Dec. 8, 1959 I. A. NAMAN 2,916,101

SOUND-ABSORBING STRUCTURES

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Fig. 1

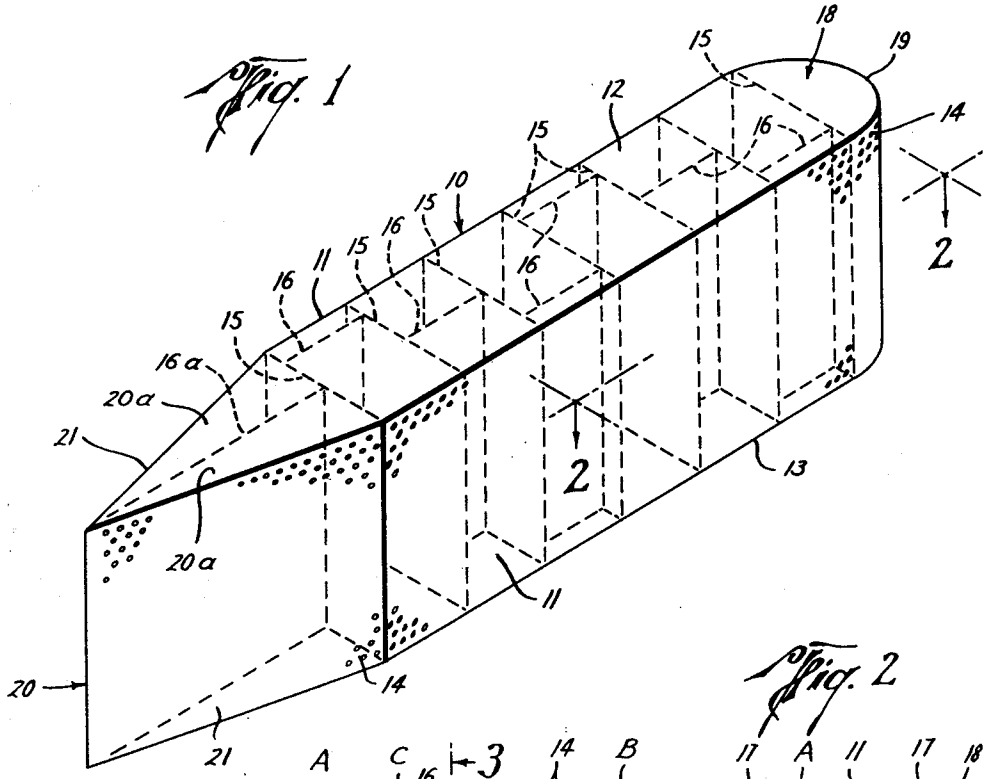
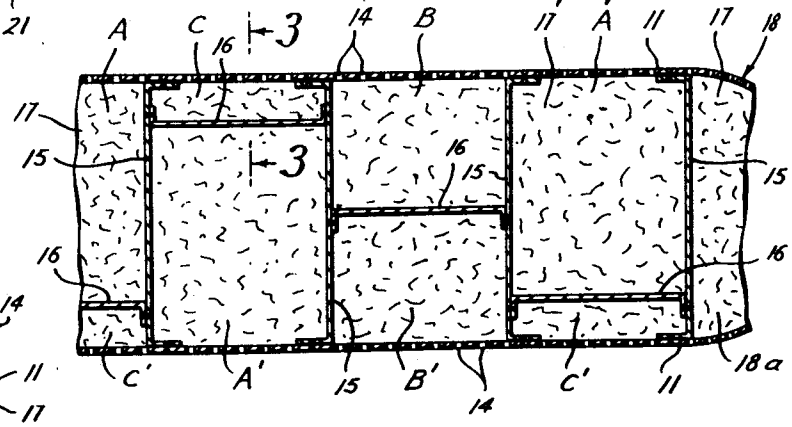


Fig. 2



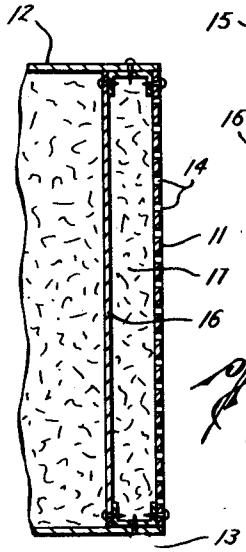


Fig. 3

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Fig. 5

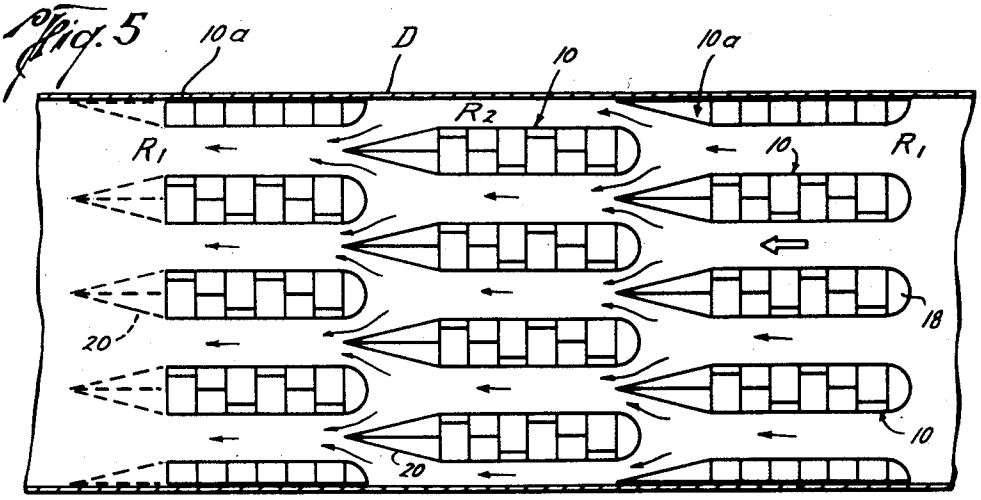


Fig. 4

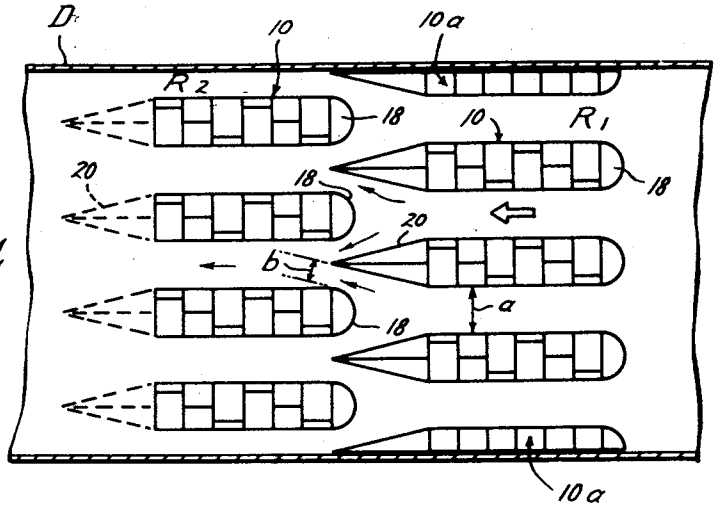
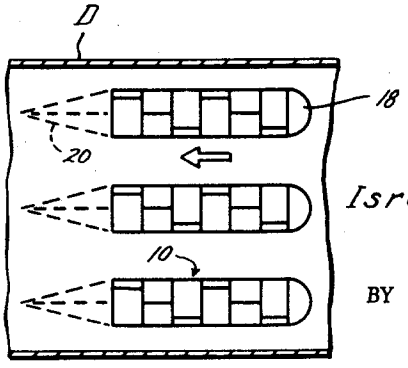


Fig. 6



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SOUND-ABSORBING STRUCTURES

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14 Claims. (Cl. 181—42)

This invention relates to sound-absorbing structures. More particularly, the invention relates to structures adapted to absorb or muffle sound normally accompanying the flow of a fluid medium such as air or gas streams in a confined space.

The movement of streams of air through confining ducts or conduits, as is required in air-conditioning systems, is frequently accompanied by objectionable sounds, elimination or muffling of which becomes highly desirable. Many types of so-called "sound traps" or acoustic absorbers have heretofore been employed for that purpose but are ordinarily of relatively complicated and expensive construction, or may be relatively inefficient sound absorbers, or cause undesirably high resistance to the fluid stream flow so as to cause excessive pressure drop in the conduit systems.

It is a primary object of this invention to provide an improved sound-absorbing structure for installation in fluid stream ducts or conduits which is of relatively simple and low-cost construction, and which possesses a high degree of sound-absorbing efficiency with minimum resistance to the flow of the fluid stream therethrough.

An important object is the provision of a sound-absorbing cell or unit of improved specialized construction which is adapted to be incorporated in arrays or assemblies of different forms to provide sound-absorbing structures of the character mentioned.

A further object is the provision of a sound-absorbing structure comprising a plurality of sound-absorbing cells disposed in an array having a shape and spacing relation of the cells adapted to effect high efficiency sound absorption with minimum pressure drop in the fluid stream.

An additional object is the provision of a sound-absorbing cell or unit comprising, a hollow casing having acoustically transparent side walls and internally partitioned to define a plurality of sound-absorbing chambers of varying depth relative to the side walls adapted to attenuate different acoustic frequencies.

A more specific object is the provision of a sound-absorbing cell or unit comprising, a generally rectangular hollow casing having spaced-apart acoustically transparent side walls, the interior of the casing between the side walls being divided transversely and longitudinally by intersecting acoustically opaque partition members into a plurality of chambers of varying depths relative to the side walls, said chambers being filled with acoustically absorbent material.

Still another object is the provision of sound-absorbing cells of the kind described wherein the opposite ends of the casing are provided with curved nose pieces and with tail pieces having convergent side walls, the angle of convergence of such side walls with respect to the longitudinal axis of the cell being in the range from about 10° to about 25°, and preferably from about 12° to 20°.

An additional object is the provision of a sound-absorbing structure comprising, an array of sound-absorbing units of the kind described arranged in longitudinally spaced rows, the units of each row being transversely spaced apart and in staggered relation to the units of the next adjacent row whereby to prevent straight passage through the array.

A further object is the provision of a structure comprising an array of sound-absorbing units of the kind described, each unit having a rounded nose member and a tapered tail member, the array comprising longitudinally spaced rows of such units, the units of each row being transversely spaced apart and in staggered relation to the units of the next adjacent row, the distance between the opposed surfaces of the nose and tail members of adjacent units being approximately half the distance between the units in each of said rows, whereby to provide non-straight-line flow through the array with minimum pressure drop.

Another object is to provide a sound-absorbing unit comprising a generally rectangular hollow casing having spaced apart, parallel foraminous side walls, the interior of the casing being divided transversely and longitudinally by intersecting imperforate partition members into two rows of chambers extending inwardly from each of the side walls, the longitudinal partition members being spaced at differing distances from the side walls whereby to vary the depths of said chambers in each of the rows relative to the side walls.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates useful embodiments in accordance with this invention.

In the drawing:

Fig. 1 is a perspective elevational view of a sound-absorbing cell or unit in accordance with this invention.

Fig. 2 is a fragmentary transverse sectional view taken generally along line **2—2** of Fig. 1;

Fig. 3 is a fragmentary vertical sectional view taken generally along line **3—3** of Fig. 2; and

Figs. 4, 5 and 6 are generally schematic views illustrating several different arrays or assemblies of the sound-absorbing units which may be employed to meet different conditions, the arrays being shown installed in conduits through which the fluid streams flow.

Referring first to Figs. 1, 2 and 3, which illustrate a sound-absorbing cell or unit in accordance with this invention, it will be seen that the unit comprises a generally rectangular casing, designated generally by the numeral **10**, defined by side walls **11—11** and top and bottom walls **12** and **13**, respectively. It will be understood that the top and bottom walls **12** and **13** may be formed by the top and bottom walls of a conduit or duct in which the unit will ordinarily be installed, although, if desired, the unit may be made entirely self-contained by providing top and bottom walls **12** and **13** as shown. Side walls **11** are foraminous or otherwise acoustically transparent and may be constructed of sheet metal having perforations **14**, or of expanded metal, wire mesh screen or the like, as is well-known for use in structures of the kind herein contemplated.

The interior of casing **10** is divided by a plurality of longitudinally spaced, transverse partition members **15** which extend vertically from top to bottom of the casing and transversely from side wall to side wall of the casing. Longitudinally extending partition members **16** are arranged between each pair of adjacent transverse partition members and extend vertically from top to bottom of the casing and are fastened along their vertical edges to the adjacent partition members **15** in any suitable manner, as by tack welding, or by means of screws, and the like. Partition members **15** and **16** are acoustically

opaque and preferably are constructed from thin imperforate sheet metal.

The arrangement of the intersecting transverse and longitudinal partition members serves to divide the interior of casing **10** into a plurality of chambers which extend inwardly from the respective side walls **11** and which communicate with the exterior of the unit through the openings or perforations **14**. The several longitudinal partition members **16** are preferably positioned at different distances from the side walls so as to vary the depths of the several chambers relative to the side walls. In the embodiment illustrated, the partition members **16** are disposed at three different distances from each side wall, thereby defining the chambers A, B and C (Fig. 2) along one of the side walls **11**, and the complementary chambers A^1, B^1 and C^1 on the opposite sides of the partitions with respect to the other side wall **11**. Thus there is provided along each of the side walls **11**, extending inwardly therefrom, a series of chambers of differing depths which will be adapted to attenuate sound waves of different frequencies, as is well understood. As shown, there may be several successive series of such chambers throughout the length of the casing. All of the chambers are preferably substantially filled with a suitable acoustically absorbent material **17**, such as fiber glass, rock wool, packed felt and the like.

Casing **10** may be provided at one end with a nose portion **18** defined by a convex rounded end wall **19** which is likewise acoustically transparent and defines a chamber **18***a* which may be filled with the absorbent material **17**. At its opposite end, casing **10** may be fitted with a tail portion **20** defined by side wall portions **21—21**, which may be extensions of side walls **11—11**. The side wall portions **21—21** converge at an angle to the longitudinal axis of the unit, the angle of convergence relative to the longitudinal axis being in the range of about 10° to 25° and preferably from about 12° to 20°. Wall portions **21** will also be foraminous or acoustically transparent and may be divided longitudinally by a partition member **16***a* into chambers **20***a*—**20***a* which may also be filled with the acoustically absorbent material **17**, as are the other chambers provided in the interior of casing **10**.

It will be understood that rounded nose portion **18** will ordinarily be the upstream end of the unit, while tail portion **20** will be the downstream end of the unit. It will also be understood that in some cases the use of the nose and tail portions may be dispensed with, particularly the tail portion, as will appear subsequently.

The sound-absorbing unit or cell heretofore described is a highly efficient sound-absorbing device when placed in a fluid stream such as air or gas, which is accompanied by sound energy of different frequencies. The fluid passing over side walls **11**, the unit ordinarily being installed parallel to the path of flow of the fluid, will, of course, penetrate the side walls and the varying depths of the internal chambers and the acoustically absorbent material therein will be effective to absorb different frequencies generally in accordance with the depths of the several chambers.

The individual units of the kind described are very efficient sound-absorbing devices and are designed so that they may be installed in arrays of various forms in the ducts or conduits in which the fluid streams flow to effectively absorb sound frequencies accompanying such fluid. Figs. 4, 5 and 6 illustrate several different arrays which are suitable.

Fig. 4 illustrates an array in which a plurality of units **10** are arranged in a rectangularly shaped duct or conduit D, such as are employed in conventional air-conditioning systems, through which an air stream flows longitudinally in a direction indicated by the arrows. In the embodiment of Fig. 4 the units **10** are arranged in two transverse rows R^1 and R^2 across the interior of the duct, it being understood the side walls of the units extend vertically from the bottom to the top of the duct and are suitably secured thereto. Downstream row R^2 comprises four complete units and upstream row R^1 contains three complete units, as shown, the units in one row being staggered transversely with respect to those in the next adjacent row, the rows being longitudinally spaced with respect to each other. The spacing between the units comprising each row will ordinarily be uniform and the same for both rows. The staggered arrangement of the rows is intended to prevent straight line-of-sight passage of fluid through the sound-absorbent structure formed by the array. This is to prevent the unimpeded passage of the high frequency sounds which would otherwise escape and to cause the fluid to traverse a zig-zag path through the array. To assure against such unimpeded movement of the high frequency sounds, half units **10***a* may be positioned in row R^1 against each of the side walls of duct D in the manner shown. The units in both rows R^1 and R^2 will preferably be equipped with the rounded nose portions **18**, while those units in rows R^1 will also preferably be equipped with tail portions **20** of the kind previously described. The longitudinal spacing between the rows, the angularity of the tail portions, and the spacing between the tail portions of row R^1 and the nose portions of rows R^2 will be so selected that the clearance or spacing between the opposing walls of the tail and nose portions of the adjacent rows, indicated by the dimension *b*, will be approximately one-half the spacing or distance between the units in each of the rows, indicated by the dimension *a*.

The angle of convergence of the wall portions forming the tail portions **20** is selected to provide change in direction of flow of the fluid medium sufficient to prevent unimpeded passage of high frequencies with minimum pressure drop. As noted previously, this angle is found to be in a range from 10° to 25° and preferably from about 12° to about 20°. Where the array includes two rows of sound-absorbing units, as in Fig. 4, the tail portions on downstream row R^2 may be dispensed with if desired and are, therefore, shown in broken lines in this illustration.

Fig. 5 illustrates another array employing one row R^2 of units **10** interspersed between two rows R^1 of units **10**, each row being of the form and arrangement previously described in connection with Fig. 4, and the units **10** being identical with those previously described. This array may be employed to secure a greater degree of sound reduction.

Fig. 6 illustrates a single row array useful in systems having relatively small sound reduction requirements. Under such conditions a row of three units **10** with or without the tail portions **20** (shown in broken lines) may be sufficient to accomplish the results desired.

It will be understood that in large installations, more than one array may be installed. In some instances, several arrays may be installed at intervals in a single duct or fluid conduit. In any case, the sound-absorbing units herein described and the various arrays which may be formed therewith will provide highly efficient sound reduction with minimum pressure drop in the fluid mediums passing therethrough.

While the invention herein described is particularly applicable to air-conditioning systems, it will be evident that it may be applied as well to other acoustic systems, such as test stacks for engines, propellers, and the like.

It will be understood that various changes and modifications may be made in the details of the illustrative embodiments within the scope of the appended claims but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. A sound-absorbing device for use in a fluid medium, comprising, a generally rectangular casing having parallel spaced-apart foraminous side walls, and a pluarlity of intersecting transverse and longitudinal imperforate partition members positioned between said walls and rela-

tively arranged to divide the interior of the casing into a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating said walls.

2. A sound-absorbing device for use in a fluid medium, comprising, a generally rectangular casing having parallel spaced-apart foraminous side walls, a plurality of intersecting transverse and longitudinal imperforate partition members positioned between said walls and relatively arranged to divide the interior of the casing into a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating said walls, and acoustically absorbent material substantially filling said chambers.

3. A sound-absorbing device for use in a fluid medium, comprising, a generally rectangular casing having parallel spaced-apart foraminous side walls, a plurality of intersecting transverse and longitudinal imperforate partition members positioned between said walls and relatively arranged to divide the interior of the casing into a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating said walls, said casing having a nose portion defined by a convexly curved end wall and a tail portion defined by convergent side wall portions.

4. A sound-absorbing device according to claim 3 wherein the angle of convergence of said side wall portions relative to the longitudinal axis of said casing is in the range from about 10° to about 25°.

5. A sound-absorbing device for use in a fluid medium, comprising, an elongate generally rectangular casing having parallel spaced-apart foraminous side walls, a plurality of intersecting transverse and longitudinal imperforate partition members positioned between said walls and relatively arranged to divide the interior of the casing into a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating said walls, said casing including a nose portion defined by a convexly curved end wall and a tail portion defined by convergent side wall portions, and acoustically absorbent material substantially filling said chambers.

6. A sound-absorbing device according to claim 5 wherein the angle of convergence of said side wall portions relative to the longitudinal axis of said casing is in the range from about 10° to about 25°.

7. In an acoustic system in which a fluid medium is adapted to flow longitudinally through a confined space, a structure for absorbing sound energy accompanying the flow of said medium, comprising, an array of sound-absorbing devices positioned in said confined space in the path of flow of said medium, said array comprising at least one transverse row of said devices arranged in transversely spaced-apart relation across said space, each of said devices comprising, a generally rectangular casing disposed parallel to the path of flow of said medium and having parallel spaced-apart foraminous side walls extending vertically from top to bottom of said confined space, and a plurality of intersecting transverse and longitudinal imperforate partition members positioned between said walls and relatively arranged to divide the interior of the casing into a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating said side walls.

8. In an acoustic system in which a fluid medium is adapted to flow longitudinally through a confined space, a structure for absorbing sound energy accompanying the flow of said medium, comprising, an array of sound-absorbing devices positioned in said confined space in the path of flow of said medium, said array comprising at least one transverse row of said devices arranged in transversely spaced-apart relation across said space, each of said devices comprising, a generally rectangular casing disposed parallel to the path of flow of said medium and having parallel spaced-apart foraminous side walls extending vertically from top to bottom of said confined space, a plurality of intersecting transverse and longitudinal imperforate partition members positioned between said walls and relatively arranged to divide the interior of the casing into a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating said side walls, and acoustically absorbent material substantially filling said chambers.

9. In an acoustic system in which a fluid medium is adapted to flow longitudinally through a confined space, a structure for absorbing sound energy accompanying the flow of said medium, comprising, an array of sound-absorbing devices positioned in said confined space in the path of flow of said medium, said array comprising two or more longitudinally spaced, transverse rows of said devices arranged in said space, the devices in each row being transversely spaced-apart and the devices in one row being staggered relative to those in a next adjacent row, each of said devices comprising, a generally rectangular casing disposed parallel to the path of flow of said medium and having parallel spaced-apart foraminous side walls extending vertically from top to bottom of said confined space, a plurality of intersecting transverse and longitudinal imperforate partition members positioned between said walls and relatively arranged to divide the interior of the casing into a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating said side walls, said casing having a nose portion defined by a convexly curved end wall and a tail portion defined by convergent side wall portions, the relative spacing of the devices in said array being such that the spacing between the opposed walls of the nose and tail portions of the devices in adjacent rows is approximately one-half the spacing between adjacent devices in each of the rows.

10. In an acoustic system in which a fluid medium is adapted to flow longitudinally through a confined space, a structure for absorbing sound energy accompanying the flow of said medium, comprising, an array of sound-absorbing devices positioned in said confined space in the path of flow of said medium, said array comprising two or more longitudinally spaced transverse rows of said devices arranged in said space, the devices in each row being transversely spaced apart and the devices in one row being staggered relative to those in the next adjacent row, each of said devices comprising, a generally rectangular casing disposed parallel to the path of flow of said medium and having parallel spaced-apart foraminous side walls extending vertically from top to bottom of said confined space, and a plurality of intersecting transverse and longitudinal imperforate partition members positioned between said walls and relatively arranged to divide the interior of the casing into a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating said side walls, acoustically absorbent material substantially filling said chambers, said casing having a nose portion defined by a convexly curved end wall and a tail portion defined by convergent side wall portions, the relative spacing of the device in said array being such that the spacing between the opposed walls of the nose and tail portions of the devices in adjacent rows is approximately one-half the spacing between adjacent devices in each of the rows.

11. An array according to claim 10 wherein the angle of convergence of said side wall portions of each of said devices relatives to the longitudinal axis of the casings thereof is in the range from about 10° to 25°.

12. A sound-absorbing device for use in a fluid medium, comprising, an elongate generally rectangular casing having parallel spaced-apart foraminous side walls, a plurality of longitudinally spaced imperforate partition members extending transversely between the side walls and from top to bottom of the casing, a lon-

gitudinal imperforate partition member extending between each pair of adjacent ones of the transverse partition members and from top to bottom of said casing, the longitudinal partition members being positioned at different distances from said side walls whereby to define with the transverse partition members a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating the side walls.

13. A sound-absorbing device according to claim 12 wherein said chambers are substantially filled with acoustically absorbent material.

14. In an acoustic system in which a fluid medium is adapted to flow longitudinally through a confined space, a structure for absorbing sound energy accompanying the flow of said medium, comprising, an array of sound-absorbing devices positioned in said confined space in the path of flow of said medium, said array comprising two or more longitudinally spaced transverse rows of said devices arranged in said space, the devices in each row being transversely spaced-apart and the devices in one row being staggered relative to those in the next adjacent row, each of said devices, comprising, an elongate generally rectangular casing disposed parallel to the path of flow of said medium and having parallel spaced-apart

foraminous side walls extending from top to bottom of said confined space, a plurality of longitudinally spaced imperforate partition members extending transversely between said side walls and from top to bottom of said casing, a longitudinal imperforate partition member extending between each pair of adjacent ones of the transverse partition members and from top to bottom of said casing, the longitudinal partition members being positioned at different distances from said side walls whereby to define with the transverse partition members a plurality of chambers of different depths relative to the side walls adapted to attenuate different acoustic frequencies penetrating the side walls, and acoustically absorbent material substantially filling said chambers.

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