United States Patent [19]

Hanson

[11] **3,900,707**

[45] **Aug. 19, 1975**

[54] **SPEAKER APPARATUS**

[75] Inventor: **Brian A. Hanson**, Woodridge, Ill.

[73] Assignee: **Hear-Muffs, Inc.**, Downers Grove, Ill.

[22] Filed: **June 6, 1973**

[21] Appl. No.: **367,521**

[52] **U.S. Cl.** ..... **179/156 R**

[51] **Int. Cl.**[2] **H04M 1/05**; H04R 5/00

[58] **Field of Search** ..... 179/156 A, 1 GQ, 1 GP, 179/146 H

[56] **References Cited**

UNITED STATES PATENTS

3,792,754	2/1974	Hanson	179/146 H X
3,794,779	2/1974	Greuzerd et al.	179/156 R
3,796,840	3/1974	Ohta	179/156 R
3,863,028	1/1975	Fixler	179/1 GQ

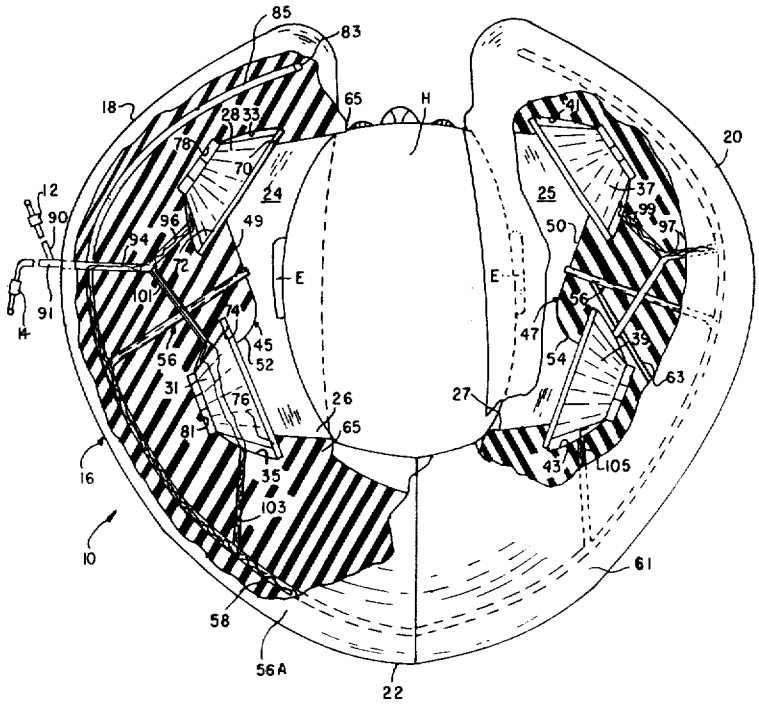
Primary Examiner—William Cooper

Attorney, Agent, or Firm—Bernard L. Kleinke; Thomas W. Speckman; Leonard J. Kalinowski

[57] **ABSTRACT**

Speaker apparatus adapted to be coupled electrically to a sound reproducing system for reproducing four separate sources of sound and adapted to be used within close proximity to the ears of the user, includes a first and second pair of oppositely-disposed spaced-apart members each having respective first and second chambers opening substantially toward one another, a first pair of spaced-apart cavities opening into the first chamber, a second pair of spaced-apart speaker cavities opening into the second chamber, a first pair of speaker units mounted within the first pair of cavities and positioned generally facing the second chamber, a second pair of speaker units mounted within the second pair of cavities and positioned generally facing the first chamber, and a pair of first and second baffles mounted at least partially within the respective first and second chambers, the first baffle member being disposed between one of the first pair of cavities and the opening of the first chamber, the second baffle member being disposed between one of the second pair of cavities and the opening of the chamber so that when the sound reproduction system energizes the speaker units, the sound emanating from the speaker units of each of the pairs of speaker units is caused to be out of phase with one another at the opening to the chambers. The first and second baffle members partially block one of the first and second pairs of cavities, respectively, to control the effective sound pressure level at the opening to the chambers. The baffle members also block to a lesser extent the other ones of the pairs of speaker cavities to produce the phase delay. A bleeder tube connects the first and second chambers in fluid communication to equalize the sound pressure levels therebetween so that the sound pressure levels and the phase relationships can more closely approximate the natural sound being reproduced.

11 Claims, 5 Drawing Figures



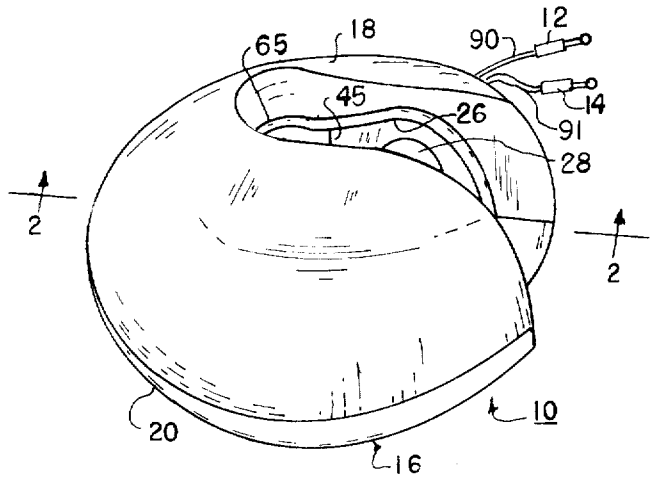


FIG. 1

FIG. 2

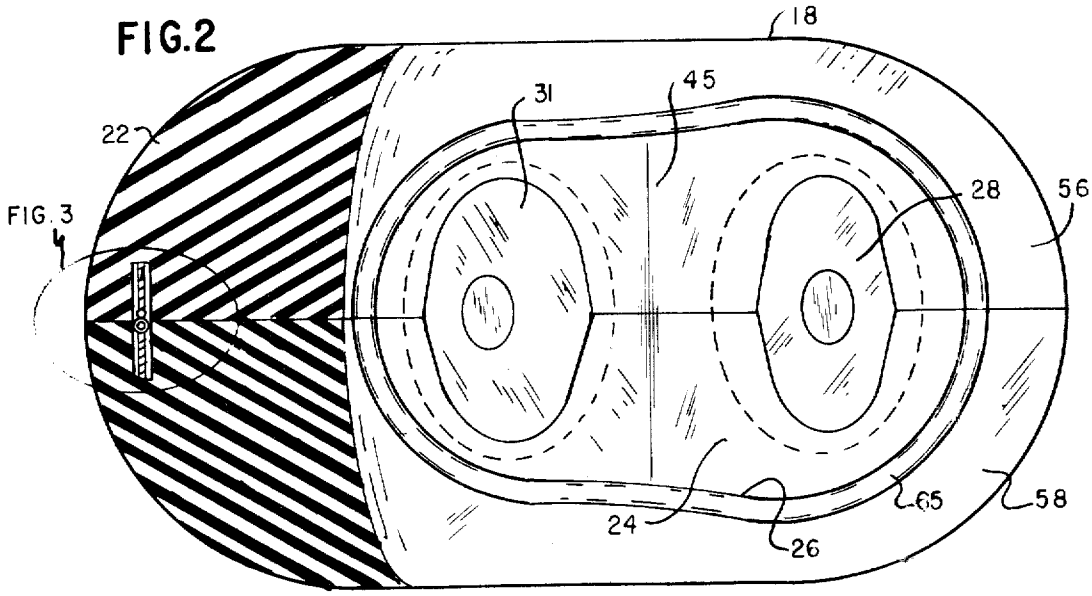


FIG. 5

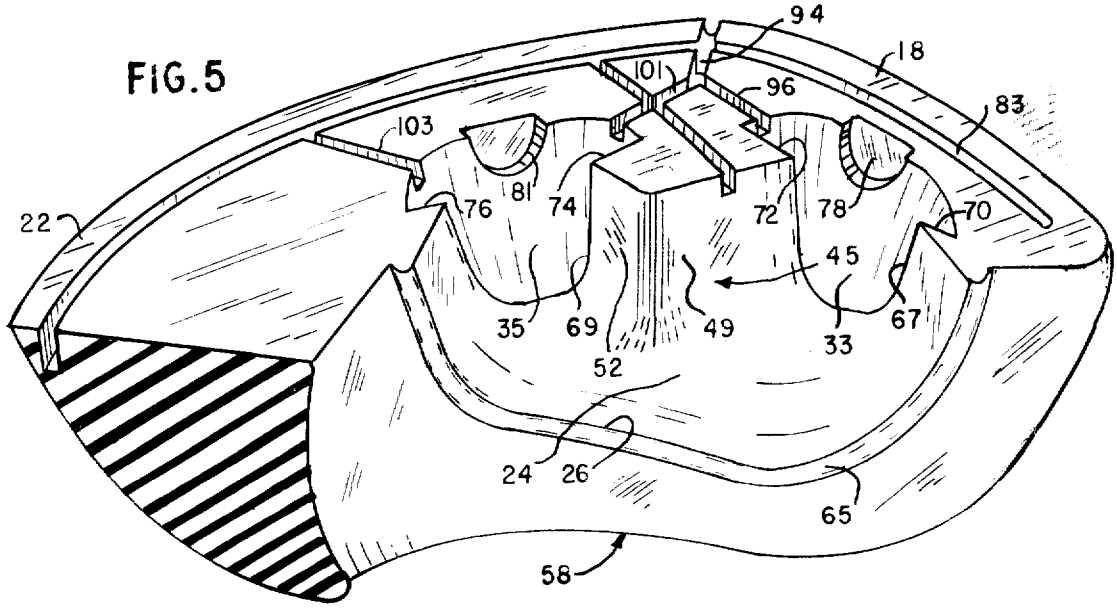


FIG. 3

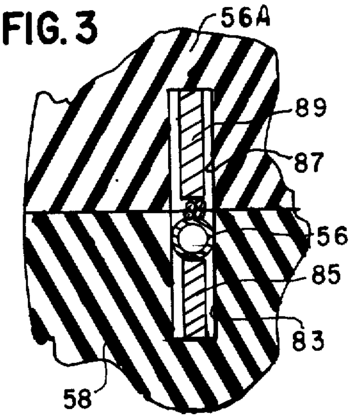
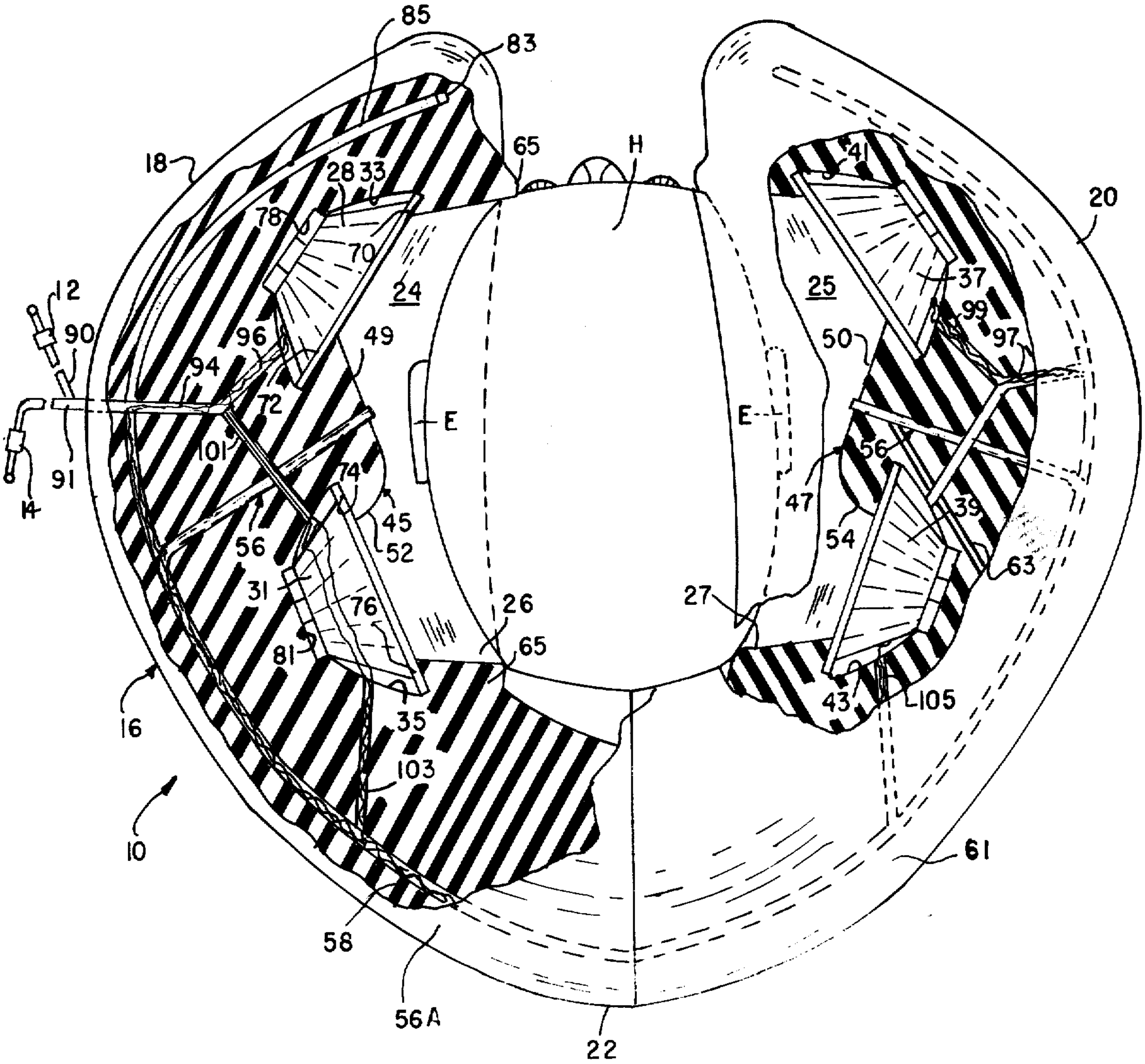

56A
89
87
56
85
83
58

FIG. 4


85
83
65
H
18
28
33
78
70
24
25
41
37
20
12
90
96
49
50
99
97
94
72
E
E
101
91
74
56
56
47
14
45
52
39
54
56
63
31
76
26
27
81
65
35
43
105
16
103
10
61
58
56A
22

SPEAKER APPARATUS

The present invention relates to a speaker apparatus, and it more particularly relates to a speaker apparatus having four speakers for reproducing four channels of sound from a sound reproduction system in a realistic quadrophonic manner.

Four channel stereo headphones have been employed to reproduce four channels of sound by providing two pairs of closely-spaced speakers adapted to be secured to the head of the user in close proximity to the ears in a manner somewhat similar to conventional headphones having only two speakers, one for each ear. However, while such four channel headphones having relatively closely spaced speakers have been successful in reproducing four channels of sound, they have not been entirely satisfactory for some applications in that they have not successfully reproduced quadraphonic sensations to a listener as compared to relatively widely spaced-apart speakers, since such speaker systems very closely approximate the acoustic effect present in an actual concert hall or elsewhere where the original sounds are reflected by walls, ceiling, floor and other objects within the room and converge upon the listener's ears with randomly varying time delays. Thus, it would be highly desirable to have a closely-spaced speaker apparatus which would reproduce four channels of sound in such a manner that it closely approximates the sound produced by four speakers spaced apart by a relatively great distance, and would provide an effect of "presence" to the listener as if he were actually present at the live performance of the original sound, the speaker apparatus being in the form of headphones or other apparatus adapted to be used in relatively close proximity to the ears of the user.

Therefore, the principal object of the present invention is to provide a new and improved speaker assembly adapted to be used in close proximity to the ears of the user and adapted to reproduce four channels of sound from a sound reproduction system in a realistic quadraphonic manner.

Briefly, the above and further objects are realized in accordance with the present invention by providing a new and improved speaker apparatus, adapted to be coupled electrically to a sound reproducing system, which includes a first and second pair of oppositely-disposed spaced-apart members each having respective first and second chambers opening substantially toward one another, a first pair of spaced-apart speaker cavities opening into the first chamber, a second pair of spaced-part speaker cavities opening into the second chamber, a first pair of speaker units mounted within the first pair of cavities and positioned generally facing the second chamber, a second pair of speaker units mounted within the second pair of cavities and positioned generally facing the first chamber, and a pair of first and second baffle members mounted at least partially within the first and second chambers, respectively, the first baffle member being disposed between one of the first pair of cavities and the opening of the first chamber, the second baffle member being disposed between one of the second pair of cavities and the opening of the second chamber so that when the system producing the sounds energizes the speakers, the sound emanating from the speaker units of each of the pairs of units is caused to be out of phase with one another at the opening to the chambers. As a result,

when a user positions his head between the first and second pair of oppositely-disposed members and when the sound reproducing system energizes the speaker units, the user experiences a psychoacoustic quadraphonic sensation in that the four speakers of the apparatus of the present invention are physically spaced apart and the pairs of speakers on each side of the head of the user are physically arranged to produce sounds which are out of phase with one another. The baffle members of the present invention partially block one of the first and second pairs of cavities to control the effective sound pressure level at the openings of the chambers from the other one of the speaker units to equalize the sound pressure levels between the two speaker units on either side of the head of the user. A bleeder tube connects the two chambers in fluid communication to equalize the sound pressure levels of both chambers to approximate further the actual psychoacoustic phenomena occurring naturally and to provide the necessary phase relationship between the speakers.

Other objects and advantages of the present invention will become apparent from a reading of the following detailed description and the accompanying sheets of drawings, wherein:

FIG. 1 is a pictorial view of speaker apparatus which is adapted to be used with a sound reproduction (not shown), and which is constructed in accordance with the present invention;

FIG. 2 is an enlarged cross-sectional view of the speaker apparatus of FIG. 1 taken substantially along the line 2—2 thereof;

FIG. 3 is an enlarged detailed view of the circled portion of the speaker apparatus of FIG. 2;

FIG. 4 is an enlarged, partially broken-away plan view of the speaker apparatus of FIG. 1, illustrating the apparatus mounted on the head of the user; and

FIG. 5 is a pictorial view of the lower left hand quarter portion of the supporting structure of the speaker apparatus of FIG. 1 illustrating it without the speaker units or other internal operating parts mounted in place.

Referring now to the drawings, and more particularly to FIGS. 1 and 4 thereof, there is shown a speaker apparatus **10** in the form of a headphone assembly and constructed in accordance with the present invention. The speaker assembly **10** is adapted to be worn on the head H of a user. The assembly **10** generally comprises a U-shaped member **16** comprised of soft flexible material, such as polyurethane, and having a pair of parallel spaced-apart legs **18** and **20** joined integrally together at their rear-end portions by a rear head engaging transverse portion **22** to engage the head H of the user with the inside surfaces of the legs **18** and **20** engaging the ears E, as shown in FIG. **4.** The legs **18** and **20** include a pair of chambers **24** and **25,** respectively, which include openings **26** and **27** facing one another for receiving the ears E of the user. A pair of left speaker units **28** and **31** are mounted within a pair of spaced-apart speaker cavities **33** and **35** opening into the chamber **24,** and similarly a pair of right speakers **37** and **39** are mounted within a pair of spaced-apart speaker cavities **41** and **43** disposed within the right hand leg **20** opening into the right hand chamber **25.** As hereinafter described in greater detail, the speaker units are wired together to the cable connectors **12** and **14** for the purpose of interconnecting them with a suit-

able sound reproduction system (not shown) for energizing the speaker units. The front speakers **28** and **37** are positioned such that they are directed at an angle rearwardly generally, toward the ears E, and the rear speakers **31** and **39** are generally directed at an angle forwardly, slightly to the rear of the ears E. A pair of baffles **45** and **47** are disposed within the respective chambers **24** and **25**, and as best shown in FIG. **4**, the baffles **45** and **47** impede the sound emanating from the rear speakers **31** and **39** so that the sound traveling therefrom must move around the baffles **45** and **47**, respectively, to contact the ears E of the user, whereby the sounds from the rear speakers are out of phase with the respective sounds from the front speakers **28** and **37** to help produce the desired quadraphonic phenomenon. In order to reduce the effective sound pressure levels at the ear from the front speakers to equalize the sound pressure levels from the rear speakers, the front portions **49** and **50** of the respective baffles **45** and **47** partially cover and thus block portions of the respective front speakers **28** and **37** for effectively reducing the sound pressure levels therefrom. Moreover, it has been found that the sound pressure levels from the rear speakers **31** and **39** should also be reduced by a similar lesser extent by having rear portions **52** and **54** of the respective baffles **45** and **47** block the speakers **31** and **39**, respectively. It has been found that with the preferred embodiment of the present invention the front portions of the baffles **45** and **47** should block between 30 percent and 40 percent, and preferably about 35 percent, of the front speakers **28** and **37**, and the rear portions **52** and **54** of the baffles **45** and **47** should block between **15** percent and **25** percent, and preferably about **20** percent, of the rear respective speakers **31** and **39**.

A bleeder tube **56** connects the two chambers **24** and **25** in fluid communication to serve as a tuned port for the two-way transfer of sound between the chambers **24** and **25** for the purpose of equalizing sound pressures between the chambers and to provide a more natural and realistic phase relationship. The length and diameter of the tube may be adjusted for the most desirable effect for a given unit. The tube **56** has one of its ends extending within the chamber **24** opposite the ear E and extends from the leg portion **18**, through the back transverse portion **22** to the leg **20** and into the chamber **25** as hereinafter described in greater detail.

While the speaker apparatus **10** is disclosed as being preferably in the form of a headphone assembly adapted to be mounted on the head of the user in the manner as shown and described, it is to be understood that the speaker apparatus of the present invention may also be employed in other types and kinds of headphone assemblies and also other types and kinds of speaker apparatus adapted to be used by the user in close proximity to the ears, such, for example, as a speaker system arranged in a headrest of a chair or within the back portion of a specially contoured shaped chair. Also, if desired, the apparatus **10** may be covered with fabric material (not shown) to provide a more pleasing appearance.

Considering now the apparatus **10** of the present invention in greater detail with reference to FIGS. **2**, **3** and **4** of the drawings, the U-shaped block **16** is composed of four similarly shaped blocks of resilient foam plastic material comprising an L-shaped upper left block **56A**, an L-shaped lower left block **58**, a similar L-shaped upper right block **61** and a similar L-shaped lower right block **63**, the quarter portions being fixed together by any suitable means, such as an adhesive. A closed loop bead **65** surrounding the opening **26** to the cavity **24** within the leg **18** as shown in FIG. **2** enables the cavity **24** to be sealed to the head of the user surrounding his ear E, it being understood that a similar bead (not shown) is disposed about the opening to the cavity **25**.

Considering now the lower left hand block **58** as shown in FIG. **5**, only one of the quarter block portions will now be considered in detail, it being understood that the remaining quarter portions being substantially identical thereto. The leg portion **18** of the block **58** has the lower half portion hollowed out to form the chamber **24**, and the block **58** includes the lower half portions of the cavities **33** and **35** which have openings **67** and **69**, which are U-shaped and which cooperate with similar shaped openings in the upper block portion to define the opening for the speakers **28** and **31**. A pair of shoulders **70** and **72** for the cavity **33** and a pair of shoulders **74** and **76** for the cavity **35** retain the mounting flange of the speakers **28** and **31** within the respective cavities when they cooperate with similar shoulders for the upper quarter block portion of the block **16**. It should be understood that if desired, a protective grille plate may be interposed between the face of the speakers and the shoulder **74** and **76**.

In accordance with the present invention, the lower half portion of the baffle **45** projects away from the cavities **33** and **35** toward the opening **26** to the chamber **24**. The baffle **45** is in the form of a triangular-shaped block with a larger face **49** extending from the opening **67**, and having a smaller face extending transversely to the face **49** and extending from the opening **69** to the cavity **35**. The opening **67** of the cavity **33** is directed toward the ear E of the user to as great an extent as possible for the particular mounting support, and the opening **69** of the cavity **35** is directed forwardly at an angle with the front rear face **52** of the baffle **49** preventing direct contact of the second waves emanating from the speaker **31** so that a phase delay is created relative to the front speaker **28**, whereby the quadraphonic sensation is realized to the greatest extent possible without the necessity of electronically modifying the phase and separation requirements.

A circular cross-sectional recess **78** at the outer portion of the cavity **33** and a circular cross-sectional recess **81** at the outer portion of the cavity **35** is adapted to receive magnet cups of the speakers **28** and **31**, respectively, it being understood that the recesses **78** and **81** cooperate with corresponding complementary-shaped recesses of the upper quarter block **56** and it being further understood that similar such recesses are provided in the other two quarter blocks **61** and **63**.

In order to facilitate the attaching of the speaker apparatus **10** to the head of the user, a groove **83** receives a C-shaped band **85** which is composed of resilient stiff material, such as tempered steel, and a groove **87** in the upper portion of the block **16** receives a similar C-shaped bank **89** as shown in FIG. **3**. The end portions of the steel bands **85** and **89** may be protected with a plastic coating or tape material (not shown) to prevent damage to the polyurethane material. The grooves **83** and **87** as shown in FIG. **3** cooperate with one another and are aligned to permit the tube **56** to be disposed

therewithin between the two bands as well as certain lead wires for the speaker units.

Considering now the wiring of the speakers, a pair of cables **90** and **91** electrically connected to the terminals **12** and **14** are disposed within the groove **94** which opens outwardly to permit the cables to extend from the apparatus **10**, the cable **90** extending from the groove **94** within a groove **90** to the speaker cavity **33**. Two of the three conductor wires extending from the cable **96** are electrically connected to the speaker **28** for energizing it, and one of those two wires together with a third wire from the cable **90** extend backwardly therefrom within the groove **96** and the groove **94** to the groove **85** so that those two wires may extend to a groove **97** and a groove **99** within the quarter lower block **63** to enter the cavity **41** and to be electrically connected to the speaker **37**. The cable **91** extends from the groove **94** within a groove **101** to the cavity **35**, so that two of its wires may be electrically connected to the speaker **31** and one of those wires, together with a third wire from the cable **91**, extend within a groove **103** to the groove **83**, whereby the two wires extend to a groove **105** within the lower block **63** of the right hand portion of the block **16** and thus enter the cavity **43** to electfically connect to the speaker **39**.

Various changes and modifications may be made in the particular embodiment disclosed, without departing from the spirit and scope of the invention as intended to be set forth in the appended claims, for example, the front and rear speakers of each chamber may be positioned at various different angles relative to the ears of the listener, but they should be positioned such that the directions of sound emanating therefrom are inclined toward one another to provide the desired interaction and are not parallel to or diverging away from one another.

What is claimed is:

1. Speaker apparatus adapted to be worn on the head of a user and adapted to be coupled to a sound reproducing system for causing sounds to be emitted from said apparatus, said speaker apparatus comprising:

a first and second pair of oppositely-disposed spaced-apart members for engaging the head of the user over the ears of the user, said members each having respective first and second chambers including respective first and second openings facing substantially toward one another for receiving the ears of the user, said ears occupying first and second central portions of the respective first and second openings;

means defining a first pair of spaced-apart front and rear cavities opening into said second chamber;

means defining a second pair of spaced-apart front and rear cavities opening into said second chamber;

a first pair of front and rear sound transmitting units mounted within said first pair of respective front and rear cavities and positioned with their front faces generally facing said first chamber;

a second pair of front and rear sound transmitting units mounted within said second pair of respective front and rear cavities and positioned with their front faces generally facing said second chamber;

conducting means adapted to couple each one of said sound transmitting units to the sound reproducing system;

means defining a pair of longer rear acoustic paths extending in acoustic communication between the respective mid portions of the front faces of said rear transmitting units and the respective mid points of the first and second chambers for guiding sound emanating from the rear units therealong to the ears of the user when positioned within said first and second openings; and

means defining a pair of shorter front acoustic paths extending in acoustic communication between the respective mid portions of the front faces of the respective front transmitting units and the respective mid points of the first and second central portions of the openings of said first and second chambers for guiding sound emanating from said front units therealong, to the ears of the user when positioned within said first and second openings, said longer rear acoustic paths being substantially greater in length than said shorter front acoustic paths to guide sound moving from said rear transmitting units energized by the system through greater distance to said first and said second openings than the distances through which sound moves from said front transmitting units energized by the system to said first and said second openings.

2. Speaker apparatus according to claim **1**, wherein said first and second baffle means partially block the opening of the other one of said first pair of cavities and partially block the opening of the other one of said second pair of cavities, respectively, to reduce sound pressure intensities from the speaker units mounted therein.

3. Speaker apparatus according to claim **2**, wherein said first and second baffle means block said openings of the other ones of said first and second pairs of cavities to reduce sound pressure levels within the range of 30 percent to 40 percent of the effective sound levels of the speaker units mounted therein.

4. Speaker apparatus according to claim **3**, wherein said baffle means causes a 35 percent reduction of said effective sound pressure levels.

5. Speaker apparatus according to claim **3**, wherein said first and second baffle means partially block the opening of said one of said first pair of cavities and partially block the opening of said one of said second pair of cavities respectively to reduce the sound pressure intensities from the speaker units mounted therein.

6. Speaker apparatus according to claim **1**, further including a tube connecting said chambers in fluid communication.

7. Speaker apparatus according to claim **1**, further including a transverse member interconnecting said pair of spaced-apart members, said transverse member and said spacedapart member forming a U-shaped member composed of resilient material.

8. Speaker apparatus according to claim **7**, further including spring means for urging resiliently said spaced-apart members together.

9. Speaker apparatus according to claim **1**, wherein said means defining a pair of longer rear paths include first and second baffle means mounted at least partially within said first and said second chambers respectively for at least partially defining said pair of longer rear paths, said first baffle means being disposed between said rear one of said first pair of cavities and the central portion of said first opening of said first chamber, said second baffle means being disposed between said rear

one of said second pair of cavities and the central portion of said second opening of said second chamber.

10. Speaker apparatus adapted to be energized by an independent sound signal system comprising: a member composed of soft resilient material having an elongated transverse block adapted to engage and extend across the back portion of the head of a user and having a pair of legs extending from the end portions of said block in a spaced-apart manner and able to be spread apart further by means of the resiliency of said rear portion to grip snugly the head of the user therebetween to at least partially support the assembly thereon and to fit over the ears of the user; means defining a pair of cavities in the ear-engaging portions of said legs having oppositely-disposed openings; a pair of speaker means mounted within said cavities having axes of sound extending through said openings when said assembly is in position over the ears of the user; wire means adapted to connect electrically said speaker means to the sound signal system for driving said speaker means; and spring means for biasing said legs inwardly, wherein said member includes an internal groove therein, said spring means including a U-shaped spring clip mounted within the complementary internal groove in said member.

11. Speaker apparatus according to claim **10,** wherein said spring means further includes a second U-shaped spring clip mounted within said internal groove.

* * * * *