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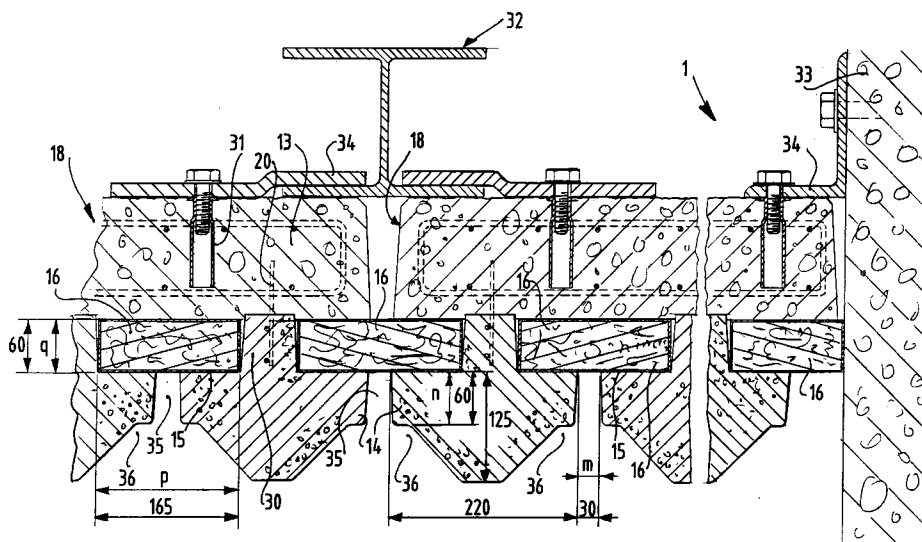
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(54) **Sound absorbing wall.**

(57) Sound absorbing wall for absorbing and screening traffic noise comprising a layer of open-cell material facing towards the traffic noise source and having a relief for enlarging of the surface for radiating; behind which is disposed a plurality of resonance chambers of Helmholtz air body resonators provided with sound absorbing material (16), wherein the wall comprises at least one layer of sufficient mass to prevent the sound passing through the screen, wherein the absorption characteristic of the open-cell material is adapted to absorbing the sound with high frequencies and the absorption characteristic of the Helmholtz air body resonators is adapted to absorbing the sound with low frequencies, and wherein both absorption characteristics together have a satisfactory absorption coefficient over a substantially continuous sound band substantially covering the traffic noise of heavy and light vehicles.

**FIG. 9****EP 0 467 476 A1**

The invention relates to a sound absorbing wall for absorbing and screening traffic noise.

The known sound absorbing walls are generally capable of absorbing high tones such as 1000-2000 Hz from the sound spectrum but they do not adequately absorb the low tones of the sound band 125-500 Hz which emanate from tyre noise and engine noise from heavy goods vehicle traffic.

In this respect the invention provides an improved sound absorbing wall which is moreover structurally robust and easy to build for a long useful life. The wall according to the invention is as designated in claim 1.

According to the invention traffic noise that consists of sound with low frequencies, mainly caused by trucks, and sound with high frequencies, caused mainly by light vehicles, is combatted by absorbing it using a structural sound absorbing screen based on the combination of the absorption characteristic of open-cell or porous material and the absorption characteristic of a plurality of Helmholtz resonators with a volume adapted to the low frequencies of the occurring traffic noise, wherein the latter absorption characteristic is substantially joined to the former. The wall according to the invention is designated in claim 1.

The wall according to the invention is particularly effective per m² of screen surface area because the sound absorbing means of the first and the second characteristic are stacked on one another in the sound direction. The sound with high frequencies is absorbed in the free outer surface which preferably has a relief configuration with a large surface area, while arranged therebehind are the Helmholtz resonance chambers, each of which has an inlet, formed and dimensioned in accordance with the theory of Helmholtz and facing the sound source, in the form of a preferably slit-like, rather narrow opening or optionally a plurality of openings together forming an inlet.

Situated in the intake of the Helmholtz resonators used according to the invention is a body of air, making these air body resonators. Located behind the Helmholtz resonance chambers is another constructional wall with sufficient mass to prevent sound passing through the screen.

DE-A-3827144 proposes a wall wherein a layer of open-cell concrete having a configuration enlarging the surface area is present facing the sound source, while empty resonator chambers are present therebehind which have an associated wall piece as resonance body. These resonators are not air body resonators and are not filled with fibre material. This known wall does not effectively absorb sound over a broad continuous sound band extending over the low and the high frequency range.

DE-A-3322189 proposes a wall of special bricks of concrete or the like. Manufacturing these special bricks with open-cell material is not proposed. Disposed mutually adjacent in the special bricks are a number of empty Helmholtz air body resonators, each of which is adapted to a different sound band so that the sound of a plurality of mutually adjacent sound bands is absorbed. This wall is nevertheless not very effective as the plurality of different resonators with different dimensions are disposed adjacent to each other and as the resonators do not each have damping material. Proposed in contrast according to the invention is a wall in which the Helmholtz resonators adapted to a quite broad low frequency sound band are located behind the other absorbing means that is adapted to absorb a rather broad high frequency band.

FR-A-2612217 and DE-A-3937756 each propose a sound absorbing wall wherein a resonance space of a Helmholtz air body resonator provided with sound absorbing material is present. Lacking here is an open-cell layer facing toward the sound source and having a relief enlarging the surface area. While the attempt is made with the wall according to these publications to broaden the sound band of absorbed sound, the invention proposes to combine two characteristics which each have their strong effect in their characteristic band. The attempt is made according to the invention to broaden the sound band of each characteristic and to make the adapting of the two characteristics to the occurring sound such that they substantially join onto one another.

CH-671054 proposes a sound absorbing wall that is profiled on the surface facing toward the sound source in order to enlarge the sound absorbing surface area of sound absorbing material such as light concrete. Helmholtz resonators are omitted here.

It is remarked that a sound absorbing wall is known which is constructed from blocks (Soundblox[®]) of the firm Asona Belgium BVBA, in Houthalen, which each consist of trays of a semi-open structure material which are filled to a small extent with a fairly thin layer of sound absorbing fibrous material and which have an air inlet. Absent here are both the enlarged surface profile and the open-cell material on the surface. This soundblox is not adapted for good absorption of two broad sound bands joining onto one another and is therefore less suitable for absorbing traffic noise.

A "Brique monolith acoustique[®]" from the firm Guiraud Frères in Toulouse Cédex is known. This brick has a plurality of resonator chambers with different volumes which are partly filled with soft absorbing material, but this brick does not have a layer of open-cell material.

FR-261225 proposes a wall wherein the side facing toward the sound source has a surface enlarging

configuration, but which is not however manufactured from open-cell material. Arrow-shaped walls fixedly hold packets of fibre material with their edges. The sound inlets present between gaps are not dimensioned as inlets of Helmholtz resonators. A considerable effect of the fibre material exposed to the direct sound radiation occurs here. This wall only absorbs a high frequency sound well.

EP-A-0282679 proposes a wall constructed from elements whereof protrusions are congruent to cavities present therebetween. In such a configuration, adapting of resonance chambers to the sound frequencies for absorbing is practically impossible. Although it is proposed in this publication to arrange rockwool in the said cavities and the side facing toward the sound source has an enlarged surface area, practically the whole traffic noise spectrum can nevertheless not be absorbed well. This wall absorbs too little of the low sound frequencies.

Further characteristics of preferred embodiments of this sound absorbing wall are to be found in the description following hereinafter with reference to drawings. In the drawings in schematic form:

Figures 1 and 8 each show a perspective view of a sound absorbing wall according to the invention at the location of a viaduct;

Figure 2 shows on a larger scale a vertical section along line II-II from figure 1;

Figure 3 shows on a larger scale a horizontal section along line III-III from figure 2;

Figures 4-6 show a section corresponding with figure 3 through three other embodiment variants of the sound absorbing wall according to the invention; and

Figure 7 shows a view of figure 5 on a smaller scale.

Figure 9 shows a section along line IX from figure 8;

Figures 10 and 11 each show a graph showing the sound absorption respectively of a wall according to the invention and a wall not designed according to the invention; and

Figure 12 is a graph of traffic noise.

The sound absorbing wall 1 of figures 1-3 is disposed along a traffic route 9 and has a support construction 3 extending into the ground 2 and consisting of a platform 4 and vertical supports 5. Standing thereon is a buttress construction 6 of reinforced construction concrete or steel against which supports the sound absorbing wall construction 7 which is constructed from three plates 18 which mutually enclose an obtuse angle, so that the side 10 facing towards the traffic route 9 is concave. The plates 18 engage with a complementary joint 11 into each other and into a base beam 12. On their front side the plates 18 have panels 8 manufactured from open-cell concrete structure. The panels consist of a closed rear wall 13 and a T-shaped construction element integrally joined thereto, the flange 14 of which faces towards the traffic route as panel 8. The flanges 14 are situated at a mutual gap distance a of 25, 15, 35 or 50 mm. Situated behind the flanges are cavities 15 in which according to figure 3 fibre-form material, for example glass wool, mineral wool, open-cell foam plastic or such sound absorbing soft material 16, is received.

The sound absorbing wall according to the invention has an aesthetically well-considered appearance.

In the embodiment variant of figure 4 panels 8 of open-cell concrete structure are first manufactured, wherein the fixing reinforcement 20 of reinforcement 21 protrudes outside the panels 8. Thereafter a construction element 23 is manufactured by laying a series of panels 8 at a mutual distance a on a surface and by laying thereon bodies of sound absorbing material 16, for example open-cell, elastic polyurethane foam. Reinforcement 24 of the back wall 13 is then aligned and attached to the fixing reinforcement 20 and the construction concrete 25 of the rear wall 13 is then poured. The factory produced, serially manufactured construction elements 23 are transported to the construction site and disposed there, for example as according to figure 2 either in a curved plane or in a straight plane.

The variants of figures 5 and 6 have a different configuration on the side facing the traffic route. Used here instead of flat panels 8 are roof-shaped panels 8 which are themselves radiated by the sound over a greater surface and which are even better in absorbing the sound between them and guiding it to the soft sound absorbing material.

An attractive relief is also realized with the protrusions 26 with sloping surfaces 27 jutting out towards the traffic route.

The sizes and dimensions in mm which are given as example can be derived from the drawing. These sizes can vary considerably within their order of magnitude.

The wall of figures 8 and 9 has a pedestal 28 of reinforced construction concrete on which three plates 18 and a concrete top strip 29 are stacked in mutual engagement. Situated in each case between these plates 18 and the top strip 29 is a strip 30 of rockwool or mineral wool behind the top and bottom edges of the plates 18. The plates 18 are constructed from elongate panels 8 of open-cell concrete or sound absorbing asphalt bitumen which is particularly absorbent at high frequencies of 1 K Hz and is known under the name VOAB (Very Open Asphalt Bitumen).

The cells or cavities of the above stated materials communicate with each other so that air can

penetrate therein to a considerable depth and strongly damped reciprocating air flows thereby occur.

The choice of an open-cell material is of essential importance, wherein the open-cell concrete is strongly recommended owing to the long life span in all kinds of climatological conditions. The possible penetration depth for the air flows is preferably considerable, while the surface receiving the radiation is preferably also large. The profile of the panels 8 with an angle of 45° is ideal. The cavities 15 behind the flanges 14 are preferably entirely filled with a packet of mineral wool or glass wool or like material 16. The panels 8 have a rear piece 30 with embedded reinforcement 20 and are fixedly joined therewith by casting to a rear wall 13 of reinforced construction concrete into which screwed sleeves 31 are embedded for fixed screwing to a steel frame 32 or other construction 33 using fixing means 34.

A packet of fibre material 16 is also present between adjoining plates 18. Each cavity 15 with its inlet 35 forms a Helmholtz air body resonator. The volume of the cavity 15, the depth and the breadth and form of the inlet 35 can be dimensioned such that a Helmholtz air body resonator results which is adapted to the sound frequency for absorbing. For the resonance frequency f , wherein the Helmholtz resonator has its maximum absorption, the following applies:

$$f_r = \frac{c}{2\pi} \sqrt{\frac{S}{V(l + 2\Delta l)}} = 1.7 \cdot 10^4 \sqrt{\frac{S}{V(l + 2\Delta l)}}$$

$$\frac{f_r}{\text{Hz}} \left| \frac{S}{\text{cm}^2} \right| \left| \frac{V}{\text{cm}^3} \right| \left| \frac{l}{\text{mm}} \right| \left| \frac{\Delta l}{\text{mm}} \right|$$

S here represents the width of the inlet, V the volume of the resonator chamber, l the depth of the inlet and Δl a correction factor for the configuration of the debouchment. 36 located in front of the inlet 35.

The air body in the inlet 35 together with to a certain extent the air body in the debouchment 36 form a mass which vibrates back and forth and which undergoes a damping. Due to the use of the filling of material 16 the frequency band width of sound absorption is greatly enlarged. Figure 10 shows a graph of the absorption coefficient A charted against the frequency f recorded during tests with a wall according to the invention, wherein, in slight contrast to figure 8, the gap width $m = 35$ mm, the gap depth $n = 60$ mm, the cavity width $P = 180$ mm and the cavity height q equals 180 mm.

Figure 11 shows a graph similar to that of figure 9 substantially of the wall 1 of figure 4 without material 16 therein. Two sound absorption characteristics can in fact be seen here, namely a Helmholtz air body resonator characteristic, the maximal absorption of which lies at ± 200 Hz, and an open cell absorption characteristic with a broad band and maximum absorption above 1 K Hz. According to the invention these two characteristics are now combined by bringing them towards one another and by increasing the absorption capacity, this in the sound band of the traffic noise, for instance as according to figure 9.

The wall 1 according to the invention is preferably combined with a road surface of VOAB.

Figure 12 is a graph of the traffic noise occurring at 100 km per hour, wherein the sound power D of the sound source in decibels is plotted against the frequency f . Herein:

40 and 41 represent the curves for heavy vehicles respectively on a VOAB road surface and a fine asphalt road surface; and

42 and 43 represent the curves for light vehicles respectively on a VOAB road surface and a fine asphalt road surface.

It can be seen that it is important to realize a good sound absorption over a broad frequency band from 125 to 4000 Hz.

The form of the debouchment 36 with a transverse edge on either side of the inlet 35 as shown in figure 9 is more effective than the form of the debouchment as shown in figure 6.

Claims

1. Sound absorbing wall for absorbing and screening traffic noise comprising a layer of open-cell material facing towards the traffic noise source and having a relief for enlarging of the surface for radiating; behind which is disposed a plurality of resonance chambers of Helmholtz air body resonators provided with sound absorbing material, wherein the wall comprises at least one layer of sufficient mass to prevent the sound passing through the screen, wherein the absorption characteristic of the open-cell

material is adapted to absorbing the sound with high frequencies and the absorption characteristic of the Helmholtz air body resonators is adapted to absorbing the sound with low frequencies, and wherein both absorption characteristics together have a satisfactory absorption coefficient over a substantially continuous sound band substantially covering the traffic noise of heavy and light vehicles.

- 5
2. Sound absorbing wall as claimed in claim 1, **characterized in that** the panels are manufactured from open-cell concrete.
- 10
3. Sound absorbing wall as claimed in claim 1 or 2, **characterized in that** the panels form part of a T-shaped construction element.
- 15
4. Sound absorbing wall as claimed in any of the preceding claims, **characterized in that** this is arranged along a traffic route with open-cell road surface, for instance VOAB.
- 20
5. Sound absorbing wall as claimed in any of the preceding claims, **characterized in that** the cavities present behind the panels are filled with sound absorbing material in the form of fibre-like material, preferably rockwool or mineral wool.
- 25
6. Sound absorbing wall as claimed in any of the preceding claims, **characterized by** three panels forming an obtuse angle in vertical cross section, so that the side facing the traffic is concave.
- 30
7. Sound absorbing wall as claimed in any of the preceding claims, **characterized in that** this contains construction elements each comprising panels of open structure concrete disposed at a mutual distance a and a rear wall of construction concrete arranged therebehind, into which are embedded bodies of sound absorbing material.
- 35
8. Sound absorbing wall as claimed in any of the preceding claims, **characterized in that** the panels have protrusions 26 jutting out towards the traffic route.
- 40
9. Sound absorbing wall as claimed in claim 8, **characterized in that** the protrusions have sloping surfaces.
- 45
10. Sound absorbing wall as claimed in any of the preceding claims, **characterized in that** the wall has a protruding front edge of concrete.
- 50
55

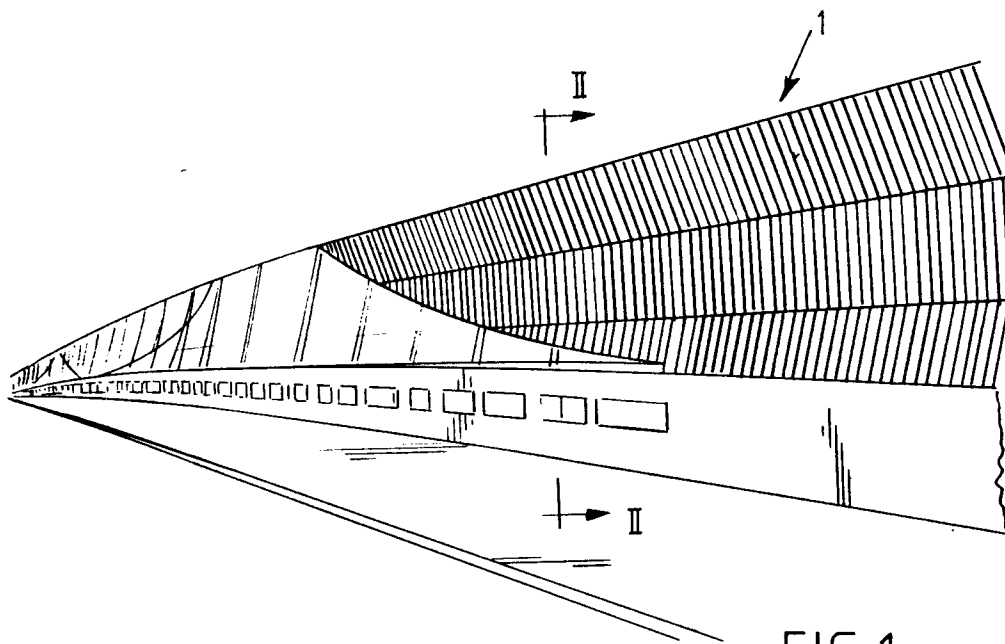


FIG. 1

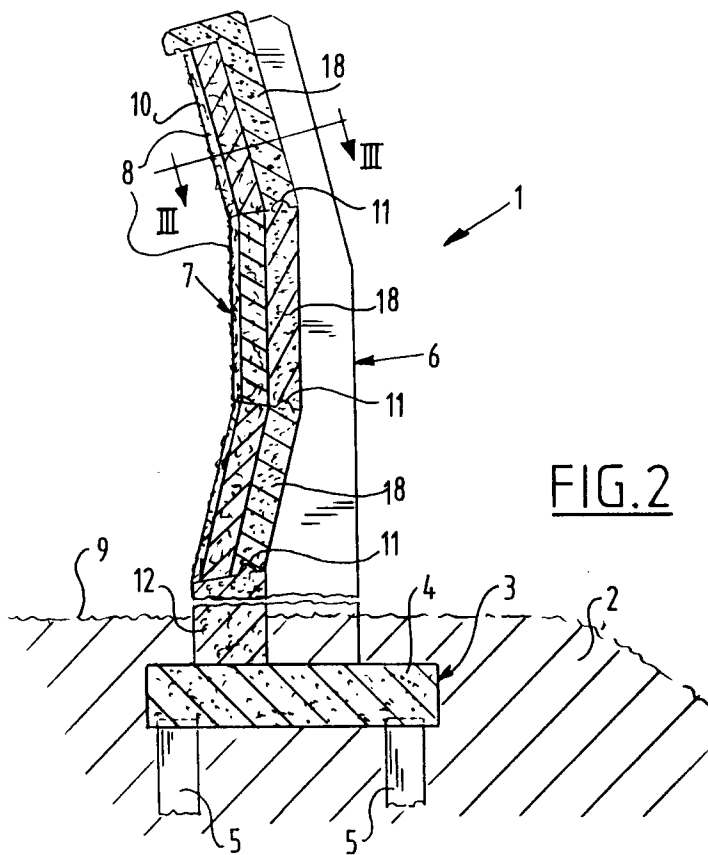


FIG. 2

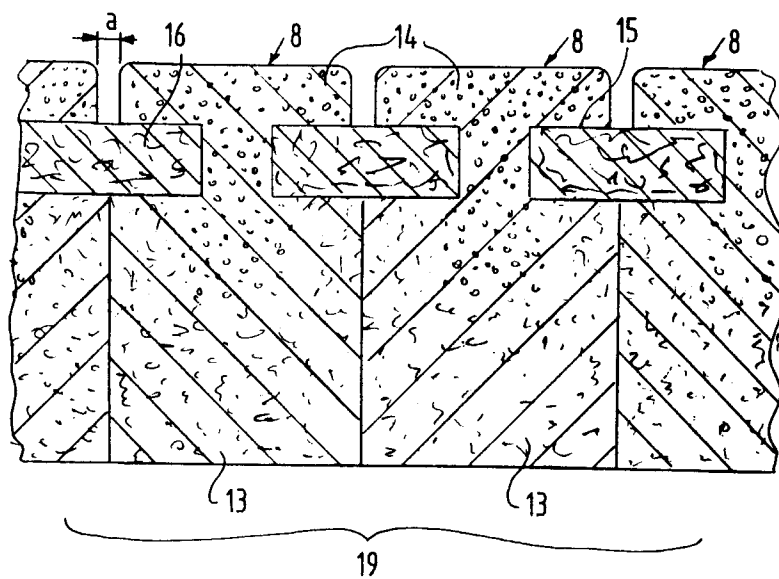


FIG. 3

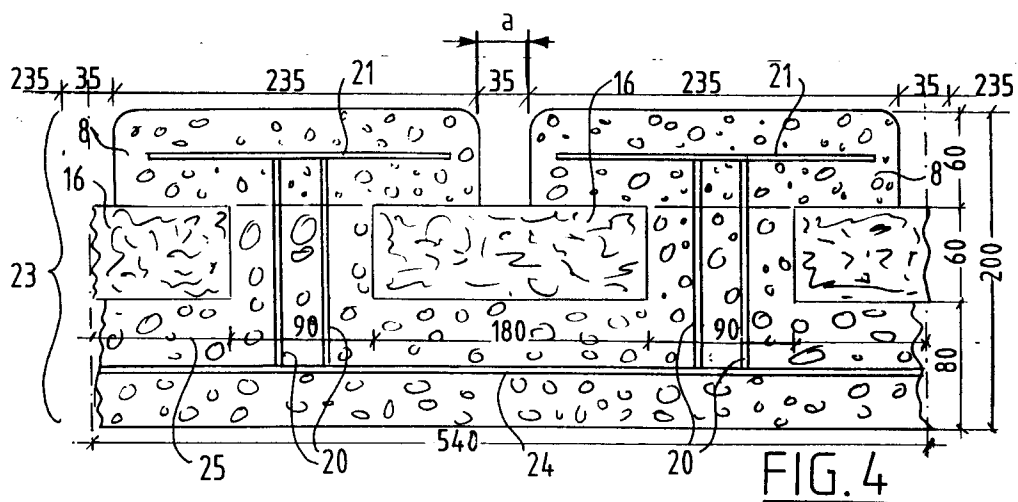


FIG. 4

FIG. 7

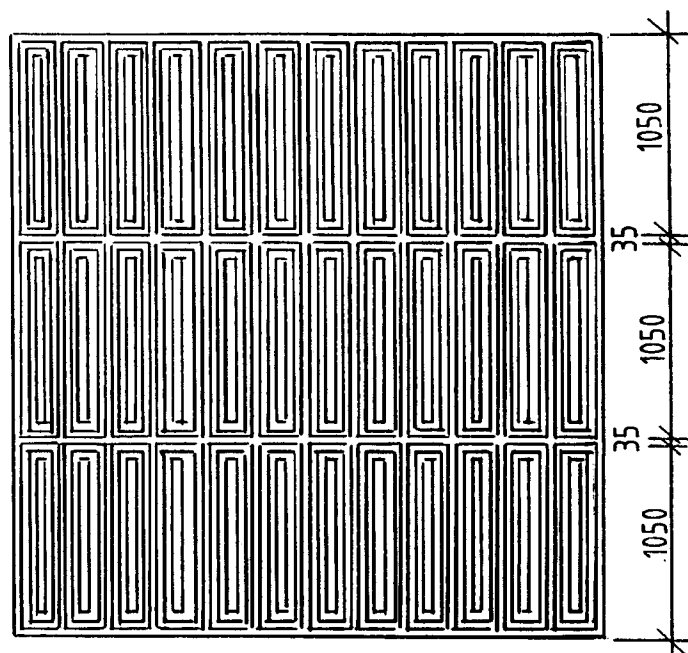


FIG. 5

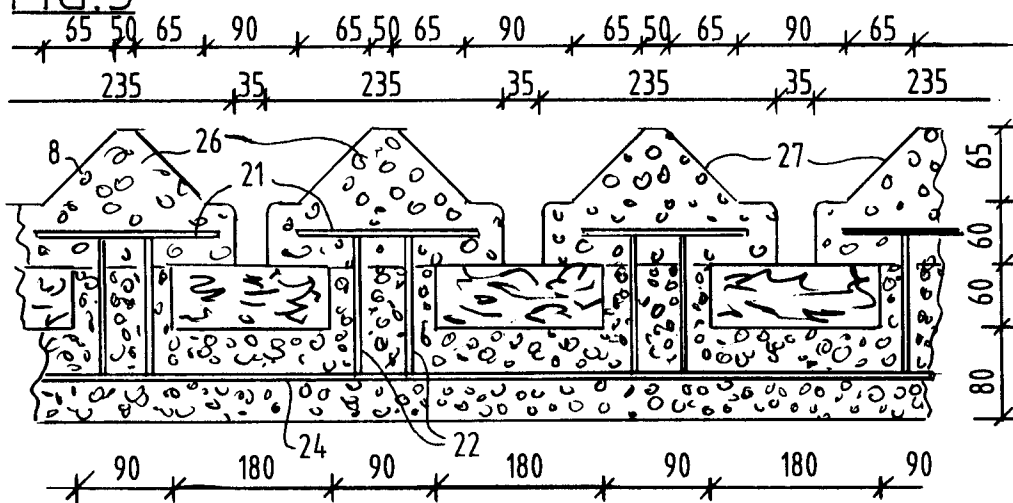
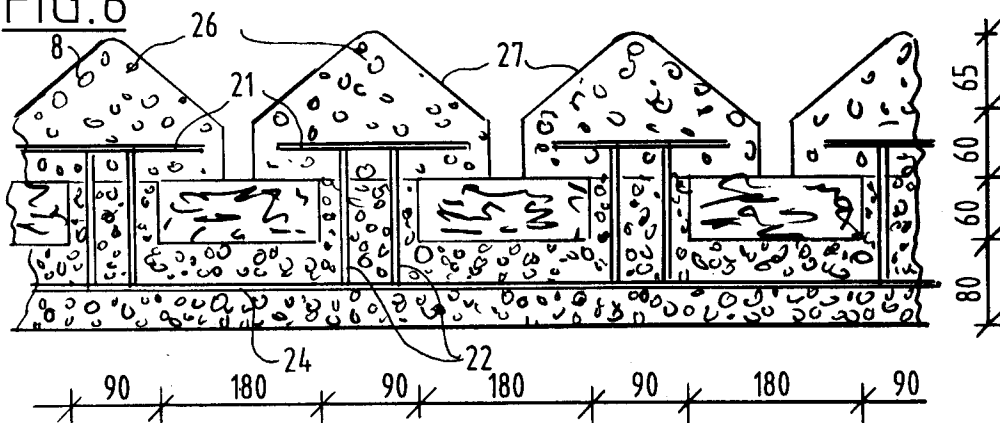


FIG. 6



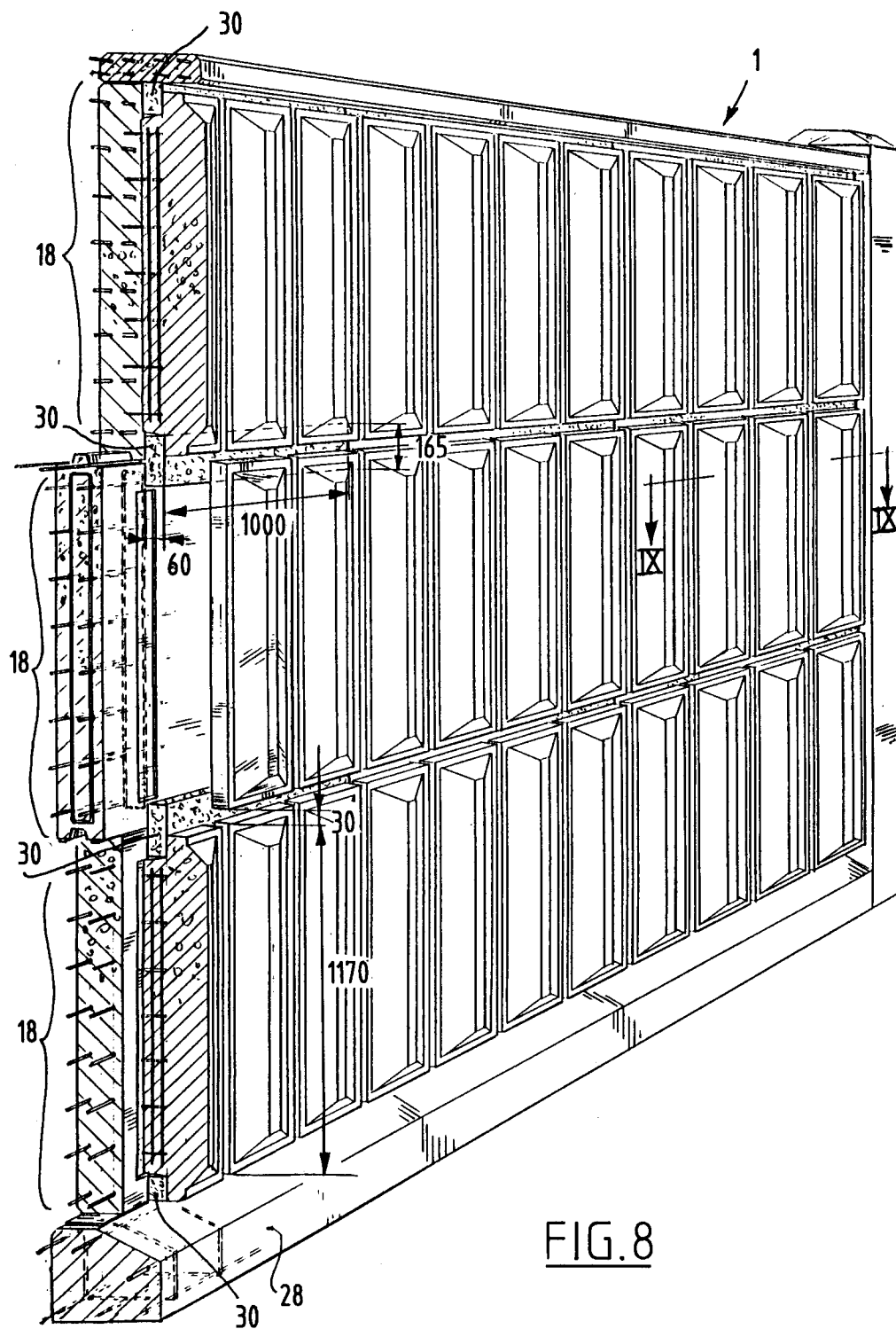


FIG. 8

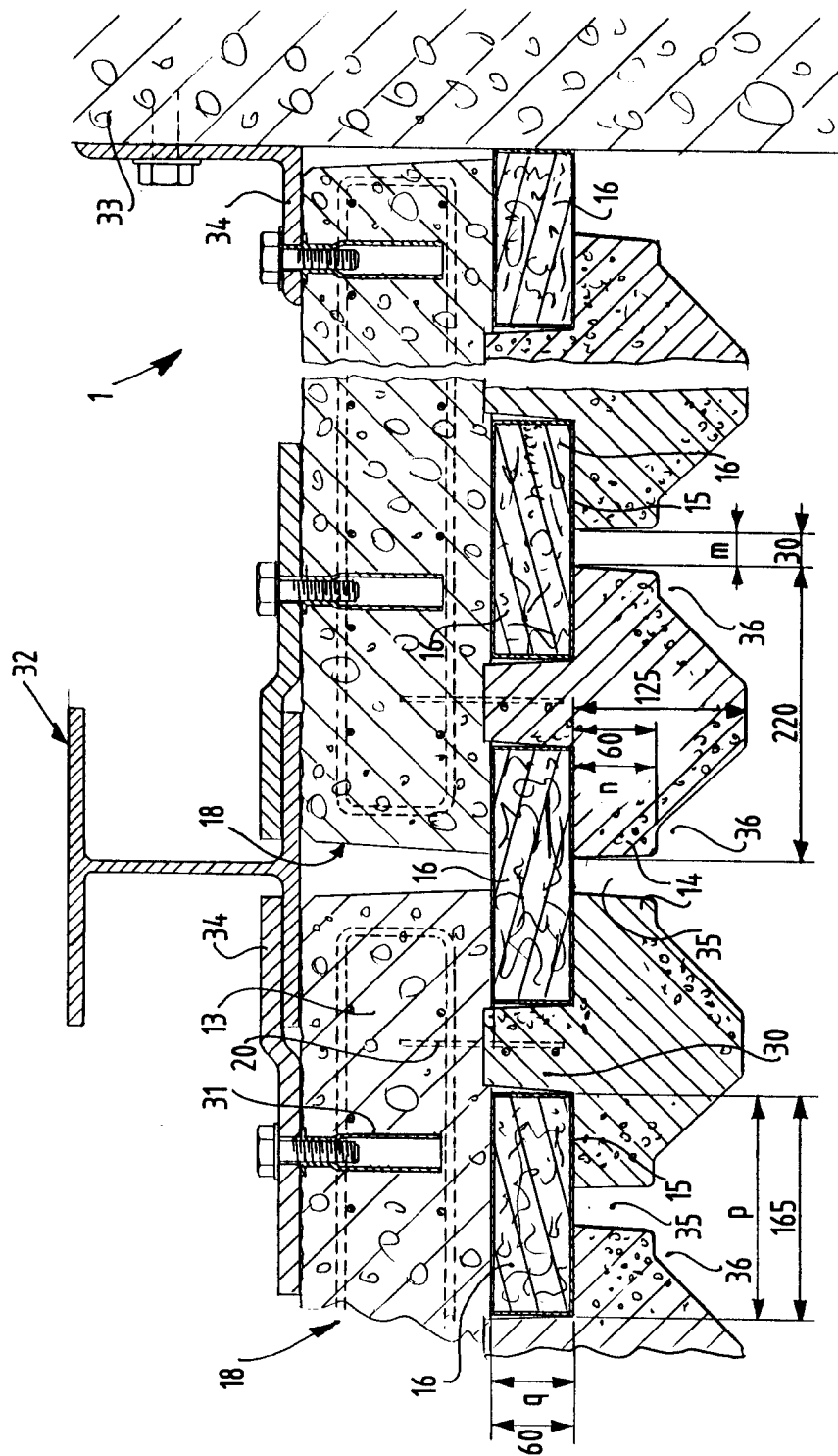


FIG. 9

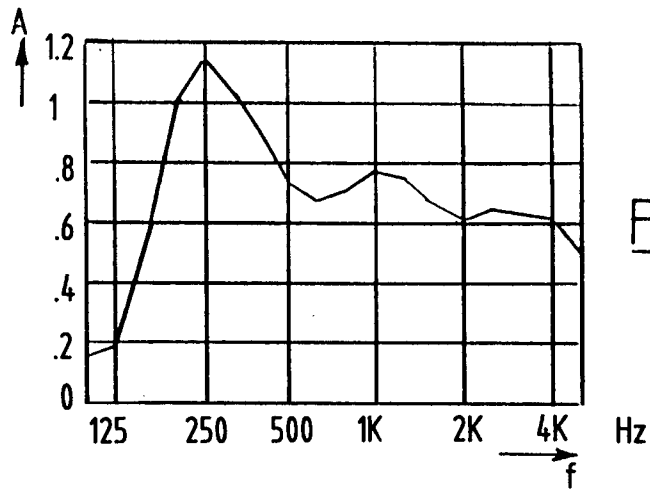


FIG. 10

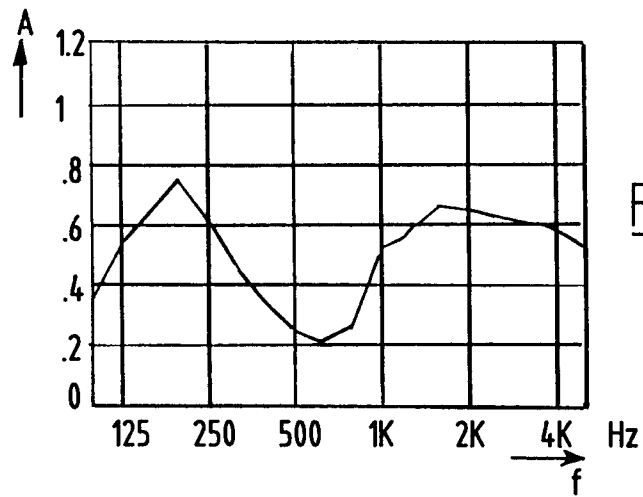


FIG. 11

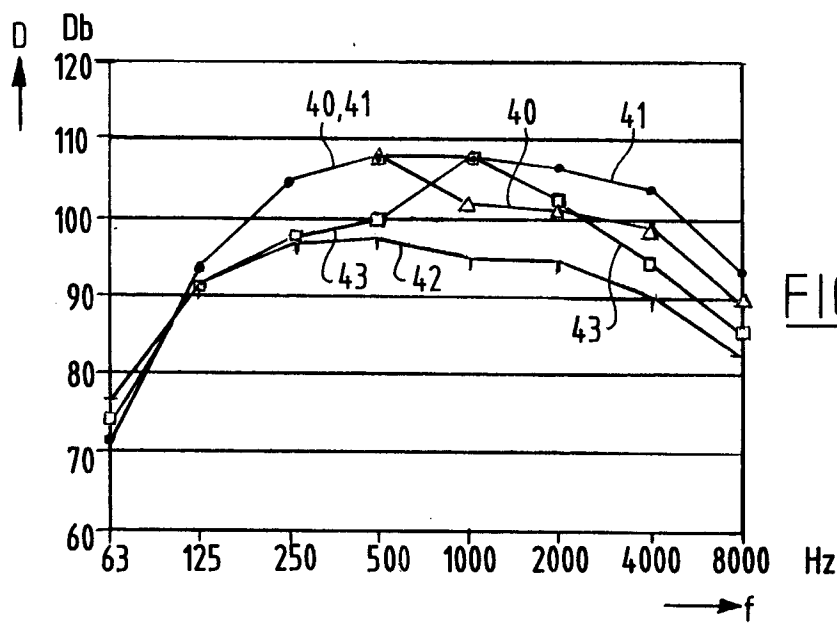


FIG. 12



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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 18 OCTOBER 1991	Examiner VERVEER D.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			



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A	DE-A-2 246 952 (G. ICKES) * page 8, paragraph 3 - page 9, paragraph 1; figure * -----	1, 7	
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 18 OCTOBER 1991	Examiner VERVEER D.
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