

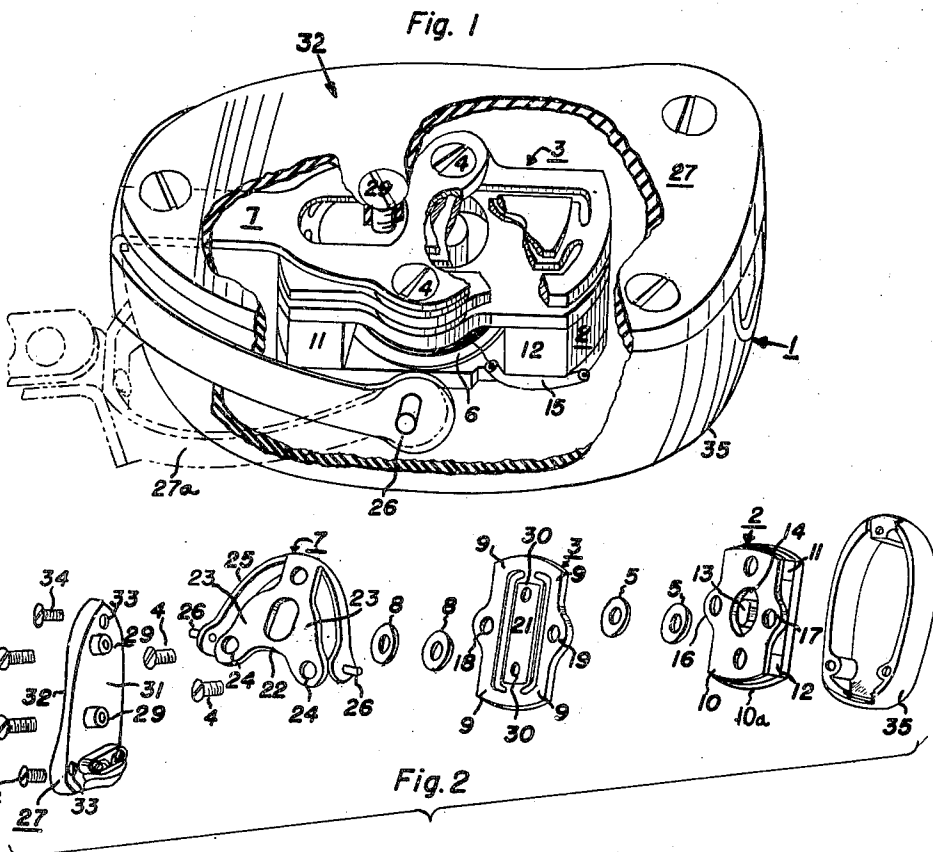
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ELECTROMAGNETIC BONE VIBRATOR

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ELECTROMAGNETIC BONE VIBRATOR

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This invention relates to electro-mechanical transducers and more specifically to such devices operable in the audio frequency range.

In electro-mechanical transducers having a driving member upon which signal voltages are impressed and a driven member supported from the driving member at an optimum distance therefrom wholly by resilient arms or members, oppositely disposed stresses on the driving member and the driven member tend to distort the resilient members. If this distortion exceeds the limits of elasticity of the resilient members permanent distortion results, the optimum spacing of the driving and driven members is destroyed, and the performance of the transducer is impaired.

Therefore, it is a principal object of this invention to provide an improved electro-mechanical transducer incorporating means for preventing permanent distortion of the resilient members linking the driving and driven members.

Another object of this invention is to provide an electro-mechanical transducer unit having extended longevity.

It is a further object of this invention to provide an improved bone conduction hearing aid receiver having a sensitivity substantially unaffected by handling of the receiver.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with accompanying drawing in which:

Figure 1 is a perspective view, partly broken away, of a device embodying this invention;

Figure 2 is an exploded view of the device of Figure 1.

In Figures 1 and 2 transducer 1 includes an electromagnetic structure 2 arranged to generate a magnetic field, a diaphragm 3 supported in that magnetic field by attaching means, such as screws 4, and separated from electromagnetic structure 2 by diaphragm spacers 5. Winding 6 is arranged, when excited by signal currents, to vibrate diaphragm 3. Frame 7 is supported from electromagnetic structure 2 and is separated therefrom by diaphragm 3, diaphragm spacers 5, and frame spacers 8, at a distance such that it serves as a stop to prevent the separation of diaphragm 3 from structure 2 from becoming

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large enough to stress arms 9 beyond their elastic limit.

In detail, electromagnetic structure 2, which may be called the driving member, includes a ferromagnetic framework having front and back plates 10 and 10a, and permanent magnets 11 and 12 supported therebetween and arranged to have like poles in contact with opposite ends of front plate 10. In addition, the framework includes core 13 supported on the back plate 10a of the framework and extending through a hole 14 in the front plate 10 whereby a constant reinforced magnetic field flows from permanent magnets 11 and 12 through core 13, and flux exists across gap 14. Winding 6 on core 13 is arranged to produce a varying magnetic field when signal voltages are impressed thereon through leads 15. Threaded openings 16 and 17 are provided in front plate 10 to receive screws 4.

The varying magnetic flux produced by signal voltages impressed on winding 6 is superimposed on the constant magnetic flux flowing from permanent magnets 11 and 12 through front or top plate 10, gap 14, core 13 and back plate 10a back to the respective magnet.

Armature 21 of diaphragm 3, being ferromagnetic and being supported in the magnetic flux path, over gap 14 between top plate 10 and core 13 by symmetrically disposed spring arms 9, assumes a static position near core 13 when no signal voltage is impressed on winding 6 and vibrates about that position, without touching core 13, when a signal voltage is impressed on winding 6.

Screws 4 pass through openings 18 and 19 in spring arms 9 to secure those arms 9 on electromagnetic structure 2.

The structure thus far described is identical with that shown and described in U. S. Patent No. 2,459,325, titled "Bone conduction unit," issued January 18, 1949, to Hugh S. Knowles and assigned to the same assignee as the present application. In that structure oppositely disposed stresses on armature 21 and electromagnetic structure 2, respectively, may tend to separate the two excessively. Excessive separation causes spring arms 9 to be distorted beyond their elastic limit, and the static separation of armature 21 from core 13 is increased.

The spacing of armature 21 from core 13 is in part determined, when spring arms 9 are not permanently distorted, by the thickness of diaphragm spacers 5. The thickness of these spacers is chosen so that armature 21 just fails to strike core 13 when the amplitude of vibration of arma-

ture 21 is a maximum. The spacing must not be greater than that necessary to assure such clearance because, for maximum sensitivity, the reluctance of the magnetic circuit including armature 21 should be a minimum. A minimum length of air gap between armature 21 and electromagnetic structure 2 assures minimum reluctance in the magnetic circuit. For a given magnetomotive force the density of the flux produced is then a maximum and the sensitivity of the transducer is also a maximum.

Cross-arm or stop 22 of frame 7 is provided to prevent the separation of armature 21 and core 13 from becoming sufficient to distort spring arms 9 permanently. Yoke 23 of frame 7 is integral with cross arm 22 and includes openings 24 through which screws or other attaching means 4 pass to secure frame 7 to electromagnetic structure 2.

When transducer 1 is assembled frame 7 is separated from electromagnetic structure 2 by frame spacers 8, diaphragm 3 and diaphragm spacers 5. Therefore, cross-arm or stop 22 passes over armature 21 at a fixed distance from electromagnetic structure 2. The separation of armature 21 from electromagnetic structure 2 cannot exceed this distance. The thickness of frame spacers 8 is chosen so that armature 21 does not strike frame 7 when the amplitude of vibration of armature 21 is a maximum. The thickness is sufficiently small, however, so that armature 21 will strike cross-arm 22 before spring arms 9 are distorted beyond their elastic limit.

Bracket 25 of frame 7 is integral with yoke 23 and contains pins 26 to which headband 27a is removably attached to provide means for supporting transducer 1 upon the human head.

A contact member 27 is coupled to armature 21 by means of screws or fasteners 28 passing through studs 29 into threaded openings 30 in armature 21. When transducer 1 is assembled studs 29 with armature 21 form a channel 31 through which cross-arm or stop 22 passes, free from contact with contact member 27, studs 29 or armature 21. Therefore, contact member 27 is free to respond to the vibrations of armature 21.

The outer surface 32 of contact member 27 is so shaped that transducer 1 fits the skull structure closely and comfortably when transducer 1 is worn upon the head, to assure efficient transmission of vibratory energy from transducer 1 to the skull structure. Openings 33 in contact member 27 permit passage of screws 34 to attach case 35 which surrounds and protects the internal elements of transducer 1.

In applications involving the placement of transducer 1 upon the head in contact with the skull structure near the auditory canal it is customary to grasp case 35 in one hand and headband 27a in the other, spreading headband 27a so that it slips over and springs back upon the head.

As long as transducer 1 is held so that during this operation the side of transducer 1 formed by contact member 27 faces inward towards the head of the wearer the stress appearing in diaphragm 3 tends to force armature 21 towards electromagnetic structure 2 and transducer 1 is not damaged. However, transducer 1 often becomes twisted by catching in the hair or clothing of the wearer so that the stresses appearing in diaphragm 3 tend to separate armature 21 from electromagnetic structure 2. Also, in removing the transducer from the pocket and in many other normal phases of handling the transducer, stresses

occur which tend to separate armature 21 of diaphragm 3 from electromagnetic structure 2 to an extent which would permanently distort spring arms 9 and would damage the transducer were it not for the existence of cross arm or stop 22 which limits that separation and preserves the sensitivity of the transducer.

In actual tests on a transducer embodying a stop like that of this invention, negligible loss of sensitivity was detected after large distorting forces had been applied. These distorting forces were of the type which would be produced by mishandling of the unit. In a corresponding transducer lacking a stop like that of this invention a loss of sensitivity of approximately 6 decibels occurred as a result of an equal amount of mishandling.

While a particular embodiment of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In combination, an electromagnetic structure arranged to generate a magnetic field, a diaphragm disposed in said magnetic field and arranged to vibrate in response to variations in the strength of said field, a contact member linked mechanically to said diaphragm and caused to vibrate thereby, and a cross arm supported from said electromagnetic structure, disposed between said contact member and said diaphragm, and separated from said diaphragm by a distance such that the maximum possible separation of said diaphragm from said electromagnetic structure due to oppositely disposed forces on said contact member and said electromagnetic structure is less than that required to produce permanent distortion of said diaphragm.

2. An electro-mechanical transducer including an electromagnetic structure arranged to generate a magnetic field, a diaphragm arranged to vibrate in said magnetic field in response to variations in the strength of said field, a contact member attached to said diaphragm and vibrated thereby, and a frame attached to said electromagnetic structure, said diaphragm being subjected to mechanical stress by simultaneous handling of said contact member and said frame, said stress tending permanently to distort said diaphragm, said frame being provided with a stop member disposed between said diaphragm and said contact member in the region of maximum displacement of said diaphragm and separated from said diaphragm by a distance such that the maximum possible displacement of said diaphragm from said electromagnetic structure is so small that damaging distortion of said diaphragm cannot occur.

3. An electro-mechanical transducer including an electromagnetic structure arranged to generate a magnetic field, a diaphragm having an armature portion and a spring arm portion integral therewith, said spring arm portion being secured to said electromagnetic structure and supporting said armature in the magnetic field of said electromagnetic structure, said armature being free to respond to variations in said field, a contact member attached to said armature portion of said diaphragm and caused to vibrate thereby, and a frame supported on said electro-

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magnetic structure including a cross arm, said cross arm passing between and being free from contact with said diaphragm and said contact member, said cross arm being separated from said diaphragm by such a distance that oppositely disposed stresses on said contact member and said electromagnetic structure can separate said diaphragm from said electromagnetic structure a distance less than that necessary to produce permanent distortion of said spring arm portion of said diaphragm.

4. A hearing aid bone conduction electro-mechanical transducer including an electromagnetic structure arranged to generate a magnetic field, a diaphragm supported from said electromagnetic structure in the magnetic field thereof, said diaphragm being arranged to vibrate in response to variations in said field, diaphragm spacers separating said diaphragm from said electromagnetic structure to allow free vibration of said diaphragm, a frame supported from said electromagnetic structure including a cross arm arranged to pass over said diaphragm on the side of said diaphragm opposite said electromagnetic structure and separated from said diaphragm in the static position of said diaphragm by a distance such that the maximum possible separation of said diaphragm from said electromagnetic structure is less than that necessary to produce permanent distortion of said diaphragm.

5. A hearing aid bone conduction receiver including an electromagnetic structure arranged to generate a magnetic field, a diaphragm supported from said electromagnetic structure in a mag-

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netic field thereof, said diaphragm being responsive to variations in the strength of said field, diaphragm spacers separating said diaphragm from said electromagnetic structure to allow free vibration of said diaphragm, a contact member attached to said diaphragm and caused to vibrate thereby, said contact member being adapted to be placed in contact with the skull structure near the auditory canal, a framework supported from said electromagnetic structure including a stop member arranged to pass between and to be normally free from contact with said diaphragm and said contact member, said cross arm being separated from said diaphragm in the static position of said diaphragm by a distance such that the maximum displacement of said diaphragm from said electromagnetic structure due to oppositely disposed forces on said contact member and said electromagnetic structure is insufficient to produce damaging distortion of said diaphragm.

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