(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 November 2013 (14.11.2013)

WIPO | PCT

(10) International Publication Number
**WO 2013/169788 A2**

(51) **International Patent Classification**:
*G10K 11/172* (2006.01)

(21) **International Application Number**:
PCT/US2013/039962

(22) **International Filing Date**:
7 May 2013 (07.05.2013)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
61/643, 449 7 May 2012 (07.05.2012) US

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published**:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) **Title**: ACOUSTIC DAMPING DEVICE AND INSTALLATION

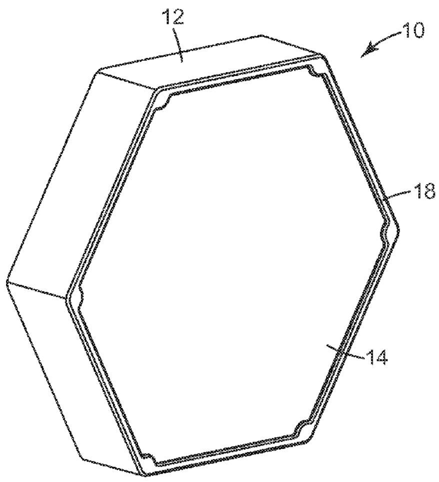


*Fig. 1*

(57) **Abstract**: An acoustic damping device comprising at least one (1) a shell having a cavity and having a first opening that communicates with the cavity and (2) an acoustic film attached to the shell and substantially spanning the opening, wherein the acoustic film has an array of through holes therein, the shell and acoustic film defining in at least part an active cavity and wherein the device is adapted to be mounted to a support.

WO 2013/169788 A2

# ACOUSTIC DAMPING DEVICE AND INSTALLATION

## Field

This invention relates to acoustic damping devices and installations, in particular, acoustic damping devices utilizing microperforated polymeric films.

## Background

Many chambers, e.g., rooms in buildings in which people live, work, and otherwise congregate, have less than desirable acoustic properties. Frequently, ambient sounds, particularly when there are many sources, lead to louder than desired ambient conditions, resulting in discomfort, fatigue, reduced productivity, etc.

Acoustic damping devices, sometimes referred to as sound absorbers, are in widespread use in a number of different applications.

While various configurations are known, one common sound absorber design utilizes one or more layers of fibrous material to dissipate sound wave energy. Such fiber-based absorbers may include, for example, fiberglass strands, open-cell polymeric foams, fibrous spray-on materials such as polyurethanes, and acoustic tiles (agglomerated fibrous and/or particulate matter). These materials permit the frictional dissipation of sound energy within the interstitial voids of the sound absorbing material. While such fiber-based absorbers are advantageous in that they are effective over a broad acoustic spectrum, they have inherent disadvantages. For instance, these sound absorbers can release particulate matter, degrading the surrounding air quality. In addition, some fiber-based sound absorbers do not possess sufficient resistance to heat or fire. They are therefore often limited in application or, alternatively, must undergo additional and sometimes costly treatment to provide desirable heat/flame resistance.

Another type of sound absorber utilizes perforated sheets, such as relatively thick metal having perforations of large diameter. These sheets may be used alone with a reflective surface to provide narrow band sound absorption for relatively tonal sounds. Alternatively, these perforated sheets may be used as a facing overlying a fibrous sound absorber to improve sound absorption over a wider acoustic spectrum. In addition to their own absorbing properties, the perforated sheets also serve to protect the fiber-material. However, these "two-piece" sound absorbers are limited in application due to their cost and relative complexity.

Perforated, sheet-based sound absorbers have also been suggested for sound absorption. Conventional perforated, sheet-based sound absorbers may use either relatively thick (e.g., greater than 2 mm) and stiff perforated sheets of metal or glass or thinner perforated sheets which are externally supported or stiffened with reinforcing strips to eliminate vibration of the sheet when subject to incident sound waves. US Patent No. 5,700,527 (Fuchs), for example, teaches a sound absorber using relatively thick and stiff perforated sheets of 2 to 20 mm thick glass or synthetic glass. Fuchs suggests using thinner sheets (e.g., 0.2 mm thick) of relatively stiff synthetic glass provided that the sheets are reinforced with thickening or glued-on strips in such a manner that incident sound cannot cause the sheets to vibrate. In this case, the thin, reinforced sheet is positioned away from an underlying reflective surface.

US Patent No. 6,598,701 (Wood et al.) discloses shaped microperforated polymeric film sound absorbers.

The need exists for improved acoustic damping devices and installations.

## Summary

The invention provides acoustic damping devices, in particular, acoustic damping devices that are well suited for use in rooms.

In brief summary, acoustic damping devices of the invention comprise (1) a shell having a cavity, i.e., an acoustic active cavity or Helmholtz cavity, and having at least one first opening that communicates with the cavity and (2) an acoustic film attached to the shell and substantially spanning the opening. As described herein, the acoustic film has an array of through holes, sometimes referred to as microperforations, therein. Together the shell and acoustic film, or in some embodiments the shell, acoustic film, and surface on which the device is mounted, define an active cavity. When installed in accordance with the invention, the device functions as a Helmholtz resonator, providing desired acoustic damping.

Acoustic damping devices of the invention can be made in a variety of configurations and are well suited for providing effective damping or absorption of sound in the frequency range of voices. Devices of the invention can provide superior acoustic damping in a myriad of installation applications, including, for example, offices, class rooms, hallways, auditoriums, museums, conference rooms, great halls, cubicles, etc. In accordance with the invention, devices as described herein may be installed on ceilings, walls, doors, floors, partitions, and other supporting surfaces in rooms.

## Brief Description of Drawing

The invention is further explained with reference to the drawing wherein:

Fig. 1 is a perspective view of the front of an illustrative embodiment of an acoustic damping device of the invention;

Fig. 2 is a perspective view of the rear of the device shown in Fig. 1;

Figs. 3a and 3b are plan views of an illustrative embodiment of a clip that can be used to mount devices of the invention on a surface;

Fig. 4a is a plan view of another embodiment of an acoustic damping device of the invention;

Fig. 4b is a plan view of the rear of device shown in Fig. 4a;

Fig. 5a is a perspective view of the front of the shell of still another embodiment of an acoustic damping device of the invention;

Fig. 5b is a perspective view of the front of still another embodiment of an acoustic damping device of the invention;

Fig. 6 is a plan view of an array of four of the acoustic damping devices shown in Figs. 1 and 2;

Fig. 7 is a plan view of an array of nine of the acoustic damping devices shown in Figs. 1 and 2;

Fig. 8 is a plan view of the acoustic film of a portion of another illustrative embodiment of an acoustic damping device of the invention;

Fig. 9 is a side view of the acoustic damping device shown in Fig. 8;

Fig. 10 is a cross-sectional view of another illustrative embodiment of an acoustic damping device of the invention;

Fig. 11 is a plan view of the front face of an illustrative acoustic damping device of the invention configured as a wall hanging;

Fig. 12 is a plan view of the front face of the acoustic damping device shown in Fig. 11 with the fascia removed;

Fig. 13 is a plan view of the back side of the device shown in Fig. 11;

Fig. 14 is a plan view of a side of the device shown in Fig. 11; and

Fig. 15 is a plan view of a frame or casing of an illustrative acoustic device of the invention.

These figures are not to scale and are intended to be merely illustrative and not limiting.

## Detailed Description of Illustrative Embodiments

Generally speaking, an acoustic damping device of the invention comprises (1) a shell having a cavity and having a first opening that communicates with the cavity and (2) an acoustic film attached to the shell and substantially spanning the first opening, wherein the acoustic film has an array of through holes therein, the shell and acoustic film defining in at least part an active cavity. Turning to Figs. 1 and 2, an illustrative acoustic damping device 10 comprising shell 12 and acoustic film 14 is shown. Shell 12 has a cavity 16 and an opening 18; acoustic film 14 spans opening 18.

As used herein, the term "first opening" refers to an opening in the shell that communicates with the cavity and which, in accordance with the invention, will be substantially spanned or covered by an acoustic film as described herein. When acoustic damping devices of the invention are installed, the first opening will typically be oriented to face broadly the directions from which sound energy whose attenuation is desired will be incident from. As used herein, the term "second opening" refers to an opening in the shell that communicates with the cavity but which is not a "first opening". When damping devices of the invention are installed, the second opening(s) will typically be oriented toward a supporting surface, e.g., a wall.

In the embodiment shown in Figs. 1 and 2, shell 12 has a hexagonal shape with six, substantially equal length sides. Devices of the invention can be made in a myriad of other regular and irregular geometric shapes as desired. Illustrative examples include circles, ovals, and right triangles such as shown in Figs. 4a, 4b, 5a, and 5b, squares, rectangles, octagons, etc. Selection of the shape will be dependent in part upon resultant visual appearance of the device, manufacturing ease, etc.

In the embodiment shown, the portion of shell 12 around the first opening 18 has lip or flange extending therefrom to provide a surface to which acoustic film 14 can be readily secured. The acoustic film is preferably sealed to the shell substantially continuously around the first opening. The film can be bonded to the lip using suitable adhesive, mechanical attachment, e.g., clips, screws, staples, etc. Preferably the acoustic film is secured under tension to avoid bagging and oil canning which affects acoustic performance in the use of the device. Similarly, the fabric or printable layer should be securely attached for appearance as well as acoustic performance overlaying the perforated film.

In some embodiments of the invention, the shell will substantially completely close about the cavity but for the first opening, which is substantially completely spanned by the acoustic film. When installed in a room, e.g., mounted on a wall, ceiling, partition, etc., acoustic energy in the form of pressure waves in the air, when incident to the acoustic film will pass through the through holes therein into the cavity where they will resonate off the inner surfaces of the shell and acoustic film, until dissipating, resulting in damping of the acoustic energy in the room.

Figs. 4a and 4b show in another embodiment in which device 110 has a triangular configuration in which shell 112 has third side walls defining first opening 118 which is spanned by acoustic film 114 and second opening 120. When installed for use, second opening 120 will be covered by the surface to which device 110 is mounted, e.g., a wall, partition, door, or other surface. Once installed in a room, acoustic energy in the form of pressure waves in the air, when incident to the acoustic film will pass through the through holes therein into the cavity where they will resonate off the inner surfaces of the shell and acoustic film, and the surface of the wall, ceiling, partition, etc. to which the device is mounted, until dissipating, resulting in damping of the acoustic energy in the room.

In some embodiments the first opening is substantially planar, e.g., as shown in Figs. 1, 4a, 5a, and 5b; in other embodiments it may be of more complex configuration.

For optimum performance, i.e., the greatest damping effect, the active cavity should be completely surrounded. In some embodiments, this is achieved with the shell being substantially continuous but for the first opening which is spanned by the acoustic film. In embodiments wherein the shell has one or more second openings, such as second opening 20 in Fig. 2 and second opening 120 in Fig. 4b, the device is configured such that the one or more second openings are seated against the surface or support (not shown) on which the device is mounted, e.g., a wall or ceiling, such that the cavity 16 in Fig. 2 and cavity 116 in Fig. 4b is completely closed or surrounded by the shell, the acoustic film, and the surface.

In many embodiments, the device is configured such that the acoustic film is positioned at a distance about 0.5 to about 3 inches from the rear surface of the shell in instances where the shell is fully closed or from the surface of the support on which the device is mounted in instances where the shell has one or more second openings that communicate with the cavity.

If the first opening is of planar configuration, it may be oriented to be substantially parallel to the rear surface of the shell or support surface, respectively, or it may be oriented at an angle thereto. In the embodiment shown in Figs. 1 and 2, first opening 18 and acoustic film 14 are substantially parallel to second opening 20. In this embodiment, the device 10 will be mounted on a support surface (not shown) so as to cover second opening 20, resulting in acoustic film 14 being substantially parallel thereto. In the embodiments shown in Figs. 5a and 5b, the planes of acoustic films (not shown in Fig. 5a, 314 in Fig. 5b) will be positioned at an angle to the plane of the respective support surfaces because the height of the side walls of the shells are varied in the z-axis. In Fig. 5b, dimension $z_1$ is less than dimension $z_2$.

The shell is preferably constructed such that device will be dimensionally stable in use, i.e., maintaining its desired configuration and shape. In many embodiments, the shell can be molded, e.g., via injection molding, of suitable plastic such as acrylonitrile-butadiene-styrene, or other suitable material which can be readily selected by one skilled in the art.

The microperforated, polymeric films, and methods for producing such films, described in US Patent No. 6,598,701 (Wood et al.) are well suited for use in the present invention.

Generally, the acoustic film has a bending stiffness of about $10^7$ dyne-cm or less.

In many embodiments, the acoustic film has a thickness between about 9 and about 35 mils. In some embodiments, the portion of the acoustic film that spans the first opening will be of substantially uniform thickness.

In some embodiments, the through holes or perforations have a diameter which varies between the first major surface and the second major surface. In some instances, the through holes have a narrowest diameter that is less than the film thickness. In some embodiments, the through holes have a maximum diameter of from about 2.0 to about 6.0 mils. In some instances, a majority of the plurality of microperforations are tapered between the first and second major surfaces of the polymeric film. In some embodiments, a majority of the plurality of microperforations are tapered between the first and second major surfaces of the polymeric film, and wherein each of the tapered microperforations has a narrowest diameter less than a thickness of the polymeric film at its thickest portion.

In some embodiments, the plurality of microperforations are arranged in a pattern comprising a density of about 100 to about 4000 per square inch., and in some embodiments, the film has an average of between about 800 and about 1100 through holes per $inch^2$

Devices of the invention can be made in range of sizes. Typically, the active cavity has a volume of from about 10 $inch^3$ to about 200 $inch^3$.

For improved visual appearance, devices of the invention may further comprise a fascia disposed in front of or over at least a portion of the acoustic film. For instance, a fabric sheet of selected appearance may be mounted in front of or over the acoustic film, e.g., preferably obscuring all of the acoustic film. The fascia is preferably acoustically transparent so as to achieve desired visual appearance without impacting the acoustic damping performance of the device. Alternatively, the front face of the acoustic film may have desired visual matter formed thereon, e.g., by printing. Such means facilitate location of devices of the invention in optimum position without undesirably impairing use of the space. For instance, devices may be configured with fascia and used as visually pleasing backdrops or decoration. In other instances, the fascia may be provided with information thereon such that the devices or an array of a plurality thereof concurrently functions as a sign, e.g., presenting explanatory for an item in a museum.

The fascia should be sufficiently open to acoustic energy so as to not unduly interfere with the desired acoustic damping function of the device. Typically, the fascia (which may be monolayer, multilayer, or composite) will be breathable, e.g., have a rayls value of from about 50 to at least about 1500.

In some embodiments, the fascia may essentially serve only to provide desired visual appearance or other non-acoustic effect. For example, the fascia may have an image or pattern provided thereon. In some cases, the fascia may be selected to be capable of engaging with mechanical fasteners, e.g., hook-and-loop fasteners. The fascia may be selected to provide other desired performance, e.g., to filter or entrap dirt and other air-borne particles. So as to not interfere undesirably with the overall acoustic performance of the device, if the components and construction of the fascia will be selected to be breathable. For instance, adhesive and other layers therein such as supporting scrims may have pores formed therein, may be discontinuously coated, be bonded or unbounded non-wovens, etc. to provide desired breathability.

In other embodiments, however, the fascia may be selected to alter the acoustic damping properties of the device as desired.

Typically, the device will constructed such that the fascia can be removed as desired, e.g., to be replaced with a fascia having a different appearance, or in the case of dirt trapping embodiments for cleaning or replacement with a clean member to maintain desired acoustic performance.

The fascia may be a single layer component selected for desired purposes or may itself be of multilayer construction to impart a desired combination of performance attributes to the resultant acoustic damping device, e.g., receptivity to printing or other imaging techniques, compatibility with hook-and-loop fastening devices, dirt and particulate capture, etc. Some illustrative features that can be provided or enhanced by incorporation of a fascia include thermal insulation, dirt and particulate entrapment, enhanced structural strength and dimensional stability, visual appearance, protection from impact and abrasion, etc.

The fascia, if any, will sometimes be attached to the acoustic damping device with releasable measures, e.g., screws, clips, hook-and-loop fasteners, etc. to permit the fascia or portions thereof to be removed for cleaning, refreshing, and replacement. In other embodiments, the fascia may be attached with other measures such as nails, staples, clips, etc.

Some illustrative examples of materials that may be used in fascia layers of devices of the invention include knit, woven, and nonwoven materials. For instance, fiberglass or other fiber batt, foam, recycled bonded fiber batts (“shoddy”), blown fibers mats such as THINSULATE™ insulation and other such materials.

In accordance with the invention, the fascia should not undesirably impede transmission of the acoustic energy from the room through the fascia to and through the acoustic film. In some embodiments, components of the fascia may be secured to other components of the fascia or to the acoustic film. In such instance, the adhesive should be in a discontinuous coat, stripes, dots, etc. such that the resultant adhesive construction is at least semi-permeable so as to permit desired transmission of acoustic energy to the acoustic film.

In many embodiments, acoustic devices of the invention will have one or more second openings and be mounted on a wall, door, partition, or other vertical surface such that the vertical surface completes the desired acoustic cavity. Turning to Fig. 11, a typical embodiment of an acoustic damping device 1110 with fascia 1140 is shown. Fig. 12 is a plan view of the front face of the acoustic damping device 1110 shown with the fascia removed to reveal acoustic film 1114 and shell 1112. In this embodiment, the shell is made from wood members attached together to form an array of four active cavities attached in a row. Turning to Fig. 13, several 3M™ COMMAND™ Mounting Strips 1124 (hook-and-loop type) are provided to securely mount the device 1110 so that each of the chambers will function effectively as a Helmholtz resonator or active cavity. In this embodiment, each of the wood members is of similar thickness such that they form an even plane on both the front and back sides so that an effective mounting to the wall can be achieved and a uniform appearance from the front side. Fig. 14 is a plan view of a side of the device. In this illustrative embodiment, device 1110 is 4 feet long, 1.5 feet wide, and about 2 inches in depth. The wood members selected for shell 1112 have a depth of about 2 inches, width of about 0.75 inch and length chosen accordingly.

Fig. 15 is a plan view of a shell or frame 1512 of an acoustic device 1510 comprising an array of three cavities by four cavities. As will be understood, other configura5triopns can be made in accordance with the invention.

In many embodiments, it will be preferred that the active cavity have lateral dimensions of from about 1 to about 1.5 feet and that the ratio of longest width to narrowest width be less than about 2:1.

In typically applications, arrays of a plurality of acoustic devices of the invention will be mounted on a support. Fig. 6 shows an illustrative array 60 of four hexagonal shaped devices 10 of the invention arranged in a loosely packed arrangement. Fig. 7 shows another illustrative array 70 of nine hexagonal devices 10 of the invention in closely packed arrangement. If desired, an array may comprise devices which are arranged in a spaced arrangement from one another, though this will tend to lessen the acoustic damping performance which may be attained per unit area, and arrays comprising devices of varied shape may be used.

In typically applications, devices of the invention will be mounted on a room such surface such as a wall, ceiling, furniture panel, room divider, floor, etc. In preferred embodiments, the device(s) are mounted removably to facilitate reconfiguration, cleaning, repair, etc.

The manner of mounting the device on a surface will be selected in part upon the application; suitable means can be readily selected. In instances where the shell has no secondary opening, a device of the invention can be adhered to the surface, e.g., with double sided tape, adhesive, etc. applied to the back or a side of the shell, suspended by wire or string, etc. In instances where the shell has one or more secondary openings, as discussed above, the device should be mounted so that the shell seats against the surface preferably substantially completely covering the second opening(s). As shown in Figs. 2, 3a, and 3b, the device 10 may comprise slotted openings 22 which can engage, preferably releasably, with clips 24 which are adapted to mount to the surface, e.g., via use of hook and loop closures (not shown), adhesive (not shown) such as 3M™ Command™ Bonding Strips. Preferably the clips 24 are configured to engage with slotted openings 22 such that the foot surface 26 of clips 24 will not protrude beyond the bottom edge of shell 12, 112 so that shell 12, 112 will seat against the surface (not shown) to provide the desired fully closed active cavity.

As discussed above, in some embodiments, the shell will completely enclose the cavity but for the first opening. In other embodiments, the shell will completely enclose the cavity but for the first opening to which the acoustic film is provided, and one or more second openings. In such embodiments, the shell completely separates the one or more first openings from the one or more second openings. The device of claim 1 wherein the shell is substantially closed about the cavity but for the first opening and at least one second opening, wherein the shell separates the first opening and the at least one second opening. When installed in accordance with the invention, e.g., mounted on a room surface such as a wall, partition, or ceiling, the one or more second opening(s) will engage with the surface. Typically, to maximize the resultant acoustic damping effect, it is preferred that the engagement may be substantially closed, i.e., the edges of the one or more second openings are substantially in contact with the surface. In other embodiments, however, the device may not be positioned in such close proximity to the surface, i.e., a substantial gap may exist between the surface and the device. Such mounting arrangements may provide desired acoustic damping benefits in accordance with the invention provided that the mounting arrangement results in sufficient constraint on air flow through the gaps between the surface and the devise such that the cavity defined by the acoustic film, shell, and portion of the surface can provide Helmholtz resonance. Accordingly, devices of the invention may be mounted on a surface in the same manner as conventional wall hangings, e.g., by picture hook(s), suspended from a ceiling or elevated rack, etc.

In some embodiments, for example, as in the illustrative embodiments shown in Figs. 1, 4a, and 5, the portion of the acoustic film spanning the first opening is substantially planar in configuration.

In other embodiments, however, it may be desired that the portion of acoustic film spanning the first opening is configured so as to have two or more planar portions. Such configurations may be used to impart desired visual appearance or to provide improved acoustic damping potential orienting portions of the acoustic film in varied directions. An illustrative example of such an embodiment is shown in Figs. 8 and 9. Device 810 has shell 812 defining two active cavities each substantially completely spanned by an acoustic film 814a, 814b, respectively. The acoustic films are configured to have four planar portions each, namely two triangles 830a, 830b and 832a, 832b, respectively and two trapezoids 834a, 836a, and 834b, 836b, respectively.

In some embodiments, acoustic damping devices of the invention will comprise two or more active cavities oriented in different directions. For example, acoustic damping devices may be assembled in arrays of two or more active chambers per array, each active chamber having an acoustic film as described herein, which are oriented in opposing directions. An illustrative example of such an embodiment is shown in Fig. 10 where device 1010 comprises two active cavities 1002 and 1004 oriented toward location A and two active cavities 1006 and 1008 oriented toward location B. In accordance with the invention, each of the active cavities is enclosed in part by acoustic film 1014a, 1014b, 1014c, and 1014d, and shell 1012a, 1012b. Device 1010 further comprises panel 1020 to which shells 1012a, 1012b are mounted.

In addition to closing the respective active cavities such that each cavity will exhibit Helmholtz resonance in accordance with the invention, it is typically preferred that panel 1020 be sufficiently strong to support the arrays of active cavities so during installation in a room and during use. For instance, panel 1020 may be sufficiently strong to permit it to be mounted on the top edge of a workspace cubicle partition. In some embodiments, the active chambers may be arranged in closely nested fashion, e.g., similar to the array shown in Fig. 7, to maximize acoustic damping performance, or they may be arranged with gaps between active cavities, e.g., such as the array shown in Fig. 6. In the latter instance, panel 1020 may, if desired, be open or light transmissive in the areas between active cavities to facilitate light flow or visibility between opposing sides of the device, such as between adjacent cubicles, or it may be closed in those areas, e.g., to provide additional privacy between opposing sides of the device.

Those skilled in the art will be able to readily select suitable materials for fabrication of acoustic damping devices in accordance with the invention. In addition to the intended acoustic properties discussed above, such factors as fire resistance or retardance, color fastness, durability, etc. may be of importance.

The complete disclosure of the patents, patent documents, and publications cited herein are incorporated by reference in their entirety as if each were individually incorporated.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

What is claimed is:

1. An acoustic damping device comprising (1) a shell having a cavity and having a first opening that communicates with the cavity and (2) an acoustic film attached to the shell and substantially completely spanning the opening, wherein the acoustic film has an array of through holes therein, the shell and acoustic film defining at least in part an active cavity and wherein the device is adapted to be mounted to a support.

2. The device of claim 1 wherein the first opening is substantially planar.

3. The device of claim 1 wherein the shell is substantially closed about the cavity but for the first opening.

4. The device of claim 1 wherein the shell is substantially closed about the cavity but for (1) the first opening and (2) one or more second openings that each communicate with the cavity and are positioned such that they face the support when the device is mounted thereof.

5. The device of claim 1 wherein the film is substantially continuously sealed to the shell around the first opening.

6. The device of claim 1 wherein the acoustic film has a bending stiffness of about $10^7$ dyne-cm or less.

7. The device of claim 1 wherein the acoustic film is between about 9 and about 35 mils thick.

8. The device of claim 1 wherein at least the portion of the acoustic film that spans the first opening has substantially uniform thickness.

9. The device of claim 1 wherein the acoustic film has an auditory depth of from about 0.5 to about 3 inches.

10. The device body of claim 1 wherein one or more of the plurality of microperforations has a diameter which varies between the first major surface and the second major surface.

11. The device of claim 10 wherein the through holes have a narrowest diameter that is less than the film thickness.

12. The device of claim 1 wherein the through holes have a maximum diameter of from about 2.0 to about 6.0 mils.

13. The device of claim 1 wherein at least one of the plurality of microperforations has a narrowest diameter less than a thickness of the polymeric film at its thickest portion.

14. The device of claim 1 wherein a majority of the plurality of microperforations are tapered between the first and second major surfaces of the polymeric film.

15. The device of claim 1 wherein a majority of the plurality of microperforations are tapered between the first and second major surfaces of the polymeric film, and wherein each of the tapered microperforations has a narrowest diameter less than a thickness of the polymeric film at its thickest portion.

16. The device of claim 1 wherein the microperforations comprise a narrowest diameter of about 20 mils or less.

17. The device of claim 1 wherein the plurality of microperforations are arranged in a pattern comprising a density of about 100 to about 4000 per square inch.

18. The device of claim 1 wherein the film comprises an average of between about 800 and about 1100 through holes per $inch^2$.

19. The device of claim 1 wherein the active cavity has a volume of from about 10 to about 200 $inch^3$.

20. The device of claim 1 wherein the shell is adapted to mount removably to a surface.

21. The device of claim 1 further comprising a fascia disposed in front of at least a portion of the acoustic film.

22. The device of claim 1 mounted on a room wall.

23. An array of the devices of claim 1 mounted on a room wall.

24. The device of claim 1 wherein the shell is substantially closed about the cavity but for the first opening and at least one second opening, wherein the shell separates the first opening and the at least one second opening.

25. The device of claim 24 mounted on a room surface such that the device is capable of a Helmholtz resonation effect.

26. The device of claim 1 wherein the portion of the acoustic film spanning the first opening is in a substantially planar configuration.

27. The device of claim 1 wherein the portion of the acoustic film spanning the first opening is in a configuration having two or more different planar portions.

28. The device of claim 27 wherein the shell is substantially closed but for the first opening.

29. The device of claim 1 comprising two or more active cavities oriented in different directions.

30. The device of claim 29 comprising a panel having first and second major sides, the first side having:

(a) at least one (1) shell having a cavity and having a first opening that communicates with the cavity and (2) an acoustic film attached to the shell and substantially completely spanning the opening, wherein the acoustic film has an array of through holes therein, the shell and acoustic film defining at least in part an active cavity; and

(b) at least one (1) shell having a cavity and having a first opening that communicates with the cavity and (2) an acoustic film attached to the shell and substantially completely spanning the opening, wherein the acoustic film has an array of through holes therein, the shell and acoustic film defining at least in part an active cavity.

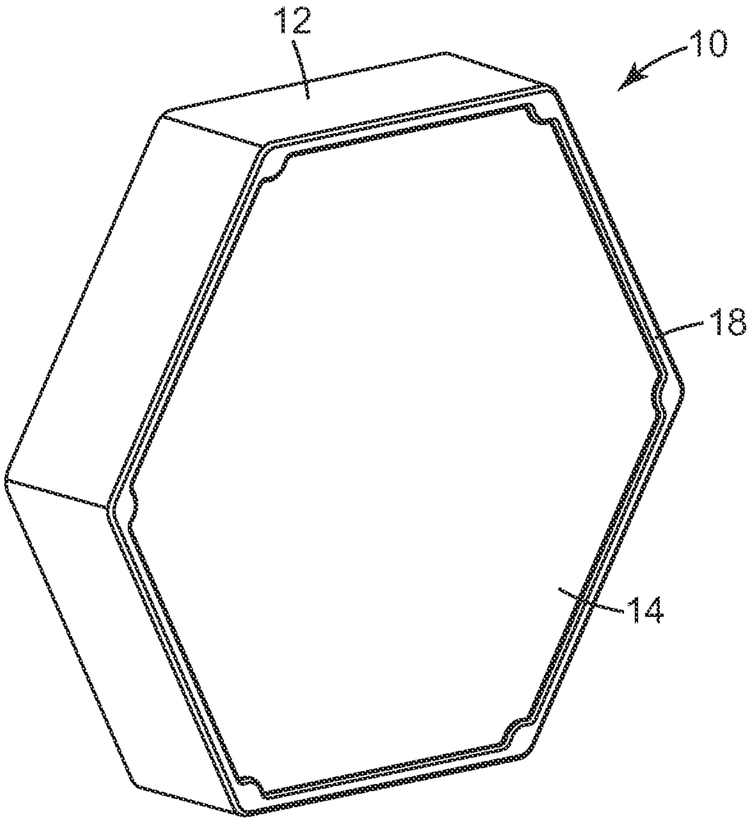


*Fig. 1*

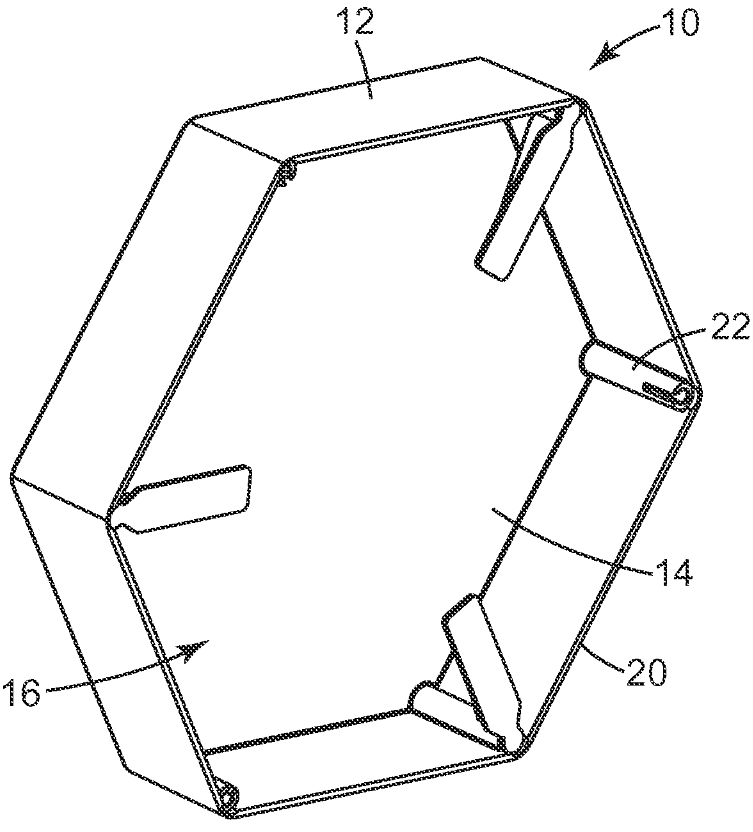


*Fig. 2*

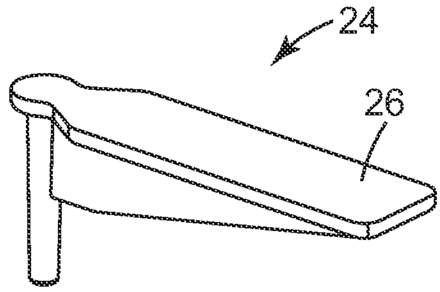


*Fig. 3a*

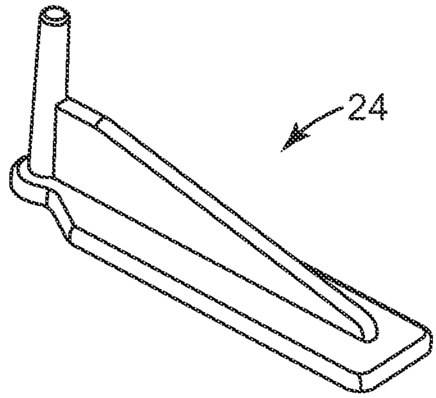


*Fig. 3b*

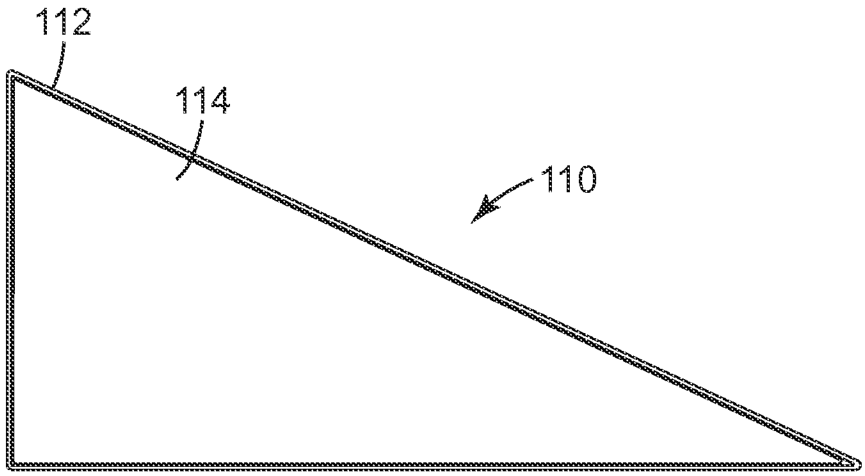


*Fig. 4a*

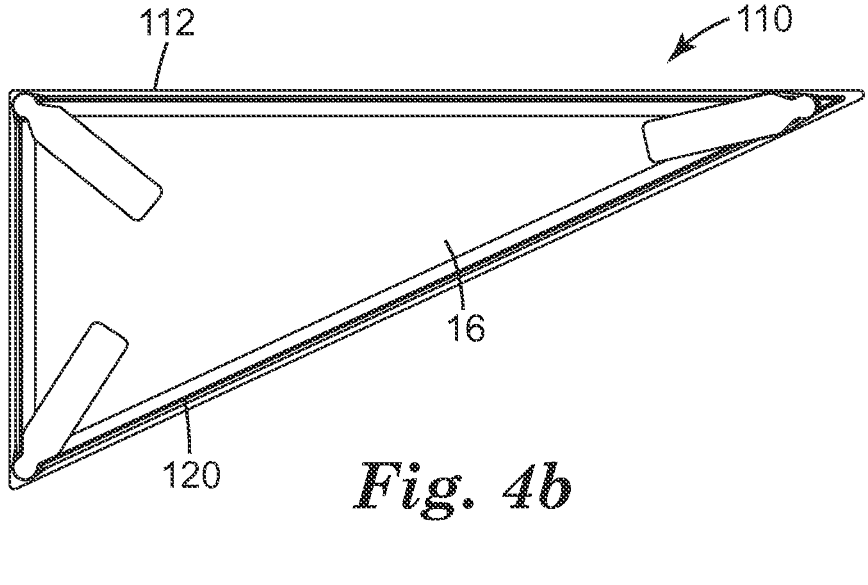


*Fig. 4b*

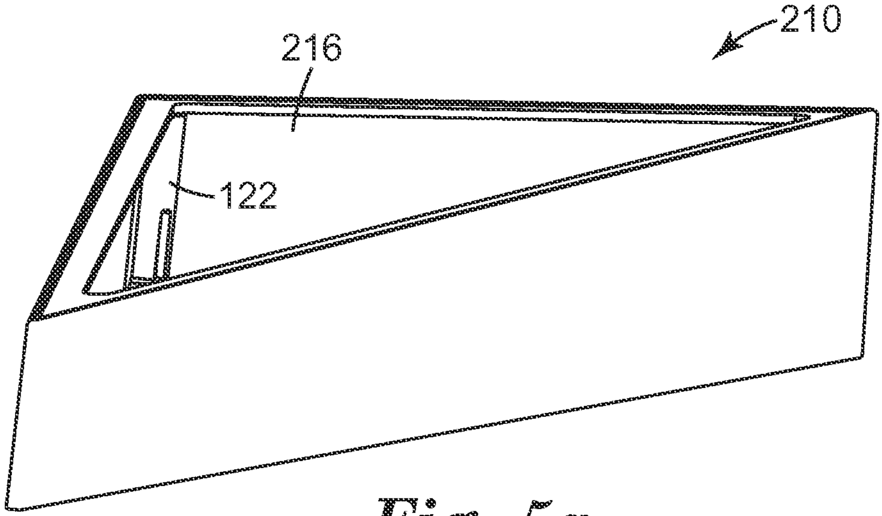


*Fig. 5a*

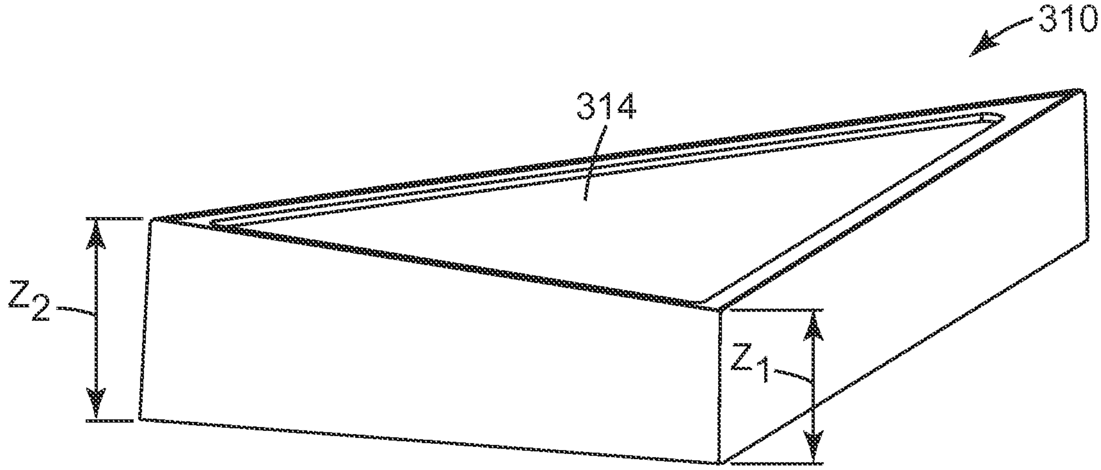


*Fig. 5b*

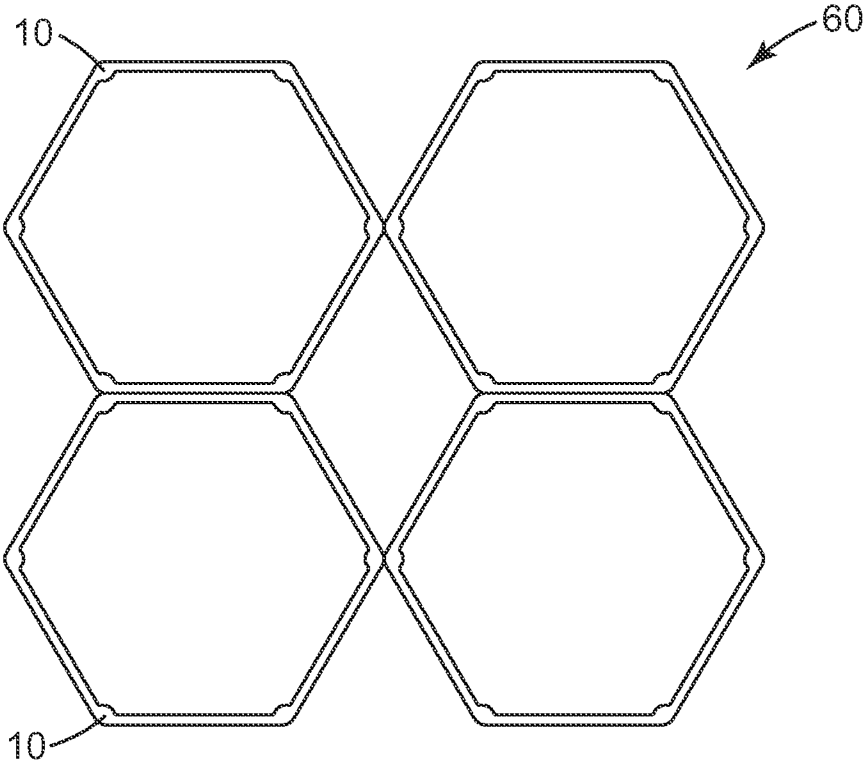


Fig. 6

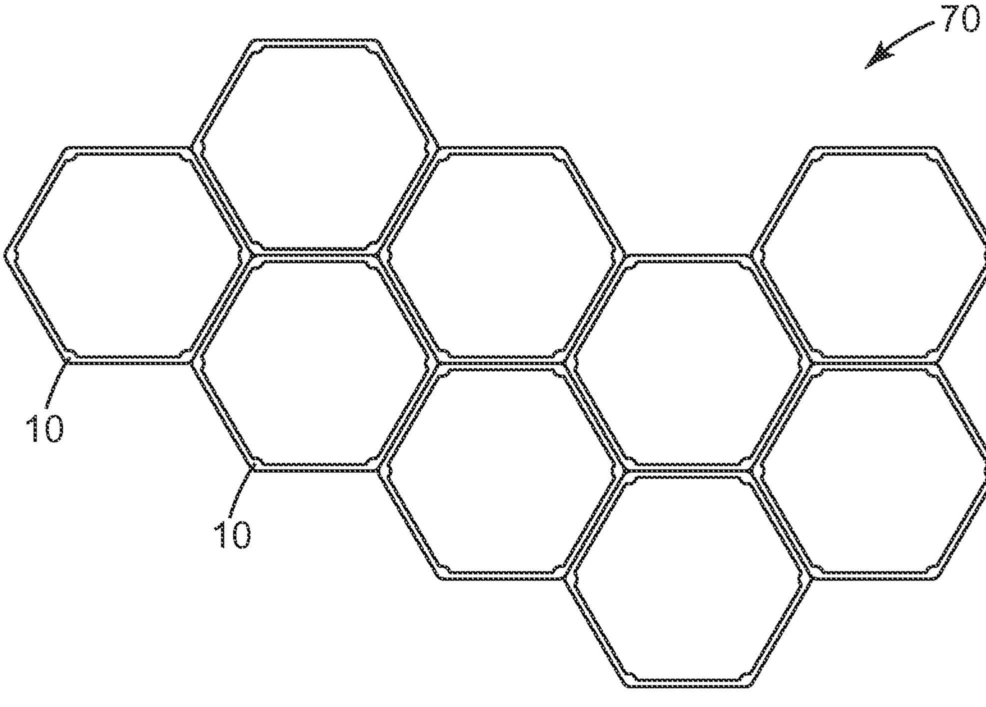


Fig. 7