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(54) MUFFLER AND REFRIGERATING SYSTEM COMPRISING MUFFLER

(57) The present application provides a muffler, comprising a cylindrical housing defining an anechoic chamber, an anechoic chamber inlet and an anechoic chamber outlet that are located at two opposite axial ends of the housing, and at least one partition plate, at least one muffling pipe, and at least one liquid discharging pipe that are located in the anechoic chamber. The at least one liquid discharging pipe is provided on the at least one partition plate and extends a certain distance along the axis of the housing on at least one side of the corresponding partition plate. Each liquid discharging pipe defines a liquid discharging channel penetrating through the corresponding partition plate. Each liquid discharging pipe is arranged in close contact with the housing or is partially formed by the housing. The position of the anechoic chamber outlet relative to the at least one liquid discharging pipe is configured so that a liquid flowing out from the at least one liquid discharging pipe can be discharged through the anechoic chamber outlet. The muffler of the present application is part of an exhaust channel of a compressor, and the liquid discharging channel provided in the anechoic chamber can meet the requirement of timely discharging a lubricating liquid from the muffler, and likewise cannot reduce the muffling effect of the anechoic chamber.

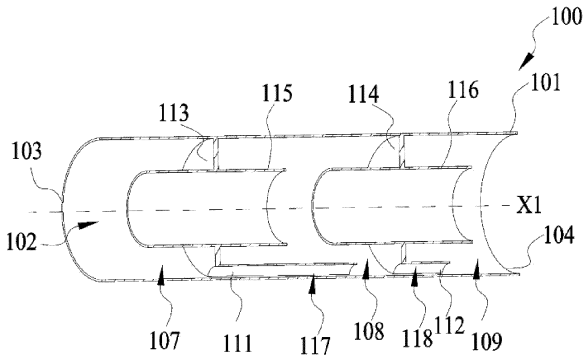

FIG. 1B

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Description

Technical Field

[0001] The present application relates to a muffler, and more particularly to a muffler for a refrigerating system, and a refrigerating system comprising a muffler.

Background Art

[0002] A muffler is usually used on an exhaust flow channel of a compressor of a refrigerating system to reduce noise generated by a refrigerant, wherein the muffler forms a section of the exhaust flow channel, and the refrigerant flows through the muffler to achieve a muffling effect. The refrigerant circulating in the refrigerating system contains a lubricating liquid, wherein for screw refrigerating systems, especially for screw units used in industrial refrigeration, the circulation volume of the lubricating liquid is often tens of tons per hour, which is two orders of magnitude higher than the oil circulation volume of general air-conditioning and refrigeration units. The lubricating liquid may enter the muffler together with the refrigerant, wherein if the volume of lubricating liquid discharged from the muffler per unit time is less than the circulation volume of lubricating liquid during the operation of the refrigerating system, the lubricating liquid may accumulate in the muffler, causing changes in a muffler cavity, resulting in a reduction in the muffling effect.

Summary of the Invention

[0003] According to a first aspect of the present application, the present application provides a muffler, comprising a cylindrical housing defining an anechoic chamber, an anechoic chamber inlet and an anechoic chamber outlet that are located at two opposite axial ends of the housing, and at least one partition plate, at least one muffling pipe, and at least one liquid discharging pipe that are located in the anechoic chamber. The housing has an axis. Each partition plate is arranged substantially perpendicular to the axis of the housing and divides the anechoic chamber into at least two compartments. The at least one muffling pipe is respectively provided on the at least one partition plate and extends a certain distance along the axis on at least one side of the corresponding partition plate. Each muffling pipe defines a travel channel penetrating through the corresponding partition plate. The at least one liquid discharging pipe is respectively provided on the at least one partition plate and extends a certain distance along the axis on at least one side of the corresponding partition plate. Each liquid discharging pipe defines a liquid discharging channel, wherein the liquid discharging channel penetrates through the corresponding partition plate. Each liquid discharging pipe is arranged in close contact with the housing or is partially formed by the housing. The position of the anechoic chamber outlet relative to the at least one liquid discharging pipe is configured so that a liquid flowing out from the at least one liquid discharging pipe can be discharged through the anechoic chamber outlet.

[0004] According to the muffler of the first aspect, each liquid discharging pipe extends a certain distance along the axis on a side of the corresponding partition plate located downstream of a liquid drainage direction. When the muffler is in use, the axis of the housing is arranged horizontally relative to the horizontal plane, the at least one liquid discharging pipe is located at the bottom of the anechoic chamber, and the anechoic chamber outlet is axially aligned with the at least one liquid discharging pipe at the bottom of the anechoic chamber. Alternatively, when the muffler is in use, the axis of the housing is arranged obliquely relative to the horizontal plane.

[0005] According to the muffler of the first aspect, each liquid discharging pipe extends a certain distance along the axis on a side of the corresponding partition plate located upstream of the liquid drainage direction, or each liquid discharging pipe extends a certain distance along the axis on the opposite sides of the corresponding partition plate located upstream and downstream of the liquid drainage direction. When the muffler is in use, the axis of the housing is arranged horizontally relative to the horizontal plane, the at least one liquid discharging pipe is located at the bottom of the anechoic chamber, and the anechoic chamber outlet is axially aligned with the at least one liquid discharging pipe at the bottom of the anechoic chamber.

[0006] According to the muffler of the first aspect, a total cross-section of the liquid discharging channel defined by the liquid discharging pipe on each partition plate is determined by a circulation volume of lubricating liquid during the operation of a unit, which is 0.1%-30% of the cross-section of the corresponding partition plate, so as to drain liquid lubricant circulating in a system in real time.

[0007] According to the muffler of the first aspect, each liquid discharging pipe comprises a single pipe.

[0008] According to the muffler of the first aspect, a portion of the single pipe along a circumferential direction is formed by the housing, and another portion is formed by an additional wall, wherein a cross-sectional shape of the liquid discharging pipe is non-circular. Alternatively, the single pipe is formed by a pipe with a circular cross-section.

[0009] According to the muffler of the first aspect, each liquid discharging pipe comprises a pipe bundle formed by a plurality of sub-pipes, the sub-pipes in the pipe bundle being configured to have the same or different lengths.

[0010] According to the muffler of the first aspect, the liquid discharging pipe communicates radially with, or is separated from the muffling pipe on the corresponding partition plate.

[0011] According to the muffler of the first aspect, if the muffler is arranged horizontally with respect to the horizontal plane when in use, the anechoic chamber inlet,

the anechoic chamber outlet and the at least one liquid discharging pipe are aligned at the bottom of the anechoic chamber.

[0012] According to the muffler of the first aspect, the distance that each liquid discharging pipe extends on one side of the corresponding partition plate is determined according to a wavelength of a sound wave expected to be attenuated.

[0013] According to a second aspect of the present application, the present application provides a muffler, comprising a cylindrical housing defining an anechoic chamber, an upstream end plate and a downstream end plate respectively closing two axial ends of the housing, an anechoic chamber inlet and an anechoic chamber outlet respectively provided on the upstream end plate and the downstream end plate, a muffling pipe located in the anechoic chamber, and a liquid discharging pipe located in the anechoic chamber. The housing has an axis. A first axial end of the muffling pipe is connected to the anechoic chamber inlet, a second axial end of the muffling pipe is closed by the downstream end plate, and the muffling pipe has a plurality of muffling pipe communication holes provided through a pipe wall of the muffling pipe, so as to communicate the anechoic chamber with a space inside the muffling pipe. A first axial end of the liquid discharging pipe is closed by the upstream end plate, a second axial end of the muffling pipe is connected to the anechoic chamber outlet, and the liquid discharging pipe has a plurality of liquid discharging pipe communication holes provided through a pipe wall of the liquid discharging pipe, so as to communicate the anechoic chamber with a space inside the liquid discharging pipe. The liquid discharging pipe is arranged in close contact with the housing or is partially formed by the housing.

[0014] According to the muffler of the second aspect, the anechoic chamber outlet is axially aligned with the liquid discharging pipe.

[0015] According to a third aspect of the present application, the present application provides a muffler, comprising a cylindrical housing defining an anechoic chamber, an anechoic chamber inlet and an anechoic chamber outlet that are located at two opposite axial ends of the housing, and at least one partition plate, at least one muffling pipe, and a liquid discharging pipe that are located in the anechoic chamber. The housing has an axis. Each partition plate is arranged substantially perpendicular to the axis of the housing and divides the anechoic chamber into at least two compartments. The at least one muffling pipe is respectively provided on the at least one partition plate and extends a certain distance along the axis on at least one side of the corresponding partition plate, each muffling pipe defines a travel channel penetrating through the corresponding partition plate. The liquid discharging pipe connects two adjacent partition plates, and the liquid discharging pipe defines a liquid discharging channel penetrating through the two adjacent partition plates; or the liquid discharging pipe is provided on the partition plate adjacent to the anechoic chamber outlet and connects the partition plate adjacent to the anechoic chamber outlet and the anechoic chamber outlet, and the liquid discharging pipe defines a liquid discharging channel penetrating through the partition plate adjacent to the anechoic chamber outlet. The liquid discharging pipe is arranged in close contact with the housing or is partially formed by the housing, and the anechoic chamber outlet is axially aligned with the liquid discharging pipe. The liquid discharging pipe is provided with a plurality of communication holes, so as to communicate the internal space of the liquid discharging pipe with the compartment where the liquid discharging pipe is located.

[0016] According to the muffler of the third aspect, when the muffler is in use, the axis of the housing is arranged horizontally relative to the horizontal plane, the liquid discharging pipe is located at the bottom of the anechoic chamber, and the anechoic chamber outlet is aligned axially with the liquid discharging pipe at the bottom of the anechoic chamber; or when the muffler is in use, the axis of the housing is arranged obliquely relative to the horizontal plane.

[0017] According to the muffler of the third aspect, a total cross-section of the liquid discharging channel defined by the liquid discharging pipe on each partition plate is determined by a circulation volume of lubricating liquid during the operation of a unit, which is 0.1%-30% of the cross-section of the corresponding partition plate, so as to drain the lubricating liquid circulating in a system in real time.

[0018] According to the muffler of the third aspect, a portion of the liquid discharging pipe along a circumferential direction is formed by the housing, and another portion is formed by an additional wall, wherein a cross-sectional shape of the liquid discharging pipe is non-circular; the liquid discharging pipe is formed by a pipe with a circular cross-section.

Brief Description of the Drawings

[0019]

FIG. 1A is a perspective view of a first embodiment of a first type of embodiment of the muffler according to the present application;

FIG. 1B is a perspective cross-sectional view of the muffler shown in FIG. 1A;

FIG. 1C is a left view of the muffler shown in FIG. 1A;

FIG. 2A is a front cross-sectional view of a second embodiment of the first type of embodiment of the muffler according to the present application;

FIG. 2B is a front cross-sectional view of a third embodiment of the first type of embodiment of the muffler according to the present application;

FIG. 2C is a perspective cross-sectional view of a fourth embodiment of the first type of embodiment of the muffler according to the present application;

FIG. 3A is a schematic diagram of a first embodiment of a sectional shape of a liquid discharging channel of the muffler according to the present application;
FIG. 3B is a schematic diagram of a second embodiment of the sectional shape of the liquid discharging channel of the muffler according to the present application;
FIG. 3C is a schematic diagram of a third embodiment of the sectional shape of the liquid discharging channel of the muffler according to the present application;
FIG. 4A is a perspective cross-sectional view of a fifth embodiment of the first type of embodiment of the muffler according to the present application;
FIG. 4B is a left view of the muffler shown in FIG. 4A;
FIG. 5A is a perspective cross-sectional view of a sixth embodiment of the first type of embodiment of the muffler according to the present application;
FIG. 5B is a left view of the muffler shown in FIG. 5A;
FIG. 6A is a perspective view of a first embodiment of a second type of embodiment of the muffler according to the present application;
FIG. 6B is an axial cross-sectional view of the muffler shown in FIG. 6A;
FIG. 7A is a perspective view of a second embodiment of the second type of embodiment of the muffler of the present application;
FIG. 7B is a perspective view of a third embodiment of the second type of embodiment of the muffler according to the present application;
FIG. 7C is an axial cross-sectional view of a fourth embodiment of the second type of embodiment of the muffler according to the present application;
FIG. 7D is an axial cross-sectional view of a fifth embodiment of the second type of embodiment of the muffler according to the present application;
FIG. 8A is a perspective view of a third type of embodiment of the muffler according to the present application;
FIG. 8B is an axial cross-sectional view of the muffler shown in FIG. 8A;
FIG. 9 is a schematic diagram of a refrigerating system using the muffler according to the present application.

Detailed Description of Embodiments

[0020] Various embodiments of the present application will be described below with reference to the accompanying drawings, which constitute a part of this specification. It should be understood that although directional terms, such as "front," "rear," "upper," "lower," "left," "right," etc., are used to describe various example structural portions and elements of the present application, these terms are used herein solely for convenience of explanation based on the example orientations shown in the drawings. Since the embodiments disclosed in the present application can be arranged in different directions, these terms indicating directions are for illustration only and should not be regarded as limiting.

[0021] The present application provides an improved muffler suitable for an exhaust channel of a compressor of a refrigerating system. In the exhaust channel of the compressor, most of the refrigerant in a gaseous state is mixed with lubricating liquids, and these lubricating liquids tend to accumulate at the bottom of the exhaust channel of the compressor when in use due to weight. The muffler according to the present application is part of an exhaust channel of a compressor, and is provided with a liquid discharging channel in an anechoic chamber, wherein the formation of the liquid discharging channel can meet the requirement of timely discharging a lubricating liquid from the muffler, and likewise cannot reduce the muffling effect of the anechoic chamber. The muffler according to the present application comprises three types, wherein the first type of muffler is an internally inserted tube type muffler, the second type of muffler is an expansion cavity type muffler, and the third type of muffler is a porous resonant cavity type muffler.

[0022] FIGS. 1A-1C show the specific structure of a muffler 100 according to a first embodiment of a first type of embodiment of the present application, where the first type of embodiment relates to an internally inserted tube type muffler, and the housing of the internally inserted tube type muffler is formed, for example, from a part of the existing exhaust channel of the compressor, and its outer diameter is substantially the same as the outer diameter of the remaining part of the exhaust channel of the compressor, where FIG. 1A shows a perspective view of the muffler 100, FIG. 1B shows a perspective cross-sectional view of the muffler 100 taken along a plane passing through the axis, and FIG. 1C shows a left view of the muffler 100.

[0023] As shown in FIGS. 1A-1C, the muffler 100 comprises a cylindrical housing 101, wherein the cylindrical housing 101 has an axis X1, and defines an anechoic chamber 102. The muffler 100 further comprises an anechoic chamber inlet 103 and an anechoic chamber outlet 104 located at two opposite axial ends of the housing 101, respectively, wherein the anechoic chamber inlet 103 and the anechoic chamber outlet 104 are in communication with the anechoic chamber 102, such that a fluid can enter the anechoic chamber 102 through the anechoic chamber inlet 103, and exit the anechoic chamber 102 through the anechoic chamber outlet 104 after being muffled. Moreover, the dimensions of the anechoic chamber inlet 103 and the anechoic chamber outlet 104 are the same as the radial dimensions of the anechoic chamber 102. That is, the fluid travels in the muffler 100 in the direction of the dotted arrow A in FIG. 1A. The muffler 100 further comprises two partition plates located in the anechoic chamber 102, namely a first partition plate 113 and a second partition plate 114, wherein the two partition plates are arranged substantially perpendicular to the axis X1 and cooperate with the housing 101 to divide the anechoic chamber 102 into

three compartments, namely a first compartment 107, a second compartment 108, and a third compartment 109.

[0024] Still as shown in FIGS. 1A-1C, the muffler 100 comprises two muffling pipes, namely, a first muffling pipe 115 and a second muffling pipe 116, wherein the two muffling pipes are respectively arranged on the first partition plate 113 and the second partition plate 114, and penetrate through the corresponding partition plates and extend a certain distance along the axis X1 on both sides of the corresponding partition plates. The distance that the muffling pipe extends on one side of the corresponding partition plate is determined based on the specific wavelength of the sound wave to be attenuated, and the distance extended on both sides of the partition plate can be used to attenuate the sound wave. The first muffling pipe 115 and the second muffling pipe 116 both define a fluid travel channel T, wherein the fluid travel channel T penetrates through the corresponding partition plate, and the fluid passes through the partition plate via the travel channels T and reach the anechoic chamber outlet 104 from the anechoic chamber inlet 103. In some other embodiments, the muffling pipe may also extend only on one side of the corresponding partition plate, as long as the travel channel T penetrates through the partition plate.

[0025] The muffler 100 further comprises two liquid discharging pipes, namely a first liquid discharging pipe 117 and a second liquid discharging pipe 118, wherein the first liquid discharging pipe 117 and the second liquid discharging pipe 118 are respectively provided on the first partition plate 113 and the second partition plate 114, and extend a certain distance on one side (i.e., the side close to the anechoic chamber outlet 104 and located downstream in the liquid discharging direction, hereinafter referred to as the "downstream side") of the corresponding partition plates. The distance that the first liquid discharging pipe 117/the second liquid discharging pipe 118 extends on the downstream side of the corresponding partition plate is determined based on the specific wavelength of the sound wave to be attenuated. The first liquid discharging pipe 117 and the second liquid discharging pipe 118 both define a liquid discharging channel P, wherein the liquid discharging channel P penetrates through the corresponding partition plate. The cross-sectional shape and dimension of the portion of the liquid discharging channel P on the first partition plate 113 is substantially the same as the cross-sectional shape and dimension of the portion in the first liquid discharging pipe 117, wherein the portion of the liquid discharging channel P on the first partition plate 113 may be formed by perforating the first partition plate 113 and communicating the perforated hole with the first liquid discharging pipe 117, or by making the first liquid discharging pipe 117 penetrating through the first partition plate 113. Similarly, the cross-sectional shape and dimension of the portion of the liquid discharging channel P on the second partition plate 114 is substantially the same as the cross-sectional shape and dimension of the portion in the second liquid discharging pipe 118, wherein the portion of the liquid discharging channel P on the second partition plate 114 may be formed by perforating the second partition plate 114 and communicating the perforated hole with the second liquid discharging pipe 118, or by making the second liquid discharging pipe 118 penetrating through the second partition plate 114.

[0026] In the illustrated embodiment, the first liquid discharging pipe 117 and the second liquid discharging pipe 118 are respectively formed by a tubular structure that is jointly enclosed by additional walls formed by arc-shaped sheets 111 and 112 and the housing 101, and have a substantially semicircular cross-section. In some other embodiments, the first liquid discharging pipe 117 and the second liquid discharging pipe 118 may also be formed by a complete pipe (for example, a pipe with a circular cross-section in the embodiment shown in FIG. 3A) instead of being formed by the housing 101, and the complete pipe is arranged in close contact with the housing 101.

[0027] As shown in FIG. 1B, the first liquid discharging pipe 117 is located in the second compartment 108, with its upstream end connected to the first partition plate 113 and in fluid communication with the second compartment 108 through its downstream end. That is, the downstream end of the first liquid discharging pipe 117 is separated from the second partition plate 114 and does not extend to the second partition plate 114. The second liquid discharging pipe 118 is located in the third compartment 109, with its upstream end connected to the second partition plate 114, and its downstream end separated from the anechoic chamber outlet 104 by a certain distance, therefore, the second liquid discharging pipe 118 is in fluid communication with the third compartment 109 through its downstream end. Since the anechoic chamber outlet 104 of the first type of embodiment is formed by the opening at the axial end of the housing 101, the dimension of the anechoic chamber outlet 104 is much larger than the dimension of the cross-section of the liquid discharging channel P defined by the first liquid discharging pipe 117 and the second liquid discharging pipe 118, such that the anechoic chamber outlet 104 is axially aligned with the first liquid discharging pipe 117 and the second liquid discharging pipe 118, and the anechoic chamber outlet 104 is located on the path along which the liquid discharging channel P defined by the first liquid discharging pipe 117 and the second liquid discharging pipe 118 axially extends, therefore, the lubricating liquid discharged from the liquid discharging channel P can be discharged from the muffler 100 through the anechoic chamber outlet 104.

[0028] The muffler 100 shown in FIGS. 1A-1C is not only applicable to the situation where the muffler 100 is placed horizontally when in use (that is, the axis X1 is arranged horizontally with respect to the horizontal plane), but also applicable to the situation where the muffler is placed obliquely when in use (that is, the axis X1 is arranged at an angle to the horizontal plane). If the

muffler 100 is placed horizontally when in use, the first liquid discharging pipe 117 and the second liquid discharging pipe 118 are located at the bottom of the muffler 100, such that the lubricating liquid accumulated at the bottom of the muffler 100 can be discharged from the muffler through the liquid discharging channel P defined by the first liquid discharging pipe 117 and the second liquid discharging pipe 118. If the muffler is placed obliquely when in use, the lubricating liquid first accumulates on the first partition plate 113 and the second partition plate 114, and then is discharged from the muffler 100 through the liquid discharging channel P. The cross-section of the liquid discharging channel P defined by the liquid discharging pipe connected to each partition plate is determined by the circulation volume of lubricating liquid in the operation of the refrigerating system (or unit), which is 0.1%-30% of the cross-section of the corresponding partition plate, so as to drain the lubricating liquid circulating in the system in real time.

[0029] After the fluid to be muffled (substantially gaseous refrigerant) enters the anechoic chamber 102 from the anechoic chamber inlet 103, the first partition plate 113 and the second partition plate 114 can block the fluid from flowing through the first partition plate 113 and the second partition plate 114 from parts other than the travel channel T and the liquid discharging channel P, wherein the gaseous refrigerant mainly flows through the first partition plate 113 and the second partition plate 114 through the travel channel T, and a small amount of the gaseous refrigerant will flow from the liquid discharging channel P through the first partition plate 113 and the second partition plate 114 together with the lubricating liquid mixed in the gaseous refrigerant. Due to the blocking of the partition plate, the incident sound wave of the fluid (along the X1 axis direction) is reflected after hitting the partition plate to form a reflected sound wave, wherein the direction of the reflected sound wave is also along the X1 axis direction, but opposite to the direction of the incident sound wave; during this process, there is a phase difference between the reflected sound wave and the incident sound wave, which allows the reflected sound wave to interfere with and cancel out the incident sound wave that subsequently enters the travel channel T, thereby producing a muffling effect, while the lengths of the first muffling pipe 115 and the second muffling pipe 116 determine the wavelength of the sound waves that can be attenuated. That is, by setting the lengths of the first muffling pipe 115 and the second muffling pipe 116, sound waves of specific wavelengths can be attenuated, and the first muffling pipe 115 and the second muffling pipe 116 can be used to attenuate sound waves of different wavelengths, and even the different lengths of each muffling pipe extending on both sides of the corresponding partition plate can also be used to attenuate sound waves of different wavelengths. Similarly, the first liquid discharging pipe 117 and the second liquid discharging pipe 118 can also be used to attenuate sound waves of specific wavelengths.

[0030] The muffler 100 of the present application is provided with a liquid discharging pipe with a certain extension length, whereby the cross-sectional dimension of the liquid discharging channel P on the partition plate can be set larger, thereby meeting the requirement of the refrigerating system for timely discharging lubricating liquid; at the same time, since the liquid discharging pipe has a muffling effect, even if the cross-sectional dimension of the liquid discharging channel P on the partition plate is set larger (relative to the area of the partition plate), the overall muffling effect of the muffler will not be weakened. As a comparative example, if there is no liquid discharging pipe provided on the partition plate and only one (or several) holes are formed in the partition plate as liquid discharging holes, since the (or these) liquid discharging hole(s) can only play a role in discharging liquid, but cannot play a role in muffling, in order not to affect the overall muffling effect of the muffler, the dimension of the liquid discharging hole can only be set relatively small, and in this case, the lubricating liquid circulating in the system cannot be drained in real time. In contrast, the muffler 100 of the present application can not only drain the lubricating liquid circulating in the system in real time, but also does not affect the overall muffling effect.

[0031] It should be noted that although the embodiments of FIGS. 1A-1C show a specific formation manner of the liquid discharging pipe, an arrangement manner of the liquid discharging pipe relative to the partition plate, and a specific cross-sectional shape of the liquid discharging channel, the muffler of the first type embodiment of the present application is not limited to the embodiment shown in FIGS. 1A-1C, the liquid discharging pipe of which may have other formation manners and arrangement manners relative to the partition plate, and the cross-sectional shape of the liquid discharging channel may also be other shapes. For example, in addition to being partially formed by the housing, the liquid discharging pipe may also be formed by a complete pipe (as shown in FIG. 3A) without the need for the housing to participate in its formation; the liquid discharging pipe can only extend a certain distance on the upstream side of the corresponding partition plate (such as the embodiment shown in FIG. 2B), or can also extend a certain distance on both sides of the corresponding partition plate (the embodiment shown in FIG. 2A); in addition to being spaced from the muffling pipe, the liquid discharging pipe can also be radially communicated with the muffling pipe (the embodiments shown in FIGS. 5A and 5B); the shape of the cross-section of the liquid discharging channel may be any shape (for example, the shapes listed in the embodiments shown in FIGS. 3A-3C). Some other embodiments of the muffler of the first type of embodiment of the present application will be listed below by way of example.

[0032] FIGS. 2A-2C show some other embodiments of the first type of embodiment of the muffler according to the present application, and these embodiments are mainly used to illustrate the arrangement manner of

the liquid discharging pipe (relative to the partition plate) that is different from the first embodiment shown in FIGS. 1A-1C.

[0033] FIG. 2A shows a muffler 120 according to a second embodiment of the first type of embodiment, where FIG. 2A is a front cross-sectional view of the muffler 120 taken along a plane passing through the axis. As shown in FIG. 2A, the muffler 120 further comprises a housing 101, and a first partition plate 123 and a second partition plate 124 provided in the housing, and comprises a first muffling pipe 125 and a second muffling pipe 126 respectively provided on the first partition plate 123 and the second partition plate 124, and a first liquid discharging pipe 127 and a second liquid discharging pipe 128 respectively provided on the first partition plate 123 and the second partition plate 124. The muffler 120 shown in FIG. 2A is substantially similar to the muffler 100 shown in FIGS. 1A-1C, and the main difference lies in that the first liquid discharging pipe 127 and the second liquid discharging pipe 128 of the muffler 120 shown in FIG. 2A both extend a certain distance on both sides (i.e., the upstream side and the downstream side) of the corresponding partition plate, while the first liquid discharging pipe 117 and the second liquid discharging pipe 118 of the muffler 100 shown in FIGS. 1A-1C only extend a certain distance on the downstream side of the corresponding partition plate. Therefore, for the muffler 120 shown in FIG. 2A, the first liquid discharging pipe 127 and the second liquid discharging pipe 128 can be muffled not only by their portions extending on the downstream side of the corresponding partition plate, but also by their portions extending on the upstream side of the corresponding partition plate. The muffler 120 shown in FIG. 2A is applicable to the situation of being placed horizontally when in use.

[0034] FIG. 2B shows a muffler 130 according to a third embodiment of the first type of embodiment, where FIG. 2B is a front cross-sectional view of the muffler 130 taken along a plane passing through the axis. As shown in FIG. 2B, the muffler 130 further comprises a housing 101, and a first partition plate 133 and a second partition plate 134 provided in the housing, and comprises a first muffling pipe 135 and a second muffling pipe 136 respectively provided on the first partition plate 133 and the second partition plate 134, and a first liquid discharging pipe 137 and a second liquid discharging pipe 138 respectively provided on the first partition plate 133 and the second partition plate 134. The main difference between the muffler 130 shown in FIG. 2B and the muffler 100 shown in FIGS. 1A-1C lies in that the first liquid discharging pipe 127 and the second liquid discharging pipe 128 of the muffler 130 shown in FIG. 2B extend a certain distance on the upstream side of the corresponding partition plate, while the first liquid discharging pipe 117 and the second liquid discharging pipe 118 of the muffler 100 shown in FIGS. 1A-1C extend a certain distance on the downstream side of the corresponding partition plate. The muffler 130 shown in FIG. 2B is applicable to the situation of being placed horizontally when in use.

[0035] FIG. 2C shows a muffler 140 according to a fourth embodiment of the first type of embodiment, where FIG. 2C is a perspective cross-sectional view of the muffler 140 taken along a plane passing through the axis. As shown in FIG. 2C, the muffler 140 further comprises a housing 101, and a first partition plate 143 and a second partition plate 144 provided in the housing, and comprises a first muffling pipe 145 and a second muffling pipe 146 respectively provided on the first partition plate 143 and the second partition plate 144. The muffler 140 further comprises a liquid discharging pipe 147. The main difference between the muffler 140 shown in FIG. 2C and the muffler 100 shown in FIGS. 1A-1C lies in that although the muffler 140 shown in FIG. 2C is provided with two partition plates, only provided with one liquid discharging pipe 147, wherein the liquid discharging pipe 147 connects the first partition plate 143 and the second partition plate 144, and the liquid discharging channel P defined by the liquid discharging pipe 147 penetrates through the first partition plate 143 and the second partition plate 144, and the first partition plate 113 and the second partition plate 114 of the muffler 100 shown in FIGS. 1A-1C are each provided with a liquid discharging pipe, which does not connect the two partition plates. In the embodiment shown in FIG. 2C, the liquid discharging pipe 147 is located in the second compartment 208 without extending into the first compartment 207 and the third compartment 209, and the lubricating liquid in the first compartment 207 enters the liquid discharging pipe through the liquid discharging channel P on the first partition plate 143. The liquid discharging pipe 147 is also provided with a plurality of communication holes 210, wherein these communication holes 210 are used to communicate the internal space of the liquid discharging pipe 147 with the second compartment 208, such that the lubricating liquid in the second compartment 208 can enter the liquid discharging pipe 147. The lubricating liquid in the liquid discharging pipe 147 is finally discharged through the liquid discharging channel P on the second partition plate 144. In some embodiments, the communication hole 210 is provided at a downstream position of the liquid discharging pipe 147 and close to the second partition plate 144, such that the muffler 140 shown in FIG. 2C is not only applicable to the situation where it is placed horizontally when in use, but also applicable to the situation where it is placed obliquely when in use.

[0036] It can be seen that in the first to fourth embodiments of the first type of embodiment shown in FIGS. 1A-2C, the liquid discharging pipe in the muffler has only one pipe, and the pipe is separated and independent from the muffling pipe. In these embodiments, the shape of the cross-section of the liquid discharging channel may be configured to be different shapes, such as the shape shown in FIG. 1C. The cross-section of the liquid discharging channel may also be in other shapes, such as the shapes shown in FIGS. 3A-3C. FIGS. 3A-3C show other embodiments of cross-sectional shapes of the

liquid discharging channel, where FIG. 3A is a schematic diagram of a first embodiment of the cross-sectional shape of the liquid discharging channel, FIG. 3B is a schematic diagram of a second embodiment of the cross-sectional shape of the liquid discharging channel, FIG. 3C is a schematic diagram of a third embodiment of the cross-sectional shape of the liquid discharging channel, and FIGS. 3A-3C show the perspective of the left view of the muffler. As shown in FIG. 3A, the liquid discharging pipe 317 is formed by a single circular pipe, such that the cross-section of the liquid discharging channel P is circular. As shown in FIG. 3B, the liquid discharging pipe 327 is jointly formed by an additional wall formed by a flat sheet and the housing 321, such that the cross-section of the liquid discharging channel P is arcuate. As shown in FIG. 3C, the liquid discharging pipe 337 is jointly formed by an additional wall formed by a sheet material with a cross-sectional shape similar to channel steel and the housing 331, such that the cross section of the liquid discharging channel P is substantially rectangular.

[0037] FIGS. 4A and 4B show a muffler 400 according to a fifth embodiment of the first type of embodiment, where FIG. 4A is a perspective cross-sectional view of the muffler 400 taken along a plane passing through the axis, and FIG. 4B is a left view of the muffler 400. The muffler 400 shown in FIGS. 4A and 4B is substantially similar to the muffler 100 shown in FIGS. 1A-1C, and the main difference lies in that the liquid discharging pipe of the fifth embodiment comprises a pipe bundle formed by a plurality of sub-pipes 420, while the muffler 100 of the first embodiment comprises a single pipe. The sub-pipes in the pipe bundle of the liquid discharging pipe each define a liquid discharging branch, and the liquid discharging branch penetrates through the corresponding partition plate, wherein these liquid discharging branches jointly define the liquid discharging channel P. In addition, these sub-pipes 420 can be configured to have the same or different extension lengths to meet the requirement of attenuating sound waves of different wavelengths.

[0038] FIGS. 5A and 5B show a muffler 500 according to a sixth embodiment of the first type of embodiment, where FIG. 5A is a perspective cross-sectional view of the muffler 500 taken along a plane passing through the axis, and FIG. 5B is a left view of the muffler 500. The main difference between the muffler 500 shown in FIGS. 5A and 5B and the muffler 100 shown in FIGS. 1A-1C is that the muffling pipe and the liquid discharging pipe of the muffler 100 of the first embodiment shown in FIGS. 1A-1C are independent (or separated) pipes, while the muffling pipe and the liquid discharging pipe of the muffler 500 of the sixth embodiment shown in FIGS. 5A and 5B are radially communicated pipes. As shown in FIGS. 5A and 5B, the muffler 500 comprises a housing 501, a first partition plate 513 and a second partition plate 514 provided in the housing 501, and a first muffling pipe 515 and a second muffling pipe 516 respectively provided on the first partition plate 513 and the second partition plate 514. The muffler 500 further comprises a first liquid discharging pipe 517 and a second liquid discharging pipe 518, wherein the first liquid discharging pipe 517 and the second liquid discharging pipe 518 are radially communicated with the first muffling pipe 515 and the second muffling pipe 516, respectively. Therefore, in the cross section of the muffler 500, the travel channel T defined by the muffling pipe is in communication with the liquid discharging path P defined by the liquid discharging pipe, and the fluid in the muffling pipe can directly flow into the liquid discharging pipe radially and be discharged from the muffler 500 along the liquid discharging pipe. The embodiment shown in FIGS. 5A and 5B is particularly applicable to application situations where the space between the muffling pipe and the housing 501 is narrow, which is because by using the method of providing the liquid discharging pipe as shown in FIGS. 5A and 5B, the liquid discharging pipe and the muffling pipe can be made into an integrated special-shaped pipe, and then the special-shaped pipe is inserted and welded into the partition plate, and finally, the assembled integral piece of the liquid discharging pipe, muffling pipe and partition plate is inserted into the housing 501. If the embodiment shown in FIGS. 1A-1C is adopted, the liquid discharging pipe needs to be welded to the partition plate separately, which may cause difficulty in welding because the liquid discharging pipe and the muffling pipe are too close to each other.

[0039] In the embodiment shown in FIGS. 5A and 5B, the bottom of the first muffling pipe 515 is provided with an opening 525 extending along its axial direction, and the first liquid discharging pipe 517 connects the opening 525 at the bottom of the first muffling pipe 515 to the housing 501 through an additional wall formed by two substantially flat sheets 522 and 524, such that the first liquid discharging pipe 517 is formed by a part of the housing 501 and the two sheets 522 and 524 (shown by the dotted box in FIG. 5B). The second liquid discharging pipe 518 is formed in a manner similar to the first liquid discharging pipe 517, and will not be described again here.

[0040] It should be noted that although in the first type of embodiment of the muffling pipe listed above, two partition plates are provided in the muffling pipe, in other embodiments not shown, the muffling pipe may also be provided with only one partition plate.

[0041] FIGS. 6A-7D show a second type of embodiment of the muffler according to the present application, where the muffler of the second type of embodiment may be similar to the muffler of the first type of embodiment in terms of the formation manner of the liquid discharging pipe, the arrangement manner of the liquid discharging pipe relative to the partition plate, and the cross-sectional shape of the liquid discharging channel, and the difference lies in that the inner diameter of anechoic chamber of the muffler of the first type of embodiment is substantially the same as the inner diameter of the exhaust channel of the compressor, while the muffler of the second type of embodiment involves an expansion chamber

type muffler, and the inner diameter of the anechoic chamber is increased relative to the inner diameter of the exhaust channel of the compressor.

[0042] FIGS. 6A and 6B show a muffler 600 according to a first embodiment of the second type of embodiment of the present application, where FIG. 6A is a perspective view of the muffler 600, and FIG. 6B is a perspective cross-sectional view of the muffler 600 cut along a plane passing through the axis. As shown in FIGS. 6A and 6B, the muffler 600 comprises a cylindrical housing 601, wherein the housing 601 defines an anechoic chamber 602 and has an axis X2. An upstream end plate 651 and a downstream end plate 653 are respectively provided at two opposite axial ends of the housing 601 for sealing the anechoic chamber 602, however, the upstream end plate 651 and the downstream end plate 653 are each provided with an opening for forming an anechoic chamber inlet 603 and an anechoic chamber outlet 604, respectively. The anechoic chamber inlet 603 and the anechoic chamber outlet 604 are therefore in communication with the anechoic chamber 602 and located at two opposite axial ends of the housing 601. At the anechoic chamber inlet 603 and the anechoic chamber outlet 604, an inlet pipe 661 and an outlet pipe 663 are connected, respectively, wherein the inlet pipe 661 and the outlet pipe 663 are used to connect the muffler 600 to the exhaust channel of the compressor, and the radial dimensions of the inlet pipe 661 and the outlet pipe 663 are substantially the same as the radial dimensions of the exhaust channel of the compressor.

[0043] As still shown in FIGS. 6A and 6B, the muffler 600 further comprises a first partition plate 613, a second partition plate 614, a first muffling pipe 615, a second muffling pipe 616, a first liquid discharging pipe 617 and a second liquid discharging pipe 618 provided therein, wherein the manner in which these components are provided is substantially the same as the manner in which the same components in the muffler 100 shown in FIGS. 1A-1C are provided.

[0044] The position of the anechoic chamber outlet 604 relative to the first liquid discharging pipe 617 and the second liquid discharging pipe 618 is configured so that a liquid flowing out from the liquid discharging pipe can be discharged through the anechoic chamber outlet 604. In the embodiment shown in FIGS. 6A and 6B, the anechoic chamber outlet 604 is positioned on the downstream end plate 653 to be in close contact with the housing 601 and axially aligned with the first liquid discharging pipe 617 and the second liquid discharging pipe 618, wherein the anechoic chamber inlet 603 is also arranged in the same manner as the anechoic chamber outlet 604. Therefore, if the muffler 600 is arranged horizontally when in use, the anechoic chamber inlet 603, the anechoic chamber outlet 604, the first liquid discharging pipe 617 and the second liquid discharging pipe 618 are axially aligned at the bottom of the anechoic chamber 602, wherein the anechoic chamber outlet 604 is located on a path along which the liquid discharging channel P defined by the first liquid discharging pipe 617 and the second liquid discharging pipe 618 axially extends, thereby ensuring that the lubricating liquid flowing out from the liquid discharging channel P can flow out from the anechoic chamber outlet 604. In the illustrated embodiment, the cross-sectional dimensions and shapes of the anechoic chamber inlet 603, the anechoic chamber outlet 604, the first liquid discharging pipe 617 and the second liquid discharging pipe 618 are all the same. In some other embodiments, the cross-sectional dimensions of the anechoic chamber inlet 603 and the anechoic chamber outlet 604 may be designed to be larger than the cross-sectional dimensions of the liquid discharging channels P of the first liquid discharging pipe 617 and the second liquid discharging pipe 618. The anechoic chamber inlet 603 may also not be arranged in the same manner as the anechoic chamber outlet 604, and it is sufficient to arrange the anechoic chamber outlet 604 in the above manner to meet the liquid discharging requirements. The muffler 600 is not only applicable to the situation where the muffler is placed horizontally when in use, but also applicable to the situation where the muffler is placed obliquely when in use.

[0045] FIG. 7A shows a muffler 710 according to a second embodiment of the second type of embodiment of the present application, where the muffler 710 of this embodiment is similar to the muffler 600 of the first embodiment, and the main difference lies in that the muffler 710 of the second embodiment is provided with only one partition plate 713, one muffling pipe 715 and one liquid discharging pipe 717, while the muffler 600 of the first embodiment is provided with two partition plates, two muffling pipes and two liquid discharging pipes. The manner in which the liquid discharging pipe 717, the anechoic chamber inlet 711 and the anechoic chamber outlet 712 in the muffler 710 of the second embodiment are provided is the same as the manner in which the liquid discharging pipe, the anechoic chamber inlet and the anechoic chamber outlet in the muffler 600 of the first embodiment are provided.

[0046] FIG. 7B shows a muffler 720 according to a third embodiment of the second type of embodiment of the present application, where the muffler 720 of this embodiment is similar to the muffler 710 of the second embodiment, and the main difference lies in that, in the muffler 710 of the second embodiment, the anechoic chamber inlet 711 is axially aligned with the anechoic chamber outlet 712 and the liquid discharging pipe 717, however, in the muffler 720 of the third embodiment, the anechoic chamber inlet 721 is non-coaxial with the muffler outlet 722 and the liquid discharging pipe 727, but staggered, and only the muffler outlet 722 and the liquid discharging pipe 727 are axially aligned.

[0047] FIG. 7C shows a muffler 730 according to a fourth embodiment of the second type of embodiment of the present application, where the muffler 730 of this embodiment is similar to the muffler 710 of the first embodiment, and the main difference lies in that in the muffler 600 of the first embodiment, two partition plates

613 and 614 are respectively provided with the first liquid discharging pipe 617 and the second liquid discharging pipe 618, while in the muffler 730 of the fourth embodiment, there is only one liquid discharging pipe 737 provided, and the manner in which the liquid discharging pipe 737 is provided is similar to the manner in which the liquid discharging pipe 147 in the fourth embodiment of the first type of embodiment shown in FIG. 2C is provided. The communication holes 760 in the liquid discharging pipe 737 are provided around the axial direction of the liquid discharging pipe 737.

[0048] FIG. 7D shows a muffler 740 according to a fifth embodiment of the second type of embodiment of the present application, where the muffler 740 of this embodiment is similar to the muffler 600 of the first embodiment, and also is provided with two partition plates (a first partition plate 743 and a second partition plate 744) and two liquid discharging pipes (a first liquid discharging pipe 747 and a second liquid discharging pipe 748), and the difference lies in that the two liquid discharging pipes in the muffler 740 of the fifth embodiment are provided in different manners from each other, whereas the two liquid discharging pipes in the muffler 600 of the first embodiment are provided in the same manner. Specifically, in the muffler 740 of the fifth embodiment, the first liquid discharging pipe 747 only extends a distance on the upstream side of the corresponding first partition plate 743, while the second liquid discharging pipe 748 not only extends a distance on both the upstream and downstream sides of the corresponding second partition plate 744, but also extends on the downstream side of the second partition plate 744 until reaching the anechoic chamber outlet 742. That is, the second liquid discharging pipe 748 connects the second partition plate 744 with the downstream end plate 753 at the anechoic chamber outlet 742. The portion of the second liquid discharging pipe 748 extending between the second partition plate 744 and the downstream end plate 753 is provided in a manner similar to the manner in which the liquid discharging pipe 737 in the fourth embodiment shown in FIG. 7C is provided.

[0049] FIGS. 8A and 8B show a muffler 800 according to the third type of embodiment (porous resonant cavity type muffler) of the present application, where FIG. 8A is a perspective view of the muffler 800, and FIG. 8B is a perspective cross-sectional view of the muffler 800. As shown in FIGS. 8A and 8B, the muffler 800 comprises a cylindrical housing 801, wherein the housing 801 defines an anechoic chamber 802 and has an axis X3. The muffler 800 further comprises an upstream end plate 851 and a downstream end plate 853 closing two axial ends of the housing 801, and an anechoic chamber inlet 803 and an anechoic chamber outlet 804 respectively provided on the upstream end plate 851 and the downstream end plate 853. At the anechoic chamber inlet 803 and the anechoic chamber outlet 804, an inlet pipe 861 and an outlet pipe 863 are connected, respectively, wherein the inlet pipe 861 and the outlet pipe 863 are used to connect the muffler 800 to the exhaust channel of the compressor, and the radial dimensions of the inlet pipe 861 and the outlet pipe 863 are substantially the same as the radial dimensions of the exhaust channel of the compressor.

[0050] A muffling pipe 815 and a liquid discharging pipe 817 are provided in the anechoic chamber 802, and both the muffling pipe 815 and the liquid discharging pipe 817 extend along the axis X3. The first axial end of the muffling pipe 815 is connected to the anechoic chamber inlet 803, the second axial end of the muffling pipe 815 is closed by the downstream end plate 853, and the muffling pipe 815 is provided with a plurality of muffling pipe communication holes 825 for communicating the space inside the muffling pipe 815 with the anechoic chamber 802. A plurality of muffling pipe communication holes 825 are arranged along the axial and circumferential directions of the muffling pipe 815. The first axial end of the liquid discharging pipe 817 is closed by the upstream end plate 851, the second axial end of the liquid discharging pipe 817 is connected to the anechoic chamber outlet 804, and the liquid discharging pipe 817 is provided with a plurality of liquid discharging pipe communication holes 827 for communicating the space inside the liquid discharging pipe 817 with the anechoic chamber 802. A plurality of liquid discharging pipe communication holes 827 are arranged along the circumferential and axial directions of the liquid discharging pipe 817.

[0051] Similar to the first and second types of embodiments, the liquid discharging pipe of the muffler of the type of third embodiments is also arranged in close contact with the housing or is partially formed by the housing. In the embodiment shown in FIGS. 8A and 8B, the liquid discharging pipe 817 is formed by a complete tubular object (similar to the liquid discharging pipe in the embodiment shown in FIG. 3A), without needing to be formed by the housing 801, and the liquid discharging pipe 817 is arranged in close contact with the housing 801. In some other embodiments, the liquid discharging pipe 817 may also be jointly formed by an additional wall and the housing 801, for example, similar to the embodiments shown in FIGS. 1, 3B, and 3C. If the muffler 800 is placed horizontally when in use, the liquid discharging pipe 817 is located at the bottommost part of the housing 801, and the anechoic chamber outlet 804 is axially aligned with the liquid discharging pipe 817, and therefore is located on a path along which the liquid discharging channel P defined by the liquid discharging pipe axially extends.

[0052] Therefore, the fluid to be muffled enters from the inlet pipe 861, directly enters the muffling pipe 815 through the anechoic chamber inlet 803, then enters the anechoic chamber 802 through the muffling pipe communication holes 825, and then enters the liquid discharging pipe 817 from the liquid discharging pipe communication holes 827 through the anechoic chamber 802, and is discharged from the muffler 800 through the anechoic chamber outlet 804 and an outlet pipe 863.

[0053] After long-term observation, the inventor of the present application found that for the mufflers of the second type of embodiment (expansion cavity type) and the third type of embodiment (porous resonant cavity type), in order to discharge lubricating liquid from the anechoic chamber in the prior art, a drainage hole is usually provided at the bottom of the muffler (whether placed horizontally or obliquely) and is externally connected to a drainage pipe, which not only increases the risk of leaking refrigerant, but also reduces the muffling effect. The mufflers of the second and third types of embodiments of the present application are provided with a liquid discharging pipe arranged in close contact with the housing or is partially formed by the housing, and the position of the anechoic chamber outlet is changed such that the anechoic chamber outlet is axially aligned with the liquid discharging pipe, which can not only meet the requirement of the refrigerating system for timely discharging lubricating liquid, but will not reduce the muffling effect, and will not bring about the risk of refrigerant leakage.

[0054] FIG. 9 is a schematic diagram of a refrigerating system 900 using a muffler according to the present application. As shown in FIG. 9, the refrigerating system 900 comprises an evaporator 910, a compressor 920, a condenser 930, and a throttle valve 940, which are connected to form a refrigeration cycle loop in which the refrigerant circulates. Specifically, the refrigerant is compressed into a high-pressure and high-temperature state in the compressor 920 and then discharged into the condenser 930. The refrigerant then performs heat exchange with other media (such as ambient air) in the condenser 930 to release heat to be condensed into a high-pressure, liquid state, and then is discharged into the throttle valve 940. In the throttle valve 940, the refrigerant is expanded and throttled to a low-pressure two-phase state, and then flows into the evaporator 910. The refrigerant then performs heat exchange with other media (such as water) in the evaporator 910 to absorb heat to be evaporated into a low-pressure, gaseous state, and then returns to the compressor 920 from a suction port of the compressor 920 to complete the refrigerant cycle. The muffler 950 according to the present application is disposed in the exhaust channel of the compressor 920, that is, on the connecting pipeline between the compressor 920 and the condenser 930, to perform a muffling operation on the substantially gaseous refrigerant in the exhaust channel of the compressor. The muffler 950 may be the muffler shown in any of the embodiments shown in FIGS. 1A-8B.

[0055] Although the present disclosure has been described in connection with the examples of embodiments outlined above, various alternatives, modifications, variations, improvements and/or substantial equivalents, whether known or now or may be foreseen in the near future, may be apparent to those of at least ordinary skill in the art. In addition, the technical effects and/or technical problems described in this specification are illustrative rather than restrictive; therefore, the disclosure in this specification may be used to solve other technical problems and have other technical effects. Accordingly, the examples of embodiments of the present disclosure set forth above are intended to be illustrative rather than restrictive. Various changes may be made without departing from the spirit or scope of the present disclosure. Accordingly, the present disclosure is intended to include all known or earlier developed alternatives, modifications, variations, improvements and/or substantial equivalents.

Claims

1. A muffler, comprising:

a cylindrical housing defining an anechoic chamber, the housing having an axis;
an anechoic chamber inlet and an anechoic chamber outlet that are located at two opposite axial ends of the housing;
at least one partition plate located in the anechoic chamber, wherein each partition plate is arranged substantially perpendicular to the axis of the housing and divides the anechoic chamber into at least two compartments;
at least one muffling pipe, wherein the at least one muffling pipe is respectively provided on the at least one partition plate and extends a certain distance along the axis on at least one side of the corresponding partition plate, each muffling pipe defines a travel channel penetrating through the corresponding partition plate; and
at least one liquid discharging pipe, wherein the at least one liquid discharging pipe is respectively provided on the at least one partition plate and extends a certain distance along the axis on at least one side of the corresponding partition plate, each liquid discharging pipe defines a liquid discharging channel penetrating through the corresponding partition plate, each liquid discharging pipe is arranged in close contact with the housing or is partially formed by the housing,
wherein, the position of the anechoic chamber outlet relative to the at least one liquid discharging pipe is configured so that a liquid flowing out from the at least one liquid discharging pipe can be discharged through the anechoic chamber outlet.

2. The muffler according to claim 1, wherein

each liquid discharging pipe extends a certain distance along the axis on a side of the corresponding partition plate located downstream of a liquid drainage direction,

wherein, when the muffler is in use, the axis of the housing is arranged horizontally relative to the horizontal plane, the at least one liquid discharging pipe is located at the bottom of the anechoic chamber, and the anechoic chamber outlet is axially aligned with the at least one liquid discharging pipe at the bottom of the anechoic chamber; or
wherein, when the muffler is in use, the axis of the housing is arranged obliquely relative to the horizontal plane.

3. The muffler according to claim 1, wherein

each liquid discharging pipe extends a certain distance along the axis on a side of the corresponding partition plate located upstream of the liquid drainage direction, or each liquid discharging pipe extends a certain distance along the axis on the opposite sides of the corresponding partition plate located upstream and downstream of the liquid drainage direction,
wherein, when the muffler is in use, the axis of the housing is arranged horizontally relative to the horizontal plane, the at least one liquid discharging pipe is located at the bottom of the anechoic chamber, and the anechoic chamber outlet is axially aligned with the at least one liquid discharging pipe at the bottom of the anechoic chamber.

4. The muffler according to claim 2 or 3, wherein
a total cross-section of the liquid discharging channel defined by the liquid discharging pipe on each partition plate is determined by a circulation volume of lubricating liquid during the operation of a unit, which is 0.1%-30% of the cross-section of the corresponding partition plate, so as to drain liquid lubricant circulating in a system in real time.

5. The muffler according to claim 4, wherein
each liquid discharging pipe comprises a single pipe.

6. The muffler according to claim 5, wherein

a portion of the single pipe along a circumferential direction is formed by the housing, and another portion is formed by an additional wall, wherein a cross-sectional shape of the liquid discharging pipe is non-circular; or
the single pipe is formed by a pipe with a circular cross-section.

7. The muffler according to claim 4, wherein
each liquid discharging pipe comprises a pipe bundle formed by a plurality of sub-pipes, the sub-pipes in the pipe bundle being configured to have the same or different lengths.

8. The muffler according to claim 4, wherein
the liquid discharging pipe communicates radially with, or is separated from the muffling pipe on the corresponding partition plate.

9. The muffler according to claim 2 or 3, wherein
wherein, if the muffler is arranged horizontally with respect to the horizontal plane when in use, the anechoic chamber inlet, the anechoic chamber outlet and the at least one liquid discharging pipe are aligned at the bottom of the anechoic chamber.

10. The muffler according to claim 2 or 3, wherein
the distance that each liquid discharging pipe extends on one side of the corresponding partition plate is determined according to a wavelength of a sound wave expected to be attenuated.

11. A muffler, comprising:

a cylindrical housing defining an anechoic chamber, the housing having an axis;
an upstream end plate and a downstream end plate respectively closing two axial ends of the housing, and an anechoic chamber inlet and an anechoic chamber outlet respectively provided on the upstream end plate and the downstream end plate;
a muffling pipe located in the anechoic chamber, wherein a first axial end of the muffling pipe is connected to the anechoic chamber inlet, a second axial end of the muffling pipe is closed by the downstream end plate, and the muffling pipe has a plurality of muffling pipe communication holes provided through a pipe wall of the muffling pipe, so as to communicate the anechoic chamber with a space inside the muffling pipe; and
a liquid discharging pipe located in the anechoic chamber, wherein a first axial end of the liquid discharging pipe is closed by the upstream end plate, a second axial end of the muffling pipe is connected to the anechoic chamber outlet, and the liquid discharging pipe has a plurality of liquid discharging pipe communication holes provided through a pipe wall of the liquid discharging pipe, so as to communicate the anechoic chamber with a space inside the liquid discharging pipe,
wherein the liquid discharging pipe is arranged in close contact with the housing or is partially formed by the housing.

12. The muffler according to claim 11, wherein
the anechoic chamber outlet is axially aligned with the liquid discharging pipe.

13. A muffler, comprising:

a cylindrical housing defining an anechoic chamber, the housing having an axis;
an anechoic chamber inlet and an anechoic chamber outlet that are located at two opposite axial ends of the housing;
at least one partition plate located in the anechoic chamber, wherein each partition plate is arranged substantially perpendicular to the axis of the housing and divides the anechoic chamber into at least two compartments;
at least one muffling pipe, wherein the at least one muffling pipe is respectively provided on the at least one partition plate and extends a certain distance along the axis on at least one side of the corresponding partition plate, each muffling pipe defines a travel channel penetrating through the corresponding partition plate; and
a liquid discharging pipe, wherein the liquid discharging pipe connects two adjacent partition plates, and the liquid discharging pipe defines a liquid discharging channel penetrating through the two adjacent partition plates; or the liquid discharging pipe is provided on the partition plate adjacent to the anechoic chamber outlet and connects the partition plate adjacent to the anechoic chamber outlet and the anechoic chamber outlet, and the liquid discharging pipe defines a liquid discharging channel penetrating through the partition plate adjacent to the anechoic chamber outlet;
wherein the liquid discharging pipe is arranged in close contact with the housing or is partially formed by the housing, and the anechoic chamber outlet is axially aligned with the liquid discharging pipe; and
wherein the liquid discharging pipe is provided with a plurality of communication holes, so as to communicate the internal space of the liquid discharging pipe with the compartment where the liquid discharging pipe is located.

14. The muffler according to claim 13, wherein

wherein, when the muffler is in use, the axis of the housing is arranged horizontally relative to the horizontal plane, the liquid discharging pipe is located at the bottom of the anechoic chamber, and the anechoic chamber outlet is axially aligned with the liquid discharging pipe at the bottom of the anechoic chamber; or
wherein, when the muffler is in use, the axis of the housing is arranged obliquely relative to the horizontal plane.

15. The muffler according to claim 14, wherein
a total cross-section of the liquid discharging channel defined by the liquid discharging pipe on each partition plate is determined by a circulation volume of lubricating liquid during the operation of a unit, which is 0.1%-30% of the cross-section of the corresponding partition plate, so as to drain the lubricating liquid circulating in a system in real time.

16. The muffler according to claim 15, wherein
a portion of the liquid discharging pipe along a circumferential direction is formed by the housing, and another portion is formed by an additional wall, wherein a cross-sectional shape of the liquid discharging pipe is non-circular; and the liquid discharging pipe is formed by a pipe with a circular cross-section.

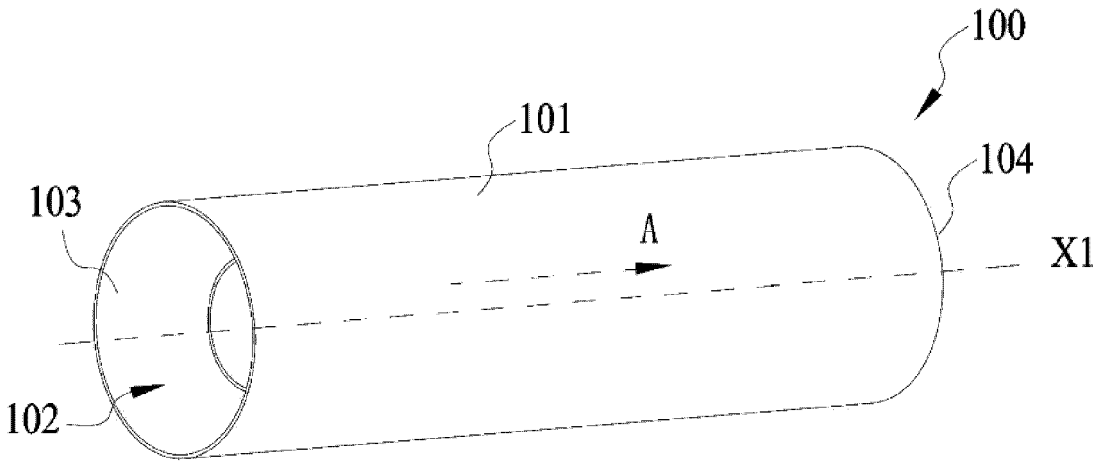


FIG. 1A

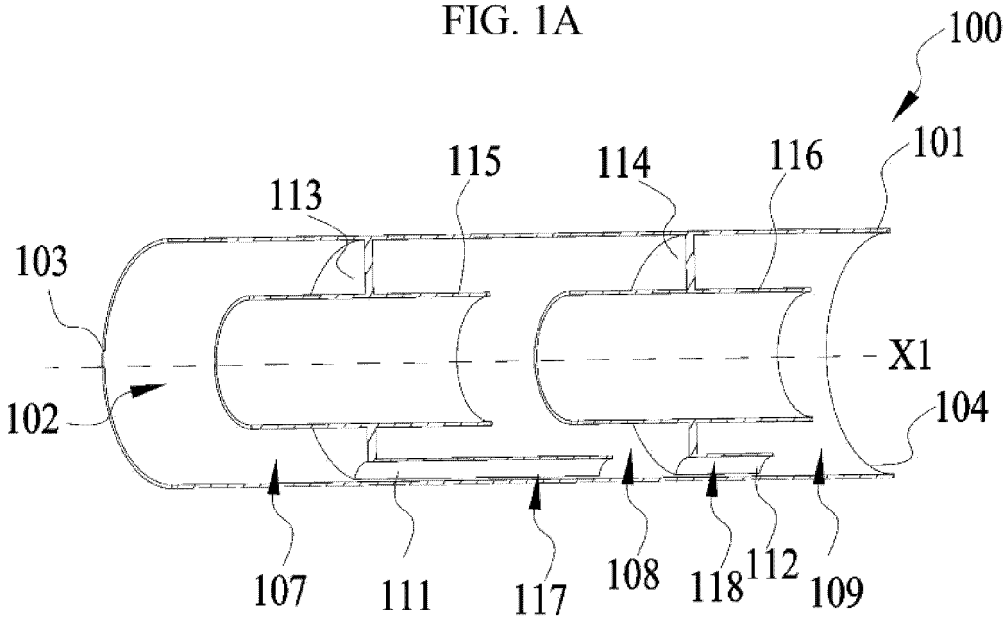


FIG. 1B

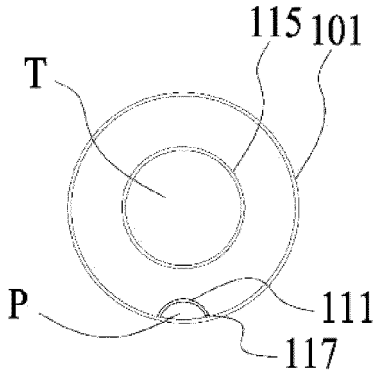


FIG. 1C

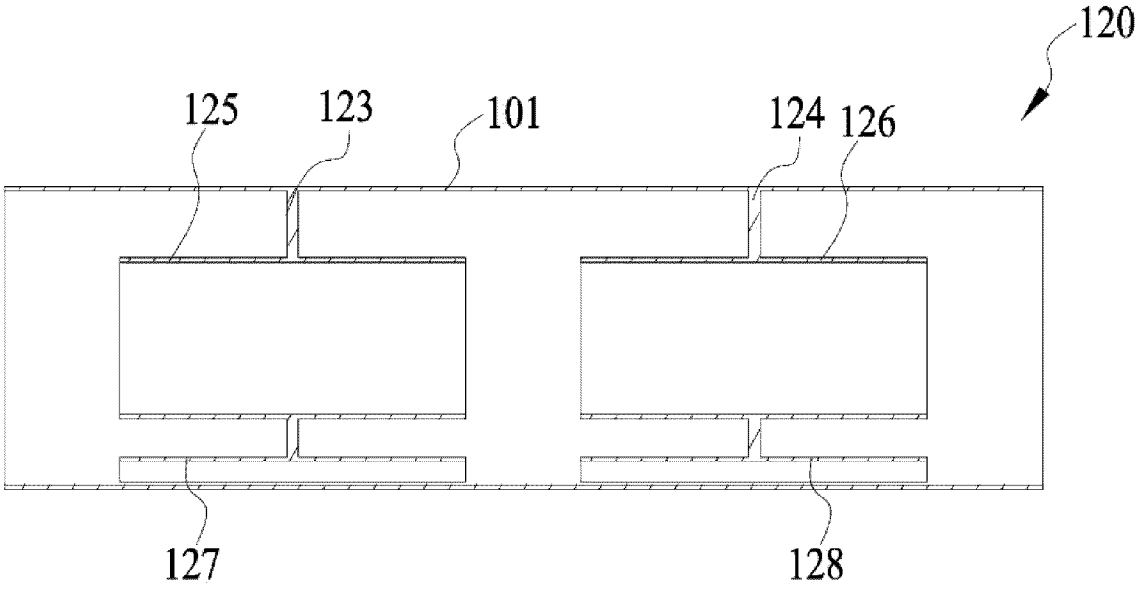


FIG. 2A

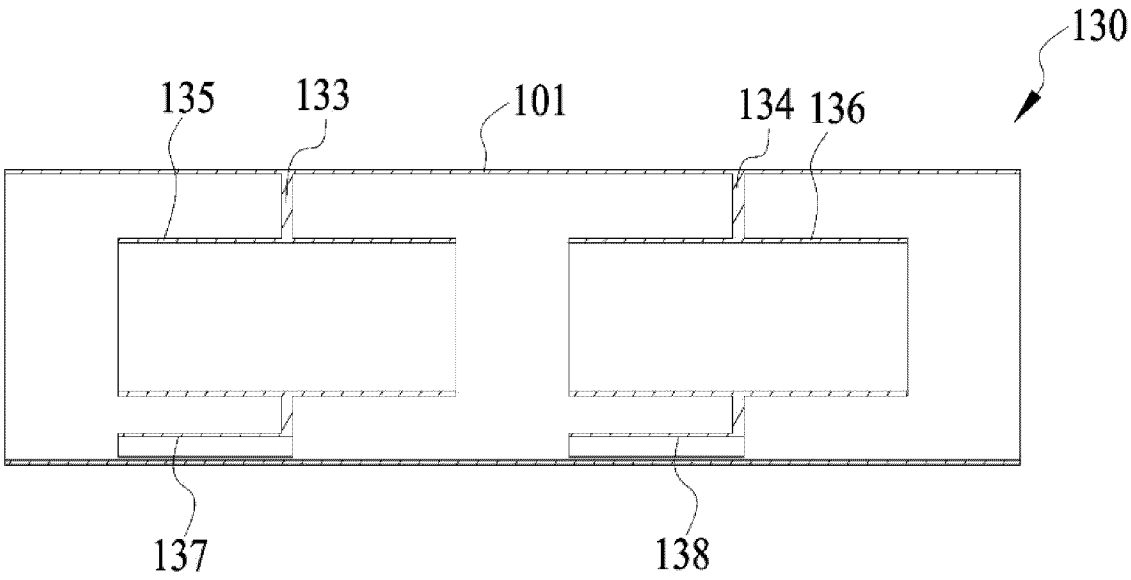


FIG. 2B

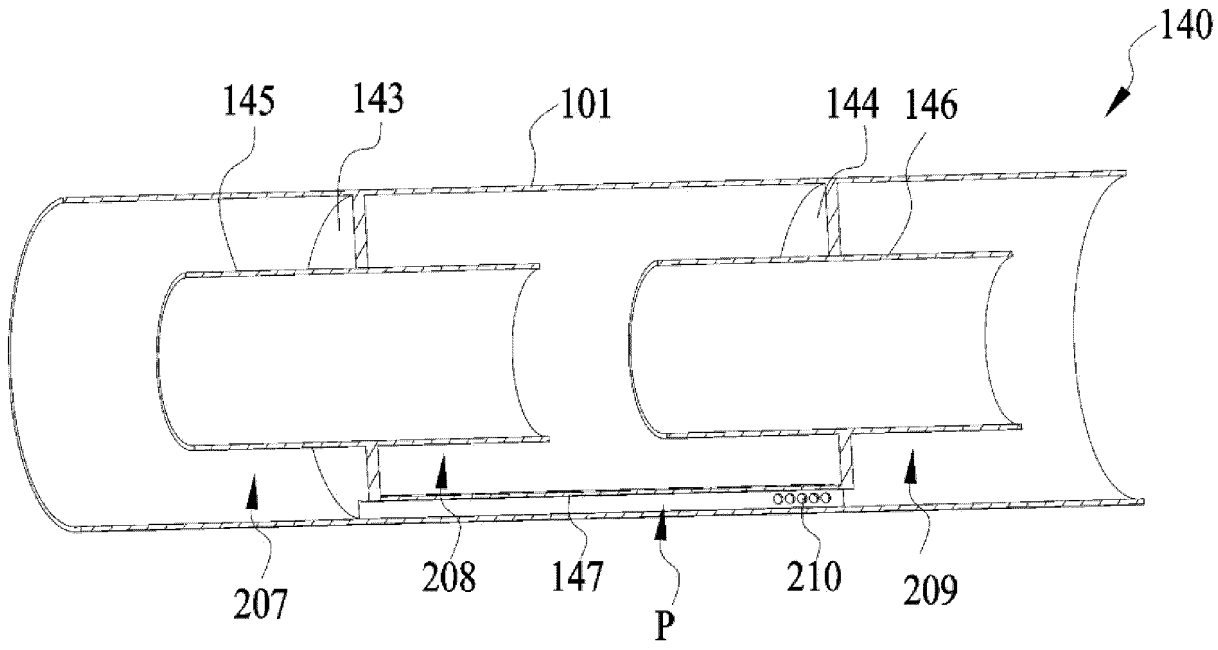


FIG. 2C

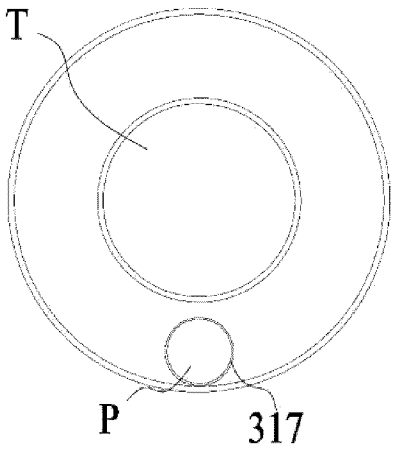


FIG. 3A

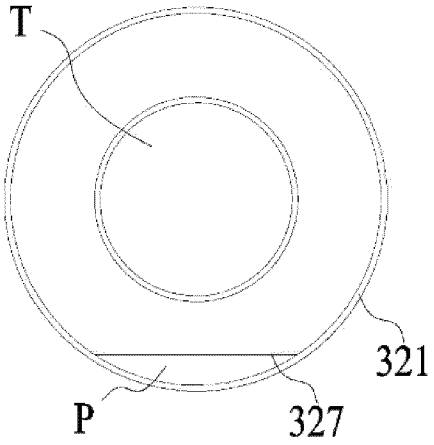


FIG. 3B

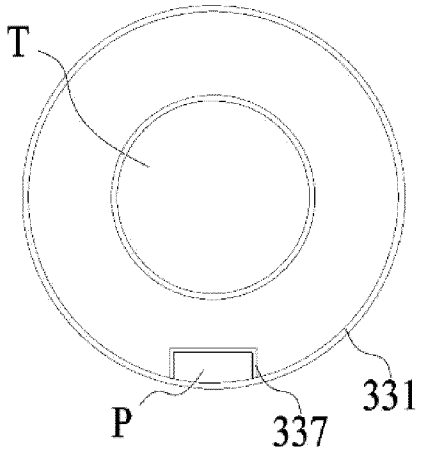


FIG. 3C

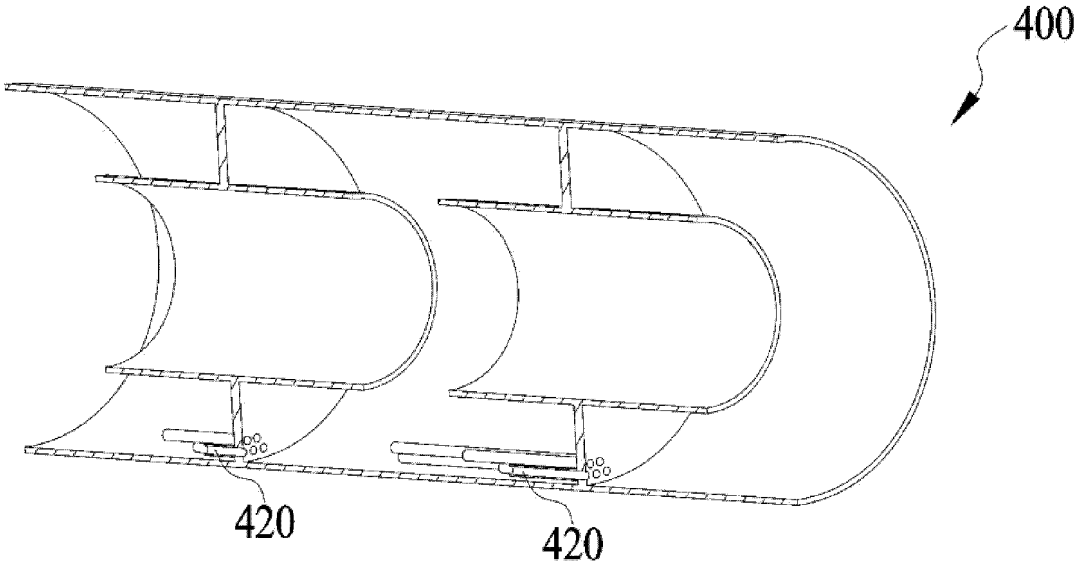


FIG. 4A

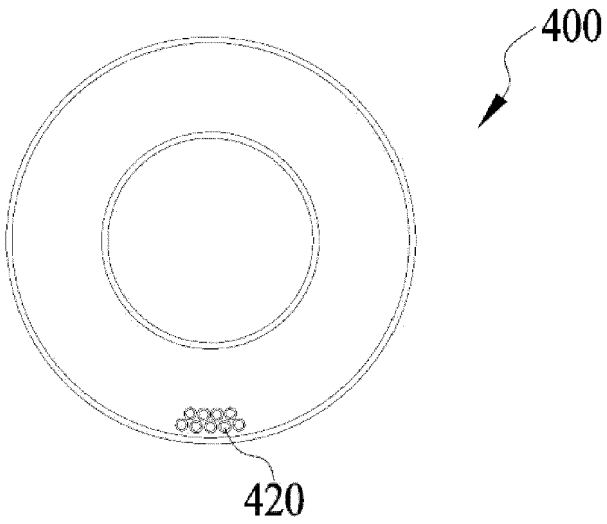


FIG. 4B

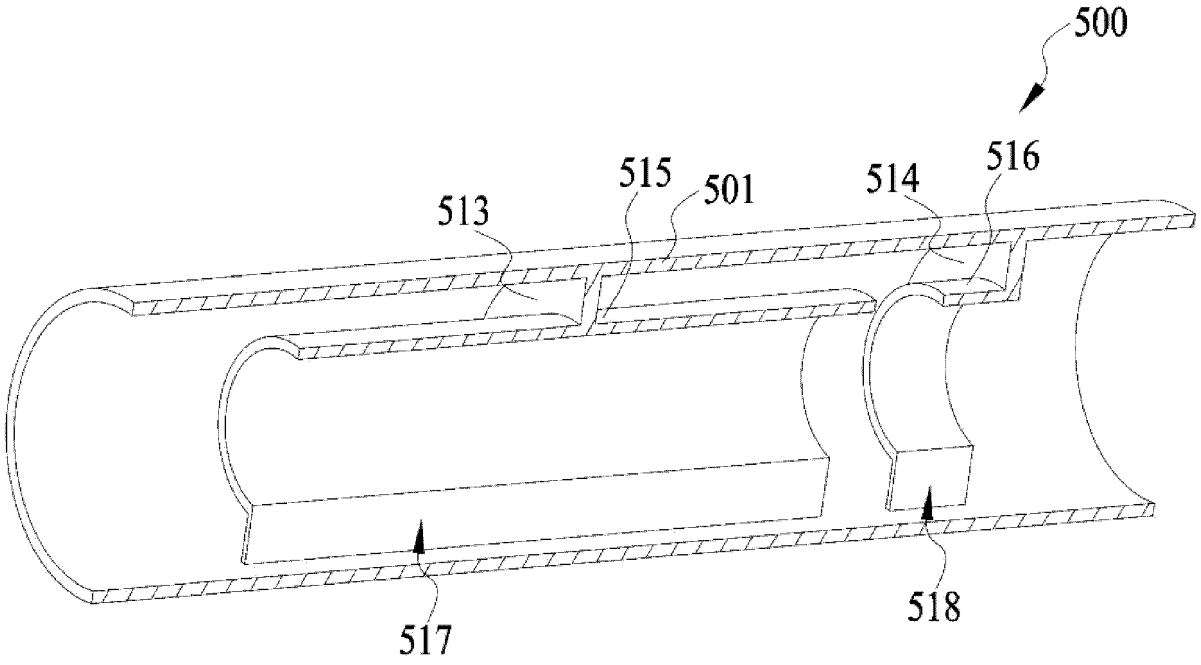


FIG. 5A

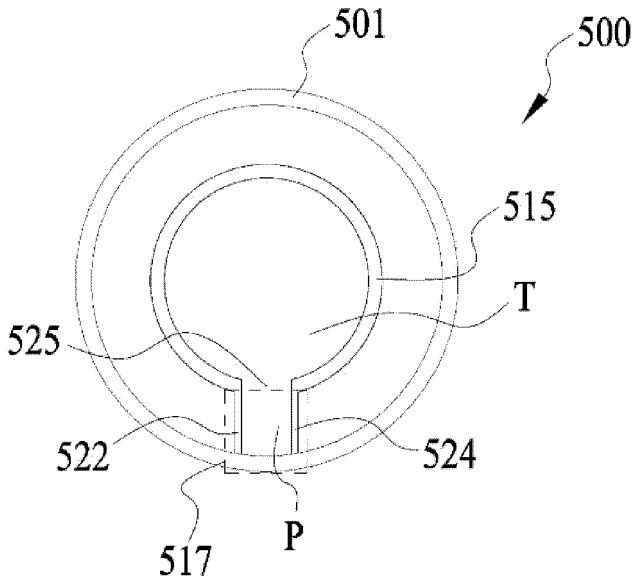


FIG. 5B

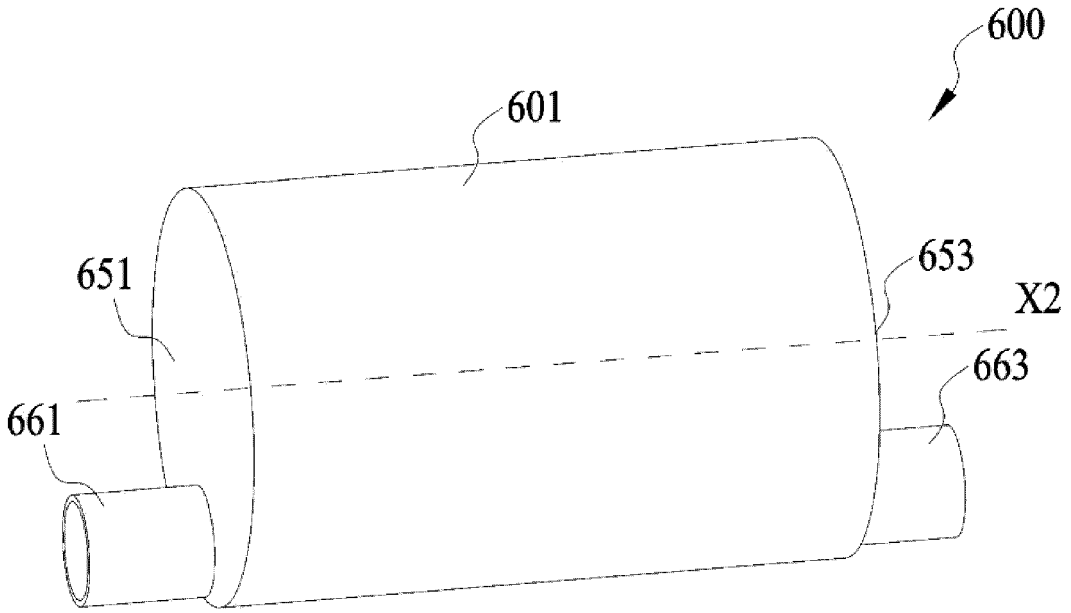
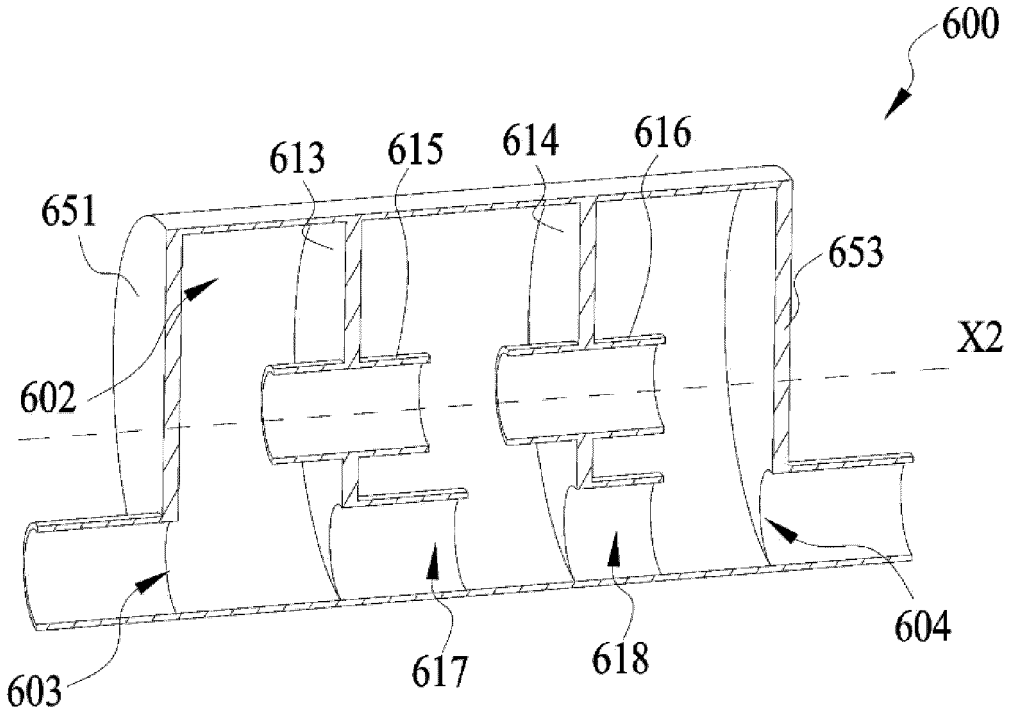

600
601
651
653
X2
663
661

FIG. 6A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604

FIG. 6B

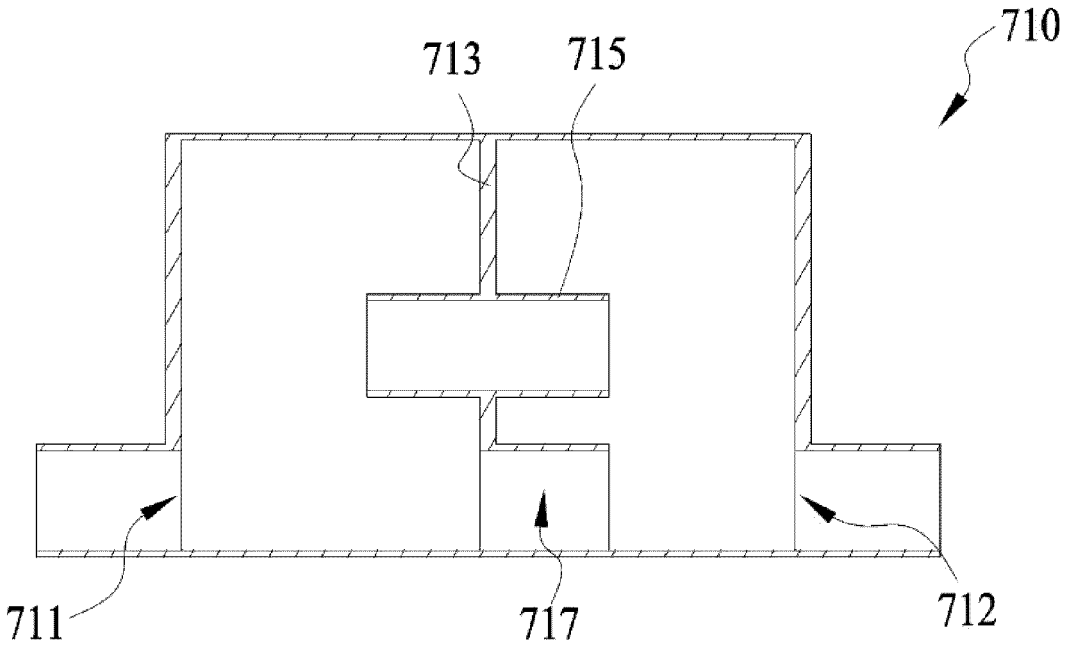


FIG. 7A

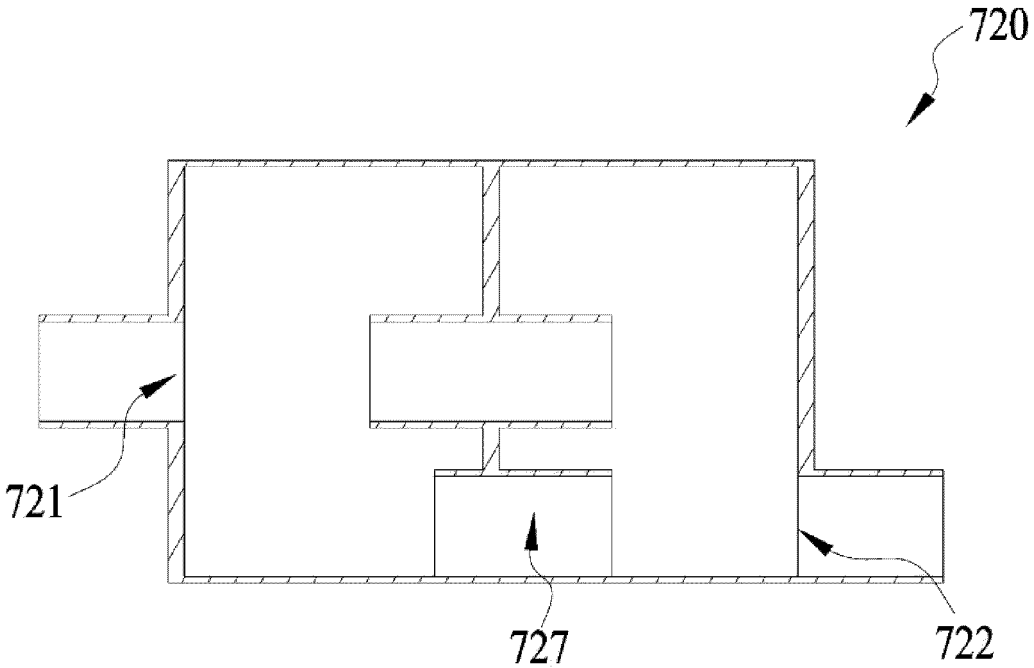


FIG. 7B

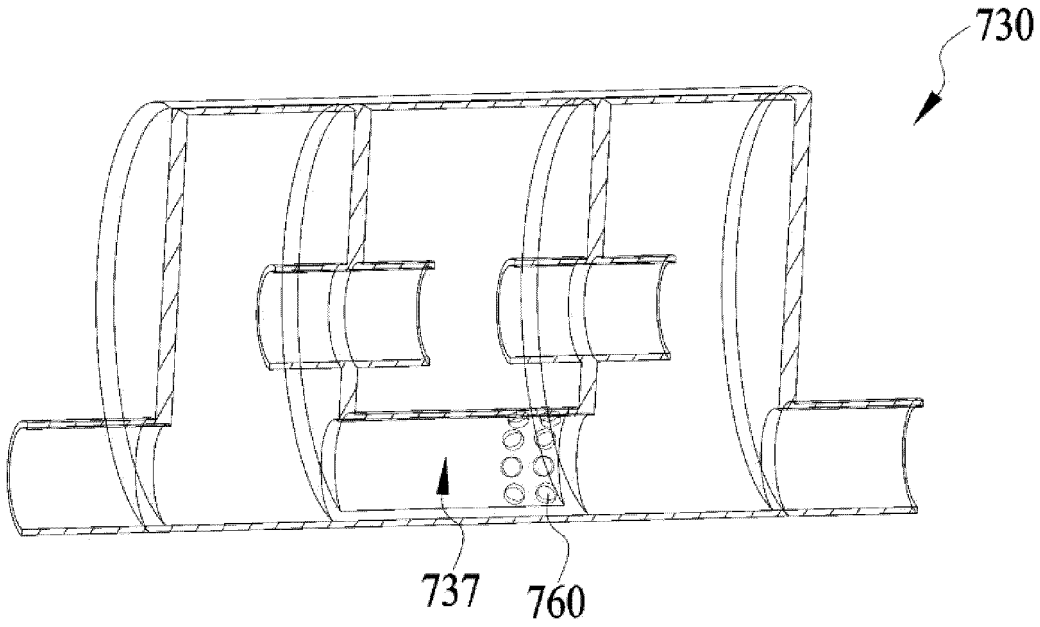


FIG. 7C

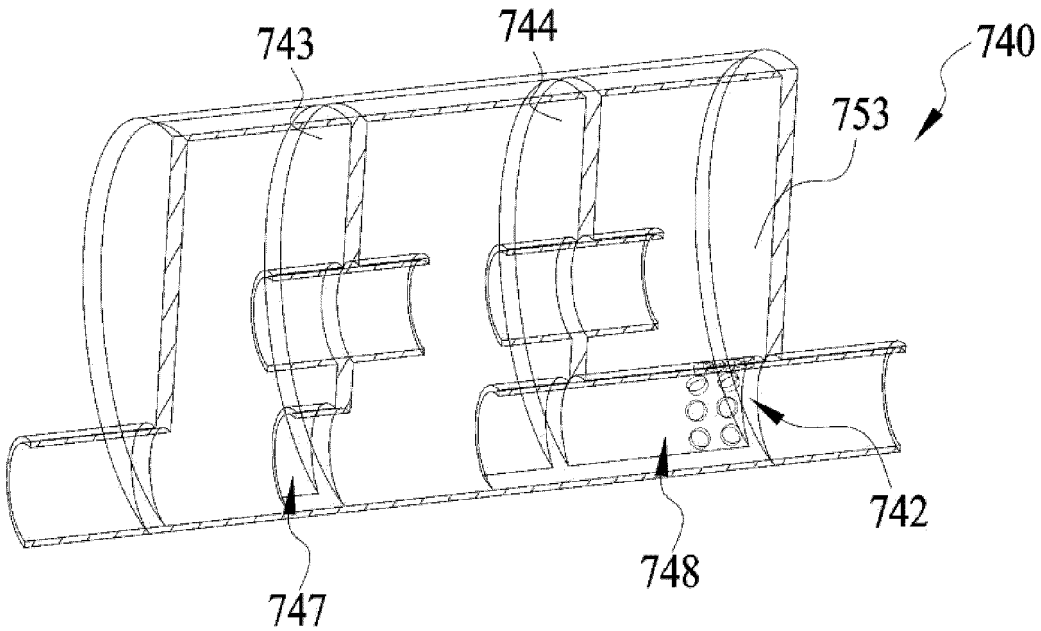
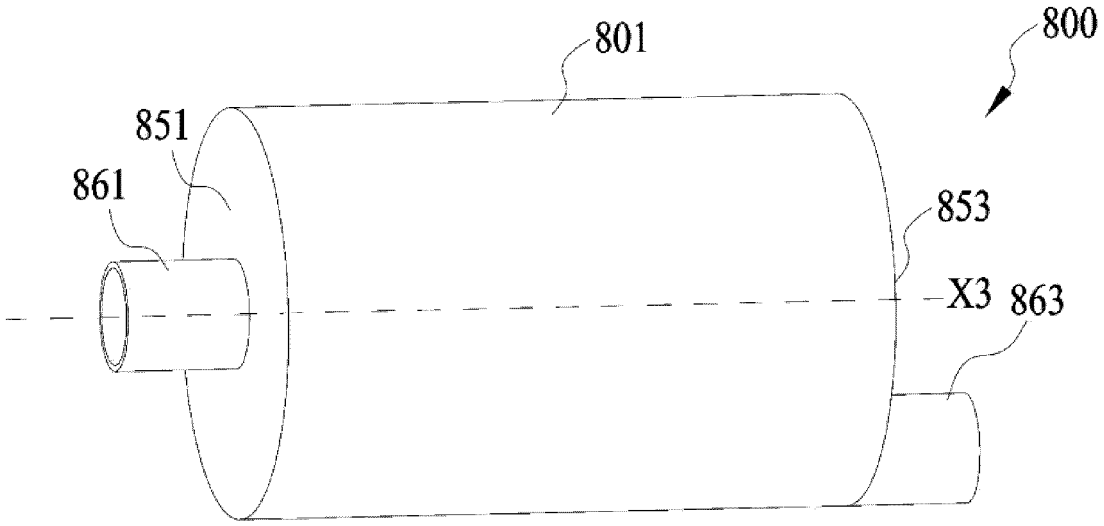


FIG. 7D


801
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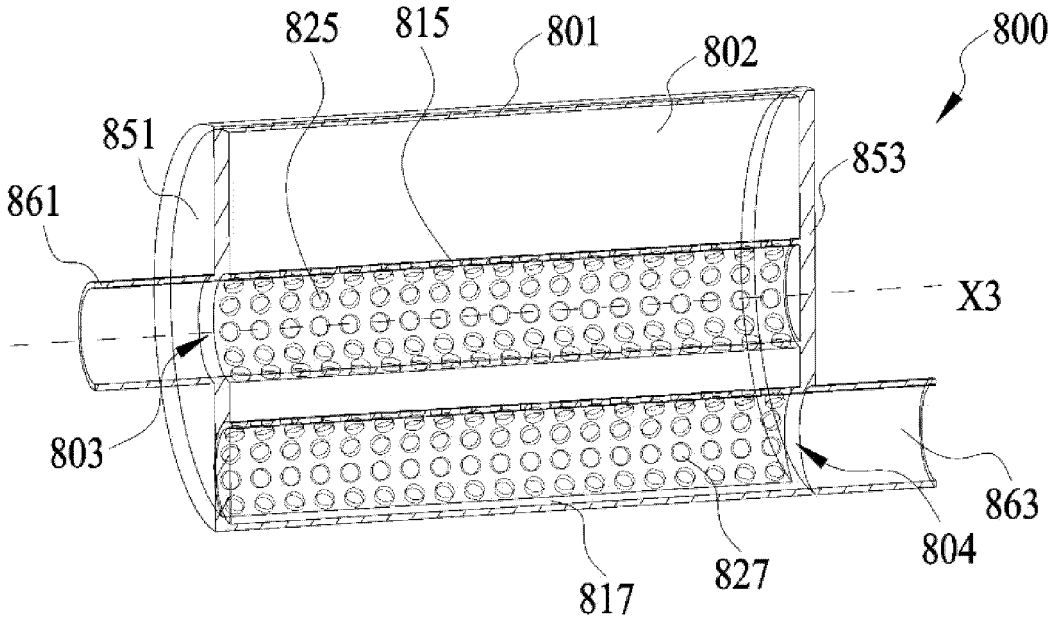
853
X3
863

FIG. 8A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853
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X3
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863
804
827
817

FIG. 8B

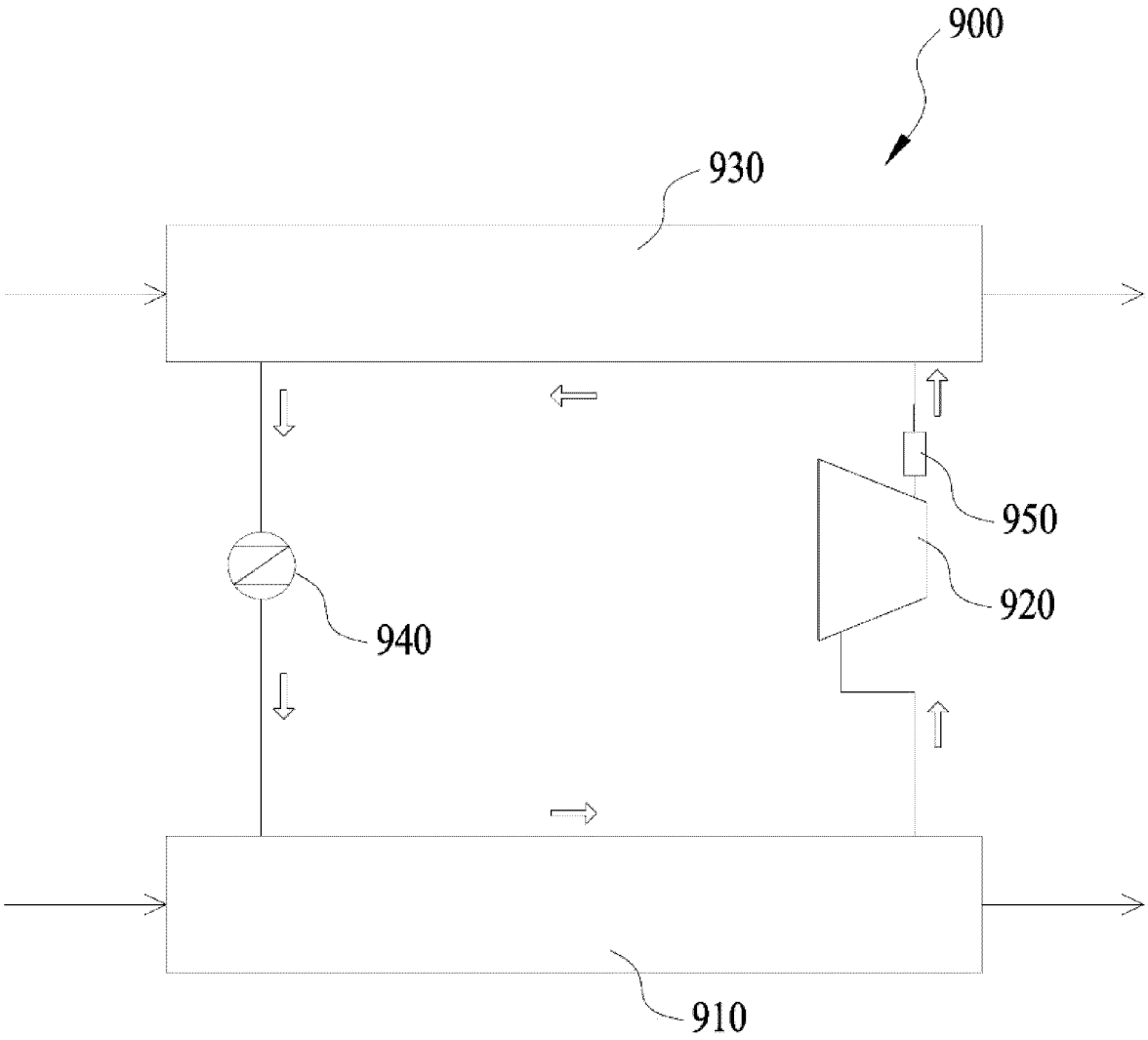

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/110530

A. CLASSIFICATION OF SUBJECT MATTER

F04C29/06(2006.01)i; F04C29/02(2006.01)i; F04C29/00(2006.01)i

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:F04C

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

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

CNABS, CNTXT, ENTXTC, CNKI: 消音器, 消声器, 隔板, 消声管, 消音管, 排液管, 排油管, 壳体, 外壳, 底部, 下部; VEN, EPTXT, USTXT, WOTXT: muffer, separate, plate, pipe, tube, drain, oil, liquid, water, shell, bottom, low.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 115419600 A (JOHNSON CONTROLS AIR-CONDITIONING & REFRIGERATION (WUXI) CO., LTD. et al.) 02 December 2022 (2022-12-02) description, paragraphs 3-75, and figures 1-9	1-16
A	CN 110145456 A (WUHU ABAUR MECHANICAL & ELECTRICAL CO., LTD.) 20 August 2019 (2019-08-20) description, paragraphs 3-45, and figures 1-3	1-16
A	CN 211397696 U (ZHENGZHOU RAILWAY VOCATIONAL & TECHNICAL COLLEGE) 01 September 2020 (2020-09-01) description, paragraphs 4-33, and figures 1-5	1-16
A	CN 102996215 A (JINTAN JIAYUE MACHINERY CO., LTD.) 27 March 2013 (2013-03-27) description, paragraphs 3-21, and figures 1-2	1-16
A	CN 204225978 U (CHERY AUTOMOBILE CO., LTD.) 25 March 2015 (2015-03-25) entire document	1-16
A	JP 2006307718 A (CALSONIC KANSEI CORP.) 09 November 2006 (2006-11-09) entire document	1-16

☐ 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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"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
06 November 2023	**12 November 2023**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/110530

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 115419600 A	02 December 2022	None	
CN 110145456 A	20 August 2019	CN 210371104 U	21 April 2020
CN 211397696 U	01 September 2020	None	
CN 102996215 A	27 March 2013	None	
CN 204225978 U	25 March 2015	None	
JP 2006307718 A	09 November 2006	None	

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