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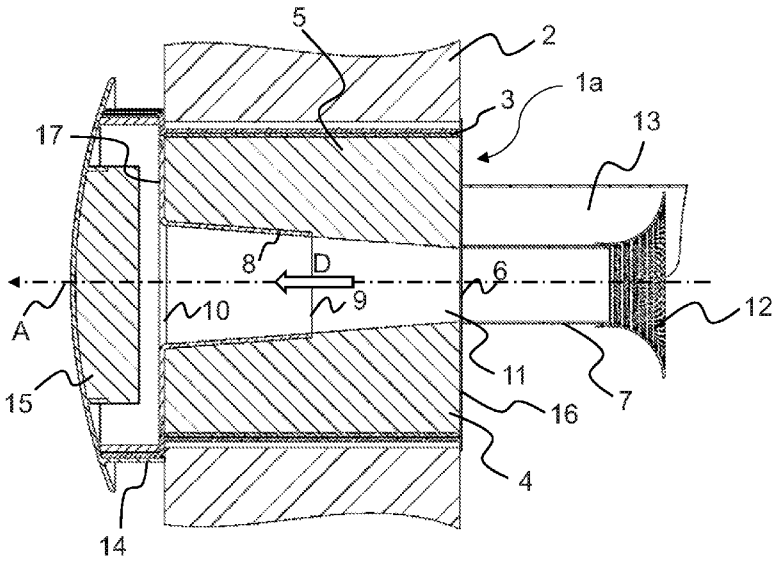

Fig. 1

(57) Abstract: An air vent (1a) for installation in a wall (2) of a building for directing a flow of air into a room of the building, the air vent comprising: - a housing (3) defining a cavity (4), wherein a sound absorbing material is arranged within the cavity; - an air inlet tube (7) for guiding air into the cavity; - an air outlet tube (8) for guiding air out of the cavity; wherein each of a volume of the air inlet tube and a volume of the air outlet tube are smaller than a volume of the cavity, and wherein the cavity has a larger cross-sectional area than each of the air inlet tube and the air outlet tube, such that the cavity together with the air inlet tube and the air outlet tube form a reactive silencer.

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An air vent

TECHNICAL FIELD OF THE INVENTION

The present invention relates to an air vent for installation in a wall of a building for directing a flow of air into a room of the building.

BACKGROUND OF THE INVENTION AND PRIOR ART

In urban areas, domestic and public buildings are often exposed to significant noise of both high and low frequencies originating from e.g. road traffic, rail traffic, etc. Buildings are therefore usually provided with soundproofing material in order to achieve acceptable indoor sound levels. However, ventilation systems including air vents installed in walls of the building, in which outdoor air is directed into rooms of the building, may constitute a weakness in the soundproofing of the building, since sound may propagate through the air vents. In particular, it is difficult to provide air vents by means of which sufficient low frequency sound attenuation and acceptable air flow properties are simultaneously achieved.

SUMMARY OF THE INVENTION

It is a primary objective of the present invention to provide an air vent for installation in a wall of a building, which air vent also provides an in at least some aspect improved sound attenuation. In particular, it is an objective to provide such an air vent that provides improved sound attenuation at a relatively broad spectrum, i.e. both at relatively low and relatively high frequencies.

At least the primary objective is achieved by means of an air vent according to claim 1. The air vent comprises:

- a housing defining a cavity, wherein a sound absorbing material is arranged within the cavity;
- an air inlet tube for guiding air into the cavity;
- an air outlet tube for guiding air out of the cavity;

wherein each of a volume of the air inlet tube and a volume of the air outlet tube are smaller than a volume of the cavity, and wherein the cavity has a larger cross-sectional area than each of the air inlet tube and the air outlet tube, such that the cavity together with the air inlet tube and the air outlet tube form a reactive silencer.

In the air vent according to the invention, efficient sound attenuation is achieved thanks to that the cavity, the outlet tube and the inlet tube together form a reactive silencer, while at the same time a sound absorbing material is provided for resistive sound attenuation. In comparison with e.g. air vents provided with merely absorptive silencing means, the air vent according to the invention is particularly efficient for attenuating sound at relatively low frequencies. This renders it useful for air ventilation in buildings having an exterior exposed to noise from e.g. rail traffic and in which the requirements on sound attenuation are high. The air vent is also suitable for transferring air from one room of a building to another room, where there is need for sound attenuation between the rooms.

In particular, the air vent is suitable for ventilation systems relying on natural ventilation, but the air vent may also be used in mechanical ventilation systems.

The sound absorbing material which is arranged within the cavity provides additional sound attenuation, in particular at relatively high frequencies. The combination of the acoustic absorption provided by the sound absorbing material and the reactive silencing results in efficient sound attenuation over a large

frequency range. The sound absorbing material can be provided in the form of at least one body of sound absorbing material.

According to one embodiment, the cavity has a minimum cross-sectional area A1 and the inlet tube has a minimum cross-sectional A2, and wherein A1>4A2. According to another embodiment, A1>6A2.

According to one embodiment, the cavity has a minimum cross-sectional area A1 and the outlet tube has a minimum cross-sectional A3, and wherein A1>4A3. According to another embodiment, A1>6A3.

According to one embodiment, the air vent defines a reactive silencer in the frequency range 90-850Hz. Reactive sound attenuation is thus the dominating sound attenuation principle in this the above-defined frequency range.

According to one embodiment, a reactive silencer is a silencer in which reactive attenuation of sound is an attenuation in which a part of the incident sound power towards an entrance of an inlet tube of the silencer is reflected back towards a sound source as a result of a modification of the acoustic impedance at the entrance of the inlet tube of the silencer, which is dependent on the ratio of the cross-sectional area of the cavity to the cross-sectional area of the inlet tube and the ratio of the cross-sectional area of the cavity to the cross-sectional area of the outlet tube.

According to one embodiment, the minimum cross-sectional area A1 of the air inlet tube is 50 mm, in order to enable a predetermined air flow rate through the air without exceeding a predetermined pressure fall over the air vent.

The distance between the inlet tube and the outlet tube should be large enough to enable spreading and reflection of sound waves inside the cavity. According to one embodiment, the distance

between opposing ends of the air inlet tube and the air outlet tube is at least 50 mm. According to one embodiment, the distance between the opposing ends of the inlet tube and the outlet tube is at least 75 mm, and according to one embodiment, the distance between the opposing ends of the inlet tube and the outlet tube is at least 100 mm. The cavity has a length that is at least the distance between the opposing ends of the air inlet tube and the air outlet tube.

The length of the air inlet tube is adapted to the cross-sectional area A2 of the air inlet tube and to the cross-sectional area A1 of the cavity such that reactive attenuation within the above-mentioned frequency range is achieved. According to one embodiment, the length of the inlet tube is at least 50 mm.

According to an embodiment, the air vent comprises an air guiding channel for guiding the air within the cavity in a direction of flow from the air inlet tube to the air outlet tube, wherein the air guiding channel has a sound permeable outer wall. The air guiding channel improves the air flow through the air vent by guiding the air through the air vent, so that pressure drops can be avoided.

The cavity may be filled with the sound absorbing material, and the air guiding channel may be formed in the sound absorbing material. Preferably, the outer wall of the air guiding channel is formed by the sound absorbing material. The relatively large amount of sound absorbing material improves the sound attenuation. The sound absorbing material provides a porous outer wall, so that air is gently guided through the air vent while as sound is allowed to propagate through the porous outer wall of the air guiding channel into the cavity. Alternatively, it is possible to partly fill the cavity with the sound absorbing material and provide a perforated or otherwise sound permeable tube that defines the air guiding channel.

The air guiding channel may have a frustoconical shape with a growing cross-sectional area in the direction of flow. This improves the air flow through the air vent and renders the air vent particularly suitable for use in a naturally ventilated building.

The air outlet tube may have a frustoconical shape with a growing cross-sectional area in the direction of flow. Thanks to the larger cross-sectional area at an outlet end of the air outlet tube, a reduced velocity of flow is achieved at the outlet end, thereby avoiding pressure drops as the air is spread into the room.

The air outlet tube may be inserted into the cavity. In other words, the air outlet tube is introduced into the cavity so that an outlet end of the air inlet tube and an inlet end of the air outlet tube are spaced apart. By inserting the air outlet tube into the cavity, the air vent becomes more compact and can thus be mounted in thinner walls. Furthermore, if the air outlet tube has a frustoconical shape with a growing cross-sectional area in the direction of flow, the cross-sectional area at an inlet end of the air outlet tube can in this way be made smaller such that the acoustic performance is improved. If the wall is relatively thick, the outlet tube may instead be located entirely or partly outside of the cavity. It is also possible to insert the air inlet tube partly or entirely into the cavity.

The air inlet tube may have a smaller cross-sectional area than the air outlet tube. The air inlet tube may have a cylindrical shape, i.e. with a cross-sectional area that does not vary in the direction of flow.

According to an embodiment, the air vent further comprises a funnel arranged at an inlet end of the air inlet tube, wherein the funnel is configured for guiding air into the air inlet tube. The funnel reduces the pressure drop at the air inlet. The funnel may be sound permeable for improved high frequency sound attenuation, or impermeable for improved low frequency sound

attenuation. To make the funnel sound permeable, it may be provided with small holes, e.g. perforations, or be made of a mesh material.

The funnel may be bell-shaped for improved air flow properties.

According to an embodiment, the air vent further comprises an adjustable vent plate configured to be arranged downstream of the air outlet tube, wherein the vent plate comprises a sound absorbing disc configured to absorb sound propagating through the air outlet tube. The sound absorbing disc is made of a sound absorbing material, e.g. of the same type as used in the cavity. The sound absorbing disc improves the sound attenuation of the air vent.

Further advantageous features and advantages of the invention will appear from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will in the following be described by means of example with reference to the appended drawings, in which:

- Fig. 1 shows a sectional view of an air vent according to a first embodiment of the invention,
- Fig. 2 shows a sectional perspective view of the air vent in fig. 1, and
- Fig. 3 shows a sectional view of an air vent according to a second embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

An air vent 1a according to a first embodiment is shown in figs. 1–2 and an air vent 1b according to a second embodiment is shown in fig. 3. Common parts and features of the air vents according to the first and second embodiments will herein be described using the same reference numerals. In both embodiments, the air vents 1a, 1b are shown mounted in a wall 2 of a building. The air vents are configured for directing a flow of air into a room of the building by means of natural ventilation, i.e. without the use of mechanical devices such as fans for creating an air flow.

The air vent 1a, 1b comprises a housing 3 defining a cavity 4 enclosed therein. The housing 3 has a rigid, impermeable outer wall. A body 5 of a sound absorbing material is arranged within the cavity 4. The sound absorbing material may be of any type that is commonly used for this purpose, such as a fibre material or a foam material with an open cell structure.

The housing 3 has an inlet opening 6 in a first end wall 16 of the housing 3. A cylindrical air inlet tube 7 extending along a centre axis A is connected to the inlet opening 6 for guiding air into the cavity 4 in a direction of flow D as shown by the arrow. The air inlet tube 7 projects from the housing 3.

An air outlet tube 8 for guiding air out of the cavity 4 is provided downstream of, and spaced apart from, the air inlet tube 7. The air outlet tube 8 extends along the centre axis A and has a frustoconical shape with an inner diameter at an inlet end 9 which is smaller than an inner diameter at an outlet end 10. The air outlet tube 8 is inserted into the cavity 4, with the inlet end 9 located approximately halfway into the cavity 4 and with the outlet end 10 being level with a second end wall 17 of the housing 3.

Both the air inlet tube 7 and the air outlet tube 8 are made with outer walls of rigid and impermeable material, without perforations or openings, and both have relatively small volumes,

and relatively small cross-sectional areas, in comparison with the cavity 4. The air within the air inlet tube 7 and the air outlet tube 8 can thereby be regarded as acoustic masses, and the cavity 4 can be regarded as an acoustic spring providing sound attenuation. The cavity 4, the air inlet tube 7 and the air outlet tube 8 thus together form a reactive silencer. Furthermore, resistive sound attenuation is provided by the body 5 of sound absorbing material within the cavity 4.

In the body 5 of sound absorbing material, a frustoconical air guiding channel 11, for guiding the air within the cavity 4 from the air inlet tube 7 to the air outlet tube 8, is formed. The air outlet tube 8 is inserted into the air guiding channel 11, such that the air outlet tube 8 forms a continuation of the air guiding channel 11, with a smooth transition between the two.

At an inlet end of the air inlet tube 7, a bell-shaped and sound permeable funnel 12 is arranged. The funnel 12 is configured for guiding air into the air inlet tube 7. A screen 13 for weather protection is in the shown embodiments mounted above the air inlet tube 7 and the funnel 12. In other embodiments, it is possible to omit the funnel and the screen, e.g. if the air vent is to be used for directing a flow of air between two rooms within a building.

Downstream of the outlet end 10 of the air outlet tube 8, an adjustable vent plate 14 is provided for distributing the air into the room of the building. The vent plate 14 comprises a sound absorbing disc 15 configured to absorb sound propagating through the air outlet tube 8. The sound absorbing disc 15 is for this purpose centred on the centre axis A and has a larger diameter than the inner diameter of the air outlet tube 8. By rotating the vent plate 14 about the centre axis A, the flow of air into the room can be adjusted. The sound absorbing disc 15 may be made of the same sound absorbing material as the body 5, or of a different sound absorbing material.

In the embodiment shown in fig. 3, the air vent 1b further comprises an elongation tube 18 that partly encloses the housing 3. In the elongation tube 18, a ring 19 of sound absorbing material is provided so that a central channel 20 is formed directly downstream of the air outlet tube 8. Air propagating through the air outlet tube 8 thus flows via the central channel 20 to the vent plate 14. The elongation tube 18 may be used to adapt the air vent 1b to various wall thicknesses, by providing the ring 19 with a suitable thickness.

The invention is of course not limited to the embodiments disclosed, but may be varied and modified within the scope of the following claims. For example, in the shown embodiments, the housing is formed of a cylindrical tube sharing a common centre axis with the air inlet tube and the air outlet tube. However, the housing may have another cross-sectional shape, e.g. square, rectangular or oval. Furthermore, the air inlet tube and the air outlet tube, which preferably shares a common centre axis, do not need to have the centre axis in common with a centre axis of the housing.

CLAIMS

1. An air vent (1a, 1b) for installation in a wall (2) of a building for directing a flow of air into a room of the building, the air vent (1a, 1b) comprising:

- a housing (3) defining a cavity (4), wherein a sound absorbing material is arranged within the cavity (4);
- an air inlet tube (7) for guiding air into the cavity (4);
- an air outlet tube (8) for guiding air out of the cavity (4);

wherein each of a volume of the air inlet tube (7) and a volume of the air outlet tube (8) are smaller than a volume of the cavity (4), and **wherein** the cavity (4) has a larger cross-sectional area than each of the air inlet tube (7) and the air outlet tube (8), such that the cavity (4) together with the air inlet tube (7) and the air outlet tube (8) form a reactive silencer.

2. An air vent according to claim 1, wherein the cavity (4) has a minimum cross-sectional area A1 and the inlet tube (7) has a minimum cross-sectional A2, and wherein A1>4A2.

3. An air vent according to claim 1 or 2, wherein the cavity (4) has a minimum cross-sectional area A1 and the outlet tube (8) has a minimum cross-sectional A3, and wherein A1>4A3.

4. An air vent according to any one of claims 1-3, wherein the air vent defines reactive silencer in the frequency range 90-850Hz.

5. An air vent according to any one of claims 1-4, wherein a reactive silencer is a silencer in which reactive attenuation of sound is an attenuation in which a part of the incident sound power towards an entrance of the air inlet tube (7) of the silencer is reflected back towards a sound source as a result of a modification of the acoustic impedance at the entrance of the air inlet tube (7) of the silencer, which is dependent on the ratio of the cross-sectional area A1 of the cavity (4) to the cross-sectional area A2 of the inlet tube (7) and the ratio of the cross-sectional

area A1 of the cavity (4) to the cross-sectional area A3 of the outlet tube (8).

6. An air vent according to any one of claims 1-5, wherein the minimum cross-sectional area A1 of the air inlet tube (7) is 50 mm.

7. The air vent according to claim any one of claims 1-6, wherein the air vent (1a, 1b) comprises an air guiding channel (11) for guiding the air within the cavity (4) in a direction of flow (D) from the air inlet tube (7) to the air outlet tube (8), wherein the air guiding channel (11) has a sound permeable outer wall.

8. The air vent according to claim 7, wherein the cavity (4) is filled with the sound absorbing material, and wherein the air guiding channel (11) is formed in the sound absorbing material.

9. The air vent according to claim 7 or 8, wherein the air guiding channel (11) has a frustoconical shape with a growing cross-sectional area in the direction of flow (D).

10. The air vent according to claim 9, wherein the air outlet tube (8) has a frustoconical shape with a growing cross-sectional area in the direction of flow (D).

11. The air vent according to any one of the preceding claims, wherein the air outlet tube (8) is inserted into the cavity (4).

12. The air vent according to any one of the preceding claims, wherein the air inlet tube (7) has a smaller cross-sectional area than the air outlet tube (8).

13. The air vent according to any one of the preceding claims, wherein the air vent (1a, 1b) further comprises a funnel (12) arranged at an inlet end of the air inlet tube (7), wherein the funnel (12) is configured for guiding air into the air inlet tube (7).

14. The air vent according to claim 13, wherein the funnel (7) is bell-shaped.

15. The air vent according to any one of the preceding claims, wherein the air vent (1a, 1b) further comprises an adjustable vent plate (14) configured to be arranged downstream of the air outlet tube (8), wherein the vent plate (14) comprises a sound absorbing disc (15) configured to absorb sound propagating through the air outlet tube (8).

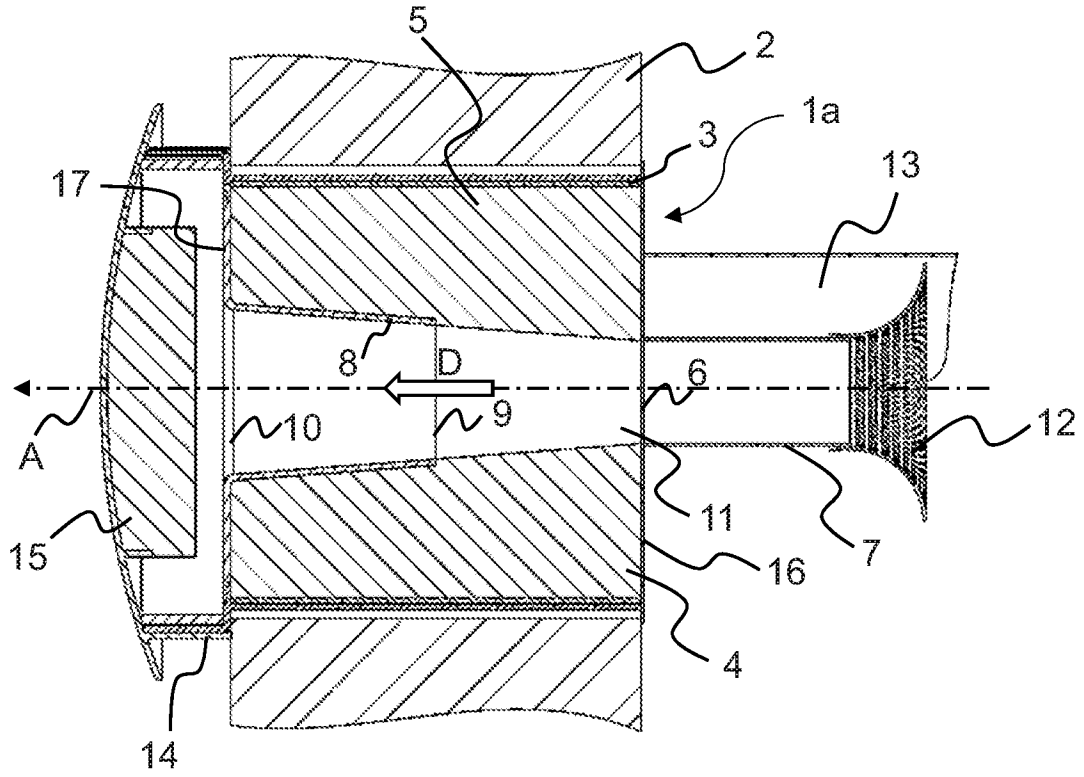
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Fig. 1

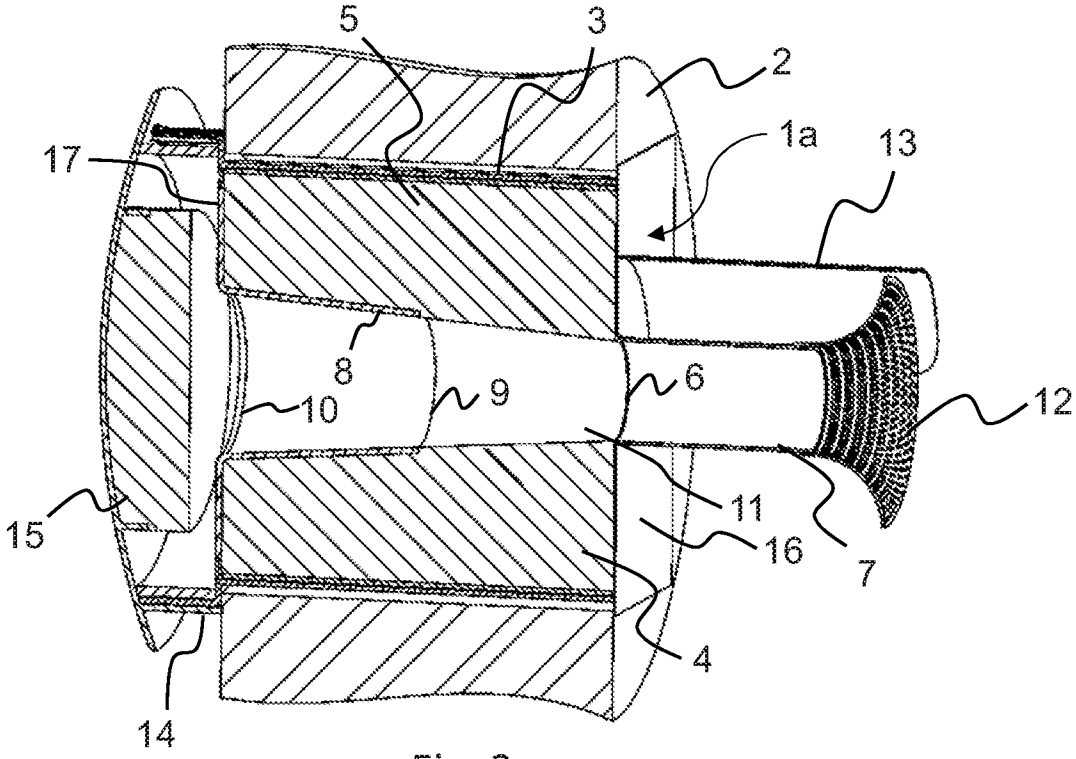
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Fig. 2

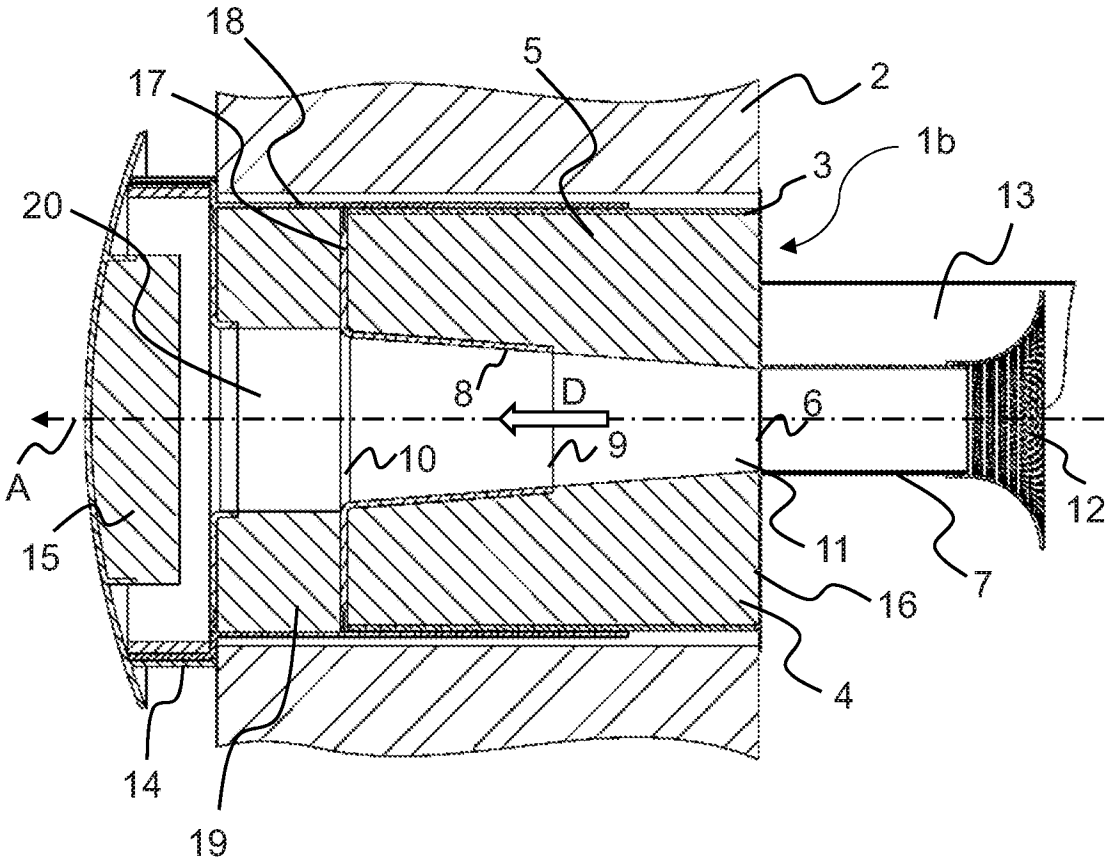

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2019/050069

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F16L, F24F, G10K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2007322043 A (MATSUSHITA ELECTRIC IND CO LTD), 13 December 2007 (2007-12-13); paragraphs [0002], [0008], [0015]; figure 1; See English machine translation.	1, 4-8, 11-12
Y		15
A		2-3, 9-10, 13-14
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X	WO 2009071963 A1 (EUR EX S R L ET AL), 11 June 2009 (2009-06-11); abstract; page 1, line 6 - line 8; page 2, line 15 - line 18; page 5, line 8 - line 27; figure 2; claim 5	1, 4-8, 11-12
A		2-3, 9-10, 13-15
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09-04-2019	10-04-2019
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2019/050069

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3507354 A (DIECKMANN JOHN J ET AL), 21 April 1970 (1970-04-21); column 1, line 12 - line 18; column 3, line 33 - line 35; column 4, line 21 - line 29; figure 5	1, 4-8, 11-12
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International application No.
PCT/SE2019/050069

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International Patent Classification (IPC)

F24F 13/24 (2006.01)
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G10K 11/16 (2006.01)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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