United States Patent [19]

Barrow

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[45] **Feb. 13, 1973**

[54] **PIEZOELECTRIC TRANSDUCER HAVING SPIDER-LIKE FRAME STRUCTURE**

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[73] Assignee: **Massa Division, Dynamics Corporation of America**, Hingham, Mass.

[22] Filed: **Oct. 19, 1970**

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[52] **U.S. Cl.**.....**179/110 A**, 310/8.2, 310/9.4

[51] **Int. Cl.** **H04r 17/00**

[58] **Field of Search**.....179/110 A, 179; 310/8.2, 9.4; 340/8 L, 8 FT, 10, 15

[56] **References Cited**

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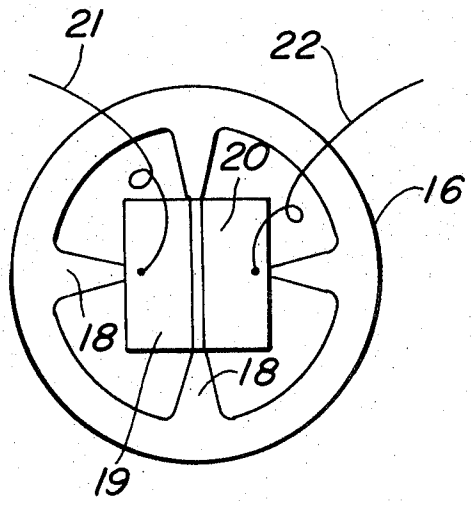
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Primary Examiner—Ralph D. Blakeslee
Assistant Examiner—Thomas L. Kundert
Attorney—Louis Bernat

[57] **ABSTRACT**

A piezoelectric ceramic element is assembled in a spider-like frame member. The piezoelectric element and the frame cooperate to form a bilaminar vibrator with combined dimensions that determine the resonant frequency. In addition, a sound opaque mask, contained within a second spider-like frame structure, may be assembled in alignment with the spider-like frame structure containing the bilaminar piezoelectric transducer element. The mask covers a portion of the bilaminar element which vibrates out-of-phase with those other portions of the element that are exposed to the medium.

11 Claims, 6 Drawing Figures



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FIG - 1

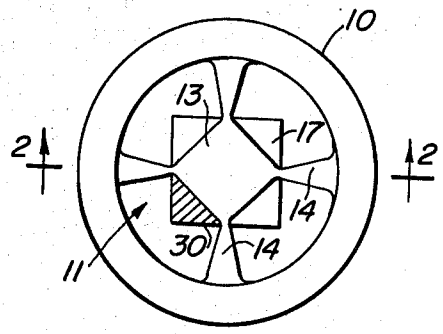


FIG - 4

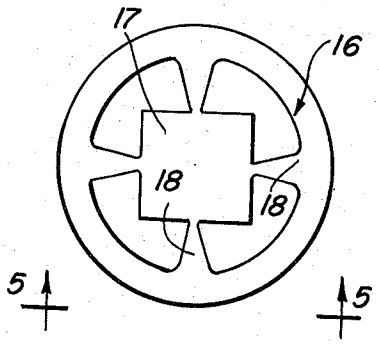


FIG - 2

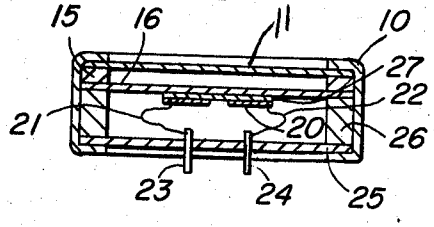


FIG - 5

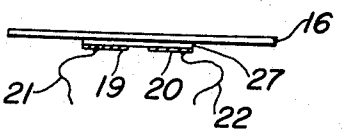
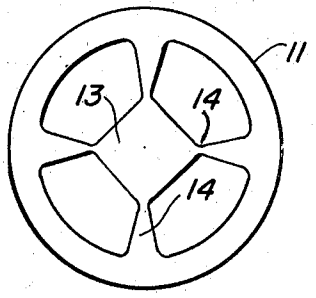


FIG - 3



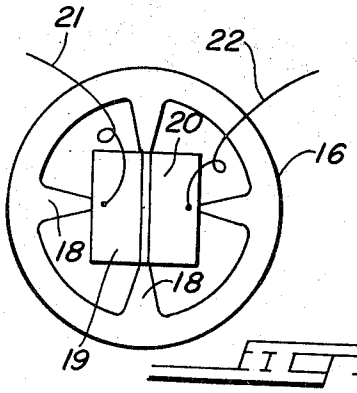


FIG - 6

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PIEZOELECTRIC TRANSDUCER HAVING SPIDER-LIKE FRAME STRUCTURE

This invention relates to piezoelectric transducers and more particularly to transducers with sound masks which block out-of-phase signals.

For more information about transducers of the described type, reference may be had to a co-pending application Ser. No. 17,430, filed Mar. 9, 1970 by Frank Massa and Gilbert C. Barrow, entitled "ELECTROACOUSTIC TRANSDUCER", and assigned to the assignee of this invention. That application shows an electroacoustic transducer employing a bilaminar resonant plate operating at its fundamental flexural mode of vibration. The present invention is a variation and improvement including a similar transducer achieving a reduced cost due to a simplified structural configuration.

Accordingly, an object of this invention is to provide new and efficient, low-cost electroacoustic transducers utilizing a bilaminar plate operating at a fundamental free resonant mode.

A further object of this invention is to accurately position a bilaminar plate within a spider-like frame structure. Here, an object is to include a spider frame with a center portion of material which forms one of the plates of the bilaminar resonant member.

Yet another object of this invention is to provide low-cost transducers of simplified structure. Here, an object is to reduce the cost of peizoelectric transducers. In this connection, an object of this invention is to provide a tubular, metallic housing within which the transducer components are stacked and held in proper mechanical alignment by a simple crimping operation.

Other objects, features, and advantages will become more apparent from the following description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a top plan view of one embodiment of the inventive transducer construction;

FIG. 2 is a cross-sectional view of the transducer, taken along the line 2—2 of FIG. 1;

FIG. 3 is a plan view of a first flat spider-like plate member including a sound mask portion at its center and four thin spoke-like connecting members running from the corners of the square mask center section to the outer rim portion of the plate;

FIG. 4 is a plan view of second flat plate member containing a square center plate portion which forms one of the vibratile plates of the bilaminar transducer assembly;

FIG. 5 is an end view taken of the assembly of FIG. 4, taken along the line 5—5 thereof; and

FIG. 6 is a bottom view of the vibratile assembly structure illustrated in FIG. 4, showing a square piezoelectric ceramic element bonded to the central plate portion of the spider-like member.

Briefly, FIGS. 1 and 2 show a first embodiment of an electroacoustic transducer of the flexural vibrating type. The major elements of the transducer are a clamping ring 10 and a first spider-like frame 11 including a center plate or sound mask 13 and spoke-like members 14. The center plate 13 is positioned over a piezoelectric plate-like transducer element 17. The thin spoke or connecting members 14 are attached between the four sides of the square center portion 13 and the outer circular periphery of the first spider-like plate section. The square piezoelectric plate member 17 is bonded to the bottom side of a second spider-like frame 16 and positioned under the center plate or sound mask portion 13.

More particularly, the reference character 10 identifies a tubular housing structure for receiving and containing a stacked assembly including the first spider-like plate member 11, best seen in FIG. 3. The plate 11, which may be stamped from thin metal, comprises a square or somewhat diamond-shaped center portion 13 attached to the peripheral rim portion by four integral spokes 14. These spokes project from the corners of the square or diamond-shaped center portion to the ring-shaped outer portion. The first plate member 11 is located in the uppermost position in the stacked assembly illustrated in FIG. 2. A spacing washer 15 separates the first spider-like plate 11 from a second spider-like plate member 16, as assembled inside the housing 10.

The second spider-like plate member 16 (FIG. 4), which may also be stamped from thin metal, comprises a square center plate portion 17, also connected by four thin spoke-like members 18 to a peripheral ring portion. A piezoelectric ceramic plate 27 is bonded to one face of the center plate portion 17 by a suitable cement, such as epoxy. Any of the well known piezoelectric ceramics may be used, such as polarized barium titanate or lead zirconate.

The ceramic plate element 27 is here shown with split or separated electrodes 19 and 20 bonded to its exposed surface. A third electrode, not shown, is located on the opposite face of the ceramic plate 27 and is bonded to the plate member portion 17. This type of electrode arrangement is exemplary of several that may be used. The electrode arrangement and the method of polarization is described in U.S. Pat. No. 3,128,532.

Electrical conductors 21 and 22 are soldered between the electrode plates 19 and 20 and the electrical terminals 23 and 24. These terminals are mounted on and extend through an insulating disc member 25 (FIG. 2), which is the bottom wall of the transducer. A cylindrical spacing washer 26 separates the spider-like plate member 16 from the terminal board 25.

These elements are stacked inside the tubular housing 10 in the relative positions indicated in FIG. 2. Then, the ends of the tubular housing 10 are crimped over on both ends of the stack to secure the entire assembly together, thus completing the transducer element assembly.

The combined center plate portion 17 of the second spider-like plate member 16 and the ceramic plate 27 attached thereto, form a bilaminar vibrating structure. The fundamental flexural resonant frequency of this structure is determined by the thickness and width dimensions of the elements 17 and 27. When the vibrating bilaminar structure operates at a free fundamental resonance mode, the four corners of the square bilaminar transducer element vibrate together and in the same phase. However, the center portion of plates 17, 27 vibrate 180° out-of-phase with the corners. Thus, the amplitudes of the four corners are in phase opposition to the amplitude of the center portion of the bilaminar element.

The four spoke-like connecting strips **18** are attached between the nodal points of the resonating square bilaminar structure **17, 27** and the outer ring. Thus, strips **18** offer negligible restraint to the freely vibrating transducer element assembly.

To improve the radiation efficiency of the vibratile transducer element, the first spider-like plate member **11** contains a sound opaque mask member **13** which is located over the out-of-phase center portion of the piezoelectric member **27**, as illustrated in FIG. **1**. The square or somewhat diamond-shaped outline of the masking plate portion **13** follows the nodal line, on the surface of the vibratile plate member **17**, which separates the out-of-phase motions. Thus, by the arrangement of the component parts, only the four corners of the vibratile resonant bilaminar structure **17, 27** are exposed to the medium. One of these exposed corners **30** is cross hatched for easy identification.

The square or somewhat diamond-shaped mask portion **13** of the first plate member **11** covers and prevents the out-of-phase radiation from the center area of vibratile plate portion **17** of the second member **16**. Thus, the out-of-phase radiation from the center is prevented from neutralizing the radiation from the four corners of the vibratile plate. A more comprehensive description of the operation of a square bilaminar transducer element and the use of a masking plate for improving the radiation efficiency may be found in the above-mentioned co-pending parent application Ser. No. 17,430.

Thus, the illustrative construction described herein provides an inexpensive transducer design which enables the mass production of an efficient electroacoustic transducer, at very low cost. Although there is no exact limit to the frequency range over which the described design may be utilized, it is extremely well adapted for transducers which operate at either the upper audible region or within the ultrasonic range of 5 kHz to 100 kHz.

While a specific embodiment of the present invention has been shown and described, it should be understood that modifications and alternative constructions may be made. Therefore, the appended claims are intended to cover all equivalents falling within their true spirit and scope.

I claim:

1. An electroacoustic transducer of the flexural vibrating type comprising laminated transducer means assembled inside a tubular housing, said transducer laminate comprising a first laminate spider-like frame member having a peripheral rim portion and a first central plate sound opaque mask portion, means including a second laminate spider-like frame member with a peripheral rim portion and a second and vibratile central plate portion, a plurality of spoke-like members for connecting said first and second central plate portions to their associated peripheral rim portions, transducer means comprising a plate of piezoelectric material bonded to the surface of said second central plate portion of said second spider-like frame member, and annular holding laminate means for supporting said first and second frame members in spaced parallel relationship.

2. The invention in claim **1** characterized in that said first central plate portion of said first frame member is square.

3. The invention in claim **2** further characterized in that said second central plate portion of said second frame member is square, and still further characterized in that the area of said first central plate portion is less than the area of said second central plate portion.

4. The invention in claim **3** further characterized in that said square central plate portions of said frame members are suspended in spaced parallel relationship to one another with their centers located on a common axis perpendicular to said plates, and still further characterized in that one of said square central plate portions is oriented with its sides rotated by **45°** with respect to the corresponding sides of the other of said square central plate portions.

5. The invention in claim **4** further characterized in that the area of said first central plate portion is approximately one-half the area of said second central plate portion.

6. The invention in claim **5** further characterized in that one end of each of the spoke-like members of said second spider-like frame member is attached to the centers of individually associated sides of said second central square portion, and still further characterized in that the first spider-like frame member also has a plurality of spoke-like connecting members, one end of each of said spoke-like members of the first frame member being attached to an individually associated corner of said first central square portion.

7. An electroacoustic transducer of a flexural vibrating type comprising a tubular housing structure; sound opaque masking means including a first frame member having a first peripheral rim portion, a first central square plate portion, and a plurality of spoke-like members interconnecting said first central plate portion and said first peripheral rim portion; vibratile means comprising a second frame member including a second peripheral rim portion, a second square central plate portion, and a plurality of spoke-like members interconnecting said second central plate portion and said second peripheral rim portion; transducing means including a piezoelectric plate bonded to the surface of said second central plate portion; annular spacer means separating said first and said second frame members from each other within said tubular housing structure; and means for securing said spacer means and said frame members in a stacked array within said housing structure.

8. The invention in claim **7** characterized in that the area of said first central square plate portion is approximately one-half the area of said second square central plate portion.

9. The invention in claim **8** further characterized in that said first and said second frame members are oriented so that the sides of said first central square portion are rotated 45° with respect to the sides of said second central square portion.

10. The invention in claim **9** further characterized in that said spoke-like members in said second frame member extend from the centers of the sides of said second central square plate portion to said rim portion whereby the flexural resonance vibration of said second central square portion is unrestricted by said spoke-like members.

11. The invention in claim **10** further characterized in that said spoke-like members connected to said first central square portion of said first frame member are attached to the corners of said central portion.

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