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(54) **A SILENCER FOR AN AIR FLOW GENERATOR**

EIN SCHALLDÄMPFER FÜR EINEN LUFTSTROMGENERATOR

AMORTISSEUR DE BRUIT POUR GENERATEUR D'ECOULEMENT D'AIR

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**WO-A-97/13443 DE-U- 7 514 249**  
**US-A- 4 280 245 US-A- 5 353 469**  
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- **PATENT ABSTRACTS OF JAPAN vol. 017, no. 349 (C-1078), 2 July 1993 (1993-07-02) -& JP 05 049561 A (MATSUSHITA ELECTRIC IND CO LTD), 2 March 1993 (1993-03-02)**
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**EP 1 266 501 B1**

## Description

**[0001]** The present invention relates to a silencer according to the preamble of claim 1, comprising a motor housing that delimits a volume which extends at least radially around the air flow generator, said housing having a wall member extending in a generally axial direction and that is provided with at least one air inlet flow passage and at least one air outlet flow passage. The invention further relates to a method of reducing noise emission according to the preamble of claim 10.

**[0002]** WO-A-97/13443 discloses a silencer for a vacuum cleaner of the above mentioned kind where the air flow generator is enclosed in a housing with an air inlet and an air outlet. The housing and the outlet is provided with sound absorbing foamed plastics material. By this solution, a good noise reduction and a compact silencer is obtained by providing sound insulation material in the housing volume and at the outlet flow passages. Although this solution offers a good damping of the noise emission, this silencer comprises many different components and it is therefore somewhat troublesome to assemble and consequently relatively expensive to manufacture.

**[0003]** Another solution to the noise reduction problem is known from EP-A-0 099 466, in which a vacuum cleaner is disclosed. This vacuum cleaner is provided with sound absorbing foam material around the motor housing and around the inlet and outlet passages that are lined with sound absorbing material. The outlet passages in this vacuum cleaner are designed with several changes in cross-section areas and with bends in order to provide changes in the acoustical properties that lead to reflections of the noise. The vacuum cleaner is moreover with a damper in front of the air inlet. Although this solution can provide an additional silencing effect, it is relatively extensive in dimensions and complex in design making it cumbersome and relatively expensive to manufacture.

**[0004]** Other kinds of vacuum cleaners with noise reduction means are known from EP-A-0 382 926, US-A-4,280,245 and US-A-5,353,469.

**[0005]** It is the object of the invention to provide a silencer for reducing the noise emission from an air flow generator that is simple to manufacture and having compact structure so as to allow for a compact design of the device in which the air flow generator is installed.

**[0006]** This object is achieved by a silencer according to the initially mentioned kind, wherein at least one of said flow passages includes at least one folded elongated flow channel that is integrally formed in the wall member of the motor housing.

**[0007]** By a silencer according to the invention, it is realised that the noise emission from air flow generators can be controlled by creating a relatively large volume around the air flow generator where this volume communicates with the outside through a long slim air flow channel. This principle of noise reduction is obtained by

applying the principle of a Helmholtz resonator. According to this principle, the system acts as a damping system where the air of the volume acts as a spring and the air in the channel as a mass. In principle the length and cross-section area of the channel and the size of the volume of the housing can be chosen in accordance with the actual noise reduction requirements.

**[0008]** By the present invention, noise at frequencies somewhat above the resonance frequency of the system is reduced without the use of sound absorbing foam material. It is no longer advantageous to reduce the volume of the motor housing in order to have a closely fitting sound absorption and/or to fill it with sound absorbing materials.

**[0009]** The resonance frequency of the system is lowered by providing a relatively large volume of the housing comprising a relatively long and narrow channel. By the invention it is realised that a plane wave condition is of preference. The plane wave condition can be obtained in the channel by the provision of ribs that are dividing the channel into a plurality of channels with smaller cross section dimensions. Moreover, by the invention contrary to the designs of the prior art silencers it is of preference to provide the channels with substantially the same opening through the system in order to keep the air velocity constant and hence the pressure loss low.

**[0010]** By "folding" or bending the channel, a relatively long and compact channel is provided compared to the volume of the housing. This allows for a compact design of the silencer by integrating it into the motor housing. This in turn means that a compact design of the appliance in which the silencer is to be used can be obtained; just as an efficient means of noise reduction is obtainable having the same or even a superior silencing effect compared to the silencers known in the art. Moreover, a silencer according to the invention, a relatively simple structure is obtained that is easy and inexpensive to manufacture.

**[0011]** In the preferred embodiment of the invention, the elongated flow channel exhibits successive duct portions with altering flow directions, and air flow bending portions between said portions. This allows for a particular compact arrangement of the channel in the wall member and a compact design of the housing.

**[0012]** In a preferred embodiment of the invention, the successive duct portions have a gradual increase in radial position in the motor housing. Hereby, a particular long yet compact channel is created by arranging the duct portions in annular or semi-annular configurations outside each other.

**[0013]** In the preferred embodiment of the invention, the air flow bending portions is a 180° bend including an end wall that is generally orthogonal to the flow directions of two successive duct portions and that a connecting passage is provided between the two successive duct portions. Hereby a further noise reducing effect is obtained, since a wave of noise coming towards

the end wall of the bend is reflected back into the duct portion. This can produce an interfering wave diminishing the noise transmitted into the successive duct portion. In particular it is found that when the height of the opening passage in the bend is four times the wave length of the sound wave in the duct, this additional noise reducing effect is particularly significant. Thus, contrary to the teaching in the prior art, by the invention it is realised that sharp bends in air flow passages do not necessarily result in a noise increase and pressure loss providing that the air velocity is kept low.

**[0014]** In a preferred embodiment, the wall member of the motor housing comprises a number of concentric shells with annular or semi-annular interior spaces between said shells defining the ducts. Hereby, a particularly simple design of the housing is provided which is easy and inexpensive to manufacture since all the components can be produced by injection moulding.

**[0015]** In a particularly simple structure of the housing in a silencer according to the invention, each of the duct portions is having an annular-shaped cross-section. Hereby, the housing can be formed by the use of concentric cylindrical wall member components that can easily be produced e.g. in a plastic material by injection moulding.

**[0016]** In the preferred embodiment of the invention, the at least one flow channel constitutes the air outlet flow passage of the housing. For use in a vacuum cleaner, the silencer is required at the outlet. However, it is realised that the invention could be used for other purposes such as a hair dryer, a cooker hood or other appliances making use of air flow generation.

**[0017]** In another preferred embodiment of the invention, the air outlet flow passage is provided with a filter upstream the flow channel at the beginning of the outlet passage. Hereby, particles are removed from the air before the air is fed through the narrow duct portions of the outlet channel, so that the risk of clogging or otherwise disturbing the air flow is eliminated. The filter will also have a sound absorbing effect.

**[0018]** The invention is in the following described in more detail with reference to the accompanying drawings, in which

- fig. 1 shows a schematical, principle view explaining the general principle of the noise reduction in a silencer according to the invention by applying the principle of a Helmholtz resonator
- fig. 2 is a graphic representation of the noise reduction characteristics of such resonator,
- fig. 3 is a schematic representation of a silencer according to the invention, and
- fig. 3a is a detail thereof, and
- fig. 4 is a cross section view of an embodiment of a silencer according to the invention.

**[0019]** By a silencer according to the invention, the principle of a Helmholtz resonator is used for silencing

an air flow generator consisting of a motor with a blower in a vacuum cleaner. In figure 1, the housing 1 defines a volume V around the air flow generator 2. The air flow generator comprises a motor 2a and a blower 2b. An air inlet 4 and an air outlet 3 is provided in the housing. At the inlet a vacuum is created and utility air, such as air for cooling the motor, is sucked in through the inlet and through the air flow generator 2 and into the volume V. This constant air flow of a relatively high speed creates noise in the housing volume V. The air exits the housing chamber through the outlet 3.

**[0020]** The air exits the volume V through a long and narrow outlet channel 3. Hereby, a damping system is created exhibiting a noise reducing effect. In this arrangement, the air inside the volume V acts as a spring and the volume of air M in the channel 3 acts as a mass in the damper system. In other word, the air flow generator oscillates the air in the channel 3 via the volume V. At extremely low frequencies, the oscillations of the air flow generator and those of the air in the channel will be the same. About the resonance frequency the oscillations of the air in the channel will be profoundly enhanced. Somewhat above the resonance frequency the oscillations of the air in the channel 3 will be much less than those of the air flow generator. When the volume V is relatively large, and the channel is long and narrow the resonance frequency is relatively low. This means that the transmission loss is positive and relatively high fore the most frequencies, such as shown graphically in figure 2.

**[0021]** By the invention, this silencing principle is adapted for use as a silencer in a vacuum cleaner, such as shown in a principle view in fig. 3. The channel 3 is bend or folded around the wall of the housing 1 whereby the same effect is obtained with regard to the long, narrow channel 3. The channel or channels 3 comprise a successive duct portions 3a and 3b that communicates with each other through a bend portion 3c of the channel (s) 3. In the bend 3c, the flow direction is reversed. The duct portions 3a, 3b are created by providing the housing 1 with a wall member having a multiple wall structure with wall sections 1a, 1b, 1c and an end wall section 1d.

**[0022]** In a preferred embodiment, the wall structure of the housing 1 is made of cylindrical shells 1a, 1b, 1c that are different in diameter and arranged concentric around the air flow generator 2.

**[0023]** By folding or bending the duct channel 3, a further effect may be obtained. As it appears from figure 3a, an opening with a height h is created between the end of the "inner" wall member 1b and the end wall 1d. An incoming wave I (i.e. noise) in air flow in the first duct portion 3a is reflected by the end wall 1d back into the duct 3a, such as shown by the arrow R. This results in an interference with the incoming wave I and a reduction in the noise transmitted (the transmitted wave T) to the following duct portion 3b is obtained. It is realised that this phenomenon is particular advantageous when the wave length of the noise is four times the height h.

**[0024]** In figure 4 is shown an air flow generator installation for a vacuum cleaner having a silencer according to the invention. The channel 3 is formed in the wall structure 1a, 1b, 1c of the housing 1. The channel 3 has in this embodiment a serpentine-like shape in a radial cross section view. The channel 3 in this embodiment is formed by three concentric shells 1a, 1b, 1c defining the interior duct passages 3a and 3b. The shells 1a-1c are formed in such a way that flow communication passages at the bends 3c are formed. The duct portions 3a and 3b are in this embodiment annular in shape with an increase in diameter for each subsequent duct portion 3b. In the embodiment shown, three shells are present whereby two duct portions are created. However, if appropriate any number of shells can be used, e.g. to provide a longer channel.

**[0025]** In principle, the channel 3 should be as narrow as possible. However, it is realised that the velocity of the air flow in the duct portions must not be increased too much, as this would create noise in itself. Furthermore, the capacity of the channel 3 must be sufficient for the required amount of air to flow through.

**[0026]** As can be seen in figure 4, the air is sucked into the air flow generator 2 through the air intake 4. The air flows through the air flow generator 2 and from there through a filter 6 and into another part of the volume V; and from there out through the silencer including the outlet channel 3.

**[0027]** In other embodiment of the invention the duct portions 3a, 3b are not annular in shape but rather semi-circular. More general, it is by the invention realised that several designs of the outlet channel geometry can be created without departing from the scope of the invention as defined in the accompanying claims.

## Claims

1. A silencer for reducing noise emission from an air flow generator (2) comprising a motor operating a blower, said silencer comprising a motor housing (1) that delimits a volume (V) which extends at least radially around the air flow generator (2), said housing (1) having a wall structure (1a-1d) extending in a generally axial direction and that is provided with at least one air inlet flow passage (4) and at least one air outlet flow passage (3), at least one of said flow passages includes at least one bend, elongated flow channel (3) that is integrally formed in the wall structure (1a, 1b, 1c) of the motor housing (1) and exhibits successive duct portions (3a, 3b) with altering flow directions, and air flow bending portions (3c) between said portions (3a, 3b),  
**characterised in that**  
the air flow bending portions (3c) include an end wall (1d) having non-sound-absorbing properties.

2. A silencer according to claim 1, wherein the succes-

sive duct portions (3a, 3b) have a gradual increase in radial position in the motor housing (1).

3. A silencer according to claim 2, wherein the air flow bending portions are a 180° bend including an end wall (1d) that is generally orthogonal to the flow directions (I, T) of two successive duct portions (3a, 3b) and wherein a connecting passage (3c) is provided between the two successive duct portions (3a, 3b).
4. A silencer according to any one of the preceding claims, wherein the cross-sectional opening of the elongated flow channel (3) is substantially the same through the system so as to keep the air velocity constant.
5. A silencer according to any one of the preceding claims, wherein the wall structure (1a, 1b, 1c, 1d) of the motor housing (1) comprises a number of concentric shells comprising a plurality of ribs oriented in the flow direction.
6. A silencer according to any one of the preceding claims, wherein each of the duct portions (3a, 3b) is having an annular-shaped cross-section.
7. A silencer according to claim 1 to 5, wherein at least some of the duct portions (3a, 3b) are successively arranged in an annular configuration.
8. A silencer according to any one of the preceding claims, wherein the at least one flow channel (3) constitutes the air outlet flow passage of the housing (1).
9. A silencer according to claim 8, wherein the air outlet flow passage (3) is provided with a filter (6) upstream the flow channel (3).

## Patentansprüche

1. Schalldämpfer zum Verringern der Lärmemission aus einem Strömungsgenerator (2), umfassend einen ein Gebläse betätigenden Motor, wobei der Schalldämpfer ein Motorgehäuse (1) umfaßt, das ein Volumen (V) begrenzt, das sich wenigstens radial um den Luftstromgenerator (2) erstreckt, wobei das Gehäuse (1) einen Wandungsaufbau (1a-1d) hat, der sich in einer allgemein axialen Richtung erstreckt und mit mindestens einem Lufteintritts-Strömungsdurchgang (4) und wenigstens einem Luftaustritts-Strömungsdurchgang (3) versehen ist, wenigstens einer der Strömungsdurchgänge mindestens einen gekrümmten, langgestreckten Strömungskanal (3) einschließt, der integral in der Wandungsstruktur (1a, 1b, 1c) des Motorgehäuses (1)

ausgebildet ist und aufeinanderfolgende Leitungsteile (3a, 3b) mit wechselnden Strömungsrichtungen sowie Luftströmungs-Krümmungsteile (3c) zwischen den Teilen (3a, 3b) aufweist,

**dadurch gekennzeichnet, daß**

die Luftströmungs-Krümmungsteile (3c) eine Endwand (1d) mit nicht-schallabsorbierenden Eigenschaften einschließen.

2. Schalldämpfer nach Anspruch 1, bei dem die aufeinanderfolgenden Leitungsteile (3a, 3b) eine allmähliche Zunahme in radialer Position in dem Motorgehäuse (1) aufweisen. 10
3. Schalldämpfer nach Anspruch 2, bei dem die Luftströmungs-Krümmungsteile eine 180° Krümmung darstellen, die eine Endwand (1d) einschließt, die allgemein orthogonal zu den Strömungsrichtungen (I, T) zweier aufeinanderfolgender Leitungsteile (3a, 3b) ist, und wobei ein Verbindungsdurchgang (3c) zwischen den beiden aufeinanderfolgenden Leitungsteilen (3a, 3b) vorgesehen ist. 15 20
4. Schalldämpfer nach einem der vorhergehenden Ansprüche, bei dem die Querschnittsöffnung des langgestreckten Strömungskanals (3) durch das System im wesentlichen die gleiche ist, um die Luftgeschwindigkeit konstant zu halten. 25
5. Schalldämpfer nach einem der vorhergehenden Ansprüche, bei dem die Wandungsstruktur (1a, 1b, 1c, 1d) des Motorgehäuses (1) eine Anzahl konzentrischer Schalen umfaßt, die eine Mehrzahl Rippen, in Strömungsrichtung ausgerichtet, umfassen. 30 35
6. Schalldämpfer nach einem der vorhergehenden Ansprüche, bei dem jeder der Leitungsteile (3a, 3b) einen ringförmigen Querschnitt aufweist.
7. Schalldämpfer nach Anspruch 1 bis 5, bei dem wenigstens einige der Leitungsteile (3a, 3b) aufeinanderfolgend in ringförmiger Ausbildung angeordnet sind. 40
8. Schalldämpfer nach einem der vorhergehenden Ansprüche, wobei der wenigstens eine Strömungskanal (3) den Luftauslaß-Strömungsdurchtritt des Gehäuses (1) bildet. 45
9. Schalldämpfer nach Anspruch 8, bei dem der Luftauslaß-Strömungsdurchtritt (3) mit einem Filter (6) stromaufwärts des Strömungskanals (3) versehen ist. 50

## Revendications

1. Amortisseur de bruit pour réduire les émissions so-

nores provenant d'un générateur d'écoulement d'air (2) comprenant un moteur actionnant une soufflante, ledit amortisseur de bruit comprenant un logement de moteur (1) qui délimite un volume (V) qui s'étend au moins radialement autour du générateur d'écoulement d'air (2), ledit logement (1) présentant une structure de paroi (1a-1d) s'étendant dans une direction généralement axiale et qui est muni d'au moins un passage d'écoulement d'entrée d'air (4) et d'au moins un passage d'écoulement de sortie d'air (3), au moins l'un desdits passages d'écoulement comprend au moins une courbure, un canal d'écoulement allongé (3) qui est formé solidairement dans la structure de paroi (1a, 1b, 1c) du logement de moteur (1) et présente des portions de gaine successives (3a, 3b) avec des directions d'écoulement variables, et des portions de courbure d'écoulement d'air (3c) entre lesdites portions (3a, 3b),

**caractérisé en ce que**

les portions de courbure d'écoulement d'air (3c) comprennent une paroi d'extrémité (1d) présentant des propriétés de non-absorption sonore.

2. Amortisseur de bruit selon la revendication 1, **caractérisé en ce que** les portions de gaine successives (3a, 3b) présentent une augmentation progressive dans la position radiale dans le logement moteur (1). 25
3. Amortisseur de bruit selon la revendication 2, dans lequel les portions de courbure d'écoulement d'air consistent en une courbure de 180° incorporant une paroi d'extrémité (1d) qui est généralement orthogonale aux directions d'écoulement (I, T) de deux portions de gaine successives (3a, 3b) et dans lequel un passage de raccordement (3c) est disposé entre les deux portions de gaine successives (3a, 3b). 30 35
4. Amortisseur de bruit selon l'une quelconque des revendications précédentes, dans lequel l'ouverture en section transversale du canal à écoulement allongé (3) est sensiblement le même dans tout le système de façon à maintenir la vitesse d'air constante. 40
5. Amortisseur de bruit selon l'une quelconque des revendications précédentes, dans lequel la structure de paroi (1a, 1b, 1c, 1d) du logement de moteur (1) comprend un certain nombre de coques concentriques comprenant une pluralité de nervures orientées dans la direction d'écoulement 45
6. Amortisseur de bruit selon l'une quelconque des revendications précédentes, dans lequel chacune des portions de gaine (3a, 3b) comporte une section transversale de forme annulaire. 50

7. Amortisseur de bruit selon la revendication 1 à 5, dans lequel au moins une partie des portions de gaine (3a, 3b) est disposée successivement en une configuration annulaire.

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8. Amortisseur de bruit selon l'une quelconque des revendications précédentes, dans lequel le moins canal d'écoulement (3) constitue le passage d'écoulement de sortie d'air du logement (1).

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9. Amortisseur de bruit selon la revendication 8, dans lequel le passage d'écoulement de sortie d'air (3) est muni d'un filtre (6) en amont du canal d'écoulement (3).

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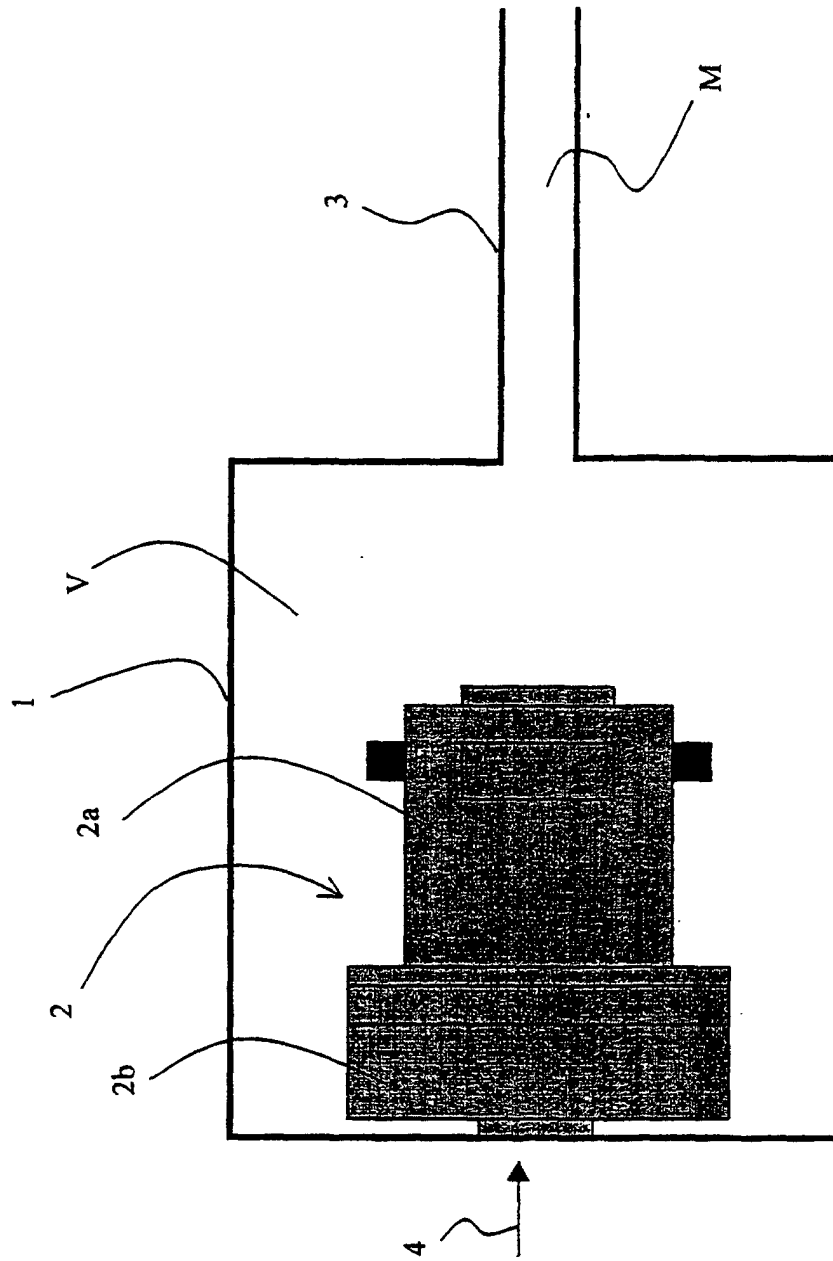
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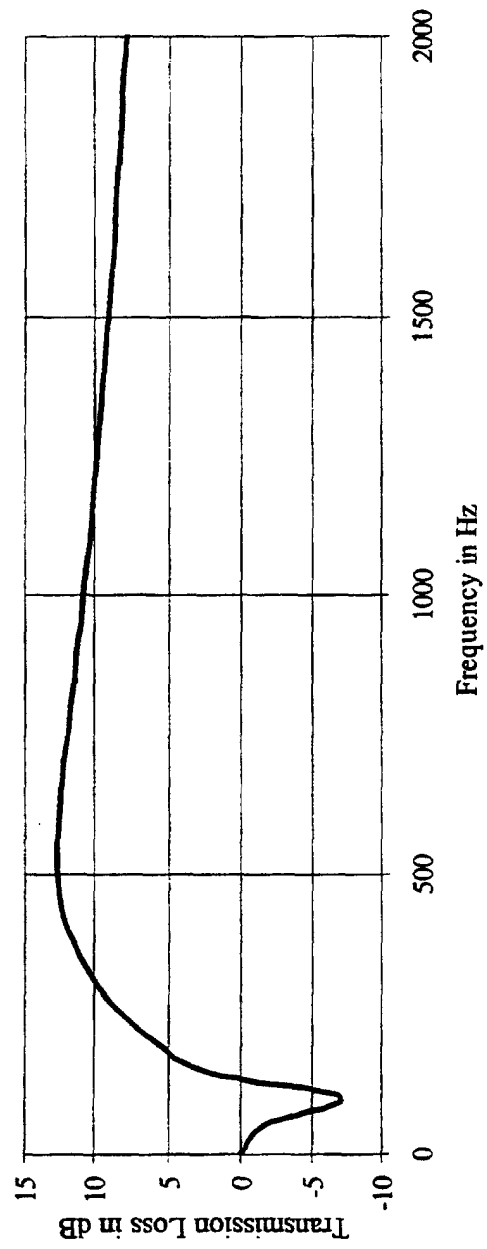
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*Fig. 1*



**Fig. 2**

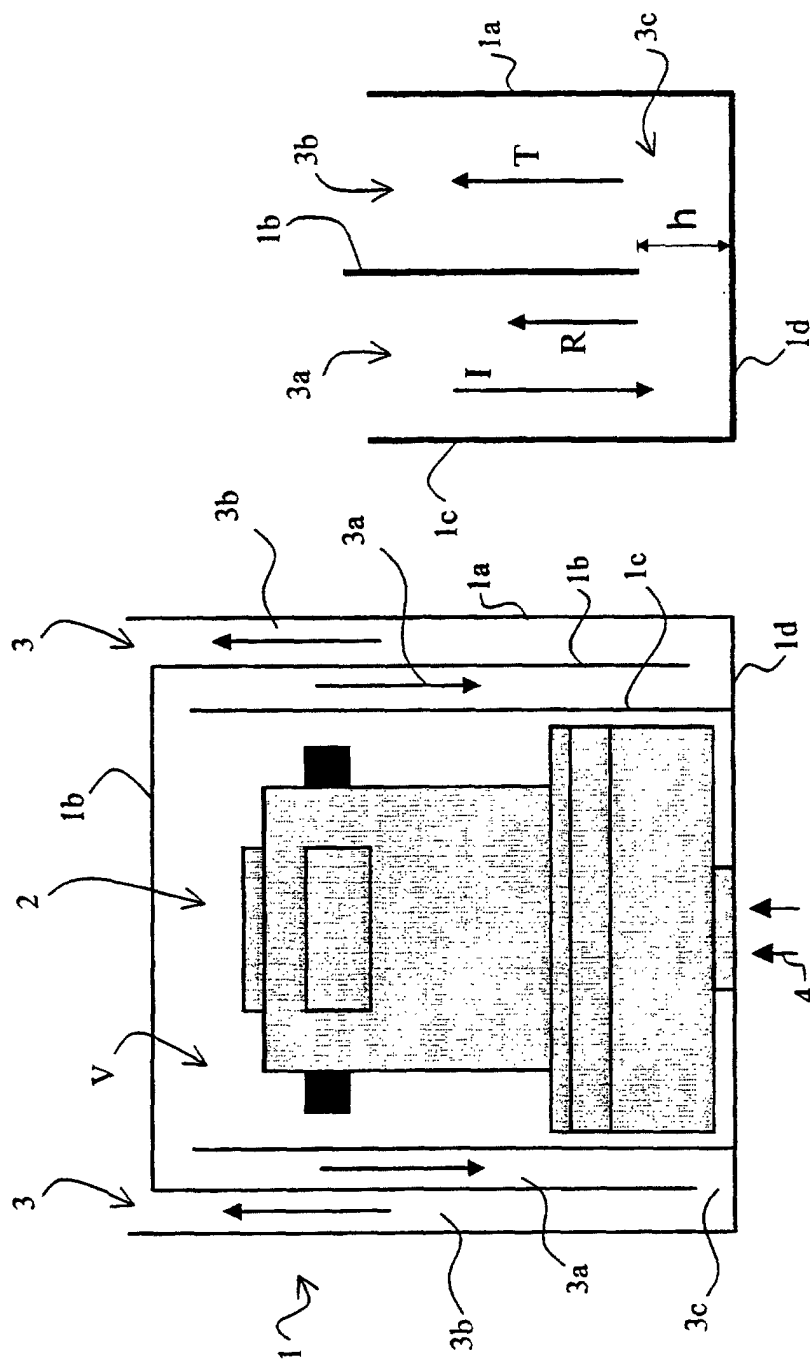


Fig. 3a

Fig. 3

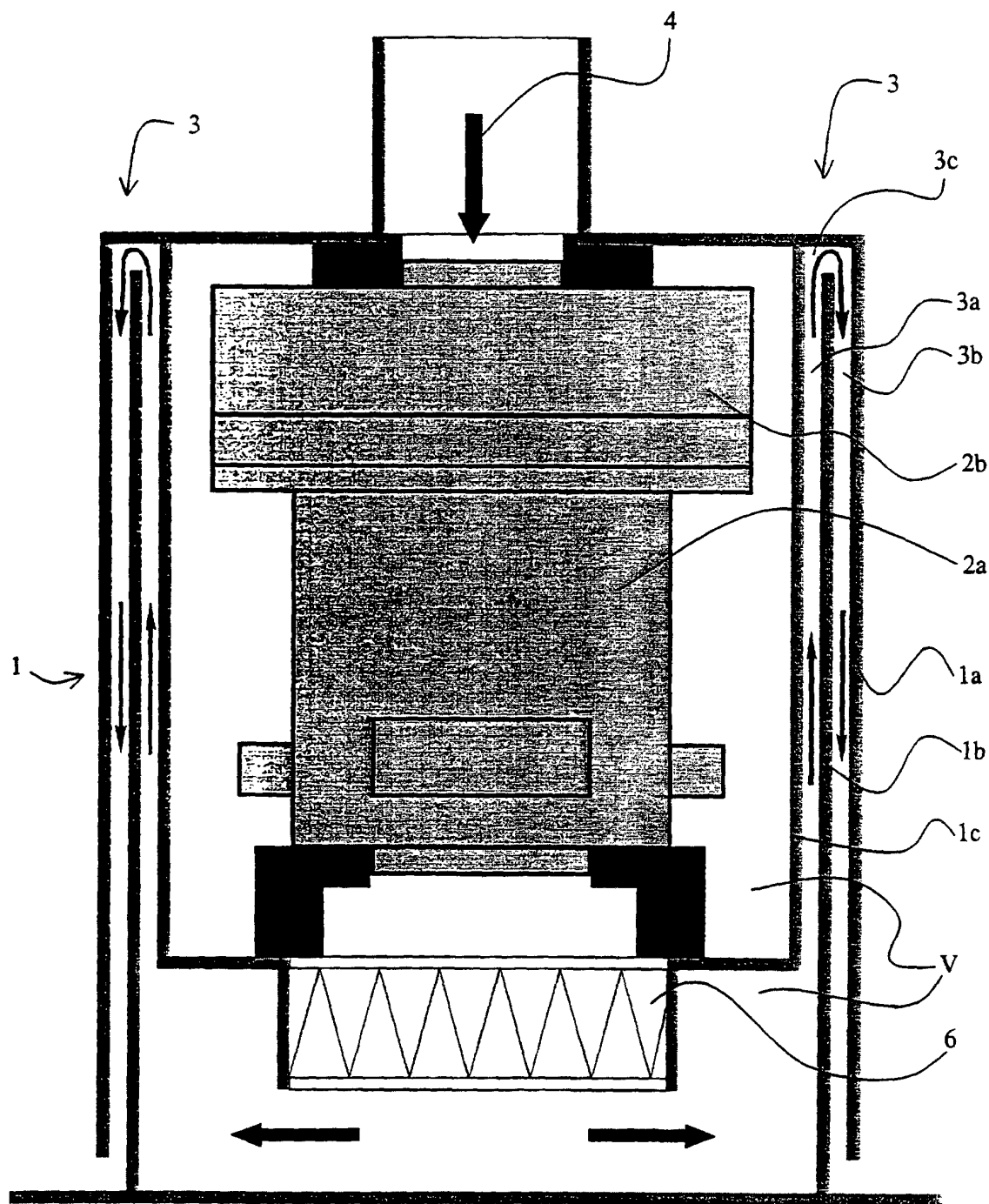


Fig. 4