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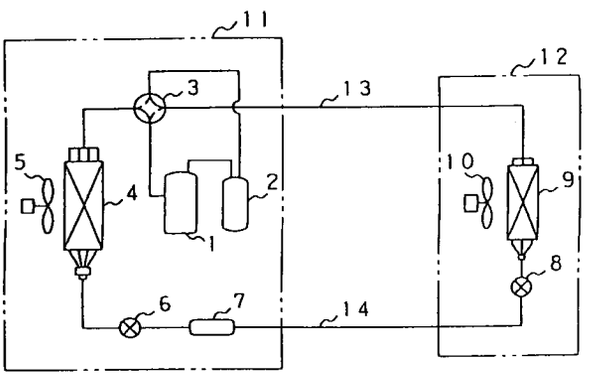
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(54) AIR CONDITIONER AND MOISTURE REMOVING DEVICE FOR USE WITH THE AIR CONDITIONER

(57) An outdoor machine having a four-way valve, a compressor, an outdoor heat exchanger and an expansion means connected via a piping in that order and an indoor machine having an indoor expansion means and an indoor heat exchanger connected via a piping are connected to each other via a liquid refrigerant piping and a gas refrigerant piping so as to form a refrigerating cycle, a flow in the liquid refrigerant piping in the refrigerating cycle is made to be a two-phase flow at all times while the refrigerating cycle is in operation and a moisture absorbing means is provided in this two-phase flow. An operating refrigerant is an HFC series refrigerant which protects the global environment, and the lubricant such as of ester series is used for a working fluid. Since the moisture absorbing means is provided in the air/liquid two-phase flow, it is possible to separate functions in such a manner that moisture is absorbed in the liquid phase, while gas is allowed to flow quickly, thereby making it possible to obtain an air conditioner which experiences low pressure loss and is highly reliable and a moisture removing device for use with the air conditioner.

FIG. 1



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Description

TECHNICAL FIELD

The present invention relates to an air conditioner employing a vapor compression refrigerating cycle, and more particularly to a moisture removing device for reducing moisture density in the refrigerating cycle.

BACKGROUND ART

In conventional moisture removing devices mounted in refrigerating apparatus such as air conditioners, for example, as disclosed in Japanese Utility Model Unexamined Publication No. 63-69961, a container with a large number of spherical desiccants enclosed in a coolant passage is disposed between a condenser and an expansion device to remove moisture in a condensate coolant. Also, Japanese Patent Unexamined Publication No. 5-66075 describes such a construction that a moisture removing device is disposed in a low-pressure gas line of an air conditioner for automotive vehicles to effectively absorb moisture contained in a coolant.

Furthermore, Japanese Utility Model Unexamined Publication No. 3-226254 discloses such a construction that a moisture removing device is disposed in a low-pressure line between an evaporator and a compressor to remove moisture without increasing a pressure loss.

Meanwhile, it was decided to prohibit manufacture of coolants that destroy the ozone layer. According to the decision, coolants made of CFC (chlorofluorocarbon) and HCFC (hydrochlorofluorocarbon) which have been widely used so far as a working fluid for refrigerating apparatus are under regulation. Therefore, coolants made of one type or a mixture of plural types of HFC (hydrofluorocarbon) that contains in the molecular structure no chlorine atoms, which are causes for destruction of the ozone layer, have been developed as alternative materials and studied aiming at practical use. But HFC materials have high intensity of polarization and exhibit almost no solubility with mineral oil and alkyl benzene-based lubricants which have been used conventionally. It is essential for a coolant to have solubility with a lubricant from the viewpoint of recirculating a lubricant in a refrigerating cycle, supplying a sufficient amount of lubricant to a mechanism section of a compressor, and ensuring reliability of the apparatus. With the above in mind, there has been developed refrigerator oils containing ether-, ester- or carbonate-based materials which, when oxygen atoms are introduced thereto, exhibit solubility due to a dipole interactive action with the oxygen molecules. Any type of those refrigerator oils has a high affinity with water molecules and a high degree of moisture absorption. If a large amount of moisture is present in a refrigerating cycle, fine passages tend to clog because of freezing and coolant hydrates produced in a low-temperature section. Also, if moisture is present in refrigerator oil or a coolant, the refrigerator oil or the coolant may deteriorate because of hydrolysis. In a refrigerating cycle using ester-based refrigerator oil, particularly, the presence of moisture causes a remarkable reduction in reliability of the apparatus for such a reason that sliding surfaces are subject to chemical abrasion by organic acids resulted from hydrolysis. This means that a refrigerating cycle using an HFC-based coolant which does not destroy the ozone layer is difficult to maintain an amount of moisture entering the refrigerating cycle at a required low level during periods of manufacture process, apparatus installation work, service or maintenance, and that the provision of moisture removing means for removing moisture down to a level free from problems is more required than before. In other words, the prior art disclosed in Japanese Unexamined Utility Model Publication No. 63-69961 offers an effective means for coolants used so far, but cannot always provide a satisfactory result in the present situation where destruction of the ozone layer must be taken into consideration.

Synthetic zeolite has been long known as a desiccant for removing moisture in a refrigerating cycle. Because of forming a cage-like molecular structure, synthetic zeolite has a characteristic of selectively taking in and retaining the substances, which have specific molecular diameters, within the cavities of cages as the result of a sieving effect developed by the cage-like molecular structure. Therefore, even when synthetic zeolite is employed with a flon-based coolant, it can adsorb only moisture without adsorbing the coolant. Then, under a condition where the density of ambient moisture is high and the velocity of motion of water molecules is low, the probability of moisture being adsorbed through the cages is increased and synthetic zeolite has a higher adsorption ability. Accordingly, the adsorption ability of synthetic zeolite is increased by bringing the adsorbent and the coolant into contact with each other in a state of liquid phase where the density is higher, the flow speed is smaller, and the velocity of molecular motion is lower than in a state of gas phase. Stated otherwise, by providing a moisture removing means in a liquid line after a condenser, an air conditioner which is gentle to the global environment can be provided with no need of greatly modifying a conventional apparatus. In addition, HFC materials have a high global worming factor and hence it is required to reduce an absolute amount of HFC materials enclosed in a refrigerating apparatus. As a method of reducing an amount of coolant required for operation of a refrigerating cycle, there is known one of passing a liquid coolant after condensation through a throttle means so that the coolant has a saturated two-phase state in a line. In a heat pump type air conditioner utilizing such a method, however, because expansion means are required in both indoor and outdoor units and a coolant flow is throttled immediately after a condenser so as to always provide a two-phase flow in a liquid connecting line, there is no place

in a refrigerating cycle where a liquid coolant is flowing at all times in any of cooling and heating operation. A two-phase flow provides a larger flow speed in terms of mass flow rate than a liquid one-phase flow. Therefore, if the conventional moisture removing device stated above is disposed in the liquid line, a pressure loss would be increased remarkably and large fluid force would act on the desiccants. This large fluid force would invite a risk that the desiccants may be worn or pulverized into powder due to abrasion caused by fluid friction, vibration, etc., and the desiccant powder may enter fine passages to make the fine passages clogged, or enter a section of sliding parts of a compressor to cause wear or seizure of the sliding parts. Further, in a heat pump type air conditioner having only one expansion means, there is also no place in a refrigerating cycle where a coolant is flowing as a liquid one-phase flow at all times in any of cooling and heating operation, and the coolant always provides a gas and liquid two-phase flow in any place of the refrigerating cycle in either operation state. Thus, such an air conditioner suffers from similar drawbacks as in the air conditioner having two or more expansion means.

If a liquid line where the phase of a coolant is changed depending on the operation state is determined beforehand and a moisture removing means is disposed in the liquid line, this case would require a check valve or the like, make the structure more complicated, and lower reliability of the apparatus.

Further, the constructions described in Japanese Patent Unexamined Publication No. 5-66075 and Japanese Utility Model Unexamined Publication No. 3-226254 have a disadvantage that a moisture absorbing ability is not sufficient because a coolant state in the position where the moisture removing means is disposed is given as a saturated condition of overheat gas or having a high degree of drying and hence the coolant and the desiccants are brought into contact with each other in a state of gas phase.

DISCLOSURE OF THE INVENTION

An object of the present invention is to not only prevent hydrolysis of a coolant and refrigerator oil caused by the presence of moisture, but also prevent desiccants from being pulverized into powder and entering a mechanism section of a refrigerating cycle, even when any HFC-based coolant that does not destroy the ozone layer is employed as a coolant in an air conditioner.

Another object of the present invention is to provide an air conditioner which can reduce an amount of coolant enclosed in a refrigerating cycle without employing a complicated structure, and a moisture removing device for use in the air conditioner.

Still another object of the present invention is to prevent desiccants from being pulverized into powder even in a heat pump type air conditioner having only one expansion means.

A further object of the present invention is to prevent hydrolysis of a coolant and refrigerator oil caused by the presence of moisture also when a refrigerating cycle is made open for repair or maintenance.

A still further object of the present invention is to provide an air conditioner and a moisture removing device for use in the air conditioner, which can efficiently remove moisture with a smaller pressure loss even when any HFC-based coolant that does not destroy the ozone layer is employed as a coolant in the air conditioner and produces a gas and liquid two-phase flow.

To achieve the above object, according to a first aspect of the present invention, there is provided an air conditioner in which a coolant compressing apparatus, a condenser, first expansion means, second expansion means and an evaporator are coupled in order to form a refrigerating cycle, a working coolant is made of at least one type of hydrocarbon fluoride that contains no chlorine atoms, and the working coolant between the first expansion means and the second expansion means is in a gas and liquid two-phase state during operation of the air conditioner, wherein moisture removing means for reducing moisture density in the refrigerating cycle is disposed between the first expansion means and the second expansion means.

Preferably, the moisture removing means disposed between the first expansion means and the second expansion means comprises a gas/liquid separator, desiccants put in a lower portion of the gas/liquid separator, and a member for holding the desiccant.

Further, preferably, the moisture removing means contains synthetic zeolite with adsorbing molecules having a mean diameter of 3.1 angstroms or less.

Preferably, the moisture removing means includes indicator means for indicating moisture density in the moisture removing means.

Preferably, the air conditioner includes control means for controlling a flow between the first expansion means and the second expansion means to become a two-phase flow.

Also, according to a second aspect of the present invention, there is provided a heat pump type air conditioner in which a coolant compressor, a four-way valve, an indoor heat exchanger, expansion means and an outdoor heat exchanger are coupled in order to form a refrigerating cycle, a coolant made of at least one type of hydrocarbon fluoride that contains no chlorine atoms is employed, and the air conditioner is selectively operated in one mode of cooling and heating by changing over the four-way valve, wherein moisture removing means for reducing moisture density in the refrigerating cycle is disposed between the expansion means and the outdoor heat exchanger or between the indoor heat exchanger and the expansion means, and the moisture removing means includes partition means for partition into a flow passage for the coolant and a moisture absorber holding portion.

Further, to achieve the above object, according to a

third aspect of the present invention, there is provided an air conditioner comprising an outdoor unit and a plurality of indoor units connected to the outdoor unit, a working coolant of the air conditioner being made of at least one type of hydrocarbon fluoride that contains no chlorine atoms, wherein each of the indoor and outdoor units has expansion means, and means for removing moisture in the coolant flowing through the air conditioner is disposed between the expansion means of the outdoor unit and the expansion means of the indoor unit.

Preferably, the moisture removing means disposed between the expansion means of the indoor unit and the expansion means of the outdoor unit comprises a gas/liquid separator, desiccants put in a lower portion of the gas/liquid separator, and a member for holding the desiccant.

Also, preferably, the air conditioner includes control means for controlling a flow between the expansion means of the outdoor unit and expansion means of the indoor unit to become a two-phase flow.

Furthermore, to achieve the above object, according to a fourth aspect of the present invention, there is provided a moisture removing device for use in an air conditioner having a refrigerating cycle to remove moisture in the refrigerating cycle, wherein the moisture removing device comprises an enclosed container to which piping lines are connected, an inner pipe disposed in the enclosed container and defining a flow passage in communication with the piping lines, and a moisture absorber held between the inner pipe and the enclosed container, the moisture absorber being made of synthetic zeolite with adsorbing molecules having a mean diameter of 3.1 angstroms or less.

The air conditioner of the present invention constructed as set forth above is an apparatus gentle to the global environment because the coolant that does not destroy the ozone layer is employed and the amount of coolant enclosed in the refrigerating cycle is cut down. Even though the coolant flow is a two-phase flow, the moisture removing device is disposed in a low-pressure flow area where it produces a small pressure loss, and the moisture removing means comprises a moisture retaining portion and a main passage portion. Therefore, a pressure loss caused by the coolant flow can be reduced and moisture can be removed from the working coolant with high efficiency. Additionally, since fluid force acting on the desiccant held by the moisture retaining portion can be reduced without using a complicated structure, it is possible to prevent the desiccant from being pulverized into powder due to abrasion caused by fluid friction, vibration, etc.

Further, the air conditioner does not require the expansion means to be changed over depending on whether the operation is in the mode of cooling or heating, and requires just one expansion means. In this case, the flow in the line where the moisture removing device is disposed can be either a liquid one-phase flow or a gas and liquid two-phase flow. However, since the moisture removing device develops small fluid resistance for any of those flows, the desiccant is prevented from being pulverized into powder. Also, the moisture removing device does not reduces its ability of removing moisture in any of those flow states.

Moreover, the provision of the gas/liquid separator enables the desiccant to be placed in a passage where only the liquid coolant flows, or in a liquid pool. Therefore, moisture in the working coolant can be effectively removed under a condition of low pressure loss.

Additionally, even in the case of using an HFC32 that has a mean molecular diameter closest to that of water molecules among HFC coolants, the coolant can be surely discriminated from water molecules and the amount of coolant molecules adsorbed by the desiccant can be made sufficiently small. Further, the action and motion of the desiccant can be confirmed. The construction enabling the desiccant to be easily replaced also contributes to improving reliability of the liquid refrigerating cycle and the moisture absorbing means.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a typical view of one embodiment of an air conditioner of the present invention, Fig. 2 is a longitudinal sectional view of one embodiment of a drier shown in Fig. 1, Fig. 3 is a typical view of a modification of the air conditioner of the present invention, Figs. 4 to 6 are longitudinal sectional views of respective modifications of the drier, Fig. 7 is a longitudinal sectional view of one embodiment of a gas/liquid separator shown in Fig. 1, and Fig. 8 is a partial sectional view of a modification of the gas/liquid separator in the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

One embodiment of the present invention will be described hereunder with reference to the drawings. Fig. 1 is a typical view of a refrigerating cycle of a heat pump type air conditioner. An outdoor unit 11 is made up of a four-way valve 3, an accumulator 2, a coolant compressing apparatus 1 represented by an inverter driven scroll compressor, an outdoor heat exchanger 4, an outdoor expansion device 6 represented by an electromagnetic expansion valve, and a drier 7 which are connected in order through piping lines. On the other hand, an indoor unit 12 is made up of an indoor expansion device 8 and an indoor heat exchanger 9 which are connected through piping lines. The outdoor unit and the indoor unit are connected each other through a gas line 13 and a liquid line 14, thereby making up a refrigerating cycle. Additionally, an outdoor blower 5 is provided to blow air to the outdoor heat exchanger of the outdoor unit, and an indoor blower 10 is provided to blow air to the indoor heat exchanger of the indoor unit. Though not shown, the indoor and outdoor units also include sensors for control of their constituent devices,

controllers for controlling the constituent devices based on outputs of the sensors, and remote control switches. Fig. 2 is a longitudinal sectional view of the drier denoted by numeral 7 in Fig. 1. The drier 7 comprises a container 21, a coolant passage 23 formed in a central portion of the container 21 and allowing a coolant to pass through it, and desiccants 22 stored in a space defined between the container 21 and the coolant passage 23. Then, pipes of the adjacent lines are connected to both ends of the container 21 opposite to each other in the direction of passage of the coolant.

The operation of one embodiment of the present invention thus constructed will be described below. The heat pump type air conditioner utilizes a vapor pressure refrigerating cycle and is operated selectively in one mode of cooling and heating by changing over the four-way valve 3. The air conditioner employs, as a working coolant, HFC (hydrofluorocarbon) that does not destroy the ozone layer. The HFC coolant is given by one type or a mixture of plural types selected from among HFC32 (difluoromethane), HFC125 (pentafluoroethane), HFC134a (1, 1, 1, 2 - totrafluoroethane) and HFC143a (1, 1, 2 - trifluoroethane). Further, the air conditioner employs, as refrigerator oil, any of ester-, ether- or carbonate-based refrigerator oils which, when oxygen atoms are introduced to molecular structures thereof, exhibit solubility with the HFC-based coolant.

The air conditioner constructed as described above operates as follows. First, in the mode of cooling operation, a high-temperature, high-pressure gas coolant delivered from the coolant compressing apparatus 1 is introduced to the outdoor heat exchanger 4 serving as a condenser where the gas coolant is converted into a liquid coolant through processes of heat radiation, condensation and supercooling. The liquid coolant is subject to a pressure reduction in the outdoor expansion device 6 under control of the controller for coming into a gas and liquid two-phase flow. The coolant in this state passes through the drier 7, flows through the liquid line 14, and then reaches the indoor unit 12. The coolant is subject to a further pressure reduction in the indoor expansion device 8 to have a lower pressure and a lower temperature. The resultant coolant is introduced to the indoor heat exchanger 9 serving as an evaporator where the coolant is evaporated while absorbing heat, and undergoes heat exchange with indoor air for cooling an indoor space. Further, the coolant enters the outdoor unit 11 through the gas line 13, passes through the four-way valve 3 and the accumulator 2 successively, and is sucked by the coolant compressing apparatus 1, thus completing one round of a refrigerating cycle. In the mode of heating operation, the four-way valve 3 is changed over so that a high-temperature, high-pressure gas coolant delivered from the coolant compressing apparatus 1 is introduced to the indoor unit 12 through the gas line 13. In the indoor heat exchanger 9 serving now as a compressor, the coolant undergoes heat exchange with indoor air to radiate heat to the indoor space for heating. The liquid coolant having been condensed and supercooled in the indoor heat exchanger 9 is subject to a pressure reduction in the indoor expansion device 8 under control of the controller for coming into a gas and liquid two-phase flow. The coolant in this state flows through the liquid line 14 and passes through the drier 7. Then, the coolant is subject to a further pressure reduction in the outdoor expansion device 6 to have a lower pressure and a lower temperature. The resultant coolant is introduced to the outdoor heat exchanger 4 serving now as an evaporator where it is evaporated while absorbing heat. After that, the coolant passes through the four-way valve 3 and the accumulator 2 successively, and is sucked by the coolant compressing apparatus 1, thus completing one round of a refrigerating cycle.

In any mode, since the coolant between the outdoor expansion device 6 and the indoor expansion device 8 is in a gas and liquid two-phase state, the amount of coolant to be passed through the liquid line 14 extending over a relatively long distance for interconnection between the outdoor unit 11 and the indoor unit 12 can be reduced corresponding to mixing of the gas coolant having low density in the liquid coolant as compared with the case of the coolant being passed through the liquid line 14 in one phase of supercooled liquid. Accordingly, the amount of coolant enclosed in the refrigerating cycle can be made smaller than that required for a full-liquid system in which the liquid line is fully filled with the liquid coolant.

Synthetic zeolite capable of selectively adsorbing only moisture in the refrigerating cycle is sintered with a binder and formed into a cylindrical core which serves as a moisture retaining portion 22. The drier 7 is formed by enclosing the moisture retaining portion 22 in the container 21 and then coupling the opposite ends of the container 21 to the pipes of the adjacent lines. The inner diameter of the moisture retaining portion 22 corresponding to the coolant passage 23 is selected to be equal to or more than that of the pipes upstream and downstream of the drier 7.

When the coolant passes through the drier 7 during the operation of the refrigerating cycle as explained above, the moisture having mixed into the refrigerating cycle during the manufacture steps of the apparatus and the installation work thereof is adsorbed by the moisture retaining portion 22 made of porous zeolite. Therefore, the moisture density in the refrigerating cycle is gradually reduced. Here, since the inner diameter of the coolant passage 23 of the drier 7 is equal to or more than that of the pipes upstream and downstream of the drier 7, a pressure loss is not increased remarkably even though the coolant in the gas and liquid two-phase state passes through the drier 7. In other words, because the moisture retaining portion 22 is not subject to large fluid force otherwise caused by flow of the coolant, the desiccants can be prevented from being pulverized into powder due to friction, vibration, etc.

According to this embodiment, as described above, since the amount of enclosed coolant is reduced, the amount of coolant that may affect destruction of the ozone layer or global warming can be cut down. Further, since the amount of moisture in the refrigerating cycle that is a factor of lowering the reliability can be reduced, it is possible to provide an air conditioner which is effective for protection of the global environment and is highly reliable.

Next, Fig. 3 shows a modification of the above embodiment. In Fig. 3, the same reference numerals denote the same parts as in Fig. 1. This modification differs from the embodiment of Fig. 1 in that the drier 7 is disposed between the outdoor heat exchanger 4 and the outdoor expansion device 6, and the indoor expansion device 8 is omitted. Also in this modification, the drier 7 has the same structure adapted for a low pressure loss as in the embodiment of Fig. 2. Therefore, the desiccants can be prevented from being pulverized into powder even when the coolant flows through the drier 7 as a gas and liquid two-phase flow.

In this modification, since the coolant flow is throttled by the outdoor expansion device 6 alone in any of the cooling and heating operation, the supercooled liquid passes through the moisture removing device during the cooling operation, while the gas and liquid two-phase flow produced after being throttled by the outdoor expansion device 6 passes through the moisture removing device during the heating operation. Because the desiccants show higher adsorption efficiency for the supercooled liquid than for the gas and liquid two-phase flow, it is effective to install the moisture removing device in the position as shown in this modification when the air conditioner is operated in the cooling mode more frequently. When the air conditioner is operated in the heating mode more frequently, it is advantageous for the drier 7 to be installed between the indoor heat exchanger 14 and the outdoor expansion device 6.

Next, Figs. 4 to 6 are longitudinal sectional views of modifications of the drier 7. Fig. 4 shows a first modification wherein the drier 7 comprises a container 31 having both ends to which connecting pipes are jointed, a moisture retaining portion 32 storing desiccants therein, a fixed plate 33 for dividing an inner space of the container 31 into a main flow passage and the moisture retaining portion 32, and a spring 34 for positioning the fixed plate in place. The installation position of the drier in the refrigerating cycle and the operation of the refrigerating cycle are the same as in the embodiment of Fig. 1.

In this embodiment, a large number of desiccants obtained by forming synthetic zeolite into bead-like granules are enclosed in a lower portion of the container 31 to serve as the moisture retaining portion 32. To keep the desiccants not mobile, the fixed plate 33 is held down by the spring 34. The fixed plate 33 has a large number of holes formed therein and being smaller than the diameter of the desiccant beads, allowing the coolant to flow through the holes. Therefore, only a liquid phase portion of the coolant in the state of a two-phase flow passing an upper portion of the container 31 resides in the container 31 and comes into contact with the moisture retaining portion 32. Since the inner space of the container 31 is thus divided into an upper area where the coolant flows and a lower area where the desiccants are present, a pressure loss is small and the desiccants are not exposed to the coolant flow at a high speed. As a result, the desiccants are prevented from being pulverized into powder. Further, the desiccants and the coolant are contacted with each other in a liquid state providing good adsorption efficiency, and the coolant residing in the container is replaced by new one successively under an action of the coolant flow. Accordingly, the desiccants can effectively develop an ability of adsorbing moisture and can quickly reduce the moisture density in the refrigerating cycle.

Next, Fig. 5 shows another modification of the drier wherein dryness of the coolant can be visually confirmed and the moisture retaining portion can be easily replaced. This modification differs from the modification of Fig. 4 in additionally comprising a sight glass 36, a moisture density sensor 37, a joint portion 38, and a shield sheet 39. The moisture density sensor 37 is formed by making a substance of which color changes depending on the moisture density, e.g., cobalt chloride, fixedly impregnated in a sheet, and is arranged so that a drying state of the refrigerating cycle can be visually confirmed through the sight glass 36. The joint portion 38 has a screw fastening structure enabling a lower portion of the container to be removed optionally. With the drier having the above construction, it is possible to confirm that moisture is surely removed, and to easily replace the desiccants when the coolant is replaced or added at the time of repair of troubles or maintenance. As a result, the moisture adsorbing ability can be restored and the reliability can be ensured.

Fig. 6 shows still another modification of the drier 7. In Fig. 6, an inner pipe 46 having substantially the same diameter as the connecting pipes is disposed in a container 41 and coupled to the connecting pipes. In a space defined between the inner tube 46 and the container 41, bead-like desiccants are stored to serve as a moisture retaining member 42. Specifically, in the space between the inner tube 46 and the container 41, there are disposed a fixed plate 43 secured by caulking at one end of the space in the direction of coolant flow, a movable plate 44 on the side nearer to the other end of the space in the direction of coolant flow, and a spring 45 interposed between the movable plate 44 and an inner wall of the container 41. The desiccants are stored in a space defined between the fixed plate 43 and the movable plate 44. The moisture retaining member 42 is fast held in that space by resilient force of the spring 45. Each of the fixed plate 43, the movable plate 44 and the inner tube 46 has a large number of holes formed therein and being smaller than the diameter of the des-

iccant beads, allowing the coolant to freely pass through the holes. With this construction, since the circulating coolant in the gas and liquid two-phase state primarily flows through the inner tube 46, the desiccants are not exposed to the coolant flowing at a high speed and hence are prevented from being pulverized into powder. Also, since this modification is realized just by slightly modifying conventional driers and can employ versatile bead-type desiccants, the drier of modification has merits that it is easily constructed and less expensive.

As still another modification of the drier for use with a two-phase flow, Fig. 7 shows an example employing a gas/liquid separator. Fig. 7 is a longitudinal sectional view of a gas/liquid separator with desiccants stored therein. Referring to Fig. 7, in an enclosed container 51, there are disposed a coolant inlet pipe 54 for introducing the coolant into the container 51 and a coolant outlet pipe 55 for introducing the coolant from the interior of the container 51 to the exterior thereof. Distal ends of these two pipes reach a position near the bottom surface of the container 51. Usually, the coolant in liquid phase is filled in the container up to a level intermediate the container and the coolant in gas phase is filled in a space of the container above the liquid coolant. Gas coolant mixing holes 56 and 57 are formed respectively in the coolant inlet pipe 54 and the coolant outlet pipe 55 so that the liquid coolant extracted from the lower portion of the container 51 is added with the gas coolant present in the upper portion of the container 51 to keep a certain degree of dryness in the coolant. Bead-like desiccants 52 are held by a desiccant retaining member in the lower portion of the container 51 where the coolant in liquid phase is filled, while the liquid coolant is allowed to freely pass among the bead-like desiccants 52. Specifically, the desiccants 52 are held in place by a desiccant retaining member 53 in the form of a net cage, for example. With this construction, since the desiccants 52 are placed in the liquid coolant flowing into the container 51 and dispersing at a low speed, they are prevented from being pulverized into powder and can be used in a liquid contact state providing good adsorption efficiency. The gas/liquid separator of the present invention also has a function of adjusting the amount of coolant when it is installed in the liquid line of the refrigerating cycle operated utilizing a gas and liquid two-phase flow. Incidentally, it is needless to say that the drier of this modification operates exactly in the same manner as described above regardless of which one of the two pipes 54, 55 inserted in the container 51 serves as the coolant introducing pipe.

Fig. 8 shows a modification of the gas/liquid separator shown in Fig. 7. This modification is suitable for use in the refrigerating cycle where the coolant flows only in one direction. In Fig. 8, the coolant in liquid phase is filled in a lower portion of the container 61 and the coolant in gas phase is filled in a space of the container above the liquid coolant. The coolant in the gas and liquid two-phase state flowing through an introducing pipe 63 inserted into an upper portion of the container 61 is separated into a liquid and gas in the container 61. A drier 62 which may be conventional one is installed in a liquid outlet pipe 64 which is inserted into the lower portion of the container filled with the liquid coolant and permits only the liquid coolant to pass through it, thereby removing moisture contained in the coolant. A pipe portion above the drier 62 and the upper portion of the container 61 are communicated with each other by a gas outlet pipe 65 to prevent the gas coolant from building up excessively in the gas/liquid separator. With this construction, since the coolant is permitted to pass through the drier 62 as a liquid one-phase flow and the desiccants can absorb moisture from the liquid phase flow, it is possible to effectively absorb moisture as with the above embodiment. An additional merit is that there is no need of using the special structure adapted for a low pressure loss and hence conventional driers can be employed as they are.

In any of the above-described embodiments, since the fluid force caused by flow of the coolant and acting on the desiccants is small, the desiccants are prevented from being pulverized into powder due to friction, vibration, etc., which prevents the desiccant powder from making fine passages clogged and entering the mechanism section of the air conditioner. As a result, an air conditioner with high reliability can be realized. Of course, similar advantages can also be obtained in refrigerating apparatus such as a refrigerator and a chiller unit, for example, by applying to them the refrigerating cycle constructed similarly to the above-described embodiment of the air conditioner.

In all of the above-described embodiments, synthetic zeolite used as desiccants is desirably selected such that absorbing molecules have a mean diameter of 3.1 angstroms or less, when the coolant is provided by a coolant containing HFC32, e.g., any of coolants having such numbers defined by ASHRAE as a series of R407 (mixture of three types of HFC32/HFC125/HFC134a) and a series of R410 (mixture of two types of HFC32/HFC125). The reason why the molecular diameter is set here to 3.1 angstroms or less is below. Of the HFC coolants, HFC32 has a minimum mean diameter of molecules as small as 3.3 angstroms, and water molecules have a diameter of 2.8 angstroms. Then, an intermediate value between those two diameters is selected here. In other words, by setting the molecular diameter of the coolant to such an intermediate value or less, water molecules are surely adsorbed, but the HFC coolant will never be adsorbed by zeolite in theory. This means that even the coolant containing HFC32 is hardly adsorbed by synthetic zeolite, the moisture absorbing ability of desiccants is not lowered, and the coolant is not decomposed. Consequently, the moisture removing device and the air conditioner using the moisture removing device are improved in reliability.

According to the present invention, the coolant that

does not destroy the ozone layer is employed, the amount of that coolant to be enclosed in the refrigerating cycle can be cut down, and moisture present in the refrigerating cycle can be reduced. Then, an air conditioner which minimizes an effect upon the global environment, is less expensive and has high reliability can be realized.

Further, according to the present invention, even when a single expansion device is employed, moisture present in the refrigerating cycle can be reduced while preventing the desiccants being pulverized into powder and deteriorating. Therefore, an air conditioner which is less expensive and has high reliability can be realized.

Also, according to the present invention, even with the coolant flowing through the liquid line in the gas and liquid two-phase state, a combination of the gas/liquid separator and the moisture removing device enables moisture to be removed without needing a special structure for reducing a pressure loss, while preventing the desiccants being pulverized into powder and deteriorating. Therefore, conventional drier manufacturing equipment can be employed without any modifications, which is effective in manufacturing the air conditioner less expensively.

Moreover, according to the present invention, since the amount of coolant adsorbed by the desiccants can be made sufficiently small, it is possible to prevent the coolant from decomposing and producing acids, to suppress not only chemical wear of the mechanism sections of both the air conditioner and the water removing device, but also decomposition of the desiccants, and to realize a highly reliable air conditioner.

In addition, according to the present invention, since whether the desiccants function properly or not can be confirmed and a time required for replacing the desiccants can be shortened, the air conditioner and the water removing device can be surely and easily improved in reliability.

Claims

1. An air conditioner in which a coolant compressing apparatus, a condenser, first expansion means, second expansion means and an evaporator are coupled in order to form a refrigerating cycle, a working coolant is made of at least one type of hydrocarbon fluoride that contains no chlorine atoms, and said working coolant between said first expansion means and said second expansion means is in a gas and liquid two-phase state during operation of said air conditioner, characterized in that moisture removing means for reducing moisture density in said refrigerating cycle is disposed between said first expansion means and said second expansion means.

2. A heat pump type air conditioner in which a coolant compressor, a four-way valve, an indoor heat exchanger, expansion means and an outdoor heat exchanger are coupled in order to form a refrigerating cycle, a coolant made of at least one type of hydrocarbon fluoride that contains no chlorine atoms is employed, and said air conditioner is selectively operated in one mode of cooling and heating by changing over said four-way valve, characterized in that

   moisture removing means for reducing moisture density in said refrigerating cycle is disposed between said expansion means and said outdoor heat exchanger or between said indoor heat exchanger and said expansion means, and said moisture removing means includes partition means for partition into a flow passage for the coolant and a moisture absorber holding portion.

3. An air conditioner according to Claim 1, characterized in that said moisture removing means disposed between said first expansion means and said second expansion means comprises a gas/liquid separator, desiccants put in a lower portion of said gas/liquid separator, and a member for holding said desiccant.

4. An air conditioner comprising an outdoor unit and a plurality of indoor units connected to said outdoor unit, a working coolant of said air conditioner being made of at least one type of hydrocarbon fluoride that contains no chlorine atoms, characterized in that

   each of said indoor and outdoor units has expansion means, and means for removing moisture in the coolant flowing through said air conditioner is disposed between the expansion means of said outdoor unit and the expansion means of said indoor unit.

5. An air conditioner according to Claim 4, characterized in that said moisture removing means disposed between the expansion means of said indoor unit and the expansion means of said outdoor unit comprises a gas/liquid separator, desiccants put in a lower portion of said gas/liquid separator, and a member for holding said desiccant.

6. An air conditioner according to Claim 1, characterized in that said moisture removing means contains synthetic zeolite with adsorbing molecules having a mean diameter of 3.1 angstroms or less.

7. An air conditioner according to Claim 1, characterized in that said moisture removing means includes indicator means for indicating moisture density in said moisture removing means.

8. An air conditioner according to Claim 1, characterized in that said moisture removing means includes a moisture retaining member and said moisture retaining member is detachably attached to said moisture removing means.

9. An air conditioner according to Claim 1 or 3, characterized in that said air conditioner includes control means for controlling a flow between said first expansion means and said second expansion means to become a two-phase flow.

10. An air conditioner according to Claim 4, characterized in that said air conditioner includes control means for controlling a flow between the expansion means of said outdoor unit and expansion means of said indoor unit to become a two-phase flow.

11. A moisture removing device for use in an air conditioner having a refrigerating cycle to remove moisture in said refrigerating cycle, characterized in that

said moisture removing device comprises an enclosed container to which piping lines are connected, an inner pipe disposed in said enclosed container and defining a flow passage in communication with said piping lines, and a moisture absorber held between said inner pipe and said enclosed container, said moisture absorber being made of synthetic zeolite with adsorbing molecules having a mean diameter of 3.1 angstroms or less.

FIG. 1

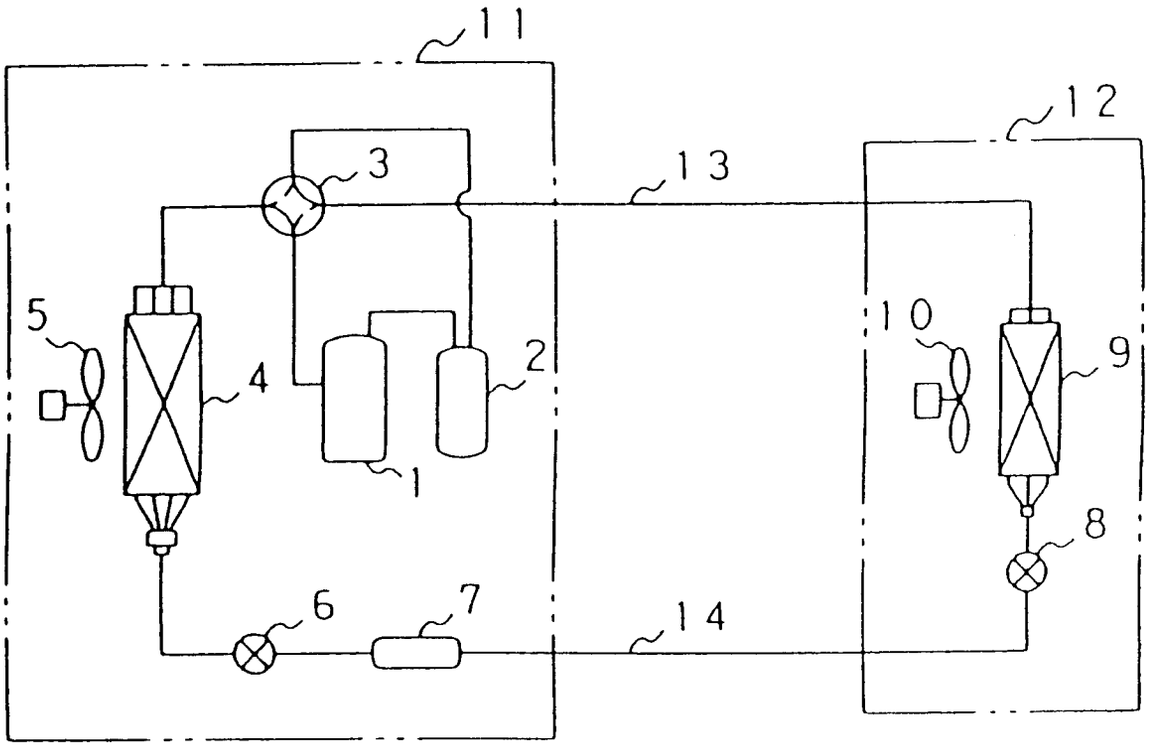


FIG. 2

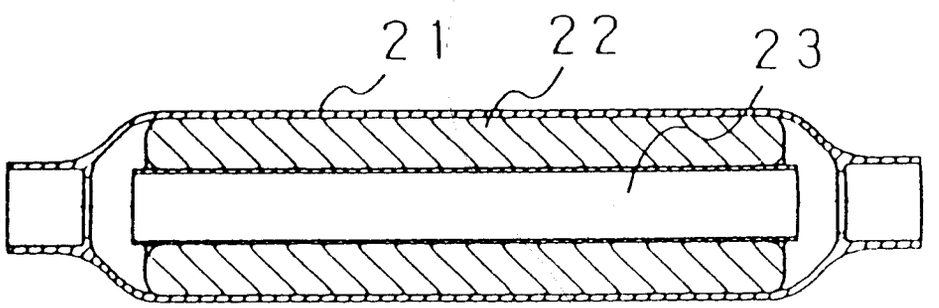


FIG. 3

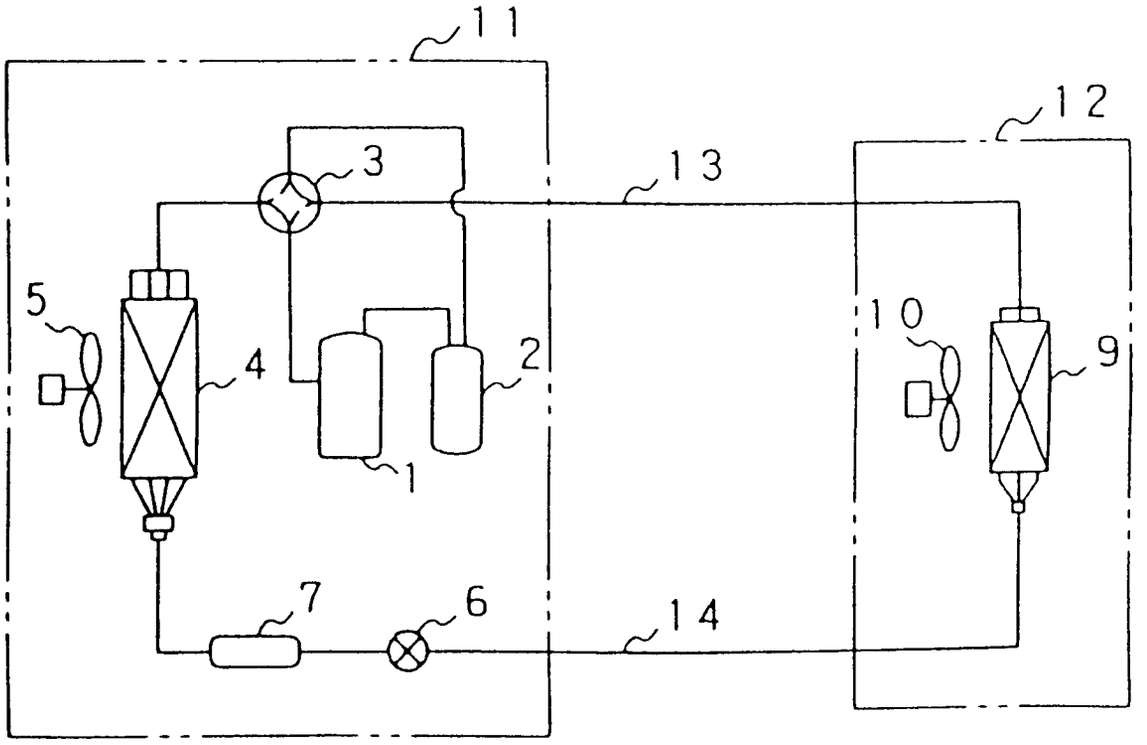


FIG. 4

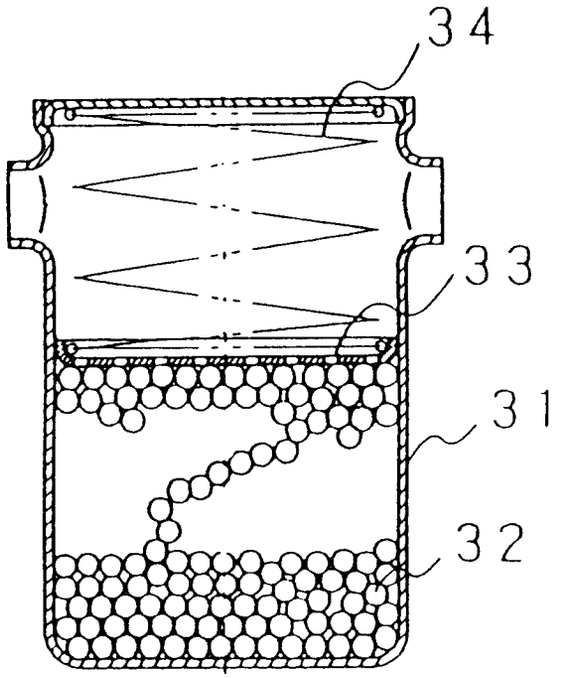


FIG. 5

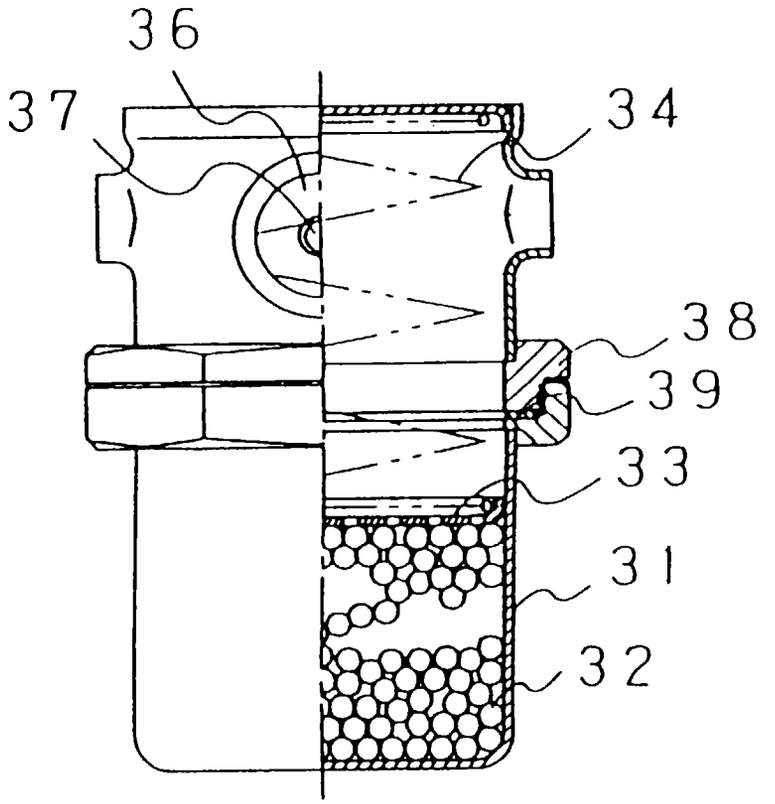


FIG. 6

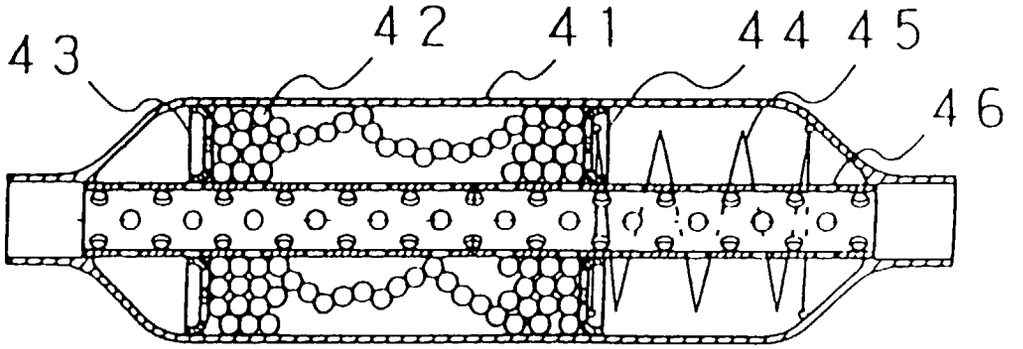


FIG. 7

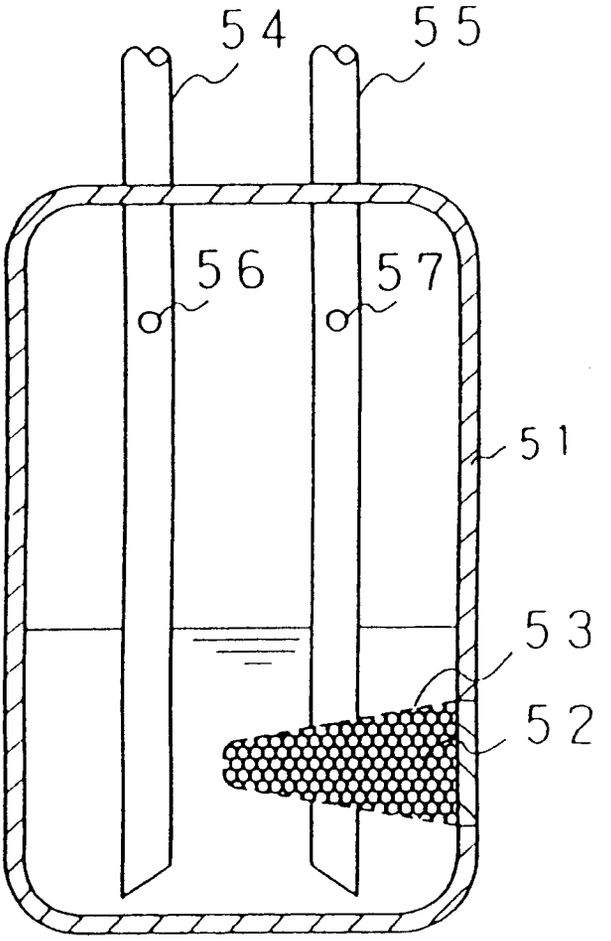
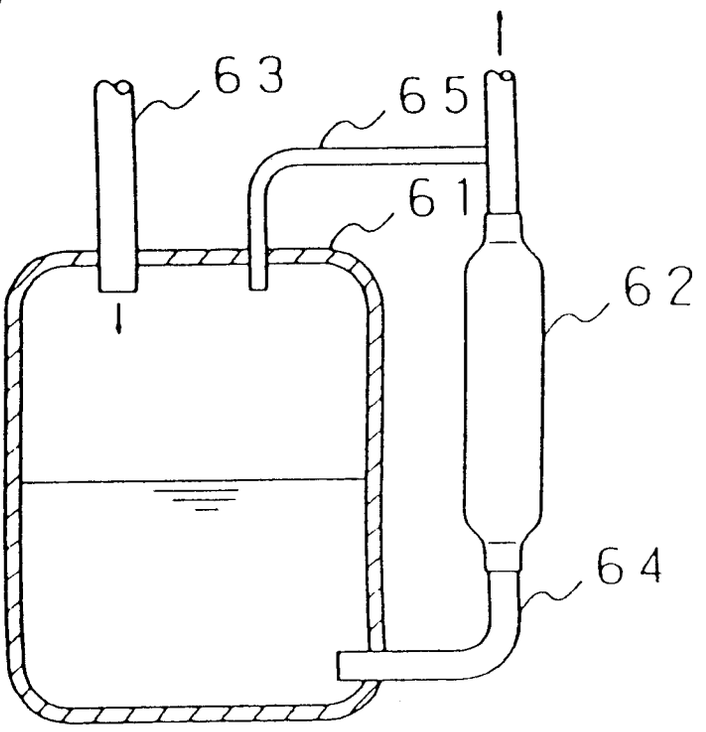


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP95/00481

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^6 F25B43/00, 1/00, 13/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^6 F25B43/00, 1/00, 13/00

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

Jitsuyo Shinan Koho 1926 - 1995
Kokai Jitsuyo Shinan Koho 1971 - 1995

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 45-14235, B1 (Toshiba Corp.), May 21, 1970 (21. 05. 70)(Family: none)	1 - 10
A	JP, 46-19878, Y1 (Toshiba Corp.), July 10, 1971 (10. 07. 71)(Family: none)	1 - 10
A	JP, 6-288662, A (Matsushita Refrigeration Co.), October 18, 1994 (18. 10. 94)(Family: none)	11
A	JP, 61-195272, U (Toshiba Corp.), December 5, 1986 (05. 12. 86)(Family: none)	11

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
June 5, 1995 (05. 06. 95)	June 20, 1995 (20. 06. 95)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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