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(54) **A resonance-absorption acoustic-insulation panel**

(57) A resonance-absorption acoustic-insulation panel is provided which comprises: a substantially rigid support plate (2) having a plurality of holes (3) of predetermined sizes opening into at least one face (2a) thereof, and at least one vibrating, smooth thin sheet (4), engaged in contact with said face (2a) of said support plate (2), the resonance frequencies of the thin sheet (4) being determined by the sizes of the holes (3) disposed under the thin sheet (4).

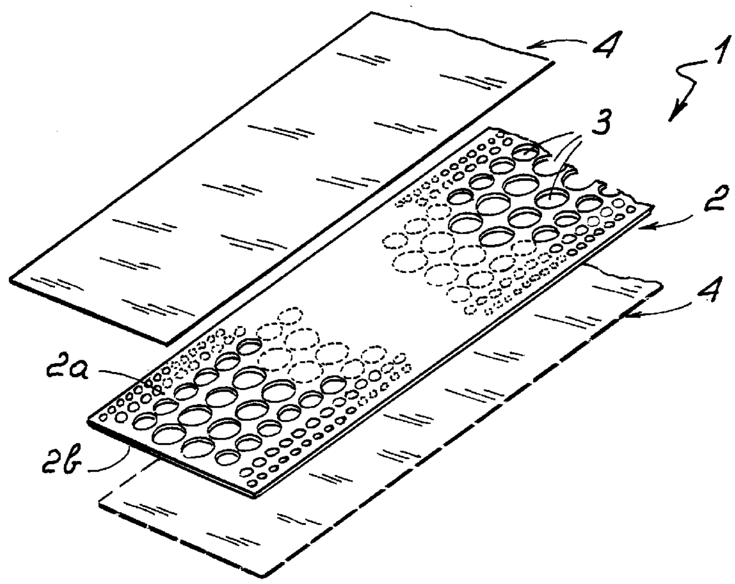

Fig.1

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Description

The invention relates to a resonance-absorption acoustic-insulation panel, of the type having a thin sheet or diaphragm vibrating when exposed to the action of sound waves, as defined in the preamble of claim 1.

It is known that panels and various acoustic insulation materials employed for attenuating reflexion of sound waves within environments in which the so-called acoustic "reverberation" or "reverberation time" is wished to be controlled, are of several different types and also that the acoustic insulation features are due to the occurrence of physical phenomena that are at least partly different.

There are, for example, porous or spongy panels in which absorption of sound wave energy mainly takes place within the pores, by the combined effect of air viscosity and friction at the pore walls. In addition, fibres in porous materials are set in vibration and sound wave energy is converted into heat energy.

Porous or spongy panels are generally thick and bulky, can constitute a danger in case of fire if they contain wooden or plastic material fibres or can show environmental incompatibility when they contain glass or rock wool fibres.

Cleaning of these panels is then of difficult accomplishment and said panels lose their acoustic insulation capability if surface protected to resist dust and moulds.

There are also perforated panels, or cavity resonators disposed at a distance from the walls to which they are applied, in which absorption of sound wave energy takes place due to the so-called "cavity resonance". These panels have wide holes In sight and are spaced apart from the walls by a hollow space, and they act in the same manner as "Helmholtz resonators" which are formed of enclosures where the inner cavity communicates with the outside through a small tube.

Panels provided with a perforated front face have a great bulkiness when installed and are quite unacceptable, due to their holes, in environments requiring important hygienic measures and subjected to frequent sanitization operations, such as food industries and hospitals.

Finally, there are resonance-absorption acoustic-insulation panels which particularly concern the present invention and which are also called vibrating panels, said panels having thin sheets or diaphragms of non-porous material, devoid of perforations, linked at their outer edges and separated by a thin hollow space from the walls of the environment in which

they are inserted. Sound waves, on impinging against one of said panels cause the diaphragm to be pushed and attracted setting it in vibration. Therefore a system is created in which there is a mass dissipating sound energy by vibration.

The closer the frequency of the incident sound is to the resonance frequency proper to the diaphragm, the greater the sound energy dissipation is.

Vibrating panels are of reduced bulkiness in terms of thickness, give satisfactory results in terms of hygiene, because they are neither surface porous nor perforated, and in addition, the acoustic insulation resulting from the phenomenon briefly described above is high.

However, said vibrating panels have the drawback of showing a very selective acoustic absorption, that only takes place with the frequency or frequencies at which the system resonates.

This drawback gives rise to various problems making planning, manufacture and installation of vibrating panels very complicated and expensive, which panels also often cause an acoustic insulation that does not correspond to expectations.

A first problem is connected with the fact that application of these vibrating panels must be carefully studied and arranged by previously identifying which are the acoustic frequencies that it is in particular necessary to damp, in a given environment.

A second problem is connected with accomplishment of these vibrating panels, since the value of maximum absorption or maximum resonance frequency greatly varies on varying of the dimensional and physical features of the panel structure.

Finally a third problem is connected with the fact that as soon as there is a variation in the acoustic features of an environment, for any reason, the already installed vibrating panels are no longer of real utility, due to the selectivity of their action.

In order to partly overcome these difficulties, by widening the frequency band in which the vibrating panels are efficient, placement of a layer of, for example, a fibrous or porous material behind the vibrating diaphragm, for damping sound waves, is known.

In this way, however, the deadening effect at the proper vibration frequency of the system is reduced.

Furthermore, addition - although in a covered position - of a layer of porous materials can give rise to drawbacks similar to those of said porous or spongy panels, that is environmental problems due to the presence of glass or rock wool fibres, or dangers in case of fire if there are wooden or plastic material fibres.

Then, panels having such a complicated structure are expensive, bulky and heavy.

Under this situation, the technical task underlying the present invention is to devise a resonance-absorption acoustic-insulation panel, capable of obviating the above mentioned drawbacks.

Within the scope of this technical task, it is an important aim of the invention to devise a panel that during the manufacturing step enables the frequency band at which the greatest acoustic absorption is wished to take place to be established in a precise manner and to be varied with ease.

Another important aim of the invention is to devise a panel capable of having a high number of resonance frequencies, so as to be able to absorb a wide range of sound waves.

A further important aim of the invention is to devise a panel suitable both for environments having high hygienic requirements where frequent sanitization operations are carried out, and for premises of high-humidity atmosphere, and further adapted to environments where fire-prevention features of very high degree are required.

A still further object of the invention is to devise a panel of simple structure, low cost and minimum bulkiness.

The technical task mentioned and the aims specified are substantially achieved by a resonance-absorption acoustic-insulation panel as claimed in the appended claim 1.

Further features and advantages of the invention will be best understood from the detailed description of a panel in accordance with the invention, shown in the accompanying drawings, in which:

Fig. 1 is a perspective exploded view of a panel in accordance with the invention, seen in an isolated position;
Fig. 2 is a perspective and partial view of the panel shown in Fig. 1 applied to a wall;
Fig. 3 is a sectional side view of Fig. 2;
Fig. 4 shows how the acoustic absorption coefficient varies on varying of the sound wave frequency in the presence of holes of a 20 mm diameter;
Fig. 5 is similar to Fig. 4, but referred to holes having a 30 mm diameter;
Fig. 6 refers to holes with a diameter of 45 mm; and
Fig. 7 refers to holes with a diameter of 80 mm.

With reference to the drawings, the panel in accordance with the invention has been generally identified by reference numeral 1.

Panel 1 comprises support elements such as anchoring members 1a to a wall, a ceiling or others, and a support plate 2 made of an appropriate material and an appropriate thickness so as to make it substantially rigid.

The support plate 2 may have a thickness included between few millimetres and some centimetres, depending on the material of which it is made: if the support plate 2 is made of sheet steel or aluminium, a thickness of few millimetres is sufficient for achieving an appropriate stiffness.

The rigid support plate 2 has a first or main face 2a in sight and a second face 2b, opposite to the first one and with said first face defining the plate thickness. In the case of application of panel 1 to a wall 5, as in Figs. 2 and 3, the second face 2b is the one turned towards wall 5.

It is pointed out that the rigid support plate 2 can be directly applied to a wall 5, or any reverberating surface, with the second face 2b merely in contact with or adhering to said surface.

The rigid support plate 2 advantageously has a plurality of holes 3 which can have any shape at will and may be of square or circular conformation, for example.

Holes 3 are preferably through holes, that is passing through both the first and second faces 2a, 2b, but they may also be blind holes opening onto the first face 2a alone of the rigid support plate 2.

Holes 3 have predetermined diameters calculated on the basis of the sound wave frequencies that are to be most damped down by panel 1.

If sound waves of a frequency within a narrow band are provided to be mainly absorbed, holes 3 will have one and the same size. If, on the contrary, the frequency band within which panel 1 is to be efficient must be widened, holes of differentiated diameters are to be provided.

The rigid support plate is completely covered, at least at its main face 2a, by a flexible sound-vibrating thin diaphragm or sheet 4. This diaphragm or thin sheet is provided to be substantially devoid of holes and has gauged elasticity and thickness.

For instance, the flexible diaphragm or thin sheet 4 is made of a continuous aluminium film of a 0.2 mm thickness, smooth on its surface, so that it can be easily washed and sanitized.

Engagement between the flexible, vibrating and smooth diaphragm or thin sheet 4 and the underlying rigid and perforated support plate 2 can take place in any manner. Preferably, for hygienic reasons, the thin sheet 4 is fixed to plate 2 in a sealingly adhering manner, for example by gluing onto the support plate 2 portions free of holes 3. Operation and use of the acoustic insulation panel 1 are as follows.

By virtue of the above described structure, each portion of the flexible diaphragm or thin sheet 4 put in register with an underlying hole 3 of the rigid support plate 2 behaves like a resonant or vibrating diaphragm that, if stressed by sound waves of a frequency corresponding to its resonance frequency, begins vibrating thereby dissipating part of the sound energy. This stress causes a loss of force in the incident energy that will be therefore subtracted from the subsequent propagation thereby representing an absorption of sound waves.

The greatest acoustic-absorption frequency depends on the width of the underlying holes 3 formed in the rigid support plate 2, thickness and elasticity of the flexible diaphragm or thin sheet 4 being the same.

Some experimental tests confirm this situation.

Figs. 4, 5, 6, 7 show by way of example how acoustic-absorption coefficient A of panel 1 varies, based on the measurement method of the "Kundt tube", depending on the sound wave frequencies, considered as included between 0 and 2500 Hz and on the hole diameter in the rigid support plate 2.

As well known in acoustics, an acoustic-absorption coefficient A can theoretically vary from a minimum of zero, in case of null absorption, to a maximum of one, in case of full absorption.

In addition, it is known that the measurement method of the "Kundt tube" uses a tube having a sound wave generator forming sine waves in the gas within the tube, at one side, and a piston shiftable along the tube and reflecting sound waves, at the opposite side.

Applied to the piston is the acoustic insulation element to be controlled.

In the tube there is a certain amount of powder that tends to become lumped at the vibration nodes.

By selecting the sound wave frequency and the piston position, it is possible to see how the effects of the acoustic insulation element applied to the piston vary and to identify how the absorption coefficient of the element itself varies.

Fig. 4 refers to a diaphragm or thin sheet 4 of aluminium, of a 0.2 mm thickness, applied to circular holes with a diameter of 20 mm, formed in a rigid support.

The acoustic-absorption coefficient A, included between zero and one, is shown on the Y axis and the sound wave frequency, considered as included between 0 and 2500 Hz is shown on the X axis. It appears that the greatest acoustic-absorption frequency is included between 2000 and 2500 Hz.

Figs. 5, 6, 7 refer to structures similar to the one shown in Fig. 4, but having holes with a diameter of 30, 45 and 80 mm, respectively.

It clearly appears that there is a lowering in those frequencies for which the maximum acoustic-absorption value occurs, which frequencies reach values included between zero and 500 Hz, for holes with a diameter of 80 mm.

Thus, if holes with diameters varying between 20 and 80 mm are disposed under the diaphragm or thin sheet 4, as in Fig. 1 for example, absorption frequencies are obtained that are along the whole frequency range, from zero to 2500 Hz.

The panel in accordance with the invention can be used as a wall or ceiling covering, in contact therewith, and for creating false ceilings.

Panel 1 can also be applied close to the reverberating surfaces and not adhering thereto. In this case panel 1 can be parallel to the reverberating surfaces or oblique relative to them.

If the thus spaced panel is supported at the edges, it is also free to vibrate as a whole, in addition to locally at various points of diaphragm 4. Thus a further resonance frequency is added, i.e. that of the whole panel taken as a body.

Panel 1 can also be used as a suspended sound absorber, that is hanging vertically from ceilings, if holes 3 are through holes and the rigid support plate 2 is covered with flexible diaphragms or thin sheets 4 on both its faces 2a, 2b.

In accordance with the invention, a process for adjusting the resonance frequency of an acoustic insulation panel is also taught, when said panel is of the type provided with at least one sound-vibrating diaphragm or thin sheet.

In particular, the process concerns a panel provided with at least one thin sheet that, depending on its physical and structural conditions, has a resonance frequency at which dissipation or absorption of sound energy is maximum.

Based on this process, the resonance or maximum-absorption frequency of said diaphragm or thin sheet is determined by engaging the thin sheet in contact with a substantially rigid support plate provided with a plurality of holes, on the one hand, and by selecting the hole sizes in the support plate, on the other hand.

In addition, based on this process, a plurality of resonance frequencies of said thin sheet applied to the rigid support plate can be obtained, by forming several holes of different sizes from each other in the support plate itself.

The invention achieves important advantages.

In fact, a vibrating panel has been conceived that, in addition to avoiding the drawbacks of the dissipative panels based on the use of porous or fibrous materials, and the perforated panels, enables a high acoustic-absorption coefficient to be obtained at the frequencies of interest by merely making holes in the support plate having diameters with sizes the operating efficiency of which has been experimentally verified.

Therefore, control of the frequency band in which there is the maximum acoustic-absorption efficiency is achievable by exclusively varying the hole diameters in the support plate, the elasticity and thickness features of the flexible covering thin sheets being unchanged.

The panel is of simple structure, low construction cost and reduced installation costs.

It is finally to point out that this panel, which can be made of metal materials and sealingly covered with a smooth non-porous and non-perforated thin sheet, is of easy washing and is not inflammable.

Therefore, it lends itself to be used in environments subjected to frequent sanitizing operations, such as food industries and hospitals, or to severe fire-prevention safety regulations, such as stadiums and conference rooms.

Claims

1. A resonance-absorption acoustic-insulation panel of the type comprising at least one flexible sound-vibrating thin sheet (4) and support elements for said thin sheet,
   characterized in that said support elements comprise at least one substantially rigid support plate (2) having a plurality of holes (3) of predetermined sizes opening into at least one main face (2a) of said support plate (2), and in that said flexible and sound-vibrating thin sheet (4) is engaged in contact with said main face (2a).

2. A panel as claimed in claim 1, in which said flexible and vibrating thin sheet (4) is a metal film adhering

to said main face (2) and having a substantially smooth, washable surface capable of being sanitized.

3. A panel as claimed in claim 1, in which two said thin sheets (4) are provided which are secured to said main face (2a) of said support plate (2) and a second face (2b) opposite to said main face (2a), respectively.

4. A panel as claimed In claim 1, in which said thin sheet (4) is secured by gluing to said substantially rigid support plate (2).

5. A panel as claimed in claim 1, in which said holes (3) in said support plate (2) are through holes.

6. A panel as claimed in claim 1, in which said support plate (2) is engaged by contact with a reverberating surface (5).

7. A panel as claimed in claim 1, in which said holes (3) disposed on said support plate (2) have constant sizes selected in connection with a predetermined acoustic-absorption frequency.

8. A panel as claimed in claim 1, in which said holes (3) disposed in said support plate (2) have a plurality of sizes selected in connection with a plurality of acoustic-absorption frequencies.

9. A process for adjusting the resonance frequency of an acoustic insulation panel of the type provided with at least one sound-vibrating thin sheet, characterized in that the resonance frequency of said thin sheet, at which the sound energy dissipation is maximum, is determined by engaging said plate in contact with a substantially rigid support plate provided with a plurality of holes, and by selecting the sizes of said holes in said support plate.

10. A process as claimed in claim 9, in which a plurality of resonance frequencies is obtained for said thin sheet by forming a plurality of holes having different sizes from each other in said substantially rigid support plate.

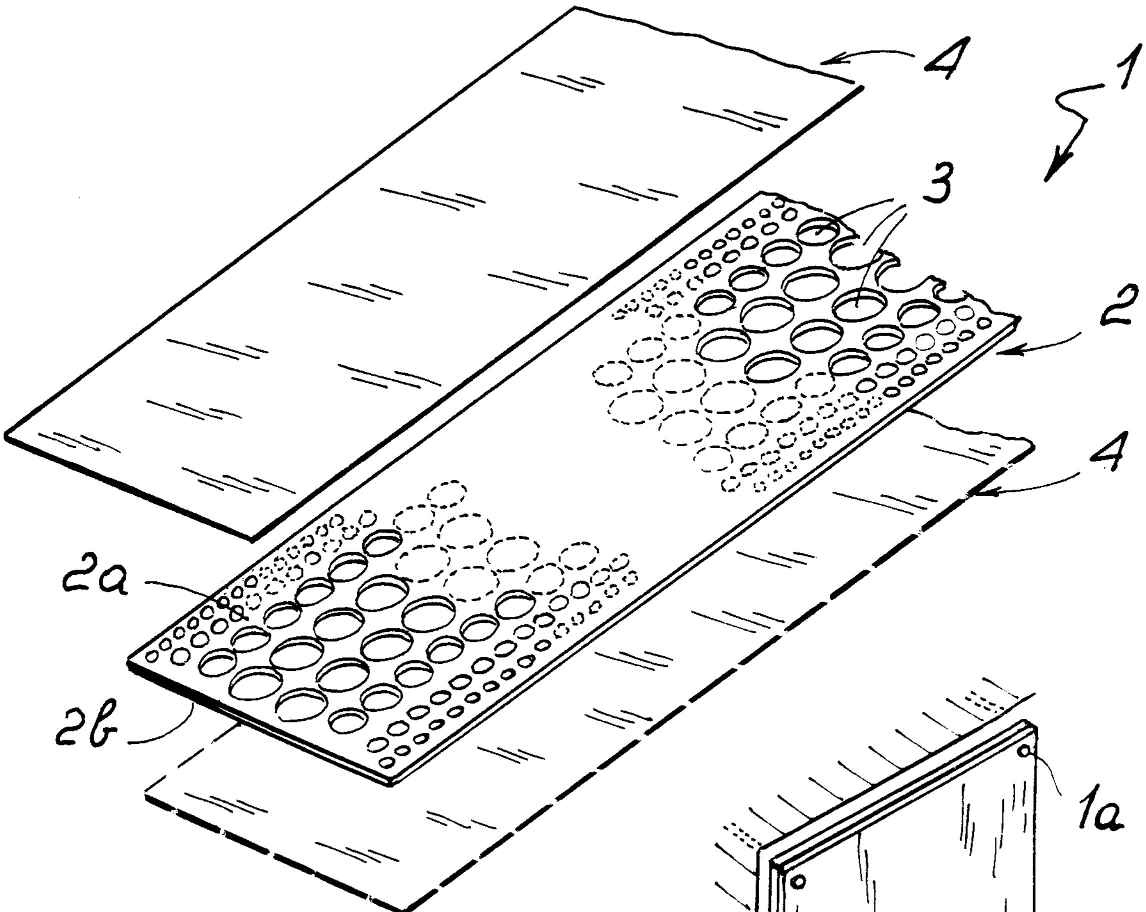

Fig.1

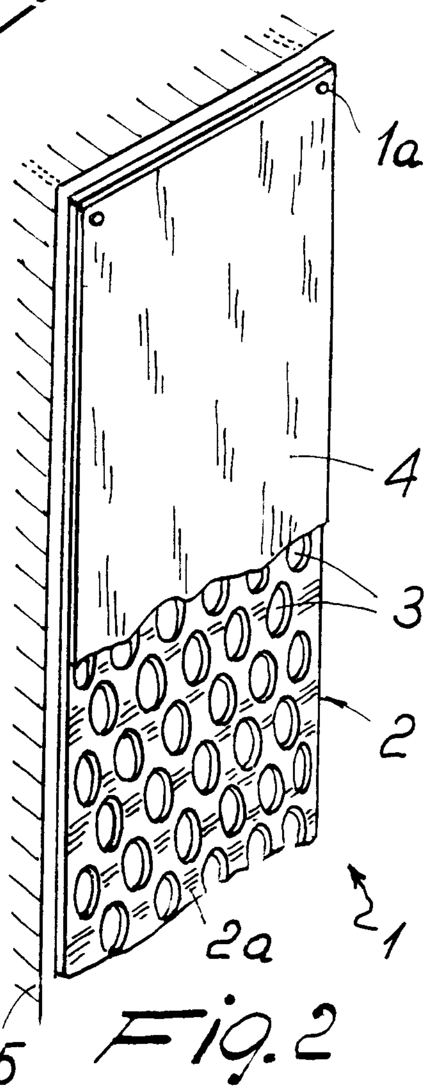

Fig.2

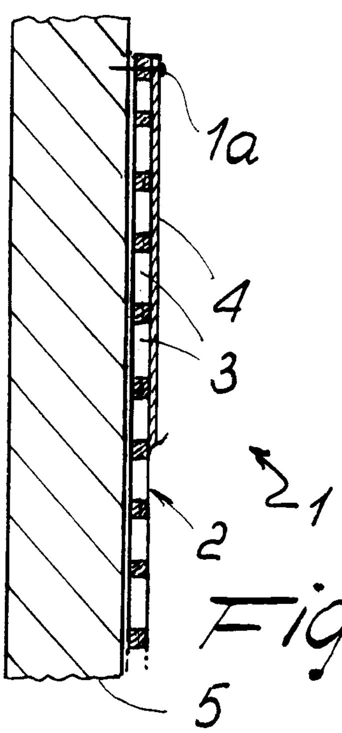

Fig.3

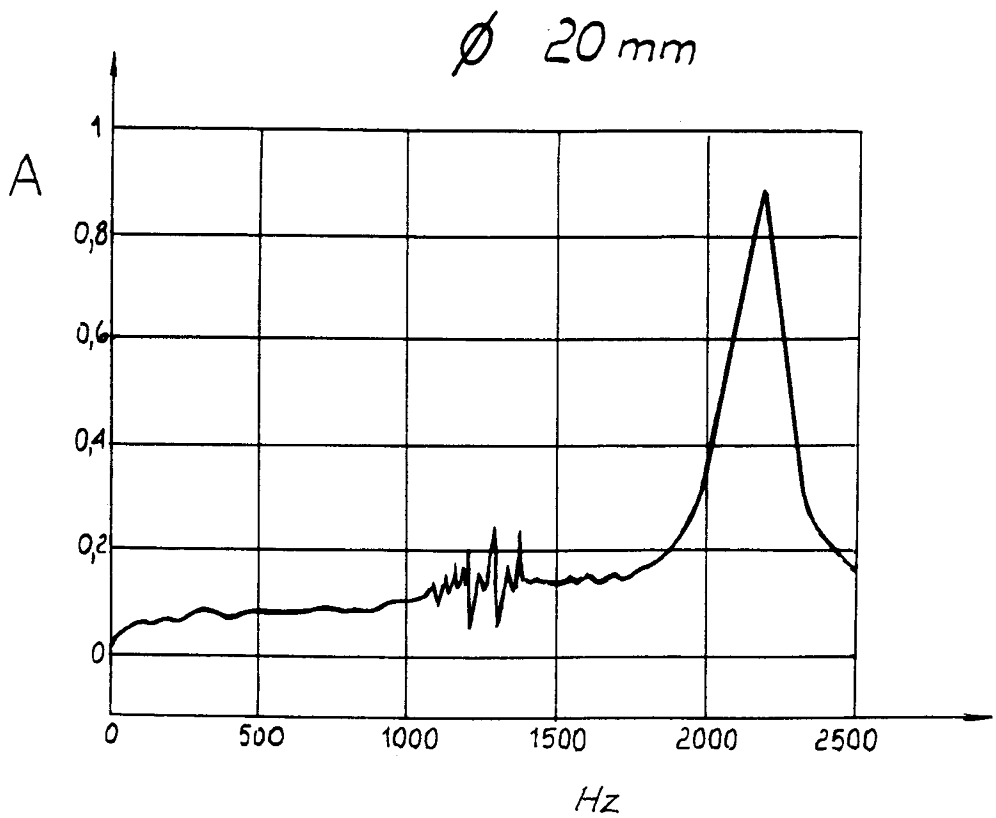
Ø 20 mm
A
1
0,8
0,6
0,4
0,2
0
0
500
1000
1500
2000
2500
Hz

Fig.4

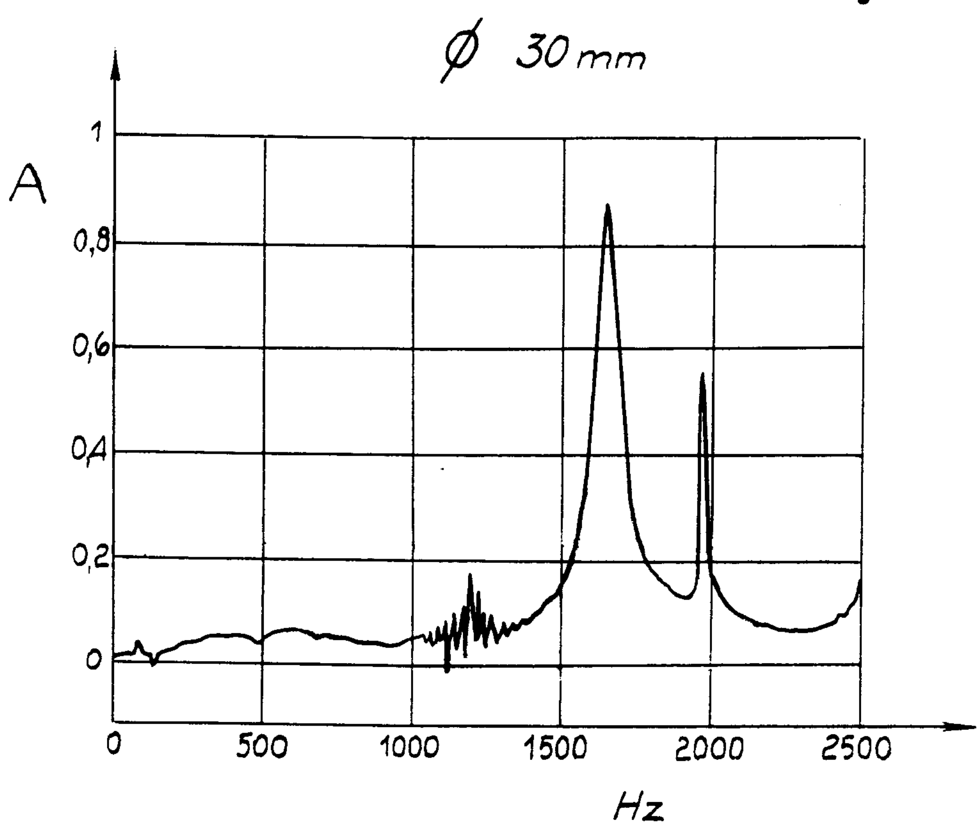
Ø 30 mm
A
1
0,8
0,6
0,4
0,2
0
0
500
1000
1500
2000
2500
Hz

Fig.5

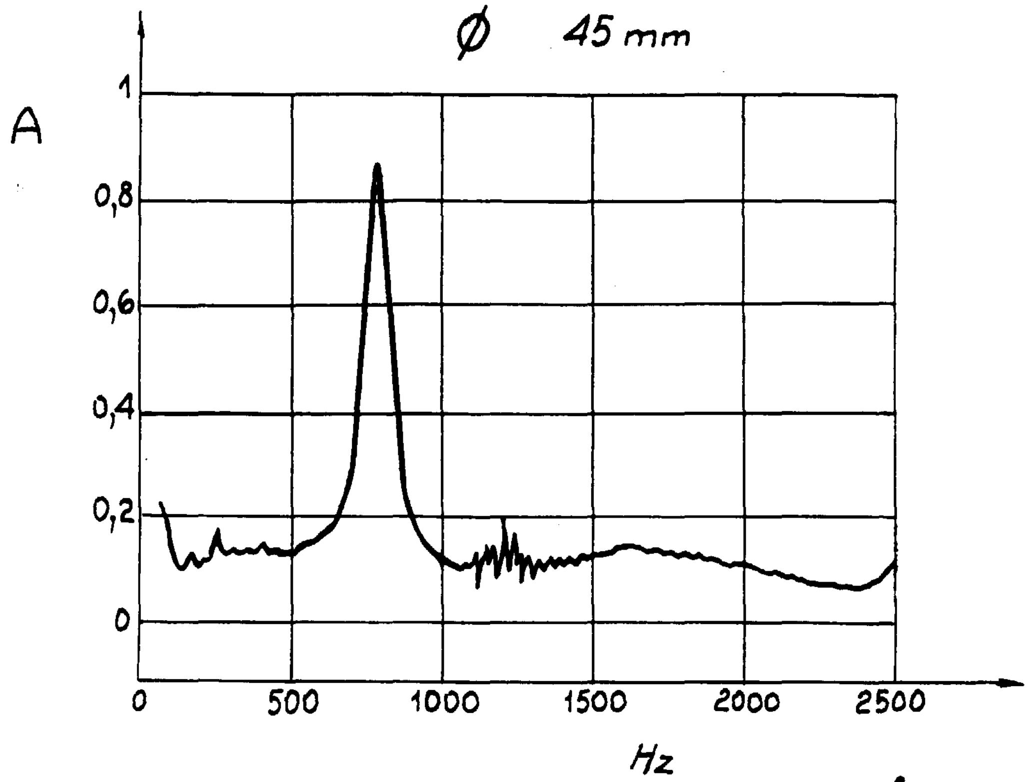
Ø 45 mm
A
1
0,8
0,6
0,4
0,2
0
0
500
1000
1500
2000
2500
Hz

Fig.6

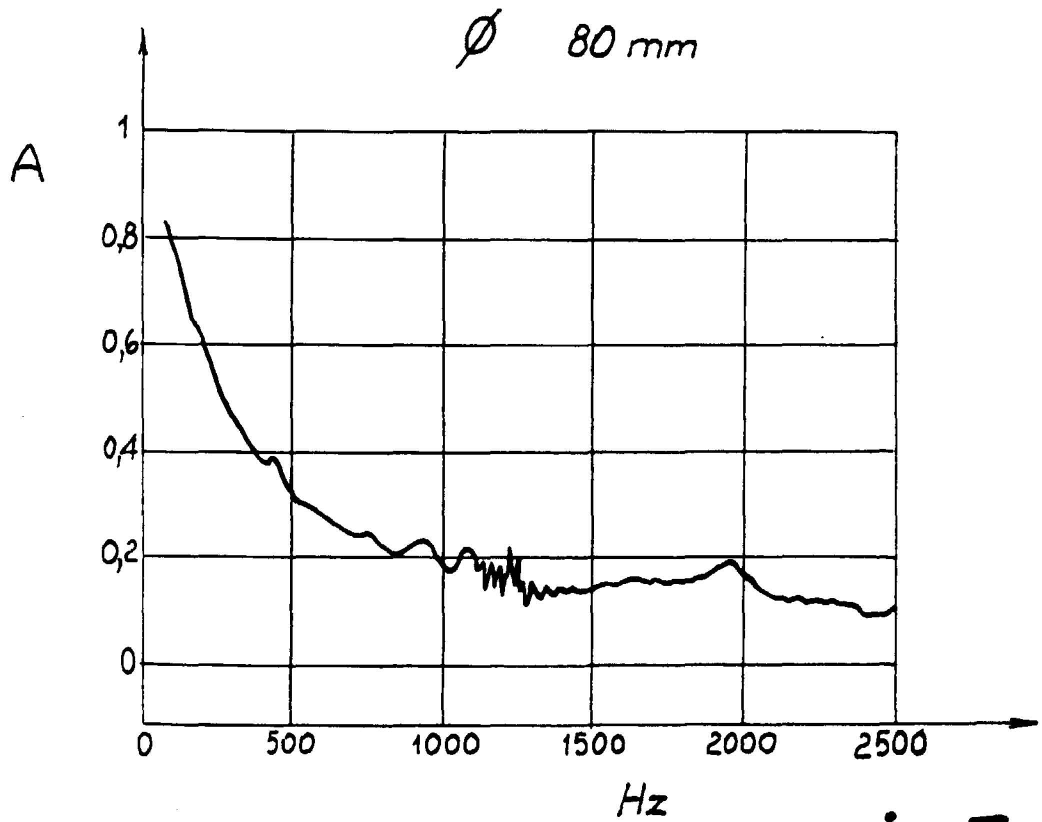
Ø 80 mm
A
1
0,8
0,6
0,4
0,2
0
0
500
1000
1500
2000
2500
Hz

Fig.7