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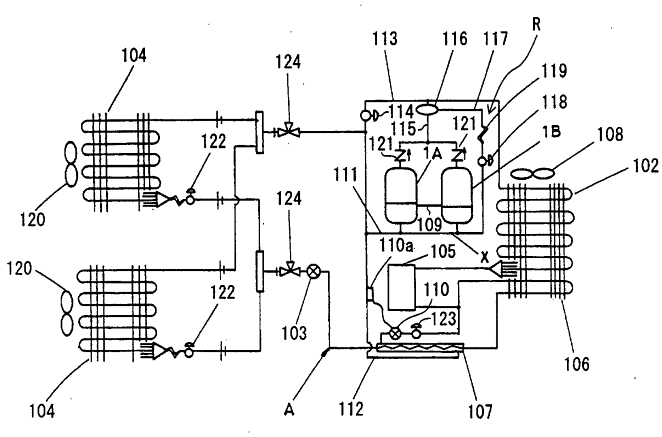
(54) REFRIGERATING DEVICE

(57) Disposed in a suction line **(X)** of compressors **(1A, 1B, ...)** having different capacities is an oil return mechanism **(Z)** operable to preferentially return a refrigerator oil separated from in a suction gas refrigerant to the compressor **(1A)** with the smallest capacity among the compressors **(1A, 1B, ...)**. On the other hand, an oil return passage **(117)** is provided through which a refrigerator oil separated in an oil separator **(116)** disposed in a discharge piping **(115)** of the compressors **(1A, 1B, ...)** is returned to the compressor **(1A)** with the smallest capacity among the compressors **(1A, 1B, ...)**. Having preferentially being returned to the smallest-capacity compressor **(1A),** the refrigerator oil separated in the oil separator **(116)** and the refrigerator oil in the suction gas refrigerant are returned successively to the compressors **(1B, 1C,** ...) which are lower in dome internal pressure, by the dome internal pressure difference.

Fig. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to an oil return arrangement for returning oil to compressors in a refrigeration system.

BACKGROUND ART

[0002] There is a refrigeration system with a plurality of compressors (for example, two compressors) which are connected together in parallel and have different capacities. In such a type of refrigeration system, there may be produced a difference in dome internal pressure between compressors when all the compressors are in operation. On the other hand, the refrigerator oil at the dome bottom of a compressor whose internal pressure is high moves, through a pressure equalization pipe, to another whose internal pressure is lower.

[0003] If the operation continues in such a state, the refrigerator oil in the high pressure dome internal compressor continues moving into the low dome internal pressure compressor. If such a state lasts, the high dome internal pressure compressor will hold no refrigerator oil in the end. This may result in producing damage to the high dome internal pressure compressor.

[0004] There is an oil equalization operation control means as a method of canceling the aforesaid inconvenience, in which the compressors are operated alternately at fixed intervals, to secure a given amount of refrigerator oil for each compressor.

PROBLEMS THAT THE INVENTION INTENDS TO SOLVE

[0005] However, if such oil equalization operation control is carried out, this allows simultaneous operation of all the compressors, only for a fixed period of time. As a result, there will be produced such inconvenience that the capacity required for a refrigeration system cannot be obtained.

[0006] Bearing in mind the above problem, the present invention was made. Accordingly, an object of the present invention is to ensure that, in a refrigeration system with a plurality of compressors differing in capacity from one another, refrigerator oil is positively returned to each compressor.

DISCLOSURE OF THE INVENTION

[0007] The present invention takes the following means in order to provide a solution to the aforesaid problem.

[0008] A first invention is intended for a refrigeration system comprising a refrigerant circuit **A** having a plurality of compressors **1A, 1B, ...,** wherein these compressors **1A, 1B, ...** are connected together in parallel and differ in capacity from one another. The refrigeration system further comprises a distribution mechanism **R** capable of returning a refrigerator oil in a refrigerant circulating through the refrigerant circuit **A** to the compressors **1A, 1B, ...** so that the refrigerator oil is distributed to the compressors **1A, 1B, ...** according to the difference in capacity among the compressors **1A, 1B,** and so on.

[0009] In the first embodiment, when the compressors **1A, 1B,** ... are in operation, the refrigerator oil is distributed among the compressors **1A, 1B, ...** from the difference in capacity among the compressors **1A, 1B,** and so on. This is unlike the conventional technique in that refrigerator oil can be secured for each compressor **1A, 1B,** ... without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0010] A second invention is intended for a refrigeration system comprising a refrigerant circuit **A** having a plurality of compressors **1A, 1B, ...,** wherein these compressors **1A, 1B, ...** are connected together in parallel and differ in capacity from one another. The refrigeration system further comprises a distribution mechanism **R** capable of returning a refrigerator oil in a refrigerant circulating through the refrigerant circuit **A** to the compressors **1A, 1B, ...** so that the refrigerator oil is distributed from the compressor **1A** with the smallest capacity to the other compressors **1B** and so on.

[0011] In the second invention, when the compressors **1A, 1B, ...** are in operation, the refrigerator oil is distributed from the compressor **1A** with the smallest capacity to the other compressors **1B,** and so on. This is unlike the conventional technique in that refrigerator oil can be secured for each compressor **1A, 1B, ...** without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0012] A third invention is intended for a refrigeration system comprising a refrigerant circuit **A** having a plurality of compressors **1A, 1B, ...,** wherein these compressors **1A, 1B, ...** are connected together in parallel and differ in capacity from one another. The refrigeration system further comprises a distribution mechanism **R** capable of returning a refrigerator oil in a refrigerant circulating through the refrigerant circuit **A** to the compressors **1A, 1B, ...** so that the refrigerator oil is distributed from the compressor **1A** with the largest capacity to the other compressors **1B,** and so on.

[0013] In the third invention, when the compressors **1A, 1B, ...** are in operation, the refrigerator oil is distributed from the compressor **1A** with the largest capacity to the other compressors **1B** and so on. This is unlike the conventional technique in that refrigerator oil can be secured for each compressor **1A, 1B, ...** without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0014] A fourth invention depends on the second invention, in which the compressors **1A, 1B, ...** are low-pressure dome type compressors. The distribution mechanism **R** includes an oil equalization pipe **109** in communication with the compressors **1A, 1B,** ... and an oil separator **116** disposed on the discharge side of the compressors **1A, 1B,** ... for separating a refrigerator oil in a discharge refrigerant, and the distribution mechanism **R** is formed so that the refrigerator oil separated in the oil separator **116** and a refrigerator oil contained in a suction refrigerant of each compressor **1A, 1B,** ... are preferentially returned to the compressor **(1A)** with the smallest capacity.

[0015] In the fourth invention, the refrigerator oil expelled from the compressors **1A, 1B, ...** is recovered in the oil separator **116.** The refrigerator oil of the oil separator **116** and the refrigerator oil that is brought back to the suction side of the compressors **1A, 1B, ...** are preferentially returned to the compressor **1A** with the smallest capacity. Thereafter, the refrigerator oil is returned, via the oil equalization pipe **109,** from the compressor **1A** with the smallest capacity to the compressors **1B, 1C,** ... of lower dome internal pressure, by the difference in dome internal pressure.

[0016] A fifth invention depends on the third invention, in which the compressors **1A, 1B, ...** are high-pressure dome type compressors. The distribution mechanism **R** includes an oil equalization pipe **48** in communication with the compressors **1A, 1B, ...** and an oil separator **36** disposed on the discharge side of the compressors **1A, 1B, ...** for separating a refrigerator oil in a discharge refrigerant, and the distribution mechanism **R** is formed so that the refrigerator oil separated in the oil separator **36** and a refrigerator oil contained in a suction refrigerant of each compressor **1A, 1B, ...** are preferentially returned to the compressor **1A** with the largest capacity.

[0017] In the fifth invention, the refrigerator oil expelled from the compressors **1A, 1B, ...** is recovered in the oil separator **36.** The refrigerator oil of the oil separator **36** and the refrigerator oil that is brought back to the suction side of the compressors **1A, 1B, ...** are preferentially returned to the compressor **1A** with the largest capacity. Thereafter, the refrigerator oil is returned, via the oil equalization pipe **48,** from the compressor **1A** with the largest capacity to the compressors **1B, ...** of lower dome internal pressure, by the difference in dome internal pressure.

[0018] A sixth invention is intended for a refrigeration system which comprises a refrigerant circuit **(A)** formed by successively connecting, through a refrigerant piping, a plurality of low-pressure dome type compressors **1A, 1B, ...** connected together in parallel and differing in capacity from one another, a heat-source side heat exchanger **2,** a pressure-reducing mechanism **3,** and a heat-application side heat exchanger **4,** and which is formed by bringing said compressors **1A, 1B, ...** in communication with one another through oil equalization pipes **9, 9,** and so on.

[0019] An oil separator **16** capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping **15** of the compressors **1A, 1B,** and so on. Further, an oil return mechanism **Z** capable of preferentially returning a refrigerator oil contained in a suction gas refrigerant to the compressor **1A** with the smallest capacity among the compressors **1A, 1B,** ... is disposed in a suction line **X** of the compressors **1A, 1B, ...** Additionally, an oil return passage **17,** through which the refrigerator oil separated in the oil separator **16** is returned to the compressor **1A** with the smallest capacity among the compressors **1A, 1B,** ..., is provided.

[0020] In the sixth invention, when the compressors **1A, 1B,** ... are in operation, the refrigerator oil separated in the oil separator **16** and the refrigerator oil in the suction gas refrigerant are preferentially returned to the compressor **1A** with the smallest capacity. Thereafter, the refrigerator oil is successively returned from the compressor **1A** with the smallest capacity to the compressors **1B, 1C, ...** which are lower in dome internal pressure, by the dome internal pressure difference (the compressor's **1A** internal pressure > the compressor's **1B** internal pressure > the compressor's **1C** internal pressure > ...). This is unlike the conventional technique in that refrigerator oil can be secured for each compressor **1A, 1B, ...** without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0021] A seventh invention depends on the sixth invention, in which the oil return mechanism **Z** is made up of a first suction piping **25** which has a given length and is substantially horizontal, the first suction piping **25** forming a part of the suction line **X** and being connected to the compressor **1A** with the smallest capacity among said compressors **1A, 1B, ...,** and second suction pipings **26, 26, ...** which branch from upper portions of the first suction piping **25** and are connected to other than the compressor **1A** with the smallest capacity among the compressors **(1A, 1B, ...),** i.e., to the compressors **(1B, 1C, ...),** respectively.

[0022] In the seventh invention, in the first suction piping **25** the refrigerator oil is separated because of the difference in specific gravity between the refrigerator oil and the gas refrigerant. The separated refrigerator oil flows in the pipe bottom. Then, the separated refrigerator oil is brought back to the compressor **1A** with the smallest capacity from the first suction piping **25.** Accordingly, by a simple arrangement of making a change in the piping structure, it is possible to secure refrigerator oil for the compressors **1A, 1B,** ... at low costs and without the drop in power.

[0023] An eighth invention depends on the sixth invention, in which the oil return mechanism **Z** is made up of a vertical pipe **27** which forms a part of the suction line **X** and has a downwardly-opened lower end, a pipe body **28** toward which a lower portion of the vertical pipe **27** faces and whose horizontal cross-sectional area is larger than that of the vertical pipe **27,** a first suction piping **25** which is connected, at one end thereof, to a lower end of the pipe body **28** and, at the other end, to the compressor **1A** with the smallest capacity among the compressors **1A, 1B, ...,** and second suction pipings **26, 26, ...** which are connected, at one ends thereof, to side-wall portions of the pipe body **28** and, at the other ends, to other than the compressor **1A** with the smallest capacity among the compressors **1A, 1B, ...,** i.e., to the compressors **1B, 1C, ...,** respectively.

[0024] In the eighth invention, the suction gas refrigerant flows, from the vertical pipe **27,** into the pipe body **28** where it rapidly expands and, as a result, the refrigerator oil is separated from the suction gas refrigerant. The separated refrigerator oil is brought back to the compressor **1A** with the smallest capacity from the first suction piping **25** by gravity and inertia. Accordingly, by a simple arrangement of making a change in the piping structure, it is possible to secure refrigerator oil for each compressor **1A, 1B,** ... at low costs and without the drop in performance.

[0025] A ninth invention depends on the sixth invention, in which the oil return mechanism **Z** is made up of a horizontal great-diameter pipe **29** which forms a part of the suction line **X** and whose vertical cross-sectional area is larger than that of the suction line **X,** a first suction piping **25** which is connected, at one end thereof, to a pipe-wall portion of the horizontal great-diameter pipe **29** and, at the other end, to the compressor **1A** with the smallest capacity among the compressors **1A, 1B, ...,** and second suction pipings **26, 26, ...** which are arranged to concentrically face the center of the horizontal great-diameter pipe **29** and are connected to other than the compressor **1A** with the smallest capacity among the compressors **(1A, 1B, ...),** i.e., to the compressors **(1B, 1C, ...),** respectively.

[0026] In the ninth invention, the flow velocity of the suction gas refrigerant flowing through the horizontal great-diameter pipe **29** is relaxed. As a result, there is created an annular flow of the refrigerator oil at the pipe-wall side where the flow velocity is slower, and the refrigerator oil is separated from the suction gas refrigerant. The refrigerator oil thus separated is returned to the first compressor **1A** with the smallest capacity from the first suction piping **25.** Accordingly, by a simple arrangement of making a change in the piping structure, it is possible to secure refrigerator oil for each compressor **1A, 1B, ...** at low costs and without the drop in performance.

[0027] A tenth invention depends on any one of the seventh, eighth, and ninth inventions, in which the oil return passage **17** is connected to the first suction piping **25.**

[0028] In the tenth invention, the refrigerator oil separated in the oil separator **16** merges with the refrigerator oil separated from the suction gas refrigerant, thereafter being returned to the compressor **1A** with the smallest capacity. As a result, there is no need to make a change in the structure of the compressor **1A** (for example, the casing structure thereof).

[0029] An eleventh invention is intended for a refrigeration system comprising a refrigerant circuit **A** which is formed by successively connecting, through a refrigerant piping, a pair of high-pressure dome type compressors **1A** and **1B** connected together in parallel and differing in capacity from each other, a four-way selector valve **2,** a heat-source side heat exchanger **3,** a pressure-reducing mechanism **4,** and a heat-application side heat exchanger **5,** and which is formed by bringing the compressors **1A** and **1B** in communication with each other through an oil equalization pipe **48.**

[0030] An oil separator **36** capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping **47** of the compressors **1A** and **1B.** Further, an oil return passage **37,** through which the refrigerator oil separated in the oil separator **36** is returned to the suction side of the compressors **1A** and **1B,** is provided. Additionally, an opening/closing valve **39,** which is closed when both the compressors **1A and 1B** are stopped, is disposed in the oil return passage **37.**

[0031] In the eleventh invention, when both the compressors **1A** and **1B** are in operation, the refrigerator oil separated in the oil separator **36** and the refrigerator oil in the suction gas refrigerant are returned to the compressors **1A** and **1B** through the oil return passage **37.** At that time, a larger amount of the refrigerator oil is returned to the compressor **1A** with a larger capacity. The internal pressure of the larger-capacity compressor **1A** is higher than that of the smaller-capacity compressor **1B.** As a result, the refrigerator oil travels from the larger-capacity compressor **1A** to the smaller-capacity compressor **1B** through the oil equalization pipe **48,** thereby ensuring that the refrigerator oil is positively returned to the compressors **1A** and **1B.**

[0032] This is unlike the conventional technique in that refrigerator oil can be secured for the compressors **1A** and **1B** without having to perform oil equalization operation control to cause the compressors to operate alternately. Further, during the period that both the compressors **1A** and **1B** are stopped, the opening/closing valve **39** is closed, thereby placing the oil return passage **37** in the non-communication state. This prevents the refrigerant from flowing toward the suction side of the compressor **1A** from the oil separator **36** when the operation is stopped.

[0033] A twelfth invention is intended for a refrigeration system comprising a refrigerant circuit **A** which is formed by successively connecting, through a refrigerant piping, a pair of high-pressure dome type compressors **1A** and **1B** connected together in parallel and differing in capacity from each other, a four-way selector valve **2,** a heat-source side heat exchanger **3,** a pressure-reducing mechanism **4,** and a heat-application side heat exchanger **5,** and which is formed by bringing the compressors **(1A, 1B)** in communication with each other through an oil equalization pipe **48.**

[0034] An oil separator **36** capable of separating a refrigerator oil from a discharge gas refrigerant is disposed in a discharge piping **47** of the compressors **1A** and **1B.**

Further, oil return passages **37A** and **37B,** through which the refrigerator oil separated in the oil separator **36** is returned to the suction side of each compressor **1A** and **1B,** are provided. Additionally, opening/closing valves **39A** and **39B,** which are closed during the period that both the compressors **1A** and **1B** are stopped, are disposed in the oil return passages **37A** and **37B,** respectively.

[0035] In the twelfth invention, when both the compressors **1A** and **1B** are in operation, the refrigerator oil separated in the oil separator **36** and the refrigerator oil in the suction gas refrigerant are returned to the compressors **1A** and **1B** through the oil return passages **37A** and **37B.** At that time, a larger amount of the refrigerator oil is returned to the compressor **1A** with a larger capacity. The internal pressure of the larger-capacity compressor **1A** is higher than that of the smaller-capacity compressor **1B.** As a result, the refrigerator oil travels from the larger-capacity compressor **1A** to the smaller-capacity compressor **1B** through the oil equalization pipe **48,** thereby ensuring that the refrigerator oil is positively returned to the compressors **1A** and **1B.**

[0036] This is unlike the conventional technique in that refrigerator oil can be secured for the compressors **1A** and **1B** without having to perform oil equalization operation control to cause the compressors to operate alternately. Further, during the period that both the compressors **1A** and **1B** are stopped, the opening/closing valves **39A** and **39B** are closed, thereby placing the oil return passages **37A** and **37B** in the non-communication state. This prevents the refrigerant from flowing toward the suction side of each of the compressors **1A** and **1B** from the oil separator **36** when the operation is stopped.

[0037] A thirteenth invention depends on any one of the eleventh and twelfth inventions, in which the oil equalization pipe **48** is provided with an opening/closing valve **49** which is closed during the period that either one of the compressors **(1A, 1B)** is stopped.

[0038] In the thirteenth invention, at the time when either one of the compressors **1A** and **1B** is stopped, the opening/closing valve **49** is closed, thereby inhibiting the refrigerator oil from traveling through the oil equalization pipe **48.** As a result of such arrangement, the movement of the refrigerant from one compressor in operation to the other which is being stopped is interrupted, whereby the compressor in operation is not starved of refrigerator oil.

[0039] A fourteenth invention is intended for a refrigeration system comprising a refrigerant circuit **A** which is formed by successively connecting, through a refrigerant piping, a pair of high-pressure dome type compressors **1A** and **1B** connected together in parallel and differing in capacity from each other, a four-way selector valve **2,** a heat-source side heat exchanger **3,** a pressure-reducing mechanism **4,** and a heat-application side heat exchanger **5,** and which is formed by bringing the compressors **1A** and **1B** in communication with each other through an oil equalization pipe **48.**

[0040] An oil separator **36** capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping **47** of the compressors **1A** and **1B.** Further, an oil return passage **37,** through which the refrigerator oil separated in the oil separator **36** is returned to the suction side of each of the compressors **1A** and **1B,** is provided. Additionally, an opening/closing valve **49,** which is closed during the period that either one of the compressors **1A** and **1B** is stopped, is disposed in the oil equalization pipe **48.**

[0041] In the fourteenth invention, when both the compressors **1A** and **1B** are in operation, the refrigerator oil separated in the oil separator **36** and the refrigerator oil in the suction gas refrigerant are returned to the compressors **1A** and **1B** through the oil return passage **37.** At that time, a larger amount of the refrigerator oil is returned to the compressor **1A** with a larger capacity. The internal pressure of the larger-capacity compressor **1A** is higher than that of the smaller-capacity compressor **1B.** As a result, the refrigerator oil travels from the larger-capacity compressor **1A** to the smaller-capacity compressor **1B** through the oil equalization pipe **48,** thereby ensuring that the refrigerator oil is positively returned to the compressors **1A** and **1B.**

[0042] This is unlike the conventional technique in that refrigerator oil can be secured for the plural compressors **1A** and **1B** without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0043] At the time when either one of the compressors **1A** and **1B** is stopped, the opening/closing valve **49** is closed, thereby inhibiting the refrigerant from traveling through the oil equalization valve **48.** As a result of such arrangement, the movement of the refrigerant from one compressor in operation to the other which is being stopped is interrupted, whereby the compressor in operation is not starved of refrigerator oil.

[0044] A fifteenth invention depends on any one of the eleventh, twelfth, and fourteenth inventions, in which a suction pipe **38** of the compressors **1A** and **1B** is disposed below suction openings **50A** and **50B** of the compressors **1A** and **1B.**

[0045] In the fifteenth invention, when one of the compressors with a larger capacity is stopped while the other compressor with a smaller capacity is in operation, it is possible to avoid a flow of refrigerator oil into the larger-capacity compressor.

EFFECTS OF THE INVENTION

[0046] According to the present invention, by use of the difference in capacity among the compressors **1A, 1B, ...,** the refrigerator oil is returned to the plural compressors **1A, 1B,** and so on. This is unlike the conventional technique in that refrigerator oil can be secured for the compressors **1A, 1B, ...** without having to perform oil equalization operation control to cause the compressors to operate alternately. Such arrangement therefore allows the refrigeration system to constantly provide necessary refrigeration power and, at the same time, makes it possible to positively secure refrigerator oil for the plural compressors **1A, 1B,** and so on.

[0047] According to the sixth invention, when the compressors **1A, 1B, ...** are in operation, the refrigerator oil separated in the oil separator **116** and the refrigerator oil in the suction gas refrigerant are preferentially returned to the compressor **1A** with the smallest capacity, thereafter being returned successively from the compressor **1A** to the compressors **1B, 1C,** ... that are lower in dome internal pressure by the dome internal pressure difference (the compressor's **1A** internal pressure > the compressor's **1B** internal pressure > the compressor's **1C** internal pressure > ...). This is unlike the conventional technique in that refrigerator oil can be secured for the plural compressors **1A, 1B, ...** without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0048] According to the seventh invention, in the first suction piping **125** the refrigerator oil is separated because of the difference in specific gravity between the refrigerator oil and the gas refrigerant. The separated refrigerator oil flows in the pipe bottom. The separated refrigerator oil is brought back to the compressor **1A** with the smallest capacity among the compressors **1A, 1B, ...** via the first suction piping **125**. Accordingly, by a simple arrangement of making a change in the piping structure, it is possible to secure refrigerator oil in the compressors **1A, 1B, ...** at low costs and without the drop in power.

[0049] According to the eighth invention, the suction gas refrigerant flows, from the vertical pipe **127,** into the pipe body **128** where it rapidly expands and, as a result, the refrigerator oil is separated from the suction gas refrigerant. The separated refrigerator oil is brought back to the compressor **1A** with the smallest capacity among the compressors **1A, 1B, ...** via the first suction piping **125** by gravity and inertia. Accordingly, by a simple arrangement of making a change in the piping structure, it is possible to secure refrigerator oil in the compressors **1A, 1B,** ... at low costs and without the drop in power.

[0050] According to the ninth invention, the flow velocity of the suction gas refrigerant flowing through the horizontal great-diameter pipe **129** is relaxed. As a result, there occurs an annular flow of the refrigerator oil at the pipe-wall side where the flow velocity is slower, and the refrigerator oil is separated from the suction gas refrigerant. The refrigerator oil thus separated is returned to the first compressor **1A** with the smallest capacity among the compressors **1A, 1B, ...** via the first suction piping **125.** Accordingly, by a simple arrangement of making a change in the piping structure, it is possible to secure refrigerator oil in the compressors **1A, 1B, ...** at low costs and without the drop in power.

[0051] According to the tenth invention, the refrigerator oil separated in the oil separator **116** merges with the refrigerator oil separated from the suction gas refrigerant and the merged refrigerator oil is returned to the compressor **1A** with the smallest capacity. As a result, there is no need to make a change in the structure of the compressor **1A** (for example, the casing structure thereof).

[0052] According to the eleventh invention, when both the compressors **1A** and **1B** are in operation, the refrigerator oil separated in the oil separator **36** and the refrigerator oil in the suction gas refrigerant are returned to the compressors **1A** and **1B** through the oil return passage **37.** Then, although a larger amount of the refrigerator oil is returned to the compressor **1A** with a larger capacity, the refrigerator oil travels to the smaller-capacity compressor **1B** through the oil equalization pipe **48** because the internal pressure of the larger-capacity compressor **1A** becomes higher than that of the smaller-capacity compressor **1B.** This ensures that the refrigerator oil is positively returned to the compressors **1A** and **1B.** This is unlike the conventional technique in that refrigerator oil can be secured for the compressors **1A** and **1B** without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0053] Further, during the period that both the compressors **1A** and **1B** are stopped, the opening/closing valve **39** is closed, thereby placing the oil return passage **37** in the non-communication state. This prevents the refrigerant from flowing toward the suction side from the oil separator **36** when the operation is stopped.

[0054] According to the twelfth invention, when both the compressors **1A** and **1B** are in operation, the refrigerator oil separated in the oil separator **36** and the refrigerator oil in the suction gas refrigerant are returned to the compressors **1A** and **1B** through the oil return passages **37A** and **37B.** Then, although a larger amount of the refrigerator oil is returned to the compressor **1A** with a larger capacity, the refrigerator oil travels to the smaller-capacity compressor **1B** through the oil equalization pipe **48** because the internal pressure of the larger-capacity compressor **1A** becomes higher than that of the smaller-capacity compressor **1B.** This ensures that the refrigerator oil is positively returned to the compressors **1A** and **1B.** This is unlike the conventional technique in that refrigerator oil can be secured for the compressors **1A** and **1B** without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0055] Further, during the period that both the compressors **1A** and **1B** are stopped, the opening/closing valves **39A** and **39B** are closed, thereby placing the oil return passages **37A** and **37B** in the non-communication state. This prevents the refrigerant from flowing toward the suction side from the oil separator **36** when the operation is stopped.

[0056] According to the thirteenth invention, at the time when either one of the compressors **1A** and **1B** is stopped, the opening/closing valve **49** is closed, thereby inhibiting the refrigerant oil from traveling through the oil equalization pipe **48.** As a result of such arrangement, the movement of the refrigerant from one compressor in operation to the other which is being stopped is interrupted, whereby the compressor in operation is not starved of refrigerator oil.

[0057] According to the fourteenth invention, when both the compressors **1A** and **1B** are in operation, the refrigerator oil separated in the oil separator **36** and the refrigerator oil in the suction gas refrigerant are returned to the compressors **1A** and **1B** through the oil return passage **37.** Then, although a larger amount of the refrigerator oil is returned to the compressor **1A** with a larger capacity, the refrigerator oil travels to the smaller-capacity compressor **1B** through the oil equalization pipe **48** because the internal pressure of the larger-capacity compressor **1A** becomes higher than that of the smaller-capacity compressor **1B.** This ensures that the refrigerator oil is positively returned to the compressors **1A** and **1B.** This is unlike the conventional technique in that refrigerator oil can be secured for the plural compressors **1A** and **1B** without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0058] Further, at the time when either one of the compressors **1A** and **1B** is stopped, the opening/closing valve **49** is closed, thereby inhibiting the refrigerator oil from traveling through the oil equalization valve **48.** As a result of such arrangement, the movement of the refrigerator oil from one compressor in operation to the other which is being stopped is interrupted, whereby the compressor in operation is not starved of refrigerator oil.

[0059] According to the fifteenth invention, when one of the compressors with a larger capacity is being stopped while the other compressor with a smaller capacity is in operation, it is possible to avoid a flow of refrigerator oil into the larger-capacity compressor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0060] Figure **1** is a refrigerant piping system diagram of a refrigeration system according to a first embodiment of the present invention.

[0061] Figure **2** is a piping system diagram showing an arrangement of a suction line section in the refrigeration system according to the first embodiment of the present invention.

[0062] Figure **3** is a piping system diagram showing an arrangement of a suction line section in a refrigeration system according to a second embodiment of the present invention.

[0063] Figure **4** is a piping system diagram showing an arrangement of a suction line section in a refrigeration system according to a third embodiment of the present invention.

[0064] Figure **5** is a piping system diagram showing an arrangement of a suction line section in a refrigeration system according to a fourth embodiment of the present invention.

[0065] Figure **6** is a refrigerant circuit diagram of a refrigeration system according to a fifth embodiment of the present invention.

[0066] Figure **7** is a piping system diagram showing an arrangement of a suction pipe section in the refrigeration system according to the fifth embodiment of the present invention.

[0067] Figure **8** is a table providing a description of the operating state of compressors and solenoid opening/closing valves in a refrigeration system according to a sixth embodiment of the present invention.

[0068] Figure **9** is a piping system diagram showing an arrangement of a suction pipe section in the refrigeration system according to the sixth embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0069] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

FIRST EMBODIMENT

[0070] Figures **1** and **2** show a refrigerant piping system of a refrigeration system according to a first embodiment of the present invention.

[0071] As shown in Figure **1,** the present refrigeration system is provided with a refrigerant circuit **A.** The refrigerant circuit **A** is formed by successively connecting, through refrigerant piping, two compressors **1A** and **1B** connected together in parallel and differing in capacity from each other, a condenser **102** which is air-cooled operating as a heat exchanger on the heat-source side, an expansion valve **103** operating as a pressure reducing mechanism, and a pair of evaporators **104** and **104** connected in parallel and operating as a heat exchanger on the heat-application side.

[0072] In the present embodiment, the capacity of the first compressor **1A** is 4 HP, whereas the capacity of the second compressor **1B** is 5 HP. An oil sump part of the first compressor **1A** and that of the second compressor **1B** are connected together by an oil equalization pipe **109.**

[0073] Interposed between the condenser **102** and the expansion valve **103** are a receiver **105** connected to the outlet side of the condenser **102,** a first supercooling heat exchanger **106** which is air-cooled for supercooling of liquid refrigerant from a liquid phase part of the receiver **105** with outdoor air, and a second supercooling heat exchanger **107** for further supercooling of the supercooled liquid refrigerant from the first supercooling heat exchanger **106** with vaporization latent heat of a gas-liquid mixed refrigerant. Disposed for the condenser **102** and the first supercooling heat exchanger **106** is an outdoor fan **108.**

[0074] A portion of the liquid refrigerant from the liquid phase part of the receiver **105** is pressure-reduced by a temperature-sensing expansion valve **110** and thereafter is supplied to the second supercooling heat exchanger **107.** A temperature-sensing tube **110a** of the temperature-sensing expansion valve **110** is disposed in a gas piping **112** which connects the second supercooling heat exchanger **107** and a suction pipe **111** forming a part of a suction line **X** of the compressors **1A** and **1B.** In other words, the temperature-sensing expansion valve **110** is designed so that it is open-controlled according to the temperature of a gas refrigerant flowing through the gas piping **112.**

[0075] Provided in the refrigerant circuit **A** is a hot gas bypass circuit **113** by which the discharge side and the suction side of the compressors **1A** and **1B** are connected together. Disposed in the hot gas bypass circuit **113** is a solenoid opening/closing valve **114** which is opened to prevent vacuum operation when the low-level pressure excessively drops.

[0076] An oil separator **116,** capable of separating a refrigerator oil contained in a gas refrigerant, is disposed in a discharge piping **115** of the compressors **1A** and **1B.** The refrigerator oil separated in the oil separator **116** is returned to the smaller-capacity compressor **1A** through an oil return passage **117,** as will be described later in detail. Disposed in the oil return passage **117** are a solenoid opening/closing valve **118** which is opened when the refrigerator oil is returned and a capillary tube **119.**

[0077] The evaporators **104** and **104** are each provided with an indoor fan **120.** In the refrigerant circuit **A,** a check valve **121** is provided at the discharge side of each compressor **1A** and **1B.** Further, disposed in the refrigerant circuit **A** are solenoid opening/closing valves **122** for controlling the supply of refrigerant to the evaporators **104** and **104,** a solenoid opening/closing valve **123** for controlling the supply of refrigerant to the second supercooling heat exchanger **107,** and a shut-off valve **124.**

[0078] Further, as shown in Figure **2,** the suction line **X** of the compressors **1A** and **1B** is provided with an oil return mechanism **Z** by which the refrigerator oil, separated from the suction gas refrigerant, is preferentially returned to the smaller-capacity compressor **1A.** The oil return mechanism **Z** is formed of a first suction piping **125** which has a given length and is substantially horizontal, forming a part of the suction line **X** and being connected to the smaller-capacity capacity compressor **1A,** and a second suction piping **126** which branches off from an upper portion of the first suction piping **125** and is connected to the larger-capacity compressor **1B.**

[0079] Moreover, the oil return passage **117** extending from the oil separator **116** is connected to the first suction piping **125.**

[0080] In other words, the refrigerant circuit **A** has a distribution mechanism **R** for returning the refrigerator oil to the compressors **1A** and **1B.** The distribution mechanism **R** is arranged such that the refrigerator oil in the refrigerant circulating through the refrigerant circuit **A** is distributed to the compressor **1A** and **1B** according to the difference in capacity between the compressors **1A** and **1B.** The distribution mechanism **R** of the present embodiment operates so that the refrigerator oil in the refrigerant circulating through the refrigerant circuit **A** is distributed from the smaller-capacity compressor **1A** (the first compressor) to the other compressor, i.e., the second compressor **1B.**

[0081] More concretely, the distribution mechanism **R** includes the oil equalization pipe **109,** the oil separator **116,** the oil return passage **117,** and the oil return mechanism **Z.** The distribution mechanism **R** is designed such that the refrigerator oil separated in the oil separator **116** and the refrigerator oil contained in the suction gas refrigerant of the compressors **1A** and **1B** are preferentially returned to the smaller-capacity compressor **1A.**

[0082] As a result of such arrangement, when the compressors **1A** and **1B** are in operation, the refrigerator oil separated in the oil separator **116** and the refrigerator oil in the suction gas refrigerant are returned to the smaller-capacity compressor **1A.** Thereafter, the refrigerator oil is returned from the first compressor **1A** to the second compressor **1B** whose dome internal pressure is lower, by the difference in dome internal pressure (the internal pressure of the compressor **1A** > the internal pressure of the compressor **1B).** This is unlike the conventional technique in that refrigerator oil can be secured for the compressors **1A** and **1B** without having to perform oil equalization operation control to cause the compressors to operate alternately.

[0083] In addition, in the inside of the first suction piping **125**, the refrigerator oil **F** is separated by the difference in specific gravity between the refrigerator oil and the gas refrigerant and flows in the pipe bottom. The refrigerator oil **F** thus separated is returned to the smaller-capacity compressor **1A** via the first suction piping **125.** Accordingly, with a simple arrangement by making a change in the piping structure, it is possible to secure refrigerator oil for the compressors **1A** and **1B** at low costs and without the drop in power.

[0084] Further, since the oil return passage **117** is connected to the first suction piping **125,** this causes the refrigerator oil separated in the oil separator **116** to merge with the refrigerator oil separated from the suction gas refrigerant in the first suction piping **125** and to be returned to the first compressor **1A,** and there is no need to make a change in the structure of the compressor **1A** (for example, the casing structure etc.). The oil return passage **117** may be connected directly to the first compressor **1A.**

SECOND EMBODIMENT

[0085] Referring to Figure **3,** there is shown a suction line section in a refrigeration system according to a second embodiment of the present invention.

[0086] For the case of the second embodiment, the refrigeration system is provided with three compressors **1A, 1B,** and **1C** having different capacities. The first suction piping **125**, connected to the first compressor **1A,** is connected, at its upper portions, to the second compressor **1B** and to the third compressor **1C** by the second suction pipings **126** and **126.** The other arrangements and operation/functions are the same as the first embodiment and their description is therefore omitted.

THIRD EMBODIMENT

[0087] Referring to Figure **4,** there is shown a suction line section in a refrigeration system according to a third embodiment of the present invention.

[0088] For the case of the third embodiment, the oil return mechanism **Z** is formed of a vertical pipe **127** which constitutes a part of the suction line **X** and has a downwardly-opened lower end, a pipe body **128** toward which a lower part of the vertical pipe **127** faces and which has a horizontal cross-sectional area larger than that of the vertical pipe **127,** a first suction piping **125** which is connected, at one end, to a lower end of the pipe body **128** and, at the other end, to the first compressor **1A** with the smallest capacity, and a second suction piping **126** which is connected, at one end, to a sidewall portion of the pipe body **128** and, at the other end, to the second compressor **1B.**

[0089] As a result of such arrangement, the suction gas refrigerant, which has flowed into the pipe body **128** from the vertical pipe **127**, expands rapidly in the interior of the pipe body **128**, wherein the refrigerator oil is separated from the suction gas refrigerant. The refrigerator oil thus separated is returned, through the first suction piping **125,** to the compressor **1A** by gravity and inertia. This therefore makes it possible to secure refrigerator oil for the compressors **1A** and **1B** with a simple arrangement of making a change in the piping structure, at low costs and without the drop in power.

[0090] The suction gas refrigerant is drawn according to the suction pressure of the compressors **1A** and **1B.** Moreover, also in such a case, the number of compressors may be three or more. The other arrangements and operation/functions are the same as the first embodiment and their description is therefore omitted.

FOURTH EMBODIMENT

[0091] Referring to Figure **5**, there is shown a suction line section in a refrigeration system according to a fourth embodiment of the present invention.

[0092] For the case of the fourth embodiment, the oil return mechanism **Z** is formed of a horizontal great-diameter pipe **129** which constitutes a part of the suction line **X** and has a vertical cross-sectional area larger than that of the suction line **X,** a first suction piping **125** which is connected, at one end, to a pipe-wall portion of the horizontal great-diameter pipe **129** and, at the other end, to the first compressor **1A** with the smallest capacity, and a second suction piping **126** which concentrically faces the center of the horizontal great-diameter pipe **129** and is connected to the second compressor **1B.**

[0093] As a result of such arrangement, as shown by a flow velocity distribution **Y**, the flow velocity of a suction gas refrigerant flowing through the horizontal great-diameter pipe **129** is relaxed, so that there occurs an annular flow of the refrigerator oil at the pipe-wall side where the flow velocity is slower and the refrigerator oil and the suction gas refrigerant are separated. The refrigerator oil thus separated is returned to the first compressor **1A** with the smallest capacity via the first suction piping **125.** This therefore makes it possible to secure refrigerator oil for the compressors **1A** and **1B** with a simple arrangement of making a change in the piping structure, at low costs and without the drop in power.

[0094] The suction gas refrigerant is drawn according to the suction pressure of the compressors **1A** and **1B.** Moreover, also in such a case, the number of compressors may be three or more. The other arrangement and operation/functions are the same as the first embodiment and their description is therefore omitted.

FIFTH EMBODIMENT

[0095] Referring to Figures **6** and **7,** there is shown a refrigerant piping system of a refrigeration system according to a fifth embodiment of the present invention.

[0096] As shown in Figure **6,** the refrigeration system of the present embodiment is made up of a refrigerant circuit **A** for heat pump type air conditioning formed by successively connecting, through a refrigerant piping, a pair of compressors **1A** and **1B** connected together in parallel and having different capacities, a four-way selector valve **2,** a heat source-side heat exchanger **3** to which an outdoor fan **11** is attached, an expansion valve **4** operating as a pressure reducing mechanism and a heat-application side heat exchanger **5,** and a refrigerant circuit **B** for refrigeration (cold storage) which branches from downstream of the expansion valve **4** in the heat pump type air conditioning refrigerant circuit **A** and is connected, through an evaporator **6** for refrigeration, to the suction side of each compressor **1A** and **1B.** The refrigerant circuit **B** for refrigeration may be defined as a heat recovery circuit.

[0097] Here, unlike the first embodiment, the capacity of the first compressor **1A** is 5 HP, whereas the capacity of the second compressor **1B** is 4 HP. An oil sump part of the first compressor **1A** and an oil sump part of the second compressor **1B** are connected together by an oil equalization pipe **48.**

[0098] Arranged between the heat source-side heat exchanger **3** and the expansion valve **4** are a receiver **7** connected to a part which becomes, in the cooling cycle, the outlet side of the heat source-side heat exchanger **3,** a first supercooling heat exchanger **8** which is air-cooled for supercooling of a liquid refrigerant from a liquid phase part of the receiver **7** with an external heating medium (for example, outdoor air), and a second supercooling heat exchanger **9** of the triple tube type for further supercooling of the supercooled liquid refrigerant from the first supercooling heat exchanger **8** with vaporization latent heat of a gas-liquid mixed refrigerant obtained by pressure-reducing a portion of that supercooled liquid refrigerant by a temperature-sensing expansion valve **10.** The gas refrigerant, vaporized and gasified in the second supercooling heat exchanger **9,** is supplied, through a low-pressure gas piping **12,** to the suction side of each compressor **1A** and **1B.** Moreover, a temperature-sensing tube **10a** of the temperature-sensing expansion valve **10** is attached to the low-pressure gas piping **12.**

[0099] Further, the air-conditioning refrigerant circuit **A** is provided with a solenoid opening/closing valve **13** which is opened only when a portion of the liquid refrigerant is supplied to the second supercooling heat exchanger **9.** Moreover, in the present embodiment, the outdoor fan 11 is shared between the heat source-side heat exchanger 3 and the first supercooling heat exchanger **8.**

[0100] Disposed on the inlet side of the receiver **7** is a bridge circuit **14** with four check valves **14a-14d.** The bridge circuit **14** operates as a flow path switching mechanism. That is, in the cooling cycle, the bridge circuit **14** guides the liquid refrigerant from the heat source-side heat exchanger **3** to the receiver **7** and guides, after the liquid refrigerant from the receiver **7** has passed through the expansion valve **4,** it to the heat-application side heat exchanger **5.** On the other hand, in the heating cycle, the bridge circuit **14** guides the liquid refrigerant from the heat-application side heat exchanger **5** to the receiver **7** and guided, after the liquid refrigerant from the receiver **7** has passed through the expansion valve **4,** it to the heat source-side heat exchanger **3.**

[0101] Furthermore, disposed in the air-conditioning refrigerant circuit **A** is a check valve **15** which allows liquid refrigerant to communicate from the heat source-side heat exchanger **3** to the receiver **7** only in the cooling cycle. Additionally, the air-conditioning refrigerant circuit **A** is provided with a solenoid opening/closing valve **16** which is opened in the heating cycle to allow refrigerant to communicate from the expansion valve **4** to the heat-application side heat exchanger **3** and which is closed in the heating heat recovery cycle to allow refrigerant to communicate from the expansion valve **4,** only to the refrigeration evaporator **6.**

[0102] Disposed in a liquid pipe **17** upstream of the refrigeration evaporator **6** in the refrigeration refrigerant circuit **B** is a plate heat exchanger **19** capable of heat exchange with the discharge gas refrigerant of a freezing compressor **18** in a freezing refrigerant circuit **C** which will be described later.

[0103] The freezing refrigerant circuit **C** is formed by successively connecting, through a refrigerant piping, the freezing compressor **18,** the plate heat exchanger **19,** the temperature-sensing expansion valve **20,** the freezing evaporator **21,** and the accumulator **22.**

[0104] Interposed between the heat-application side heat exchanger **5** and the bridge circuit **14** is a reversible circulation mechanism **23** made up of a series circuit **23a** of a solenoid opening/closing valve **24** and a check valve **25** for allowing the circulation of refrigerant only in the cooling cycle and a series circuit **23b** of a solenoid opening/closing valve 26 and a check valve **27** for allowing the circulation of refrigerant only in the heating cycle. Further, the reversible circulation mechanism **23** is provided with a capillary tube **28** for liquid escape which bypasses the solenoid opening/closing valve **26.**

[0105] Provided in the refrigeration refrigerant circuit **B** is a bypass circuit **29** which bypasses the refrigeration evaporator **6.** Disposed in the bypass circuit **29** is a solenoid opening/closing valve **30** which is opened only when the refrigeration evaporator **6** is stopped.

[0106] Further, the refrigeration refrigerant circuit **B** is provided with a solenoid opening/closing valve **31** which is closed only when the refrigeration evaporator **6** is stopped. Moreover, the freezing refrigerant circuit **C** is provided with a solenoid opening/closing valve **32** which is closed only when the freezing evaporator **21** is stopped.

[0107] Furthermore, the heat-application side heat exchanger **5** is provided with an indoor fan **33,** the refrigeration evaporator **6** is provided with a fan **34** for refrigeration, and the freezing evaporator **21** is provided with a fan **35** for freezing.

[0108] Disposed in a discharge pipe **47** of the compressors **1A** and **1B** is an oil separator **36** for separating lubricant contained in the gas refrigerant. The lubricating oil thus separated is returned, through an oil return passage **37,** to a suction pipe **38** of the compressors **1A** and **1B.** Disposed in the oil return passage **37** is a solenoid opening/closing valve **39** which is opened at the oil return time.

[0109] Further, disposed on the discharge side of the compressors **1A** and **1B** is a pressure sensor **40** operating as a high-level pressure detecting means for detecting a high-level pressure which is the discharge pressure of the compressors **1A** and **1B.** The aforesaid refrigeration system has a room temperature sensor **41** for detection of a temperature of the indoor air. Moreover, a discharge temperature sensor **42** for detecting a temperature of the discharge gas refrigerant is disposed on the discharge side of the compressors **1A** and **1B,** and a pressure sensor **43** for detecting a pressure of the suction gas refrigerant is disposed on the suction side of the compressors **1A** and **1B.** The refrigeration system has an outside air temperature sensor **44** for detecting a temperature of the outside air. On the other hand, disposed in the air conditioning refrigerant circuit **A** and the freezing refrigerant circuit **C** are shut-off valves **45** and **46.**

[0110] The refrigeration system as arranged above provides the following operation/functions.

(I) COOLING CYCLE

[0111] During this cycle, the four-way selector valve **2** is switched as indicated by solid lines of Figure **6,** in which the solenoid opening/closing valve **13** is opened, the solenoid opening/closing valve **16** is closed, the solenoid opening/closing valve **24** is opened, the solenoid opening/closing valve **26** is closed, the solenoid opening/closing valve **30** is closed, the solenoid opening/closing valves **31** and **32** are opened, and the solenoid opening/closing valve **39** is opened.

[0112] In the air conditioning refrigerant circuit **A,** gas refrigerant discharged from the compressors **1A** and **1B** is condensation-liquefied in the heat source-side heat exchanger **3** operating as a condenser and thereafter is delivered to the receiver **7** by way of the check valve **15** and the bridge circuit **14.** The liquid refrigerant from the liquid phase part of the receiver **7** is supercooled by heat exchange with outdoor air in the first supercooling heat exchanger **8.** When further supercooling is required, in other words, when the solenoid opening/closing valve **13** is opened, the supercooled liquid refrigerant from the first supercooling heat exchanger **8** is further supercooled in the second supercooling heat exchanger **9** by vaporization latent heat of a gas-liquid mixed refrigerant which is a portion of that supercooled liquid refrigerant pressure-reduced by the temperature-sensing expansion valve **10.** The liquid refrigerant is pressure-reduced in the expansion valve **4** and then is fed to the heat-application side heat exchanger **5** where it is vaporized, and vaporization latent heat obtained is utilized as a heat sink for cooling. Thereafter, the refrigerant is flowed back to the compressors **1A** and **1B.**

[0113] Moreover, in the refrigeration refrigerant circuit **B,** the refrigerant, pressure-reduced in the expansion valve **4,** branches off from the air conditioning refrigerant circuit **A,** passes through the plate heat exchanger **19,** and is fed to the refrigeration evaporator **6** where it is vaporized, and vaporization latent heat obtained is utilized as a heat sink for refrigeration. Thereafter, the refrigerant is flowed back to the compressors **1A** and **1B.**

[0114] Further, in the freezing refrigerant circuit **C**, gas refrigerant discharged from the freezing compressor **18** is condensation-liquefied in the plate heat exchanger **19** operating as a condenser by heat exchange with liquid refrigerant circulating through the liquid pipe **17** in the refrigeration refrigerant circuit **B.** Thereafter, the condensed liquid refrigerant is pressure-reduced in the expansion valve **20** and is supplied to the freezing evaporator **21** where it is vaporized, and vaporization latent heat obtained is utilized as a heat sink for freezing. Thereafter, the refrigerant is flowed back to the compressor **18** by way of the accumulator **22.**

[0115] Apart from the above, when the refrigeration/freezing compartment temperature is high, it is desired that the indoor fan **33** be low-speed operated for the prevention of refrigeration/freezing draft.

(II) HEATING CYCLE

[0116] During this cycle, the four-way selector valve **2** is switched as indicated by broken lines of Figure **6,** in which the solenoid opening/closing valve **13** is opened, the solenoid opening/closing valve **16** is closed, the solenoid opening/closing valve **24** is closed, the solenoid opening/closing valve **26** is opened, the solenoid opening/closing valve **30** is closed, the solenoid opening/closing valves **31** and **32** are opened, and the solenoid opening/closing valve **39** is opened.

[0117] In the refrigerant circuit **A** for air conditioning, gas refrigerant discharged from the compressors **1A** and **1B** is condensation-liquefied in the heat-application side heat exchanger **5** operating as a condenser, and condensation latent heat obtained is utilized as a heat source for heating. Thereafter, the liquid refrigerant is delivered to the receiver **7** by way of the check valve **15** and the bridge circuit **14**, and the liquid refrigerant from the liquid phase part of the receiver **7** is supercooled in the first supercooling heat exchanger **8** by heat exchange with outdoor air. When further supercooling is required, in other words, when the solenoid opening/closing valve **13** is opened, the supercooled liquid refrigerant from the first supercooling heat exchanger **8** is further supercooled in the second supercooling heat exchanger **9** by vaporization latent heat of a gas-liquid mixed refrigerant which is a portion of that supercooled liquid refrigerant pressure-reduced by the temperature-sensing expansion valve **10.** Thereafter, the liquid refrigerant is pressure-reduced in the expansion valve **4,** passes through the plate heat exchanger **19** in the refrigeration refrigerant circuit **B,** and is fed to the evaporator **6** where it is vaporized, and vaporization latent heat obtained is utilized as a heat sink for refrigeration. Thereafter, the refrigerant is flowed back to the compressors **1A** and **1B.**

[0118] Moreover, in the freezing refrigerant circuit **C,** gas refrigerant discharged from the freezing compressor **18** is condensation-liquefied in the plate heat exchanger **19** operating as a condenser by heat exchange with liquid refrigerant circulating through the liquid pipe **17** in the refrigerant circuit **B.** Thereafter, the liquid refrigerant is pressure-reduced in the expansion valve **20** and then is supplied to the freezing evaporator **21** where it is vaporized, and vaporization latent heat obtained is utilized as a heat sink for freezing. Thereafter, the refrigerant is flowed back to the compressor **18** by way of the accumulator **22.**

[0119] As described above, in the present embodiment, waste heat, utilized as a heat sink for refrigeration in the evaporator **6** of the refrigerant circuit **B** in the heating cycle, is recovered as a heat source for heating in the heat-application side heat exchanger **5.** At this time, one of the compressors **1A** and **1B** is stopped. In other words, the compressor power is turned down.

[0120] Apart from the above, when the heating load is small, that is, when the difference between the set temperature and the room temperature is small, the evaporator **6** is likely to lack in heat source for refrigeration. To cope with such a condition, the four-way selector valve **2** is switched to a cooling mode of operation (the cooling cycle) and the solenoid opening/closing valve **16** is opened so as to cause the heat source-side heat exchanger **3** to operate as a condenser. When the heating load increases during the cooling cycle operation, that is, when the difference between the set temperature and the room temperature increases, the four-way selector valve **2** is switched to a heating mode of operation (the heating cycle) and the solenoid opening/closing valve **16** is closed, whereby the operation mode is returned back to a heating heat recovery mode of operation in which the heat-application side heat exchanger **5** is made to operate as a condenser.

[0121] Further, when the refrigeration load and the freezing load decrease during the heating operation, in other words when the low-level pressure which is the suction pressure of the compressors **1A** and **1B** decreases, the balance in power between the heat-application side heat exchanger **5** and the evaporator **6** can be maintained by automatic reduction in the capacity of the indoor fan **33.**

[0122] Furthermore, when the refrigeration/freezing load decreases during the heating cycle operation, in other words when the low-level pressure which is the suction pressure of the compressors **1A** and **1B** decreases, the heat-application side heat exchanger **5** is likely to lack in heat source for heating. Therefore, the solenoid opening/closing valve **16** is opened to cause the heat source-side heat exchanger **3** to operate as an evaporator.

[0123] Additionally, when the indoor fan **33** is drive-stopped, that is, even when the heat-application side heat exchanger **5** stops operating, it is possible that the four-way selector valve **2** is switched to the heating operation and, in addition, the solenoid opening/closing valve **16** is closed to automatically perform heating heat recovery operation if the room temperature is below a given value.

[0124] In the present embodiment, the suction pipe **38** is arranged below suction openings **50A** and **50B** of the compressors **1A** and **1B,** as shown in Figure **7**. The oil return passage **37** is connected to a portion of the suction pipe **38** near the suction opening **50A** of the first compressor **1A** (i.e., the larger-capacity compressor). Moreover, disposed in the oil equalization pipe **48** is a solenoid opening/closing valve **49** which is closed when either one of the compressors **1A** and **1B** is stopped. The oil return passage **37** is provided with a filter **51.**

[0125] The compressors **1A** and **1B** and the solenoid opening/closing valves **39** and **49** are made on or off, as shown in Figure **3.** In Figure **8,** the symbol (circle) indicates OPENED and the symbol (cross) indicates CLOSED.

[0126] That is, the air conditioning refrigerant circuit **A** has a distribution mechanism **R** for returning refrigerator oil to the compressors **1A** and **1B.** The distribution mechanism **R** is formed such that the refrigerator oil in the refrigerant circulating through the refrigerant circuit **A** is distributed to the compressors **1A** and **1B** by the difference in capacity between the compressors **1A** and **1B.** In order that a refrigerator oil in the refrigerant circulating through the refrigerant circuit **A** is distributed from the larger-capacity compressor **1A** to the other compressor **1B,** the distribution mechanism **R** of the present embodiment is operable to return the refrigerator oil to the compressors **1A** and **1B.**

[0127] More concretely, the distribution mechanism **R** includes the oil equalization pipe **48,** the oil separator **36,** and the oil return passage **37.** The distribution mechanism **R** is formed such that the refrigerator oil separated in the oil separator **36** and the refrigerator oil contained in the suction gas refrigerant of the compressors **1A** and **1B** are preferentially returned to the first compressor **1A** with a larger capacity.

[0128] As a result of such arrangement, during the time that both the compressors **1A** and **1B** are in operation, both the solenoid opening/closing valves **39** and **49** are opened. Then, the refrigerator oil **F** separated in the oil separator **36** is returned to the suction pipe **38** through the oil return passage **37** and is returned, together with the refrigerator oil **F** in the suction gas refrigerant, to the compressors **1A** and **1B** according to the suction pressure.

[0129] At that time, a larger amount of the refrigerator oil **F** is returned to the first compressor **1A** with a larger capacity. However, since the internal pressure of the first compressor **1A** of larger capacity increases beyond that of the second compressor **1B,** the refrigerator oil **F** travels to the second compressor **1B** of smaller capacity through the oil equalization pipe **48.** This ensures that the refrigerator oil **F** is positively returned to the compressors **1A** and **1B.** Accordingly, unlike the prior art technique, it is possible to secure the refrigerator oil **F** for the compressors **1A** and **1B** without having to perform oil equalization control to cause the compressors to operate alternately.

[0130] Additionally, during the time that both the compressors **1A** and **1B** are stopped, the opening/closing valve **39** is closed, thereby placing the oil return passage **37** in the non-communication state. As a result, there is no flow of refrigerant from the oil separator **36** to the suction side at the operation stop time.

[0131] Further, during the time that either one of the compressors **1A** and **1B** is stopped, the opening/closing valve **49** is closed, thereby preventing the refrigerator oil **F** from traveling through the oil equalization pipe **48.** As a result, the movement of the refrigerator oil **F** from one compressor in operation to the other compressor which is being stopped is inhibited, and the compressor in operation will not be starved of the refrigerator oil **F.**

[0132] Further, since the suction pipe **38** extending to the compressors **1A** and **1B** is arranged below the suction openings **50A** and **50B** of the compressors **1A** and

1B, this arrangement prevents the refrigerator oil **F** from flowing into the larger-capacity compressor **1A** through the suction pipe **38** during the period that the larger-capacity compressor **1A** is stopped while the smaller-capacity compressor **1B** is in operation.

SIXTH EMBODIMENT

[0133] Referring to Figure **9,** there is shown a suction pipe section in a refrigeration system according to a sixth embodiment of the present invention.

[0134] In the present embodiment, in order to ensure that the refrigerator oil **F** separated in the oil separator **36** is positively returned to the suction openings **50A** and **50B** of the first and second compressors **1A** and **1B,** there are provided two oil return passages **37A** and **37B** which are connected to portions of the suction pipe **38** near the suction openings **50A** an **50B.** Moreover, opening/closing valves **39A** and **39B,** which are closed when both the compressors **1A** and **1B** are stopped, are disposed in the oil return passage **37A** and in the oil return passage **37B,** respectively.

[0135] As a result of such arrangement, during the period that both of the compressors **1A** and **1B** are in operation, having passed through the oil return passages **37A** and **37B,** the refrigerator oil separated in the oil separator **36** is returned to the compressors **1A** and **1B,** together with the refrigerator oil contained in the suction gas refrigerant. This further ensures that the refrigerator oil is returned positively. The other arrangements and operation/functions are the same as the fifth embodiment and their description is therefore omitted.

OTHER EMBODIMENTS

[0136] In the first, third, and fourth embodiments of the present invention, the refrigeration systems with two compressors having different capacities have been described. However, the present invention may include three or more compressors having different capacities. For instance, the present invention is applicable to a refrigeration system with three compressors having a capacity of 3 HP, a capacity of 4 HP, and a capacity of 4 HP, respectively, and to a refrigeration system with three compressors having a capacity of 3 HP, a capacity of 4 HP, and a capacity of 5 HP, respectively.

INDUSTRIAL APPLICABILITY

[0137] As described above, the refrigeration systems of the present invention are available for air conditioners with a plurality of compressors, particularly for air conditioners with a plurality of compressors having different capacities.

Claims

1. A refrigeration system comprising a refrigerant circuit **(A)** having a plurality of compressors **(1A, 1B, ...),** said compressors **(1A, 1B, ...)** being connected together in parallel and differing in capacity from one another,

wherein said refrigeration system further comprises a distribution mechanism **(R)** capable of returning a refrigerator oil in a refrigerant circulating through said refrigerant circuit **(A)** to said compressors **(1A, 1B, ...)** so that said refrigerator oil is distributed to said compressors **(1A, 1B, ...)** according to the difference in capacity among said compressors **(1A, 1B, ...).**

2. A refrigeration system comprising a refrigerant circuit **(A)** having a plurality of compressors **(1A, 1B, ...),** said compressors **(1A, 1B, ...)** being connected together in parallel and differing in capacity from one another,

wherein said refrigeration system further comprises a distribution mechanism **(R)** capable of returning a refrigerator oil in a refrigerant circulating through said refrigerant circuit **(A)** to said compressors **(1A, 1B, ...)** so that said refrigerator oil is distributed from said compressor **(1A)** with the smallest capacity to the other compressors **(1B, ...).**

3. A refrigeration system comprising a refrigerant circuit **(A)** having a plurality of compressors **(1A, 1B, ...),** said compressors **(1A, 1B, ...)** being connected together in parallel and differing in capacity from one another,

wherein said refrigeration system further comprises a distribution mechanism **(R)** capable of returning a refrigerator oil in a refrigerant circulating through said refrigerant circuit **(A)** to said compressors **(1A, 1B, ...)** so that said refrigerator oil is distributed from said compressor **(1A)** with the largest capacity to the other compressors **(1B, ...).**

4. The refrigeration system of claim 2,

wherein said compressors **(1A, 1B, ...)** are low-pressure dome type compressors; and

wherein said distribution mechanism **(R)** includes an oil equalization pipe **(109)** in communication with said compressors **(1A, 1B, ...)** and an oil separator **(116)** disposed on the discharge side of said compressors **(1A, 1B, ...)** for separating a refrigerator oil in a discharge refrigerant, and

wherein said distribution mechanism **(R)** is formed so that said refrigerator oil separated in said oil separator **(116)** and a refrigerator oil contained in a suction refrigerant of each of said compressors **(1A, 1B, ...)** are preferentially returned to said compressor **(1A)** with the smallest capacity.

5. The refrigeration system of claim 3,

wherein said compressors **(1A, 1B, ...)** are high-pressure dome type compressors; and wherein said distribution mechanism **(R)** includes an oil equalization pipe **(48)** in communication with said compressors **(1A, 1B, ...)** and an oil separator **(36)** disposed on the discharge side of said compressors **(1A, 1B, ...)** for separating a refrigerator oil in a discharge refrigerant, and wherein said distribution mechanism **(R)** is formed so that said refrigerator oil separated in said oil separator **(36)** and a refrigerator oil contained in a suction refrigerant of each of said compressors **(1A, 1B, ...)** are preferentially returned to said compressor **(1A)** with the largest capacity.

6. A refrigeration system which comprises a refrigerant circuit **(A)** formed by successively connecting, through refrigerant piping, a plurality of low-pressure dome type compressors **(1A, 1B, ...)** connected together in parallel and differing in capacity from one another, a heat-source side heat exchanger **(2),** a pressure-reducing mechanism **(3),** and a heat-application side heat exchanger **(4),**

wherein said refrigeration system is formed by bringing said compressors **(1A, 1B, ...)** in communication with one another through oil equalization pipes **(9, 9, ...);**
wherein an oil separator **(16)** capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping **(15)** of said compressors **(1A, 1B, ...);**
wherein an oil return mechanism **(Z)** capable of preferentially returning a refrigerator oil contained in a suction gas refrigerant to said compressor **(1A)** with the smallest capacity among said compressors **(1A, 1B, ...)** is disposed in a suction line **(X)** of said compressors **(1A, 1B, ...);** and
wherein an oil return passage **(17),** through which said refrigerator oil separated in said oil separator **(16)** is returned to said compressor **(1A)** with the smallest capacity among said compressors **(1A, 1B, ...),** is provided.

7. The refrigeration system of claim **6,**
wherein said oil return mechanism **(Z)** is made up of:

a first suction piping **(25)** which has a given length and is substantially horizontal, said first suction piping **(25)** forming a part of said suction line **(X)** and being connected to said compressor **1A** with the smallest capacity among said compressors **(1A, 1B, ...);** and
second suction pipings **(26, 26, ...)** which branch from upper portions of said first suction piping **(25)** and are connected to other than said compressor **(1A)** with the smallest capacity among said compressors **(1A, 1B, ...),** i.e., to said compressors **(1B, 1C, ...),** respectively.

8. The refrigeration system of claim **6,**
wherein said oil return mechanism **(Z)** is made up of:

a vertical pipe **(27)** which forms a part of said suction line **(X)** and has a downwardly-opened lower end;
a pipe body **(28)** toward which a lower portion of said vertical pipe **(27)** faces and whose horizontal cross-sectional area is larger than that of said vertical pipe **(27);**
a first suction piping **(25)** which is connected to a lower end of said pipe body **(28)** and to said compressor **(1A)** with the smallest capacity among said compressors **(1A, 1B, ...);** and
second suction pipings **(26, 26, ...)** which are connected to sidewall portions of said pipe body **(28)** and to other than said compressor **(1A)** with the smallest capacity among said compressors **(1A, 1B, ...),** i.e., to said compressors **(1B, 1C, ...),** respectively.

9. The refrigeration system of claim 6,
wherein said oil return mechanism **(Z)** is made up of:

a horizontal great-diameter pipe **(29)** which forms a part of said suction line **(X)** and whose vertical cross-sectional area is larger than that of said suction line **(X);**
a first suction piping **(25)** which is connected to a pipe-wall portion of said horizontal great-diameter pipe **(29)** and to said compressor **(1A)** with the smallest capacity among said compressors **(1A, 1B, ...)** ; and
second suction pipings **(26, 26, ...)** which are arranged to concentrically face the center of said horizontal great-diameter pipe **(29)** and are connected to other than said compressor **(1A)** with the smallest capacity among said compressors **(1A, 1B, ...),** i.e., to said compressors **(1B, 1C, ...),** respectively.

10. The refrigeration system of any one of claims 7, 8, and 9,
wherein said oil return passage **(17)** is connected to said first suction piping **(25).**

11. A refrigeration system comprising a refrigerant circuit **(A)** which is formed by successively connecting, through refrigerant piping, a pair of high-pressure dome type compressors **(1A, 1B)** connected together in parallel and differing in capacity from each other, a four-way selector valve **(2),** a heat-source side heat exchanger **(3),** a pressure-reducing mechanism **(4),** and a heat-application side heat exchanger **(5),**

wherein said refrigeration system is formed by bringing said compressors **(1A, 1B)** in communication with each other through an oil equalization pipe **(48);**
wherein an oil separator **(36)** capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping **(47)** of said compressors **(1A, 1B);**
wherein an oil return passage **(37),** through which said refrigerator oil separated in said oil separator **(36)** is returned to the suction side of each of said compressors **(1A, 1B),** is provided; and
wherein an opening/closing valve **(39),** which is closed when both said compressors **(1A, 1B)** are stopped, is disposed in said oil return passage **(37).**

12. A refrigeration system comprising a refrigerant circuit **(A)** which is formed by successively connecting, through refrigerant piping, a pair of high-pressure dome type compressors **(1A, 1B)** connected together in parallel and differing in capacity from each other, a four-way selector valve **(2),** a heat-source side heat exchanger **(3),** a pressure-reducing mechanism **(4),** and a heat-application side heat exchanger **(5),**

wherein said refrigeration system is formed by bringing said compressors **(1A, 1B)** in communication with each other through an oil equalization pipe **(48);**
wherein an oil separator **(36)** capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping **(47)** of said compressors **(1A, 1B);**
wherein oil return passages **(37A, 37B),** through which said refrigerator oil separated in said oil separator **(36)** is returned to the suction side of each of said compressors **(1A, 1B),** are provided; and
wherein opening/closing valves **(39A, 39B),** which are closed during the period that both said compressors **(1A, 1B)** are stopped, are disposed in said oil return passages **(37A, 37B),** respectively.

13. The refrigeration system of any one of claims 11 and 12,

wherein said oil equalization pipe **(48)** is provided with an opening/closing valve **(49)** which is closed during the period that either one of said compressors **(1A, 1B)** is stopped.

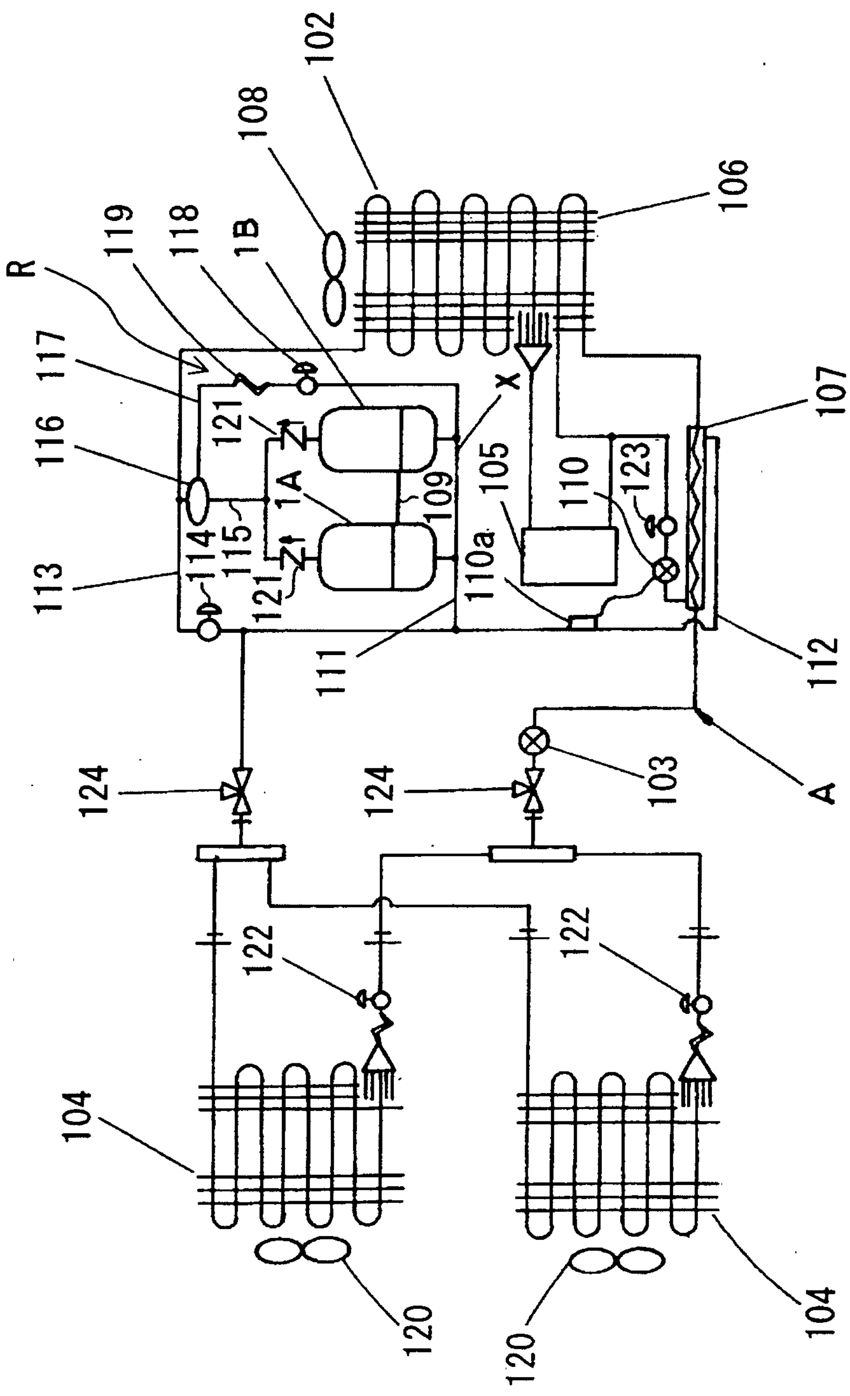
14. A refrigeration system comprising a refrigerant circuit **(A)** which is formed by successively connecting, through refrigerant piping, a pair of high-pressure dome type compressors **(1A, 1B)** connected together in parallel and differing in capacity from each other, a four-way selector valve **(2),** a heat-source side heat exchanger **(3),** a pressure-reducing mechanism **(4),** and a heat-application side heat exchanger **(5),**

wherein said refrigeration system is formed by bringing said compressors **(1A, 1B)** in communication with each other through an oil equalization pipe **(48);**
wherein an oil separator **(36)** capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping **(47)** of said compressors **(1A, 1B);**
wherein an oil return passage **(37),** through which said refrigerator oil separated in said oil separator **(36)** is returned to the suction side of each of said compressors **(1A, 1B),** is provided; and
wherein an opening/closing valve **(49),** which is closed during the period that either one of said compressors **(1A, 1B)** is stopped, is disposed in said oil equalization pipe **(48).**

15. The refrigeration system of any one of claims 11, 12, and 14,

wherein a suction pipe **(38)** of said compressors **(1A, 1B)** is disposed below suction openings **(50A, 50B)** of said compressors **(1A, 1B).**

Fig. 1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120
120

Fig. 2

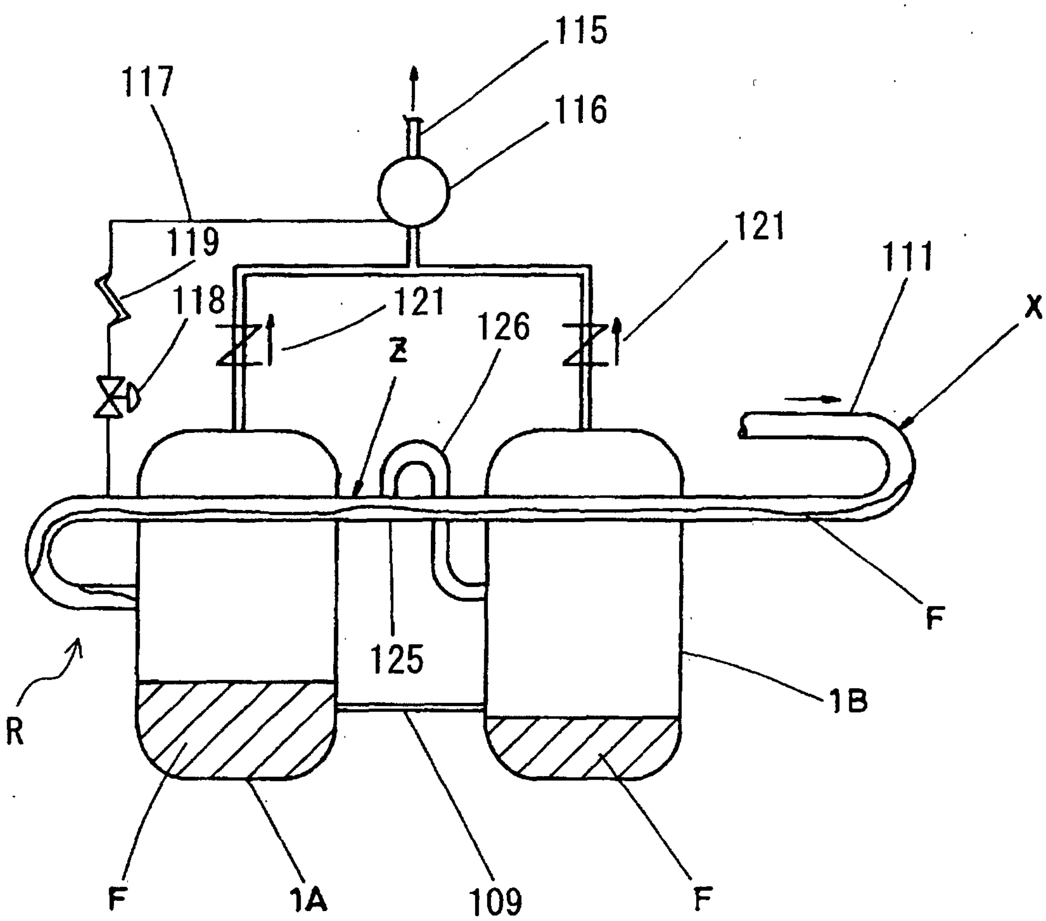
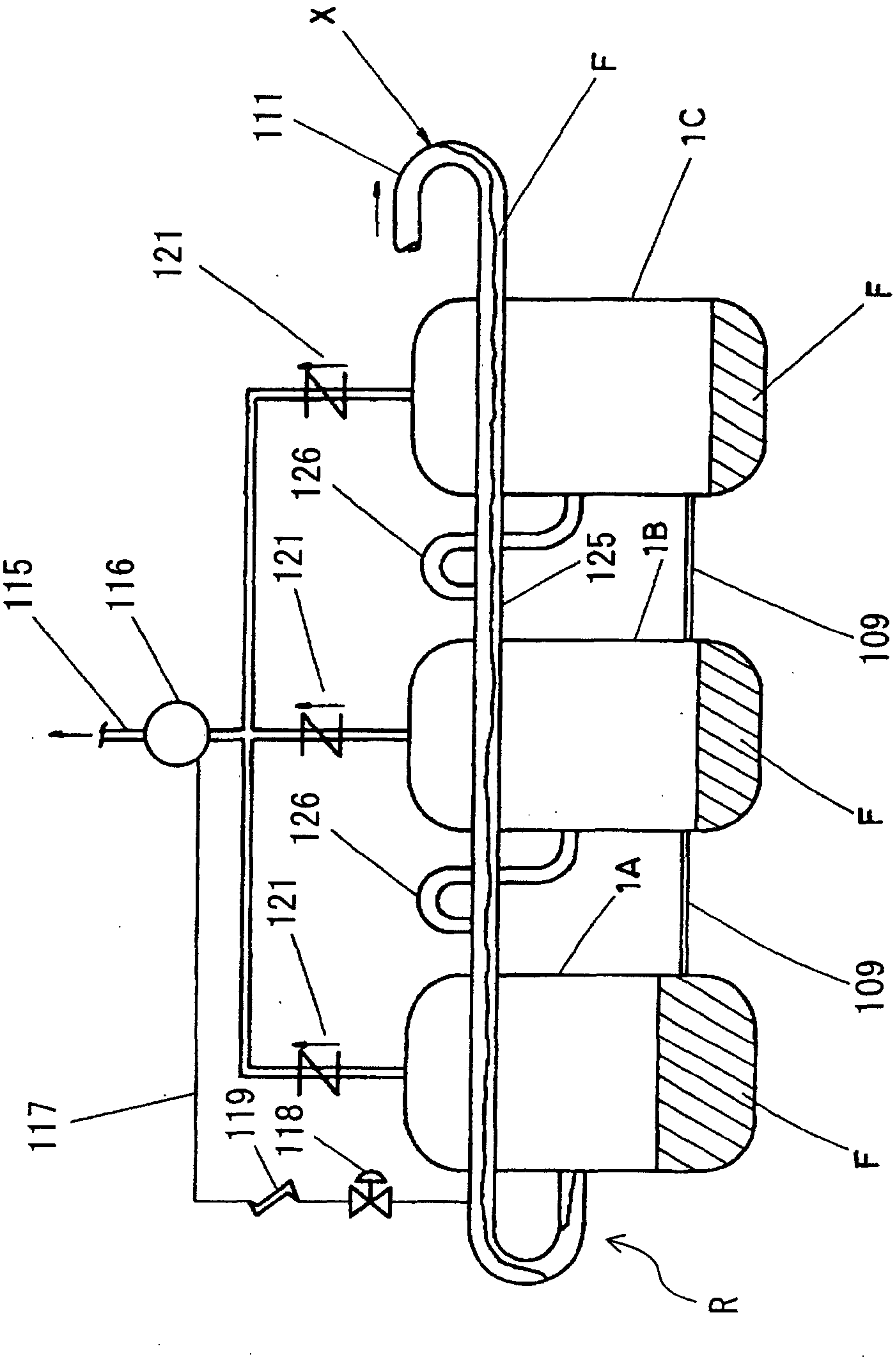


Fig. 3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126
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1B
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F
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121
109
117
119
118
F
R

Fig. 4

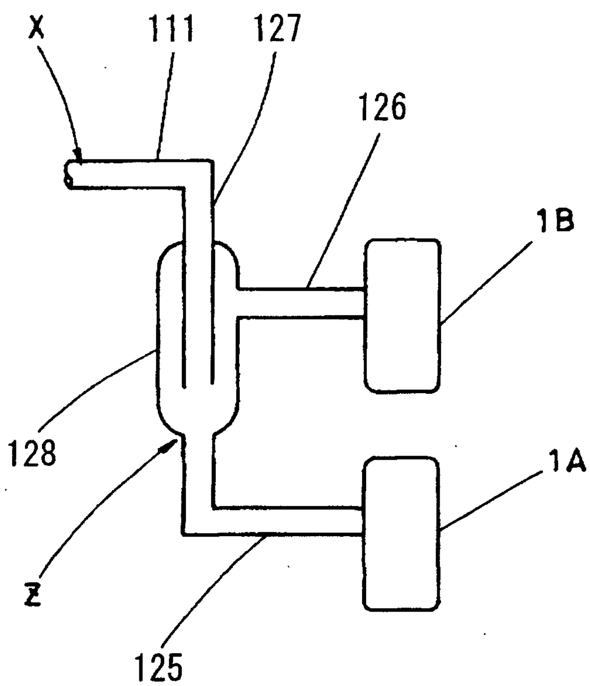
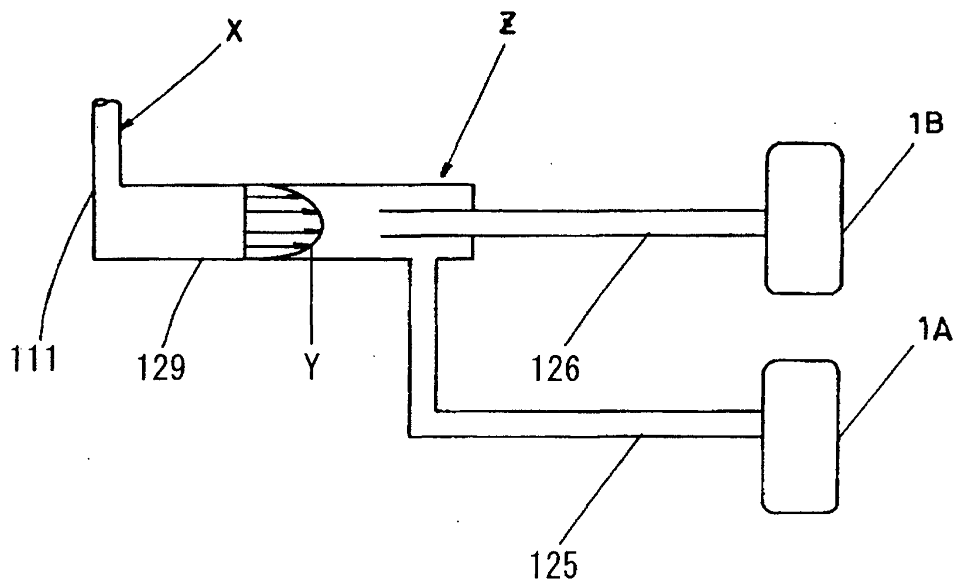
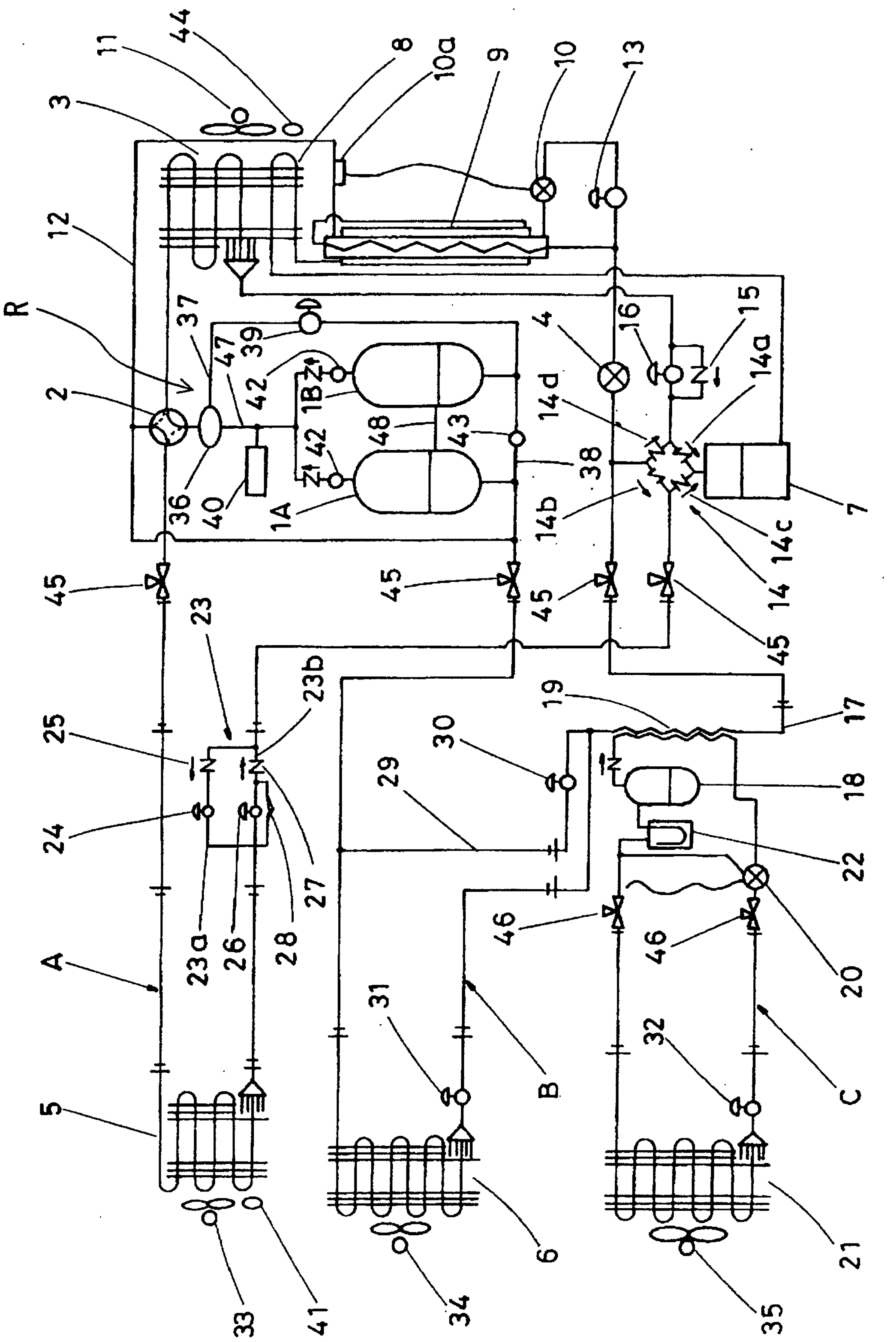


Fig. 5




R
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1B
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36
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1A
38
3
11
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10a
9
10
13
12
4
16
15
14d
14a
14b
14c
14
7
45
45
45
45
45
23
23b
25
24
23a
26
28
27
A
5
33
41
29
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19
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18
22
20
46
46
31
B
32
C
6
34
21
35

Fig. 6

Fig. 7

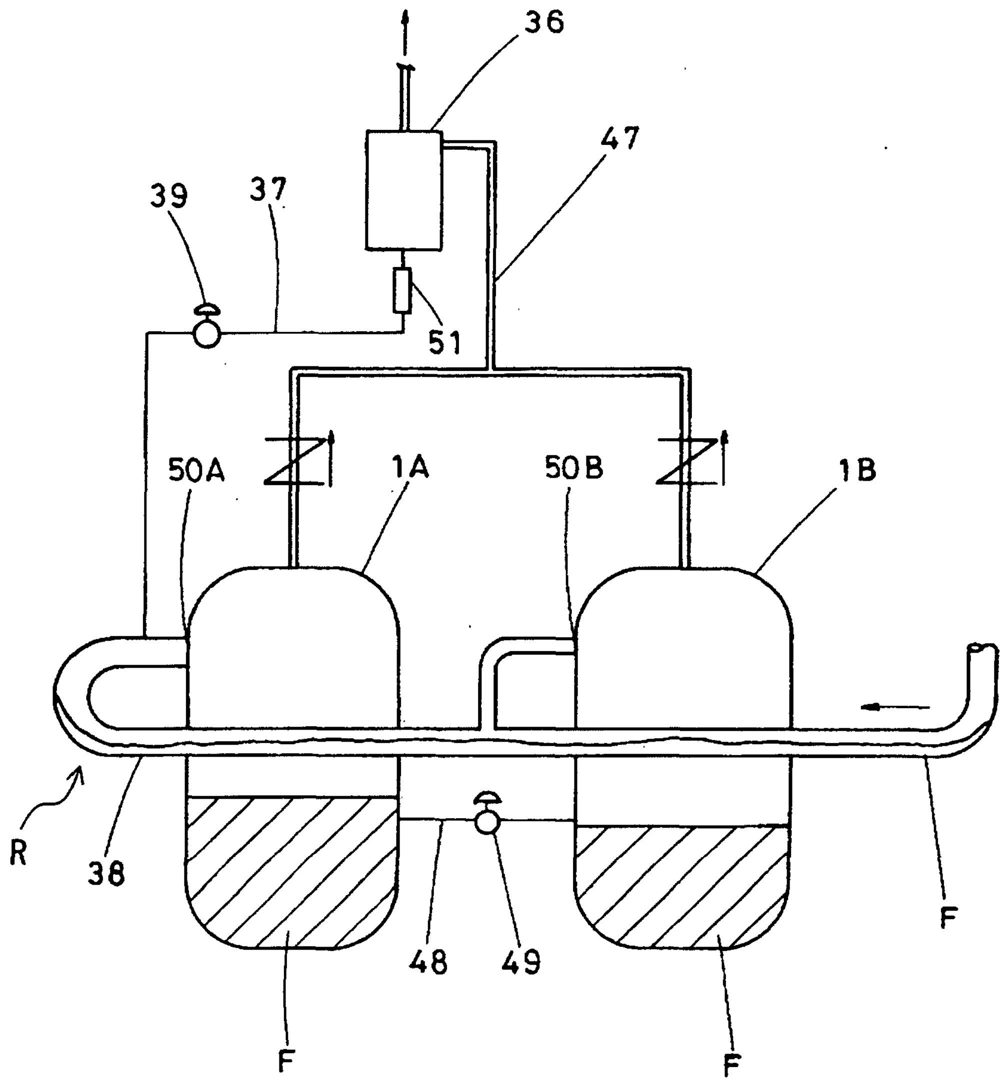
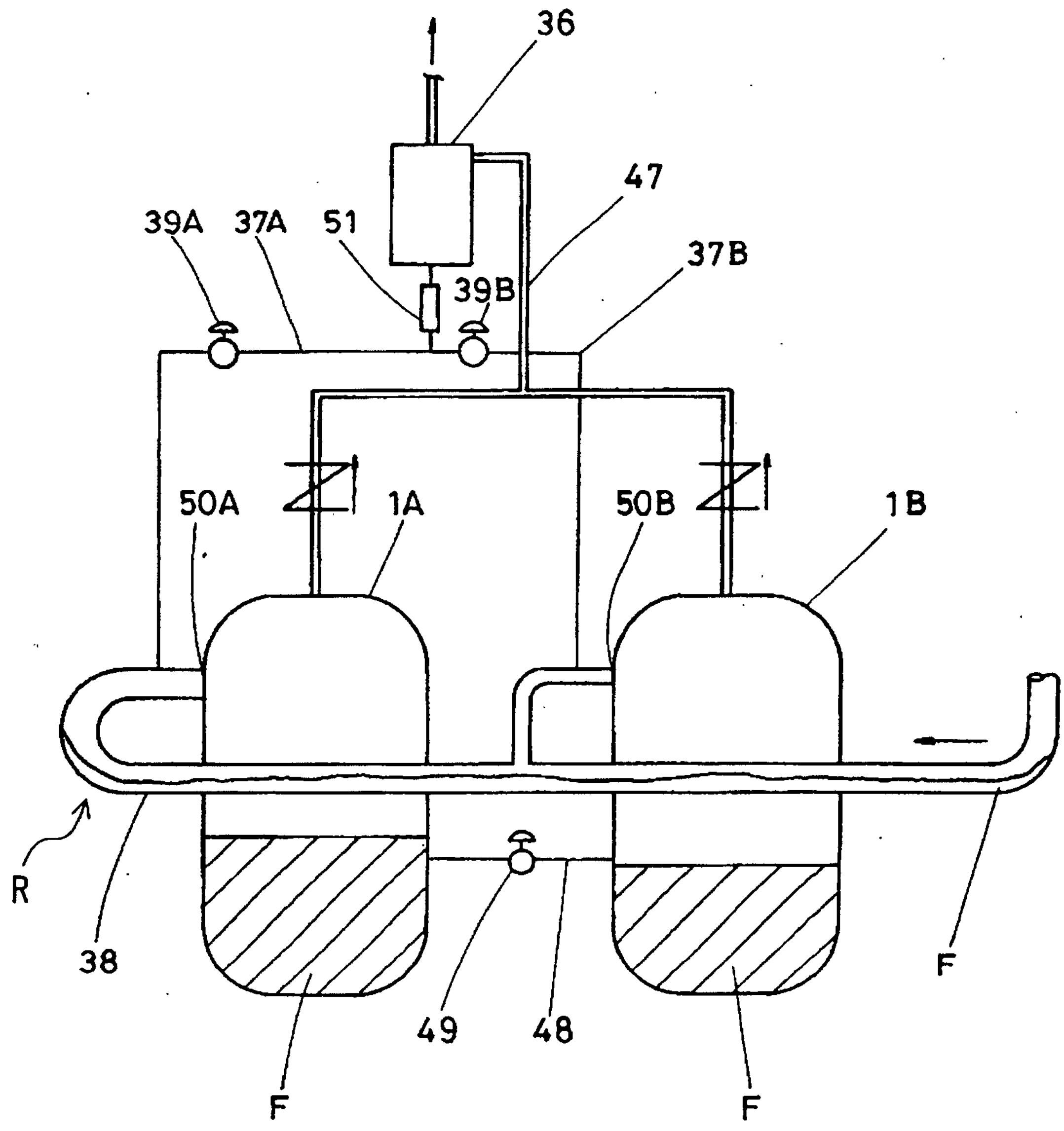


Fig. 8

compressor 1A	ON	ON	OFF	OFF
compressor 1B	ON	OFF	ON	OFF
sol.O/C value 39	○	○	○	×
sol.O/C value 49	○	×	×	○

Fig. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/04836

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F25B1/00

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)
Int.Cl[7] F25B1/00

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

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2000
Kokai Jitsuyo Shinan Koho	1971-2000	Jitsuyo Shinan Toroku Koho	1996-2000

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 5-57501, B2 (Daikin Industries, Ltd.), 24 August, 1993 (24.08.93) (Family: none)	1-15
Y	JP, 2-99786, A (Sanyo Electric Co., Ltd.), 11 April, 1990 (11.04.90) (Family: none)	1-15
X Y	US, 4729228, A1 (Clifford N. Johnsen), 08 May, 1988 (08.05.88) & JP, 63-105379, A & GB, 8709696, A & FR, 2605393, A & DE, 3718651, A & CA, 1277501, A	1 2,4,6-9
Y	JP, 4-214991, A (Daikin Industries, Ltd.), 05 August, 1992 (05.08.92) (Family: none)	1,2,4,6,7,9
Y	JP, 4-365990, A (Hitachi, Ltd.), 17 December, 1992 (17.12.92) (Family: none)	1,3,5,11-15
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No.6585/1982 (Laid-open No.110758/1983) (Mitsubishi Electric Corporation),	1,3,5,11-15

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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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
16 October, 2000 (16.10.00)	24 October, 2000 (24.10.00)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP00/04836

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	28 July, 1983 (28.07.83) (Family: none)	
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No.229/1982 (Laid-open No.102793/1983) (Hitachi, Ltd.), 13 July, 1983 (13.07.83) (Family: none)	11-15
Y	JP, 4-80555, A (Sanyo Electric Co., Ltd.), 13 March, 1992 (13.03.92) (Family: none)	11-15
Y	JP, 8-5169, A (Matsushita Refrig. co., Ltd.), 12 January, 1996 (12.01.96) (Family: none)	15

Form PCT/ISA/210 (continuation of second sheet) (July 1992)