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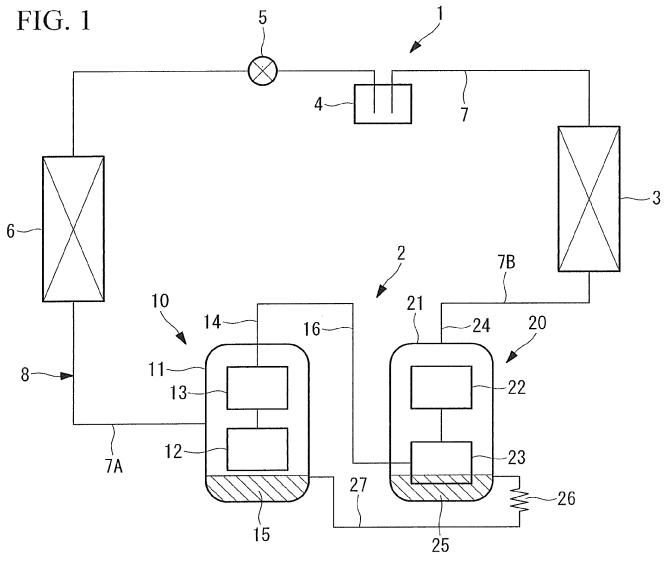
(54) Two-stage compression device and chilling/air-conditioning device using the same

(57) There are provided a two-stage compression device having two serially connected compressors, of which the number of components is reduced through omission of an oil separator, and thereby the configuration is made simpler, lower in cost, and more compact, and a chilling/air-conditioning device using the two-stage compression device. The two-stage compression device 2 which compresses a refrigerant in two stages includes two serially connected compressors of which a low stage-side compressor 10 and a high stage-side compressor 20 in which, of the two compressors 2, the low stage-side compressor 10 is a low pressure housing-type compressor 10, while the high stage-side compressor 20 is a high pressure housing-type compressor 20, and an oil sump 25 of the high pressure housing-type compressor 20 and an oil sump 15 of the low pressure housing-type compressor 10 are connected through an oil return pipe 27.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a two-stage compression device which compresses a refrigerant in two stages with two serially connected compressors, and to a chilling/air-conditioning device using the same.

{Background Art}

[0002] There are two types of known two-stage compression device which compresses a refrigerant in two stages. One type has two compression mechanisms of which a low stage-side compression mechanism and a high stage-side compression mechanism, which are provided inside a single hermetic housing and driven by a common electric motor. The other type has two separate electric compressors connected in series to perform two-stage compression, with a front stage-side compressor as a low stage-side compressor and a rear stage-side compressor as a high stage-side compressor.

[0003] The former can be controlled in the same way as with a stand-alone compressor with respect to lubrication of the compressor with lubricating oil (chiller oil) and oil outflow from the compressor (oil circulation rate; OC%). However, the compression device which has two serially connected compressors requires separate control of the lubricating oil so that the respective compressors do not run short of the lubricating oil.

[0004] Patent Literature 1 discloses a two-stage compression device having two serially connected compressors, of which a high stage-side compressor is a compressor of an internal low-pressure system (low pressure housing type), and is provided with an oil separator in the downstream of a discharge pipe to return from its oil tank the oil separated by the oil separator to each compressor through respective oil pipes and oil level controllers, while intermediate pressure is applied to the oil tank.

[0005] Further, Patent Literature 2 discloses a two-stage compression device, in which a high pressure housing-type compressor is used as a low stage-side compressor and a low pressure housing-type compressor is used as a high stage-side compressor, and an oil separator is provided in the downstream of a discharge pipe of the high stage-side compressor, being the low pressure housing type, to return the oil separated by the oil separator through an oil return pipe to the low stage-side compressor, while an oil equalizing pipe is provided between the low stage-side compressor and the high stage-side compressor.

Citation List

Patent Literature

[0006]

{PTL 1}
Japanese Unexamined Patent Application, Publication No. Hei 5-26526
{PTL 2}
Japanese Unexamined Patent Application, Publication No. Hei 7-301465

Summary of Invention

Technical Problem

[0007] However, as shown in Patent Literatures 1 and 2, if a low pressure housing-type compressor is used as the low stage-side compressor and the high stage-side compressor in the two-stage compression device having two serially connected compressors, it is necessary to control so that each compressor does not run short of the lubricating oil, by providing an oil separator in the downstream of the discharge pipe of the respective compressors, or at least in the downstream of the discharge pipe of the high stage-side compressor, to return the oil separated by the oil separator to the respective compressors. For this reason, installation of the oil separator is essential. However, the increase in the number of components is accompanied by problems such as a more complicated structure, a higher cost, and an increase in the unit size to secure an installation space.

[0008] The present invention has been made in view of this situation, and an object thereof is to provide a two-stage compression device having two serially connected compressors, the number of components of which is reduced through omission of an oil separator, and thereby the configuration is made simpler, lower in cost, and more compact, and a chilling/air-conditioning device using the two-stage compression device. Solution to Problem

[0009] A two-stage compression device according to the present invention is a two-stage compression device which compresses a refrigerant in two stages and includes two serially connected compressors of which a low stage-side compressor and a high stage-side compressor, wherein, of the two compressors, the low stage-side compressor is a low pressure housing-type compressor, while the high stage-side compressor is a high pressure housing-type compressor, and an oil sump of the high pressure housing-type compressor and an oil sump of the low pressure housing-type compressor are connected through an oil return pipe.

[0010] According to this configuration, the lubricating oil returned along with sucked refrigerant gas to the low stage-side compressor is separated inside a low-pressure housing and accumulated in its oil sump. On the other hand, the lubricating oil discharged along with compressed gas from the low stage-side compressor is directly sucked into a compression chamber of the high stage-side compressor and used for sealing, etc. of the compression chamber. The lubricating oil is thereafter discharged together with the high-pressure refrigerant gas into a high-pressure housing, and separated from

the high-pressure refrigerant gas due to a change in velocity, collision with internal components, etc. at the time of being discharged. Then, the lubricating oil accumulated in the oil sump inside the high-pressure housing is partly returned through the oil return pipe to the oil sump inside the low-pressure housing of the low stage-side compressor, and used for lubrication of each compressor by being accumulated in a predetermined amount in the respective oil sumps of the low stage-side compressor and the high stage-side compressor. Thus, in the two-stage compression device having two serially connected compressors, it is possible to control the compressors so as not to run short of the lubricating oil by separating the oil from the refrigerant gas through the use of the high-pressure housing of the high stage-side compressor, without providing an oil separator, and partly returning the oil to the oil sump of the low stage-side compressor. Accordingly, the number of components as a two-stage compression device can be reduced, and thereby the configuration can be made simpler, lower in cost, and more compact.

[0011] In the two-stage compression device described above, the high pressure housing-type high stage-side compressor may be either a rotary compressor or a scroll compressor.

[0012] According to this configuration, by using either the existing direct suction-type rotary compressor or scroll compressor as the high stage-side compressor, it is possible to configure a highly-reliable two-stage compression device which uses a low pressure housing-type compressor as the low stage-side compressor and a high pressure housing-type compressor as the high stage-side compressor. Thus, through a combination of the existing technologies, the number of components of the two-stage compression device can be reduced, and thereby the configuration can be made simpler, lower in cost, and more compact.

[0013] In either of the above-described two-stage compression devices, the low pressure housing-type low stage-side compressor may be a scroll compressor, while the high pressure housing-type high stage-side compressor may be a rotary compressor.

[0014] According to this configuration, by using the low pressure housing-type scroll compressor which, albeit with a relatively large oil outflow (oil circulation rate; OC%), has good efficiency, as the low stage-side compressor, and the high pressure housing-type rotary compressor, which has smaller oil outflow (oil circulation rate; OC%), as the high stage-side compressor, even if the oil outflow is large in the low stage-side compressor, the oil outflow can be suppressed in the high pressure housing-type rotary compressor, so that the oil outflow in the two-stage compression device as a whole can be suppressed. Thus, it is possible to provide a high-efficiency two-stage compression device with little oil outflow, which requires no oil separator and is compact and low in cost.

[0015] Further, a chilling/air-conditioning device according to the present invention has a compressor of any one of the above-described two-stage compression devices.

[0016] According to this configuration, in the chilling/air-conditioning device using the efficient two-stage compression device, by suppressing the oil outflow (oil circulation rate; OC%) from the two-stage compression device, the heat exchange efficiency in the condenser and the evaporator can be further increased. Thus, it is possible to further increase the efficiency and the performance of the chilling/air-conditioning device, as well as to make it lower in cost and more compact.

Advantageous Effects of Invention

[0017] According to the two-stage compression device of the present invention, the lubricating oil returned along with the sucked refrigerant gas to the low stage-side compressor is separated inside the low-pressure housing and accumulated in its oil sump. On the other hand, the lubricating oil discharged along with the compressed gas from the low stage-side compressor is directly sucked into the compression chamber of the high stage-side compressor and used for sealing, etc. of the compression chamber. The lubricating oil is thereafter discharged together with the high-pressure refrigerant gas into the high-pressure housing, and separated from the high-pressure refrigerant gas due to a change in velocity, collision with the internal components, etc. at the time of being discharged. Then, the lubricating oil accumulated in the oil sump inside the high-pressure housing is partly returned through the oil return pipe to the oil sump inside the low-pressure housing of the low stage-side compressor, and used for lubrication of each compressor by being accumulated in a predetermined amount in the respective oil sumps of the low stage-side compressor and the high stage-side compressor. Therefore, in the two-stage compression device having two serially connected compressors, it is possible to control the compressors so as not to run short of the lubricating oil by separating the oil from the refrigerant gas through the use of the high-pressure housing of the high stage-side compressor, without providing an oil separator, and partly returning the oil to the oil sump of the low stage-side compressor. Accordingly the number of components as a two-stage compression device can be reduced, and thereby the configuration can be made simpler, lower in cost, and more compact.

[0018] According to the chilling/air-conditioning device of the present invention, in the chilling/air-conditioning device using the efficient two-stage compression device, by suppressing the oil outflow (oil circulation rate; OC%) from the two-stage compression device, the heat exchange efficiency in the condenser and the evaporator can be further increased. Therefore, it is possible to further increase the efficiency and the performance of the chilling/air-conditioning device, as well as to make it lower in cost and more compact. Brief Description of Drawing

{Fig. 1}

Fig. 1 is a chilling cycle diagram of a two-stage compression device according to one embodiment of the present invention and a chilling/air-conditioning device using the same.

Description of Embodiment

[0019] Hereinafter, one embodiment according to the present invention will be described with reference to Fig. 1.

[0020] Fig. 1 is a chilling cycle diagram of a two-stage compression device according to the one embodiment of the present invention and a chilling/air-conditioning device using the same.

[0021] A chilling/air-conditioning device 1 in this embodiment includes a closed chilling cycle 8 constituted of a compressor (two-stage compression device) 2, a condenser 3, a receiver 4, an electronic expansion valve (EEV) 5, and an evaporator 6 sequentially connected in this order through a refrigerant pipe 7.

[0022] The compressor 2 integrated in the chilling cycle 8 is a two-stage compression device 2 having two separately configured hermetic electric compressors 10 and 20 connected in series, of which a front stage-side compressor in a circulation direction of a refrigerant is the low stage-side compressor 10, and a rear stage-side compressor serially connected with this compressor is the high stage-side compressor 20.

[0023] The low stage-side compressor 10 is a motor-embedded hermetic electric compressor 10, in which an electric motor 12 and a compressor 13 are embedded inside a hermetic housing (low-pressure housing) 11 and the compressor 13 is driven by rotation of the electric motor 12. At the same time, the low stage-side compressor 10 is a so-called low pressure housing-type compressor (a type of compressor in which the inside of the hermetic housing 11 is at a low pressure), in which low-pressure refrigerant gas sucked from the evaporator 6 through a suction pipe 7A is sucked into the hermetic housing 11, and the refrigerant gas is taken into the compressor 13 and compressed before being discharged from a discharge chamber through a discharge pipe 14 directly to the outside.

[0024] As the low pressure housing-type hermetic electric compressor 10, for example, a known hermetic scroll compressor can be used. This hermetic electric scroll compressor 10 has an oil sump 15, which is filled with a predetermined amount of lubricating oil (chiller oil), at the bottom of the hermetic housing 11, and the compressor 13 can be lubricated with this lubricating oil.

[0025] The high stage-side compressor 20 is a motor-embedded hermetic electric compressor 20, in which an electric motor 22 and a compressor 23 are embedded inside a hermetic housing (high-pressure housing) 21 and the compressor 23 is driven by rotation of the electric motor 22. At the same time, the high stage-side compressor 20 is a so-called high pressure housing-type compressor (a type of compressor in which the inside of the hermetic housing 21 is at a high pressure), in which an intermediate-pressure refrigerant gas compressed in the low stage-side compressor 10 is directly sucked into a compression chamber of the compressor 23 through a connection pipe 16, and after being compressed to a high pressure, the high-pressure compressed gas is discharged into the hermetic housing 21.

[0026] The high-pressure refrigerant gas discharged into the hermetic housing 21 is introduced through a discharge pipe 24 and a discharge pipe 7B to the condenser 3. As this high pressure housing-type hermetic electric compressor 20, for example, a known hermetic electric rotary compressor or hermetic electric scroll compressor 20 can be used. The hermetic electric rotary compressor or hermetic electric scroll compressor 20 has an oil sump 25, which is filled with a predetermined amount of the lubricating oil (chiller oil), at the bottom of the hermetic housing 21, and the compressor 23 can be lubricated with this lubricating oil.

[0027] As described above, the high stage-side compressor 20 is a high pressure housing-type compressor, and is configured such that the high-pressure refrigerant gas compressed in the compressor 23 is discharged into the hermetic housing 21. Therefore, the oil contained in the refrigerant gas is separated from the refrigerant gas due to a change in velocity, collision with internal components including a motor, etc. at the time of being discharged into the hermetic housing 21. Accordingly, the refrigerant gas is discharged to the outside with a lower oil content. In particular, the high pressure housing-type hermetic electric rotary compressor, which has the compressor 23 installed at the lower part and can secure a sufficient internal volume (space) for oil separation, is considered to be capable of reducing the oil outflow and therefore is suitable as the high stage-side compressor 20.

[0028] In this way, by using the high pressure housing-type hermetic electric rotary compressor 20 (or the hermetic electric scroll compressor 20) as the high stage-side compressor 20, it is possible to make the hermetic housing 21 function as the oil separator and separate the oil content from the refrigerant gas inside the hermetic housing 21 before discharging the refrigerant gas to the outside. Thus, the oil separator conventionally installed in the downstream of the discharge pipe 7B can be omitted.

[0029] Then, the lubricating oil separated inside the hermetic housing 21 of the high stage-side compressor 20 is returned from the oil sump 25 through the oil return pipe 27, which includes a flow-regulating capillary tube 26 as a pressure reduction means, to the oil sump 15 of the low stage-side compressor 10, whereby a predetermined amount of the lubricating oil is respectively secured in the low stage-side compressor 10 and the high stage-side compressor 20 so that the compressors 10 and 20 do not run short of the lubricating oil. It is preferable that the height position at which the oil return pipe

27 is connected to the hermetic housing 21 of the high stage-side hermetic electric rotary compressor 20 is at about the middle position in the height direction of a cylinder of the compressor 23 which is immersed in the oil sump 25.

[0030] According to the present embodiment, the following effects can be obtained due to the configuration described above.

[0031] The high-temperature, high-pressure refrigerant gas discharged from the compressor (two-stage compression device) 2 of the chilling/air-conditioning device 1 releases heat through heat exchange with the outside air, etc. and is turned into condensate in the condenser 3. This refrigerant is temporarily accumulated in the receiver 4, and thereafter supplied to the electronic expansion valve (EEV) 5 in a regulated circulation amount, and undergoes adiabatic expansion while passing through the electronic expansion valve 5 before being supplied to the evaporator 6. In the evaporator 6, the refrigerant absorbs heat through heat exchange with the room air, etc. and is evaporated into gas. The gasified low-pressure refrigerant gas is returned to the compressor 2 and circulated in the chilling cycle 8. In this way, the refrigerant is used for chilling, air conditioning, etc.

[0032] The compressor 2 in this embodiment is the two-stage compression device 2 having the low stage-side compressor 10 and the high stage-side compressor 20 connected in series, of which the low stage-side compressor 10 is the low pressure housing-type hermetic electric compressor (e.g., known hermetic scroll compressor) 10, while the high stage-side compressor 20 is the high pressure housing-type hermetic electric compressor (e.g., known hermetic electric rotary compressor or hermetic electric scroll compressor) 20.

[0033] Thus, the low-pressure refrigerant gas evaporated into gas in the evaporator 6 is sucked into the hermetic housing 11 of the low pressure housing-type hermetic electric compressor 10 through the suction pipe 7A, and the lubricating oil returned along with the sucked refrigerant gas from the chilling cycle 8 to the low stage-side compressor 10, is separated inside the low-pressure hermetic housing 11 and accumulated in the oil sump 15 so as to be used for lubrication of the compressor 13 of the low stage-side compressor 10.

[0034] On the other hand, the lubricating oil discharged from the low stage-side compressor 10 together with the refrigerant gas compressed in the low stage-side compressor 10 is directly sucked into the compression chamber of the compressor 23 of the high stage-side compressor 20 serially connected through the connection pipe 16. The high stage-side compressor 20 is the high pressure housing-type hermetic electric compressor (e.g., known hermetic electric rotary compressor or hermetic electric scroll compressor) 20 in which the high-pressure refrigerant gas compressed in the compressor 23 is discharged into the hermetic housing 21. For this reason, the lubricating oil mixed in the high-pressure refrigerant gas is separated by a change in velocity, collision with the internal components including the electric motor 22, etc. at the time of being discharged into the hermetic housing 21, and accumulated in the oil sump 25.

[0035] Then, the high-pressure refrigerant gas, from which the lubricating oil has been adequately separated, is discharged from the discharge pipe 7B and delivered to the condenser 3, whereby the oil outflow toward the chilling cycle 8 (oil circulation rate; OC%) can be reduced. Further, the lubricating oil is separated through the use of the hermetic housing 21 of the high stage-side compressor 20, and the lubricating oil accumulated in the oil sump 25 is partly returned to the oil sump 15 of the low stage-side compressor 10 through the oil return pipe 27 including the capillary tube 26. In this way, it is possible to secure a predetermined amount of the lubricating oil respectively in the low stage-side compressor 10 and the high stage-side compressor 20 and lubricate the respective compressors 13 and 23 so as not to run short of the oil.

[0036] Thus, according to this embodiment, in the two-stage compression device having the two compressors 10 and 20 connected in series, it is possible to control the respective compressors 10 and 20 so as not to run short of the oil by separating the oil from the refrigerant gas through the use of the high-pressure housing 21 of the high stage-side compressor 20, without providing an oil separator, and partly returning the oil to the oil sump 15 of the low stage-side compressor 10. Accordingly, the number of components as the two-stage compression device 2 can be reduced, and thereby the configuration can be made simpler, lower in cost, and more compact.

[0037] Further, the high pressure housing-type high stage-side compressor 20 is either a rotary compressor or a scroll compressor. Thus, by using either the existing direct suction-type rotary compressor or scroll compressor as the high stage-side compressor 20, it is possible to configure the highly-reliable two-stage compression device 2 which uses the low pressure housing-type compressor as the low stage-side compressor 10 and the high pressure housing-type compressor as the high stage-side compressor 20. Thus, through a combination of the existing technologies, the number of the components as the two-stage compression device 2 can be reduced, and thereby the configuration can be made simpler, lower in cost, and more compact.

[0038] Further, the low pressure housing-type low stage-side compressor 10 is a scroll compressor, while the high pressure housing-type high stage-side compressor 20 is a rotary compressor. Thus, by using the low pressure housing-type scroll compressor which, albeit with a relatively large oil outflow (oil circulation rate; OC%), has good efficiency, as the low stage-side compressor 10, and the high pressure housing-type rotary compressor, which has smaller oil outflow (oil circulation rate; OC%), as the high stage-side compressor 20, even if the oil outflow is large in the low stage-side compressor 10, the oil outflow can be suppressed on the high pressure housing-type rotary compressor side, so that the oil

outflow in the two-stage compression device 2 as a whole can be suppressed. Thus, it is possible to provide a high-efficiency two-stage compression device 2 with little oil outflow, which requires no oil separator and is compact and low in cost.

[0039] Further, the chilling/air-conditioning device 1 in this embodiment has, as a compressor, the above-described two-stage compression device 2. Thus, in the chilling/air-conditioning device 1 using the efficient two-stage compression device 2, by further suppressing the oil outflow (oil circulation rate; OC%) from the two-stage compression device 2, the heat exchange efficiency in the condenser 3 and the evaporator 6 can be further increased. Thus, it is possible to further increase the efficiency and the performance of the chilling/air-conditioning device 1, as well as to make it lower in cost and more compact.

[0040] It is intended that the present invention is not limited to the invention according to the above-described embodiment, but can be appropriately modified within the scope of the invention. For example, in the above embodiment, the example of the unidirectional chilling cycle 8 has been described. However, it is obvious that the present invention can be as well applied to a reversible chilling cycle provided with a four-way switching valve. Needless to say, the present invention can also be applied to heat pumps for a water heater, etc.

[0041] Moreover, in the above embodiment, the example has been described where the low pressure housing-type hermetic electric scroll compressor is used as the low stage-side compressor 10, and the hermetic electric rotary compressor or the hermetic electric scroll compressor is used as the high stage-side compressor 20. However, the low stage-side compressor 10 and the high stage-side compressor 20 may be another type of low pressure housing-type compressor or another type of high pressure housing-type compressor.

{Reference Signs List}

[0042]

1	Chilling/air-conditioning device
2	Compressor (two-stage compression device)
3	Condenser
5	Electronic expansion valve (EEV)
6	Evaporator
10	Low stage-side compressor (hermetic electric scroll compressor)
11	Hermetic housing (low-pressure housing)
15	Oil sump
20	High stage-side compressor (hermetic electric rotary compressor)
21	Hermetic housing (high-pressure housing)
25	Oil sump
27	Oil return pipe

Claims

1. A two-stage compression device (2) which compresses a refrigerant in two stages, the device (2) comprising two serially connected compressors of which a low stage-side compressor (10) and a high stage-side compressor (20), and the device being **characterized in that**
of the two compressors, the low stage-side compressor (10) is a low pressure housing-type compressor, while the high stage-side compressor (20) is a high pressure housing-type compressor, and
an oil sump (25) of the high pressure housing-type compressor (20) and an oil sump (15) of the low pressure housing-type compressor (10) are connected through an oil return pipe (27).

2. The two-stage compression device (2) according to claim 1, wherein
the high pressure housing-type high stage-side compressor is either a rotary compressor or a scroll compressor.

3. The two-stage compression device (2) according to claim 1 or 2, wherein
the low pressure housing-type low stage-side compressor (10) is a scroll compressor, while the high pressure housing-type high stage-side compressor (20) is a rotary compressor.

4. A chilling/air-conditioning device (2) including, as a compressor, the two-stage compression device according to any one of claims 1 to 3.

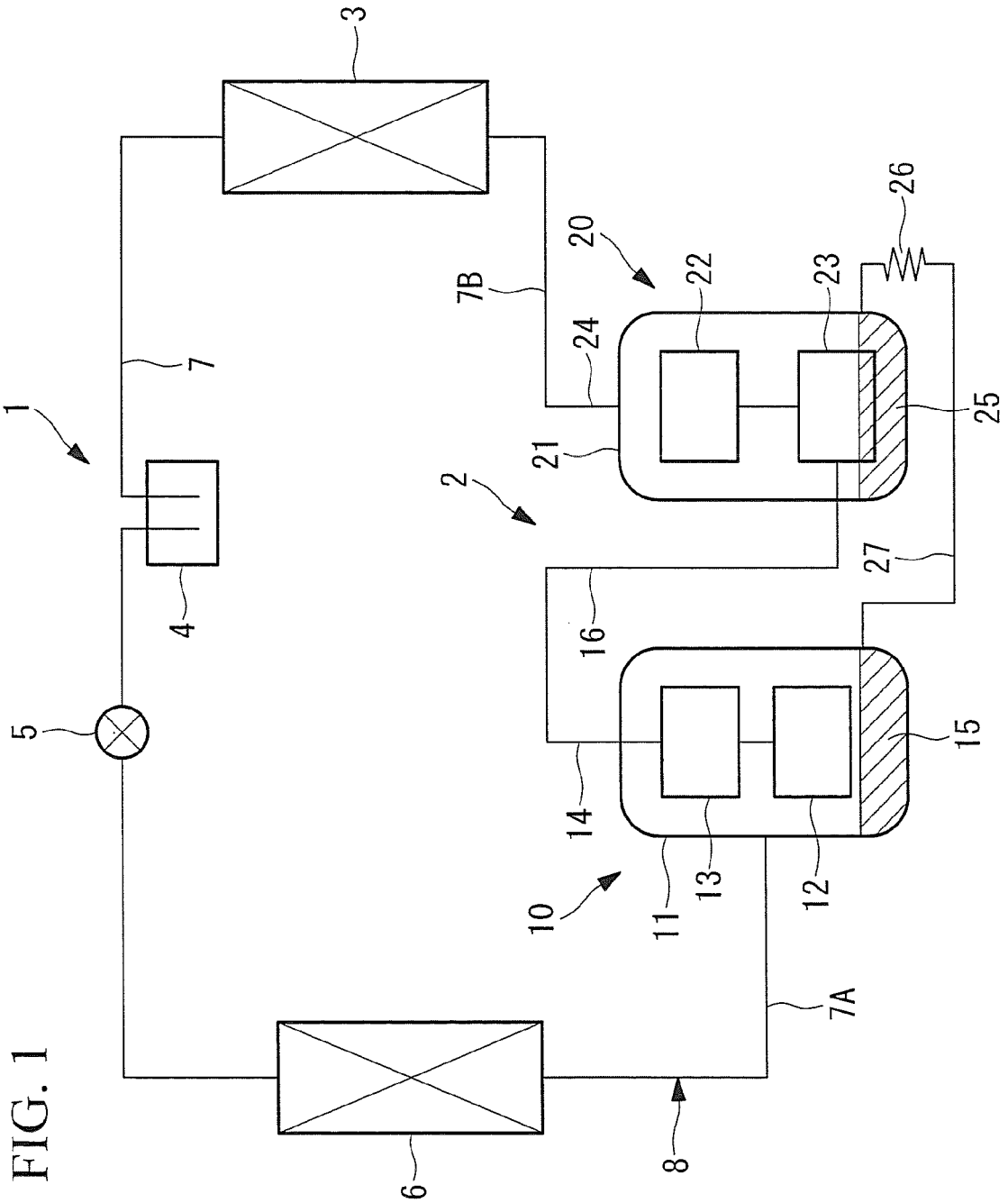

FIG. 1

REFERENCES CITED IN THE DESCRIPTION

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