United States Patent [19]

Johanson et al.

[11] **3,836,732**

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[54] **HEARING AID HAVING SELECTABLE DIRECTIONAL CHARACTERISTICS**

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[52] **U.S. Cl.** ..... **179/107 FD,** 179/107 E

[51] **Int. Cl.** **G02c 11/06**

[58] **Field of Search** ..... 179/107, 121 D, 107 FD

[56] **References Cited**

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3,749,853	7/1973	Ely	179/107 FD
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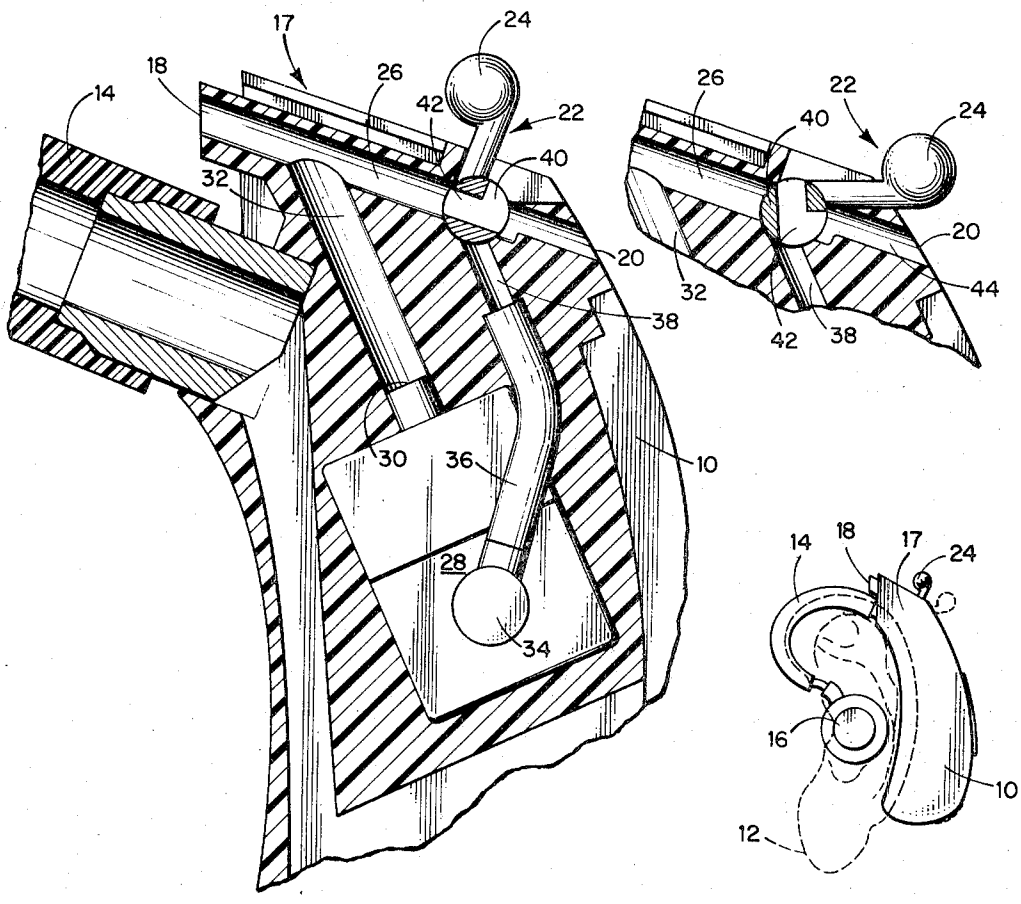
[57] **ABSTRACT**

A hearing aid in which the sound reception characteristics are selectable by a user to provide omnidirectional or directional reception, as desired. The hearing aid employs a differential transducer for converting sound information into an electrical output and to which sound energy can be directed in one of two modes. In one mode of operation, for providing omnidirectional reception, sound is received from a front and rear aperture of the hearing aid and directed to a first input of the transducer. In a second mode of operation, for providing directional reception, sound energy received by the front facing aperture of the hearing aid is directed to the first input of the transducer, while energy received by the rearwardly facing aperture is directed to a second input of the transducer to substantially minimize the magnitude of sounds received from rearward positions.

6 Claims, 4 Drawing Figures



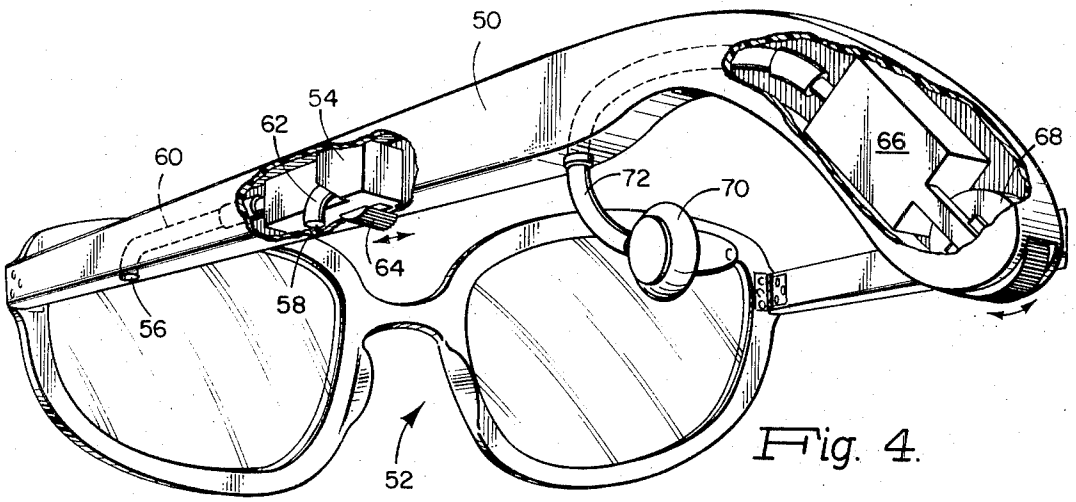


Fig. 4.

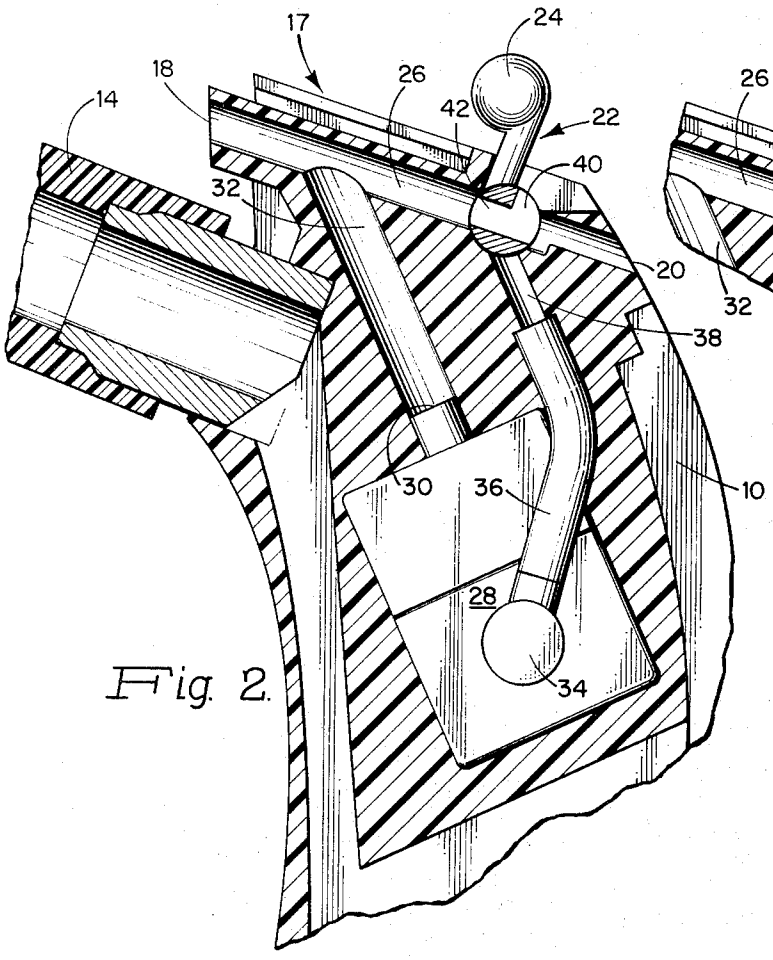


Fig. 2.

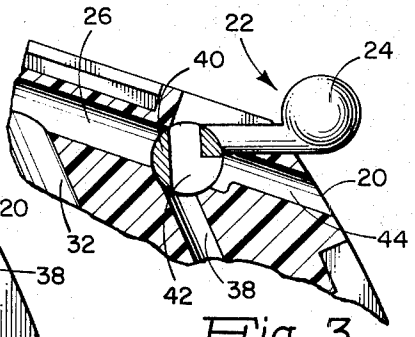


Fig. 3.

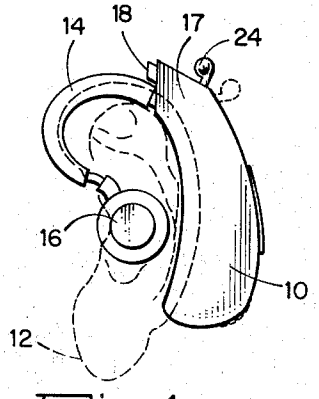


Fig. 1.

HEARING AID HAVING SELECTABLE DIRECTIONAL CHARACTERISTICS

FIELD OF THE INVENTION

This invention relates to hearing aids and more particularly to a hearing aid adjustable by a user to selectively provide omnidirectional or directional receiving characteristics.

BACKGROUND OF THE INVENTION

It is usually desirable that a hearing aid provide good omnidirectional response to sounds emanating from points to the front, rear and sides of a user. A particularly effective multidirectional hearing aid is described in U.S. Pat. No. 3,201,528, assigned to the assignee of the present invention, wherein both forward facing and rearward facing receiving ports are provided to direct received sound information to a microphone and to provide substantially uniform gain for sounds emanating from various points about the user. In many instances however, such as in listening to lectures, conversations in a noisy environment, and the like, it would be desirable to enhance the directional characteristics of the hearing aid to accentuate the gain of sounds emanating forwardly of the user. Directionality is undesirable in many listening situations, and it is useful to provide a capability of both omnidirectional and directional characteristics in one hearing aid.

SUMMARY OF THE INVENTION

In accordance with the present invention, a hearing aid is provided in which the sound reception characteristics are selectable by the user to provide omnidirectional or directional response, as desired. The invention makes use of a differential transducer which has first and second sound receiving input ports and which, when both ports are operative, substantially minimizes the effects of sound energy received by the second port. The hearing aid employs a forwardly directed sound receiving aperture which is coupled to the first port of the differential transducer. A rearwardly facing sound receiving aperture is also provided and which is selectively communicative with either the first or second differential transducer ports depending upon the position of a manually adjustable control valve.

With the valve in the omnidirectional position, sound entering from both the front aperture and rear aperture are channelled to the first input port of the differential transducer to provide reception of sound with substantially uniform gain for sounds emanating from all points about the user. With the control valve in its directional position, sound entering the front aperture is channelled to the first transducer port while sound entering the rear aperture is channelled to the second transducer port. The sound entering the second transducer port tends to be cancelled or substantially reduced in amplitude by operation of the differential transducer, with the result that the hearing aid is most sensitive to sounds emanating from points forward of the user and thereby providing a directional sound response. The directionality of the hearing aid in this latter mode of operation is particularly enhanced since rearward sounds are received and differentially processed to substantially lessen their effect on overall hearing aid performance.

The invention can be embodied in both the behind-the-ear type of hearing aid supported by the wearer's ear, or in the eyeglass frame type in which the hearing aid is incorporated in the bow or temple of an eyeglass frame.

DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a perspective view of a behind-the-ear type of hearing aid according to the invention;

FIG. **2** is an enlarged elevation view of the embodiment of FIG. 1;

FIG. **3** is a partly cut away enlarged elevation view of a portion of the structure of FIG. **2** with the control valve in a position opposite to that shown in FIG. **2**; and

FIG. **4** is a pictorial cut away view of the invention embodied in an eyeglass type hearing aid.

DETAILED DESCRIPTION OF THE INVENTION

The invention as embodied in a behind-the-ear type of hearing aid is shown in FIG. **1** and includes a housing **10** adapted and configured to be worn on the ear **12** of a user and coupled by a length of tubing **14** to an earpiece **16** worn in the user's ear. Included within housing **10** is a transducer for converting received sound energy into corresponding electrical energy, amplifying and processing circuitry, a battery source and volume and other controls and a receiver for transducing the amplified electrical signals into acoustical energy for conveyance via tubing **14** to the earpiece **16.** Alternatively, the earpiece can include the receiver which is electrically energized via interconnecting wires from the aid circuitry.

The housing **10** includes an upper portion **17** which extends above the ear of a user and which contains an aperture **18** which is positioned to receive sounds emanating from points forwardly of the user. A rearwardly facing aperture **20,** visible in FIGS. **2** and **3,** is also provided in the rear surface of upper portion **17** of housing **10** to receive sounds from points rearwardly of the user. A manually adjustable control valve **22** having a control knob **24** is provided in the upper housing portion and is operative according to the invention to alter the directional response characteristics of the hearing aid.

Referring to FIG. **2,** it is seen that frontwardly facing aperture **18** communicates via a longitudinal passage **26** provided in the top portion of housing **10** and which extends to the rear surface of the housing, terminating in rear aperture **20.** A differential transducer **28** is contained within housing **10** and has a first port **30** coupled to a passage **32** which is in sound communication with passage **26** at a position between aperture **18** and control valve **22.** A second port **34** of transducer **28** is coupled via a tube **36** to valve **24** via a passage **38.** The control valve **22** includes a cylinder **40** disposed within a cylindrical recess formed transversely across housing **10** and in which cylinder **40** is rotatable by action of a manual force applied to control knob **24.**

An opening **42** is provided through cylinder **40,** and in one position, depicted in FIG. **2,** provides a sound communication path from rear aperture **20** through the valve into passage **26,** and thence via passage **32** to the first port **30** of transducer **28.** With the valve **22** rotated

to its second position, as depicted in FIG. 3, the passage 26 is occluded by the solid portion of cylinder 40, and a sound communication path is provided from aperture 20 to passage 44, through valve 22 and thence via passage 38 to the second port 34 of transducer 28.

The transducer 28 is of the differential type in which sound energy entering the second port 34 is subtracted from energy entering the first port 30, such that the transducer is responsive to the difference in received energy to provide a corresponding electrical output signal. Such transducers, also known as unidirectional microphones, are per se well known in the art, a typical example being the directional microphone manufactured by Knowles Electronics, Inc., Model BL-1687.

With the control valve in the position illustrated in FIG. 3, sounds emanating from points rearwardly of a user enter the hearing aid via aperture 20 and thence via passages 44, 38 and 36 to port 34. The transducer 28 is operative to substantially cancel the effects of energy received by port 34, and to provide an output signal which is essentially representative of energy received by port 30 and resulting from sounds from points forwardly of a user. The hearing aid in this mode of operation is therefore directional and provides enhanced reception for sounds in front of the user.

With control valve 22 in its raised position, as depicted in FIG. 2, the port 34 of transducer 28 is blocked and sounds received by both apertures 18 and 20 are directed to port 30 of the transducer. The hearing aid is, consequently, responsive to both forward and rearward sounds to provide omnidirectional reception as no cancellation of sound energy is provided by reason of the inoperative state of port 34.

The directional characteristics of the hearing aid are essentially cardioid in shape, as is usual for directional microphones, and the particular shape of such characteristics can be varied as desired by adjusting the distance between apertures 18 and 20 to effectively vary the force pattern on transducer ports 30 and 34.

The invention can also be embodied in hearing aids other than behind-the-ear types; for example, the invention can be implemented in an eyeglass frame type of aid. In this embodiment, the front aperture would be disposed in the temple of an eyeglass frame forwardly of the user's ear, while the rear aperture would be disposed in the temple in a position rearwardly of the ear. A control valve is provided to selectively occlude the rear aperture to provide omnidirectional or directional sound reception as in the above embodiment. A variation of such eyeglass frame embodiment is depicted in FIG. 4 wherein both sound receiving apertures of the hearing aid are disposed forwardly of the user's ear. Referring to FIG. 4, there is shown a temple 50 of an eyeglass frame 52, the temple having a differential transducer 54 mounted therein having a front aperture 56 and a rear aperture 58, each of which is disposed on a downward facing surface of temple 50. The aperture 56 is disposed forwardly of transducer 54 and is coupled thereto by a tube 60. Aperture 58 is disposed rearwardly of aperture 56 and is coupled thereto via a tube 62. The rear aperture 58 is occluded by means of a slide switch or valve 64 to provide omnidirectional reception characteristics, and opened to provide directional reception. However, in this embodiment, the rear aperture need not be channelled to the front transducer port for omnidirectional reception, as both apertures 56 and 58 are forward of the user's ear. The associated elements of the hearing aid, such as processing electronic circuitry 66 and volume control 68, are disposed near the rearward end of temple 50 in any convenient packaging arrangement. An earpiece 70 is provided for mounting in the ear of a user and is coupled to circuitry 66 by means of a tube 72.

It will be appreciated that the invention can be implemented in different ways to suit particular operation requirements. For example, the control value can be of many different configurations to provide the intended function and the particular sound communication paths between the front and rear apertures for coupling forward and rearward sounds to the differential transducer can be selected to suit specific constructional requirements of a particular embodiment. Accordingly, it is not intended to limit the invention by what has been particularly shown and described except as indicated in the accompanying claims.

What is claimed is:

1. A hearing aid comprising:
- a differential transducer having first and second sound receiving ports;
- a housing having a forwardly facing sound receiving aperture and a rearwardly facing sound receiving aperture;
- a first sound receiving path between said forwardly facing aperture and said first transducer port;
- a second sound receiving path for selectively coupling said rearwardly facing aperture to said first or second transducer port and including
  - control valve means operative in a first position to couple sound energy received by said rearwardly facing aperture to said second sound receiving port, and in a second position to couple sound energy received by said rearwardly facing aperture to said first sound receiving port;
  - electronic circuitry for amplifying and processing sound information received by said transducer; and
  - an earpiece coupled to said circuitry and adapted to the ear of a user.

2. A hearing aid according to claim 1 wherein

said first sound receiving path includes a first passage between said forwardly facing aperture and said valve means, and a second passage between said first passage and said first transducer port; and

said second sound receiving path includes a third passage between said rearwardly facing aperture and said valve means, and a fourth passage between said valve means and said second transducer port;

said valve means being operative in its first position to provide a sound receiving path through said third and fourth passages, and operative in its second position to provide a sound receiving path through said first and third passages.

3. A hearing aid according to claim 2 wherein said valve means includes
- a rotatable member disposed at the juncture of said first, third and fourth passages and having an opening therethrough for coupling said third and fourth passages in said first position, and for coupling said first and third passages in said second position; and
- a manually actuable control knob attached to said rotatable member and operative to rotate said member between said first and second positions.

4. A hearing aid comprising:
a housing adapted for disposition on the outer ear of a user and having a forwardly facing aperture for receipt of sounds from points forward of the user and a rearwardly facing aperture for receipt of sounds from points rearward of the user;
a differential transducer having first and second sound receiving ports;
a first sound receiving path between said forwardly facing aperture and said first transducer port;
a second sound receiving path for selectively coupling said rearwardly facing aperture to said first or second transducer port and including
valve means operative in a first position to couple said rearwardly facing aperture to said second sound receiving port, and operative in a second position to couple said rearwardly facing aperture to said first sound receiving port;
electronic circuitry for amplifying and processing sound information received by said transducer; and

an earpiece coupled to said circuitry and adapted to be attached to the ear of the user.

5. A hearing aid adapted to be disposed in the temple of an eyeglass frame and comprising:
a differential transducer having first and second sound receiving ports;
a first sound receiving aperture in the temple of said eyeglass frame forward of the ear position of a user;

a second sound receiving aperture in said temple of said eyeglass frame forward of the ear position of a user and rearward of the first sound receiving aperture;
a network of sound conducting paths having:
a first sound conducting passage between said first sound receiving port and said first aperture to provide generally omnidirectional sound at said first sound receiving port;
a second sound conducting passage between said second sound receiving port and said second aperture to provide sound at said second port which causes cancellation of generally rearward components of sound in the response of said transducer to the sound present at the first and second ports thereof;
a valve including a movable member located for selective occlusion of said second passage; and
a handle for moving said member between first and second positions with said member defining a portion of said second passage in said first position and with said member occluding said second passage in said second position thereby to provide a forwardly directed directional response by said transducer to said sound with said handle in said first position and a generally omnidirectional response with said handle in said second position.

6. A hearing aid comprising:
a differential transducer having first and second sound receiving ports;
a housing adapted to be worn about the ear of a user and having a forward aperture and a rearward aperture;
a network of sound conducting paths having:
a first sound conducting passage between said first sound receiving port and said first aperture to provide generally omnidirectional sound at said first sound receiving port;
a second sound conducting passage between said second sound receiving port and said second aperture to provide sound at said second port which causes cancellation of generally rearward components of sound in the response of said transducer to the sound present at the first and second ports;
a valve including a movable member located for selective occlusion of said second passage;
a handle for moving said member between first and second positions with said member defining a portion of said second passage in said first position and occluding said second passage in said second position thereby to provide a forwardly directed directional response by said transducer to said sound with said handle in said first position and a generally omnidirectional response with said handle in said second position.

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