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- **PATENT ABSTRACTS OF JAPAN vol. 007, no. 094 (E-171), 20 April 1983 (1983-04-20) & JP 58 019099 A (MURATA SEISAKUSHO:KK), 3 February 1983 (1983-02-03)**

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Description

[0001] The invention relates to piezoelectric vibration exciters e.g. of the kind which may be used to apply bending wave energy to resonant panels to form loudspeakers, and to panel-form loudspeakers employing such exciters. Our International patent application W097/09842 describes such resonant panel loudspeakers and vibration exciters therefor.

[0002] Many attempts have been made to provide piezoelectric devices having increased mechanical output displacement.

[0003] Prior art devices include 'Rainbow' piezoelectric actuators as well as more conventional piezoelectric actuators.

[0004] Conventional piezoelectric actuators exhibit limited mechanical displacement. The output of conventional piezoelectric devices is limited by the materials' basically low piezoelectric charge constant. Thus conventional devices of reasonable thickness (i.e. of the order of a few millimetres) offer only micrometer-sized mechanical output motion. 'Rainbow' actuators, 'Moonies', unimorphic and bimorphic piezoelectric actuators exhibit greater mechanical output motion. However, even the thinnest ceramic wafers, which exhibit the maximum observed output motion, provide a displacement limited to approximately lmm of motion in the z-axis direction for a device that is 3-4cm long. Additionally, 0.25mm thick ceramic devices are extremely brittle and fragile so that they are prone to breakage and require special handling.

[0005] U.S. patents 5,632,841 and 5,802,195 and International application W096/31333 describe high displacement ferro-electric devices. US-A-5 309 519 shows a curved piezoelectric device but with no additional mass. In US-A-4 654 554 a mass is attached to a free portion of a piezoelectric device but remote from the peripheral edge.

[0006] It is an object of the invention to provide a piezoelectric device of enhanced output.

[0007] According to the invention there is provided a vibration exciter comprising a curved piezoelectric device having an attachment portion at which the device is to be attached to a substrate to be vibrated and at least one free portion remote from the attachment portion, and

a mass load provided on at least one of the or each free portion.

[0008] The piezoelectric device may be a ferro-electric device and may be pre-stressed. Mass loading such pre-stressed ferroelectric devices may provide a suprisingly large increase in output, of around an order of magnitude, when the devices are used to drive resonant bending wave panel.

[0009] The device may be arcuate in shape or may be a generally circular dished device.

[0010] From another aspect the invention is a resonant panel-form loudspeaker driven in resonance by a vibration exciter as described above.

[0011] Specific embodiments of the invention will now be described, purely by way of example, with reference to the accompanying drawings in which

Figure 1 shows a first embodiment of a piezoelectric device according to the invention,
Figure 2 shows a second embodiment,
Figure 3 shows a third embodiment and
Figure 4 shows a fourth embodiment.

[0012] Referring to Figure 1, a loudspeaker 1 comprises a plate 11 capable of supporting resonant bending wave modes, as set out in W097/09842. A curved, composite piezoelectric device 13 such as described in US 5632841 has an attachment portion 12 centrally located on the piezoelectric device. The attachment portion 12 is mounted on a preferred, off-centre location on the panel 11. The ends 14 of the device are free. At each end of the piezoelectric device 13 a mass 15 is provided along the end of the piezoelectric device to mass-load the piezoelectric vibration exciter to increase the output of the exciter.

[0013] Fig.2 shows a similar arrangement except that instead of a single mass 15, a pair of masses 19 are provided at each end of the piezoelectric vibration exciter 13.

[0014] In Fig. 3, the piezoelectric vibration exciter 21 is genuinely circular, attached to the panel at the centre of the circle, with a single mass 23 provided on the free peripheral rim 25 of the exciter. The mass 23 mass-loads the piezoelectric vibration exciter to increase the output of the exciter.

[0015] Fig. 4 shows an alternative arrangement in which the continuous ring 23 of Fig. 3 is replaced by a plurality of discreet masses 27, symmetrically arranged the rim 25 of the piezoelectric device.

[0016] The invention thus provides a simple way of increasing the output of an exciter.

Claims

1. A vibration exciter comprising
   a curved piezoelectric device (13) having an attachment portion (12) at which the device is to be attached to a substrate to be vibrated (11) and at least one free end or peripheral rim portion (14) remote from the attachment portion (12), and
   a mass load provided on at least one of the or each free end or peripheral rim portion.

2. A vibration exciter according to claim 1 wherein the piezoelectric device (13) is a ferroelectric device.

3. A vibrations exciter according to claim 2 wherein the ferroelectric piezoelectric device is a pre-stressed device.

4. A vibration exciter according to any preceding claim wherein the piezoelectric device is arcuate.

5. A vibration exciter according to any of claims 1 to 3 wherein the piezoelectric device is dish-shaped.

6. A loudspeaker comprising
a diaphragm (11) capable of vibration to produce sound,
a curved piezoelectric device (13) having an attachment portion (12) mounted to the diaphragm and at least one free end or peripheral rim portion (14) remote from the attachment portion (12), and
a mass load provided on at least one of the or each free end or peripheral rim portion (14).

7. A loudspeaker according to claim 6 wherein the diaphragm (11) is a panel capable of supporting bending waves and the piezoelectric device (13) is arranged to excite bending waves in the panel.

8. A loudspeaker according to claim 6 or .7 wherein the piezoelectric device (13) is a ferroelectric device.

9. A loudspeaker according to claim 8 wherein the ferroelectric device (13) is a pre-stressed device.

10. A loudspeaker according to any of claims 6 to 9 wherein the piezoelectric device (13) is arcuate.

11. A loudspeaker according to any of claims 6 to 9 wherein the piezoelectric device (13) is dish-shaped.

Patentansprüche

1. Schwingungserreger, mit:

- einer gekrümmten piezoelektrischen Einrichtung (13), die einen Befestigungsabschnitt (12) hat, mit dem die Einrichtung an einem in Schwingungen zu versetzenden Substrat (11) zu befestigen ist, und mindestens einem vom Befestigungsabschnitt (12) entfernten freien Ende oder Umfangsrandabschnitt (14); und
- einer Massenlast, die an dem mindestens einen oder an jedem freien Ende oder Umfangsrandabschnitt angeordnet ist.

2. Schwingungserreger nach Anspruch 1, bei dem die piezoelektrische Einrichtung (13) eine ferroelektrische Einrichtung ist.

3. Schwingungserreger nach Anspruch 2, bei dem die ferroelektrische Einrichtung eine vorgespannte Einrichtung ist.

4. Schwingungserreger nach einem der vorhergehenden Ansprüche, bei dem die piezoelektrische Einrichtung bogenförmig ist.

5. Schwingungserreger nach einem der Ansprüche 1 bis 3, bei dem die piezoelektrische Einrichtung schalenförmig ist.

6. Lautsprecher, mit:

- einer Membran (11), die zu schwingen vermag, um Schall zu erzeugen;
- einer gekrümmten piezoelektrischen Einrichtung (13), die einen an der Membran angebrachten Befestigungsabschnitt (12) und mindestens ein vom Befestigungsabschnitt (12) entferntes freies Ende oder Umfangsrandabschnitt (14) ausweist; und
- einer Massenlast, die an dem mindestens einen oder an jedem freien Ende oder Umfangsrandabschnitt (14) angeordnet ist.

7. Lautsprecher nach Anspruch 6, bei dem die Membran (11) ein zur Unterstützung von Biegewellen geeignetes Paneel ist und die piezoelektrische Einrichtung (13) zum Erregen von Biegewellen im Paneel angeordnet ist.

8. Lautsprecher nach Anspruch 6 oder 7, bei dem die piezoelektrische Einrichtung (13) eine ferroelektrische Einrichtung ist.

9. Lautsprecher nach Anspruch 8, bei dem die ferroelektrische Einrichtung (13) eine vorgespannte Einrichtung ist.

10. Lautsprecher nach einem der Ansprüche 6 bis 9, bei dem die piezoelektrische Einrichtung (13) bogenförmig ist.

11. Lautsprecher nach einem der Ansprüche 6 bis 9, bei dem die piezoelektrische Einrichtung (13) schalenförmig ist.

Revendications

1. Excitateur de vibrations, comprenant :

un dispositif piézoélectrique incurvé (13) ayant une portion de fixation (12) au niveau de laquelle le dispositif doit être assujetti sur un substrat à faire vibrer (11) et au moins une extrémité libre ou portion de bord périphérique (14) éloignée de la portion de fixation (12), et
une masse de charge disposée sur au moins l'une ou chaque extrémité libre ou portion de bord périphérique.

2. Excitateur de vibrations selon la revendication 1, dans lequel le dispositif piézoélectrique (13) est un dispositif ferroélectrique.

3. Excitateur de vibrations selon la revendication 2, dans lequel le dispositif piézoélectrique ferroélectrique est un dispositif précontraint.

4. Excitateur de vibrations selon l'une quelconque des revendications précédentes, dans lequel le dispositif piézoélectrique est arqué.

5. Excitateur de vibrations selon l'une quelconque des revendications 1 à 3, dans lequel le dispositif piézoélectrique est en forme d'assiette.

6. Haut-parleur, comprenant

une membrane (11) capable de vibrations pour produire des sons,

un dispositif piézoélectrique incurvé (13) ayant une portion de fixation (12) montée sur la membrane et au moins une extrémité libre ou une portion de bord périphérique (14) éloignée de la portion de fixation (12), et

une masse de charge disposée sur au moins l'une ou chaque extrémité libre ou portion de bord périphérique (14).

7. Haut-parleur selon la revendication 6, dans lequel la membrane (11) est un panneau capable de supporter des ondes de flexion et le dispositif piézoélectrique (13) est disposé pour exciter les ondes de flexion dans le panneau.

8. Haut-parleur selon la revendication 6 ou 7, dans lequel le dispositif piézoélectrique (13) est un dispositif ferroélectrique.

9. Haut-parleur selon la revendication 8, dans lequel le dispositif ferroélectrique (13) est un dispositif précontraint.

10. Haut-parleur selon l'une quelconque des revendications 6 à 9, dans lequel le dispositif piézoélectrique (13) est arqué.

11. Haut-parleur selon l'une quelconque des revendications 6 à 9, dans lequel le dispositif piézoélectrique (13) est en forme d'assiette.

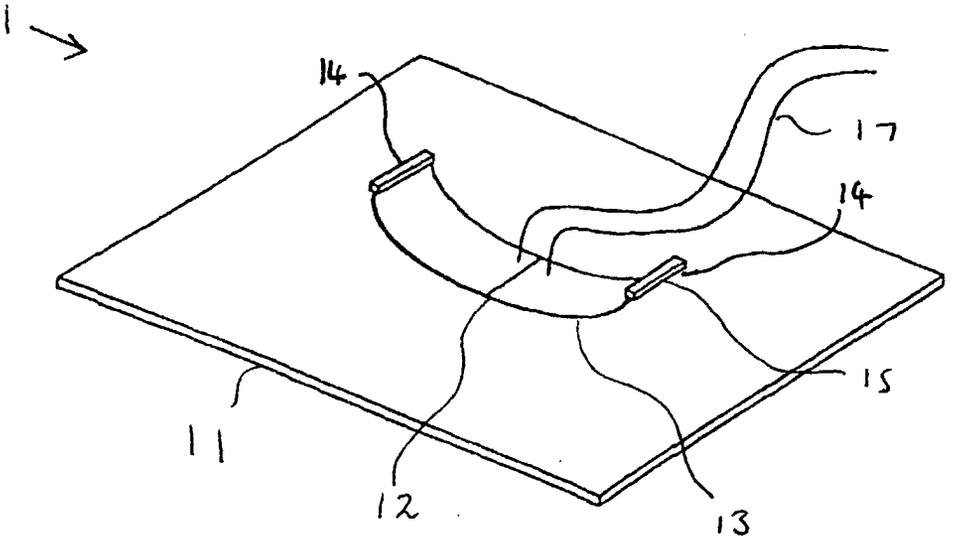

Fig. 1

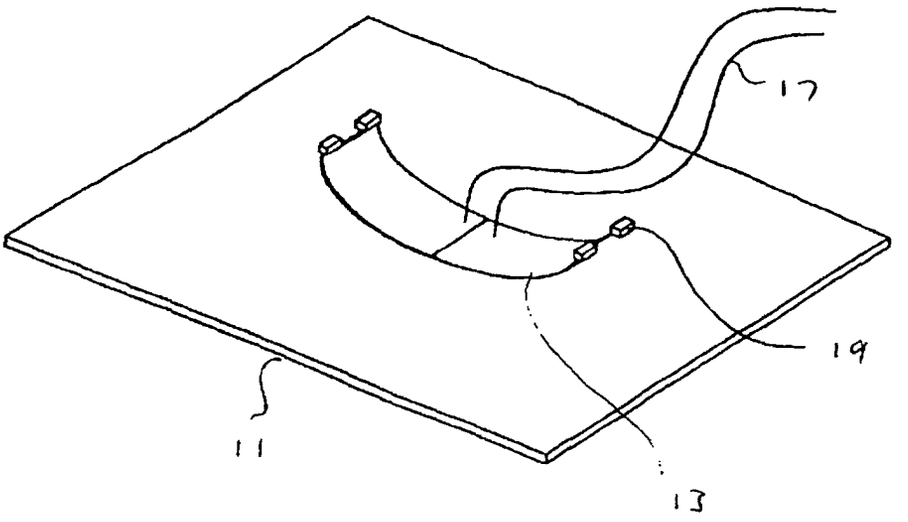

Fig 2

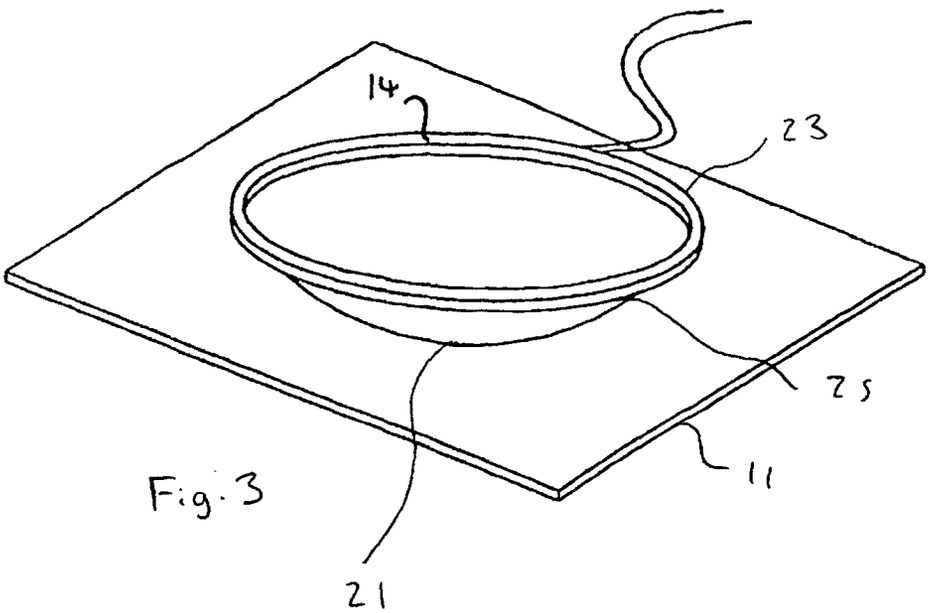

Fig. 3

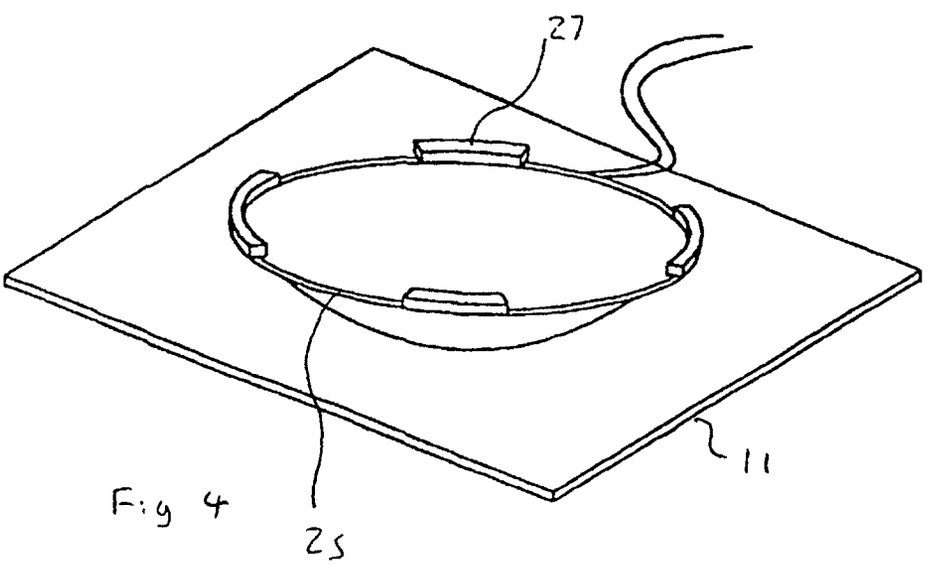

Fig 4