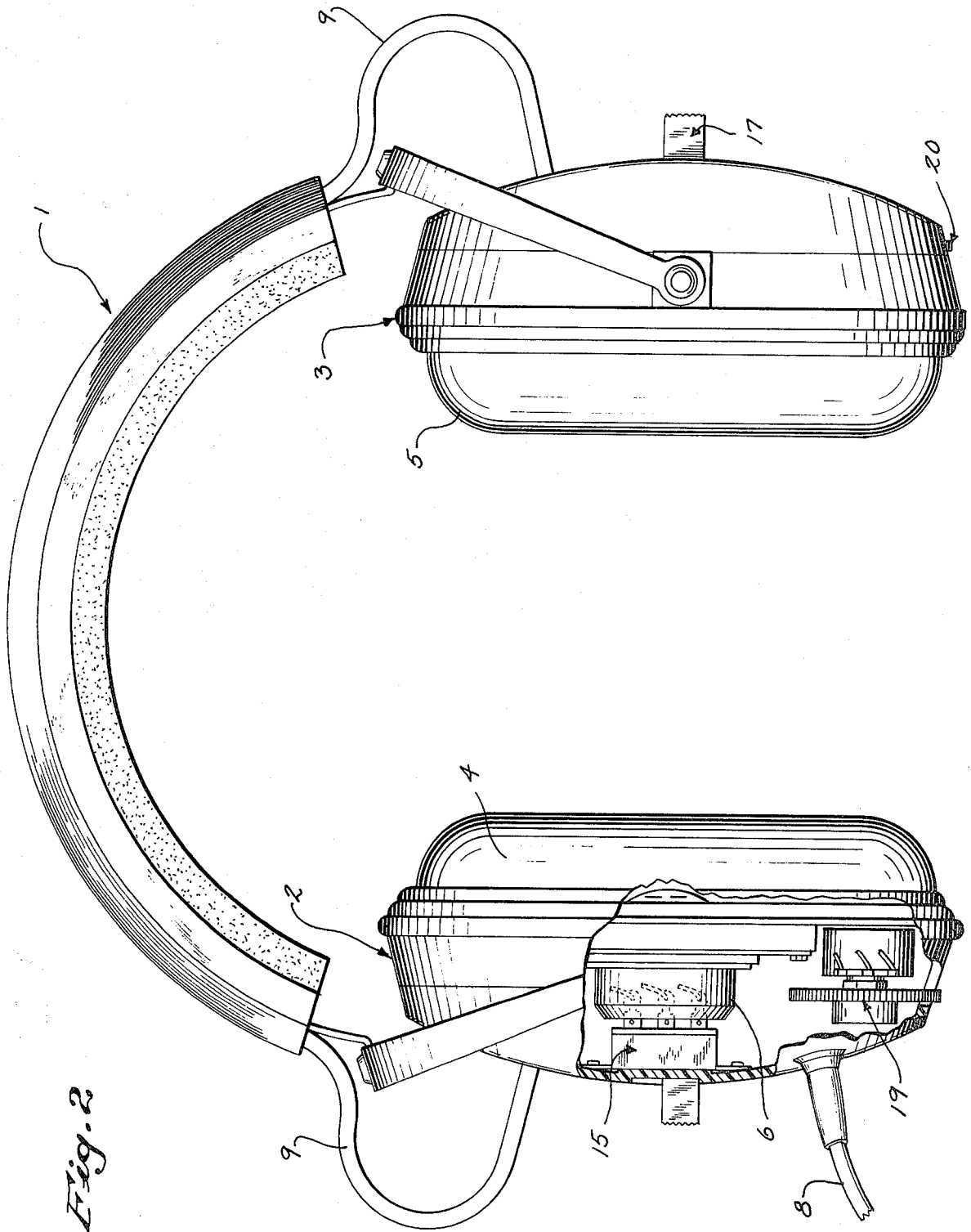


Fig. 2

HEADPHONE WITH CROSS FEEDING AMBIENCE CONTROL

Background of the Invention

The field of the invention is headphones, and particularly, high fidelity headphones for reproducing stereophonically recorded programs.

Commercially available stereophonically recorded program materials include two completely separate channels of program information which are formed, for example, by combining recorded signals from microphones disposed at many locations in the recording studio. When reproduced by a pair of loudspeakers located in a room, such stereophonic program material provides not only directionality, but also, because the sound from each loudspeaker reaches both ears of the listener, either directly or after being reflected from surfaces in the room, the left and right channels are mixed before they reach the listener's ears to provide a panorama of sound.

The manner in which the sound from each loudspeaker mixes with that of the other before reaching the ear of the listener depends upon numerous factors. For example, the position of the listener with respect to the loudspeakers, the frequency of the program material, and the size, shape and contents of the room in which the loudspeakers and listeners are located all contribute to this mixing process. The mixing is not, therefore, merely the addition of a portion of one channel to the other, but instead, involves the complex addition of phase-shifted sounds. A similar mixing process occurs if the listener hears the program material live as it is being recorded, and it is this mixing process which provides true "binaural" listening.

A preponderance of commercially available stereophonically recorded program materials presume that some mixing of the left and right channels will occur when played back through loudspeakers. However, when reproduced through headphones, this complex mixing of the left and right channels does not occur, and instead, the program material in the left channel is coupled directly to the left ear of the listener and the program material of the right channel is coupled directly to the right ear. Although the resulting complete separation of the left and right channels provides a most pleasing listening experience, a "panorama" of sound is difficult to achieve with some recorded materials. For example, when listening to a vocalist accompanied by an orchestra, the vocalist may appear in the center, the brass on the right and the strings on the left. Rather than a continuous blending of these three apparent sources of sound, however, gaps may appear between them. The extent to which this effect is noticed varies greatly depending on the nature of the program material, the type of recording technique used, and the sensitivities of the individual listener.

Summary of the Invention

The present invention relates to a stereophonic headphone in which means are provided for introducing ambient program information into each ear of the listener which electrically simulates the mixing which occurs when listening to stereophonically recorded programs through a loudspeaker system. More specifically, the invention resides in a stereophonic headphone having a first audio transducer which connects to receive the audio signal from one channel of a stereophonic re-

ording, a second audio transducer connected to receive an audio signal from the second channel of the stereophonic recording, first means for coupling a portion of the audio signal applied to the first audio transducer to the second audio transducer and imparting a substantial phase shift thereto, and second means for coupling a portion of the audio signal applied to the second audio transducer to the first audio transducer and imparting a substantial phase shift thereto.

A general object of the invention is to simulate the mixing of stereophonically recorded program material which occurs when reproduced through a loudspeaker system. This mixing is accomplished by sampling a portion of the audio signal applied to each transducer and coupling it to the other transducer. Rather than merely adding the sampled audio signal to the other transducer, however, a substantial phase shift is first imparted to it. Therefore, rather than merely reducing the separation, or stereophonic effect, the mixing of the two separate channels fills in the gaps and provides a panorama of sound without diminishing separation.

Another object of the invention is to provide a means for adjusting the amount of mixing of the two audio signals to enable the listener to blend the two channels to his own particular taste. This is accomplished by ambience control potentiometers which are mounted to each cup of the headphone and which are electrically connected to control the amount of coupling between channels.

A more specific object of the invention is to provide a headphone in which the user may alter the phase and mixing of the two audio channels. In addition to the ambience control potentiometers, a phase switch is provided which allows the phase of one audio channel to be reversed with respect to the other channel. Many additional blending effects can thus be obtained by the user merely by changing the phase switch.

The foregoing and other objects and advantages of the invention will appear from the following description. In the description reference is made to the accompanying drawings which form a part hereof, and in which there is shown by way of illustration a preferred embodiment of the invention. Such embodiment does not necessarily represent the full scope of the invention and reference is made to the claims herein for interpreting the breadth of the invention.

Brief Description of the Drawings

FIG. 1 is an electrical schematic diagram of the invented ambience headphone,

FIG. 2 is a front view with parts cut away of the invented ambience headphone, and

FIG. 3 is a sideview of one cup which forms a part of the headphone in FIG. 2.

Description of the Preferred Embodiment

Referring particularly to FIG. 2, the invention is embodied in a stereophonic headphone which includes a head band 1 which extends over the listener's head and provides support for a left cup 2 and a right cup 3. The cups 2 and 3 are substantially similar and each includes a liquid filled cushion 4 and 5 which provides a comfortable fit over the listener's ears. An audio transducer 6 is mounted in the cup 2 and is positioned to direct sound through a central opening in the cushion 4 into one ear of the listener, and similarly, an audio transducer 7 is mounted in the cup 3 to direct sound into the

listener's other ear. A cable 8 connects the left cup 2 with a stereophonic signal source and a connecting cable 9 supported by the head band 1 electrically couples the left cup 2 to the right cup 3. Structurally, the headphone is substantially similar to the model PRO/4AA headphone which is commercially available from the Koss Corporation.

Referring particularly to FIG. 1, the cable 8 includes three leads: a ground lead 10; a left channel lead 11; and a right channel lead 12. The left channel lead 11 connects to a positive terminal 13 on the left audio transducer 6 and connects through a first coupling resistor 14 to one movable contact of a double-pole-double-throw ambience switch 15. The right channel lead 12 connects to the other movable contact on the ambience switch 15 through a second coupling resistor 16 and it also connects to one movable contact on a double-pole-double-throw phase reversal switch 17.

The ground lead 10 is electrically common to both the left and right audio channels. It connects to one pair of stationary contacts 18 on the ambience switch 16 and it also connects to one end of the resistance element in a left ambience control potentiometer 19 and to one end of the resistance element in a right ambience control potentiometer 20. The other end of the resistance element in the left ambience control potentiometer 19 connects to a negative terminal 21 on the left audio transducer 6 and the other end of the resistance element in the right ambience control potentiometer 20 connects to the other movable contact 22 on the phase switch 17. A first pair of stationary contacts 24 on the phase switch 17 connect to a positive terminal 25 and a negative terminal 26 on the right audio transducer 7, and they are cross connected with a second set of stationary contacts 27 on the phase reversal switch 17.

The wiper on the left ambient control potentiometer 19 connects with a stationary contact 28 on the ambience switch 15. When the ambience switch 15 is in its operating position, therefore, the wiper is connected to the second coupling resistor 16. Similarly, the wiper on the right ambience control potentiometer 20 connects with a stationary contact 29 on the ambience switch 15, and when the ambience switch 15 is in its operating position, the wiper connects with the first coupling resistor 14.

The ambience switch 15 is operable between two positions and when it is switched to its "test" position, the coupling resistors 14 and 16 are both connected to the ground lead 10 and the headphone operates in a conventional manner. More specifically, the left audio signal on the lead 11 is applied to the positive terminal 13 on the left audio transducer 6 and is voltage divided between the audio transducer and the left ambience control potentiometer 19. Similarly, the right audio signal is applied through the lead 12 and phase switch 17 to the right audio transducer 7. It is voltage divided between the audio transducer 7 and the right ambience control potentiometer 20. In this standard mode of operation left channel program information is applied to the left audio transducer 6 and right channel program information is applied to the right audio transducer 7. No mixing is provided, however, the phase of the right channel audio signal can be reversed 180° by operating the phase switch 17.

When the ambience switch 15 is in its operating position, the left and right audio channels are mixed by

coupling a portion of the left channel signal to the right audio transducer 7 and coupling a portion of the right channel signal to the left audio transducer 6. More specifically, the left channel signal on the lead 11 is applied through the first coupling resistor 14 to the right ambience control potentiometer 20 and the right channel signal on the lead 12 is applied through the second coupling resistor 16 to the left ambience control potentiometer 19. The mixing which is thus obtained is not merely the addition of a portion of the right channel to the left and vice versa, but instead, involves a substantial phase shift of the cross coupled audio signals. The left channel signal is coupled to the right transducer 7 through the series connected right ambience control 20 and is applied 180° out of phase with respect to the applied right channel signal. Similarly, the right channel signal is coupled to the left audio transducer 6 through the series connected left ambience control potentiometer 19 and is applied 180° out of phase with respect to the applied left channel signal. The amount of mixing which occurs is controlled separately for each channel by the position of the wipers on the ambience control potentiometers 19 and 20.

Referring particularly to FIGS. 2 and 3, the ambience control potentiometers are physically mounted in the respective headphone cups 2 and 3 where they are easily accessible to the listener. The amount of mixing of the stereophonically recorded program can thus be separately controlled by the listener to obtain the most pleasing effect. The phase switch 17 is also mounted to the right cup 3 to add yet another easily accessible control for the listener.

Although the values of the coupling resistors 14 and 16 and the values of the ambience control potentiometers 19 and 20 can be varied considerably, there are a number of design constraints which lead to the particular values used in the preferred embodiment described herein. The resistance of each audio transducer 6 and 7, for example, is approximately 220 ohms and to insure efficient operation of the headphones, the resistance of the series connected ambience control potentiometers 19 and 20 must be limited to a reasonable value. On the other hand, commercially available audio amplifiers to which the headphones are attached, typically include a series resistor of from 150 to 600 ohms in each of the leads 11 and 12. It has been discovered that unless the resistances of the ambience control potentiometers 19 and 20 are significant with respect to these series connected resistors, the control of the mixing is somewhat unpredictable and noticeably non-linear. A value of 1,000 ohms was selected for each ambience control potentiometer 19 and 20 and is believed to be a reasonable compromise between these two design objectives.

The values of the coupling resistors 14 and 16 are determined primarily by the amount of maximum mixing that is desired. Just as the amount of mixing is very subjective, so is the maximum amount, and therefore, the values of the coupling resistors 14 and 16 can be varied considerably according to taste. A value of 390 ohms has been chosen for the coupling resistors 14 and 16 in the preferred embodiment described herein and this value provides a most pleasing effect.

A stereophonic headphone has been described which provides the listener with a means of introducing and controlling the ambient sounds which reach his ears. These ambient sounds simulate the mixing of sounds

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which occurs when listening to stereophonic program material binaurally.

We claim:

1. In a stereophonic headphone having a first audio transducer mounted in a first cup for positioning over one ear of a listener and having a pair of input terminals, a second audio transducer mounted in a second cup for positioning over the other ear of the listener and having a pair of input terminals, and cable means for coupling separate audio signals to each of said audio transducers, the improvement therein comprising:

a left channel lead in said cable means connected to one input terminal on said first audio transducer; a right channel lead in said cable means connected to one input terminal on said second audio transducer;

first ambience resistor means mounted in one of said cups and connected between the other terminal on said first audio transducer and a ground lead in said cable means, said first ambience resistor means being operable to voltage divide an audio signal applied across said left channel lead and said ground lead with said first audio transducer;

a first coupling resistor mounted within one of said cups and connected to the right channel lead and coupled to said first ambience resistor means, said first coupling resistor being operable to couple a portion of said left channel signal generated across

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said first ambience resistor means to said one input terminal on said second audio transducer;

a second ambience resistor means mounted within one of said cups and connected between the other terminal on said second audio transducer and said ground lead, said second ambience resistor means being operable to voltage divide an audio signal applied across said right channel lead and said ground lead with said second audio transducer; and

a second coupling resistor mounted within one of said cups and connected to the left channel lead and coupled to said second ambience resistor means, said second coupling resistor being operable to couple a portion of said right channel signal generated across said second ambience resistor means to said one input terminal on said first audio transducer.

2. The stereophonic headphone as recited in claim 1 which includes a double pole single throw ambience switch mounted within one of said cups and having one pole connected in series circuit with said first coupling resistor and its other pole connected in series circuit with said second coupling resistor.

3. The stereophonic headphone as recited in claim 1 in which said first and second ambience resistor means are potentiometers, each having a resistance element and a slider.

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