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(54) Tunable response transducer.

(57) A tunable response transducer (20) includes a frame (22) providing an opening (24) covered by a diaphragm and a motor (50, 52, 54) coupled to the diaphragm to cause motion of the diaphragm in response to motor action. A cavity (66) defined behind the diaphragm is vented through a second opening (26) provided in the frame. Venting through the second opening is controlled by a valve mechanism (40, 42, 44, 46) which is adjustable to vary selectively the damping of the frequency response characteristic of the transducer in the region of its principal resonant frequency.

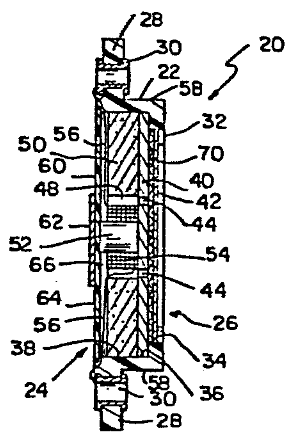

FIG. 2

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Tunable Response Transducer

This invention relates to transducers, and more specifically to a tunable response transducer such as a tunable response variable reluctance speaker.

Microphones having variable directional characteristics are known. There are, for example, the devices disclosed in U.S. Patents 3,527,902 and 3,536,862. There are also the disclosures of U.S. Patents 3,502,811; 4,327,257; and 4,363,937.

According to the invention, a transducer comprises a frame for providing first and second openings, a diaphragm for covering the first opening, a motor, means for coupling the motor to the diaphragm such that actuation of the motor excites the diaphragm, the diaphragm defining a chamber within the frame and behind the diaphragm, means defining a passageway between the chamber and the second opening, and an adjustable valve for selectively controlling air flow through the second opening to permit tuning of the diaphragm's frequency response to motor actuation.

Additionally according to the invention, the transducer comprises a variable reluctance speaker.

Further according to the invention, the motor comprises a magnet, means for mounting the magnet in the frame, a transducer coil, means for reacting to the fields provided by the magnet and the transducer coil to produce diaphragm movement, and means for coupling the reacting means to the diaphragm.

Further according to the invention, the reacting means comprises a reluctor plate, for example, a disk of ferrous material, and the means for coupling the reacting means to the diaphragm comprises means for mounting the reluctor plate from the diaphragm.

In addition, according to an embodiment of the invention, the means for selectively controlling the flow of air from the second opening comprises a plate covering the second opening, means for movably mounting the plate relative to the second opening, and means providing a port in the plate. Alignment of the port with the second opening optimizes venting of the chamber and movement of the plate into a position in which the port is less aligned with the second opening reduces the venting of the chamber.

According to another embodiment of the invention, the means for selectively controlling the flow of air from the second opening comprises a plate covering the second opening, means for movably mounting the plate relative to the second opening, and means providing a port in the plate. A porous compressible material is captured between the frame and the plate. The means for movably mounting the plate relative to the second opening includes means for selectively compressing the compressible material between the second opening and the port in the plate to control selectively the air flow between the second opening and the port in the plate.

More specifically, according to an illustrative embodiment, the means for selectively controlling the flow of air from the second opening comprises a first plate covering the second opening, means for stationarily mounting the first plate over the opening, means providing a port in the first plate, a second plate, means for movably mounting the second plate relative to the first, and means providing a port in the second plate. Alignment of the port in the first plate with the port in the second plate optimizes the venting of the chamber. Movement of the second plate into a position in which the ports in the first and second plates are less aligned reduces the venting of the chamber.

Further according to a specific illustrated embodiment, the means for selectively controlling the flow of air from the second opening comprises a first plate covering the second opening, means providing a port in the first plate, a second plate, means for movably mounting the second plate relative to the first, and means for providing a port in the second plate. A porous compressible material is captured between the first and second plates. The means for movably mounting the second plate relative to the first includes means for selectively compressing the compressible material between the first and second plates to control selectively the air flow between the port in the first plate and the port in the second plate.

Additionally according to the invention, a method for tuning the frequency response of a transducer comprises the steps of providing a transducer frame having first and second openings, with the first opening covered by a diaphragm to define a cavity behind the diaphragm and within the frame, providing a passageway between the cavity and the second opening, providing an adjustable valve for varying selectively the air flow through the second opening, driving the motor element of the transducer, testing the response of the transducer, and adjusting the valve to provide the desired frequency response.

Additionally, the method comprises the step of testing the response of the transducer after adjusting the valve.

According to another aspect of the invention, a tuned transducer is obtained by providing a transducer frame having first and second openings, with the first opening covered by a diaphragm to define a cavity within the frame and behind the diaphragm, providing a passageway between the cavity and the second opening, providing an adjustable valve for selectively varying the air flow through the second opening, driving the motor element of the transducer, testing the response of the transducer, and adjusting the valve to provide the desired transducer response.

Additionally, the transducer response is again tested after adjustment of the valve.

The invention may best be understood by referring to the following description and accompanying drawings which illustrate the invention. In the drawings:

Fig. 1 is a rear elevational view of a device constructed according to the present invention;

Fig. 2 is a sectional side elevational view of the device of Fig. 1, taken generally along section lines 2-2 thereof;

Fig. 3 is a rear elevational view of a device constructed according to the present invention;

Fig. 4 is a sectional side elevational view of the device of Fig. 3, taken generally along section lines 4-4 thereof; and

Fig. 5 illustrates in dotted line the frequency response characteristic of an untuned transducer immediately after manufacture, and in solid line the frequency response characteristic of the same transducer after tuning according to the method of the present invention.

Turning now to Figs. 1 and 2, a tunable response transducer 20 includes a frame, or basket, 22, illustratively molded from a resin. The basket 22 is generally right circular cylindrical in configuration, and provides a front opening 24 and a rear opening 26. Basket 22 is provided with radially outwardly extending ears 28 disposed generally diametrically from each other. Each of ears 28 is provided with an eyelet 30 for mechanical mounting purposes, as well as to provide electrical terminations to the components inside the basket 22.

An annular lip 32 is provided around the perimeter of rear opening 26. As best seen in Fig. 2, the annular lip includes a rearward radially inner step 34 and a forward radially outer step 36. Step 36 steps out to the dimension of the generally right circular cylindrical inner wall 38 of basket 22. The rear opening 26 is covered by two generally circular flat plates 40, 42. The diameter of plate 42 is such that it fits within the diameter of step 34 with sufficient clearance to be rotated when force is applied to rotate it. When no force is applied to plate 42, however, the frictional engagement between plate 42 and step 34 is sufficient to hold plate 42 in its adjusted position. The diameter of plate 40 is sufficient that it is stationary within the inner wall 38.

Plate 40 serves as the pole plate for the transducer 20. Plate 40 is provided with a plurality of ports 44, illustratively four. Plate 42 is provided with a plurality of ports 46, also illustratively four in number. The ports 44, 46 are spaced sufficiently close together that they all lie within the diameter of the center opening 48 provided in a right circular cylindrical magnet 50 positioned within the inner wall

38 against plate 40. Magnet 50 may be mounted in the basket 22 by the use of an adhesive. Plate 40 is provided with a pole piece 52 which extends generally coaxially within the center opening 48. Pole piece 52 is generally right circular cylindrical in configuration. A stationary coil 54 surrounds pole piece 52, and includes leads 56 which extend through the side wall 58 of basket 22 and terminate at respective eyelets 30.

The front opening 24 is closed by a phenolic, or the like, film diaphragm 60 which is glued or otherwise attached to the basket 22 edge surrounding the front opening 24. Although not illustrated, the diaphragm may be formed with concentric compliances in it. A reluctor plate 62 is glued or otherwise attached to the outside surface 64 of diaphragm 60. The reluctor plate is typically constructed from a ferromagnetic stainless steel.

Application of audio frequency voltage across eyelets 30 results in the passage of current through the coil 54 and variation of the reluctance in the center opening 48. This results in the application of force to the reluctor plate 62, causing the plate 62 and the diaphragm 60 to which it is coupled to react, converting the audio frequency electrical voltage applied across eyelets 30 to acoustical energy. The cavity 66 formed behind diaphragm 60 is vented through the region of the center opening 48 radially outside the coil 54 and the ports 44, 46 to atmosphere. As best illustrated in Fig. 1, plate 42 is provided with spanner wrench holes 68 which can be engaged by a spanner wrench to rotate plate 42 to vary the alignment between ports 44, 46. Alignment of the ports 44, 46 in the first and second plates 40, 42, respectively, optimizes the venting of the cavity 66. Rotation of plate 42 into a position in which the ports 44, 46 are less aligned reduces the venting of the cavity 66 and dampens the response of the transducer 20 in the vicinity of the principal resonant frequency of the moving system. A layer 70 of woven material is inserted between plates 40, 42 to enhance the tuning effect of this adjustment.

Turning now to the embodiment of Figs. 3 and 4, a tunable response transducer 120 includes a frame, or basket, 122. The basket 122 is generally right circular cylindrical in configuration, and is provided with a front opening 124 and a rear opening 126. Basket 122 is provided with generally diametrically disposed, radially outwardly extending ears 128. Each of ears 128 is provided with an eyelet 130 for mechanical mounting purposes and electrical termination.

An annular lip 132 is provided around the perimeter of rear opening 126. As best seen in Fig. 4, the annular lip includes a rearward radially inner step 134 and a forward radially outer step 136. Step 136 steps out to the dimension of the generally right circular cylindrical inner wall 138 of basket 122. The rear opening 126 is covered by two generally circular flat plates 140, 142. The diameter of plate 142 is such that it fits within the diameter of step 134 with sufficient clearance to be moved axially of inner wall 138 relative to plate 140. The diameter of plate 140 is sufficient that it is maintained stationary within the inner wall 138. A screw-threaded opening 141 is provided at the center of plate 140. An unthreaded opening 143 is provided at the center of plate 142. A layer 147 of a woven material is inserted between plates 140, 142. A screw 145 is passed through opening 143 and cloth 147, and is threaded into opening 141.

Plate 140 serves as the pole plate for the transducer 120. Plate 140 is provided with a plurality of ports 144, illustratively four. Plate 142 is provided with a plurality of ports 146, also illustratively four. The ports 144, 146 are spaced sufficiently close together that they all lie within the diameter of the center opening 148 provided in a right circular cylindrical magnet 150 positioned within the inner wall 138 against plate 140. Magnet 150 may be mounted in the basket 122 by the use of an adhesive. Plate 140 is provided with a pole piece 152 which extends generally coaxially within the center opening 148. Pole piece 152 is generally right circular cylindrical in configuration. A stationary coil 154 surrounds pole piece 152, and includes leads 156 which extend through the side wall 158 of basket 122 and terminate at respective eyelets 130.

The front opening 124 is closed by a phenolic, or the like, film diaphragm 160 which is glued or otherwise attached to the basket 122 edge surrounding the front opening 124. A reluctor plate 162, typically constructed from a ferromagnetic stainless steel, is glued or otherwise attached to the outside surface 164 of diaphragm 160.

Application of audio frequency voltage across eyelets 130, the input terminals, results in the passage of current through the coil 154 and variation of the reluctance in the center opening 148. This results in the application of force to the reluctor plate 162, causing the plate 162 and the diaphragm 160 to which it is coupled to react, converting the audio frequency electrical voltage applied across eyelets 130 to acoustical energy. The cavity 166 behind diaphragm 160 is vented through the region of the center opening 148 radially outside the coil 154 and the ports 144, 146 to atmosphere. As best illustrated in Fig. 4, tightening of screw 145 compresses the woven material 147. The venting of cavity 166 through ports 144, woven material 147, and ports 146 can be controlled by controlling this compression of the layer of woven material. This permits selective tuning of the dampening of the response of transducer 120 in the vicinity of its principal resonant frequency. Other techniques which can be used to tune the stiffness of the transducer include, without limitation, the use of screw-adjustable valves, and combined rotary plate port-alignment and woven layer-compression techniques. Of course, the configuration of the ports and the types of woven materials are also variable to achieve desired damping and tuning effects.

Referring now to Fig. 5, immediately after assembly, a device of the type illustrated in Figs. 1-4 can have a frequency response characteristic like that illustrated in dotted line. Testing of the frequency response of the device immediately after manufacture yields this frequency response characteristic. The device is then tuned, illustratively by rotation of the plate 42 with a spanner wrench (Figs. 1-2), or by loosening or tightening of the screw 145 to reduce or increase, respectively, the compression of the layer 147 of woven material (Figs. 3-4) until the frequency response characteristic is "flattened" somewhat in the operative range of the transducer, to achieve a characteristic such as that illustrated in solid line in Fig. 5. Typically, after tuning, the transducer is tested again to ensure that its frequency response is satisfactorily flattened.

CLAIMS

1. A transducer comprising a frame for providing first and second openings (24,26; 124,126), a diaphragm (60; 160) for covering the first opening (24; 124), a motor (50,52,54; 150,152,154), means for coupling the motor to the diaphragm such that actuation of the motor excites the diaphragm, the diaphragm defining a chamber (66;166) within the frame and behind the diaphragm, characterised by means defining a passageway (48;148) between the chamber and the second opening, and an adjustable valve (40,42,44, 46;140,142,144,146) for selectively controlling air flow through the second opening (126).

2. A transducer according to claim 1, characterised in that the transducer comprises a variable reluctance speaker.

3. A transducer according to claim 1 or 2, characterised in that the motor comprises a magnet (50;150), means for mounting the magnet in the frame, a transducer coil (54;154),means for reacting to the fields provided by the magnet and the transducer coil to produce diaphragm movement, and means for coupling the reacting means to the diaphragm.

4. A transducer according to claim 3, characterised in that the reacting means comprises a reluctor plate (62;162) and the means for coupling the reacting means to the diaphragm comprises means for mounting the reluctor plate on the diaphragm.

5. A transducer according to claim 3 or 4, and further characterised by means for mounting the transducer coil (54;154) stationarily with respect to the magnet (50;150).

6. A transducer according to any one of the preceding claims, characterised in that the valve comprises a plate (42;142) covering the second opening, means (32;132) for movably mounting the plate relative to the second

opening and a port (46;146) in the plate.

7. A transducer according to any one of claims 1 to 5, characterised in that the valve comprises: a plate (142) covering the second opening; means for movably mounting the plate relative to the second opening; a port (146) in the plate; and a porous compressible material (147) captured between the frame and the plate (142), the means for movably mounting the plate relative to the second opening including means (145) for selectively compressing the compressible material (147) between the second opening and the port (146) in the plate.

8. A transducer according to any one of claims 1 to 5, characterised in that the valve comprises a first plate (40;140) covering the second opening, means for stationarily mounting the first plate over the opening, means providing a port (44;144) in the first plate, a second plate (42;142), means (32;132) for movably mounting the second plate relative to the first, and a port (46;146) in the second plate.

9. A transducer according to any one of claims 1 to 5, characterised in that the valve comprises a first plate (140) covering the second opening, a port (144) in the first plate, a second plate (142), means (143) for movably mounting the second plate (42;142) relative to the first, a port in the second plate, a porous compressible material captured between the first and second plates, the means (145) for movably mounting the second plate (142) relative to the first (140) including means (145) for selectively compressing the compressible material between the first and second plates (140,142).

10. A method for tuning the frequency response of a transducer comprising the steps of providing a transducer frame having first and second openings (24,26; 124,126), with the first opening (24;124) covered by a diaphragm (64;164) to define a cavity (66;166) behind the diaphragm and within the frame, and with a passageway between the cavity and the second opening, characterised

in that an adjustable valve is provided for varying selectively the air flow through the second opening (26;126), and further characterised by the steps of driving the motor element (50,52,54;150,152,154) of the transducer, testing the response of the transducer, and adjusting the valve (40,42,44,46;140,142,144,146).

11. A method according to claim 10, and further characterised by the step of again testing the response of the transducer after adjusting the valve.

12. A tuned transducer obtained by providing a transducer frame having first and second openings (24,26;124,126), the first opening (24;124) covered by a diaphragm (64;164) to define a cavity (66;166) within the frame and behind the diaphragm, providing a passageway (48;148) between the cavity and the second opening, providing an adjustable valve (40,42,44,46;140,142,144,146) for selectively varying the air flow through the second opening, driving the motor element (50,52,54;150,152,154) of the transducer, testing the response of the transducer, and adjusting the valve.

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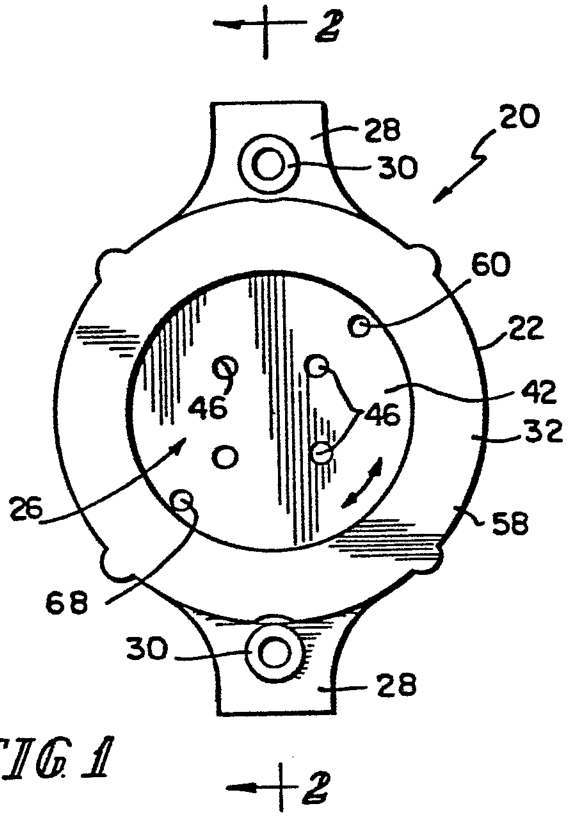


FIG. 1

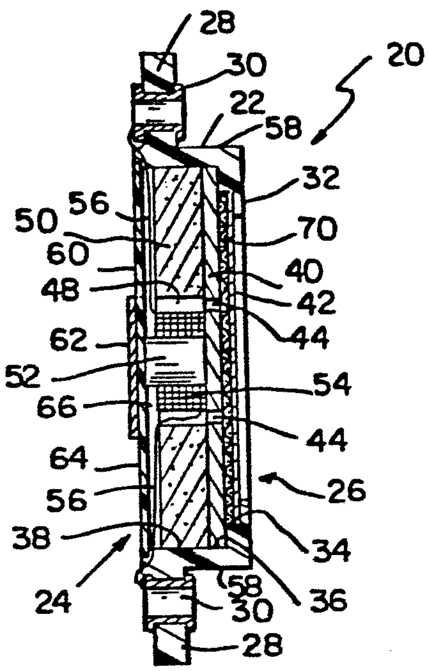


FIG. 2

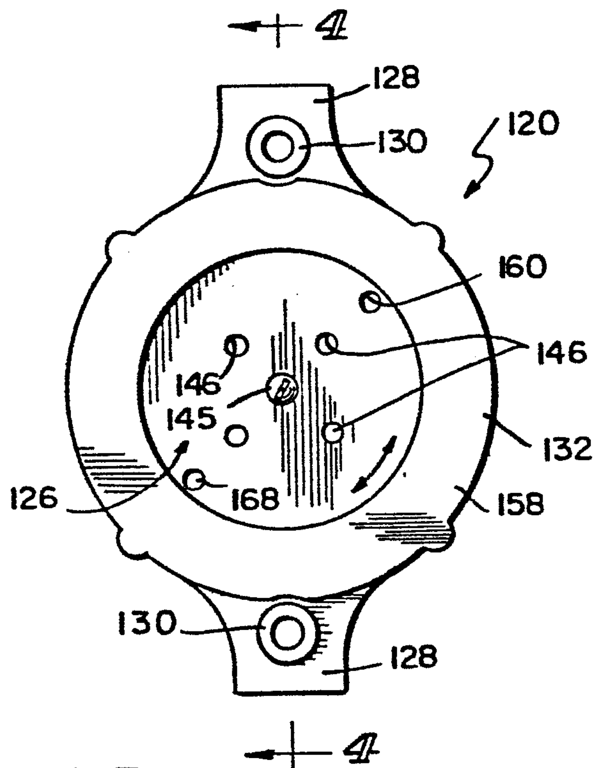


FIG. 3

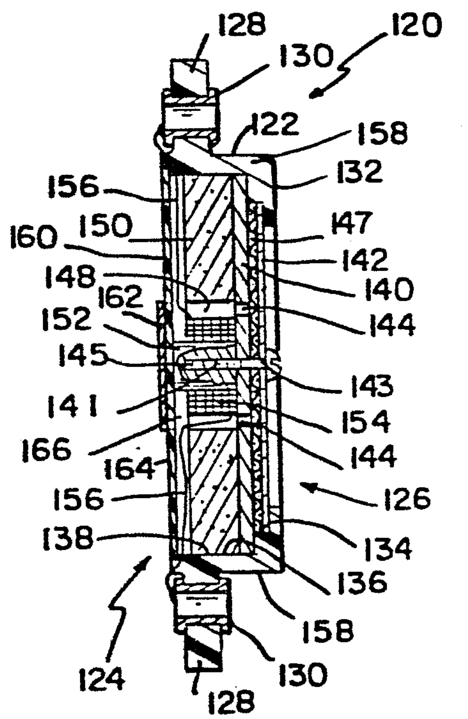
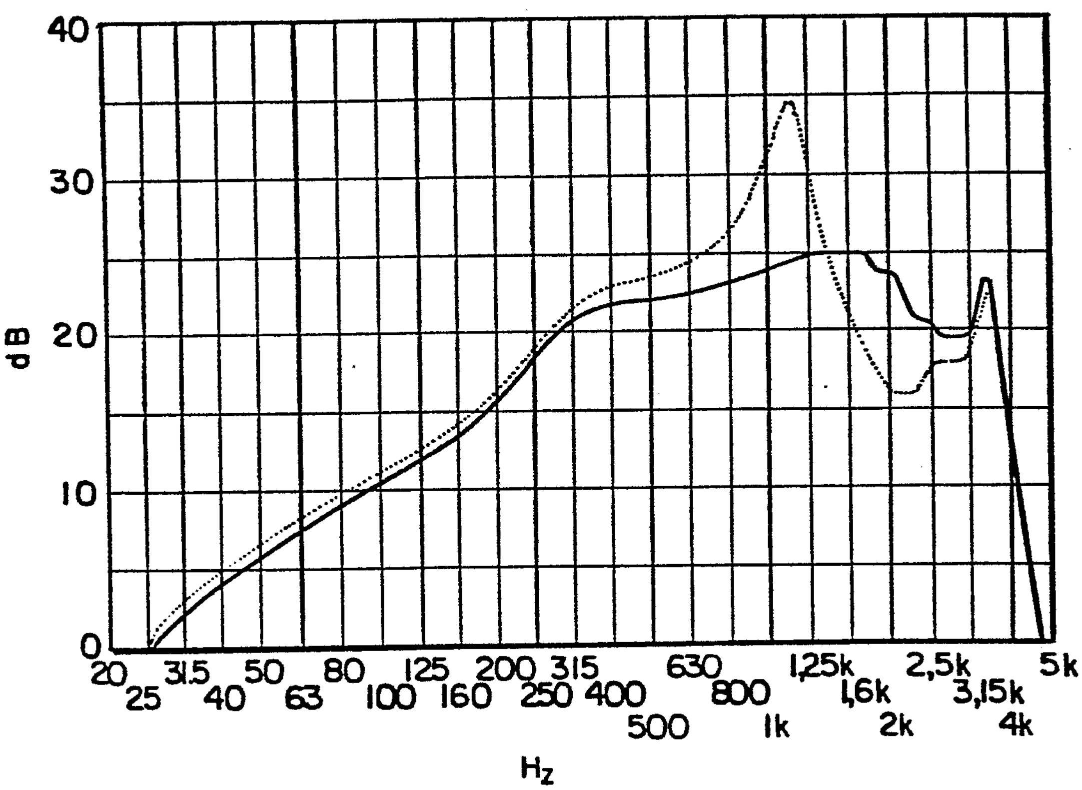


FIG. 4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2k
2,5k
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FIG. 5