Feb. 13, 1951 P. H. GEIGER 2,541,159

SOUND DEADENER FOR VIBRATORY BODIES

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Fig. 1.

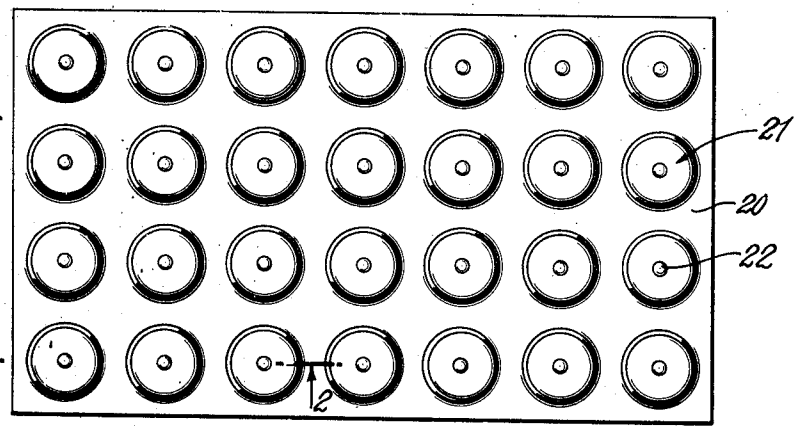


Fig. 2.

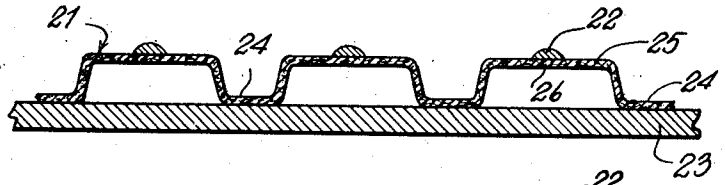


Fig. 3.

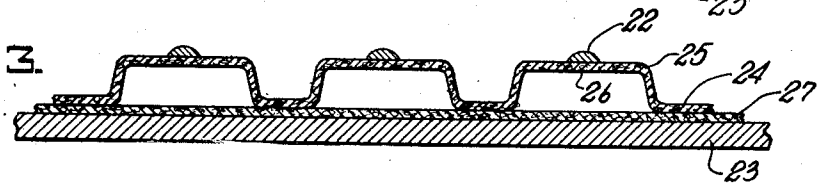
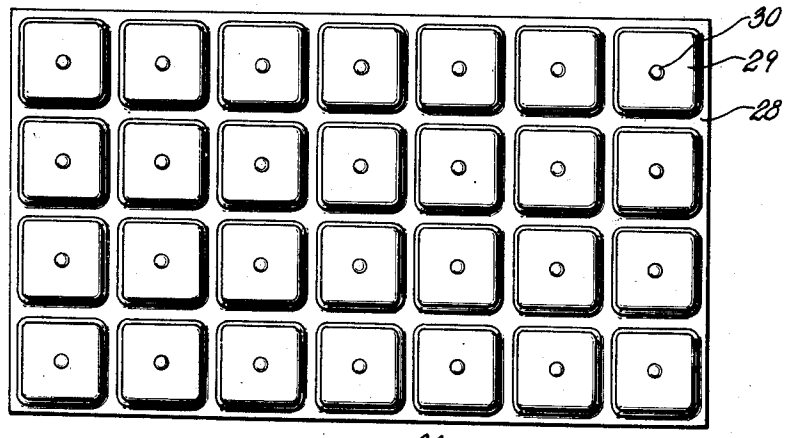


Fig. 4.



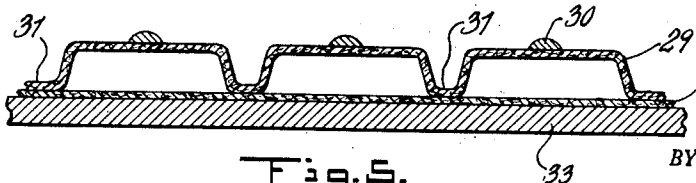


Fig. 5.

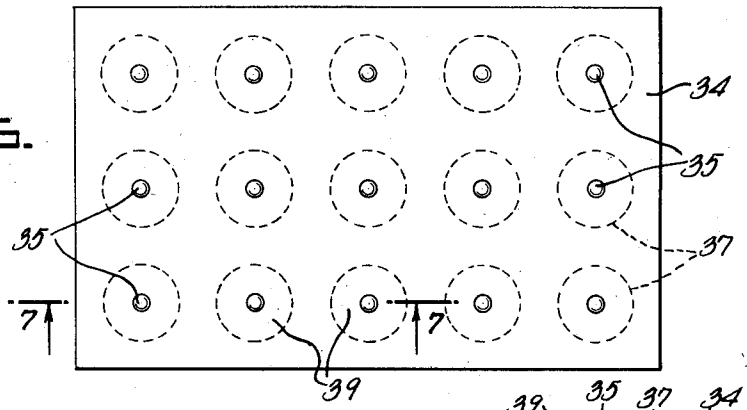
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SOUND DEADENER FOR VIBRATORY BODIES

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Fig. 6.



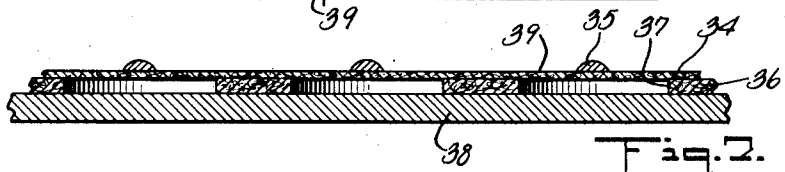


Fig. 7.

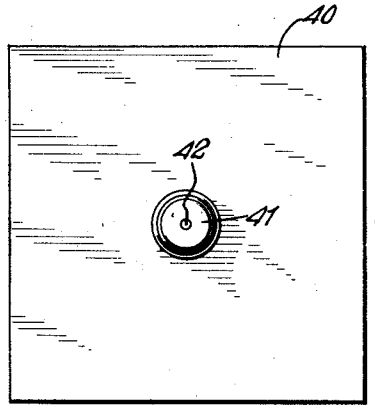


Fig. 8.

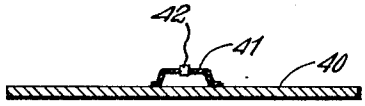


Fig. 9.

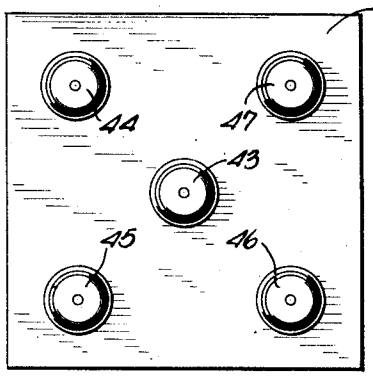


Fig. 10.

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SOUND DEADENER FOR VIBRATORY BODIES

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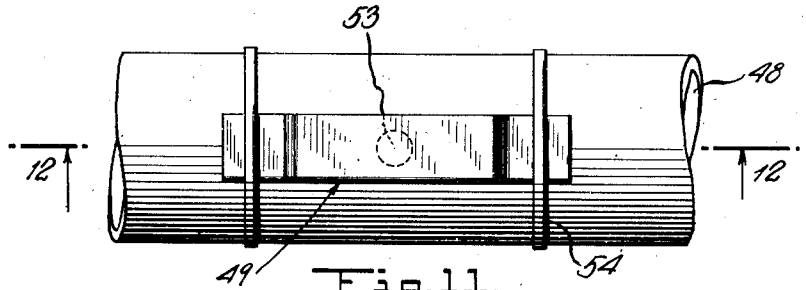


Fig. 11.

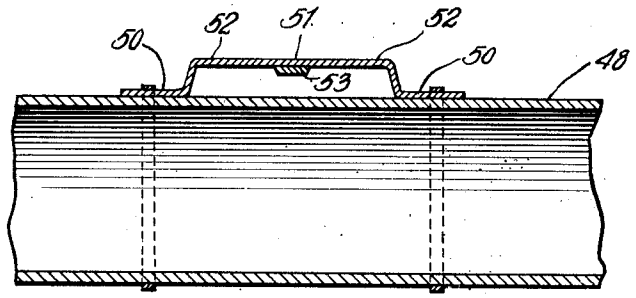


Fig. 12.

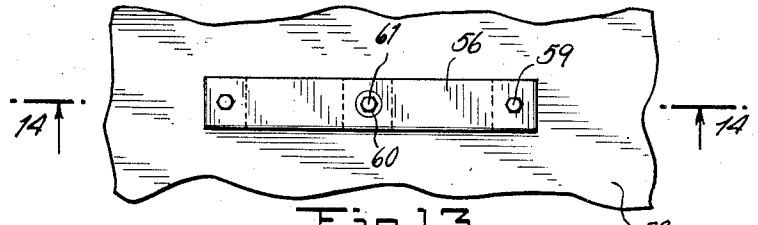


Fig. 13.

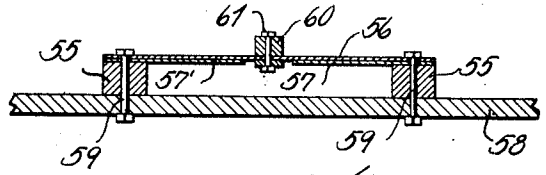


Fig. 14.

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Patented Feb. 13, 1951

2,541,159

UNITED STATES PATENT OFFICE

2,541,159

SOUND DEADENER FOR VIBRATORY BODIES

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Application January 22, 1946, Serial No. 642,599

12 Claims. (Cl. 181—33)

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This invention relates to sound deadeners and relates particularly to sound deadeners adapted to damp the vibrations of audible frequency of surfaces of bodies so as to minimize the intensity and duration of the sound produced by such vibrations.

Whenever a body is free to vibrate at an audible frequency without substantial damping of the vibrations, it is "noisy" in that whenever it is struck or otherwise excited it sets up vibrations which result in persistent sound, the intensity of which depends upon the intensity or amplitude of vibration of the surface of the body. The noisiness of such bodies can be counteracted by damping the vibrations so that the amount and duration of the sound radiated into the air are reduced.

One of the fields in which sound deadeners are used extensively at the present time and which is illustrative of the practical commercial utility of sound deadeners, is the automobile field, the sound deadener being used for the purpose of damping the vibrations of the metal panels of the doors, top, luggage compartment, etc., of automobile bodies so that the automobile will not have an objectionable rumble or "tinny" sound.

Sound deadeners have heretofore been made in several forms. Some sound-deadener materials are made up in a semi-liquid form and are applied to the vibratory surface to be damped as by use of a spray gun and after application are baked or air dried. Other sound deadeners are made in the form of felts or blankets for application by means of an adhesive. Usually, such felts or blankets are indented prior to application so that they may more readily be conformed to the contours of irregularly-shaped parts of automobile bodies. The use of such sound deadeners has, however, proved to be disappointing. In the first place, the damping of the sound-producing vibration has not proven to be particularly effective. For example, the natural frequencies of vibration of an automobile door panel vary from about 150 cycles per second to 600 or more, there being certain frequencies within the range which are particularly pronounced, depending upon the size and shape of the door panel. The vibrations of higher frequency are more readily damped than the lower frequencies. However, it is the lower frequencies that are particularly objectionable in producing the rumble or "tinny" noise of automobiles and the sound deadener materials heretofore used have had only a slight damping effect on such vibrations.

Another disadvantage of sound-deadener materials heretofore used is that it is difficult to obtain uniformity of effectiveness. For example, materials which appear to be identical as far as specifications are concerned with respect to weight and kind of material, amount of saturation, etc., may differ widely in sound deadening effect.

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It is a purpose of this invention to provide sound deadener means for damping the vibrations of a vibrating body which is much more effective weight for weight than sound deadeners heretofore made. It is a further purpose of this invention to provide sound deadeners which can be made so as to have a predetermined vibration damping effect and so as to afford uniformity in effectiveness. It is a further purpose of this invention to provide sound deadeners which have the above-mentioned advantages and which at the same time are simple and inexpensive to manufacture. It is important for many commercial applications that a sound deadener be light in weight, and it is a further purpose of this invention to provide a sound deadener which can be made very light in weight and which at the same time is highly effective.

According to this invention, a sound deadener is afforded which has greatly increased effectiveness because of the employment of a special structure which is operative on a new principle so as to obtain much more rapid damping of surface vibration than heretofore has been regarded as possible. It is a feature of the special structure of the sound deadener of this invention that it comprises a weight and a weight support. The weight support is constructed so as to comprise a base portion for attachment to a surface of a vibrating body and a weight-carrying portion. Between the weight-carrying portion and the base portion is a flexible portion having substantial mechanical hysteresis upon flexure, namely, the capacity when flexed of converting all or a large proportion of the force required to cause the flexure into heat. The weight is affixed to the weight-carrying portion of the weight support and is carried thereby for free vibratory motion relative to the surface to which the base portion of the weight support is attached. When the base portion of the weight support is affixed to a surface of the vibrating body, the flexible portion of the weight support is disposed so that the inertia supplied by the weight causes flexure of the flexible portion of the weight support. The result of such flexure of the flexible portion of the weight support is to accomplish a very rapid conversion of the mechanical energy of the vibrating body into heat with resultant effective

damping of the vibration of the body and deadening of the sound.

By use of a localized weight or mass disposed for free vibratory motion with flexure of a material having substantial mechanical hysteresis, it is possible to dissipate the energy of a vibrating body by conversion into heat many times as effectively as is possible with conventional sound-deadening materials. While the sound deadener of this invention involves the use of localized weight, the structure as a whole is so highly effective that a sound deadener embodying this invention can be made which weighs much less than conventional sound-deadener materials and which at the same time is much more effective.

The new principle which is utilized in sound deadeners according to this invention, lends itself to many different structural embodiments. Certain of these structural embodiments are shown, merely by way of exemplification in the accompanying drawings, wherein:

Fig. 1 is a plan view of a sound deadener embodying this invention;

Fig. 2 is a sectional elevation on a larger scale of the sound deadener of this invention as applied to the surface of a vibrating body;

Fig. 3 is similar to Fig. 2 showing an alternative embodiment of this invention;

Fig. 4 is a plan view of an alternative sound deadened embodying this invention;

Fig. 5 is a sectional elevation on a larger scale of the sound deadener shown in Fig. 4 as applied to the surface of a vibrating body;

Fig. 6 is a plan view of a further alternative embodiment of this invention;

Fig. 7 is a sectional elevation on an enlarged scale of the sound deadener shown in Fig. 6 as applied to the surface of a vibrating body;

Fig. 8 is a plan view of a single sound-deadener element as applied to the surface of a test plate;

Fig. 9 is a sectional elevation of the sound-deadener element and test plate shown in Fig. 8;

Fig. 10 is a plan view of the test plate and sound-deadener element shown in Fig. 8 with four additional similar sound deadener elements also applied to the plate;

Fig. 11 is a plan view of a further embodiment of a sound-deadener device according to this invention which is applied to the exterior of a tubular body;

Fig. 12 is a sectional elevation taken on the line 12—12 of Fig. 11;

Fig. 13 is a sectional elevation of a still further modification of this invention wherein mechanical hysteresis is obtained by surface friction, and

Fig. 14 is a plan view of the sound-deadener device shown in Fig. 13.

The embodiments of this invention shown in Figs. 1 to 7 are well adapted for application to the inside of the metal panels of automobiles such as the doors, the top, the luggage compartment, etc. to deaden the noise of the car. The material that is employed for the weight support advantageously is composed of felt that has been impregnated with a bituminous waterproofing binder material. Such a material has relatively high mechanical hysteresis, in that the material requires substantial force to flex it but has very little resilience. Because of this combination of properties, felt impregnated with bitumen is well-adapted for use according to this invention due to the fact that the force expended in flexing the material is largely converted into heat. A material such as felt impregnated with bitumen is to be contrasted with a material such

as spring steel which has the property of storing mechanical energy imparted as a result of deformation instead of dissipating the mechanical energy by conversion into heat. Spring steel or other springy and highly-resilient materials are not suitable for use as the flexible portion of sound-deadener devices embodying this invention. On the contrary, the portion of the sound-deadener devices which is subjected to flexure should be such that the internal friction of the material converts into heat the energy required to produce flexure. While a resilient material such as springy steel is unsuitable, a flexible member made of such material can be utilized, however, if the parts are arranged so as to accomplish rubbing friction between surfaces upon flexure, the rubbing friction converting a substantial portion of the energy required to produce flexure into heat.

Referring to the embodiment of this invention shown in Figs. 1 and 2, the weight support of the sound deadener is composed of sheet material 20 having a plurality of cup-shaped deformations therein which are indicated generally by the reference character 21. The sheet material 20, may, for example, be conventional organic fiber felt which has been impregnated with a bituminous saturant. The impregnated sheet may, for example, weigh about 0.25 pound per square foot. Secured to the bottom of the cup-shaped deformations 21 are the weights 22, one weight being employed for each deformation. The weights 22 may be composed of any suitable material. When, as in the embodiment shown, the sheet material of the weight support is composed of felt impregnated with bitumen, the weights 22 may desirably be composed of some finely-divided mineral material such as sand, barytes or the like, the particles of which are bonded together by a bituminous binder. The weights 22 may be caused to adhere to the sheet material by a blending of the bitumen in the sheet material and the bitumen in the weights so as to provide a permanent adhesive bond. Each of the weights may, for example, weigh about .6 oz. The cup-shaped deformations may be about 2½ to 3 inches in diameter with the centers spaced apart about 4 to 5 inches.

In Fig. 2, the sound deadener is shown affixed to plate 23 for the purpose of damping the vibrations of this plate. The deformed sheet material constitutes the weight support of the sound-deadener elements, and the portions of the sheet material 20 which are between the rims of the individual cup-shaped deformations constitute the base portions 24 of the weight support, which base portions are adapted to be secured to the plate 23. The base portions 24 can be secured to the plate 23 by use of a suitable adhesive such as a suitable asphalt cement (not shown).

Referring to each of the cup-shaped deformations which constitute the operative elements of the sound-deadener material, it is apparent that between the base portion 24 thereof and the weight-carrying portion 26 thereof to which the weight 22 is attached, there is a flexible portion 25 whereby the weight 22 and the weight-carrying portion 26 of the weight support are disposed for free vibratory motion toward and away from the plate 23. From a somewhat different point of view, it is apparent that the base portion 24 of each of the sound-deadening elements provides spaced base means for attachment to a body for damping the virbations thereof and that the weight is attached to a bridging member be-

tween the spaced base means at an intermediate point of the bridging member.

When the plate 23 is struck or otherwise excited so as to vibrate normal to the surface thereof, the base portions 24 of the sound-deadening elements will vibrate with the surface of the plate 23. Due, however, to the inertia of the weights 22, the weights 22 will not follow the vibratory motion of the plate 23 and there will be flexure of the flexible portions 25 of sound-deadening elements. Since the sheet material of which the weight support is composed, including the flexible portions 25 thereof, has substantial mechanical hysteresis, the energy which produces the flexing of the flexible portions 25 of the sound-deadening elements is converted into heat. Moreover, the inertia provided by the weights 22 produces such a pronounced flexure of the material having mechanical hysteresis that the energy originally contained in the vibrating plate is very rapidly dissipated by conversion into heat with the result that the vibration is damped very quickly and the sound radiated from the vibrating plate soon becomes inaudible.

While it is believed that for most vibration frequencies the weights 22 remain relatively stationary as compared with the vibratory motion of the surface of the body to which the sound deadener is attached, it may be the case that for certain frequencies of vibration, the weights 22 will be caused to vibrate at an amplitude greater than the amplitude of vibration of the surface of the body to which the sound deadener is attached. However, in either event, there will be a pronounced flexing of the material having substantial mechanical hysteresis due to the action of the weights and the vibrations of the surface of the body will be effectively damped due to the rapid dissipation of the energy of the vibrating body in the form of heat.

Referring to Fig. 3, the structure of the sound-deadening elements of the sound deadener is the same as that shown in Figs. 1 and 2, and the structural elements thereof have been indicated by the same reference characters that are used in connection with the foregoing description of the embodiment of this invention shown in Figs. 1 and 2. In Fig. 3, however, the sound deadener comprises a second layer 27 of sheet material which may, for example, be bituminized felt of the same type that is used in the sheet 20 which contains the cup-shaped deformations 21 therein. The embodiment of this invention which is shown in Fig. 3 may be made up at the factory containing the sheets 20 and 27 in permanently bonded relation as by use of an adhesive (not shown). The sound-deadener material thus formed is then adapted for attachment to a vibrated surface by adhering the sheet 27 thereof face-to-face with a vibrating surface, such as the surface of plate 23, as by means of a suitable adhesive (not shown). In such case, the sheet 27 constitutes part of the base portion of the sound-deadening elements which is adapted to be secured to a vibrating surface. By having the sheet 27 disposed so as to underlie the cup-shaped deformations, it is possible to provide a greater area for direct adhesion between the sound deadener and the vibrating surface. In the embodiment of this invention shown in Fig. 3, it is apparent that the weights 22 and the weight-carrying portion of the weight supports of the sound-deadening elements are maintained by the weight supports for free vibratory motion toward and away from the vibrating surface to which the sound-deadener material is secured. By free vibratory movement, it is to be understood that the weight 22 and the weight-carrying portion 26 of each of the weight supports do not contact the vibrating surface or any other body such as the sheet material 27 of Fig. 3 that vibrates with the vibrating surface of the plate 23 when the sound deadener is subjected to the ordinary conditions of use.

In Figs. 4 and 5, an alternative embodiment of this invention is shown wherein the sound-deadening elements are shaped so that a maximum number of the sound-deadening elements can be provided for a given area of surface. The sheet material 28 has cup-shaped deformations 29 therein which are of generally square shape. The weights 30 are attached to the bottom of the cup-shaped deformations 29. The portions 31 of the sheet material 28 are adhesively united to the sheet material 32, which in turn is adapted to be secured to the surface of the body 33 in face-to-face relation therewith. In the embodiment of this invention shown in Fig. 4, it is desirable to use the layer of the sheet material 32 for providing the adhesion to the surface of the body 33 due to the limited area of the portions 31 between the rims of the cup-shaped deformations. However, the sheet material 32 may be omitted, if desired. The sheet material 28 is composed of some material such as bituminized felt which has substantial mechanical hysteresis, and the principle of operation of the embodiment of this invention shown in Figs. 4 and 5 is essentially the same as that of the embodiment of this invention shown in Figs. 1, 2 and 3. However, by increasing the number of individual sound-deadening elements which can be applied to a given area of vibrating surface, the amount of energy required to flex the material having substantial mechanical hysteresis is increased and the effectiveness of the sound deadener is also increased.

It is not essential that the sound-deadening elements be made by producing cup-shaped deformations in sheet material. In Figs. 6 and 7, a sound deadener embodying this invention is shown in which ordinary flat sheet material is used. Two layers of sheet material are employed. One layer 34 is in the form of a continuous sheet which may, for example, be bituminized felt. At spaced intervals about the sheet, the weights 35 are secured thereto. A second sheet 36 may likewise be composed of bituminized felt, and has apertures 37 therein which are shown as circular but may be of any other desired shape. The apertures in the sheet 36 are disposed at intervals corresponding to the spacing of the weights on the sheet 34 and the sheet 36 is adhered to the sheet 34 as by use of an adhesive (not shown) so that the weights 35 will be disposed respectively substantially at the mid-point of the apertures 37. The sound deadener, made as above described, can be secured to the surface of a body 38 as by the use of a suitable adhesive (not shown) for adhering the sheet 36 to the surface of the body 38. In the embodiment of this invention shown in Figs. 6 and 7, it is apparent that a weight support is provided in which the sheet 36 acts as the base portion and in which the sheet 34 provides a flexible portion 39 between the base portion and the weights 35. Moreover, the weights 35 are disposed for free vibratory motion toward and away from the surface of the

body 38 to which the sound-deadening material is secured.

Any of the embodiments of this invention shown in Figs. 1 to 7 is extremely effective in damping the vibrations of a vibrating surface and is extremely effective in deadening the sound caused by the vibrations of such surface. The effectiveness of the sound deadener of this invention may be illustrated in connection with the following description of the results obtained by the use of isolated sound-deadening elements for damping the vibrations of a vibrating plate.

The effectiveness of a sound deadener may be effectively determined by application of the sound deadener to a steel plate measuring 20 by 20 by ¼ inches which has been prepared so that it will have a natural frequency of vibration of 160 cycles per second, the accepted frequency for comparative test. Vibrations of low frequency in the audible range have been found to be the most difficult to damp by means of a sound deadener and any sound deadener which is effective for damping vibrations of low frequency will be effective for all ordinary commercial applications. By providing a steel plate of standard size and frequency of vibration, an accurate standard of comparison is afforded. Such a plate can be mounted so that it will be free to vibrate as by suspending it from a flexible cord or by supporting the plate at its nodes on resilient supports. If the plate is struck or otherwise excited, the plate will continue to vibrate for a considerable time. For testing the rate of decay of vibration, the sound produced by the vibration of the plate can be picked up by a microphone which is connected to an oscilloscope which records oscillations in direct correspondence to the amplitude of the vibration of the vibrating plate. By photographing the amplitude of oscillations as shown by the oscilloscope upon a photographic film moved at a constant speed, the time for producing a given amount of decay of the amplitude of vibration can be accurately measured. From the data so recorded, the rate of decay of the sound produced by the vibrating plate can be calculated in terms of decibels per second. The rate of decay of the sound produced by the vibrating plate without any sound-deadening material applied thereto is substantially 0.5 decibel per second. The effectiveness of a sound deadener applied to the plate will be evidenced by an increase in the rate of decay expressed in decibels per second that results from the use of a sound deadener. The greater the rate of sound decay, the more effective is the action of the sound deadener in damping the vibrations of the plate.

For purposes of comparison, bituminized felt weighing about .26 pound per square foot was applied to one surface of the test plate above described, using the bituminous asphalt cement. The felt was impregnated to the extent of about 100% by weight of the weight of dry fibers with the saturating asphalt having a softening point of about 100° F. The felt had been indented so as to provide a multiplicity of small indentations throughout the lateral extent thereof. Such indented felt is typical of the bituminous organic fiber felt material that is extensively used for sound deadening in automobiles. When the plate was tested for determining the effectiveness of this sound-deadening material, it was found that the sound decay was at the rate of about 3 decibels per second. This does not constitute any very substantial increase in the rate of sound decay as compared with the bare plate.

As shown in Figs. 8 and 9, a single sound-deadening element embodying this invention was applied to the test plate 40. The weight support of the sound-deadening element consisted of a single cup-shaped body 41 substantially three inches in diameter and composed of the same felt material that was used for overall application to the test plate in the conventional manner in the test previously described. In the center of the cup-shaped material, a weight 42 weighing about .3 ounce was secured. As shown, the sound-deadening element was placed in the center of the test plate. When the plate with the sound-deadener element embodying this invention was tested for determining the effectiveness of the sound-deadening element, it was found that the rate of sound decay was about 14 decibels per second. When it is considered that the single sound-deadening element averaged only about 0.01 pound per square foot of the surface area of the test plate, as against .26 pound per square foot for the overall application of felt in the convention manner, it is apparent that the sound-deadener element of this invention, on a weight-for-weight basis, had over 100 times the sound-deadening effectiveness of the felt per se. In order to demonstrate the essentiality of the weight 42, the weight 42 was removed from the sound-deadening element and the plate was again tested with the weight support 41 only affixed thereto. It was found that without the weight, the rate of sound decay was only 1.0 decibel per second and that the weight support 41 by itself and without the weight affixed thereto had virtually no effectiveness in damping the vibrations of the plate.

In Fig. 10, the plate 40 is shown with a sound-deadening element 43 affixed to the center thereof which sound-deadening element is identical with the sound-deadening element shown in Figs. 8 and 9 and described above. In addition to the sound-deadening element 43, four additional sound-deadening elements 44, 45, 46 and 47 were affixed to the plate in the position shown, each of these sound-deadening elements being identical with the sound-deadening element 43. The plate, when tested with the sound-deadening elements 43, 44, 45, 46 and 47 applied thereto as shown in Fig. 10, exhibited a rate of sound decay of about 19 decibels per second. It may be noted that the sound-deadening effect as produced by the five sound-deadening elements as compared with the sound-deadening effect produced by a single element is not in direct proportion to the number of elements applied. This is due, however, to the fact that the sound-deadening element 43 in Fig. 10 is located at the position in the test plate at which maximum amplitude of vibration occurs. The amplitude of vibration of the test plate in the regions covered by the elements 44, 45, 46 and 47 is considerably less than the amplitude of vibration of the test plate in the center thereof. In other words, the amount of energy of vibration which is dissipated in the form of heat is greatest when a sound-deadening element is positioned at the location where maximum amplitude of vibration occurs.

With further reference to the test plate shown in Fig. 10, the weights were removed from the sound-deadening elements 43, 44, 45, 46 and 47 leaving only the weight supports composed of felt affixed to the test plate. When the plate

was subjected to test in this condition, it was found that the rate of sound decay was only 1.25 decibels per second showing that the presence of the weight is essential for producing the high degree of sound-deadening effect that can be obtained according to this invention.

The use of one or more individual sound-deadening elements as shown in Figs. 8, 9 and 10 is not representative of ordinary commerical use of this invention for damping the vibration of metal panels in automobile bodies, since for such purpose the sound-deadening material is usually made up in sheet form comprising a plurality of the sound-deadening elements as has been illustrated in the embodiments of this invention shown in Figs. 1 to 7. However, the use of individual sound-deadening elements as shown in Figs. 8, 9 and 10 indicates the special advantages that can be obtained by the use of the sound-deadening elements of this invention at selected locations on the surface of a vibrating body. Such use of the sound-deadening elements of this invention is of a special utility when reduction in weight is of importance since a very high degree of sound-deadening effect can be obtained for the weight of material applied to the vibrating surface. For example, the vibration of large panels in airplanes can be very effectively damped by placing a single sound-deadening unit or a limited number thereof at one or more selected zones of limited area at which the amplitude of vibration of the vibrating surface is greatest.

In order to further demonstrate the effectiveness of the sound deadener of this invention, a sheet of felt of the same kind that resulted in a sound decay of about 3 decibels per second when applied in flat condition to the surface of the plate, was deformed so as to afford cup-shaped deformations of the kind shown in Figs. 1 and 2, the deformations being substantially 3 inches in diameter and spaced five inches apart center to center. Weights weighing about .3 ounce were attached to each of the deformations. Upon applying the sound-deadener material as thus produced to the test plate as shown in Figs. 1 and 2, it was found that the rate of sound decay was 46 decibels per second. In other words, the vibration of the plate was damped extremely rapidly. Upon removing the weights from the cup-shaped deformations, it was found that the rate of sound decay was only 2.25 decibels per second, thereby showing the essentiality of the weights in affording the extremely rapid damping action which is obtainable according to this invention.

The sound deadener of this invention is applicable not only to flat surfaces but is also applicable to any surface of a body which is subject to vibration. Moreover, the sound deadener of this invention may be made in shapes other than a cup shape. In Figs. 11 and 12, a sound deadener embodying this invention is shown as applied to the tube 48 for the purpose of damping the vibrations thereof. The weight support of the sound-deadener element may be composed of any suitable material having mechanical hysteresis and may, for example, be composed of a metal such as lead or tin. In this embodiment of the invention, the weight support is in the form of a strip which is indicated generally by the reference character 49 and which includes the base portion 50, the weight-carrying portion 51 and the portion 52 which is subjected to flexure. The base portion 50 provides spaced base means with a bridging member therebetween to which the weight 53 is attached for free vibratory motion toward and away from the tube 48. In this embodiment of the invention, the weight is secured to the under side of the weight-carrying portion of the weight support. The base portion 50 of the weight support is shown as attached to the tube 48 by means of bands 54, although any other securing means may be used so as to cause the base portion 50 of the weight support to vibrate integrally with any vibration of the surface of the tube 48. It is apparent that the operation of the embodiment of this invention that is shown in Figs. 11 and 12 is the same as the operation of the embodiments of this invention which have been hereinabove described.

As stated hereinabove, it is not essential that the flexible portion of the base portion be composed of material which per se has the property of mechanical hysteresis upon flexure due to internal friction, for the mechanical hysteresis can be obtained as a result of friction between surfaces. An embodiment of this invention wherein the mechanical hysteresis is obtained by friction resulting from relative movement of contacting surfaces is shown in Figs. 13 and 14. The weight support of the sound-deadening element comprises the base portions 55 which may be metal spacing members. Between the base portions 55 is the resilient metal strip 56 which is flexible and which in and of itself may have little or no mechanical hysteresis upon flexure. In conjunction with the metal strip 56 there are employed the metal strips 57 and 57' which are composed of resilient metal and which have a conformation prior to assembly such that the strips 57 and 57' will be maintained in pressure contact with the strip 57 during vibration of the strip 56 in normal use of the sound-deadening element. The strips 56, 57 and 57' and the spacing members 55 are affixed to the plate 58 by the bolts 59. A weight 60 is affixed to the center of the strip 56 by the bolt 61 and, for purposes of illustration, the weight is shown as having two parts, one part being on each side of the strip 56. When the plate 58 is excited so as to vibrate normally to the surface thereof, the inertia of the weight 60 will cause flexure of the strip 56. When the strip 56 is flexed, the surfaces at the interface between the strip 56 and the strips 57 and 57' are rubbed relatively to each other with resultant friction which dissipates in the form of heat the mechanical energy for producing the flexure.

While embodiments of this invention have been shown for purposes of illustration wherein the weight support of the sound-deadening element comprises spaced base means with a bridging member therebetween, this is not essential. For example, the sound-deadening elements shown in any of Figs. 11, 12, 13 and 14 may be modified by being severed at the center so that each half will be comprised of only a single base portion which is adapted to be affixed to a vibrating surface and a weight that is disposed for free vibratory motion by means of a flexible member projecting from such base portion. When it is stated herein and in the claims that the sound deadener of this invention comprises a base portion and a flexible or bridging member which is "integral" with the base portion, it is to be understood that the sound deadener may be one wherein the member carrying the weight is made fast to the base portion by being secured thereto by an adhesive or other securing means as in

any of the embodiments shown in Figs. 6, 7, 13 and 14, or may be one wherein all or a part of the base portion is made in one piece with the flexible or bridging member as in the embodiments shown in Figs. 1–5, 11 and 12. Similarly, in the embodiment shown in Fig. 3, the portions 24 of the sheet 20 are to be regarded as "integral" with the sheet 27, and the same is true with reference to the portions 31 of sheet 28 which are united with the sheet 32 in the embodiment shown in Figs. 4 and 5.

It is apparent that the sound deadener of this invention may be varied considerably as compared with the embodiments thereof that have been described hereinabove and shown in the accompanying drawings. Thus, the weight support can be varied in its form and dimensions depending upon the material used and the nature and size of the body to which the weight support is to be secured. In general, it may be stated, however, that the dimensions of the weight support should be consistent with affixing a suitable number of elements, which are flexed by the weight, to a surface of a vibrating body so that the vibrations may be effectually damped. When the sound-deadening elements consist of opposed base means with a bridging member having a flexible portion therebetween, the distance between the spaced means will generally not be greater than about 7 inches. On the other hand, the distance between the spaced base means, is generally at least about 0.5 inch. For use in damping the vibrations of the metal panels in the bodies of automobiles, the distance between the spaced base means will generally be of the order of 1.5 to 3.5 inches. The weight support can be of any shape that is adapted to carry the weight for free vibratory motion when the base portion of the weight support is affixed to a body for integral movement with a vibrating surface of the body.

The bituminized felt above referred to may have as a base not only organic fibers but also asbestos fibers. In addition impregnating materials other than bitumen may be employed such as flexible synthetic resins. Other materials having substantial mechanical hysteresis may be employed such as leather or such as fabrics which, by virtue of the weaving thereof, or by virtue of a binder impregnant have sufficient stiffness to carry the weight and at the same time have flexibility. Flexible synthetic resin sheet material may also be used. The use of metals such as lead and tin has been previously mentioned. Such materials per se have substantial mechanical hysteresis upon flexure.

The weight that is affixed to the weight support should have substantial mass so that the inertia of the weight will subject the weight support to substantial flexure when the base portion of the sound deadener is caused to vibrate in unison with a vibrating surface to which it is attached. The mass of the weight is not critical but the mass selected will, of course, depend upon a number of variables including the dimensions and form of the weight support and the stiffness and strength of the material of which the flexible portion of the weight support is composed. In the case of sound-deadener elements which are cup-shaped or are otherwise provided with base means spaced 0.5 to 7 inches apart and in which the weight support is composed of bituminized felt, the individual weights will ordinarily weigh from about 0.1 ounce to about 1.0 ounce. When it is considered that the entire weight support of an individual weight support composed of such material weighs only about 0.5 to 1 ounce, it is apparent that the weight constitutes a mass weighing several times the weight of the weight-carrying portion of the weight support to which the weight is attached, and that a localized mass is provided which, by its inertia, causes vigorous flexure of the weight support when the weight support is affixed to a vibrating surface. While the weight should provide a localized mass weighing several times the weight support should be consistent with affixing which it is attached, it should not be so heavy as to cause excessive sagging of the weight support which would permit the weight or the weight-carrying portion to contact the vibrating surface or any other member integral therewith during normal use of the sound deadener. In other words, the weight and weight-support are made so that the weight support carries the weight for free vibratory movement relative to the base portion of the weight support when the base portion is attached to a surface of a vibrating body, such vibratory movement being induced by the inertia of the weight when the base portion of the weight support is subjected to the vibration of a surface to which it is attached.

The weights may, of course, be comosed of any suitable material such as a finely-divided material (preferably of high density) bonded together by a binder. Alternatively, a metal, e. g. lead may be used. The weight can be affixed to the weight support in any suitable way as by means of an adhesive or by some mechanical securing means.

The sound deadener of this invention may be used wherever it is desired to effectively dampen the vibrations of a body. The application of the sound deadener of this invention to panels of automobile bodies, to panels of airplanes, to parts of railroad coaches, to housings for machinery, to walls and partitions, to piping, etc. is merely illustrative.

While this invention has been described in connection with certain specific embodiments thereof, it is to be understood that this has been done merely for purpose of exemplification and that the scope of this invention is to be governed by the language of the following claims.

I claim:

1. A sound deadener for damping the vibration of a vibrating body comprising a weight and a weight support, said weight support comprising a base portion adapted to be affixed to a surface of said vibrating body for integral vibratory movement of said base portion with said surface, a weight carrying portion spaced substantially from said base portion, and between said base portion and said weight carrying portion flexible sheet material having substantial mechanical hysteresis upon flexure, said weight being an essentially unitary localized mass whose inertia is several times greater than that of said weight-carrying portion of said support and being affixed to said weight carrying portion of said support and carried thereby for free vibratory motion relative to said surface when said base portion of said weight support is affixed to said surface, and said flexible sheet material of said weight support being disposed for flexure due to the inertia of said weight when the base portion of said weight support is subjected to vibration of said surface.

2. A sound deadener for application to a body

presenting a vibratory surface for damping vibrations normal to said surface which comprises a plurality of elements integrally united in sheet-like form adapted to overlie and to be affixed to the surface of said body to damp the vibration of said surface, each of said elements comprising a weight and a weight support, said weight support having a base portion adapted to be affixed to said body for integral movement of said base portion with said vibratory surface, a weight carrying portion spaced from said base portion, and a flexible portion having substantial mechanical hysteresis upon flexure between said base portion and said weight carrying portion, said weight being affixed to and carried by said weight carrying portion of said weight support, said weight support being adapted to maintain said weight carrying portion thereof and said weight carried thereby spaced from and overhanging said surface when said base portion of said weight support is affixed to said body so as to permit free vibratory movement of said weight toward and away from said surface upon flexure of said flexible portion of said weight support, and the inertia of said weight being several times greater than the inertia of the weight carrying portion of said weight support and being adapted to subject said flexible portion of said weight support to substantial flexure upon vibration of said base portion of said weight support at an audible frequency normal to said surface when said base portion of said weight support is affixed to said body.

3. A sound deadener for application to a body presenting a vibratory surface for damping vibrations of said surface normal to said surface, said sound deadener comprising a weight and a weight support, said weight support comprising flexible sheet material which has substantial mechanical hysteresis upon flexure and which provides a bridging member between and integral with oppositely disposed base means of a base portion of said weight support adapted to be affixed to said body for integral movement with said surface, the density of said weight being substantially greater than that of said flexible sheet material providing said bridging member, said weight being affixed to said bridging member at an intermediate position between said base means, said weight providing a localized mass the inertia of which is several times greater than that of the portion of said bridging member to which it is affixed leaving the balance of the span of said bridging member essentially free of any such mass, and said weight being maintained by said bridging member for free vibratory movement toward and away from said surface when said base portion of said weight support is affixed to said body.

4. A sound deadener according to claim 3 wherein the portion of said bridging member to which said weight is affixed is substantially parallel to said surface when said base portion of said weight support is affixed to said body.

5. A sound deadener according to claim 3 wherein said flexible sheet material comprises felted fiber impregnated with bituminous binder.

6. A sound deadener according to claim 3 wherein the oppositely disposed base means are spaced apart by a distance of the order of 0.5 to 7 inches.

7. A sound deadener for application to a body presenting a vibratory surface for damping vibrations of said surface normal to said surface, said sound deadener comprising flexible sheet material which has substantial mechanical hysteresis upon flexure and which is provided with a plurality of shallow essentially flat bottom cup shaped deformations, a weight being secured to the bottom of each of a plurality of said cup shaped deformations for free vibratory motion, the inertia of said weight being adapted to cause flexure of said sheet material when the rim portion of the cup shaped deformation carrying same is vibrated at an audible frequency normal to the bottom portion thereof.

8. A sound deadener according to claim 7 wherein a second sheet of sheet material is integrally united with the rim portion of said cup shaped deformations and is adapted for face-to-face securement to a vibratory surface.

9. A sound deadener according to claim 7 wherein said flexible sheet material is composed of bituminized felt, wherein said cup shaped deformations are of the order of 1.5 to 3.5 inches across, and wherein said weights weigh from about .1 to 1.0 ounce.

10. A sound deadener element comprising a weight and a weight support, said weight support comprising bituminized felt in the form of spaced support means with a bridging member therebetween and secured thereto, said spaced support means being spaced from about 0.5 to about 7 inches apart and being adapted to be affixed to a vibratory surface, said weight weighing about .1 to about 1.0 ounce and being affixed to said bridging member adjacent the center thereof between said support means, and said bridging member carrying said weight for free vibratory motion toward and away from said surface when said base means of said weight support is affixed to said vibratory surface.

11. A sound deadener for application to a body presenting a vibrating surface for damping vibrations normal to said surface comprising in integral sheet form a plurality of weights affixed respectively to a plurality of support means therefor provided by a succession of spaced base portions adapted to be affixed to said body for integral movement with said vibratory surface and by bridging members extending between said base portions, said weights being secured to said bridging members for free vibratory movement toward and away from said surface and being localized in approximately mid-position between said spaced base portions, and said bridging members comprising flexible sheet material having substantial mechanical hysteresis disposed between said weights and said base portions and adapted to be flexed by the inertia of said weights when said base portions are affixed to said surface and are caused to vibrate at an audible frequency.

12. A sound deadener for application to a body presenting a vibratory surface for damping vibrations of said body, said sound deadener comprising a weight and a weight support, said weight support comprising a base portion including oppositely disposed base means and a bridging member integral with said base means, said oppositely disposed base means being spaced apart by a distance of the order of 0.5 to 7 inches, said base means being adapted to be affixed to said body for integral movement with a surface thereof, said weight being affixed to said bridging member and localized at approximately mid-position between said base means, said base means when affixed to said body being adapted to carry said weight for free vibratory movement relative to said surface, said bridging member comprising a

weight carrying portion which carries said weight, the inertia of said weight being several times greater than the inertia of said weight carrying portion of said bridging member and the density of said weight being substantially greater than that of said bridging member, and said bridging member comprising flexible sheet material which is between said weight carrying portion and said base means, which has substantial mechanical hysteresis upon flexure and which is adapted to be flexed by the inertia of said weight when said base means is affixed to said surface of said body and is caused to vibrate therewith at an audible frequency.

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Certificate of Correction

Patent No. 2,541,159 February 13, 1951

PAUL H. GEIGER

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 2, line 24, for "efiective" read *effective*; column 3, line 30, for the word "deadened" read *deadener*; column 11, line 29, before "means" insert *base*; column 12, line 12, before "support" insert *of the portion of the weight*; same line, after "support" strike out "should be consistent with affixing"; line 13, before "which" insert *to*; line 29, for "comosed" read *composed*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 8th day of May, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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