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(54) **Sound-damped combustion system, and damper for such a system**

(57) In a combustion system a predetermined part of a wall of the system, a wall of the air inlet duct of the system and/or a wall (6; 24) of the flue gas duct of the system is flexible. The remaining part of the wall is made of a rigid material. The outside of the flexible wall part (6; 24) is covered with a container (8; 26) of a rigid material whose edges connect to the rigid part of the wall. The volume bounded by the flexible wall part (6; 24) and the container (8; 26) is in communication with the environment of the combustion system by way of an open pipe (14; 28) with a predetermined diameter and length. Several containers (8a, 8b, 8x; 8aa, 8bb) can be connected in series.

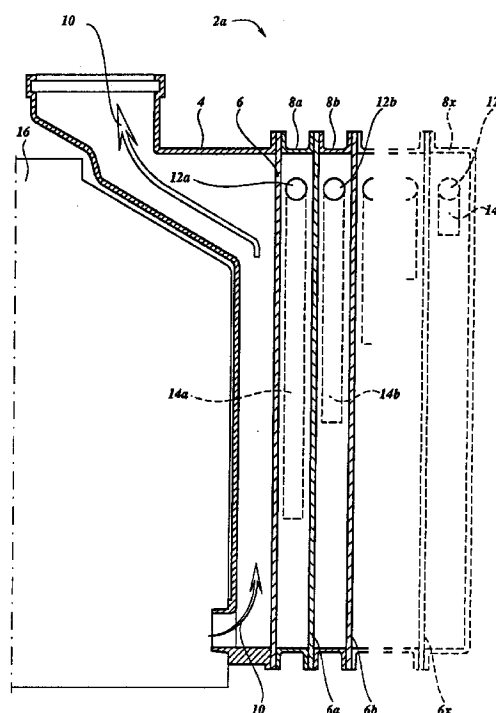


Fig. 4

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Description

The invention relates to a sound-damped combustion system. The invention also relates to an acoustic damper to be used in such a combustion system.

Known combustion systems, such as boilers for heating, produce noise which is caused, inter alia, by the combustion process. The flame occurring during the combustion in acoustic respects is a source of noise and an amplifier for frequencies between zero and one thousand Hertz. Other noise sources in combustion systems are, for example, fans, gas flows in the system, etc.

There are various factors which, in the absence of special measures, in the combustion system can easily lead to the occurrence of undesirable acoustic resonances in the abovementioned frequency range, which resonances are not only very irritating for persons in the vicinity of the system, but can also lead to faults in the system through the fluctuating mechanical loads thereof associated with the resonance vibrations of system parts.

The frequencies of such resonances are difficult to forecast. For instance, account must be taken of the fact that in a combustion system there are variable sound velocities, variable gas/air/flue gas masses and variable flame behaviour at different temperatures, which occur, for example, during output variations of the combustion system. In this connection it is also pointed out the trend towards reducing the size of combustion systems, making them suitable for burning various fuels, and making the systems a closed design, all of which factors have an influence on the pitch of the resonance frequencies. Moreover, in particular in the case of boilers for central heating systems, there are different flue gas duct lengths for different types of houses.

Various measures were proposed in the past for preventing resonances and damping noise in combustion systems. A first example of such a known measure concerns the fitting of one or more Helmholtz resonators, but these have a limited application on account of the fact that they are effective only at specific frequencies. Therefore, as soon as there is any question of fluctuating plant or operating conditions, Helmholtz resonators offer little or no relief for acoustic problems which are broad band and occur particularly in the low-frequency range (0-250 Hz). Besides, Helmholtz resonators would have to have relatively large, unwieldy dimensions for damping at very low frequencies.

Generally known measures relate in general to an increase in the acoustic impedance (unit: pressure per volume flow rate) of the inlet, a reduction in the acoustic impedance of the outlet or an increase in the acoustic losses of the combustion system. What is common in the abovementioned measures is that they interfere in the characteristics of the vibrating gaseous medium, in other words: the measures are of a pneumatic-acoustic nature. The fact that the stationary gas flow losses increase can be a disadvantage here.

The object of the invention is to provide a combustion system based on a totally different damping principle, in which noise can be damped over a broad frequency range. Another object of the invention is to offer a compact solution to the abovementioned noise problems.

To this end, the invention provides a combustion system which is characterized in that a predetermined part of an otherwise rigid wall of the system, an otherwise rigid wall of an air inlet duct of the system and/or an otherwise rigid wall of a flue gas duct of the system is flexible. The flexible wall part, the surface area of which need be only a few square decimetres, acts as a mechanical resonator, and has a very low impedance for the envisaged frequency range. When such a resonator is placed at a pressure maximum of the resonance, and preferably as close as possible to the place of combustion, an acoustic "short-circuit" occurs at this place. Viewed from the flame, the acoustic impedance changes through this measure. Moreover, the acoustic losses can increase.

In addition to an impedance reduction in the system, a strong resonator also introduces new resonances around the natural frequency of the resonator. It is found that this undesirable side-effect can be suppressed effectively by covering the outside of the flexible wall part with a container made of a rigid material whose edges connect to the rigid part of the wall, the volume bounded by the flexible wall part and the container being in communication with the environment of the container by way of at least one opening in the container wall. This environment can be the ambient air around the combustion system, but it can also relate to other parts of the damping system according to the invention, as will emerge from what follows below. The quantity of air in the container acts like an air spring which is much more rigid than the flexible wall part. This means that the movement of the air through the flexible wall part is passed on by the air spring to the opening in the container, where friction is consequently created. The desired damping effect can be set by adapting the measurements of the opening.

The natural frequency of the flexible wall part is determined by the degree of flexibility and the mass thereof. If a very low natural frequency is desired, for example 20 Hz, the flexible wall part would have to be relatively soft, and its mass would have to be very great. In order to overcome this drawback, in communication with each opening of the volume bounded by the flexible wall part and the container a pipe of a predetermined length and cross-section which is open at both ends is fitted. The weight of the air in the pipe, transformed by the ratio of the square of the surface area of the flexible wall part to the square of the surface area of the pipe cross-section, has the effect of a considerable weight on the flexible wall part. The damping characteristics of such a construction can be set further by selecting a suitable length and cross-section for each pipe.

In a special embodiment flexible wall parts are placed in series, for example by making a predetermined part of the otherwise rigid container wall locally flexible. Both the rigid and the flexible container wall part can contain the abovementioned opening(s) with the damping action. In addition, the outside of the flexible container wall part of a container can be covered by a next container made of a rigid material whose edges connect to the rigid part of the wall of the first-mentioned container. In a preferred embodiment the abovementioned pipe communicating with an opening in the container wall can form a connection between two or more different containers. An opening in the flexible container wall part can also form a connection between two adjacent containers.

Each additional container has to damp higher frequencies than a preceding container. This effect can advantageously be achieved through the fact that the flexibility of the flexible wall parts decreases per flexible wall part in the direction of the outside of the combustion system and/or by making the dimensions of the flexible wall parts decrease per flexible wall part in the direction of the outside of the combustion system.

In a preferred embodiment the flexible wall part forms part of the wall of a Helmholtz resonator. A conventional Helmholtz resonator for a specific frequency can thus advantageously be combined with the damping measures according to the invention for a broad frequency range.

In another preferred embodiment the mass of the flexible wall part for the damping of in particular low frequencies is increased by placing on the flexible wall part with a specific surface area a layer of material with a smaller surface area than said surface area.

The flexible wall part is not active if there is a pressure minimum in the gas at the position of the flexible wall part. However, it is possible more or less to fix such a pressure minimum at some distance from a flexible wall part by providing a narrowing of the passage locally over some length in the system, the air inlet duct or the flue gas duct.

The flexible wall part is preferably formed by a membrane of a fluorine-containing polymer, such as PVDF, or stainless steel, materials which can readily withstand high temperatures and show few ageing phenomena.

The measures according to the invention are preferably used in a boiler for central heating and/or heating of running water, in particular in the flue gas duct thereof.

The invention will be explained in greater detail with reference to the drawing, in which:

Fig. 1 shows a front view of a damper according to the invention;

Fig. 2 shows a cross-section of the damper of Fig. 1 along the line II-II, with added narrowed part;

Fig. 2a shows on a reduced scale a top view of the damper of Fig. 2 in the direction of the arrow IIa;

Fig. 3 shows a cross-section of the damper of Fig. 1 along the line III-III;

Fig. 4 shows a part of a diagrammatically shown combustion system according to the invention with a first variant of a damper according to Fig. 2;

Fig. 5 shows a part of a diagrammatically shown combustion system according to the invention with a second variant of a damper according to Fig. 2;

Fig. 6 shows a graph illustrating the improved acoustic characteristics of the combustion system obtained by the damping according to the invention; and

Fig. 7 shows diagrammatically in cross-section another variant embodiment of the damper according to the invention.

In the various figures the same reference numbers relate to the same parts or parts with the same function.

Figs. 1, 2, 2a and 3 show a damper 2 which comprises a housing part 4, a membrane 6 and a container 8. The damper is intended to form part of a flue gas duct of a combustion system, for example a boiler for central heating and/or the heating of running water. The flow of flue gases through the damper 2 is illustrated in Fig. 2 by arrows 10. For the sake of clarity, no further details of the combustion system are shown in Figs. 1 - 3.

The membrane 6 is clamped along its edges between flanges of the housing part 4 and the container 8. The membrane 6 can be glued between the flanges, but it is also possible to clamp the membrane between the flanges by means of a screw connection or the like between the flanges. The housing part 4 and the container 8 are made of a rigid material such as a plastic or a metal, while the membrane 6 is so flexible that it can be impinged upon by the noise pressure in the combustion system and in that case starts acting like a mass-spring damper system. Through a suitable selection of the material, such as PVDF, and the dimensions of the membrane 6, a resonance in the flue gas duct is greatly reduced in a predetermined frequency range. This damping effect already occurs if the damper comprises only a housing part 4 and a membrane 6, thus in the absence of the container 8. The container 8 is provided with an opening 12 which leads to an open pipe 14 which at its free end is in open communication with the environment, i.e. the ambient air of the damper. The membrane 6 and the container 8 bound an air spring, which has been made leaky by means of the opening 12 leading to the environment. Since the air spring is much more rigid than the membrane 6, the air spring acts as a conductor of the air movement through the membrane 6 to the opening 12 and the pipe 14, where the air encounters friction. This produces a vibration damping which can be set to a desired frequency range by making a suitable selection of the dimensions of the opening 12 and those of the pipe 14, in particular the length thereof. Moreover, even in the absence of the pipe 14, i.e. if the container 8 is merely provided with an opening 12, the air friction in the opening 12 already produces a

sound-damping effect which can be sufficient in certain circumstances. If desired, the container 8 can comprise several openings, each with or without a pipe. As can be seen in particular from Figs. 2 and 2a, the damper can be provided at some distance from the membrane 6 with an element 13 with the function of narrowing the passage locally over some length, so that a pressure minimum in the gas flowing through the damper is not "fixed" at the membrane 6, but at the position of the element 13.

Fig. 4 shows on a slightly enlarged scale a damper 2a comprising a housing part 4 and a membrane 6. The damper 2a is connected to an only roughly shown combustion system 16. Unlike the damper of Figs. 1 - 3, the damper 2a according to Fig. 4 comprises a number of containers 8a, 8b,..., 8x of a rigid material, and membranes 6a, 6b,..., 6x of a flexible material. The volume formed by the membrane 6, the container 8a and the membrane 6a is provided with an opening 12a which communicates with a pipe 14a. The volume formed by the membrane 6a, the container 8b and the membrane 6b is provided with an opening 12b which communicates with a pipe 14b which is shorter in length than the pipe 14a. The volume formed by the membrane 6x and the container 8x is also provided with an opening 12x which communicates with an open pipe 14x which is shorter than all other pipes. For the sake of clarity, the depths of the containers 8a-8x are shown disproportionately large in the drawing. The membrane 6a is more rigid than the membrane 6, the membrane 6b is more rigid than the membrane 6a, and the membrane 6x is more rigid than all other membranes. Thus, starting from the principle of the damper shown in Fig. 2, it is possible to design a damper according to Fig. 4 which is effectively active over a large frequency range through series connection of the containers 8a-8x. In this case the container 8a is active for damping relatively low frequencies, while the containers 8b,...8x are in succession active for damping respective higher frequencies. In order to achieve certain damping characteristics of the damper 2a, two or more of the pipes 14a,...14x can be interconnected to form one (possibly branching) pipe, which interconnects the respective corresponding openings 12a,...12x. One or more of the membranes 6a,...6x can also be provided with a damping connection opening.

Fig. 5 shows a damper 2b which, like the damper 2a of Fig. 4, comprises a number of series-connected containers 8aa and 8bb of a rigid material. Unlike the damper 2a of Fig. 4, the damper 2b of Fig. 5 has membranes 6 and 6aa of a flexible material, which membranes are all made of the same sheet-type material and differ from each other only as regards surface area. The damper 2b can comprise more than the two containers 8aa and 8bb shown in Fig. 5 if required, as is suggested by dashed lines. The container 8aa is provided with an opening 12aa which has an open pipe 14aa coupled thereto, and in a corresponding way the container 8bb is provided with an opening 12bb and an

open pipe 14bb connecting thereto. The container 8aa is active for damping relatively low frequencies, while higher frequencies are damped by means of the container 8bb.

A layer of material, for example of bitumen, can be applied, for example glued, on one or more of the flexible wall parts 6, 6a-6x or 6aa according to Figs. 1 - 5, which layer of material has a smaller surface area than the membrane surface area, with the result that the membrane will no longer resonate at higher frequencies. In Fig. 2 the layer of material on membrane 6 is indicated by reference number 16.

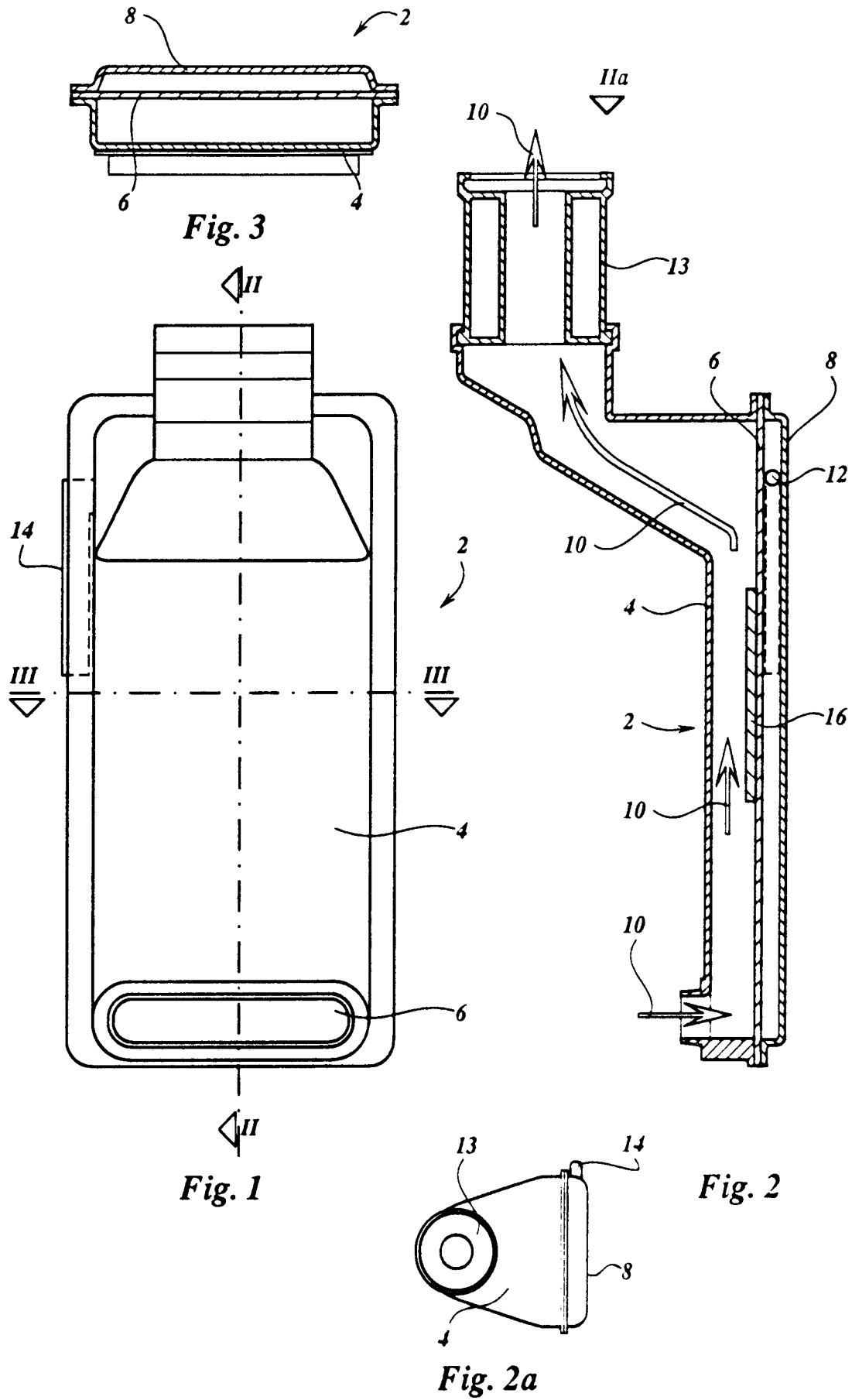
Fig. 6 shows a graph in which the frequency in Hz is plotted along the horizontal axis, while the sound pressure level in dB is plotted along the vertical axis. Curve A shows the loudspeaker response of a certain heat exchanger of a combustion system without damping measure; curve B shows the loudspeaker response for the same heat exchanger after the fitting of a damper according to the invention. As can be seen from Fig. 6, the damping of the tops of the curve A over the frequency range shown is between 4 and 10 dB.

Fig. 7 illustrates a combination of a Helmholtz resonator 22 and a damper fitted near a combustion point 20 of a combustion system, comprising a membrane 24, a container 26 and an open pipe branch 28. The Helmholtz resonator can, for example, damp a frequency of 300 Hz, while the membrane 24, the container 26 and the pipe branch 28 damp lower frequencies.

Claims

1. Sound-damped combustion system, characterized in that a predetermined part (6; 24) of an otherwise rigid wall of the system, an otherwise rigid wall of an air inlet duct of the system and/or an otherwise rigid wall of a flue gas duct of the system is flexible.
2. Combustion system according to claim 1, characterized in that the outside of the flexible wall part is covered with a container (8; 26) made of a rigid material whose edges connect to the rigid part of the wall, the volume bounded by the flexible wall part (6; 24) and the container being in communication with the environment of the container by way of at least one opening (12) in the container wall.
3. Combustion system according to claim 2, characterized in that in communication with each opening (12) a pipe (14; 28) of a predetermined length and cross-section which is open at both ends is fitted.
4. Combustion system according to claim 2 or 3, characterized in that a predetermined part (6a; 6aa) of the otherwise rigid container wall is locally flexible.

5. Combustion system according to claim 4, characterized in that the outside of the locally flexible container wall part (6a; 6aa) of a container (8a; 8aa) is covered by a next container (8b, 8x; 8bb) of a rigid material whose edges connect to the rigid part of the wall of the first-mentioned container (8a; 8aa). 5
6. Combustion system according to claims 3 and 5, characterized in that the pipe (14a, 14b, 14x; 14aa, 14bb) forms a connection between two or more different containers (8a, 8b, 8x; 8aa, 8bb). 10
7. Combustion system according to claims 4, 5 or 6, characterized in that the flexibility of the flexible wall parts (6, 6a, 6b, 6x) decreases per flexible wall part in the direction of the outside of the combustion system. 15
8. Combustion system according to claims 4, 5 or 6, characterized in that the dimensions of the flexible wall parts (6, 6aa) decrease per flexible wall part in the direction of the outside of the combustion system. 20
9. Combustion system according to any of the preceding claims, characterized in that the flexible wall part (24) forms part of the wall of a Helmholtz resonator (22). 25
10. Combustion system according to any of the preceding claims, characterized in that on the flexible wall part (6) with a specific surface area a layer of material (16) with a smaller surface area than said surface area is placed. 30
11. Combustion system according to any of the preceding claims, characterized in that a narrowing of the passage locally is provided over some length in the system, the air inlet duct or the flue gas duct (13) at some distance from a flexible wall part (6) thereof. 35
12. Combustion system according to any of the preceding claims, characterized in that the flexible wall part (6; 6a, 6b, 6x; 6aa; 24) is formed by a membrane of a fluorine-containing polymer or stainless steel. 40
13. Combustion system according to any of the preceding claims, characterized in that the system (16) is a boiler for central heating and/or heating of running water. 45
14. Damper (2) for a combustion system according to any of the preceding claims, characterized by an essentially closed housing (4) of a rigid material, provided with an inlet and an outlet, in which a predetermined part (6) of the otherwise rigid wall of the housing is flexible. 50
15. Damper according to claim 14, characterized in that it is provided with one or more containers and one or more flexible wall parts according to one or more of claims 2 - 11. 55
16. Damper according to claim 14 or 15, characterized in that the damper is intended for accommodation in the flue gas duct of the combustion system.



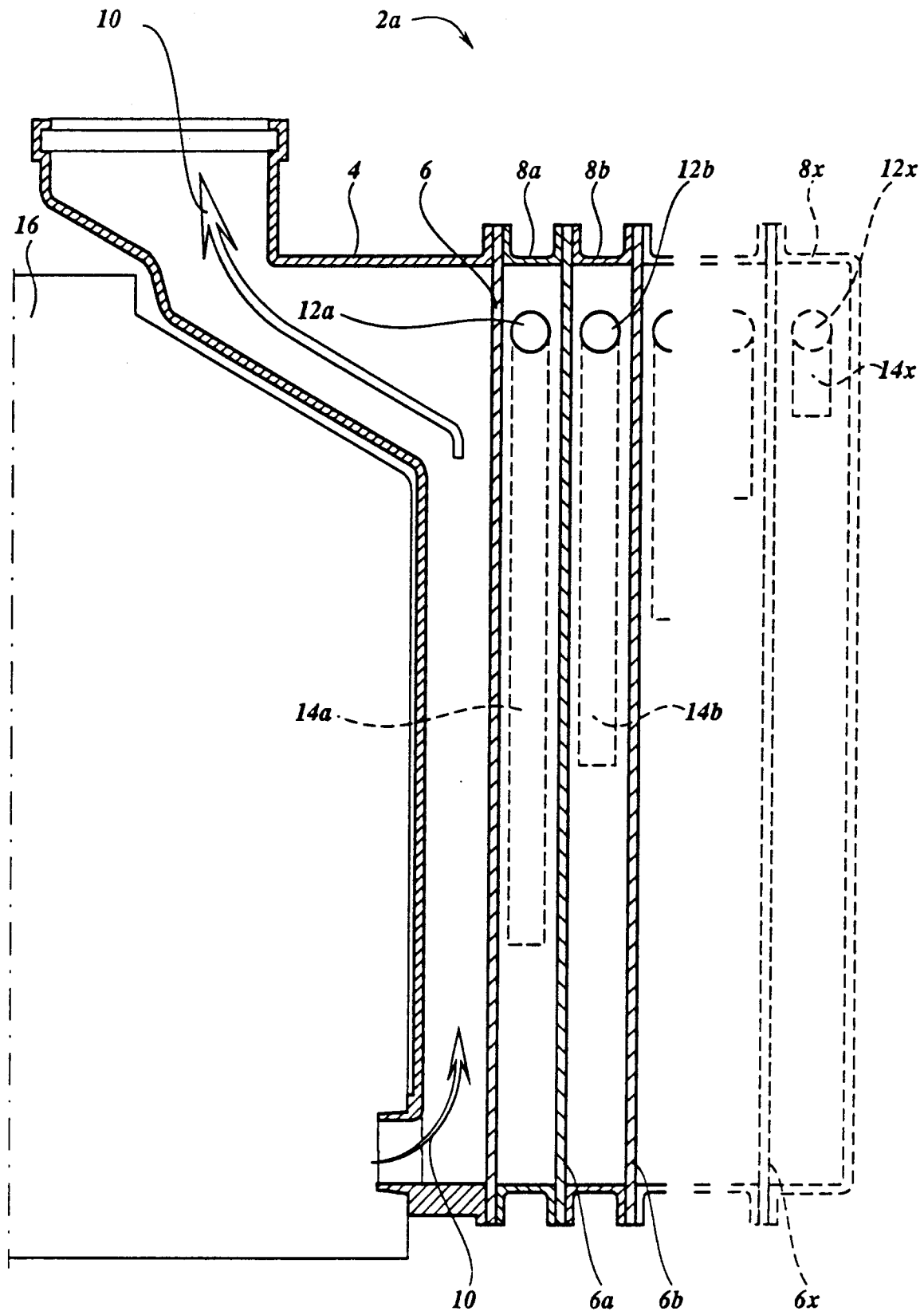


Fig. 4

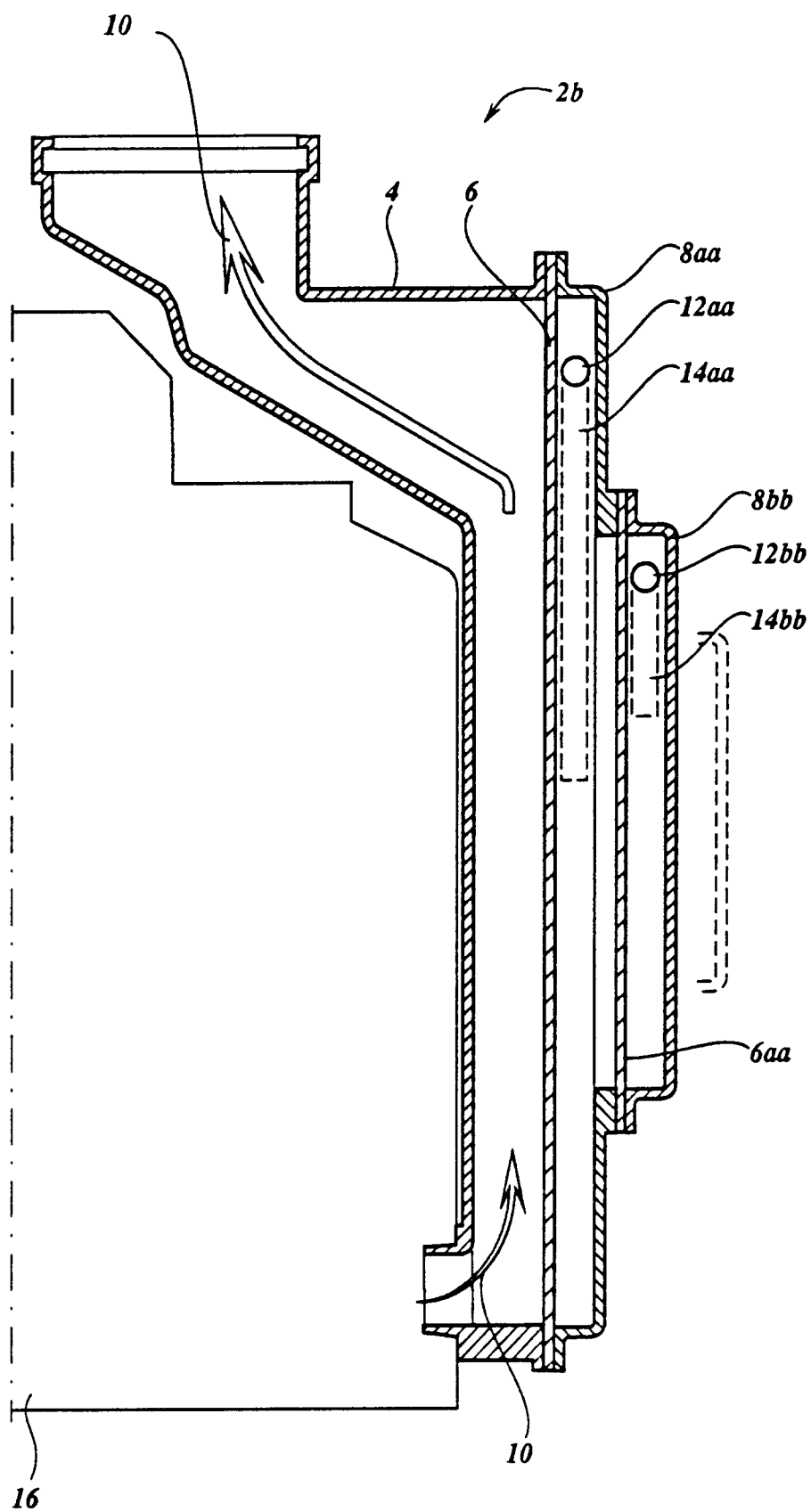
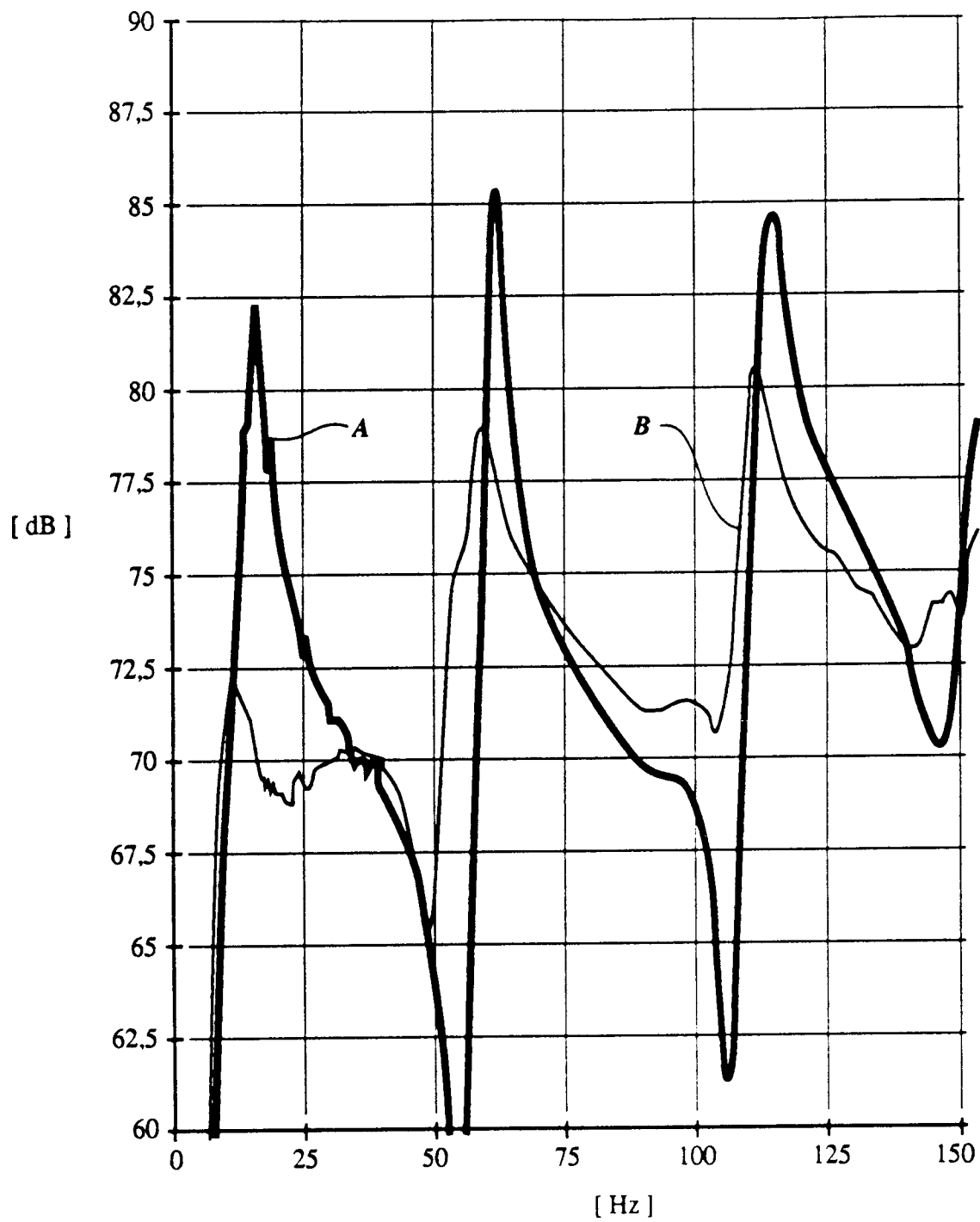


Fig. 5

*Fig. 6*

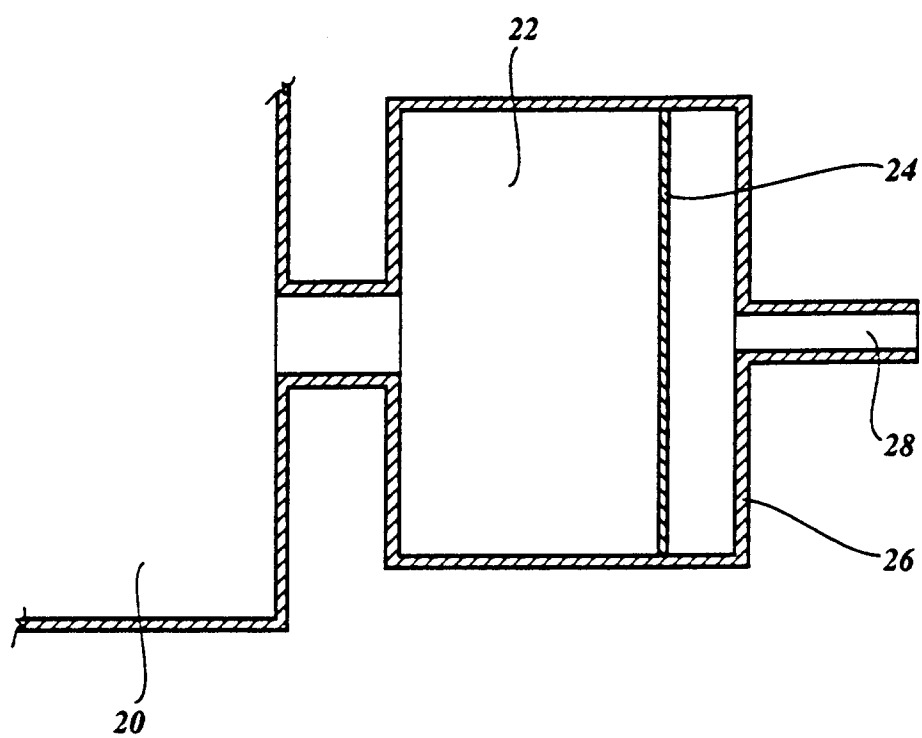


Fig. 7



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EUROPEAN SEARCH REPORT

Application Number
EP 96 20 0151

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	FR-A-2 504 659 (SDECC) 29 October 1982 * claims 1,2; figures *	1,2	F24H9/00 F23M13/00
X	DE-A-35 17 859 (WOLF KLIMATECHNIK GMBH) 20 November 1986 * page 19, line 20 - page 19, line 29; figures 25,26 *	1,2	
A	---	9	
A	DE-A-42 26 890 (GROSSCHWEISWERK UND DAMPFKESSE) 20 January 1994 * abstract *	11	
X	NL-C-87 151 (N.V. BRONSWERK) 15 February 1957 * claims 1,3; figures *	1,2	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			F24H F23M F01N
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 9 April 1996	Examiner Van Gestel, H
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