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(54) AIR CONDITIONING APPARATUS

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(57) **ABSTRACT**

An air conditioning apparatus is provided whereby the pressure pulsation generated by a compressor can be entirely reduced both during cooling and during heating, and a muffler can be shared. The air conditioning apparatus has a refrigerant circuit. The refrigerant circuit is configured so that a compressor for compressing a refrigerant, an indoor heat exchanger, an outdoor heat exchanger, and a four-way switch valve are connected via a refrigerant pipe. The four-way switch valve switches the flow of refrigerant compressed by the compressor to either the indoor heat exchanger or the outdoor heat exchanger. The air conditioning apparatus further includes a pressure pulsation reducing component. The pressure pulsation reducing component is provided between the four-way switch valve and the indoor heat exchanger. The pressure pulsation reducing component reduces pressure pulsation inside the refrigerant circuit. The pressure pulsation is generated by the compressor.

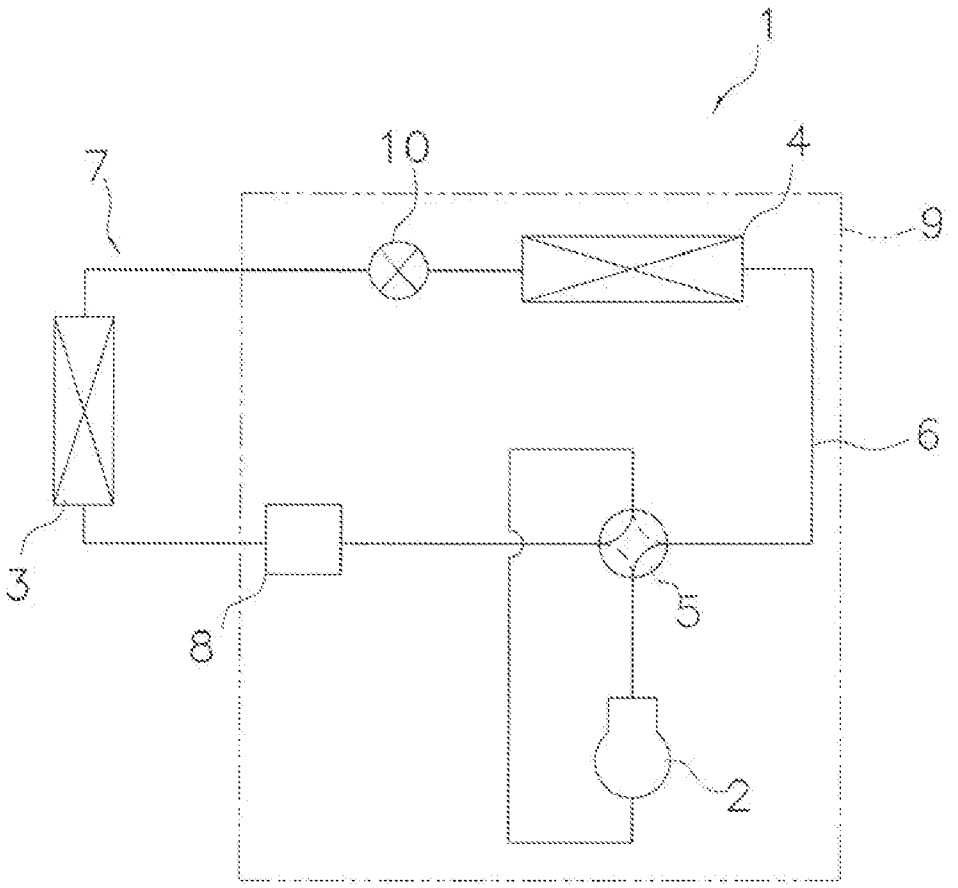


FIG. 1

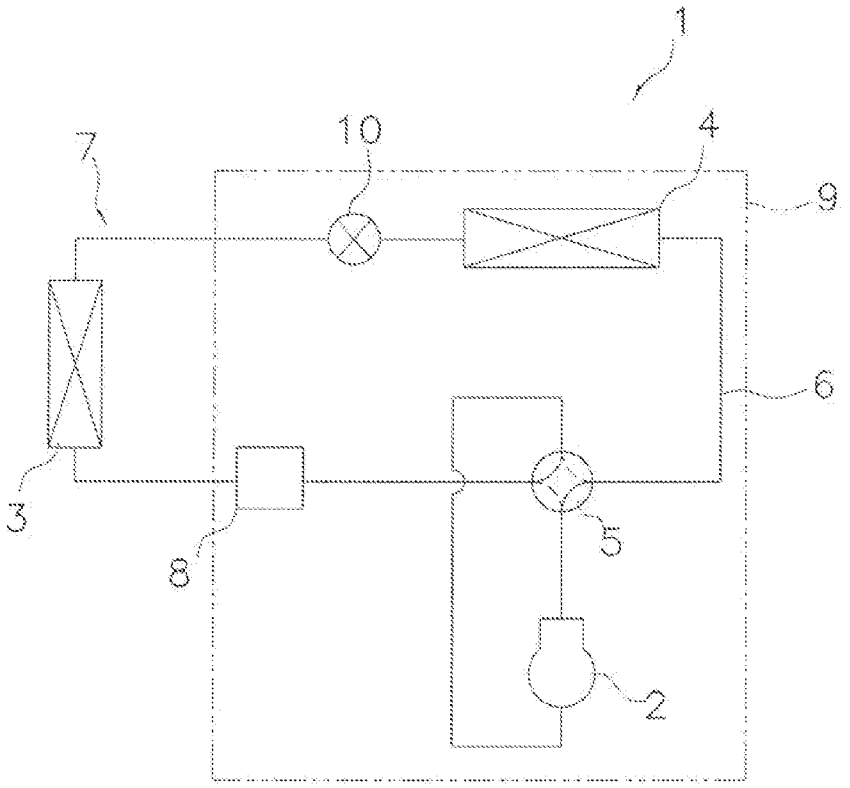


FIG. 2

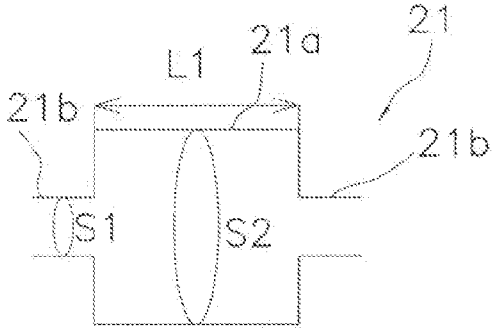


FIG. 3

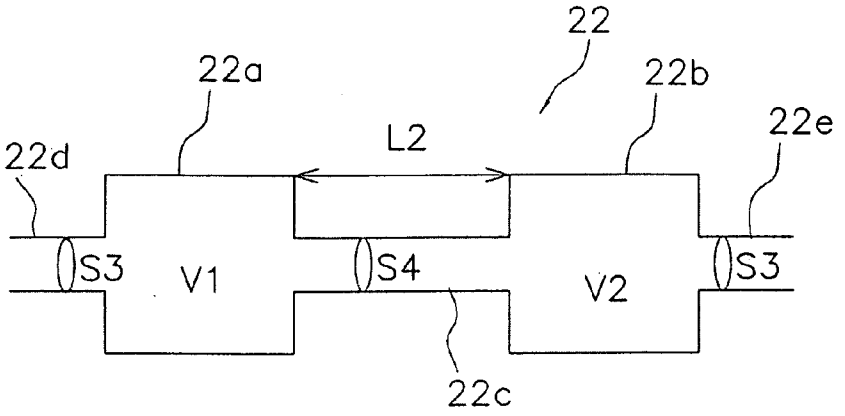


FIG. 4

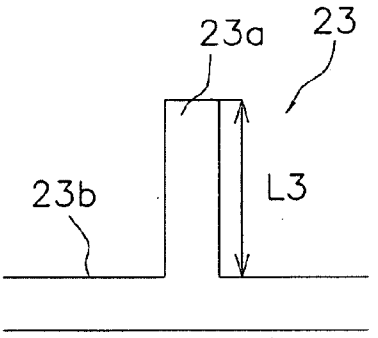
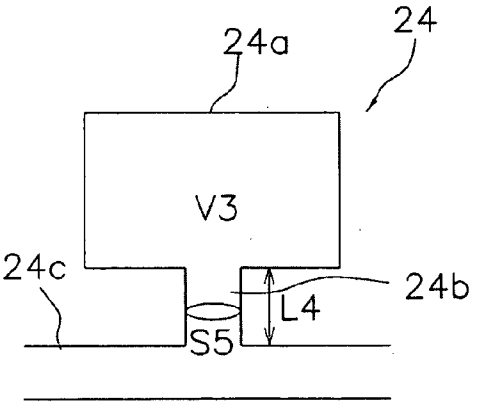


FIG. 5



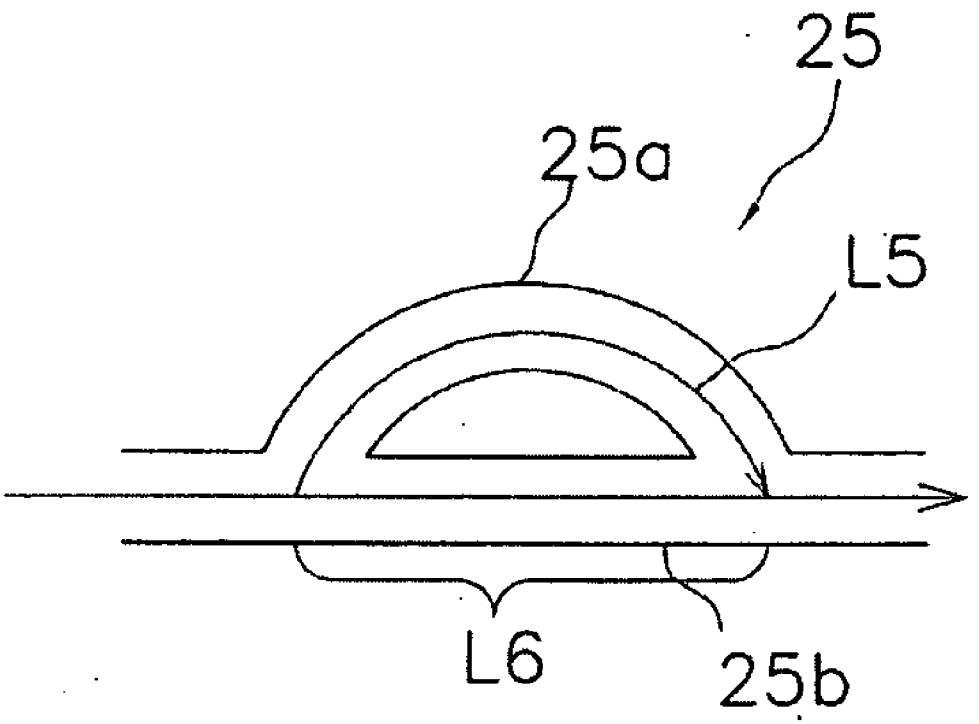


FIG. 6

AIR CONDITIONING APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to an air conditioning apparatus provided with a refrigerant circuit that includes a compressor.

BACKGROUND ART

[0002] Conventional refrigerant circuits have problems in that pressure pulsation generated by a compressor is propagated through a refrigerant pipe into an indoor refrigerant pipe near the indoor units, and vibration and/or abnormal noise is generated from the indoor refrigerant pipe arid the indoor units. An air conditioning apparatus has therefore been disclosed in Patent Document 1, in which a single muffler is provided between the compressor and a four-way switch valve in order to suppress the propagation of pressure pulsation to the indoor refrigerant pipe.

[0003] <Patent Document 1> Japanese Laid-open Patent Publication No. 9-250831

DISCLOSURE OF THE INVENTION

Problems the Invention is Intended to Solve

[0004] In the case of the air conditioning apparatus disclosed in Patent Document 1, the pressure pulsation can be reduced by the muffler when the pulsation generated by the compressor is directed toward the indoor units via the four-way switch valve (i.e., in the ease of suction pulsation during heating, and exhaust pulsation during cooling). However, when the pulsation generated by the compressor is directed toward the indoor units and not through the four-way switch valve (i.e., in the case of exhaust pulsation during heating, and suction pulsation during cooling), the pressure pulsations do not pass through the muffler, and it is therefore impossible both during cooling and heating to entirely reduce the pressure pulsation generated by the compressor through the use of the muffler before the pressure pulsation reaches the indoor refrigerant pipe near the indoor units.

[0005] Further, providing a muffler to both the suction side and the exhaust side of the compressor has a problem in that it increases the number of components and the manufacturing cost.

[0006] An object of the present invention is to provide an air conditioning apparatus wherein the pressure pulsation generated by the compressor can be entirely reduced during cooling as well as during heating and it is capable of muffler sharing.

Means for Solving These Problems

[0007] An air conditioning apparatus according to a first aspect of the present invention is an air conditioning apparatus comprising a refrigerant circuit. The refrigerant circuit is configured so that a compressor for compressing a refrigerant, an indoor heat exchanger, an outdoor heat exchanger, and a four-way switch valve are connected via a refrigerant pipe. The four-way switch valve switches the flow of refrigerant compressed by the compressor to either the indoor heat exchanger ox the outdoor heat exchanger. The air conditioning apparatus further comprises a pressure pulsation reducing component. The pressure pulsation reducing component is provided between the four-way switch valve and the indoor heat exchanger. The pressure pulsation reducing component reduces pressure pulsation inside the refrigerant circuit. The pressure pulsation is generated by the compressor.

[0008] In this configuration, since the pressure pulsation reducing component is provided, between the four-way switch valve and the indoor heat exchanger, the pressure pulsation generated by the compressor can be entirely reduced before reaching the indoor refrigerant pipe both during cooling and during heating in the case of an air conditioning apparatus that switches between cooling and heating. Further, a muffler used tor reducing pressure pulsations can be shared, and the number of components can be reduced.

[0009] An air conditioning apparatus according to a second aspect of the present invention is the air conditioning apparatus of the first aspect, wherein the pressure pulsation reducing component is provided within an outdoor unit. The compressor and the outdoor heat exchanger are housed in the outdoor unit.

[0010] Since the pressure pulsation reducing component is provided within the outdoor unit in which the compressor and the outdoor heat exchanger are housed, the pressure pulsation reducing component is easily installed and maintained. Moreover, since the pressure pulsation reducing component is installed at the position near the compressor, which is the source of the pressure pulsation, within the refrigerant circuit, the pressure pulsation reducing effects thereof are significant.

[0011] An air conditioning apparatus according to a third aspect of the present invention is the air conditioning apparatus of the first or second aspect, wherein the refrigerant is CO_2.

[0012] In this configuration, CO_2 is used as the refrigerant, and pressure pulsations are more significant compared with other refrigerants, but pulsations can be reduced both during cooling and during heating by the pressure pulsation reducing component provided between the four-way switch valve and the indoor heat exchanger. A CO_2 refrigerant has low global warming potential and enables products that are environmentally friendly. The CO_2 refrigerant also has high refrigeration capacity per unit volume, and a cylinder tor achieving the same capacity as other refrigerants can be reduced in size, and the compressor can also be reduced in size.

[0013] An air conditioning apparatus according to a fourth aspect of the present invention is the air conditioning apparatus of any of the first through third aspects, wherein the pressure pulsation reducing component is a vessel having a muffler function.

[0014] In this configuration, since the pressure pulsation reducing component is a vessel having a muffler function, not only can pressure pulsations be reduced, but liquid-vapor separation of the refrigerant is also possible inside the vessel.

[0015] An air conditioning apparatus according to a fifth aspect of the present invention is the air conditioning apparatus of any of the first through fourth aspects, wherein the pressure pulsation reducing component is one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference muffler.

[0016] In this configuration, because the pressure pulsation reducing component is one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference

muffler, pressure pulsation can be effectively reduced using these conventionally known mufflers.

Effect of the Invention

[0017] According to the first aspect, the pressure pulsation generated by the compressor can be entirely reduced before reaching the indoor refrigerant pipe both during cooling and during heating. A muffler used for reducing pressure pulsations can also be shared, and the number of components can be reduced.

[0018] According to the second aspect, the pressure pulsation reducing component is easily installed and maintained, and the pressure pulsation reducing effects of the pressure pulsation reducing component are significant.

[0019] According to the third aspect, although pressure pulsations are more significant compared with other refrigerants, pulsations can be reduced both during cooling and during heating by the pressure pulsation reducing component provided between the four-way switch valve and the Indoor heat exchanger. A CO_2 refrigerant has low global warming potential and enables products that are environmentally friendly. A CO_2 refrigerant also has high refrigeration capacity per unit volume, and a cylinder for achieving the same capacity as other refrigerants can be reduced in size, and the compressor can also be reduced in size.

[0020] According to the fourth aspect, not only can pressure pulsations be reduced, but liquid-vapor separation of the refrigerant is also possible inside the vessel.

[0021] According to the fifth aspect, pressure pulsation can be effectively reduced using a conventionally known muffler.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. **1** is a schematic diagram showing an air conditioning apparatus according to an embodiment of the present invention.

[0023] FIG. **2** is a schematic diagram showing an expansion muffler as a specific example of a pressure pulsation reducing component of FIG. **1**.

[0024] FIG. **3** is a schematic diagram showing a π-type filter as a specific example of the pressure pulsation reducing component of FIG. **1**.

[0025] FIG. **4** is a schematic diagram showing a side branch muffler as a specific example of the pressure pulsation reducing component of FIG. **1**.

[0026] FIG. **5** is a schematic diagram showing a Helmholtz muffler as a specific example of the pressure pulsation reducing component of FIG. **1**.

[0027] FIG **6** is a schematic diagram showing an interference muffler as a specific example of the pressure pulsation reducing component of FIG **1**.

KEY

[0028] **1** air conditioning apparatus
2 compressor
3 indoor heat exchanger
4 outdoor heat exchanger
5 four-way switch valve
6 refrigerant pipe
7 refrigerant circuit
8 pressure pulsation reducing component
9 outdoor unit

BEST MODE FOR CARRYING OUT THE INVENTION

[0029] An air conditioning apparatus **1** shown in FIG. **1** is capable of both a cooling operation and a heating operation, and is provided with a refrigerant circuit **7** configured so that a compressor **2** for compressing a CO_2 refrigerant; an indoor heat exchanger **3**; an outdoor heat exchanger **4**; a four-way switch valve **5** for switching the flow of refrigerant compressed by the compressor **2** to either the indoor heat exchanger **3** or outdoor heat exchanger **4**; and an electromagnetic expansion valve **10** are connected via a refrigerant pipe **6**. The air conditioning apparatus **1** is further provided with a pressure pulsation reducing component **8** for reducing pressure pulsation that is generated by the compressor **2** within the refrigerant circuit **7**.

[0030] The pressure pulsation reducing component **8** is provided between the four-way switch valve **5** arid the indoor heal exchanger **3**. Therefore, the pressure pulsation generated by the compressor can be entirely reduced both during cooling and during healing in the case of the air conditioning apparatus **1** that switches between cooling and heating. The muffler used for reducing pressure pulsations can also be shared, and the number of components can be reduced.

[0031] The pressure pulsation reducing component **8** is provided within an outdoor unit **9** in which the compressor **2** and outdoor heat exchanger **4** are housed.

[0032] In the air conditioning apparatus **1**, CO_2 is used as the refrigerant. The pressure pulsations of a CO_2 refrigerant are more significant than the pressure pulsations of other refrigerants, but pulsations can be reduced both during cooling and during heating by the pressure pulsation reducing component **8** provided between the four-way switch valve **5** and the indoor heat exchanger **3**.

[0033] The pressure pulsation reducing component **8** is specifically one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference muffler.

[0034] As shown in FIG. **2**, an expansion muffler **21** has an expansion portion **21***a* and straight pipe portions **21***b* connected on both sides thereof. The cross-sectional area S**2** of the expansion portion **21***a* is larger than the cross-sectional area S**1** of the straight pipe portions **21***b*.

[0035] The value of the transmission loss TL of the expansion muffler **21** is indicated by the equation below.

$$TL=10\times\log(1+1/4\times(m-1/m)^2\times\sin^2(K\times L1)) \quad \text{(Eq.1)}$$

[0036] In the equation, L**1** is the length of the expansion portion **21***a*, m=S**2**/S**1**, and k=2πf/c, wherein c is the speed of sound.

[0037] As shown in FIG. **3**, a π-type filter **22** has a first expansion portion **22***a*, a second expansion portion **22***b*, a connecting pipe portion **22***c*, a first straight pipe portion **22***d*, and a second straight pipe portion **22***e*. The connecting pipe portion **22***c* connects the first expansion portion **22***a* and the second expansion portion **22***b*. The first straight pipe -portion **22***d* is connected on the opposite side from the connecting pipe portion **22***c* in the first expansion portion **22***a*. The second straight pipe portion **22***e* is connected on the opposite side from the connecting pipe portion **22***c* in the second expansion portion **22***b*. Each of the cross-sectional areas of the first expansion portion **22***a* and the second expansion portion **22***b*

are larger than cross-sectional areas S3, S4 of the connecting pipe portion **22***c*, and the first straight pipe portion **22***d* and second-straight pipe portion **22***e*, respectively.

[0038] The value of the transmission loss TL of the π-type filter **22** is as shown below. (Note that L**2** is the length of the connecting pipe portion **22***c*, V**1** is the volume of the first expansion portion **22***a*, V**2** is the volume of the second expansion portion **22***b*, S**3** is the cross-sectional area of each of the first straight pipe portion **22***d* and the second straight pipe portion **22***e*, and S**4** is the cross-sectional area of the connecting pipe portion **22***c*.)

$$TL=10\times\log(\sigma^2) \quad \text{(Eq. 2)}$$

[0039] In the equation, $\sigma=V^2\times\omega^3\times L2/(S3\times S4\times c^3)$, wherein c is the speed of sound.

[0040] As shown in FIG. **4**, a side branch muffler **23** has a branch, portion **23***a* and a straight pipe portion **23***b*. The brunch portion **23***a* branches at a right angle from the straight pipe portion **23***b*.

[0041] The frequency f of the side branch muffler **23** is as shown below.

$$f=c/(4\times L3) \quad \text{(Eq. 3)}$$

[0042] In the equation, L**3** is die length of the branch portion **23***a*, and c is die speed of sound.

[0043] As shown in FIG. **5**, a Helmholtz muffler **24** has an expansion portion **24***a*, a connecting pipe portion **24***b*, and a straight pipe portion **24***c*. The connecting pipe portion **24***b* branches at a right angle from the straight pipe portion **24***c*. The connecting pipe portion **24***b* connects the expansion portion **24***a* and the straight pipe portion **24***c*. The cross-sectional area of the expansion portion **24***a* is larger than the cross-sectional area of each of the connecting pipe portion **24***b* and the straight pipe portion **24***c*.

[0044] The frequency f of the Helmholtz muffler **24** is as shown below.

$$F=c/2\pi\times\sqrt{(S5/(V3\times L4))} \quad \text{(Eq. 4)}$$

[0045] In the equation, V**3** is the volume of the expansion portion **24***a*, S**5** is the cross-sectional area of the connecting pipe portion **24***b*, L**4** is the length of the connecting pipe portion **24***b*, and c is the speed of sound.

[0046] As shown in FIG. **6**, an interference muffler **25** has a curved pipe portion **25***a* that extends in an arch, and a straight pipe portion **25***b*. Both ends of the curved pipe portion **25***a* are connected to the straight pipe portion **25***b*.

[0047] The half wavelength λ/2 of the interference muffler **25** is in the relationship as shown below:

$$\lambda/2=L5-L6 \quad \text{(Eq. 5)}$$

[0048] In the equation, L**5** is the pipe length of the curved pipe portion **25***a*, and L**6** is the pipe length of the straight pipe portion **25***b*.

[0049] <Characteristics>

[0050] (1) In the air conditioning apparatus **1** according to the embodiment, since the pressure pulsation reducing component **8** is provided between the four-way switch valve **5** and the indoor heat exchanger **3**, the pressure pulsation generated by the compressor **2** can be entirely reduced before reaching the indoor refrigerant pipe both during cooling and during heating in the case of the air conditioning apparatus **1** that switches between cooling, and heating. The muffler used for reducing pressure pulsations can also be shared, thereby the number of components can be reduced.

[0051] Particularly in a ceiling-mounted indoor unit or room air conditioner, the length of the refrigerant pipe is relatively small, and the indoor refrigerant pipe tends to vibrate and readily generate noise, but pressure pulsation can be effectively reduced in the air conditioning apparatus **1** of the present embodiment in such a case.

[0052] (2) In the air conditioning apparatus **1** of the present embodiment, since the pressure pulsation reducing component **8** is provided within an outdoor unit **9** in which the compressor **2** and the outdoor heat exchanger **4** are housed, the pressure pulsation reducing component **8** is easily installed and maintained. Further, since the pressure pulsation reducing component **8** is installed at a position near the compressor **2**, which is the source of the pressure pulsation, within the refrigerant circuit **7**, the pressure pulsation reducing effects thereof are significant.

[0053] (3) In the air conditioning apparatus **1** of the present invention, CO_2 is used as the refrigerant, and although pressure pulsations are more significant compared with other refrigerants, pulsations can be reduced both during cooling and during heating by the pressure pulsation reducing component **8** provided between the four-way switch valve **5** and the indoor heat exchanger **3**. A CO_2 refrigerant has low global warming potential and enables products that are environmentally friendly. A CO_2 refrigerant also has high refrigeration capacity per unit volume, and a cylinder for achieving the same capacity as other refrigerants can be reduced in size, and the compressor can also be reduced in size.

[0054] (4) In the air conditioning apparatus **1** of the present embodiment, the pressure pulsation reducing component **8** is one component selected from the group that consists of an expansion muffler, a π-type filter, a side-branch muffler, a Helmholtz muffler, and an interference muffler; and pressure pulsation can therefore be effectively reduced using these conventionally known mufflers.

[0055] <Modification>

[0056] The pressure pulsation reducing component **8** may also be a component that has a function in addition to a muffler function. For example, the pressure pulsation reducing component **8** may be a vessel having a muffler function. In this case, not only can pressure pulsations be reduced, but liquid-vapor separation of the refrigerant is also possible inside the vessel.

[0057] The vessel having a muffler function may also be one component selected from the above-described group that consists of an expansion muffler, a π-type filter, a side-branch muffler, a Helmholtz muffler, and an interference muffler.

INDUSTRIAL APPLICABILITY

[0058] The present invention can be widely used in air conditioning apparatus provided with a refrigerant circuit that includes a compressor.

1. An air conditioning apparatus, comprising:

a refrigerant circuit having

a compressor being configured to compress a refrigerant,

an indoor heat exchanger,

an outdoor heat exchanger, and

a four-way switch valve being configured to switch the flow of refrigerant compressed by the compressor to

either the indoor heat exchanger or the outdoor heal exchanger,

the compressor, the indoor heat exchanger, the outdoor heat exchanger, and the four-way switch valve being connected via a refrigerant pipe; and

a pressure pulsation reducing component being provided between the four-way switch valve and the indoor heat exchanger and configured to reduce pressure pulsation inside the refrigerant circuit generated by the compressor.

2. The air conditioning apparatus according to claim **1**, wherein

the pressure pulsation reducing component is provided within an outdoor unit configured to house the compressor and the outdoor heat exchanger therein.

3. The air conditioning apparatus according to claim **2**, wherein the refrigerant is CO_2.

4. The air conditioning apparatus according to claim **3**, wherein

the pressure pulsation reducing component is a vessel having a muffler function.

5. The air conditioning apparatus according to claim **4**, wherein

the pressure pulsation reducing component is one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference muffler.

6. The air conditioning apparatus according to claim **3**, wherein

the pressure pulsation reducing component is one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference muffler.

7. The air conditioning apparatus according to claim **2**, wherein

the pressure pulsation reducing component is a vessel having a muffler function.

8. The air conditioning apparatus according to claim **7**, wherein

the pressure pulsation reducing component is one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference muffler.

10. The air conditioning apparatus according to claim **1**, wherein the refrigerant is CO_2.

11. The air conditioning apparatus according to claim **10**, wherein

the pressure pulsation reducing component is a vessel having a muffler function.

12. The air conditioning apparatus according to claim **11**, wherein

the pressure pulsation reducing component is one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference muffler.

13. The air conditioning apparatus according to claim **10**, wherein

the pressure pulsation reducing component is one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference muffler.

14. The air conditioning apparatus according to claim **1**, wherein

the pressure pulsation reducing component is a vessel having a muffler function.

15. The air conditioning apparatus according to claim **14**, wherein

the pressure pulsation reducing component is one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference muffler.

16. The air conditioning apparatus according to claim **1**, wherein

the pressure pulsation reducing component is one component selected from the group consisting of an expansion muffler, a π-type filter, a side branch muffler, a Helmholtz muffler, and an interference muffler.

* * * * *