

29 December 2003

DESCRIPTION**REFRIGERATION SYSTEM****TECHNICAL FIELD**

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

BACKGROUND ART

There is a refrigeration system with a plurality of
compressors (for example, two compressors) which are
connected together in parallel and have different capacities.
10 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
15 equalization pipe, to another whose internal pressure is
lower.

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
20 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.

There is an oil equalization operation control means as a
25 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

However, if such oil equalization operation control is
5 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.

Bearing in mind the above problem, the present invention
10 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

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

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, ...
20 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
25 the refrigerator oil is distributed to the compressors 1A, 1B,

... according to the difference in capacity among the compressors 1A, 1B, and so on.

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.

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.

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

29 December 2003

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.

5 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
10 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
15 on.

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
20 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.

A fourth invention depends on the second invention, in
25 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.

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.

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.

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.

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.

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.

15 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

29 December 2003

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.

5 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
10 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
15 the compressors (1B, 1C, ...), respectively.

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
20 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,
25 1B, ... at low costs and without the drop in power.

An eighth invention depends on the sixth invention, in which the oil return mechanism 2 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 sidewall 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.

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.

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.

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.

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

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
10 a result, there is no need to make a change in the structure of the compressor 1A (for example, the casing structure thereof).

An eleventh invention is intended for a refrigeration system comprising a refrigerant circuit A which is formed by
15 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-
20 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.

An oil separator 36 capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge
25 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.

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.

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.

5 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
10 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.

15 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
20 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.

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.

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.

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.

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.

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.

An oil separator 36 capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge

pipings 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.

5 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.

In the fourteenth invention, when both the compressors 1A and 1B are in operation, the refrigerator oil separated in
10 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
15 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
20 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.

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
5 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.

A fifteenth invention depends on any one of the eleventh,
10 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.

In the fifteenth invention, when one of the compressors with a larger capacity is stopped while the other compressor
15 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

According to the present invention, by use of the
20 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
25 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.

5 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
10 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
15 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.

According to the seventh invention, in the first suction
20 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
25 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.

5 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
10 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
15 costs and without the drop in power.

 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
20 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.
25 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.

According to the tenth invention, the refrigerator oil
5 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
10 example, the casing structure thereof).

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
15 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
20 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.

Further, during the period that both the compressors 1A and 1B are stopped, the opening/closing valve 39 is closed, 5 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.

According to the twelfth invention, when both the 10 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 15 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 20 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.

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
5 refrigerant from flowing toward the suction side from the oil separator 36 when the operation is stopped.

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
10 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.

15 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
20 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
25 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
5 control to cause the compressors to operate alternately.

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
10 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.

According to the fifteenth invention, when one of the
15 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

20 Figure 1 is a refrigerant piping system diagram of a refrigeration system according to a first embodiment of the present invention.

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

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.

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

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.

10 Figure 6 is a refrigerant circuit diagram of a refrigeration system according to a fifth embodiment of the present invention.

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

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.

20 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

Hereinafter, embodiments of the present invention will be
25 described in detail with

reference to the drawings.

FIRST EMBODIMENT

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

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.

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.

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
5 the condenser 102 and the first supercooling heat exchanger 106 is an outdoor fan 108.

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
10 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
15 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.

Provided in the refrigerant circuit A is a hot gas bypass
20 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.

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
5 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.

10 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
15 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.

Further, as shown in Figure 2, the suction line X of the
20 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
25 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 5 1B.

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

In other words, the refrigerant circuit A has a distribution mechanism R for returning the refrigerator oil 10 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 15 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.

20 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 25 refrigerator oil contained in the suction gas refrigerant of

the compressors 1A and 1B are preferentially returned to the smaller-capacity compressor 1A.

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.

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.

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.

10 SECOND EMBODIMENT

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

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

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

5 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
10 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
15 connected, at one end, to a sidewall portion of the pipe body 128 and, at the other end, to the second compressor 1B.

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
20 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
25 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.

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

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

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.

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.

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

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

15 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.

20 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
25 the freezing evaporator 21 is stopped.

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.

5 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
10 return passage 37 is a solenoid opening/closing valve 39 which is opened at the oil return time.

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
15 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
20 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
25 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.

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

5 (I) COOLING CYCLE

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.

15 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
20 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
25 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.

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.

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.

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.

10 (II) HEATING CYCLE

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.

20 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.

25 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
5 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
10 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
15 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.

20 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
25 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
5 back to the compressor 18 by way of the accumulator 22.

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-
10 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.

Apart from the above, when the heating load is small, that is, when the difference between the set temperature and the
15 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
20 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
25 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.

5 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
10 6 can be maintained by automatic reduction in the capacity of the indoor fan 33.

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
15 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.

20 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.

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.

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.

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.

More concretely, the distribution mechanism R includes the
5 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
10 returned to the first compressor 1A with a larger capacity.

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
15 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.

At that time, a larger amount of the refrigerator oil F is
20 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
25 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
5 cause the compressors to operate alternately.

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
10 refrigerant from the oil separator 36 to the suction side at the operation stop time.

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
15 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.

20 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

29 December 2003

period that the larger-capacity compressor 1A is stopped while the smaller-capacity compressor 1B is in operation.

SIXTH EMBODIMENT

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

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
10 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 and 50B. Moreover, opening/closing valves 39A and 39B, which are closed when both the compressors 1A and 1B
15 are stopped, are disposed in the oil return passage 37A and in the oil return passage 37B, respectively.

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
20 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

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

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.

WHAT IS CLAIMED IS:

1. 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 (102), a pressure-reducing mechanism (103), and a heat-application side heat exchanger (104),

wherein said refrigeration system is formed by bringing said compressors (1A, 1B, ...) in communication with one another through oil equalization pipes (109, 109, ...);

wherein an oil separator (116) capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping (115) 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

29 December 2003

wherein an oil return passage (117), through which said refrigerator oil separated in said oil separator (116) is returned to said compressor (1A) with the smallest capacity among said compressors (1A, 1B, ...), is provided; and

wherein said oil return mechanism (Z) is made up of:

a first suction piping (125) which has a given length and is substantially horizontal, said first suction piping (125) 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 (126, 126, ...) which branch from upper portions of said first suction piping (125) 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.

2. 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, ...)

29 December 2003

connected together in parallel and differing in capacity from one another, a heat-source side heat exchanger (102), a pressure-reducing mechanism (103), and a heat-application side heat exchanger (104),

wherein said refrigeration system is formed by bringing said compressors (1A, 1B, ...) in communication with one another through oil equalization pipes (109, 109, ...);

wherein an oil separator (116) capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping (115) 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 (117), through which said refrigerator oil separated in said oil separator (116) is returned to said compressor (1A) with the smallest capacity among said compressors (1A, 1B, ...), is provided; and

29 December 2003

wherein said oil return mechanism (Z) is made of:

a vertical pipe (127) which forms a part of said suction line (X) and has a downwardly-opened lower end;

a pipe body (128) toward which a lower portion of said vertical pipe (127) faces and whose horizontal cross-sectional area is larger than that of said vertical pipe (127);

a first suction piping (125) which is connected to a lower end of said pipe body (128) and to said compressor (1A) with the smallest capacity among said compressors (1A, 1B, ...); and

second suction pipings (126, 126, ...) which are connected to sidewall portions of said pipe body (128) and to other than said compressor (1A) with the smallest capacity among said compressors (1A, 1B, ...), i.e., to said compressors (1B, 1C, ...), respectively.

3. 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

29 December 2003

capacity from one another, a heat-source side heat exchanger (102), a pressure-reducing mechanism (103), and a heat-application side heat exchanger (104),

wherein said refrigeration system is formed by bringing said compressors (1A, 1B, ...) in communication with one another through oil equalization pipes (109, 109, ...);

wherein an oil separator (116) capable of separating a refrigerator oil in a discharge gas refrigerant is disposed in a discharge piping (115) 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 (117), through which said refrigerator oil separated in said oil separator (116) is returned to said compressor (1A) with the smallest capacity among said compressors (1A, 1B, ...), is provided; and

wherein said oil return mechanism (Z) is made up of:

29 December 2003

a horizontal great-diameter pipe (129) 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 (125) which is connected to a pipe-wall portion of said horizontal great-diameter pipe (129) and to said compressor (1A) with the smallest capacity among said compressors (1A, 1B, ...) ; and

second suction pipings (126, 126, ...) which are arranged to concentrically face the center of said horizontal great-diameter pipe (129) 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.

4. The refrigeration system of any one of claims 1, 2, and 3,

wherein said oil return passage (117) is connected to said first suction piping (125).

5. A refrigeration system comprising a refrigerant circuit (A) which is formed by successively connecting, through refrigerant piping, a pair of

29 December 2003

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); and

29 December 2003

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

6. 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

29 December 2003

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; and

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

7. 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);

29 December 2003

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); and

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