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TUNED SOUND DEADENER

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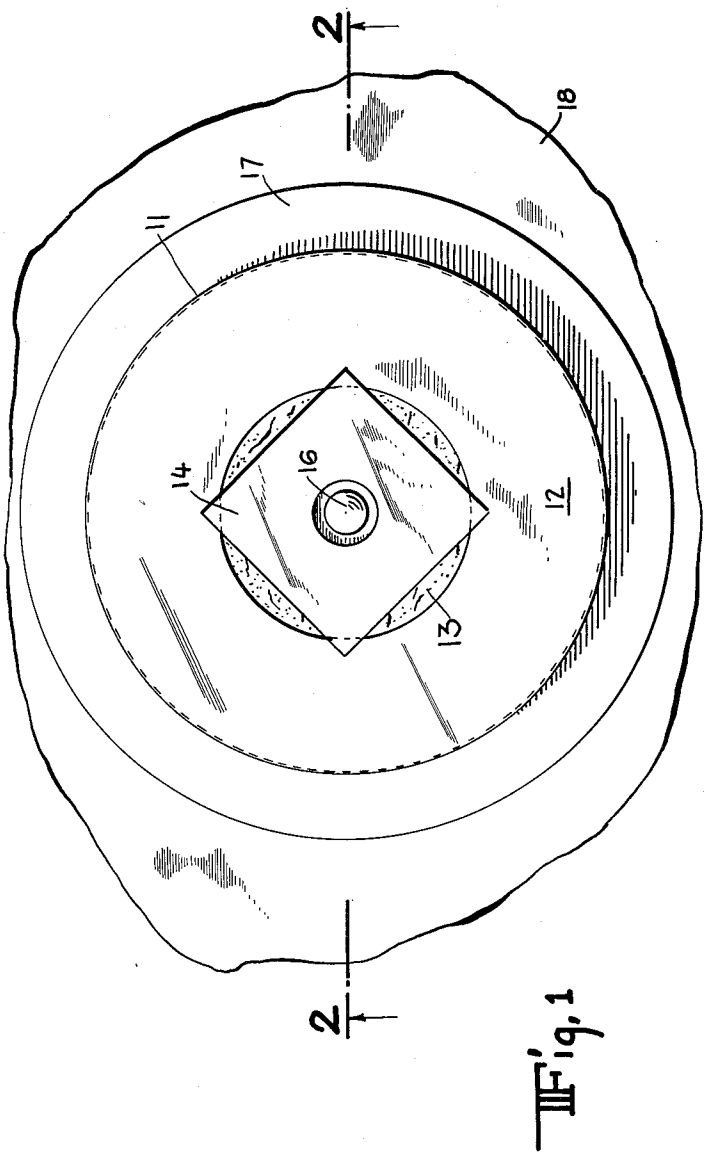


FIG. 1

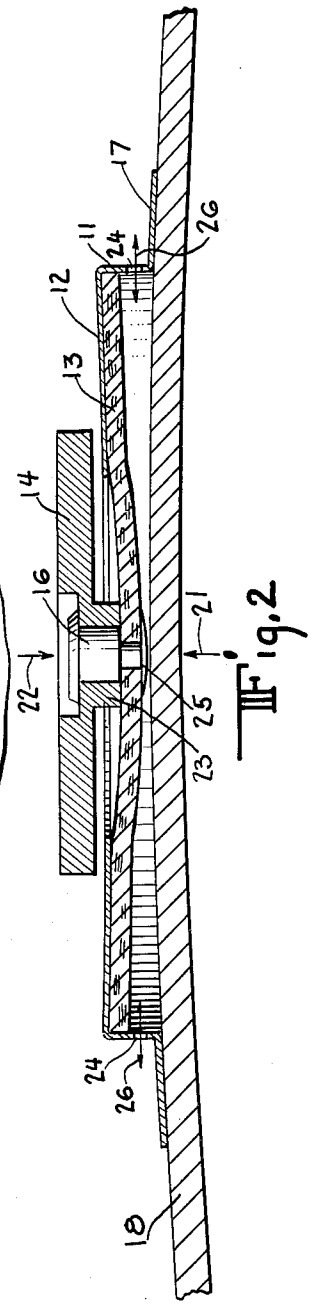


FIG. 2

INVENTOR
HUGH A. McPHERSON II
BY
Kenyon & Kenyon
ATTORNEYS

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TUNED SOUND DEADENER

Hugh A. McPherson II, Box 592, Fajardo, Puerto Rico

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This invention relates to sound deadening devices for reducing the radiated sound of vibrating plates and structures by dissipating the vibratory energy in the form of heat. The invention is an improvement on the sound deadening device described in United States Patent No. 2,541,159 to Paul H. Geiger.

The basic idea on which a sound deadener of the type described in the preceding Geiger patent, as well as the present invention, is based consists of setting into vibratory motion a diaphragm of a material having high mechanical hysteresis, that is, a material which readily transforms mechanical vibrations into heat. This material must also be firm enough so that deformations induced by vibrations will not be permanent. The diaphragm is attached to the vibrating body in such a way that at least a part of the diaphragm is free to move in response to the vibrations, and in order to increase the movement and thus to increase the rate at which vibratory energy is transformed into heat, a weight is attached to a freely-moving part of the diaphragm to increase the inertia of the diaphragm.

The present invention provides an improved mounting structure for the diaphragm and for the weight and permits the diaphragm to be manufactured as a unitary structure suitable for attachment to a wide variety of vibrating bodies and tunable to different operating frequencies so as to provide the necessary deadening qualities with the least amount of additional weight to the structure.

In the present invention the diaphragm is in the form of a disk which is cemented to the bottom of a shallow cup of thin, flexible material. This cup has an outwardly extending flange at its rim for attachment to the surface of a vibrating body either by being glued thereto or by any other suitable means. A weight is attached to the center of the diaphragm and in order to increase the freedom of movement of the weight the central area of the bottom of the shallow cup is cut away around the point of attachment of the weight so that over a fairly large area the diaphragm is free to move unhindered. When a sound deadener of this type is attached to the surface of the vibrating body, the movement of the body is transmitted to the side walls of the shallow cup. However, by virtue of the inertia of the relatively large mass of the weight, which is suspended from the resilient diaphragm, the weight resists moving in response to the vibrations and so causes the diaphragm to flex. This flexing generates heat in the diaphragm material, which heat is dispersed to the surrounding atmosphere or structure. As a result, the mechanical energy in the vibrations is transformed into heat and is dissipated so that the vibrations cease or are diminished.

In describing the invention in greater detail, reference will be made to the drawings, in which:

FIG. 1 shows a plan view of a sound deadener constructed according to the invention; and

FIG. 2 shows a cross-section of the sound deadener of FIG. 1 attached to a vibrating body.

The sound deadener consists of a shallow circular cup **11** having a substantially flat bottom plate **12**, the central area of which is cut away so as to leave an annular disk. A diaphragm of high mechanical hysteresis material, one example of which is cork, is glued to the bottom of the cup and a weight **14** is attached to the center of the hysteresis diaphragm **13** by means of a central rivet **16**. The

cup **11** is provided with an outwardly extending flange **17** by which it may be attached to a vibrating body.

In FIG. 2 the sound deadener is shown mounted on a vibrating body **18** by means of the outwardly extending flange **17**. This flange **17** is glued to the surface of the vibrating body although it may be attached in any convenient way so long as there is firm contact between the vibrating body and the cup **11**.

The vibrating body **18** is shown moving in the upward direction in response to a force indicated by arrow **21**. This upward directional movement is transmitted through the cup **11** to the diaphragm **13** and through it to the weight **14**. However, by virtue of the resilience of the diaphragm and the mass o fthe weight **14** an inertial force, indicated by the arrow **22**, prevents the weight **14** from moving in response to the movement of the vibrating body **18**. This is to say that the weight **14** remains relatively stationary while the vibrating body **18** moves back and forth. Of course, there will be a certain amount of transmission of movement to the weight **14**, but the greater the relative motion between the weight **14** and the cup **11** the more efficient is the transformation of vibratory energy to heat. This is because the diaphragm **13** is required to flex in response to the opposing forces depicted by arrows **21** and **22** and this flexing sets up heat in the diaphragm **13** due to internal friction of the material of which it is formed.

According to well-known acoustical laws, the system comprising diaphragm **13** and weight **14** may be analyzed as a damped, oscillatory system having a lower cut-off frequency below which it is relatively ineffective as a sound deadener. This frequency is determined by the mass of weight **14** and the stiffness of the diaphragm **13**. As shown in FIG. 2, the stiffness of diaphragm **13** is divided between two sections. The center of the diaphragm is considerably less stiff than the outer section of the diaphragm because the latter is glued to the inner surface of the bottom plate **12**. The overall stiffness may therefore be reduced by increasing the diameter of the cut-away portion of the bottom plate **12** or by making the cup **11**, including the bottom plate **12**, of the thinnest possible material consistent with the requirements of strength. The lower the stiffness of the diaphragm **13** the lower will be the minimum operating acoustical frequency of the sound deadener.

Another factor in reducing the stiffness is the mode of attachment of the weight **14**. Instead of attaching the entire weight **14** so that it makes contact with a large area of diaphragm **13**, only the central area of the weight **14** is in contact therewith. A spacer **23** holds the body of the weight **14** away from contact with either the diaphragm **13** or the bottom **12**, thus allowing a greater area of resilience.

Still another factor which controls the stiffness of the system is the air pressure between the diaphragm **13** and the upper surface of the vibrating body **18**. In order to permit air to flow out of this enclosed space the cup **11** is provided with one or more openings **24** through which air may flow as indicated by the arrows **26**. Thus when the motion is in the direction indicated by arrows **21** and **22**, air flows out of the openings **24**, and when motion is in the opposite direction, air flows into the space through the openings **24**. The size and number of these openings **24** will be partly determined by the minimum operating frequency of the structure and by the depth of the cup **11**. The depth of the cup **11** in turn will be determined by compromise between the overall thickness of the sound deadener and the amplitude of vibrations to which it must respond, since obviously it is desirable that the cup **11** be deep enough to permit the membrane **13** to flex inwardly as far as is necessary without causing

the head of rivet **16** to strike the surface of the vibrating body **18**. It may thus be necessary to provide cups **11** of greater depth for attachment to vibrating bodies having high amplitude vibrations.

The other factor determining the minimum frequency of operation of the system is the mass of weight **14**. The greater this mass, the lower will be the frequency of operation. However, since an increase in the mass of weight **14** increases the total weight of the sound deadener and since it is frequently very desirable to hold the overall weight to a minimum, as, for example, when the sound deadener is used in aircraft structures, it is preferable to reduce the stiffness of diaphragm **13** rather than to increase the mass of weight **14**. The compromise which must be made in so doing is that the diaphragm **13** must have sufficient material in it to provide the necessary support for the weight **14** and to provide the necessary heat generation. So that tuning may be readily effected if desired by replacement of the weight **14** with a weight having a different mass, the headed extremity **25** of the rivet **16** may be held frictionally with the body portion thereof or be in the form of a threaded screw.

The sound deadener should be connected to the vibrating body **18** at an antinode so as to take advantage of the maximum vibratory excursions of that section of the vibrating body. Because of its self-supporting and unitary type of construction sound deadeners of this invention may be scattered about on the surface of a vibrating body in an optimum way to take advantage of all of the antinodal points that may be present. In this way the vibrations of the body may be as effectively dampened with a few selectively placed sound deadeners as with an entire covering of uniformly spaced sound deadeners.

While this invention has been described in terms of a particular concentric structure, it will be apparent to those skilled in the art that modifications may be made therein which will be within the scope of the invention. For example, except when it is desired to utilize the effect of the apertures **24** on air movement, the side wall of the cup need not be continuous so long as means is provided for holding the apertured plate in rigid spaced relation to a vibrating body. Materials other than cork having high mechanical hysteresis are disclosed in the aforesaid Patent No. 2,541,159.

What is claimed is:

1. A sound deadener comprising a diaphragm of high mechanical hysteresis material; a weight attached to a central point of said diaphragm; a spacer between said weight and said diaphragm to limit the area of said diaphragm in contact with said weight; and a support for said diaphragm, said support comprising a cup having a flange extending outwardly from the rim thereof, an annular side wall and a bottom having a central portion thereof removed providing an opening therein, said diaphragm being attached to the bottom of said cup, and said spacer being located in said opening provided in the bottom of said cup.

2. A sound deadener comprising a circular diaphragm of high mechanical hysteresis material; a weight attached to the center of said diaphragm, a spacer between said weight and said diaphragm to restrict the area of said diaphragm in contact with said weight; means for attaching said diaphragm to a vibrating body, said means comprising a shallow drawn cup of flexible material, the central area of the bottom of said cup being removed and said diaphragm being attached to the inner surface of the bottom of said cup with said spacer extending through the removed portion thereof; and openings in said cup extending into the region between the rim of said cup and the surface of said diaphragm to permit air to flow into and out of said region.

3. A sound deadener which comprises a diaphragm of high mechanical hysteresis material; a weight attached to said diaphragm at a point intermediate the margins thereof; and a support for said diaphragm, said support comprising a plate having an aperture therein, said margins of said diaphragm secured to said plate in face-to-face relation therewith, and said weight being disposed within said aperture in substantially spaced relation to said plate; and means in rigid relation to said plate for holding said plate in spaced relation to said vibrating body.

4. A sound deadener according to claim 3 which comprises a spacer between said weight and said diaphragm to restrict the area of said diaphragm in contact with said weight, said diaphragm being secured to the underside of said plate and said spacer extending through said aperture.

5. A sound deadener according to claim 3 wherein said weight is attached to said diaphragm by readily releasable attaching means.

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