

SPECIFICATION

TITLE OF THE INVENTION

AIR CONDITIONER

BACKGROUND OF THE INVENTION

The present invention relates to an air conditioner of a split type wherein an external unit having an external heat exchanger and an internal unit having an internal heat exchanger are disposed separately from each other, and respective heat exchangers are connected to each other by a refrigerant piping, to thus constitute a refrigeration cycle.

As the air conditioner of a split type wherein an external heat exchanger is connected to an internal heat exchanger by a refrigerant piping, for example, Japanese Patent Publication No. sho 57-31057 has been disclosed an air conditioner of a split type which includes an external heat exchanger disposed in the outdoor garden and an internal heat exchanger disposed in the interior.

In such an air conditioner of a split type, since the internal heat exchanger and the external heat exchanger are disposed separately from each other, the length of a refrigerant piping for connecting the external heat exchanger to the internal heat exchanger becomes different depending upon the locations where these heat exchangers are disposed.

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Also, since the diameter of the refrigerant piping is generally limited at the specified value, in the case that refrigerant is made to flow in the refrigerant piping, there is generated a specified passage resistance in the refrigerant piping. The resistance tends to increase in proportional to the length of the refrigerant piping.

Accordingly, when the resistance in the refrigerant piping is large, namely, the length of the refrigerant piping is long, the refrigerant circulating amount is reduced to be less than the designed value of the refrigeration cycle. This presents such a problem that the refrigeration ability in design cannot be obtained.

It may be considered to use a compressor having a large ability in the refrigeration cycle and a receiver tank having a large capacity for achieving the high ability. This makes it possible to cope with the state that the refrigerant piping is long. The above attempt, however, is disadvantageous in that, for the short refrigerant piping, the high ability compressor and a large sized receiver tank are made wasteful, and further, the internal unit and the external unit are made larger, thereby obstructing the miniaturization of these units.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide an air conditioner capable of carrying out the optimal

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operation even for the longer refrigerant piping without making the size of each unit larger and enhancing the ability of each component in the refrigeration cycle.

An air conditioner of the present invention comprises a refrigeration cycle using a refrigerant compressor, a four-way valve, an external heat exchanger, an expansion device, and an internal heat exchanger in such a manner that these components are separately mounted in an external unit and an internal unit, wherein the external heat exchanger is mounted on the external unit; the internal heat exchanger is mounted in the internal unit; both of the heat exchangers mounted in the units are connected to each other by means of a refrigerant piping to form the refrigeration cycle; and a control means is provided for changing the expansion amount of the expansion device according to the length of the refrigerant piping thereby adjusting the high-low pressure difference in the refrigeration cycle.

The above expansion device is intended to reduce the expansion amount of the refrigerant by the control means in the case that the refrigerant piping is long.

Also, the above expansion device comprises a main expansion element for permitting a refrigerant to flow in a refrigeration cycle for cooling operation or a refrigeration cycle for heating operation; an auxiliary expansion element connected in series to the main expansion element for permitting

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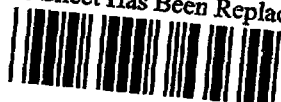
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a refrigerant to flow only in a refrigeration cycle for heating operation; a refrigerant bypass passage for bypassing either of the main expansion element and the auxiliary expansion element; and an opening/closing valve provided on the bypass passage, wherein the opening/closing valve is opened in reducing the expansion amount of the expansion device by the controller.

The above bypass passage further comprises an auxiliary expansion element.

Also, an air conditioner of the present invention comprises a refrigeration cycle using a refrigerant compressor, a four-way valve, an external heat exchanger, an expansion device, and an internal heat exchanger in such a manner that these components are separately mounted in an external unit and an internal unit, thereby constituting a refrigeration cycle for cooling operation of changing the four-way valve for evaporating a refrigerant by the internal heat exchanger and a refrigeration cycle for heating operation of changing the four-way valve for condensing the refrigerant by the external heat exchanger, wherein the external heat exchanger is mounted on the external unit; the internal heat exchange is mounted in the internal unit; both of the heat exchangers mounted in the units are connected to each other by means of a refrigerant piping to form the refrigeration cycle; and a control means is provided for changing the expansion amount of the expansion device according to the length of the refrigerant piping and the state

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of the cooling operation or the heating operation thereby adjusting the high-low pressure in the refrigeration cycle.

The above expansion device is intended to reduce the expansion amount of a refrigerant in the case that the refrigerant piping is longer.

Also, the above expansion device is intended to reduce the expansion amount of the refrigerant by the controller in the case that the refrigerant piping is longer and a refrigeration cycle for heating operation is constituted.

Further, the above expansion device comprises a main expansion element for permitting a refrigerant to flow in a refrigeration cycle for cooling operation or a refrigeration cycle for heating operation; an auxiliary expansion element connected in series to the main expansion element for permitting a refrigerant to flow in a refrigeration cycle for heating operation; a refrigerant bypass passage for bypassing either of the main expansion element and the auxiliary expansion element; and an opening/closing valve provided on the bypass passage, wherein the opening/closing valve is opened in reducing the expansion amount of the expansion device by the controller.

The above bypass passage further comprises an auxiliary expansion element.

Namely, according to the air conditioner of the present invention thus constructed, in the case that the refrigerant

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piping for connecting the external heat exchanger to the internal heat exchanger is long so that the resistance due to the refrigerant piping is enlarged, it is possible to usually keep the difference between the high pressure and low pressure of the refrigerant in the refrigeration cycle within the specified range by adjustment of the expansion amount (resistance) of the expansion device. Accordingly, it is possible to usually keep the refrigeration cycle in the optimal condition irrespective of the length of the refrigerant piping.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a refrigerant circuit diagram of an air conditioner showing a first embodiment of the present invention;

Fig. 2 is a perspective view showing a main part of an external unit of the air conditioner according to the first embodiment of the present invention;

Fig. 3 is a perspective view showing a main part of a receiver tank of the air conditioner according to the first embodiment of the present invention;

Fig. 4 is a side view showing a main part of the receiver tank of the air conditioner according to the first embodiment of the present invention;

Fig. 5 is a refrigerant circuit diagram showing a main part of a second embodiment of the present invention;

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Fig. 6 is a refrigerant circuit diagram showing a main part of a third embodiment of the present invention;

Fig. 7 is a refrigerant circuit diagram showing a main part of a fourth embodiment of the present invention; and

Fig. 8 is a refrigerant circuit diagram showing a main part of a check valve of the air conditioner of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Hereinafter, the preferred embodiments will be described with reference to the drawings. Referring to Fig. 1, reference numeral 1 indicates an air conditioner, which includes an external unit 2 and an internal unit 4 connected to the external unit 2 by a refrigerant piping 3.

The external unit 2 mainly includes a compressor 5, four-way valve 6 for switching operations between heating and cooling, an external heat exchanger 7, a receiver tank 8, an expansion device 9, two accumulators 10 and 11, and a controller 12 for controlling an opening/closing valve 17 constituting the above expansion device 9.

The internal unit 4 mainly includes an internal heat exchanger 13 and a controller 14 for controlling a cooling operation and heating operation. These components are connected to each other by a refrigerant piping, to thus constitute a refrigeration cycle. When the four-way valve 6 is

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in the state as shown by the solid line of Fig. 1, the compressed refrigerant discharged from the compressor 5 is circulated through the internal heat exchanger 13, expansion device 9, receiver tank 8, and external heat exchanger 7. In the above, the internal heat exchanger 13 functions as a condenser and the external heat exchanger 7 functions as an evaporator. Thus, the heating operation is made by the internal heat exchanger 13.

Also, when the four-way valve 6 is in the state as shown by the dotted line of Fig. 1, the compressed refrigerant discharged from the compressor 5 is circulated through the external heat exchanger 7, receiver tank 8, expansion device 9 and internal heat exchanger 13. In the above, the internal heat exchanger 13 functions as the evaporator and the external heat exchanger 7 functions as the condenser. Thus, the cooling operation is made by the internal heat exchanger 13.

In addition, during this refrigeration cycle (refrigerant circuit), the external unit 2 and the internal unit 4 are disposed separately from each other, and which are filled with the refrigerant in such an amount as to correspond to the case that the refrigerant piping 4 for connecting these units 2 and 4 to each other has a length of 25m . When the length of the refrigerant piping 3 is short, the excessive refrigerant is stayed in the receiver tank 8, and accordingly, the refrigerant in a suitable amount can be usually circulated during the

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refrigeration cycle.

Here, an external fan and an internal fan for supplying air to the external heat exchanger 7 and the internal heat exchanger 13 are not shown.

The expansion device 9 is constituted of a main expansion element (capillary tube) 15, an auxiliary expansion element (capillary tube) 16 connected in series to the main expansion element 15, an opening/closing valve 17 provided with a bypass passage through which the refrigerant bypasses the auxiliary expansion element 16, and a check valve 18 for permitting the refrigerant to flow only in one direction (from the external heat exchanger 7 to the internal heat exchanger 13).

In the heating operation, the refrigerant discharged from the compressor 5 is condensed at the internal heat exchanger 13, being expanded by the expansion device 9, and then evaporated at the external heat exchanger 7. At this time, the refrigerant passes through the expansion device 9 in order of the auxiliary expansion element 16 and main expansion element 15 (the opening/closing valve 17 is in the closed state). Accordingly, the high pressure refrigerant is expanded by an amount set by the main expansion element 15 and the auxiliary expansion element 16.

In the cooling operation, the refrigerant discharged from the compressor 5 is condensed at the external heat exchanger 7, being expanded at the expansion device 9, and is evaporated at

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the internal heat exchanger 13, thus performing the cooling. At this time, in the expansion device 9, the refrigerant passes the check valve 18 for bypassing the auxiliary expansion element 16, and thus passes only the main expansion element 15 (the opening/closing valve 17 is in the closed state). Accordingly, the high pressure refrigerant is expanded by an amount set only by the main expansion element 15.

Next, in the heating operation at the time when the opening/closing valve 17 is in the opening state according to a signal from the controller 12, the refrigerant discharged from the compressor 5 is condensed at the internal heat exchanger 13 to release the heat, being expanded in the expansion device 9, and is evaporated at the external heat exchanger 7. At this time, in the expansion device 9, the refrigerant passes the opening/closing valve 17 and the main expansion element 15 in this order. Accordingly, the high pressure refrigerant is expanded in an amount set only by the main expansion element 15.

Reference numeral 19 indicates a set-up switch, which is set in the case that, in the disposition of the external unit 2 and the internal unit 4, the length of the refrigerant piping 3 for connecting the external unit 2 to the internal unit 4 is more than a specified dimension (for example, in the range of from 15 to 25m). In the case that the length of the refrigerant piping 3 is within the specified value (for example,

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less than 15m), the set-up switch is not set. In the installation works for the external unit 3, for example, in connection of the refrigerant piping 3 or the wiring 20, the set-up switch 19 is switched according to the installation dimension of the refrigerant piping 3.

When the heating operation is carried out in the case that the set-up switch 19 is set, the controller 12 outputs a signal for opening the opening/closing valve 17.

In addition, as shown in Fig. 2, the set-up switch 19 is provided on a terminal board 21 connected to the wiring 20 of the external unit 2, and is intended not to be operated when a terminal cover 22 is mounted.

Also, in Fig. 1, reference numeral 23 indicates a flow dividing tube for connecting the external heat exchanger 7, expansion device 9 and receiver tank 8 to each other; 24 is a flow dividing tube for connection of a service valve 25; 26 is a flow dividing tube for connection of a hot gas bypass tube 27.

Further, reference numeral 28 indicates an opening/closing valve provided on the hot gas bypass tube 27, which is opened according to a signal from the controller 12 in a defrost operation, to introduce part of the high temperature refrigerant from the compressor 5 to the external heat exchanger (evaporator) 7 through the refrigerant piping 29 (connecting the external heat exchanger 7 to the flow dividing tube 27), thus performing the defrost of the external heat exchanger 7.

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Reference numeral 30 indicates a refrigerant piping for connecting the flow dividing tube 26 to the flow dividing tube 23, which is intended to introduce part of the high temperature refrigerant supplied through the opening/closing valve 28 to the flow dividing tube 23. Reference numeral 31 indicates a refrigerant piping for connecting the external heat exchanger 7 to the flow dividing tube 24; 32 is a refrigerant piping for connecting the flow dividing tube 24 to the service valve 25; 33 is a refrigerant piping for connecting the flow dividing tube 23 to the receiver tank 8; 34 is a refrigerant piping for connecting the flow dividing tube 23 to the flow dividing tube 24; and 35 is a refrigerant piping for connecting the flow dividing tube 23 to the expansion device 9.

Reference numeral 36 is a set-up switch provided on the internal unit 4, by means of which the cooling operation and the heating operation are set.

In addition, the actual disposition and the shape of the piping in the receiver tank 8 and the vicinity thereof are shown in Fig. 3 or 4.

In the air conditioner 1 having the above construction, the internal unit 4 and the external unit 2 are disposed separately from each other, and accordingly, the refrigerant piping 3 needs to be made longer or is sufficient to be shorter according to the installed location.

First, there will be described the standard piping

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wherein the refrigerant has a length less than 15m. In this case, the set-up switch 19 of the external unit 2 is at the "standard piping" in the installation works (in the state that the switch 19 is not set). Accordingly, the controller 12 always closes the opening/closing valve 17 in both the cooling operation or the heating operation. In the cooling operation, since the refrigerant from the external heat exchanger 7 passes the main expansion element 15 and the check valve 18, it is expanded only by the main expansion element 15.

Also, in the heating operation, since the refrigerant from the internal heat exchanger 13 passes the auxiliary expansion element 16 and the main expansion element 15, it is expanded by the auxiliary expansion element 16 and the main expansion element 15.

In this standard piping, since the refrigerant is filled to correspond to the case of the longer piping, it is somewhat excessive; however, the excessive refrigerant is stayed in the receiver tank 8 and the accumulators 10 and 11, which makes it possible to prevent the refrigerant from being stayed in the heat exchangers 7 and 13 to the utmost.

The excessive refrigerant is stayed mainly in the receiver tank 8 in the cooling operation, whereas it is stayed in the two accumulators 10 and 11 in the heating operation. As shown in Figs. 3 and 4, the receiver tank 8 is connected to the refrigerant circuit between the external heat exchanger 7 and

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the expansion device 9 by one refrigerant piping 33, so that in the cooling operation the excessive liquid refrigerant is gradually stayed in the tank 8 from the lower portion by the pressure of the refrigerant circuit.

In the conventional structure including two refrigerant pipings of inlet tube and the outlet tube on the way of the refrigerant circuit, there occurs the noise through the echo of the flushed sound of the refrigerant; however, according to the structure of this embodiment, it is possible to prevent the flush of the refrigerant in the tank 8 and hence to suppress the flush sound to the utmost. Also, since the lower portion of the tank 8 is connected to the refrigerant circuit by the refrigerant piping 33, the return of the refrigerant in the refrigerant circuit is made rapid.

Next, there will be described the case of the the longer piping wherein the refrigerant piping has a length in the range of from 15 to 25m. In this case, in the installation works, the set-up switch 19 of the internal unit 2 is set at the "longer piping" (in the state that the switch 19 is set).

In the case that the set-up switch 19 is set at the "longer piping", the controller 12 opens the opening/closing valve 17 when the heating operation is started. In the cooling operation, the refrigerant from the external heat exchanger 7 passes through the main expansion element 15 and the check valve 18, and accordingly, it is expanded only by the main expansion

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element 15. On the other hand, in the heating operation, the controller 12 opens the opening/closing valve 17, the refrigerant from the internal heat exchanger 13 passes through the opening/closing valve 17 and the main expansion element 15, and it is expanded only by the main expansion element 15.

Accordingly, when the refrigerant piping has a long size and the refrigeration cycle is set at the cycle for heating operation, the expansion amount is reduced under the consideration of the expansion resistance due to the refrigerant piping 3, so that even in the longer refrigerant piping 3, the total of the expansion amount due to the refrigerant piping 3 and the expansion amount due to the expansion device 9 is almost equal to the expansion amount due to the expansion device 9 in the case of the shorter refrigerant piping 3. Accordingly, it is possible to keep the high-low pressure difference in the refrigeration cycle to be an approximately equal value (within a specified allowance range) irrespective of the length of the refrigerant piping 3.

As a consequence, it is possible to solve the disadvantages that the flow of the refrigerant becomes worse for the longer refrigerant piping 3 and the refrigerant is stayed in the internal heat exchanger 3, and that the temperature of the discharged refrigerant of the compressor is excessively increased and thereby the safety apparatus (not shown) is operated.

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Also, in the air conditioner 1, since the switch 19 for setting the longer piping and the standard piping is disposed in the external unit 2, it is possible to set the the set-up switch 19 along with the connection works of of the external unit 2 and the wiring 20.

Also, after connection works at the external unit 2 in which the installation dimension of the refrigerant piping 3 is determined, the set-up switch 19 is set, so that it is possible to prevent the mistake in setting the set-up switch 19. Further, the set-up switch 19 is disposed in the external unit 2, and accordingly, when being set once, it is not re-set if the length of the refrigerant piping is not changed. Also, since the set-up switch 19 includes the terminal cover 22, it is possible to eliminate the fear that the operator touches and operates it carelessly.

Fig. 5 is a refrigerant circuit diagram showing a main part of an expansion device 9a showing a second embodiment of the present invention. In this case, the expansion device 9a includes an auxiliary expansion element 40 through which the refrigerant flows in the heating operation, a check valve 41 connected in parallel to the element, a main expansion element 42 connected in series to the auxiliary expansion element 40, and an opening/closing valve 43 connected in parallel to the element.

In the case of the longer piping (in the state that the

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set-up switch is set), the opening/closing valve 43 is opened in the heating operation by the controller (not shown). In the case of the standard piping wherein the refrigerant piping 3 has a standard length, the refrigerant passes through the auxiliary expansion element 40 and the main expansion element 42 to be expanded in the heating operation. In the case of the longer piping wherein the refrigerant piping 3 has a longer length, the refrigerant passes only through the auxiliary expansion element 40 to be expanded in the heating operation. Accordingly, when the refrigerant piping 3 is longer, the expansion amount at the expansion device 9a is made smaller, to thus adjust the high-low pressure difference in the refrigeration cycle.

Also, Fig. 6 is a refrigerant circuit diagram showing a main part of an expansion device 9b of a third embodiment of the present invention. In this figure, the expansion device 9b includes a main expansion element 50 through which the refrigerant flows in the heating operation, an opening/closing valve 51 connected in parallel to the element, an electric expansion valve which is connected in parallel to the element 50 and is controlled such that the opening is made smaller in the heating operation than that in the cooling operation.

In the case of the longer piping (in the state that the set-up switch 19 is set), the opening/closing valve 51 is opened in the heating operation by a controller (not shown).

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In the case of the standard piping wherein the refrigerant piping 3 has a standard length, the refrigerant passes through the electric expansion valve 52 and the main expansion element 50 to be expanded in the heating operation. In the case of the standard piping wherein the refrigerant piping has a standard length, the refrigerant passes only through the electric expansion valve 52 to be expanded at the heating operation. Accordingly, when the refrigerant piping 3 is longer, the expansion amount at the expansion device 9b is made smaller, to thus adjust the high-low pressure difference in the refrigeration cycle.

Further, Fig. 7 is a refrigerant circuit diagram showing a main part of an expansion device 9c of a fourth embodiment of the present invention. In the above expansion devices 9, 9a and 9b, in particular, when the heating operation is started with the opening/closing valve 17 being opened, there exists little a pressure difference across both ends of the opening/closing valve 17; however, since the valve body in the check valve 18 is vibrated due to the pressure difference generated by the pulsation of the compressor 5 to generate the noise (there occurs the so-called chattering phenomenon), the expansion device 9c in this embodiment includes an auxiliary expansion element 60 disposed in series to the opening/closing valve 17.

The auxiliary expansion element 60 is constituted of a tube having an inside diameter of 4.5mm smaller than a bypass

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tube 61 having an inside diameter of 3mm. This auxiliary expansion element 60 is intended to make the pressure difference between the upstream side and the down stream side at about 0.01 to 0.05kg/cm², and which has a lowest resistance as compared with the expansion elements 15 and 16.

Fig. 8 is a sectional view of the check valve 18, wherein reference numeral 18a is a valve body made of nylon, and is provided with a weight 18b made of metal. The valve body 18a is set at a specific gravity of from 1.15 to 1.20 g/cm² slightly heavier than that (1.1g//cm²) of the refrigerant liquid. Accordingly, as shown in Fig. 8, even in the state that the check valve 18 is disposed in the longitudinal direction, and the refrigerant liquid reaches to the check valve 18 from the up and down directions, the valve body 18 is prevented from being floated in the refrigerant liquid. Reference numeral 18c indicates a valve seat, and 18d indicates a stopper.

Accordingly, when the opening/closing valve 17 is opened, the pressure difference across the opening/closing valve 17 is kept to be 0.01 to 0.05 Kg/cm² by means of the auxiliary expansion element 60. Thus, since the pressure is applied in the direction of closing the check valve 18, the check valve 18 is free of the chattering phenomenon.

Also, in starting the compressor 5, while the pressure difference across the opening/closing valve 17 provided with the

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auxiliary expansion element 60 is small yet, the valve body 18a of the check valve 18 is heavier than the refrigerant liquid to be prevented from being floated, thereby preventing the chattering phenomenon to the utmost.

In addition, by provision of the auxiliary expansion element 60, the chattering phenomenon of the check valve is thus prevented. This chattering phenomenon is generated until the refrigerant pressure of each refrigerant piping becomes somewhat stable. Accordingly, there may be adopted the following manner; namely, in the case of the longer piping, upon the starting of the heating operation, without the auxiliary expansion element 60 in this embodiment, by means of the controller 12 for controlling the opening/closing valve 12, the opening/closing valve 17 is opened so as to retard the opening by a specified time, for example, 3.5 min. (required for somewhat stabilizing the refrigerant pressure of each refrigerant piping) since the starting of the operation of the compressor 5, thus preventing the chattering phenomenon.

Also, there may be used a capillary tube and a conduit in which the midway portion is crushed as the auxiliary expansion element 60.

As described above, according to the air conditioner of the present invention, since the controller 12 opens the opening/closing valve 17 in the heating operation, the refrigerant is allowed to flow in the opening/closing valve 17

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to reduce the expansion resistance of the refrigerant.

Consequently, in the case that the refrigerant piping is longer than the specified dimension and the expansion resistance is larger, it is possible to allow the refrigerant to smoothly flow in the refrigerant circuit, and to perform the control according to the condition in such a case. Namely, in the case that the refrigerant piping 3 for connecting the external heat exchanger 7 to the internal heat exchanger 13 is made longer, and the resistance due to the refrigerant piping 3 is large, it is possible to keep the high-low pressure difference of the refrigerant in the refrigeration cycle within a specified range by adjustment of the expansion amount of the expansion device 9.

Accordingly, it is possible to usually keep the refrigeration cycle at the suitable state irrespective of the length of the refrigerant piping.

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WHAT IS CLAIMED IS:

1. An air conditioner comprising a refrigeration cycle using a refrigerant compressor, a four-way valve, an external heat exchanger, an expansion device, and an internal heat exchanger in such a manner that these components are separately mounted in an external unit and an internal unit,

wherein said external heat exchanger is mounted on said external unit; said internal heat exchange is mounted in said internal unit; both of said heat exchangers mounted in said units are connected to each other by means of a refrigerant piping to form said refrigeration cycle; and a control means is provided for changing the expansion amount of said expansion device according to the length of said refrigerant piping thereby adjusting the high-low pressure difference in said refrigeration cycle.

2. An air conditioner according to claim 1, wherein said expansion device is intended to reduce the expansion amount of the refrigerant by said control means in the case that said refrigerant piping is long.

3. An air conditioner according to claim 2, wherein said expansion device comprising a main expansion element for permitting a refrigerant to flow in a refrigeration cycle for cooling operation or a refrigeration cycle for heating operation; an auxiliary expansion element connected in series

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to said main expansion element for permitting a refrigerant to flow only in a refrigeration cycle for heating operation; a refrigerant bypass passage for bypassing either of said main expansion element and said auxiliary expansion element; and an opening/closing valve provided on said bypass passage, wherein said opening/closing valve is opened in reducing the expansion amount of said expansion device by said controller.

4. An air conditioner according to claim 2, wherein said bypass passage further comprises an auxiliary expansion element.

5. An air conditioner comprising a refrigeration cycle using a refrigerant compressor, a four-way valve, an external heat exchanger, an expansion device, and an internal heat exchanger in such a manner that these components are separately mounted in an external unit and an internal unit, thereby constituting a refrigeration cycle for cooling operation of changing said four-way valve for evaporating a refrigerant by said internal heat exchanger and a refrigeration cycle for heating operation of changing said four-way valve for condensing the refrigerant by said external heat exchanger,

wherein said external heat exchanger is mounted on said external unit; said internal heat exchange is mounted in said internal unit; both of said heat exchangers mounted in said units are connected to each other by means of a refrigerant piping to form said refrigeration cycle; and a control means is

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provided for changing the expansion amount of said expansion device according to the length of said refrigerant piping and the state of said cooling operation or said heating operation thereby adjusting the high-low pressure in said refrigeration cycle.

6. An air conditioner according to claim 5, wherein said expansion device is intended to reduce the expansion amount of a refrigerant in the case that said refrigerant piping is longer.

7. An air conditioner according to claim 5, wherein said expansion device is intended to reduce the expansion amount of the refrigerant by said controller in the case that said refrigerant piping is longer and a refrigeration cycle for heating operation is constituted.

8. An air conditioner according to claim 7, wherein said expansion device comprising a main expansion element for permitting a refrigerant to flow in a refrigeration cycle for cooling operation or a refrigeration cycle for heating operation; an auxiliary expansion element connected in series to said main expansion element for permitting a refrigerant to flow in a refrigeration cycle for heating operation; a refrigerant bypass passage for bypassing either of said main expansion element and said auxiliary expansion element; and an opening/closing valve provided on said bypass passage, wherein said opening/closing valve is opened in reducing the expansion

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amount of said expansion device by said controller.

9. An air conditioner according to claim 8, wherein
said bypass passage further comprises an auxiliary
expansion element.

10. An air conditioner comprising a compressor (5),
an expansion device (9), an internal heat exchanger
(7), and an external heat exchanger (13) connected in a
refirgeration circuit, the internal heat exchanger
being mounted in an internal unit (4) and the external
heat exchanger being mounted in a remote external unit
(2) and coupled in said refrigerant circuit by
refrigerant piping (3), characterised by control means
(12, 19, 17) for selectively permitting control of
operation of the expansion device (9) in dependence
upon the length of said piping (3).

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ABSTRACT

AIR CONDITIONER

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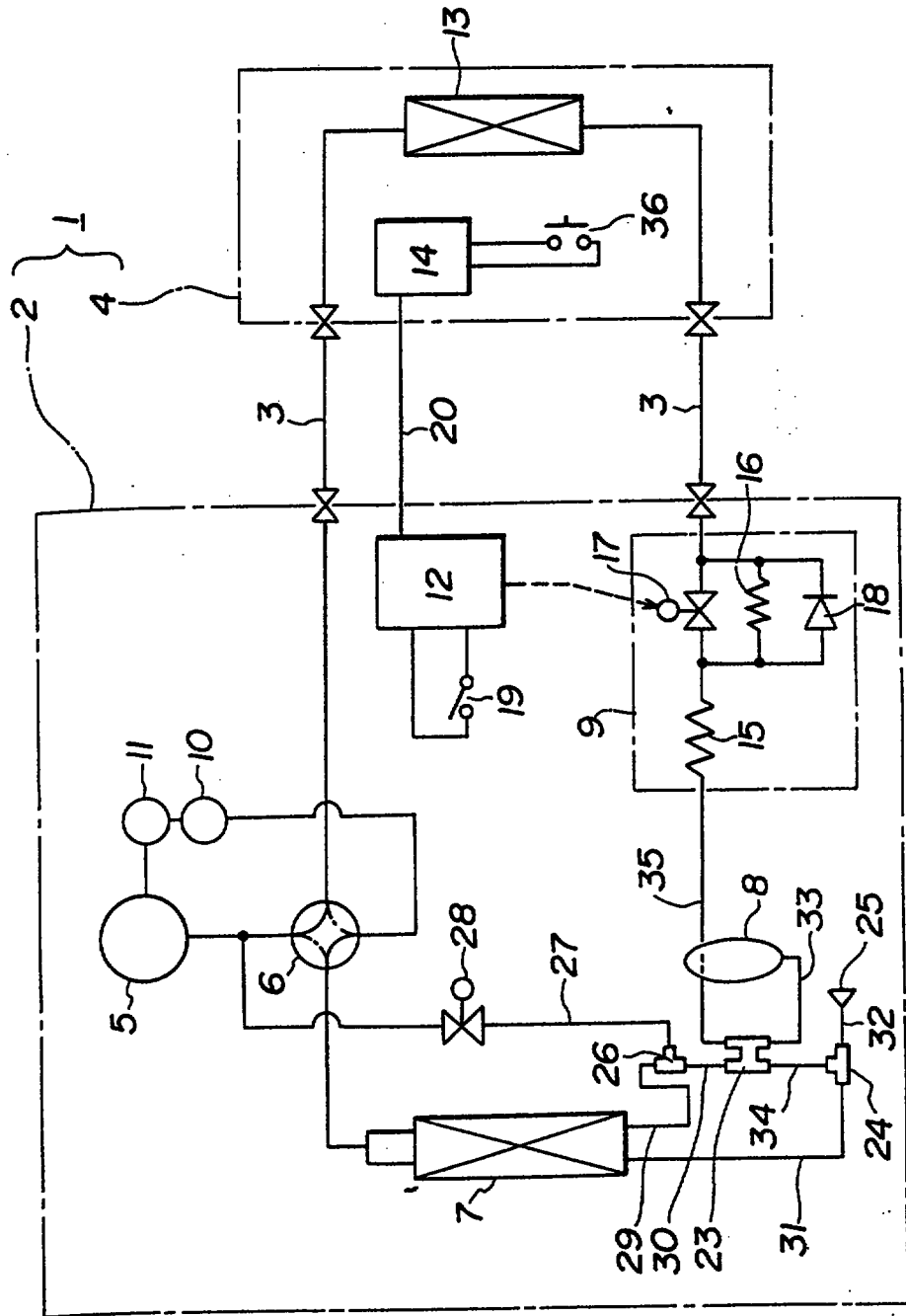
An air conditioner includes a refrigeration circuit
5 that includes a refrigerant compressor (5) a four-way
valve (6), an external heat exchanger (13), an
expansion device (4), and an internal heat exchanger
(7), these components being mounted in an external unit
(2) and an internal unit (4), wherein the external heat
10 exchanger is mounted in the external unit and the
internal heat exchanger is mounted in the internal
unit. The heat exchangers (7, 13) are connected to
each other by means of a refrigerant piping (3) to form
the refrigeration circuit. A control means (19, 12,
15 17) is provided for changing the expansion amount of
the expansion device (9) according to the length of the
refrigerant piping thereby adjusting the pressure
differential in the refrigeration current. With this
construction, it is possible to carry out the optimal
20 operation for a longer length refrigerant piping,
without the need to make the size of each unit larger.

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FIG.1

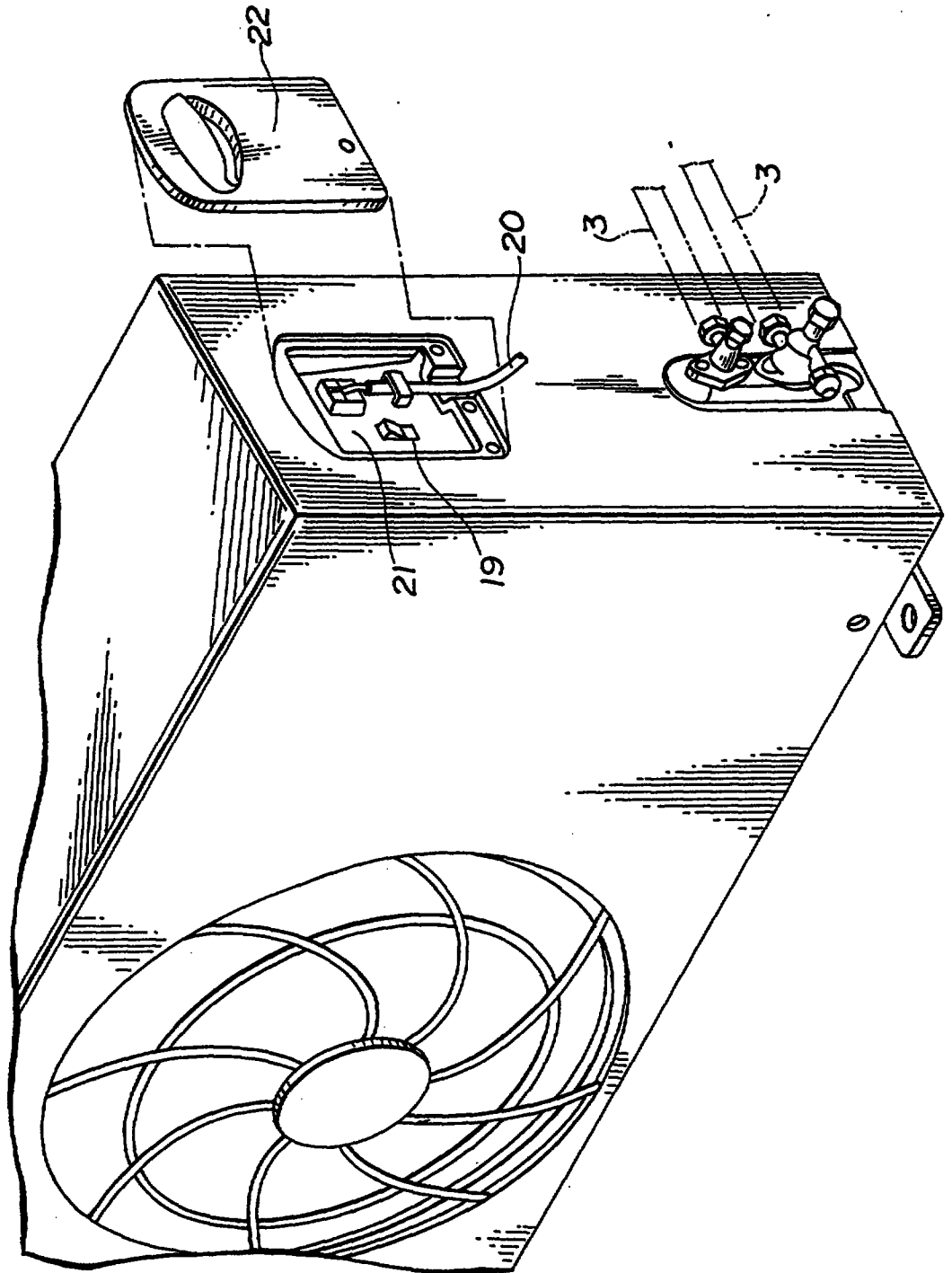


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FIG.2



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FIG.3

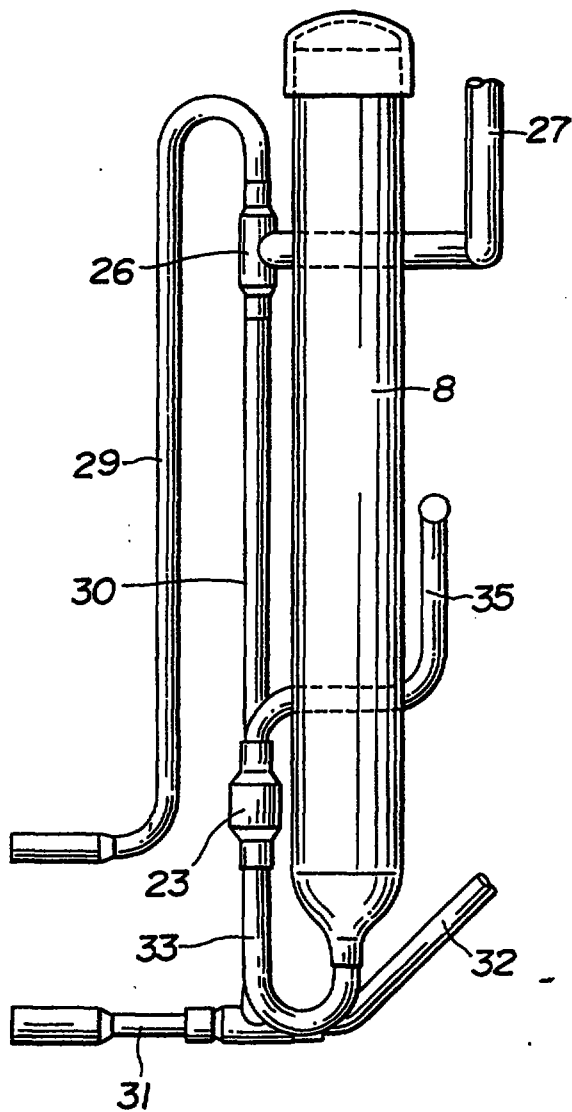
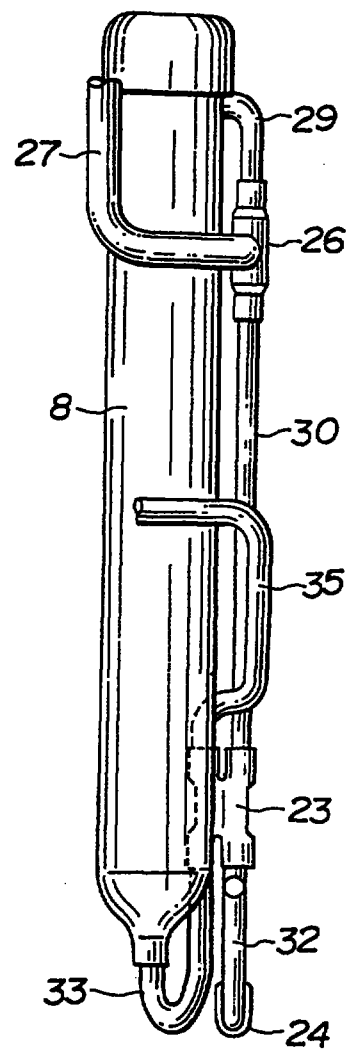


FIG.4



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FIG.5

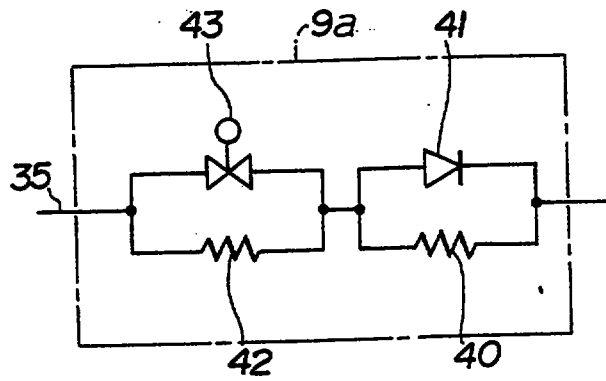


FIG.6

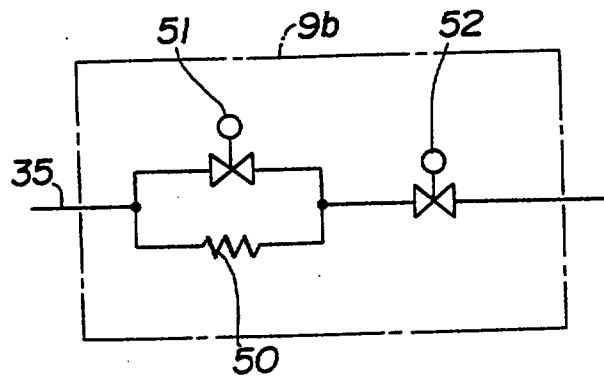


FIG.7

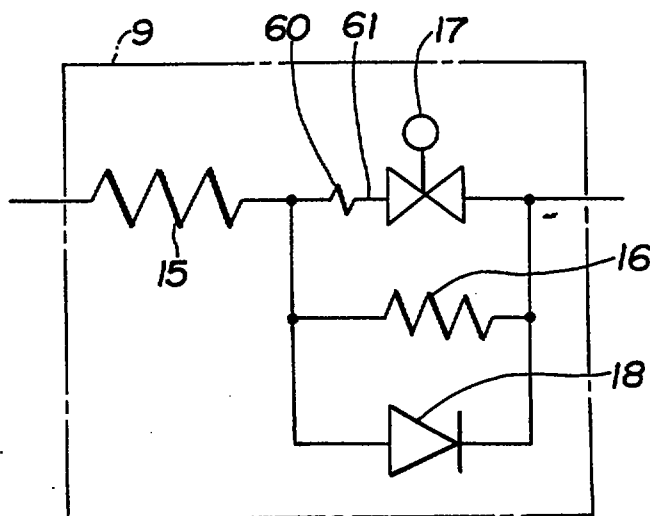
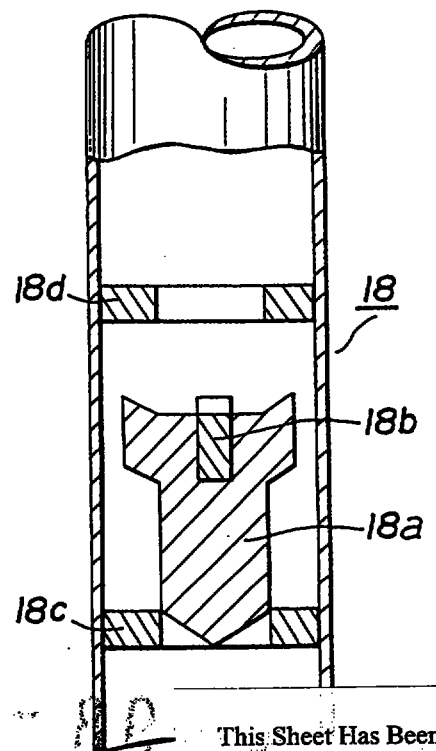


FIG.8



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SPECIFICATION

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TITLE OF THE INVENTION

AIR CONDITIONER

BACKGROUND OF THE INVENTION

The present invention relates to an air conditioner of a split type wherein an external unit having an external heat exchanger and an internal unit having an internal heat exchanger are disposed separately from each other, and respective heat exchangers are connected to each other by a refrigerant piping, to thus constitute a refrigeration cycle.

As the air conditioner of a split type wherein an external heat exchanger is connected to an internal heat exchanger by a refrigerant piping, for example, Japanese Patent Publication No. sho 57-31057 has been disclosed an air conditioner of a split type which includes an external heat exchanger disposed in the outdoor garden and an internal heat exchanger disposed in the interior.

In such an air conditioner of a split type, since the internal heat exchanger and the external heat exchanger are disposed separately from each other, the length of a refrigerant piping for connecting the external heat exchanger to the internal heat exchanger becomes different depending upon the locations where these heat exchangers are disposed.

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Also, since the diameter of the refrigerant piping is generally limited at the specified value, in the case that refrigerant is made to flow in the refrigerant piping, there is generated a specified passage resistance in the refrigerant piping. The resistance tends to increase in proportional to the length of the refrigerant piping.

Accordingly, when the resistance in the refrigerant piping is large, namely, the length of the refrigerant piping is long, the refrigerant circulating amount is reduced to be less than the designed value of the refrigeration cycle. This presents such a problem that the refrigeration ability in design cannot be obtained.

It may be considered to use a compressor having a large ability in the refrigeration cycle and a receiver tank having a large capacity for achieving the high ability. This makes it possible to cope with the state that the refrigerant piping is long. The above attempt, however, is disadvantageous in that, for the short refrigerant piping, the high ability compressor and a large sized receiver tank are made wasteful, and further, the internal unit and the external unit are made larger, thereby obstructing the miniaturization of these units.

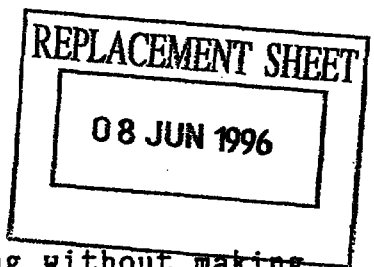
SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide an air conditioner capable of carrying out the optimal

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operation even for the longer refrigerant piping without making the size of each unit larger and enhancing the ability of each component in the refrigeration cycle.

An air conditioner of the present invention comprises a refrigeration cycle using a refrigerant compressor, a four-way valve, an external heat exchanger, an expansion device, and an internal heat exchanger in such a manner that these components are separately mounted in an external unit and an internal unit, wherein the external heat exchanger is mounted on the external unit; the internal heat exchanger is mounted in the internal unit; both of the heat exchangers mounted in the units are connected to each other by means of a refrigerant piping to form the refrigeration cycle; and a control means is provided for changing the expansion amount of the expansion device according to the length of the refrigerant piping thereby adjusting the high-low pressure difference in the refrigeration cycle.

The above expansion device is intended to reduce the expansion amount of the refrigerant by the control means in the case that the refrigerant piping is long.

Also, the above expansion device comprises a main expansion element for permitting a refrigerant to flow in a refrigeration cycle for cooling operation or a refrigeration cycle for heating operation; an auxiliary expansion element connected in series to the main expansion element for permitting

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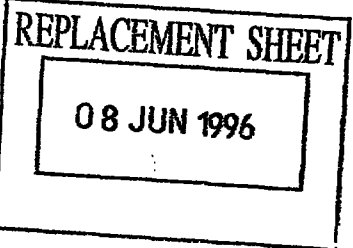


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a refrigerant to flow only in a refrigeration cycle for heating operation; a refrigerant bypass passage for bypassing either of the main expansion element and the auxiliary expansion element; and an opening/closing valve provided on the bypass passage, wherein the opening/closing valve is opened in reducing the expansion amount of the expansion device by the controller.

The above bypass passage further comprises an auxiliary expansion element.

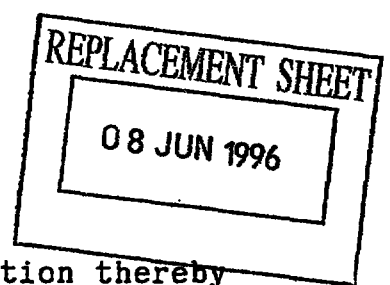
Also, an air conditioner of the present invention comprises a refrigeration cycle using a refrigerant compressor, a four-way valve, an external heat exchanger, an expansion device, and an internal heat exchanger in such a manner that these components are separately mounted in an external unit and an internal unit, thereby constituting a refrigeration cycle for cooling operation of changing the four-way valve for evaporating a refrigerant by the internal heat exchanger and a refrigeration cycle for heating operation of changing the four-way valve for condensing the refrigerant by the external heat exchanger, wherein the external heat exchanger is mounted on the external unit; the internal heat exchange is mounted in the internal unit; both of the heat exchangers mounted in the units are connected to each other by means of a refrigerant piping to form the refrigeration cycle; and a control means is provided for changing the expansion amount of the expansion device according to the length of the refrigerant piping and the state

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of the cooling operation or the heating operation thereby adjusting the high-low pressure in the refrigeration cycle.

The above expansion device is intended to reduce the expansion amount of a refrigerant in the case that the refrigerant piping is longer.

Also, the above expansion device is intended to reduce the expansion amount of the refrigerant by the controller in the case that the refrigerant piping is longer and a refrigeration cycle for heating operation is constituted.

Further, the above expansion device comprises a main expansion element for permitting a refrigerant to flow in a refrigeration cycle for cooling operation or a refrigeration cycle for heating operation; an auxiliary expansion element connected in series to the main expansion element for permitting a refrigerant to flow in a refrigeration cycle for heating operation; a refrigerant bypass passage for bypassing either of the main expansion element and the auxiliary expansion element; and an opening/closing valve provided on the bypass passage, wherein the opening/closing valve is opened in reducing the expansion amount of the expansion device by the controller.

The above bypass passage further comprises an auxiliary expansion element.

Namely, according to the air conditioner of the present invention thus constructed, in the case that the refrigerant

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piping for connecting the external heat exchanger to the internal heat exchanger is long so that the resistance due to the refrigerant piping is enlarged, it is possible to usually keep the difference between the high pressure and low pressure of the refrigerant in the refrigeration cycle within the specified range by adjustment of the expansion amount (resistance) of the expansion device. Accordingly, it is possible to usually keep the refrigeration cycle in the optimal condition irrespective of the length of the refrigerant piping.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a refrigerant circuit diagram of an air conditioner showing a first embodiment of the present invention;

Fig. 2 is a perspective view showing a main part of an external unit of the air conditioner according to the first embodiment of the present invention;

Fig. 3 is a perspective view showing a main part of a receiver tank of the air conditioner according to the first embodiment of the present invention;

Fig. 4 is a side view showing a main part of the receiver tank of the air conditioner according to the first embodiment of the present invention;

Fig. 5 is a refrigerant circuit diagram showing a main part of a second embodiment of the present invention;

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Fig. 6 is a refrigerant circuit diagram showing a main part of a third embodiment of the present invention;

Fig. 7 is a refrigerant circuit diagram showing a main part of a fourth embodiment of the present invention; and

Fig. 8 is a refrigerant circuit diagram showing a main part of a check valve of the air conditioner of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Hereinafter, the preferred embodiments will be described with reference to the drawings. Referring to Fig. 1, reference numeral 1 indicates an air conditioner, which includes an external unit 2 and an internal unit 4 connected to the external unit 2 by a refrigerant piping 3.

The external unit 2 mainly includes a compressor 5, four-way valve 6 for switching operations between heating and cooling, an external heat exchanger 7, a receiver tank 8, an expansion device 9, two accumulators 10 and 11, and a controller 12 for controlling an opening/closing valve 17 constituting the above expansion device 9.

The internal unit 4 mainly includes an internal heat exchanger 13 and a controller 14 for controlling a cooling operation and heating operation. These components are connected to each other by a refrigerant piping, to thus constitute a refrigeration cycle. When the four-way valve 6 is

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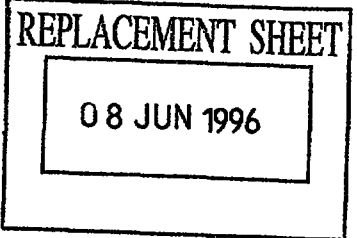
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in the state as shown by the solid line of Fig. 1, the compressed refrigerant discharged from the compressor 5 is circulated through the internal heat exchanger 13, expansion device 9, receiver tank 8, and external heat exchanger 7. In the above, the internal heat exchanger 13 functions as a condenser and the external heat exchanger 7 functions as an evaporator. Thus, the heating operation is made by the internal heat exchanger 13.

Also, when the four-way valve 6 is in the state as shown by the dotted line of Fig. 1, the compressed refrigerant discharged from the compressor 5 is circulated through the external heat exchanger 7, receiver tank 8, expansion device 9 and internal heat exchanger 13. In the above, the internal heat exchanger 13 functions as the evaporator and the external heat exchanger 7 functions as the condenser. Thus, the cooling operation is made by the internal heat exchanger 13.

In addition, during this refrigeration cycle (refrigerant circuit), the external unit 2 and the internal unit 4 are disposed separately from each other, and which are filled with the refrigerant in such an amount as to correspond to the case that the refrigerant piping 4 for connecting these units 2 and 4 to each other has a length of 25m. When the length of the refrigerant piping 3 is short, the excessive refrigerant is stayed in the receiver tank 8, and accordingly, the refrigerant in a suitable amount can be usually circulated during the

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refrigeration cycle.

Here, an external fan and an internal fan for supplying air to the external heat exchanger 7 and the internal heat exchanger 13 are not shown.

The expansion device 9 is constituted of a main expansion element (capillary tube) 15, an auxiliary expansion element (capillary tube) 16 connected in series to the main expansion element 15, an opening/closing valve 17 provided with a bypass passage through which the refrigerant bypasses the auxiliary expansion element 16, and a check valve 18 for permitting the refrigerant to flow only in one direction (from the external heat exchanger 7 to the internal heat exchanger 13).

In the heating operation, the refrigerant discharged from the compressor 5 is condensed at the internal heat exchanger 13, being expanded by the expansion device 9, and then evaporated at the external heat exchanger 7. At this time, the refrigerant passes through the expansion device 9 in order of the auxiliary expansion element 16 and main expansion element 15 (the opening/closing valve 17 is in the closed state). Accordingly, the high pressure refrigerant is expanded by an amount set by the main expansion element 15 and the auxiliary expansion element 16.

In the cooling operation, the refrigerant discharged from the compressor 5 is condensed at the external heat exchanger 7, being expanded at the expansion device 9, and is evaporated at

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the internal heat exchanger 13, thus performing the cooling. At this time, in the expansion device 9, the refrigerant passes the check valve 18 for bypassing the auxiliary expansion element 16, and thus passes only the main expansion element 15 (the opening/closing valve 17 is in the closed state). Accordingly, the high pressure refrigerant is expanded by an amount set only by the main expansion element 15.

Next, in the heating operation at the time when the opening/closing valve 17 is in the opening state according to a signal from the controller 12, the refrigerant discharged from the compressor 5 is condensed at the internal heat exchanger 13 to release the heat, being expanded in the expansion device 9, and is evaporated at the external heat exchanger 7. At this time, in the expansion device 9, the refrigerant passes the opening/closing valve 17 and the main expansion element 15 in this order. Accordingly, the high pressure refrigerant is expanded in an amount set only by the main expansion element 15.

Reference numeral 19 indicates a set-up switch, which is set in the case that, in the disposition of the external unit 2 and the internal unit 4, the length of the refrigerant piping 3 for connecting the external unit 2 to the internal unit 4 is more than a specified dimension (for example, in the range of from 15 to 25m). In the case that the length of the refrigerant piping 3 is within the specified value (for example,

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less than 15m), the set-up switch is not set. In the installation works for the external unit 3, for example, in connection of the refrigerant piping 3 or the wiring 20, the set-up switch 19 is switched according to the installation dimension of the refrigerant piping 3.

When the heating operation is carried out in the case that the set-up switch 19 is set, the controller 12 outputs a signal for opening the opening/closing valve 17.

In addition, as shown in Fig. 2, the set-up switch 19 is provided on a terminal board 21 connected to the wiring 20 of the external unit 2, and is intended not to be operated when a terminal cover 22 is mounted.

Also, in Fig. 1, reference numeral 23 indicates a flow dividing tube for connecting the external heat exchanger 7, expansion device 9 and receiver tank 8 to each other; 24 is a flow dividing tube for connection of a service valve 25; 26 is a flow dividing tube for connection of a hot gas bypass tube 27.

Further, reference numeral 28 indicates an opening/closing valve provided on the hot gas bypass tube 27, which is opened according to a signal from the controller 12 in a defrost operation, to introduce part of the high temperature refrigerant from the compressor 5 to the external heat exchanger (evaporator) 7 through the refrigerant piping 29 (connecting the external heat exchanger 7 to the flow dividing tube 27), thus performing the defrost of the external heat exchanger 7.

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Reference numeral 30 indicates a refrigerant piping for connecting the flow dividing tube 26 to the flow dividing tube 23, which is intended to introduce part of the high temperature refrigerant supplied through the opening/closing valve 28 to the flow dividing tube 23. Reference numeral 31 indicates a refrigerant piping for connecting the external heat exchanger 7 to the flow dividing tube 24; 32 is a refrigerant piping for connecting the flow dividing tube 24 to the service valve 25; 33 is a refrigerant piping for connecting the flow dividing tube 23 to the receiver tank 8; 34 is a refrigerant piping for connecting the flow dividing tube 23 to the flow dividing tube 24; and 35 is a refrigerant piping for connecting the flow dividing tube 23 to the expansion device 9.

Reference numeral 36 is a set-up switch provided on the internal unit 4, by means of which the cooling operation and the heating operation are set.

In addition, the actual disposition and the shape of the piping in the receiver tank 8 and the vicinity thereof are shown in Fig. 3 or 4.

In the air conditioner 1 having the above construction, the internal unit 4 and the external unit 2 are disposed separately from each other, and accordingly, the refrigerant piping 3 needs to be made longer or is sufficient to be shorter according to the installed location.

First, there will be described the standard piping

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wherein the refrigerant has a length less than 15m. In this case, the set-up switch 19 of the external unit 2 is at the "standard piping" in the installation works (in the state that the switch 19 is not set). Accordingly, the controller 12 always closes the opening/closing valve 17 in both the cooling operation or the heating operation. In the cooling operation, since the refrigerant from the external heat exchanger 7 passes the main expansion element 15 and the check valve 18, it is expanded only by the main expansion element 15.

Also, in the heating operation, since the refrigerant from the internal heat exchanger 13 passes the auxiliary expansion element 16 and the main expansion element 15, it is expanded by the auxiliary expansion element 16 and the main expansion element 15.

In this standard piping, since the refrigerant is filled to correspond to the case of the longer piping, it is somewhat excessive; however, the excessive refrigerant is stayed in the receiver tank 8 and the accumulators 10 and 11, which makes it possible to prevent the refrigerant from being stayed in the heat exchangers 7 and 13 to the utmost.

The excessive refrigerant is stayed mainly in the receiver tank 8 in the cooling operation, whereas it is stayed in the two accumulators 10 and 11 in the heating operation. As shown in Figs. 3 and 4, the receiver tank 8 is connected to the refrigerant circuit between the external heat exchanger 7 and

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the expansion device 9 by one refrigerant piping 33, so that in the cooling operation the excessive liquid refrigerant is gradually stayed in the tank 8 from the lower portion by the pressure of the refrigerant circuit.

In the conventional structure including two refrigerant pipings of inlet tube and the outlet tube on the way of the refrigerant circuit, there occurs the noise through the echo of the flushed sound of the refrigerant; however, according to the structure of this embodiment, it is possible to prevent the flush of the refrigerant in the tank 8 and hence to suppress the flush sound to the utmost. Also, since the lower portion of the tank 8 is connected to the refrigerant circuit by the refrigerant piping 33, the return of the refrigerant in the refrigerant circuit is made rapid.

Next, there will be described the case of the the longer piping wherein the refrigerant piping has a length in the range of from 15 to 25m. In this case, in the installation works, the set-up switch 19 of the internal unit 2 is set at the "longer piping" (in the state that the switch 19 is set).

In the case that the set-up switch 19 is set at the "longer piping", the controller 12 opens the opening/closing valve 17 when the heating operation is started. In the cooling operation, the refrigerant from the external heat exchanger 7 passes through the main expansion element 15 and the check valve 18, and accordingly, it is expanded only by the main expansion

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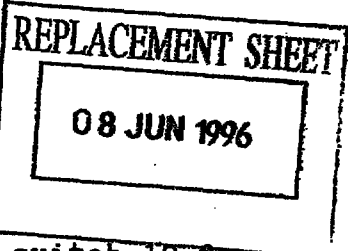
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element 15. On the other hand, in the heating operation, the controller 12 opens the opening/closing valve 17, the refrigerant from the internal heat exchanger 13 passes through the opening/closing valve 17 and the main expansion element 15, and it is expanded only by the main expansion element 15.

Accordingly, when the refrigerant piping has a long size and the refrigeration cycle is set at the cycle for heating operation, the expansion amount is reduced under the consideration of the expansion resistance due to the refrigerant piping 3, so that even in the longer refrigerant piping 3, the total of the expansion amount due to the refrigerant piping 3 and the expansion amount due to the expansion device 9 is almost equal to the expansion amount due to the expansion device 9 in the case of the shorter refrigerant piping 3. Accordingly, it is possible to keep the high-low pressure difference in the refrigeration cycle to be an approximately equal value (within a specified allowance range) irrespective of the length of the refrigerant piping 3.

As a consequence, it is possible to solve the disadvantages that the flow of the refrigerant becomes worse for the longer refrigerant piping 3 and the refrigerant is stayed in the internal heat exchanger 3, and that the temperature of the discharged refrigerant of the compressor is excessively increased and thereby the safety apparatus (not shown) is operated.

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Also, in the air conditioner 1, since the switch 19 for setting the longer piping and the standard piping is disposed in the external unit 2, it is possible to set the the set-up switch 19 along with the connection works of of the external unit 2 and the wiring 20.

Also, after connection works at the external unit 2 in which the installation dimension of the refrigerant piping 3 is determined, the set-up switch 19 is set, so that it is possible to prevent the mistake in setting the set-up switch 19. Further, the set-up switch 19 is disposed in the external unit 2, and accordingly, when being set once, it is not re-set if the length of the refrigerant piping is not changed. Also, since the set-up switch 19 includes the terminal cover 22, it is possible to eliminate the fear that the operator touches and operates it carelessly.

Fig. 5 is a refrigerant circuit diagram showing a main part of an expansion device 9a showing a second embodiment of the present invention. In this case, the expansion device 9a includes an auxiliary expansion element 40 through which the refrigerant flows in the heating operation, a check valve 41 connected in parallel to the element, a main expansion element 42 connected in series to the auxiliary expansion element 40, and an opening/closing valve 43 connected in parallel to the element.

In the case of the longer piping (in the state that the

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set-up switch is set), the opening/closing valve 43 is opened in the heating operation by the controller (not shown). In the case of the standard piping wherein the refrigerant piping 3 has a standard length, the refrigerant passes through the auxiliary expansion element 40 and the main expansion element 42 to be expanded in the heating operation. In the case of the longer piping wherein the refrigerant piping 3 has a longer length, the refrigerant passes only through the auxiliary expansion element 40 to be expanded in the heating operation. Accordingly, when the refrigerant piping 3 is longer, the expansion amount at the expansion device 9a is made smaller, to thus adjust the high-low pressure difference in the refrigeration cycle.

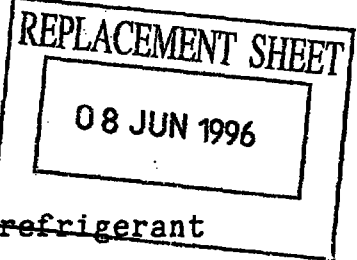
Also, Fig. 6 is a refrigerant circuit diagram showing a main part of an expansion device 9b of a third embodiment of the present invention. In this figure, the expansion device 9b includes a main expansion element 50 through which the refrigerant flows in the heating operation, an opening/closing valve 51 connected in parallel to the element, an electric expansion valve which is connected in parallel to the element 50 and is controlled such that the opening is made smaller in the heating operation than that in the cooling operation.

In the case of the longer piping (in the state that the set-up switch 19 is set), the opening/closing valve 51 is opened in the heating operation by a controller (not shown).

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In the case of the standard piping wherein the refrigerant piping 3 has a standard length, the refrigerant passes through the electric expansion valve 52 and the main expansion element 50 to be expanded in the heating operation. In the case of the standard piping wherein the refrigerant piping has a standard length, the refrigerant passes only through the electric expansion valve 52 to be expanded at the heating operation. Accordingly, when the refrigerant piping 3 is longer, the expansion amount at the expansion device 9b is made smaller, to thus adjust the high-low pressure difference in the refrigeration cycle.

Further, Fig. 7 is a refrigerant circuit diagram showing a main part of an expansion device 9c of a fourth embodiment of the present invention. In the above expansion devices 9, 9a and 9b, in particular, when the heating operation is started with the opening/closing valve 17 being opened, there exists little a pressure difference across both ends of the opening/closing valve 17; however, since the valve body in the check valve 18 is vibrated due to the pressure difference generated by the pulsation of the compressor 5 to generate the noise (there occurs the so-called chattering phenomenon), the expansion device 9c in this embodiment includes an auxiliary expansion element 60 disposed in series to the opening/closing valve 17.

The auxiliary expansion element 60 is constituted of a tube having an inside diameter of 4.5mm smaller than a bypass

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tube 61 having an inside diameter of 3mm. This auxiliary expansion element 60 is intended to make the pressure difference between the upstream side and the down stream side at about 0.01 to 0.05kg/cm², and which has a lowest resistance as compared with the expansion elements 15 and 16.

Fig. 8 is a sectional view of the check valve 18, wherein reference numeral 18a is a valve body made of nylon, and is provided with a weight 18b made of metal. The valve body 18a is set at a specific gravity of from 1.15 to 1.20 g/cm² slightly heavier than that (1.1g//cm²) of the refrigerant liquid. Accordingly, as shown in Fig. 8, even in the state that the check valve 18 is disposed in the longitudinal direction, and the refrigerant liquid reaches to the check valve 18 from the up and down directions, the valve body 18 is prevented from being floated in the refrigerant liquid. Reference numeral 18c indicates a valve seat, and 18d indicates a stopper.

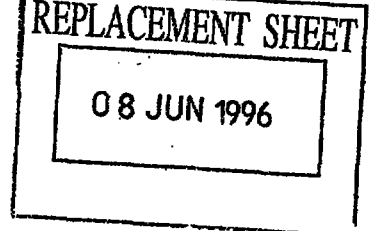
Accordingly, when the opening/closing valve 17 is opened, the pressure difference across the opening/closing valve 17 is kept to be 0.01 to 0.05 Kg/cm² by means of the auxiliary expansion element 60. Thus, since the pressure is applied in the direction of closing the check valve 18, the check valve 18 is free of the chattering phenomenon.

Also, in starting the compressor 5, while the pressure difference across the opening/closing valve 17 provided with the

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auxiliary expansion element 60 is small yet, the valve body 18a of the check valve 18 is heavier than the refrigerant liquid to be prevented from being floated, thereby preventing the chattering phenomenon to the utmost.

In addition, by provision of the auxiliary expansion element 60, the chattering phenomenon of the check valve is thus prevented. This chattering phenomenon is generated until the refrigerant pressure of each refrigerant piping becomes somewhat stable. Accordingly, there may be adopted the following manner; namely, in the case of the longer piping, upon the starting of the heating operation, without the auxiliary expansion element 60 in this embodiment, by means of the controller 12 for controlling the opening/closing valve 12, the opening/closing valve 17 is opened so as to retard the opening by a specified time, for example, 3. 5 min. (required for somewhat stabilizing the refrigerant pressure of each refrigerant piping) since the starting of the operation of the compressor 5, thus preventing the chattering phenomenon.

Also, there may be used a capillary tube and a conduit in which the midway portion is crushed as the auxiliary expansion element 60.

As described above, according to the air conditioner of the present invention, since the controller 12 opens the opening/closing valve 17 in the heating operation, the refrigerant is allowed to flow in the opening/closing valve 17

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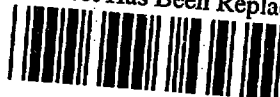
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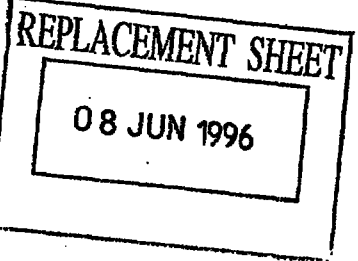
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to reduce the expansion resistance of the refrigerant. Consequently, in the case that the refrigerant piping is longer than the specified dimension and the expansion resistance is larger, it is possible to allow the refrigerant to smoothly flow in the refrigerant circuit, and to perform the control according to the condition in such a case. Namely, in the case that the refrigerant piping 3 for connecting the external heat exchanger 7 to the internal heat exchanger 13 is made longer, and the resistance due to the refrigerant piping 3 is large, it is possible to keep the high-low pressure difference of the refrigerant in the refrigeration cycle within a specified range by adjustment of the expansion amount of the expansion device 9.

Accordingly, it is possible to usually keep the refrigeration cycle at the suitable state irrespective of the length of the refrigerant piping.

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WHAT IS CLAIMED IS:

1. An air conditioner comprising a refrigeration cycle using a refrigerant compressor, a four-way valve, an external heat exchanger, an expansion device, and an internal heat exchanger in such a manner that these components are separately mounted in an external unit and an internal unit,

wherein said external heat exchanger is mounted on said external unit; said internal heat exchange is mounted in said internal unit; both of said heat exchangers mounted in said units are connected to each other by means of a refrigerant piping to form said refrigeration cycle; and a control means is provided for changing the expansion amount of said expansion device according to the length of said refrigerant piping thereby adjusting the high-low pressure difference in said refrigeration cycle.

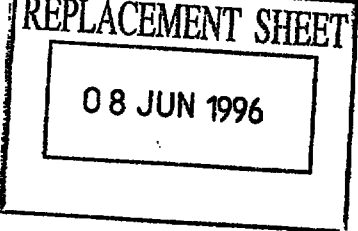
2. An air conditioner according to claim 1, wherein said expansion device is intended to reduce the expansion amount of the refrigerant by said control means in the case that said refrigerant piping is long.

3. An air conditioner according to claim 2, wherein said expansion device comprising a main expansion element for permitting a refrigerant to flow in a refrigeration cycle for cooling operation or a refrigeration cycle for heating operation; an auxiliary expansion element connected in series

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to said main expansion element for permitting a refrigerant to flow only in a refrigeration cycle for heating operation; a refrigerant bypass passage for bypassing either of said main expansion element and said auxiliary expansion element; and an opening/closing valve provided on said bypass passage, wherein said opening/closing valve is opened in reducing the expansion amount of said expansion device by said controller.

4. An air conditioner according to claim 2, wherein said bypass passage further comprises an auxiliary expansion element.

5. An air conditioner comprising a refrigeration cycle using a refrigerant compressor, a four-way valve, an external heat exchanger, an expansion device, and an internal heat exchanger in such a manner that these components are separately mounted in an external unit and an internal unit, thereby constituting a refrigeration cycle for cooling operation of changing said four-way valve for evaporating a refrigerant by said internal heat exchanger and a refrigeration cycle for heating operation of changing said four-way valve for condensing the refrigerant by said external heat exchanger,

wherein said external heat exchanger is mounted on said external unit; said internal heat exchange is mounted in said internal unit; both of said heat exchangers mounted in said units are connected to each other by means of a refrigerant piping to form said refrigeration cycle; and a control means is

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provided for changing the expansion amount of said expansion device according to the length of said refrigerant piping and the state of said cooling operation or said heating operation thereby adjusting the high-low pressure in said refrigeration cycle.

6. An air conditioner according to claim 5, wherein said expansion device is intended to reduce the expansion amount of a refrigerant in the case that said refrigerant piping is longer.

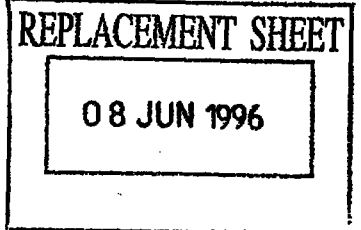
7. An air conditioner according to claim 5, wherein said expansion device is intended to reduce the expansion amount of the refrigerant by said controller in the case that said refrigerant piping is longer and a refrigeration cycle for heating operation is constituted.

8. An air conditioner according to claim 7, wherein said expansion device comprising a main expansion element for permitting a refrigerant to flow in a refrigeration cycle for cooling operation or a refrigeration cycle for heating operation; an auxiliary expansion element connected in series to said main expansion element for permitting a refrigerant to flow in a refrigeration cycle for heating operation; a refrigerant bypass passage for bypassing either of said main expansion element and said auxiliary expansion element; and an opening/closing valve provided on said bypass passage, wherein said opening/closing valve is opened in reducing the expansion

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amount of said expansion device by said controller.

5 9. An air conditioner according to claim 8, wherein said bypass passage further comprises an auxiliary expansion element.

10 10. An air conditioner comprising a compressor (5), an expansion device (9), an internal heat exchanger (7), and an external heat exchanger (13) connected in a refrigeration circuit, the internal heat exchanger being mounted in an internal unit (4) and the external heat exchanger being mounted in a remote external unit (2) and coupled in said refrigerant circuit by refrigerant piping (3), characterised by control means
15 (12, 19, 17) for selectively permitting control of operation of the expansion device (9) in dependence upon the length of said piping (3).

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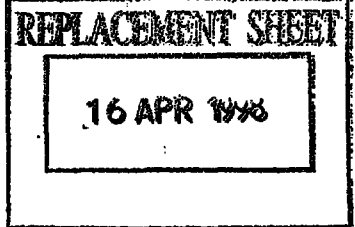
ABSTRACTAIR CONDITIONER

An air conditioner includes a refrigeration circuit that includes a refrigerant compressor (5) a four-way valve (6), an external heat exchanger (13), an expansion device (4), and an internal heat exchanger (7), these components being mounted in an external unit (2) and an internal unit (4), wherein the external heat exchanger is mounted in the external unit and the internal heat exchanger is mounted in the internal unit. The heat exchangers (7, 13) are connected to each other by means of a refrigerant piping (3) to form the refrigeration circuit. A control means (19, 12, 17) is provided for changing the expansion amount of the expansion device (9) according to the length of the refrigerant piping thereby adjusting the pressure differential in the refrigeration current. With this construction, it is possible to carry out the optimal operation for a longer length refrigerant piping, without the need to make the size of each unit larger.

FIGURE 1.

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AIR CONDITIONER

The present invention relates to a split-type air conditioner in which an external unit having an external heat exchanger and an internal unit having an internal heat exchanger are disposed separately from each other, and respective heat exchangers are connected to each other by refrigerant piping to provide a refrigeration cycle.

An air conditioner of this general type is disclosed in Japanese patent publication No. sho 57-31057 in which an external heat exchanger is disposed outdoors and connected by refrigerant piping to an internal heat exchanger which is disposed indoors. Since the internal and external heat exchangers are disposed separately from each other, the length of a refrigerant piping for connecting them together can vary depending on where the heat exchangers are disposed.

Also, since the diameter of the refrigerant piping is generally limited to a specified value, when refrigerant flows through it a specified resistance will be generated in the piping which tends to increase in proportion to the length of the piping.

Accordingly, when the resistance in the refrigerant piping is large because the length of the piping is long,

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the amount of circulating refrigerant is reduced to less than the designed value of the refrigeration cycle so the required refrigeration ability of the system cannot be obtained.

To overcome this problem, large capacity compressor and a receiver tank can be used but this has the disadvantage that they are not needed for the shorter refrigerant piping lengths and thus are wasteful. Furthermore, the internal unit and the external unit need to be larger, thereby reducing the possibility of miniaturization of these units.

It is therefore an object of the present invention to provide an air conditioner capable of optimal operation even for longer refrigerant piping lengths without increasing the size of the internal and external heat exchangers to enhance the ability of each component in the refrigeration cycle.

According to the present invention, there is provided an air conditioner comprising a compressor, an expansion device, an internal heat exchanger, an external heat exchanger and control means connected in a refrigeration circuit, the internal heat exchanger being mounted in an internal unit and the external heat exchanger being mounted in a remote external unit and coupled in said refrigeration circuit by refrigerant piping characterised

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in that the expansion device comprises at least a main expansion element, an auxiliary expansion element and a valve, the control means being operable to open and close the valve to direct refrigerant through either one or both expansion elements to set the amount of expansion of the refrigerant in the expansion device in dependence upon the connected length of the refrigerant piping between the external unit and internal unit in the refrigerant circuit.

Preferably the valve is operable to direct the refrigerant through only one expansion element to reduce the amount of expansion of the refrigerant when the refrigerant piping between the external unit and internal unit in the refrigerant circuit is over a specified length.

Preferably, the control means controls the operation of the expansion device when a heating operation is initiated.

In a preferred embodiment, the auxiliary expansion element is connected in series to the main expansion element through which a refrigerant flows in a refrigeration circuit during a heating operation only and the expansion device includes a refrigerant bypass passage for bypassing the auxiliary expansion element.

Preferably, the bypass passage comprises a second auxiliary expansion element.

In the preferred embodiment, a four-way valve is provided in the refrigeration circuit to allow switching between a cooling operation wherein the internal heat exchanger evaporates the refrigerant and a heating operation wherein the external heat exchanger condenses the refrigerant.

Preferably, the expansion device consists of a plurality of capillary tubes and a valve to control the flow of coolant through said capillary tubes.

With the air conditioner of the present invention it is possible to keep the difference between the high and low pressure of the refrigerant in the refrigeration cycle within a predetermined range by adjusting the expansion amount (resistance) of the expansion device. Accordingly, it is possible to usually keep the refrigeration cycle in the optimal condition irrespective of the length of the refrigerant piping.

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a refrigerant circuit diagram for a first

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embodiment of air conditioner of the present invention;
Figure 2 is a perspective view of part of an external unit of the air conditioner of Figure 1;
Figure 3 is a perspective view of part of a receiver tank of the air conditioner of Figure 1;
Figure 4 is a side view showing part of the receiver tank of the air conditioner of Figure 1;
Figure 5 is a refrigerant circuit diagram of part of a second embodiment of air conditioner of the present invention;
Figure 6 is a refrigerant circuit diagram of part of a third embodiment of air conditioner of the present invention;
Figure 7 is a refrigerant circuit diagram showing part of a fourth embodiment of air conditioner of the present invention; and
Figure 8 is a refrigerant circuit diagram showing a part of a check valve for use with an air conditioner of the present invention.

Referring to Figure 1, there is shown an air conditioner 1, which includes an external unit 2 and an internal unit 4 connected to the external unit 2 by refrigerant piping 3.

The external unit 2 includes a compressor 5, a four-way valve 6 for switching between heating and cooling operations, an external heat exchanger 7, a receiver tank

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8, an expansion device 9, two accumulators 10 and 11, and a controller 12 for controlling an opening/closing valve 17 constituting the above expansion device 9.

The internal unit 4 includes an internal heat exchanger 13 and a controller 14 for controlling the cooling operation and heating operations. These components are connected to each other by refrigerant piping to thus constitute a refrigeration cycle. When the four-way valve 6 is in the state shown by the solid line in Figure 1, the compressed refrigerant discharged from the compressor 5 is circulated through the internal heat exchanger 13, expansion device 9, receiver tank 8, and external heat exchanger 7, the internal heat exchanger 13 functioning as a condenser and the external heat exchanger 7 functioning as an evaporator. Thus, the heating operation is carried out by the internal heat exchanger 13.

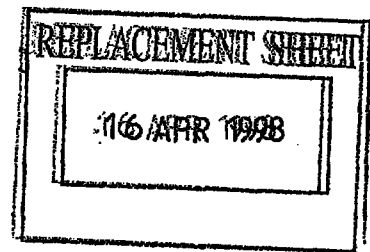
When the four-way valve 6 is in the state shown by the dotted line in Figure 1, the compressed refrigerant discharged from the compressor 5 is circulated through the external heat exchanger 7, receiver tank 8, expansion device 9 and internal heat exchanger 13, the internal heat exchanger 13 functioning as the evaporator and the external heat exchanger 7 functioning as the condenser. Thus, the cooling operation is carried out by the internal heat exchanger 13.

In addition, during the refrigeration cycle (refrigerant circuit), the external unit 2 and the internal unit 4 are disposed separately from each other and filled with the quantity of refrigerant required for connecting units 2 and 4 to each other with piping 3 having a length of 25m. When the length of the refrigerant piping 3 is short, excess refrigerant remains in the receiver tank 8 so a suitable amount of refrigerant can be circulated during the refrigeration cycle.

Here, an external fan and an internal fan for supplying air to the external heat exchanger 7 and the internal heat exchanger 13 are not shown.

The expansion device 9 comprises a main expansion element (capillary tube) 15, an auxiliary expansion element (capillary tube) 16 connected in series to the main expansion element 15, an opening/closing valve 17 provided with a bypass passage through which the refrigerant bypasses the auxiliary expansion element 16, and a check valve 18 for permitting the refrigerant to flow only in one direction (from the external heat exchanger 7 to the internal heat exchanger 13).

In the heating operation, the refrigerant discharged from the compressor 5 is condensed at the internal heat exchanger 13, expanded by the expansion device 9, and then evaporated at the external heat exchanger 7. The



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refrigerant then passes through the expansion device 9, the auxiliary expansion element 16 and main expansion element 15 (the opening/closing valve 17 is in the closed state). Accordingly, the high pressure refrigerant is expanded by an amount set by the main expansion element 15 and the auxiliary expansion element 16.

In the cooling operation, the refrigerant discharged from the compressor 5 is condensed at the external heat exchanger 7, expanded at the expansion device 9, and then evaporated at the internal heat exchanger 13, thus performing the cooling function. At this time, in the expansion device 9, the refrigerant passes through the check valve 18 thereby bypassing the auxiliary expansion element 16, and passing to only the main expansion element 15 (the opening/closing valve 17 is in the closed state). Accordingly, the high pressure refrigerant is expanded by an amount set only by the main expansion element 15.

Next, in the heating operation at the time when the opening/closing valve 17 is in its open state according to a signal received from the controller 12, the refrigerant discharged from the compressor 5 is condensed at the internal heat exchanger 13 to release the heat, expanded in the expansion device 9, and evaporated at the external heat exchanger 7. At this time, in the expansion device 9, the refrigerant passes the

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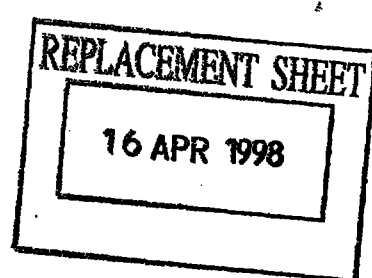
opening/closing valve 17 and the main expansion element 15 in this order. Accordingly, the high pressure refrigerant is expanded by an amount set only by the main expansion element 15.

A set-up switch 19, which is set when the length of the refrigerant piping 3 connecting the external unit 2 to the internal unit 4 is more than a specified dimension (for example, in the range of from 15 to 25m). In the case that the length of the refrigerant piping 3 is within the specified value (for example, less than 15m), the set-up switch 19 is not set. During installation of the external unit 2, for example, when the refrigerant piping 3 or the wiring 20 are connected, the set-up switch 19 will be switched depending on the installation dimensions of the refrigerant piping 3.

When the heating operation is carried out in the case that the set-up switch 19 is set, the controller 12 outputs a signal for opening the opening/closing valve 17.

In addition, as shown in Figure 2, the set-up switch 19 is provided on a terminal board 21 connected to the wiring 20 of the external unit 2, and is intended not to be operated when a terminal cover 22 is mounted.

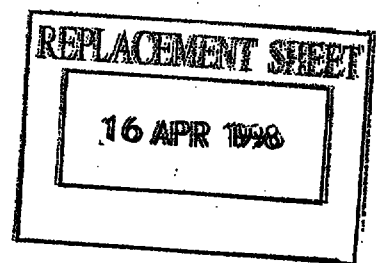
Also, in Figure 1 there is shown a flow dividing tube 23



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connected to the external heat exchanger 7, expansion device 9 and receiver tank 8; a flow dividing tube 24 is connected to a service valve 25; and a flow dividing tube 26 is connected to a hot gas bypass tube 27. An opening/closing valve 28 is provided on the hot gas bypass tube 27, which is opened in response to a signal received from the controller 12 when it is in its defrost mode, to introduce part of the high temperature refrigerant from the compressor 5 to the external heat exchanger (evaporator) 7 through the refrigerant piping 29 (connecting the external heat exchanger 7 to the flow dividing tube 26), thus defrosting the external heat exchanger 7.

Refrigerant piping 30 connects the flow dividing tube 26 to the flow dividing tube 23, which is intended to introduce part of the high temperature refrigerant supplied through the opening/closing valve 28 to the flow dividing tube 23. Refrigerant piping 31 connects the external heat exchanger 7 to the flow dividing tube 24; refrigerant piping 32 connects the flow dividing tube 24 to the service valve 25; refrigerant piping 33 connects the flow dividing tube 23 to the receiver tank 8; refrigerant piping 34 connects the flow dividing tube 23 to the flow dividing tube 24; and refrigerant piping 35 connects the flow dividing tube 23 to the expansion device 9.



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Set-up switch 36 provided on the internal unit 4, sets the cooling and heating operations.

The actual disposition and shape of the piping in the receiver tank 8 and the vicinity thereof are shown in Figures 3 and 4.

In the air conditioner 1 having the above construction, the internal unit 4 and the external unit 2 are disposed separately from each other, and accordingly, the length of the refrigerant piping 3 can be longer or shorter depending on the installed location.

First, there will be described a "standard piping" layout wherein the refrigerant has a length of less than 15m. In this case, the set-up switch 19 of the external unit 2 is set to its "standard piping" setting during installation (in the state that the switch 19 is not set). Accordingly, the controller 12 always closes the opening/closing valve 17 in both the cooling or heating operations. In the cooling operation, since the refrigerant from the external heat exchanger 7 passes the main expansion element 15 and the check valve 18, it is expanded only by the main expansion element 15.

Also, in the heating operation, since the refrigerant from the internal heat exchanger 13 passes the auxiliary expansion element 16 and the main expansion element 15,

it is expanded by the auxiliary expansion element 16 and the main expansion element 15.

With this "standard piping", since the system has to be filled with refrigerant work with an installation having "longer piping", it is somewhat excessive. However, the excessive refrigerant remains in the receiver tank 8 and the accumulators 10 and 11, thereby preventing the refrigerant from remaining in the heat exchangers 7 and 13.

The excessive refrigerant remains mainly in the receiver tank 8 during the cooling operation, whereas it remains in the two accumulators 10 and 11 during the heating operation. As shown in Figures 3 and 4, the receiver tank 8 is connected to the refrigerant circuit between the external heat exchanger 7 and the expansion device 9 by a single refrigerant pipe 33, so that during the cooling operation, any excessive liquid refrigerant is gradually stored in the tank 8 from the lower portion by the pressure of the refrigerant circuit.

In a conventional layout using refrigerant inlet and outlet tubes in the refrigerant circuit, noise is generated by the echo of the flushed sound of the refrigerant. However, with the described embodiment, it is possible to prevent the flush of refrigerant in the tank 8 so any flush sound is suppressed. Also, since the

lower portion of the tank 8 is connected to the refrigerant circuit by the refrigerant piping 33, the return of the refrigerant in the refrigerant circuit is rapid.

The case where a "longer piping" run is required will now be described in which the refrigerant piping has a length in the range of from 15 to 25m. In this case, during installation, the set-up switch 19 of the internal unit 2 is set to its "longer piping" mode (in the state that the switch 19 is set).

When the set-up switch 19 has been set at the "longer piping" setting, the controller 12 opens the opening/closing valve 17 and the heating operation is started. During its cooling operation, the refrigerant from the external heat exchanger 7 passes through the main expansion element 15 and the check valve 18, and is expanded only by the main expansion element 15. On the other hand, during the heating operation, the controller 12 opens the opening/closing valve 17, the refrigerant from the internal heat exchanger 13 passes through the opening/closing valve 17 and the main expansion element 15, and it is expanded only by the main expansion element 15.

Accordingly, when the refrigerant piping is long and the refrigeration cycle is set for heating operation, the

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expansion amount is reduced due to the expansion resistance of refrigerant piping 3, so that even in the longer refrigerant piping 3, the total of the expansion amount due to the refrigerant piping 3 and the expansion amount due to the expansion device 9 is almost equal to the expansion amount due to the expansion device 9 in the case of the shorter refrigerant piping 3. Thus, it is possible to keep the high-low pressure difference in the refrigeration cycle to an approximately equal value (within a specified allowance range) irrespective of the length of the refrigerant piping 3.

As a consequence, it is possible to overcome the disadvantages that the flow of refrigerant becomes worse for the longer refrigerant piping 3 and the refrigerant is kept in the internal heat exchanger 3, and that the temperature of the discharged refrigerant of the compressor is excessively increased and thereby the safety apparatus (not shown) is operated.

In the air conditioner 1, since the switch 19 for setting for "longer piping" or "standard piping" is disposed in the external unit 2, it is possible to set the switch 19 at the same time as the connection works of the external unit 2 and the wiring 20 are done.

Following connection of the external unit 2 in which the installation dimension of the refrigerant piping 3 is

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determined, the switch 19 is set, so it is impossible to make a mistake in setting switch 19. Further, the set-up switch 19 is disposed in the external unit 2, and accordingly, once set, it will not need to be reset unless the length of the refrigerant piping is changed. Also, since the set-up switch 19 includes the terminal cover 22, it is possible to eliminate any risk of the operator touching and operating it accidentally.

Figure 5 is a refrigerant circuit diagram showing the main part of an expansion device 9a of a second embodiment of the present invention. In this case, the expansion device 9a includes an auxiliary expansion element 40 through which the refrigerant flows in the heating operation, a check valve 41 connected in parallel thereto, a main expansion element 42 connected in series with the auxiliary expansion element 40, and an opening/closing valve 43 connected in parallel with the expansion element 40.

In the case where "longer piping" is needed (i.e. the set-up switch needs to be set), the opening/closing valve 43 is opened in the heating operation by the controller (not shown). In the case of "standard piping" wherein the refrigerant piping 3 has a standard length, the refrigerant passes through the auxiliary expansion element 40 and the main expansion element 42 to be expanded in the heating operation. In the case of

"longer piping" wherein the refrigerant piping 3 has a longer length, the refrigerant passes only through the auxiliary expansion element 40 to be expanded in the heating operation. Accordingly, when the refrigerant piping 3 is longer, the expansion amount at the expansion device 9a is made smaller, to thus adjust the high-low pressure difference in the refrigeration cycle.

Figure 6 shows a refrigerant circuit diagram showing the main part of an expansion device 9b of a third embodiment of the present invention in which the expansion device 9b includes a main expansion element 50 through which the refrigerant flows in the heating operation, an opening/closing valve 51 connected in parallel to the element, an electric expansion valve which is connected in parallel to the element 50 and is controlled such that the opening is made smaller in the heating operation than that in the cooling operation.

In the case of "longer piping" (i.e. when the set-up switch 19 needs to be set), the opening/closing valve 51 is opened in the heating operation by a controller (not shown). In the case of "standard piping" wherein the refrigerant piping 3 has a standard length, the refrigerant passes through the electric expansion valve 52 and the main expansion element 50 to be expanded in the heating operation. In the case of "standard piping" wherein the refrigerant piping has a standard length, the

refrigerant passes only through the electric expansion valve 52 to be expanded at the heating operation. Accordingly, when the refrigerant piping 3 is longer, the expansion amount at the expansion device 9b is made smaller, to thus adjust the high-low pressure difference in the refrigeration cycle.

Figure 7 is a refrigerant circuit diagram showing the main part of an expansion device 9c of a fourth embodiment of the present invention. In the above expansion devices 9, 9a and 9b, in particular, when the heating operation is started with the opening/closing valve 17 being opened, there is little pressure difference across both ends of the opening/closing valve 17; however, since the valve body in the check valve 18 is vibrated due to the pressure difference generated by the pulsation of the compressor 5 which also generates noise the so-called "chattering" phenomenon), the expansion device 9c in this embodiment includes an auxiliary expansion element 60 disposed in series with the opening/closing valve 17.

The auxiliary expansion element 60 comprises a tube having an inside diameter of 4.5mm smaller than bypass tube 61 which has an inside diameter of 3mm. This auxiliary expansion element 60 is intended to make the pressure difference between the upstream and downstream sides about 0.01 to 0.5kg/cm², which has a lower

resistance compared with the expansion elements 15 and 16.

Figure 8 is a sectional view of the check valve 18 which has a valve body 18a made of nylon, and a metal weight 18b fitted thereto. The valve body 18a is set at a specific gravity of from 1.15 to 1.20g/cm³ which is slightly heavier than that (1.1g/cm³) of the refrigerant liquid. As shown in Figure 8 even when the check valve 18 from the up and down directions, the valve body 18 is prevented from floating in the refrigerant liquid. Reference numeral 18c indicates a valve seat, and 18d indicates a stopper.

Accordingly, when the opening/closing valve 17 is opened, the pressure difference across the valve is kept between 0.01 and 0.05Kg/cm² by means of the auxiliary expansion element 60. Thus, since the pressure is applied in the direction of closing the check valve 18, it is free of the "chattering" phenomenon.

Also, during starting of the compressor 5, while the pressure difference across the opening/closing valve 17 provided with the auxiliary expansion element 60 is still small, the valve body 18a of the check valve 18 is heavier than the refrigerant liquid so it cannot float thereby preventing the "chattering" phenomenon.

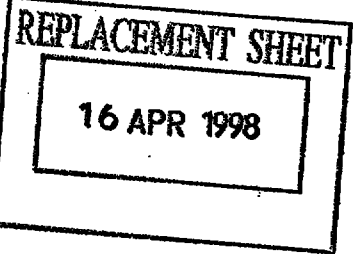
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In addition, by using the auxiliary expansion element 60, "chattering" of the check valve is prevented. This "chattering" is generated until such time as the refrigerant pressure in each refrigerant pipe becomes stable. Accordingly, in the case of the "longer piping", upon the starting of the heating operation, without the auxiliary expansion element 60 in this embodiment, by means of the controller 12 for controlling the opening/closing valve 12, the opening/closing valve 17 is opened so as to retard the opening by a specified time, for example, 3. 5 min. (required to stabilize the refrigerant pressure of each refrigerant piping) since the starting of the operation of the compressor 5, thus preventing "chattering".

Also, there may be used a capillary tube and a conduit in which the midway portion is crushed as the auxiliary expansion element 60.

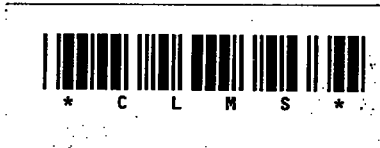
As described, above, with the air conditioner of the present invention, since the controller 12 opens the opening/closing valve 17 in the heating operation, the refrigerant is allowed to flow in the opening/closing valve 17 to reduce the expansion resistance of the refrigerant. Consequently, in the case that the refrigerant piping is longer than the specified dimension and the expansion resistance is larger, it is possible to allow the refrigerant to smoothly flow in the refrigerant



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circuit, and to perform the control according to the condition in such a case. Namely, in the case that the refrigerant piping 3 for connecting the external heat exchanger 7 to the internal heat exchanger 13 is made longer, and the resistance due to the refrigerant piping 3 is large, it is possible to keep the high-low pressure difference of the refrigerant in the refrigeration cycle within a specified range by adjustment of the expansion amount of the expansion device 9.

Accordingly, it is possible to usually keep the refrigeration cycle at the required state irrespective of the length of the refrigerant piping.



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CLAIMS

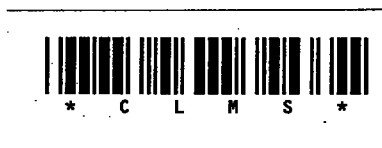
1. An air conditioner comprising a compressor (5), an expansion device (9,9a,9b,9c), an internal heat exchanger (7), an external heat exchanger (13) and control means (12,19) connected in a refrigeration circuit, the internal heat exchanger (13) being mounted in an internal unit (4) and the external heat exchanger (7) being mounted in a remote external unit (2) and coupled in said refrigeration circuit by refrigerant piping (3) characterised in that the expansion device (9,9a,9b,9c) comprises at least a main expansion element (15,42,50), an auxiliary expansion element (16,40,52) and a valve (17,43,51), the control means (12,19) being operable to open and close the valve (17,43,51) to direct refrigerant through either one or both expansion elements (15,42,50) (16,40,50) to set the amount of expansion of the refrigerant in the expansion device (9,9a,9b,9c) in dependence upon the connected length of the refrigerant piping (3) between the external unit (2) and internal unit (4) in the refrigerant circuit.

2. An air conditioner as claimed in claim 1 characterised in that the valve is operable to direct the refrigerant through only one expansion element to reduce the amount of expansion of the refrigerant piping between the internal unit (4) in the refrigerant circuit to a specified length.



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3. An air conditioner as claimed in claim 2 characterised in that the control means (12,19) controls the operation of the expansion device (9,9a,9b,9c) when a heating operation is initiated.
4. An air conditioner as claimed in any preceding claim characterised in that the auxiliary expansion element (16,40,60) is connected in series to the main expansion element (15,42,50) through which a refrigerant flows in a refrigeration circuit during a heating operation only and the expansion device (9,9a,9b,9c) includes a refrigerant bypass passage for bypassing the auxiliary expansion element (16,40).
5. An air conditioner as claimed in claim 4 characterised in that the bypass passage comprises a second auxiliary expansion element (60).
6. An air conditioner as claimed in any preceding claim characterised by a four-way valve (6) in the refrigeration circuit to allow switching between a cooling operation wherein the internal heat exchanger (13) evaporates the refrigerant and a heating operation wherein the external heat exchanger (7) condenses the refrigerant.
7. An air conditioner as claimed in any preceding claim characterised in that said expansion device (9,9a,9b,9c) includes a refrigerant bypass passage for bypassing the auxiliary expansion element (16,40).



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consists of a plurality of capillary tubes (9,9a,9b,9c) and a valve (17,43,51) to control the flow of coolant through said capillary tubes (9,9a,9b,9c).

ABSTRACT

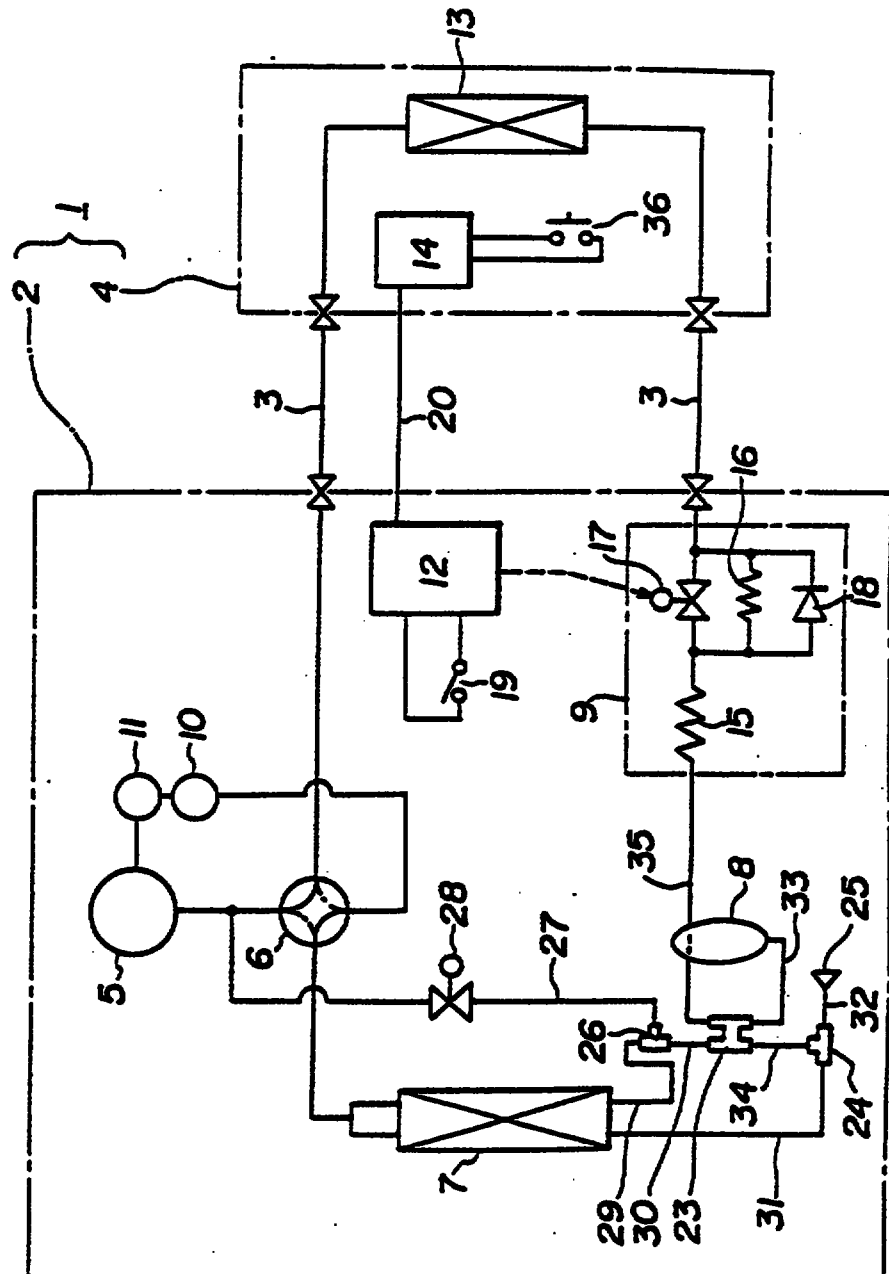
AIR CONDITIONER

An air conditioner includes a refrigeration circuit that includes a refrigerant compressor (5) a four-way valve (6), an external heat exchanger (13), an expansion device (4), and an internal heat exchanger (7), these components being mounted in an external unit (2) and an internal unit (4), wherein the external heat exchanger is mounted in the external unit and the internal heat exchanger is mounted in the internal unit. The heat exchangers (7, 13) are connected to each other by means of a refrigerant piping (3) to form the refrigeration circuit. A control means (19, 12, 17) is provided for changing the expansion amount of the expansion device (9) according to the length of the refrigerant piping thereby adjusting the pressure differential in the refrigeration current. With this construction, it is possible to carry out the optimal operation for a longer length refrigerant piping, without the need to make the size of each unit larger.

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FIG. 1



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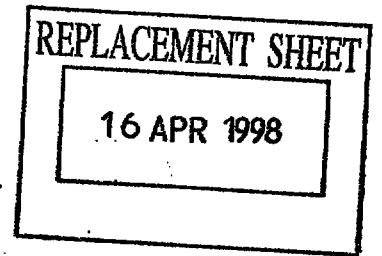


FIG.3

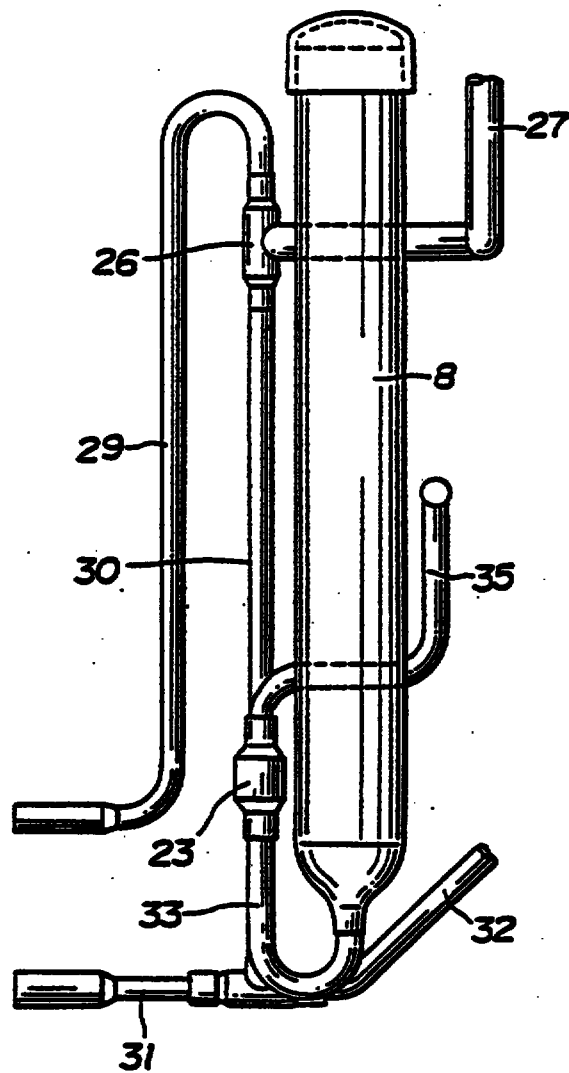
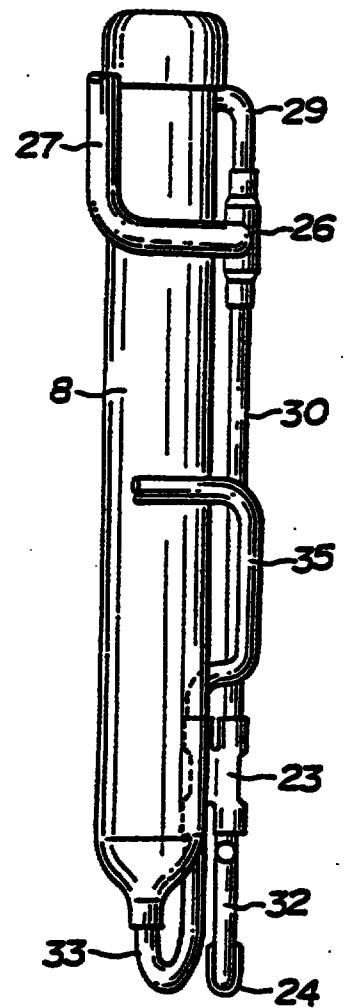


FIG.4

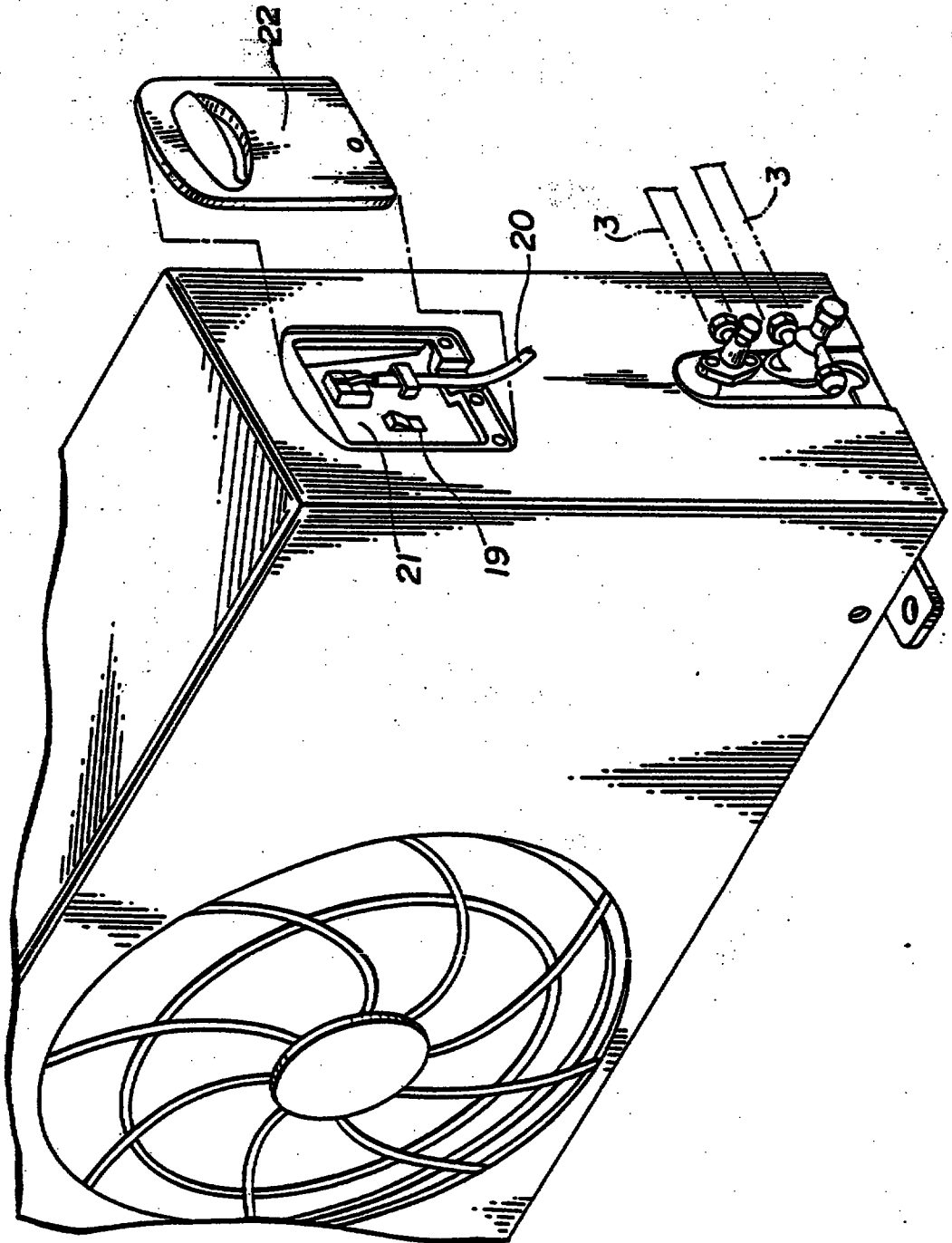


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FIG.2



REPLACEMENT SHEET

31 JUL 1998

FIG.3

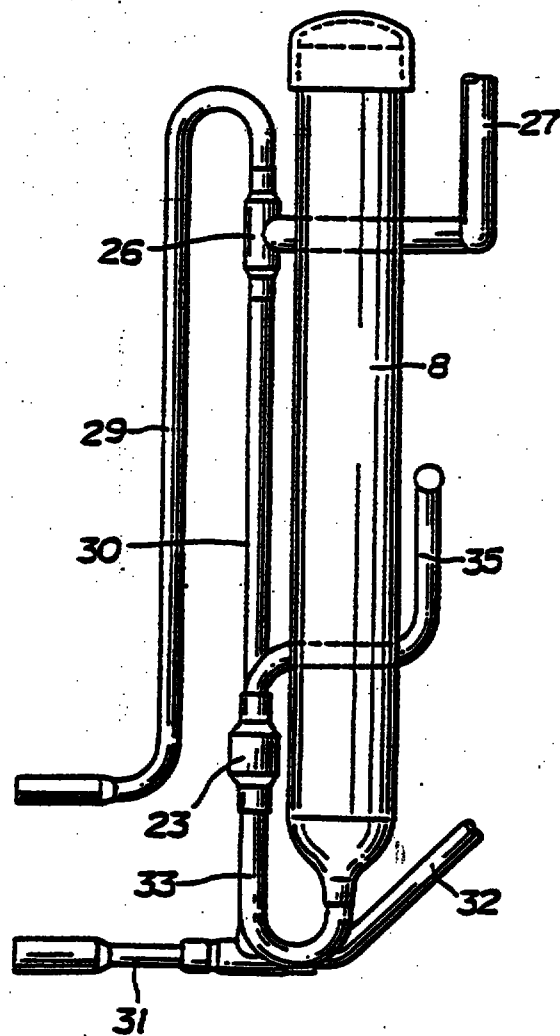
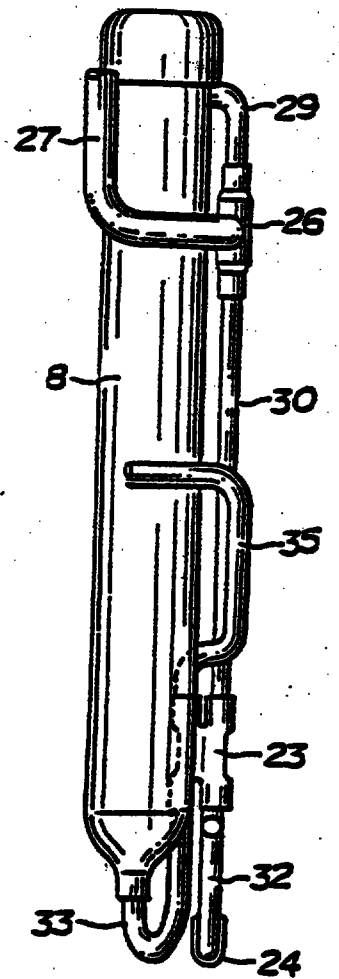


FIG.4



REPLACEMENT SHEET

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FIG.5

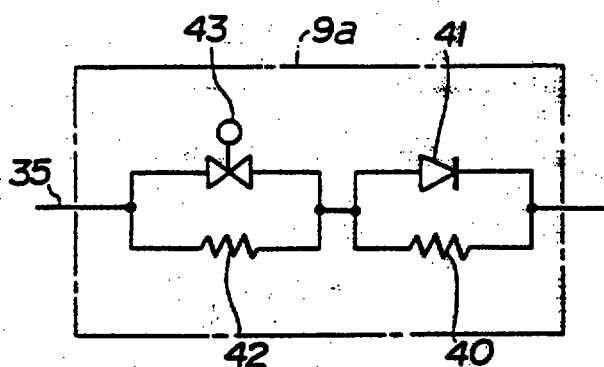


FIG.6

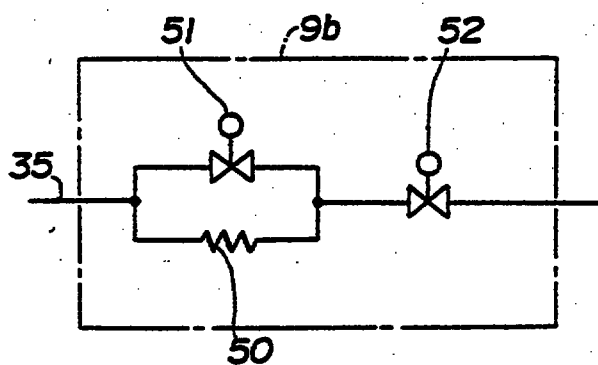


FIG.7

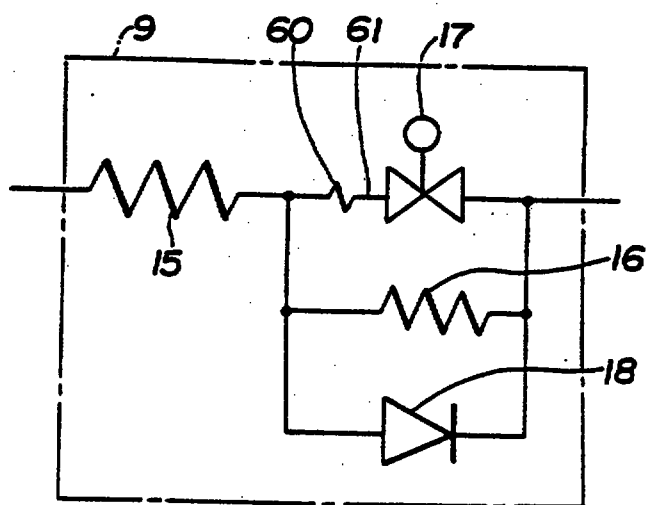


FIG.8

