

May 19, 1959

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2,887,173

SOUND ABSORBING AND INSULATING PANEL

Filed May 22, 1957

2 Sheets-Sheet 1

Fig. 1

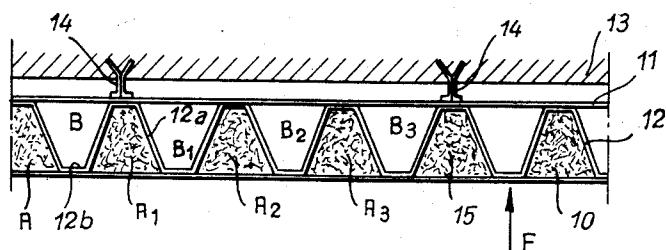
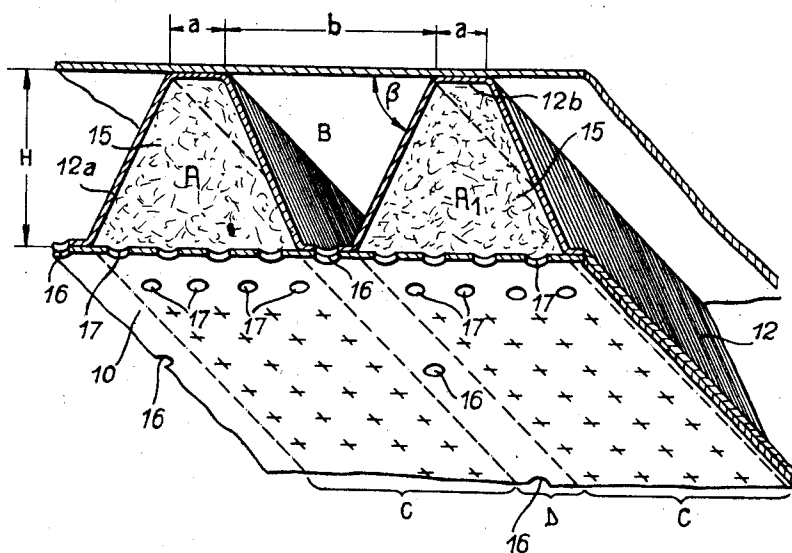


Fig. 2



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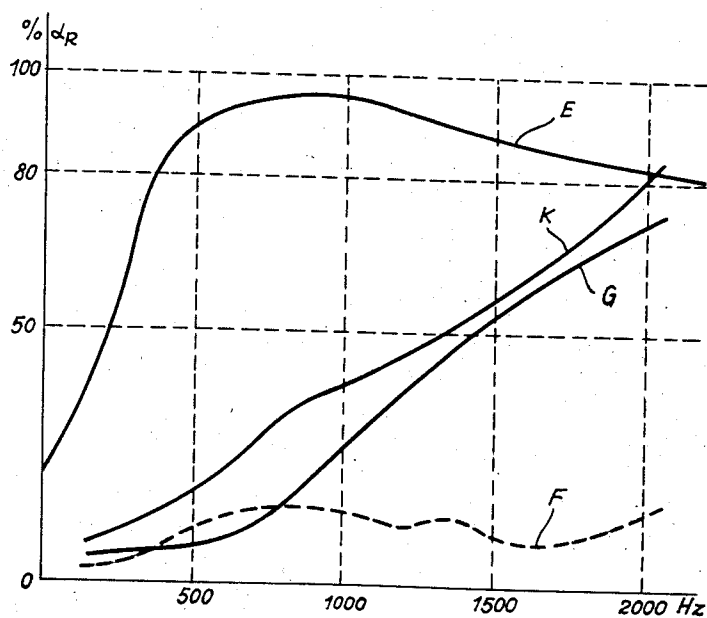
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Fig. 3



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SOUND ABSORBING AND INSULATING PANEL

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5 Claims. (Cl. 181—33)

This invention relates to the technique of absorbing noise within inclosures, such as office rooms, machine or motor rooms and compartments by means of panels which are normally fitted to the ceiling and/or walls of said inclosures.

On thorough investigation of the nature of the noise which more frequently occurs therein, I ascertained that most of it is composed of acoustic frequencies within a range between about 400 and about 2,000–5,000 hertz cycles per second, the intensity of said frequencies prevailing throughout the acoustic spectrum of said noise. I further ascertained that frequencies over and above 2,500 Hz. (hertz) impose no particular problems, inasmuch as they can easily be absorbed by a considerable extent (up to 90% and more) by means of suitable linings of mineral wool or similar fibrous material, which are, however, inadequate in respect of lower frequencies included within the above mentioned range.

A first object of this invention is to provide a sound absorbing and insulating panel adapted to satisfactorily absorb frequencies ranging between about 400 and about 2,000 hertz and even frequencies exceeding 2,000 hertz.

A further object of this invention is to provide a sound absorbing and insulating panel, having an improved absorbing capacity, that is, a panel the volume of which is almost fully utilized for sound absorbing purposes.

A still further object of this invention is to provide a sound absorbing and insulating panel which is light, stiff, moisture-proof and withstands acidic vapours usually present in closed workplaces, and is easy and inexpensive to manufacture.

According to a first aspect of this invention I provide a sound absorbing and insulating panel comprising a pair of parallel spaced walls including a front and a rear wall, an undulated member of sheet material interposed between the walls having its opposite ridge portions fixedly secured to the front and rear walls respectively whereby a plurality of adjacent parallel channels of a substantially trapezoidal cross-sectional shape is defined between the front and rear walls, a row of openings in the front wall and the undulated member along each ridge portion of the member adjacent the front wall whereby alternate channels are accessible through the front wall, each opening of the said series having associated therewith a volume of 43 to 44 cm.³ of the associated channel, a filling of a fibrous material in the other alternate channels having their large base portions formed by the front wall of the panel, and a plurality of openings in the front wall leading to the said other alternate channels, each of the last named openings having associated therewith a volume of 2.5 to 3 cm.³ of the associated channel.

According to a further aspect of the invention, I provide a sound absorbing and insulating panel comprising a pair of parallel spaced walls including a front and a rear wall, an undulated member of sheet material interposed between the walls having its opposite ridge portions fixedly secured to the front and rear walls respectively, the undulations of the said member providing transverse

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partitions between the walls inclined with respect of the latter through an angle of 60–70° whereby a plurality of adjacent parallel channels of a trapezoidal cross-sectional shape is defined between the front and rear walls, the said channels having alternately small and large bases adjacent the front wall, a row of openings in the front wall and the undulated member along each ridge portion of the member adjacent the front wall whereby channels having their small bases adjacent to the front wall are accessible through the wall, each opening of the said series having associated therewith a volume of 43 to 44 cm.³ of the associated channel, a filling of a fibrous material in the channels having their large base portions adjacent the front wall, and a plurality of openings in the front wall leading to the said last named channels, each of the last named openings having associated therewith a volume of 2.5 to 3 cm.³ of the associated channel.

According to a still further aspect of this invention I provide a sound absorbing and insulating panel comprising a sheet metal member undulated to a uniform trapezoidal wave form, a pair of flat sheet-metal walls including a foraminated front wall superposed onto opposite faces of the undulated member and fixed to opposite ridge portions of the member respectively whereby a plurality of adjacent channels of alternately inverted trapezoidal cross-sectional shape is defined between the walls, the cross-sectional area of each channel being of approximately 8.5 to 9.0 cm.², the said foraminated front wall including rows of openings leading to alternate channels through small bases of the channels with the openings in each row mutually spaced through approximately 5 cm., and a plurality of openings leading to the other alternate channels through large bases thereof, each of the last named openings having associated therewith a volume of approximately 2.7 cm.³ of the associated channel, and a filling of a fibrous material in the said other alternate channels.

In panels of this kind a panel side usually faces the source of sound or noise to be absorbed, its opposite face being adjacent the wall or ceiling of the inclosure which is to be made sound-proof, and I refer herein to the wall of sheet material facing the source of sound or noise or adapted to face said direction as "front wall of the panel," the opposite wall of the panel being referred to as "rear wall of the panel."

In order to make this invention more clearly understood I will refer hereafter to the accompanying drawing which shows by way of example an embodiment of my panel, and wherein:

Figure 1 is an end view in a direction parallel with the generatrices of the undulations of the undulated member of an improved panel hanging to the ceiling;

Fig. 2 is a perspective sectional view of the panel of Fig. 1.

Figure 3 is a diagram demonstrating the absorbing properties of this panel over other currently employed materials. On this diagram acoustic frequencies in hertz (Hz.) are given on the abscissae, the ordinates denoting the absorption degree α_R by percent.

The panel shown in Figures 1 and 2 essentially comprises a front wall 10, a rear wall 11 and an undulated member 12 interposed between the walls. The rear wall 11 hangs to the ceiling 13 by means of suspension means 14, which may be of any suitable type and not within the scope of this invention.

The walls 10 and 11 as well as the undulated member 12 are manufactured according to this embodiment of sheet aluminum of about 0.5–1 mm. gauge; however, I can employ other sheet materials, such as synthetic resins, sheets of molded or laminated wood conglomerate, paperboard advantageously impregnated with synthetic resins, or other metals in sheet form. However, I pre-

fer using sheet aluminum on account of both its light weight and the possibility of superficial anodic oxidation which makes it substantially unaffected by moisture, acid vapours and other deleterious agents.

In Figure 1 the arrow F denotes the general direction of incidence of sounds or noise on the front wall 10 of the panel.

The walls 10 and 11 extend parallel with each other and are spaced apart by an extent H equalling about 3.5 cm. but variable between about three and four centimeters. The undulations of the undulated member 12 are in the form of a regular trapezoidal wave with flat sides 12a and likewise flat ridge-ports 12b, the width a of the latter being about one centimeter. The sides 12a of the undulations are inclined with respect to the front wall 10 and rear wall 11 through an angle β ranging between 60° and 70°. In the embodiment shown this angle has been selected so that the spacing b equals four centimeters. The opposite ridge portions of the undulated member 12 are fitted against the walls 10, 11 and securely fixed to the latter in any known manner, such as by welding, gluing or the like.

The space between the walls 10, 11 is thereby subdivided into a plurality of parallel prismatic channels of alternately inverted trapezoidal cross-sectional shape, said channels being all equal in cross sectional shape and area. In fact, in each of them the smaller base amounts to $a=1$ cm., the larger base amounts to $b=4$ cm., their common height being $H=3.5$ cm., so that the cross sectional area of each channel is:

$$(a+b)\frac{H}{2}=8.75 \text{ cm.}^2$$

Broadly speaking, in the manufacture of the improved panel the values H, a, b and β shall be mutually adjusted so that the cross sectional area of the channels ranges between 8.5 and 9.0 cm.². The channels have therefore each a volume 8.5–9.0 cubic centimeter per each centimeter length of the channel measured perpendicularly to the plane of Figure 1.

Each other channel, such as A, A₁, A₂, A₃ etc. has its larger base (amounting to b) adjacent the front wall 10 and formed by the said wall 10, the remaining channels such as B, B₁, B₂, B₃ etc., alternating with the first mentioned channels having their smaller base adjacent the front wall 10, said smaller base consisting of the ridge portions of the member 12 which are adjacent and welded to the front wall 10; this arrangement is defined by me as a plurality of channels of alternately inverted trapezoidal cross-sectional shape.

The channels A, A₁, A₂ etc. having their larger base adjacent the front wall 10 are filled with a fibrous material, advantageously mineral wool, glass wool or the like, denoted on the drawing by 15. Vegetable fibre materials may alternately be used, advantageously when fire-proofed. The channels such as B, B₁, B₂ etc. are deprived of any filling.

Finally, it should be noted that the front wall 10 has a considerable number of holes bored therethrough, some holes being clearly shown in Figure 2, the location of the other holes being simply symbolized by a cross. All these holes are about 4 mm. in diameter, their overall area amounting to about 8.5% of the overall area of the front wall 10. In other words, in a panel 100 x 100 cm. in size, the overall holes area amounts to about 850 cm.²

However, these holes are distributed in a special manner over the front wall 10. In fact, the front wall 10 comprises regions or strips D one centimeter wide, which are supported by the ridge portions of the undulated member 12, and unsupported regions or strips C interposed between the former. The holes 16 bored through each supported region D also extend through the adjacent ridge portion of the undulated member and are spaced about 5 cm. in this embodiment, so that the holes each have associated therewith a volume of $8.75 \times 5 =$ about 44 cubic centi-

meters of their respective channel B, B₁, B₂ etc. Generally, the holes 16 are spaced along the strips D so that each hole has associated therewith a volume of 43–44 cubic centimeters of its respective channel.

The regions or strips C comprise in the embodiment shown four rows of holes 17 uniformly spaced over the width b of the region. The holes 17 on each row are spaced by 1.25 cm., so that each hole 17 has associated therewith a volume of about

$$\frac{8.75 \times 1.25}{4} = 2.7$$

cubic centimeters of its respective channel such as A, A₁, A₂ etc. Generally, the holes 17 shall be distributed so that they each have associated therewith a volume of 2.5 to 3 cubic centimeters of the channel adjacent said holes.

It will be seen that the channels A, A₁ . . . B, B₁ etc. each form with their holes 17 and 16, respectively, a family of acoustic resonators. So, for instance, each channel, such as the channel B contains over each linear meter on its length twenty resonators each of a volume of 43–44 cm.³, that is, as many resonators as there are holes 16 opening into the channel. Similarly, the channels of type A comprise over each linear meter 320 holes 17, hence 320 resonators each of a volume of 2.5–3 cubic centimeters. Apart from the thickness of the partitions such as 12a provided by the undulated member 12, it will be seen that all these resonators substantially fill the full panel volume. Therefore, a panel of 100 x 100 cm. size, comprising 20 strips C and 20 strips D has 6,400 resonators associated with the holes 17, and 400 resonators associated with the holes 16. Since the area of each hole (4 mm. diameter) is 0.126 square centimeters, the overall area of all the holes is: $6,800 \times 0.126 = 860$ square centimeters, that is, 8.6% of the overall area of the panel.

Consequently, the improved panel possesses a considerable sound and noise absorbing efficiency per square meter of its surface, in addition to being light weight, fireproof and relatively rigid in structure.

In Figure 3 the curve E denotes the characteristics of the improved panel. It is clearly seen that frequencies ranging between about 400 and about 2,500 hertz are absorbed by at least 80% of their intensity incident on the panel, and frequencies ranging between about 500 and 1,500 hertz are absorbed by at least 90%. The curves F, G and K refer respectively to a lining of a sprayed porous material, mineral wool and wood fibres. It is seen from these curves that fibrous linings (curves G and K) become effective only within the frequency range over and above 2,000 hertz, the curve E, which is representative of the improved panel, being considerably more advantageous.

It is pointed out that the partitions such as 12a and ridge portions such as 12b need not necessarily be flat, as shown on the drawing, but could be curved approaching the shape of a sinusoidal wave, provided the size relationship set out above in respect of the H and β values as well as the distribution of the holes 16, 17 are maintained, the scope of the invention being in any case defined by the appended claims.

What I claim is:

1. In a sound absorbing and insulating panel a pair of parallel spaced walls including a front and a rear wall, an undulated member of sheet material interposed between the walls having its opposite ridge portions fixedly secured to the front and rear walls respectively whereby a plurality of adjacent parallel channels of a substantially trapezoidal cross-sectional shape is defined between the front and rear walls, a row of openings in the front wall and the undulated member along each ridge portion of the member adjacent the front wall whereby alternate channels are accessible through the front wall, each opening of the said series having associated therewith a volume of 43 to 44 cm.³ of the associated channel, a filling of a fibrous material in the other

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alternate channels having their large base portions formed by the front wall of the panel, and a plurality of openings in the front wall leading to the said other alternate channels, each of the last named openings having associated therewith a volume of 2.5 to 3 cm.³ of the associated channel.

2. In a sound absorbing and insulating panel a pair of parallel spaced walls including a front and a rear wall, an undulated member of sheet material interposed between the walls having its opposite ridge portions fixedly secured to the front and rear walls respectively, the undulations of the said member providing transverse partitions between the walls inclined with respect of the latter through an angle of 60-70° whereby a plurality of adjacent parallel channels of a trapezoidal cross-sectional shape is defined between the front and rear walls, the said channels having alternately small and large bases adjacent the front wall, a row of openings in the front wall and the undulated member along each ridge portion of the member adjacent the front wall whereby channels having their small bases adjacent to the front wall are accessible through the wall, each opening of the said series having associated therewith a volume of 43 to 44 cm.³ of the associated channel, a filling of a fibrous material in the channels having their large base portions adjacent the front wall, and a plurality of openings in the front wall leading to the said last named channels, each of the last named openings having associated therewith a volume of 2.5 to 3 cm.³ of the associated channel.

3. In a sound absorbing and insulating panel a pair of parallel spaced sheet metal walls including a front and a rear wall at a mutual distance of about 3.5 cm., an undulated sheet metal member interposed between the walls having its opposite ridge portions fixedly secured to the front and rear walls respectively, the undulations of the said member providing transverse partitions between the walls inclined with respect of the latter through an angle of 60-70° whereby a plurality of adjacent parallel channels of a trapezoidal cross-sectional shape is defined between the front and rear walls, the said channels having alternately small and large bases adjacent the front wall, a row of openings in the front wall and the undulated member along each ridge portion of the member

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adjacent the front wall whereby channels having their small bases adjacent to the front wall are accessible through the wall, each opening of the said series having associated therewith a volume of 43 to 44 cm.³ of the associated channel, a filling of a fibrous material in the channels having their large base portions adjacent the front wall, and a plurality of openings in the front wall leading to the said last named channels, each of the last named openings having associated therewith a volume of 2.5 to 3 cm.³ of the associated channel.

4. In a sound absorbing and insulating panel a sheet metal member undulated to a uniform trapezoidal wave form, a pair of flat sheet-metal walls including a foraminated front wall superposed onto opposite faces of the undulated member and fixed to opposite ridge portions of the member respectively, whereby a plurality of adjacent channels of alternately inverted trapezoidal cross-sectional shape is defined between the walls, the cross-sectional area of each channel being of approximately 8.5 to 9.0 cm.², the said foraminated front wall including rows of openings leading to alternate channels through small bases of the channels with the openings in each row mutually spaced through approximately 5 cm., and a plurality of openings leading to the other alternate channels through large bases thereof, each of the last named openings having associated therewith a volume of approximately 2.7 cm.³ of the associated channel, and a filling of a fibrous material in the said other alternate channels.

5. In the sound absorbing and insulating panel as claimed in claim 4, the total area of the openings being approximately 8.5% of the total area of the front wall.

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