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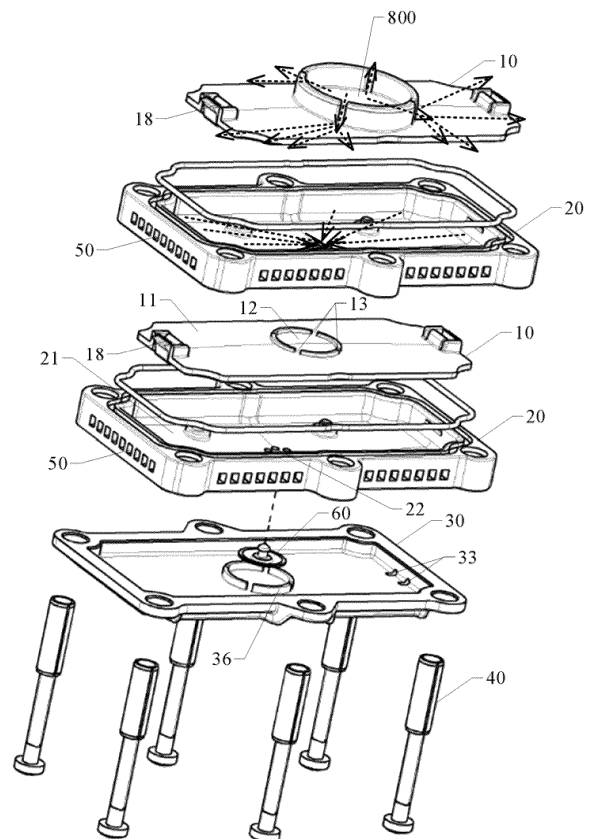
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(54) SILENCER AND ELECTRIC VACUUM PUMP

(57) The present invention relates to the technical field of silencing, and provides a silencer and an electric vacuum pump. The silencer includes: first silencing members (10) and second silencing members (20), which are alternately stacked, each first silencing member being provided with dispersed first flow guide channels, and each second silencing member being provided with gathered second flow guide channels; and an exhaust member (30) provided with an exhaust hole (33), an edge of the exhaust member being connected to an edge of each silencing member, and the silencer forming a three-dimensional maze silencing path (P) leading to the exhaust hole (33) from an intake port (800) through the alternating first flow guide channels and second flow guide channels. The silencer according to the present invention can effectively reduce the noise level by means of the three-dimensional maze silencing path. When the silencer according to the present invention is assembled to an electric vacuum pump, the NVH problem of the electric vacuum pump can be effectively solved.

**FIG. 1****EP 4 542 042 A1**

Description

Technical Field

[0001] The present invention relates to the technical field of silencing, and in particular, to a silencer and an electric vacuum pump.

Background Art

[0002] In a scenario in which aerodynamic noise needs to be reduced, silencers can be used to reduce the noise level. For example, a silencer is usually provided at an exhaust port of an electric vacuum pump of a vehicle to reduce noise.

[0003] Current silencers usually use some sound-absorbing materials to reduce noise, or are provided with some planar blocking structures to reduce noise, so that the noise reduction level is very limited, which cannot meet noise reduction requirements for devices such as electric vacuum pumps.

[0004] It should be noted that information disclosed in the above background art section is only used to enhance the understanding of the background of the present invention, and therefore may include information that does not constitute the prior art known to those of ordinary skill in the art.

Summary of the Invention

[0005] In view of this, the present invention provides a silencer, which can effectively reduce the noise level by means of a three-dimensional maze silencing path. When the silencer according to the present invention is assembled to an electric vacuum pump, the noise, vibration and harshness (NVH) problem of the electric vacuum pump can be effectively solved.

[0006] An aspect of the present invention provides a silencer, including: first silencing members and second silencing members, which are alternately stacked, each first silencing member being provided with dispersed first flow guide channels, and each second silencing member being provided with gathered second flow guide channels; and an exhaust member provided with an exhaust hole, an edge of the exhaust member being connected to an edge of each silencing member, and the silencer forming a three-dimensional maze silencing path leading to the exhaust hole from an intake port through the alternating first flow guide channels and second flow guide channels.

[0007] In some embodiments, the first flow guide channel includes: a first flow guide surface, a downstream of the first flow guide surface being distributed at the edge of the first silencing member; an intake cavity provided upstream of the first flow guide surface; and notches distributed in a side wall of the intake cavity.

[0008] In some embodiments, the second flow guide channel includes: a second flow guide surface, an up-

stream of the second flow guide surface being distributed at the edge of the second silencing member; and a vent hole provided downstream of the second flow guide surface and aligned with the adjacent intake cavity.

[0009] In some embodiments, the edge of each second silencing member is provided with a first flange; and the edge of each first silencing member is in clearance fit with a corresponding first flange, the edge of the exhaust member is in sealing fit with a corresponding first flange, and the first flanges are in sealing fit with each other.

[0010] In some embodiments, the edge of each first silencing member is connected to the corresponding first flange via a snap-fit member, the edge of the exhaust member is connected to the corresponding first flange via a guide pin, and the first flanges are connected to each other via the guide pin.

[0011] In some embodiments, the first silencing member is made of a porous material, and the first flow guide channel includes pores dispersed in the porous material; and the second flow guide channel includes pores provided in a central area or a corner area of the second silencing member in a centralized manner.

[0012] In some embodiments, the edge of one of the second silencing members is provided with a second flange; and the edge of the first silencing member abuts against the second flange, and the edge of the exhaust member is hermetically connected to the second flange.

[0013] In some embodiments, the silencer further includes: a reinforcing rib arranged at an outer wall of a flange.

[0014] In some embodiments, a convex rib is arranged on a path of the exhaust member leading to the exhaust hole.

[0015] In some embodiments, the silencer further includes: a check valve arranged in the exhaust hole or in a second flow guide channel adjacent to the exhaust hole.

[0016] Another aspect of the present invention provides an electric vacuum pump, which is equipped with a silencer according to any of the above embodiments, wherein an intake port of the silencer is in communication with an exhaust port of the electric vacuum pump.

[0017] Compared with the prior art, the present invention has at least the following beneficial effects.

[0018] In the silencer according to the present invention, the first silencing members and the second silencing members are alternately stacked, each first silencing member is provided with dispersed first flow guide channels, and each second silencing member is provided with gathered second flow guide channels, so that the three-dimensional maze silencing path for alternately dispersing and gathering a gas is formed, which not only effectively reduces the pressure and noise of the gas, but also effectively guides the gas to achieve shock absorption and noise reduction.

[0019] When the silencer according to the present invention is assembled to an electric vacuum pump, it has been tested that the noise level of the electric vacuum pump can be reduced to 70 db or below, thereby effec-

tively solving the NVH problem of the electric vacuum pump.

[0020] It should be understood that the above general description and the following detailed description are only exemplary and explanatory, and cannot limit the present invention.

Brief Description of the Drawings

[0021] The accompanying drawings herein, which are incorporated into and constitute a part of this description, illustrate embodiments consistent with the present invention and, together with the description, are used to explain principles of the present invention. Obviously, the accompanying drawings described below show merely some of the embodiments of the present invention, and those of ordinary skill in the art would also have obtained other accompanying drawings according to these accompanying drawings without any creative effort.

FIG. 1 is a schematic structural diagram of a silencer according to an embodiment of the present invention;

Fig. 2 is a schematic diagram of a silencing path of the silencer shown in FIG. 1;

FIG. 3 is a schematic structural diagram of another silencer according to an embodiment of the present invention; and

FIG. 4 is a schematic diagram of a silencing path of the silencer shown in FIG. 3.

Detailed Description of Embodiments

[0022] Now exemplary implementations will be described more fully with reference to the accompanying drawings. However, the exemplary implementations can be implemented in many forms and should not be construed as being limited to the implementations set forth herein. On the contrary, these implementations are provided to make the present invention thorough and complete, and to fully convey the concept of the exemplary implementations to those skilled in the art.

[0023] The accompanying drawings are only schematic illustrations of the present invention, and are not necessarily drawn to scale. In the accompanying drawings, the same reference signs denote the same or similar parts, and thus the repeated description thereof will be omitted.

[0024] The terms "first", "second" and similar terms used in the specific description do not denote any order, quantity, or importance, but are merely used to distinguish between different components. Furthermore, in the description of the present invention, orientations or positional relationships indicated by the terms such as "upper" and "lower" are based on orientations or positional relationships shown in the drawings, which is only for convenience of describing the present invention and simplifying the description, rather than indicating or im-

plying that an apparatus or an element referred to must have a specific orientation or be constructed and operated in a specific orientation, and therefore cannot be construed as limiting the present invention.

[0025] It should be noted that the embodiments of the present invention and features of the various embodiments can be combined with each other without conflict.

[0026] FIG. 1 shows a structure of a silencer according to an embodiment of the present invention. FIG. 2 shows a silencing path of the silencer shown in FIG. 1. FIG. 3 shows a structure of another silencer according to an embodiment of the present invention. FIG. 4 shows a silencing path of the silencer shown in FIG. 3. With reference to FIGS. 1 to 4, a silencer according to an embodiment of the present invention includes:

first silencing members 10 and second silencing members 20, which are alternately stacked, each first silencing member 10 being provided with dispersed first flow guide channels (see the arrows marked on the first silencing members 10 in FIG. 1 and 3), and each second silencing member 20 being provided with gathered second flow guide channels (see the arrows marked on the second silencing members 20 in FIG. 1 and 3); and an exhaust member 30 provided with an exhaust hole 33. An edge of the exhaust member 30 is connected to an edge of each silencing member, and the silencer forms a three-dimensional maze silencing path P leading to the exhaust hole 33 from an intake port 800 through the alternating first flow guide channels and second flow guide channels.

[0027] In the silencer shown in FIGS. 1 and 2, the intake port 800 is formed at an inlet of each first flow guide channel of the first silencing member 10 located at the top layer. When entering a silencer cavity from the intake port 800, a gas is first dispersed and guided by the first silencing member 10 at the uppermost layer to reduce the pressure and noise, and the second silencing member 20 at a second layer is configured to gather the guided gas, so that the gas passes through corners of a three-dimensional maze formed by the first silencing member 10 at the uppermost layer and the second silencing member 20 at the second layer to increase air flow resistance and achieve a silencing effect. Then, the gas is dispersed and guided by the first silencing member 10 at a third layer to further reduce the pressure and noise, then passes through corners of a three-dimensional maze formed by the first silencing member 10 at the third layer and the second silencing member 20 at a fourth layer to enhance the silencing effect, is gathered and guided by the second silencing member 20 at the fourth layer to a chamber of the exhaust member 30, and is finally discharged through the exhaust hole 33. By the alternating first flow guide channels and second flow guide channels, the gas entering the silencer cavity can not only pass through a three-dimensional maze

detour path of dispersion, gathering, dispersion and gathering to fully reduce the pressure and noise, but can also be subjected to shock absorption and noise reduction through a flow guide effect, thereby effectively reducing the noise level to a desired range.

[0028] In the silencer shown in FIGS. 3 and 4, the intake port 800 is formed at an inlet of each second flow guide channel of the second silencing member 20 located at the top layer. When entering a silencer cavity from the intake port 800, a gas is first gathered and guided by the second silencing member 20 at the uppermost layer, is then subjected to full pressure and noise reduction under a dispersion flow guide effect of the first silencing member 10 at a second layer, and is then gathered and guided by the second silencing member 20 at a third layer, and the gas passes through a three-dimensional maze detour path in the silencer cavity through dispersion flow guides and gathering flow guides that are alternate vertically, to increase air flow resistance and reduce the pressure and noise to achieve a silencing effect. The gas then enters a chamber of the exhaust member 30 after being further subjected to pressure and noise reduction under a dispersion flow guide effect of the first silencing member 10 at a fourth layer, and is finally discharged through the exhaust hole 33. By the alternating second flow guide channels and first flow guide channels, the gas entering the silencer cavity can not only pass through the three-dimensional maze detour path of gathering, dispersion, gathering and dispersion to fully reduce the pressure and noise, but can also be subjected to shock absorption and noise reduction through a flow guide effect, thereby effectively reducing the noise level to a desired range.

[0029] It should be noted that FIGS. 1 to 4 only schematically show the structures of two types of silencers according to the embodiments of the present invention. In other embodiments, the number, stacking order, etc. of first silencing members 10 and second silencing members 20 can be adjusted according to an actual situation, and are not limited to those shown in FIGS. 1 to 4.

[0030] In the silencer according to the present invention, the first silencing members 10 and the second silencing members 20 are alternately stacked, each first silencing member 10 is provided with dispersed first flow guide channels, and each second silencing member 20 is provided with gathered second flow guide channels, so that the three-dimensional maze silencing path P for alternately dispersing and gathering a gas is formed, which not only effectively reduces the pressure and noise of the gas, but also effectively guides the gas to achieve shock absorption and noise reduction.

[0031] Referring to FIGS. 1 and 2, in some embodiments, the first flow guide channel includes: a first flow guide surface 11, a downstream of the first flow guide surface 11 being distributed at the edge of the first silencing member 10; an intake cavity 12 provided upstream of the first flow guide surface 11; and notches 13 distributed in a side wall of the intake cavity 12.

[0032] After entering the intake cavity 12, the gas is dispersed and flows out through the notches 13, is guided and silenced along the first flow guide surface 11, and enters a chamber of the adjacent second silencing member 20 from the edge of the first silencing member 10. The first flow guide surface 11 may be formed into a curved surface, a cambered surface, an inclined surface, or the like, so as to guide and silence the gas.

[0033] With continued reference to FIGS. 1 and 2, in some embodiments, the second flow guide channel includes: a second flow guide surface 21, an upstream of the second flow guide surface 21 being distributed at the edge of the second silencing member 20; and a vent hole 22 provided downstream of the second flow guide surface 21 and aligned with the adjacent intake cavity 12.

[0034] The gas may enter the chamber of the second silencing member 20 from the edge of the second silencing member 20, is guided and silenced along the second flow guide surface 21, and enters the adjacent intake cavity 12 from the vent hole 22. The second flow guide surface 21 may be formed into a curved surface, a cambered surface, an inclined surface, or the like, so as to guide and silence the gas.

[0035] With continued reference to FIGS. 1 and 2, in some embodiments, the edge of each second silencing member 20 is provided with a first flange 25. The edge of each first silencing member 10 is in clearance fit with a corresponding first flange 25. The edge of the exhaust member 30 is in sealing fit with a corresponding first flange 25, and the first flanges 25 are in sealing fit with each other.

[0036] Due to the fact that the edge of the exhaust member 30 is in sealing fit with the first flange 25, and the first flanges 25 are in sealing fit with each other, a sealed housing of the silencer is formed. The first flanges 25 may be in tight fit with each other by means of a sealing ring 26. Due to the fact that the edge of each first silencing member 10 is in clearance fit with the first flange 25, a clearance is formed for flow guide.

[0037] With continued reference to FIGS. 1 and 2, in some embodiments, the edge of each first silencing member 10 is connected to the corresponding first flange 25 via a snap-fit member 18. The edge of the exhaust member 30 is connected to the corresponding first flange 25 via a guide pin 40, and the first flanges 25 are connected to each other via the guide pin.

[0038] By means of the snap-fit member 18, the first silencing member 10 is firmly fitted with the second silencing member 20. The guide pin 40 facilitates positioning and fitting of the exhaust member 30 and the second silencing members 20.

[0039] With reference to FIGS. 3 and 4, in some embodiments, the first silencing member 10 is made of a porous material, and the first flow guide channel includes pores (not specifically shown in the figures) dispersed in the porous material. The second flow guide channel includes pores 28 provided in a central area or a corner area of the second silencing member 20 in a centralized

manner.

[0040] The first silencing member 10 may be made of sponge or another suitable porous material, so as to effectively reduce the pressure and noise of the gas.

[0041] With continued reference to FIGS. 3 and 4, in some embodiments, the edge of one of the second silencing members 20 is provided with a second flange 29. The edge of the first silencing member 10 abuts against the second flange 29, and the edge of the exhaust member 30 is hermetically connected to the second flange 29.

[0042] Due to the fact that the edge of the exhaust member 30 is hermetically connected to the second flange 29, a sealed housing of the silencer is formed. Due to the fact that the edge of the first silencing member 10 abuts against the second flange 29, full pressure and noise reduction of the gas is implemented through the pores scattered in the first silencing member 10.

[0043] Referring to FIGS. 1 and 3, in some embodiments, the silencer further includes: a reinforcing rib 50 arranged at an outer wall of a flange. Radiation noise is reduced by the reinforcing rib 50.

[0044] With reference to FIGS. 1 to 4, in some embodiments, a convex rib 36 is arranged on a path of the exhaust member 30 leading to the exhaust hole 33. By means of the convex rib 36, air flow resistance can be further increased before the gas is discharged from the silencer, to enhance the silencing effect.

[0045] With continued reference to FIGS. 1 to 4, in some embodiments, the silencer further includes: a check valve 60 arranged in the exhaust hole 33 or in a second flow guide channel adjacent to the exhaust hole 33.

[0046] By means of the check valve 60 arranged at the bottom of the silencer, the gas in the silencer is allowed to be discharged, while preventing external moisture from entering the silencer.

[0047] An embodiment of the present invention further provides an electric vacuum pump, which is equipped with a silencer described according to any of the above embodiments. An intake port 800 of the silencer is in communication with an exhaust port of the electric vacuum pump.

[0048] For the electric vacuum pump equipped with the silencer according to the present invention, it has been tested that the noise level in front of the electric vacuum pump could be reduced from the original 75.3 db to 64.7 db, and the noise level on a side of the electric vacuum pump could be reduced from the original 76.6 db to 69.8 db. In this way, the overall noise level of the electric vacuum pump can be effectively reduced to 70 db or below, thereby effectively solving the NVH problem of the electric vacuum pump.

[0049] In addition to being applied to the electric vacuum pump, the silencer according to the present invention may be applied to other pneumatic devices, which can also effectively improve the noise level.

[0050] To sum up, in the silencer according to the

present invention, the first silencing members 10 and the second silencing members 20 are alternately stacked, each first silencing member 10 is provided with dispersed first flow guide channels, and each second silencing member 20 is provided with gathered second flow guide channels, so that the three-dimensional maze silencing path P for alternately dispersing and gathering a gas is formed, which not only effectively reduces the pressure and noise of the gas, but also effectively guides the gas to achieve shock absorption and noise reduction.

[0051] The silencer according to the present invention can be provided in pneumatic devices such as an electric vacuum pump, and can effectively reduce the noise level of the pneumatic devices such as the electric vacuum pump.

[0052] The above is a further detailed description of the present invention with reference to the specific preferred implementations, and it cannot be considered that the specific implementation of the present invention is limited to these descriptions. For those of ordinary skill in the art of the present invention, several simple deductions or substitutions can be further made without departing from the concept of the present invention, and should be regarded as falling within the scope of protection of the present invention.

Claims

1. A silencer, **characterized by** comprising:

first silencing members and second silencing members, which are alternately stacked, each first silencing member being provided with dispersed first flow guide channels, and each second silencing member being provided with gathered second flow guide channels; and an exhaust member provided with an exhaust hole, an edge of the exhaust member being connected to an edge of each silencing member, and the silencer forming a three-dimensional maze silencing path leading to the exhaust hole from an intake port through the alternating first flow guide channels and second flow guide channels.

2. The silencer according to claim 1, **characterized in that** the first flow guide channel comprises:

a first flow guide surface, a downstream of the first flow guide surface being distributed at the edge of the first silencing member; an intake cavity provided upstream of the first flow guide surface; and notches distributed in a side wall of the intake cavity.

3. The silencer according to claim 2, **characterized in**

that the second flow guide channel comprises:

a second flow guide surface, an upstream of the second flow guide surface being distributed at the edge of the second silencing member; and a vent hole provided downstream of the second flow guide surface and aligned with the adjacent intake cavity.

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4. The silencer according to claim 3, **characterized in that** the edge of each second silencing member is provided with a first flange; and the edge of each first silencing member is in clearance fit with a corresponding first flange, the edge of the exhaust member is in sealing fit with a corresponding first flange, and the first flanges are in sealing fit with each other. 10 15
5. The silencer according to claim 4, **characterized in that** the edge of each first silencing member is connected to the corresponding first flange via a snap-fit member, the edge of the exhaust member is connected to the corresponding first flange via a guide pin, and the first flanges are connected to each other via the guide pin. 20 25
6. The silencer according to any of the preceding claims, **characterized in that** the first silencing member is made of a porous material, and the first flow guide channel comprises pores dispersed in the porous material; and the second flow guide channel comprises pores provided in a central area or a corner area of the second silencing member in a centralized manner. 30 35
7. The silencer according to claim 6, **characterized in that** the edge of one of the second silencing members is provided with a second flange; and the edge of the first silencing member abuts against the second flange, and the edge of the exhaust member is hermetically connected to the second flange. 40
8. The silencer according to claim 4 or 7, **characterized by** further comprising: a reinforcing rib arranged at an outer wall of a flange. 45
9. The silencer according to any of the preceding claims, **characterized in that** a convex rib is arranged on a path of the exhaust member leading to the exhaust hole. 50
10. The silencer according to any of the preceding claims, **characterized by** further comprising: a check valve arranged in the exhaust hole or in a second flow guide channel adjacent to the exhaust hole. 55

11. An electric vacuum pump, **characterized in that** it is equipped with a silencer according to any one of claims 1 to 10, wherein an intake port of the silencer is in communication with an exhaust port of the electric vacuum pump.

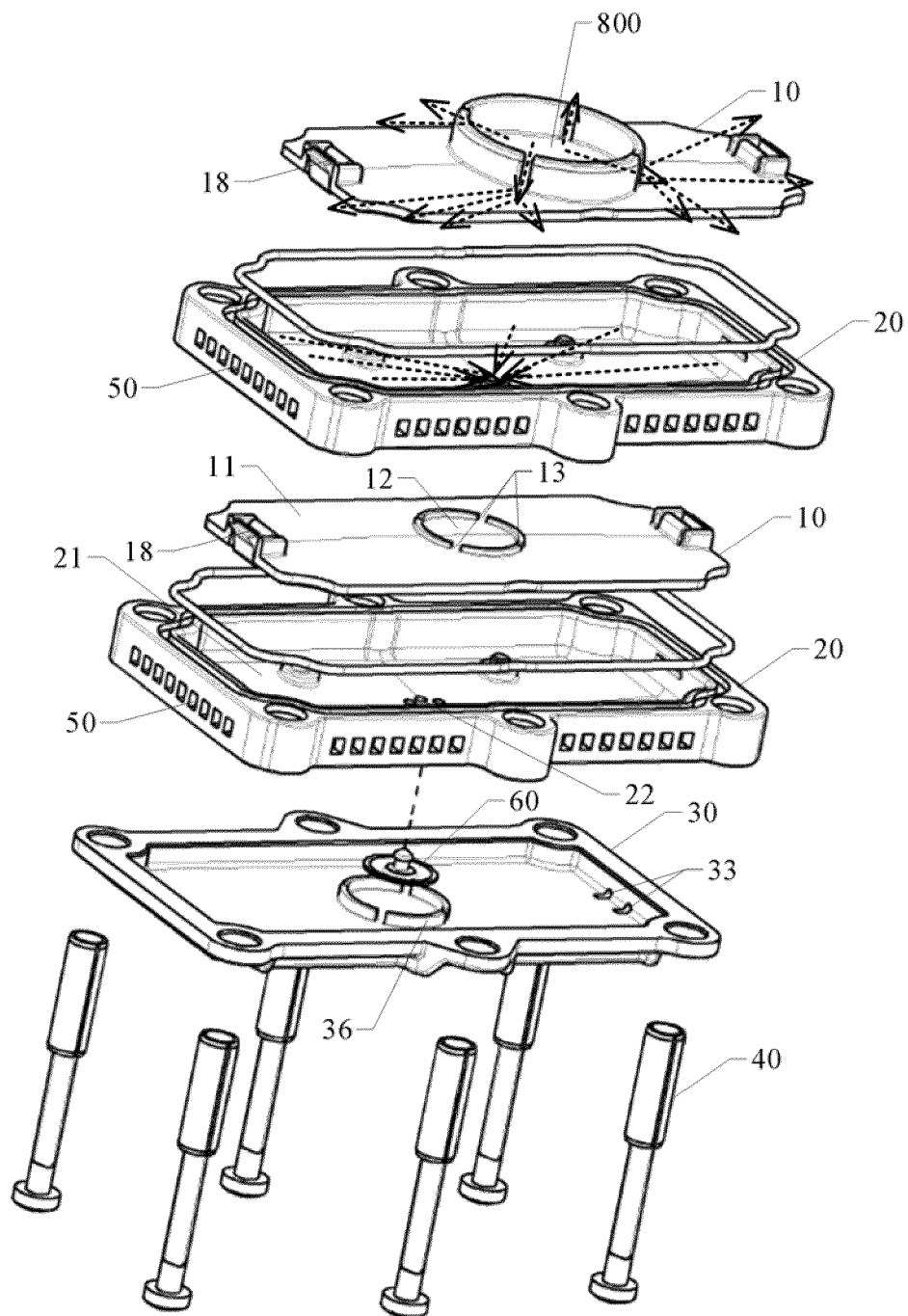


FIG. 1

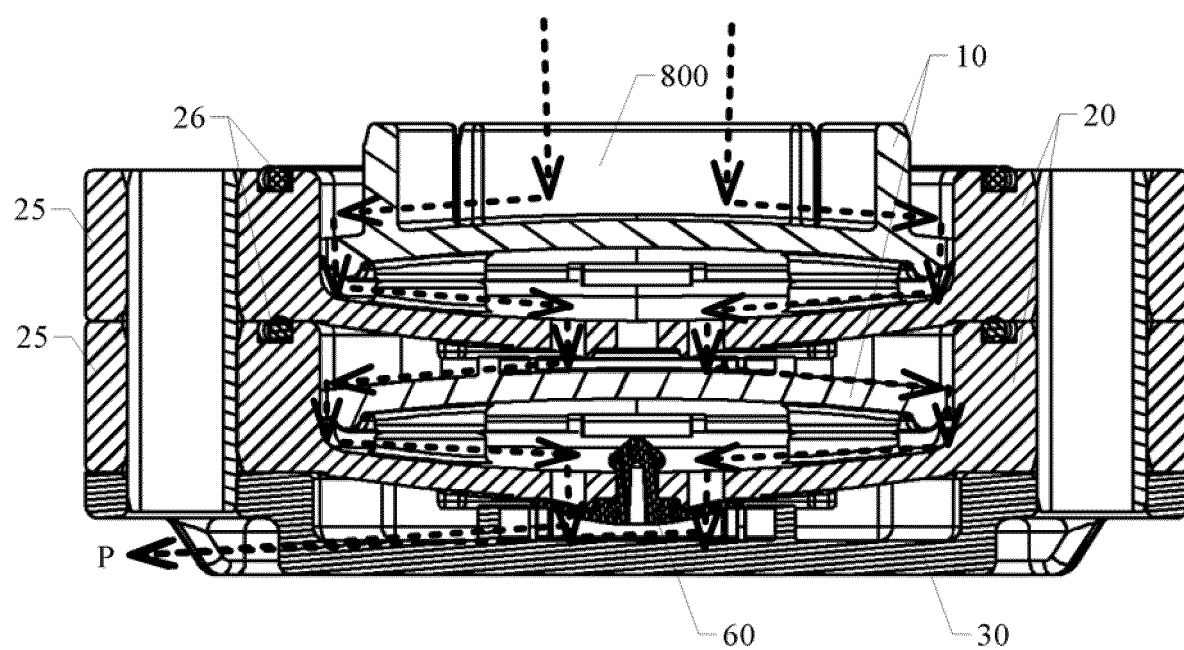


FIG. 2

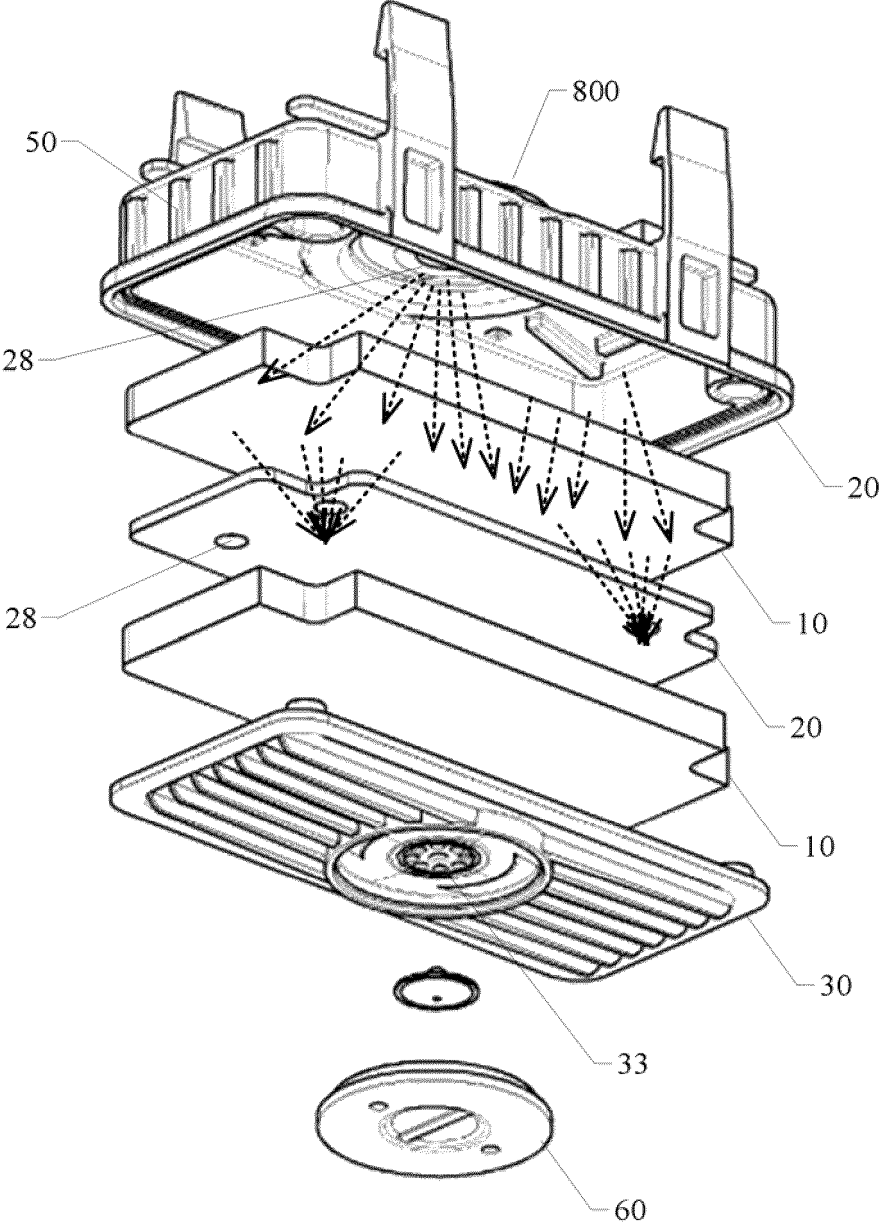


FIG. 3

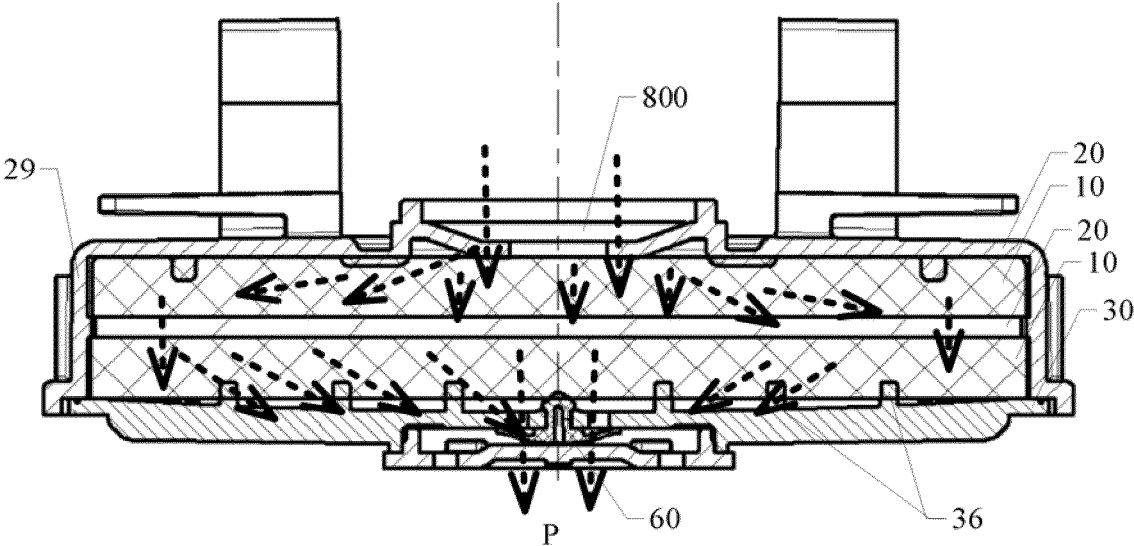


FIG. 4



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Application Number

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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
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