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(54) **REFRIGERANT COMPRESSOR PROVIDED WITH A SOUND DAMPER FOR AN AIR CONDTIONING UNIT**

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(57) **ABSTRACT**

The invention relates to a refrigerant compressor provided with a muffler for an air conditioning unit in a vehicle, wherein the refrigerant compressor includes a swash plate or pivoting ring rotatably supported in a casing of the refrigerant compressor for driving axially moving pistons arranged in cylinders, a suction side provided with an inlet channel and an inlet chamber, and a pressure side provided with an outlet channel and an outlet chamber. The muffler including a partition wall having a plurality of apertures formed therein is disposed in at least one of the suction side and the outlet side of the casing.

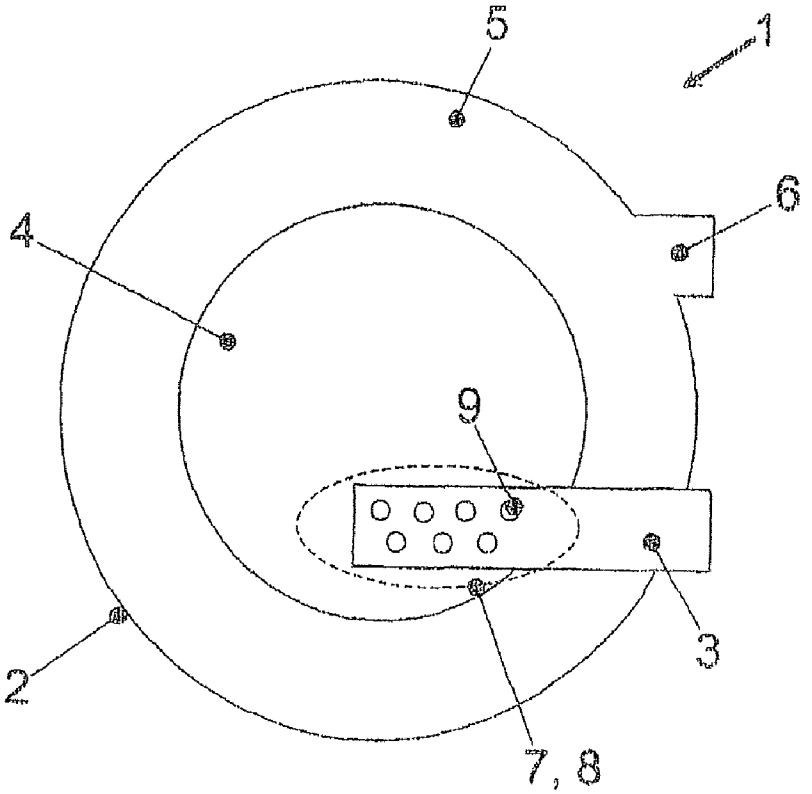


FIG. 1 - Prior Art

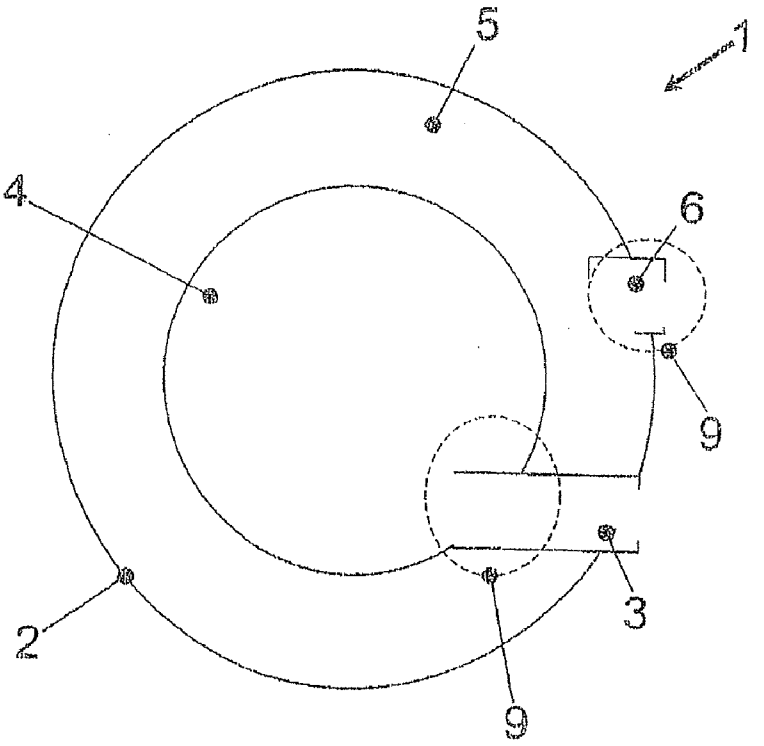


FIG. 2

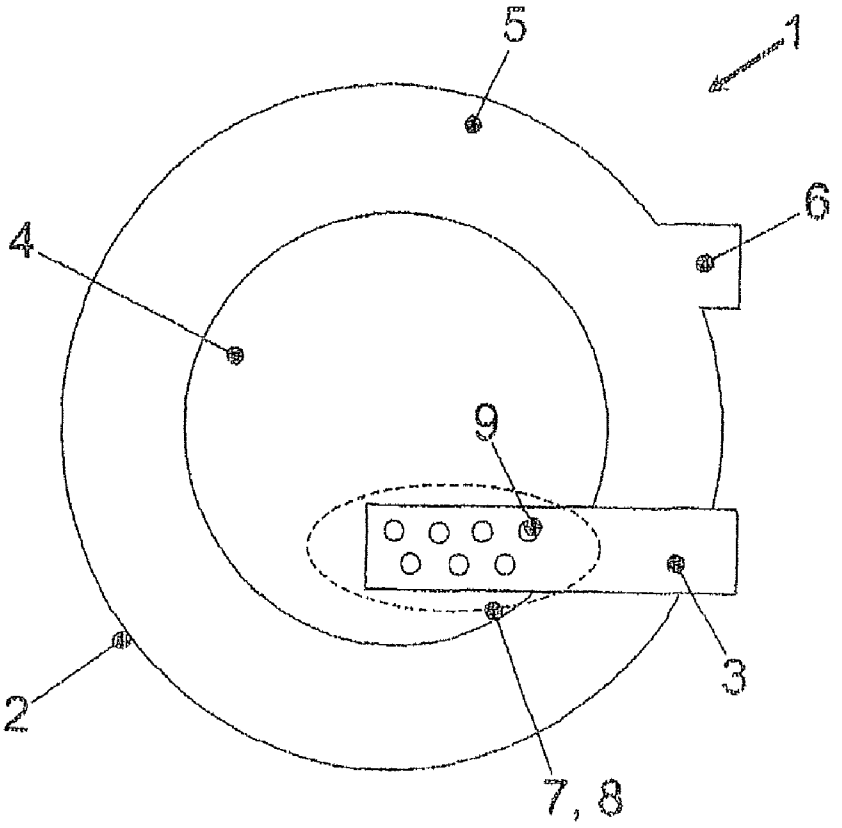


FIG. 3

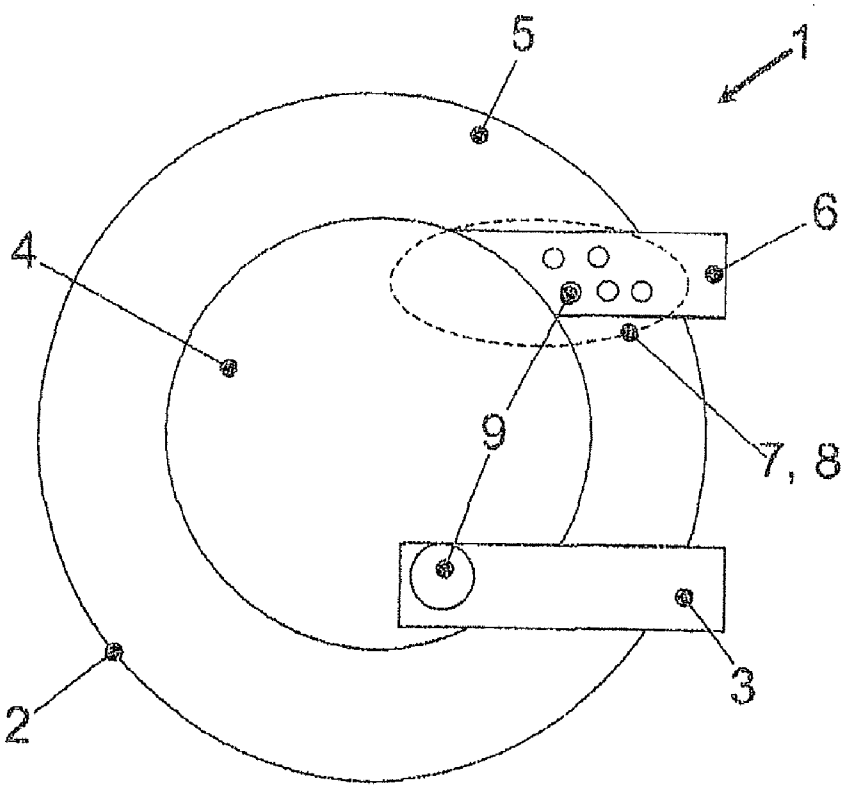
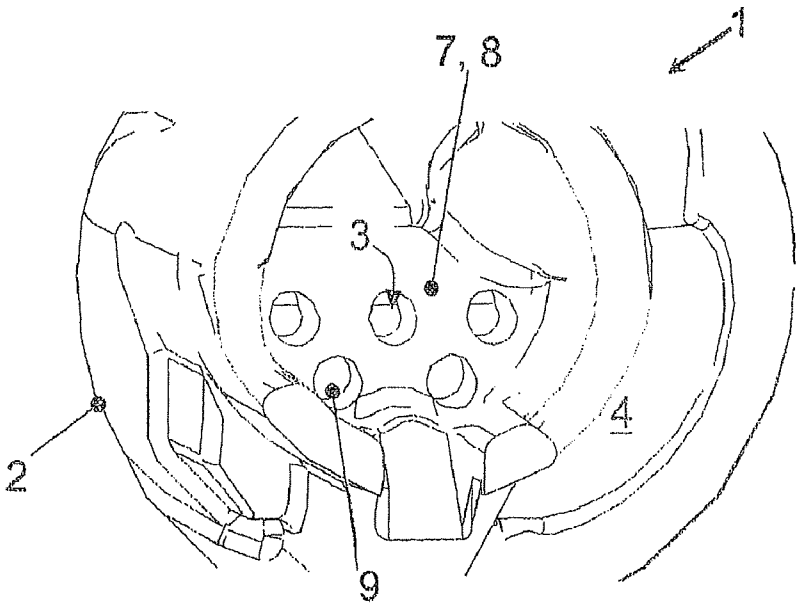


FIG. 4



REFRIGERANT COMPRESSOR PROVIDED WITH A SOUND DAMPER FOR AN AIR CONDTIONING UNIT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to German Patent Application Serial Number 102006044821.9-15, filed Sep. 14, 2006, the entire disclosure of which is hereby incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The invention relates to a refrigerant compressor provided with a muffler for an air conditioning unit in a vehicle, and more particularly to a muffler including a partition wall having a plurality of apertures formed therein.

BACKGROUND OF THE INVENTION

[0003] In vehicles, mufflers are used in order to damp noise, especially noise caused by pressure pulsations. The process of compression of a refrigerant such as CO_2, for example, in a compressor causes pressure pulsations which can be transmitted to an air conditioning unit over an inlet and an outlet of the compressor. The pressure pulsations can be perceived as unwanted noise in an interior of a vehicle by occupants of the vehicle.

[0004] In practice, different structures are used to reduce the noise by attenuating the pressure pulsation inside or outside of the compressor.

[0005] In DE 43 42 299 A1, a refrigerant compressor is disclosed for an air conditioning unit for use in a vehicle. The compressor includes a swash plate with axially moving pistons arranged in cylinder bodies, a suction side with a suction channel and inlet valves, and a high-pressure side with outlet valves. In the compressor, a damping device is disposed including a diffuser insert disposed in the suction channel. The diffuser insert includes an inflow pipe connection followed by a pipe with a closed face and a pipe jacket with holes. The holes form a fluid connection between the suction channel and the inflow pipe connection. A disadvantage of the invention is that the diffuser is an insert that has to be manufactured separately, which increases manufacturing costs and may cause incorrect flow in a sealing region of the suction or the pressure connections.

[0006] In DE 100 11 023 A1, a muffler for a connection to a pressure outlet of a compressor is disclosed. A partition wall is disposed between a bottom wall and a top wall dividing an interior of a casing into an inflow chamber and an outflow chamber. The partition wall includes a passage zone having several small holes. Parallel to the partition wall, a passage zone is at a distance to an inflow opening and an outflow opening. The partition wall is disposed such that a gaseous medium delivered by the compressor flows from the inflow opening through the inflow chamber to the passage zone and from the passage zone through the outflow chamber to the outflow opening.

[0007] A particular disadvantage of the muffler as an external component is the amount of assembly space for disposition of the compressor. In addition, the muffler can only be used on the high pressure side of the compressor.

[0008] Further, in U.S. Pat. No. 3,577,891, a swash plate compressor is disclosed having a muffler on a high-pressure side. The muffler comprises a stilling chamber into which a pipe leads which is established as a separate component and is provided with holes for a refrigerant. The pipe is disposed in a portion of the high-pressure channel. Two disadvantages of the invention are: (1) the pipe, as a separate component, increases manufacturing costs; and (2) the muffler is prevented from being used on the suction side of the swash plate compressor.

[0009] Furthermore, in EP 1 270 945 A1, a compressor is disclosed with a structure for pressure pulsation attenuation. The structure includes two holes distanced from each other that connect an outlet chamber to an outlet. The defined distance between both holes causes two pressure waves to develop with corresponding amplitudes. The superposition of which results in a pressure wave having a reduced amplitude, and hence, in sound damping of the pressure pulsations. However, the pressure pulsations generated by a refrigerant compressor capable of utilizing CO_2 are prevented from being sufficiently attenuated.

[0010] It would be desirable to produce a refrigerant compressor having a muffler for an air conditioning unit in a vehicle that efficiently attenuates pressure pulsations and is cost effective.

SUMMARY OF THE INVENTION

[0011] In concordance and agreement with the present invention, a refrigerant compressor having a muffler for an air conditioning unit in a vehicle that efficiently attenuates pressure pulsations and is cost effective, has been surprisingly discovered.

[0012] According to the concept of the invention, a refrigerant compressor having a muffler for an air conditioning unit in a vehicle includes a swash plate or pivoting ring rotatably supported in a casing of the refrigerant compressor for driving axially moving pistons arranged in cylinder bodies, a suction side provided with an inlet channel and an inlet chamber, and a pressure side provided with an outlet channel and an outlet chamber. A muffler is provided that includes a partition wall with a plurality of apertures.

[0013] In one embodiment, the partition wall is an integral component of the inlet channel and directed towards the inlet chamber, whereby the apertures allow a refrigerant of the low-pressure side to flow between the inlet channel and the inlet chamber.

[0014] In another embodiment, the partition wall is an integral component of the outlet channel and be directed towards the outlet chamber, whereby the apertures allow a refrigerant of the high-pressure side to flow between the outlet channel and the outlet chamber.

[0015] Favorable results have been found for CO_2 refrigerant compressors. However, the CO_2 causes more intense pressure pulsations than conventional refrigerants due to a high system pressure in the vehicle air conditioning unit. Therefore, pressure pulsation attenuation of refrigerant compressors capable of using CO_2 is of considerable importance.

[0016] An advantage of the invention is the feasibility of manufacturing the complex design of the muffler. The partition wall of the muffler is an integral component of the casing which can be manufactured in one process step together with the casing, rendering the invention more cost-efficient as compared to prior art. Furthermore, the integral partition wall of the muffler can be loaded with a higher system pressure.

[0017] The partition wall is an integral component of at least one of the inlet channel or the outlet channel, causing

the casing to be formed having a generally curved cross-sectional shape such as semicircular, for example, with the apertures in the curved wall extending substantially parallel to each other. The longitudinal axes of the apertures are substantially orthogonal to a direction of flow of the refrigerant into the inlet channel and to a direction of flow of the refrigerant out of the outlet channel. A face of the inlet channel and a face of the outlet channel are directed towards the inlet chamber and the outlet chamber, respectively. The faces are closed to be substantially media-tight. The apertures can be factory-made holes or capillaries with a defined flow cross-section.

[0018] Efficient pressure pulsation is achieved by dividing the flow into partial flows with the sum of the flow cross-sectional areas of all apertures in the partition wall being smaller than the flow cross-section area of the channel in which the partition is disposed. Therefore, according to the fundamentals of hydrodynamics, a hydrodynamic pressure proportion and a hydrostatic pressure proportion of the total refrigerant pressure are caused to interchange.

[0019] On the suction side of the refrigerant compressor, the reduction in cross-sectional area achieved by the apertures of the partition wall compared with the cross-sectional area of the inlet channel increases a hydrodynamic pressure and decreases a hydrostatic pressure of the refrigerant. When the refrigerant flows out of the apertures of the partition wall into the inlet chamber, the cross-sectional area increases, causing the hydrodynamic pressure and the hydrostatic pressure proportions to change.

[0020] On the pressure side of the refrigerant compressor, identical effects are achieved in that the reduction of the cross-sectional area by the apertures causes an increased hydrodynamic pressure and a decreased hydrostatic pressure of the refrigerant. When the refrigerant at a high pressure flows out of the apertures into the outlet channel, the hydrodynamic pressure and hydrostatic pressure proportions of the total refrigerant pressure are caused to change.

[0021] In another embodiment of the invention, the sum of the flow cross-sectional areas of all of the apertures in the partition wall is approximately 0.3 to 0.7 of the flow cross-sectional area of the inlet channel or the outlet channel. A smaller number of flow cross-sectional areas of all of the apertures in the partition wall is shown to improve the pressure pulsation attenuation. More generally, the flow cross-sectional area of the inlet channel or the outlet channel is always a multiple of the sum of the flow cross-sectional areas of all of the apertures in the partition wall. The minimum number of apertures in the partition wall is two, while a larger number of apertures improves pressure pulsation attenuation.

[0022] According to the invention, the reduction of the cross-sectional area for the refrigerant flow results in an increased pressure pulsation attenuation and, thus, a reduced perceptible noise in the interior of the vehicle and higher pressure losses. Therefore, the interdependent parameters are dimensioned such that a critical pressure loss of the refrigerant is not exceeded and a maximum pressure pulsation attenuation is optimized.

[0023] In order to ensure a high possible refrigerant mass flow, i.e. to avoid flow losses, the apertures of the suction side partition wall and the pressure side partition wall have different cross-sectional areas dependent on the positions of the apertures on the partition wall. The apertures disposed in a longer flow path of the refrigerant are formed to have larger cross-sectional areas to compensate for the lower pressures.

[0024] The arrangement of the apertures in the integral partition wall of the casing, or the division of the flow into several flow paths, leads to theoretically higher flow losses compared with only one opening. In another embodiment of the invention, the theoretical increase of the flow pressure losses of the refrigerant is lessened by forming the apertures such that the direction of the inflow of the refrigerant into the inlet channel or the direction of the outflow of the refrigerant out of the outlet channel is substantially curved or inclined with respect to the longitudinal axis of the inlet channel or the outlet channel, respectively. The apertures of the partition wall may be formed to have a generally circular, oval or angular cross-sectional shape, for example. For apertures having flow cross-sectional shapes other than circular, the hydraulic diameter is determined according to the formula

$$d_{hyd} = \frac{4A}{U}.$$

[0025] Experiments have shown that when CO_2 is used as a refrigerant, efficient pressure pulsation attenuation is achieved by forming five apertures in the partition wall. Each aperture having a circular diameter of 3 mm.

[0026] Several advantages and features of the invention over prior art are:

[0027] Division of the flow into several partial flows;

[0028] Multiple interchange of the hydrodynamic and hydrostatic pressure proportions of the total refrigerant pressure reflects the pressure waves, thereby efficiently reducing the pressure pulsations of the refrigerant and the operational noise perceived by the vehicle occupants;

[0029] Optional placement of the partition wall in both the suction side between the inlet channel and the inlet chamber and the pressure side between the outlet chamber and the outlet channel;

[0030] Higher pressure loadability of the compressor casing resulting from the use of the integral partition wall;

[0031] Less space required for the refrigerant compressor as a result of functional integration of the muffler, rendering the refrigerant compressor suitable for use in smaller engine bays; and

[0032] Lower manufacturing costs resulting from reduced material and manufacturing demand because the partition wall is an integral part of the casing.

DESCRIPTION OF THE DRAWINGS

[0033] The objects and advantages of the present invention will become readily apparent to those skilled in the art from the following detailed description of the exemplary, not-limiting embodiments here preferred when considered in the light of the accompanying drawings in which is shown by:

[0034] FIG. **1** is a schematic of a refrigerant compressor from prior art;

[0035] FIG. **2** is a schematic of a refrigerant compressor provided with a muffler including a partition wall having a

plurality of apertures disposed in a suction-side of the compressor according to an embodiment of the invention;

[0036] FIG. **3** is a schematic of a refrigerant compressor provided with a muffler including a partition wall having a plurality of apertures disposed in a pressure-side of the compressor according to another embodiment of the invention; and

[0037] FIG. **4** is a perspective view of a refrigerant compressor with an inlet channel and an inlet chamber.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0038] The following detailed description and appended drawings describe and illustrate various exemplary embodiments of the invention. The description and drawings serve to enable one skilled in the art to make and use the invention, and are not intended to limit the scope of the invention in any manner.

[0039] FIG. **1** shows a refrigerant compressor **1** of prior art. The refrigerant compressor **1** includes a casing **2**, an inlet channel **3** leading into a inlet chamber **4** having a generally circular cross-sectional shape, an outlet chamber **5** having a generally annular cross-sectional shape surrounding the inlet chamber **4**, and an outlet channel **6** which in a direction of a flow of a compressed refrigerant is disposed subsequently to the outlet chamber **5**.

[0040] As clearly shown in FIG. **1**, the inlet channel **3** having a substantially uniform cross-section is formed to extend through the outlet chamber **5**. The refrigerant flows into the inlet chamber **4** passing through a face-side opening, or through an unobstructed cross-sectional area of the inlet channel **3**. The outlet channel **6** having a substantially uniform cross-section is formed to militate against the acceleration and deceleration of the refrigerant flowing from the outlet chamber **5** into the outlet channel **6**, as there is only one face-side opening, or unobstructed cross-section of the outlet channel **6**. The refrigerant drawn into and through the inlet chamber **4** flows in direction of the longitudinal axis of the inlet channel **3**, and the compressed refrigerant drawn into and through the outlet chamber **5** flows in direction of the longitudinal axis of the outlet channel **6**.

[0041] FIG. **2** illustrates a refrigerant compressor **1** according to an embodiment of the invention provided with a muffler **8** disposed in a suction side of the compressor **1**. The basic structure of the refrigerant compressor **1** is similar to the refrigerant compressor illustrated in FIG. **1**. The muffler **8** includes a partition wall **7** having a plurality of apertures **9** formed therein. The partition wall **7** is an integral component of an inlet channel **3** and thus also of a casing **2**. An inlet chamber **4** extends from a first distal end passing through an annular outlet chamber **5** to a second distal end, which ends within the inlet chamber **4**. In the region of the second distal end, which ends within the inlet chamber **4**, the apertures **9** of the partition wall **7** are adapted for the flow of a refrigerant therethrough. In the embodiment shown, the partition wall **7** includes seven apertures **9** disposed in two rows. The second distal end of the inlet channel **3**, the distal end ending within the inlet chamber **4**, has a face side which is substantially closed tight to mediums. All apertures **9** are substantially equidistant from each other for hydrodynamic reasons such that neighboring apertures **9** of a row and neighboring apertures **9** of column are substantially equidistant from each other.

[0042] A direction of flow of the refrigerant follows from the position of the apertures **9**, which extend substantially orthogonal to a longitudinal axis of the inlet channel **3** and substantially parallel to each other. Therefore, the direction of flow is generally redirected about 90 degrees within the inlet channel **3**, resulting in a flow pressure loss. The flow pressure loss is compensated for by a greater number of apertures **9**. However, the number and cross-sectional area of the apertures **9** are dependent on the cross-sectional area of the inlet channel **3** such as the sum of the cross-sectional areas of all apertures **9** formed in the partition wall **7** is equal to 0.5-fold of the cross-sectional area of the inlet channel **3**. In contrast, the outlet channel **6** has only one aperture **9** formed in the direction of the longitudinal axis of the outlet channel **6**. The aperture **9** is formed by the face of the outlet channel **6**, the face being open in the direction of the outlet chamber **5**.

[0043] FIG. **3** shows a refrigerant compressor **1** according to another embodiment of the invention having a muffler **8** for pressure pulsation attenuation disposed in the pressure side of the refrigerant compressor **1**. The basic structure of the refrigerant compressor **1** is similar to the refrigerant compressor illustrated in FIGS. **1** and **2**. The muffler **8** includes a partition wall **7** and is an integral component of an outlet channel **6** and thus a casing **2**. Within the partition wall **7**, in the region of an outlet chamber **5**, a plurality of apertures **9** is formed therein substantially parallel and equidistant to each other. In the embodiment shown, the partition wall **7** includes five apertures formed therein.

[0044] A flow connection between the outlet chamber **5** and the outlet channel **6** for a compressed refrigerant is achieved through the apertures **9**. The inlet channel **3** extending through the annular outlet chamber **5** includes at least one aperture **9**. In the embodiment shown, the inlet channel **3** includes one aperture **9** which corresponds to the cross-section of the inlet channel **3**. The face of the inlet channel **3**, which is directed towards the inlet chamber **4**, and the face of the outlet channel **6**, which is directed towards the outlet chamber **5**, are substantially closed tight to mediums.

[0045] The apertures **9** of the partition wall **7** of the muffler **8** disposed in the pressure side and the aperture **9** leading into the inlet chamber **4** of the inlet channel **3** are formed substantially orthogonal to the direction of inflow of the refrigerant into the refrigerant compressor **1** and orthogonal to the direction of outflow of the refrigerant out of the refrigerant compressor **1**, respectively. Therefore the flow of refrigerant into the inlet chamber **4** and the outlet channel **6** subsequent the pressure increase is redirected.

[0046] The path of the inventive idea will not be left even if both the inlet channel **3** and the outlet channel **6** of the refrigerant compressor **1** are provided with a muffler **8** including a partition wall **7** having a plurality of apertures **9**.

[0047] FIG. **4** illustrates a refrigerant compressor **1** provided with a muffler **8** according to another embodiment of the invention. In the embodiment shown, the muffler **8** includes a partition wall **7** having five apertures **9**. The partition wall **7**, which limits an inlet chamber **4** against an inlet channel **3**, is an integral component of the cylindrical inlet channel **3** and therefore a casing **2**. The apertures **9** are disposed in at least one row, each aperture **9** having a generally circular cross-section. A flow connection between an inlet channel **3** and an inlet chamber **4** for a refrigerant drawn into and through the inlet channel **3** into the inlet chamber **4** is achieved through the apertures **9**.

[0048] From the foregoing description, one ordinarily skilled in the art can easily ascertain the essential characteristics of this invention and, without departing from the spirit and scope thereof, can make various changes and modifications to the invention to adapt it to various usages and conditions.

NOMENCLATURE

1	refrigerant compressor
2	casing
3	inlet channel
4	inlet chamber
5	outlet chamber
6	outlet channel
7	partition wall
8	muffler
9	apertures

What is claimed is:

1. A muffler comprising:

a partition wall disposed in a casing to reflect fluid pressure waves, and thereby minimize fluid pressure pulsations, wherein the casing includes an inlet having an inlet channel and an inlet chamber in fluid communication with an outlet having an outlet channel and an outlet chamber; and

at least two apertures formed in the partition wall.

2. The muffler according to claim **1**, wherein the partition wall is disposed in at least one of the inlet channel and the outlet channel.

3. The muffler according to claim **1**, wherein the partition wall has a generally arcuate cross-sectional shape.

4. The muffler according to claim **1**, wherein the apertures are formed substantially orthogonal to a flow of a fluid through at least one of the inlet and the outlet.

5. The muffler according to claim **1**, wherein the apertures are equidistant from each other.

6. The muffler according to claim **1**, wherein the partition wall and associated apertures facilitate an interchange of hydrodynamic and hydrostatic pressure proportions of a total fluid pressure.

7. The muffler according to claim **1**, wherein a sum of cross-sectional areas of the apertures is less than a cross-sectional area of at least one of the inlet channel and the outlet channel.

8. The muffler according to claim **7**, wherein the sum of cross-sectional areas of the apertures is in the range of 0.3 to 0.7 of the cross-sectional area of at least one of the inlet channel and the outlet channel.

9. The muffler according to claim **7**, wherein the cross-sectional area of the apertures is dependent on a disposition of the partition wall in the casing, whereby the apertures disposed in a longer fluid flow path are formed having a larger cross-sectional area to compensate for a fluid pressure loss.

10. The muffler according to claim **7**, wherein a fluid pressure pulsation attenuation is dependent on the cross-sectional area of the apertures, whereby the fluid pressure pulsation attenuation increases as the cross-sectional area of the apertures decreases.

11. The muffler according to claim **1**, wherein the partition wall includes five apertures having a circular diameter of 3 mm.

12. The muffler according to claim **1**, wherein the partition wall is formed as an integral part of the casing.

13. The muffler according to claim **1**, wherein the muffler is disposed in a refrigerant compressor.

14. A muffler assembly comprising:

a casing having an inlet in fluid communication with an outlet, wherein the inlet includes an inlet channel and an inlet chamber and the outlet includes an outlet channel and an outlet chamber; and

a partition wall having a generally arcuate cross-sectional shape integrally formed with the casing in at least one of the inlet channel and the outlet channel to reflect fluid pressure waves and thereby minimize fluid pressure pulsations, the partition wall having a plurality of apertures formed therein substantially orthogonal to a flow of a fluid through at least one of the inlet and the outlet and substantially equidistant from each other to facilitate an interchange of hydrodynamic and hydrostatic pressure proportions of a total fluid pressure, wherein a sum of cross-sectional areas of the apertures is less than a cross-sectional area of the at least one of the inlet channel and the outlet channel and dependent on a disposition of the partition wall in the casing, whereby the apertures disposed in a longer fluid flow path are formed having a larger cross-sectional area to compensate for a fluid pressure loss, and wherein the minimized fluid pressure pulsation is dependent on the cross-sectional area of the apertures, whereby a fluid pressure pulsation attenuation increases as the cross-sectional area of the apertures decreases.

15. The muffler assembly according to claim **14**, wherein the sum of cross-sectional areas of the apertures is in the range of 0.3 to 0.7 of the cross-sectional area of the at least one of the inlet channel and the outlet channel.

16. The muffler assembly according to claim **14**, wherein the partition wall includes five apertures having a circular diameter of 3 mm.

17. The muffler assembly according to claim **14**, wherein the muffler is disposed in a refrigerant compressor.

18. A compressor comprising:

a casing having a swash plate rotatably supported therein for driving a plurality of axially moving pistons disposed in a plurality of cylinders;

an inlet including an inlet channel and an inlet chamber formed in the casing,

an outlet including an outlet channel and an outlet chamber formed in the casing in fluid communication with the inlet; and

a muffler disposed in at least one of the inlet and the outlet, the muffler including a partition wall having a generally arcuate cross-sectional shape integrally formed with the casing in at least one of the inlet channel and the outlet channel to reflect fluid pressure waves and thereby minimize fluid pressure pulsation, the partition wall having a plurality of apertures formed therein substantially orthogonal to a flow of a fluid through at least one of the inlet and the outlet and substantially equidistant from each other to facilitate an interchange of hydrodynamic and hydrostatic pressure proportions of a total fluid pressure, wherein a sum of cross-sectional areas of the apertures is less than a cross-sectional area of the at least one of the inlet

channel and the outlet channel and dependent on a disposition of the partition wall in the casing, whereby the apertures disposed in a longer fluid flow path are formed having a larger cross-sectional area to compensate for a fluid pressure loss, and wherein the minimized fluid pressure pulsation is dependent on the cross-sectional area of the apertures, whereby a fluid pressure pulsation attenuation increases as the cross-sectional area of the apertures decreases.

19. The compressor according to claim **18**, wherein the sum of cross-sectional areas of the apertures is in the range of 0.3 to 0.7 of the cross-sectional area of the at least one of the inlet channel and the outlet channel.

20. The compressor according to claim **18**, wherein the partition wall includes five apertures having a circular diameter of 3 mm.

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