Dec. 26, 1967 J. H. VOGELMAN 3,360,071

ACOUSTICAL COUPLER

Filed Aug. 2, 1965

FIG. 1

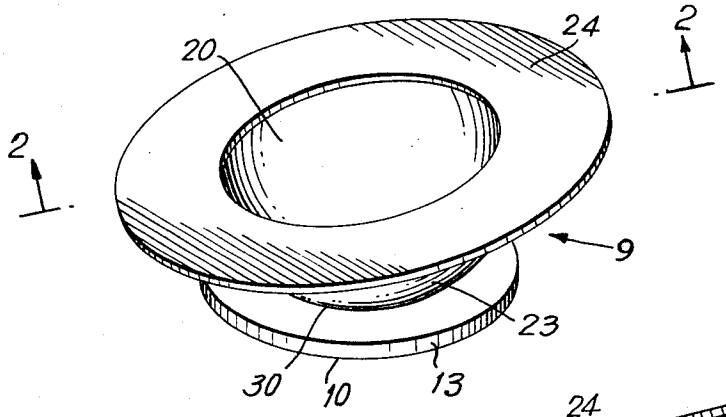


FIG. 2

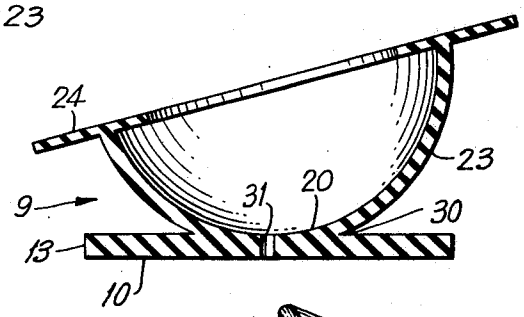
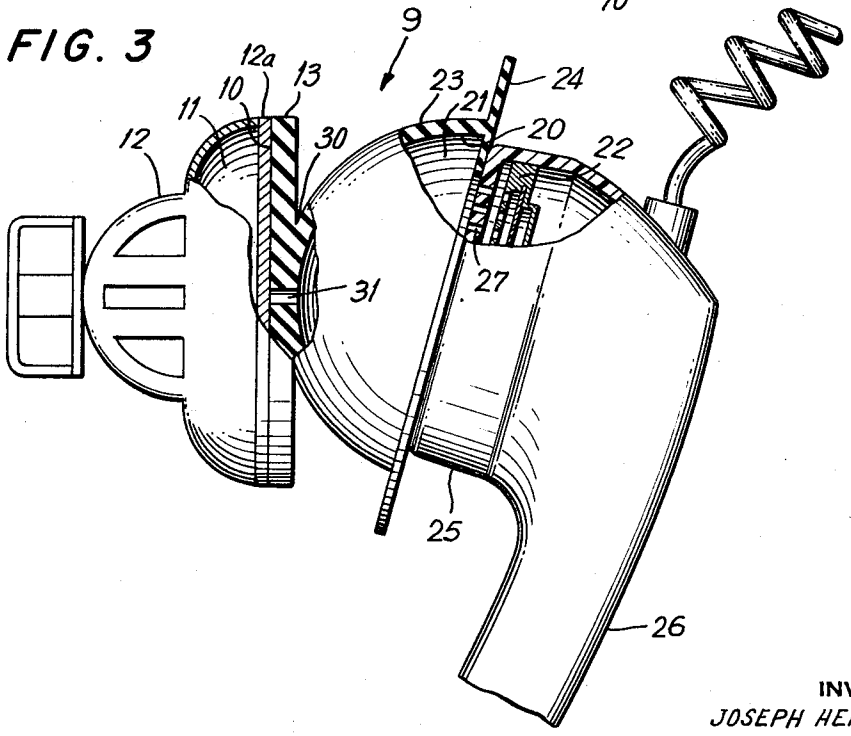


FIG. 3



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ACOUSTICAL COUPLER

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ABSTRACT OF THE DISCLOSURE

Apparatus for coupling the acoustical output of an electrical-to-acoustical transducer to the input of an acoustical-to-electrical transducer. The coupling is effected through means which are disposed between the two transducers and which form separate cavities with the acoustical chambers of the transducers. A passageway having a substantially smaller cross-sectional area than either of the cavities extends through the coupling member and between the two cavities. The composition and dimensions of the coupling member may be selected to provide the desired acoustical impedance transformation between the transducers.

The present invention relates to a device for coupling the output of an electrical-to-acoustical transducer, such as a loudspeaker, to the input of an acoustical-to-electrical transducer, such as a microphone.

Often in communications systems information must be transferred without an actual physical connection to the existing electrical circuitry. For example, it may be desired to transmit the voice of an incoming call to a telephone to some remote location via a wireless radio frequency system or, alternatively, to transmit the voice of an incoming signal to a radio frequency receiver to some remote location via a telephone system. In many areas, the telephone companies prohibit actual physical connections to be made to the existing telephone circuitry.

In the past, in such situations electromagnetic and electrostatic pickup devices have been used since such devices do not require an actual connection to the circuitry. There are, however, many instances where such devices may not be used or are undesirable for one reason or another. Where, for example, a carbon or crystal microphone is being used in the system to which the information is to be transferred, neither an electrostatic nor an electromagnetic pickup device may be employed since both the carbon and crystal microphones are purely pressure sensitive devices. In addition, where the electric and magnetic fields to which the electrostatic and electromagnetic devices respond are inaccessible or these fields are too weak to be sensed by these devices, electrostatic and electromagnetic pickup devices may not be used.

In the past some attempts have been made to acoustically couple the output of a loudspeaker to the input of a microphone. Generally, the devices employed were air tubes arranged to couple as much of the sound as possible and limit the energy loss to a minimum. No adequate consideration was given to the development of a proper acoustical impedance transformation between the two transducers. Without the proper impedance transformation the sound being coupled is apt to be distorted, thereby subjecting a listener to discomfort or if the distortion is great there is a loss in intelligibility.

It is an object of the present invention to provide a new and improved acoustical coupler.

A feature of an acoustical coupler constructed in accordance with the present invention is that a wide range of desired acoustical impedance transformations may be developed between the two transducers being coupled together. Where an accurate reproduction of the sound

emanating from a loudspeaker is desired, the coupler is arranged to provide an optimized acoustical impedance transformation. If, on the other hand, accentuation of certain portions of the audio frequency range is desired, the acoustical coupler may be arranged to have a shaped frequency response.

Another feature of an acoustical coupler constructed in accordance with the present invention is that the sound is coupled with little or no energy loss. Thus, low-level sounds are not lost in the coupling.

It is a further object of the present invention to provide a new and improved acoustical coupler which is simple in construction and inexpensive to fabricate.

One acoustical coupler constructed in accordance with the present invention, to be described hereinbelow, includes a first surface of selected material for forming a first cavity with the acoustical chamber of an electrical-to-acoustical transducer and a second surface of selected material for forming a second cavity with the acoustical chamber of an acoustical-to-electrical transducer. This coupler also includes a passageway running from the first surface to the second surface for interconnecting the first and second cavities. The hardness of the first and second surfaces and the shapes and dimensions of the first and second surfaces and the passageway are so selected that a desired acoustical impedance transformation is developed between the two transducers.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description, taken in connection with accompanying drawing, and its scope will be pointed out in the appended claims.

Referring to the drawing:

FIGURE 1 is a perspective view of one embodiment of an acoustical coupler constructed in accordance with the present invention;

FIGURE 2 is a cross-section view taken along line 2—2 of FIGURE 1; and

FIGURE 3, partially in section, shows the acoustical coupler of FIGURES 1 and 2 interposed between a loudspeaker and the mouthpiece of a telephone.

Referring to the drawing, an acoustical coupler constructed in accordance with the present invention and designated generally by reference numeral **9** includes first and second surfaces **10** and **20**, respectively, each of particularly selected materials. Surface **10** is the bottom surface, as viewed in FIGURES 1 and 2, of a member **13** which, for the embodiment illustrated, is substantially flat. Surface **20** is the inside surface of a member **23** which, for the embodiment illustrated, is substantially cup-shaped. Member **23** is provided with a flanged rim portion **24** along its open end. Members **13** and **23** are made of a soft material such as 30 Durometer neoprene. As will become apparent from the description that follows, members **13** and **23** may be both of the same material or of different materials.

Members **13** and **23** are joined together along a line designated by reference numeral **30**. For the construction illustrated the two members are preferably formed as a single unit. Passing through members **13** and **23** and running from surface **10** to surface **20** is a passageway **31** of circular cross-section for the embodiment illustrated.

FIGURE 3 shows how the acoustical coupler **9** may be interposed between a loudspeaker **12** and the microphone **22** in the mouthpiece **25** of a telephone handset **26**. Surface **10** of member **13** serves to form a first cavity with the acoustical chamber of the loudspeaker **12** as surface **10** is positioned against the rim **12***a* of the loudspeaker. The cavity formed by the acoustical chamber of the loudspeaker **12** and the surface **10** corresponds to

the space **11** within the acoustical chamber of the loudspeaker.

Surface **20** serves to form a second cavity with the acoustical chamber of the microphone **22** as the flanged rim portion **24** of member **23** is positioned against the rim of the mouthpiece **25**. The cavity formed by the acoustical chamber of the microphone **22** and the surface **20** corresponds to the space **21** bounded by surface **20** and the relatively shallow space within the acoustical chamber of the microphone. Although the mouthpiece structure and the narrow passages **27** in the mouthpiece serve merely to support the microphone and permit the passage of sound to the microphone, the passages **27** are also part of the cavity formed by the acoustical chamber of the microphone and the surface **20**. In this connection, there is apt to be an addition to the cavity **11** if the loudspeaker **12** were mounted for support in some suitable structure. In such a case, the member **13** could not be positioned flush against the rim **12***a*.

The acoustical coupler **9** operates by converting a volume source, in particular, cavity **11** within the loudspeaker **12**, into a point or cylindrical source, in particular, the passageway **31**. The sound waves pass through the passageway **31** and enter cavity **21** by acoustic diffraction. By providing air-tight fits at the points at which the surface **10** bears against the rim **12***a* and the flanged rim **24** bears against the mouthpiece **25**, leakage into or out of the chamber is prevented thereby reducing the introduction of distortion and the possibility of any energy loss in the coupling.

The particular acoustical impedance transformation effected between any two transducers by an acoustical coupler constructed in accordance with the present invention is dependent upon the materials used for surfaces **10** and **20** and members **13** and **23**, the shapes and dimensions of the surfaces **10** and **20** and members **13** and **23**, the shape and dimensions of the passageway **31**, and the shapes, dimensions and materials employed in the acoustical chambers of the two transducers. It is within the scope of the present invention to select whatever appropriate materials, shapes and dimensions are needed for the variables just enumerated to arrive at the desired combination which will provide the desired acoustical impedance transformation between two selected transducers. The various parameters are interdependent so that the same impedance transformation is possible with a number of different combinations. The selection of materials, shapes and dimensions is dependent upon the combined effect of the values selected and the desired acoustical impedance transformation. In one application, it may be desired to supply to the microphone **22** an accurate reproduction of the sound emanating from the loudspeaker **12** in which case the acoustical coupler **9** is designed to have an optimized acoustical impedance transformation. On the other hand, where it is desired to accentuate certain portions of the audio frequency range and to attenuate other portions, the acoustical coupler may be designed to have a shaped frequency response. Generally, the cross-sectional areas of the members **13** and **23** will be substantially greater than the cross-sectional area of the passageway **31**. The cross-sectional area of the passageway **31** is proportional to the lowest wavelength which is to be passed by the coupler. Thus, for lower wavelengths, the passageway **31** is made larger.

The following values have been found especially advantageous for the particular application described herein, resulting in a passband extending from 300 c.p.s. to 3000 c.p.s.:

Material of members **13** and **23**, 30 Durometer neoprene.
O.D. member **13**, 2¾″.
Thickness of member **13**, 3/16″.
Center of curvature of member **23**, 1.45″ from surface **10** along axis of passageway **31**.
Inside radius of member **23**, 1.264″.
Thickness of member **23**, 3/32″.

O.D. flanged rim portion **24**, 3 7/16″.
I.D. flanged rim portion **24**, 2 1/32″.
Thickness of flanged rim portion **24**, 0.62″.
Diameter of passageway **31**, 1/16″.
Angle between plane of flanged rim portion **24** and plane of member **13**, 15°.

While there has been described what is at present considered to be the preferred embodiment of this invention it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. Sound coupling apparatus comprising: first and second transducer units, one of said units including sound translating means of the type operable by electrical input signals to produce corresponding sound signals, the other of said units including sound translating means of the type operable by sound signals to produce corresponding electrical output signals; an acoustical coupler between said transducer units to transfer sound energy between the respective sound translating means thereof, said coupler including a first part of generally cup-shaped configuration and provided with a first engagement surface around the mouth of the cup, said engagement surface being engaged with a corresponding surface of said first transducer unit, the sound translating means of said first transducer unit being positioned adjacent the mouth of said cup-shaped part to serve as one wall of a first cavity within the interior spaces of said cup-shaped part; said cup-shaped part being provided with a passageway one end of which communicates with said first cavity near the bottom of the cup at least approximately opposite the sound translating means of said first transducer unit, said passageway having a small cross-sectional area adapted to conduct sound energy; said coupler further including a second part integral with said cup-shaped part and presenting a second engagement surface surrounding the other end of said small passageway, said second engagement surface being engaged with a corresponding surface of said second transducer unit, said second transducer unit being formed to define a second cavity with the sound translating means of said second transducer unit serving as one wall of said second cavity opposite said other end of said small passageway, said first and second cavities having cross-sectional areas substantially greater than that of said passageway and providing acoustic communication between both sound translating means through said passageway.

2. Apparatus as in claim **1**, wherein said first engagement surface comprises a substantially planar flange portion extending around the mouth of said cup-shaped part.

3. Apparatus as in claim **2**, wherein said second engagement surface is substantially planar.

4. Sound translating apparatus comprising: an electrical-to-acoustical transducer with sound-producing means operable by electrical input signals; an acoustical-to-electrical transducer with sound-responsive means for producing electrical output signals corresponding to received sound signals; acoustical coupling means disposed between said transducers to transfer sound energy from one to the other with high efficiency and desired frequency-response characteristics, said coupling means including first wall means contiguous with said electrical-to-acoustical transducer to form a first cavity having at one end the sound-producing means of said transducer and provided at an opposite end with an opening defining a passageway for conducting sound waves out from said first cavity, the interior surfaces of said first wall means presenting an imperforate sealed enclosure for said first cavity extending continuously from the periphery of said sound-producing means to the edges of said passageway opening so as to prevent the transmission of sound energy out from said first cavity other than through said

passageway; said coupling means further including second wall means contiguous with said acoustical-to-electrical transducer to form a second cavity having at one end an opening to said passageway and having at an opposite end the sound-responsive means of said acoustical-to-electrical transducer, the interior surfaces of said second wall means presenting an imperforate sealed enclosure for said second cavity extending continuously from the edges of said passageway opening to the periphery of said sound-responsive means so as to prevent loss of sound energy from said second cavity, said passageway providing an enclosed communication channel between said cavities having a cross-sectional area substantially smaller than the cross-sectional areas of either of said cavities to serve as an effectively point source of sound energy for transmitting sound waves by acoustic diffraction from the sealed volume of said first cavity to the sealed volume of said second cavity.

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