



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
17.04.2013 Bulletin 2013/16

(51) Int Cl.:
F24H 1/00 (2006.01) F25B 1/00 (2006.01)
F25B 30/02 (2006.01)

(21) Application number: **11774847.5**

(86) International application number:
PCT/JP2011/059492

(22) Date of filing: **18.04.2011**

(87) International publication number:
WO 2011/136064 (03.11.2011 Gazette 2011/44)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

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(30) Priority: **28.04.2010 JP 2010103827**

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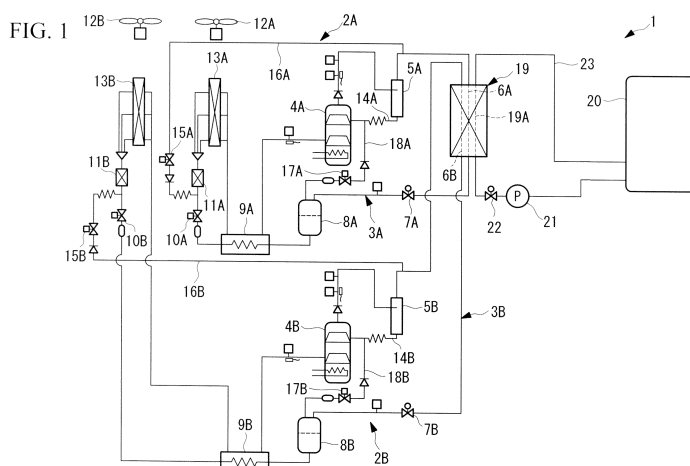
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(54) **HEAT PUMP WATER HEATER USING CO₂ REFRIGERANT**

(57) Provided is a heat-pump hot water supply system employing CO₂ refrigerant whose capacity can be increased while keeping container of constituent devices at or below a certain size regulated by the High Pressure Gas Safety Law. In a heat-pump hot water supply system (1) employing CO₂ refrigerant provided with refrigerant circulation circuits (3A and 3B) employing CO₂ refrigerant, which includes compressors (4A and 4B), heat sinks (6A and 6B), depressurizing means (10A and 10B), and heat absorbers (13A and 13B), and a hot-water supplying

heat exchanger (19) having a water channel (19A) that performs heat exchange with the heat sinks (6A and 6B), and in which multiple systems of the refrigerant circulation circuits (3A and 3B) are provided in parallel for the hot-water supplying heat exchanger (19), container sizes for all individual constituent devices of individual heat pumps (2A and 2B) formed in the multiple systems of the refrigerant circulation circuits (3A and 3B) are 160 mm or below in terms of inner diameters, and the total refrigerating capacity thereof is three refrigerating tons or greater.



Description

{Summary of Invention}

Technical Field

{Technical Problem}

[0001] The present invention relates to a heat-pump hot water supply system employing CO₂ refrigerant in which multiple systems of refrigerant circulation circuits are provided in parallel for a hot-water supplying heat exchanger.

Background Art

[0002] There are generally two methods of increasing the capacity of refrigerators or air conditioners, that is, (1) a method in which a plurality of heat source units are connected in parallel and (2) a method in which a plurality of compressors are installed in parallel in a single heat source unit. Although method (1) requires pipes for oil equalization and control thereof, the capacity can be easily increased. However, cost effectiveness cannot be expected. In contrast, because method (2) makes it possible to provide refrigerants circuit in the same unit, it suffices to have a single cabinet, and thus, cost reduction can be expected. However, because refrigerant is used by being merged in a single circuit, the refrigerant volume doubles, thus making it necessary to increase the size of containers for compressors, oil separators, receivers, and so forth.

[0003] Although the capacity of heat-pump hot water supply systems employing CO₂ refrigerant is also expected to be increased in the future, currently, method (1) is mainly employed. The reason for this is that, as opposed to the case of R401A refrigerant whose design pressures are 4.15 MPa on the high-pressure side and 2.21 MPa on the low-pressure side, the design pressures in the case of CO₂ refrigerant are several times greater at 14 MPa on the high-pressure side and 8.5 MPa on the low-pressure side. In spite of this, as disclosed in Patent Literatures 1 and 2, supercritical cycle heat-pump hot-water supply systems in which a plurality of compressors are connected in parallel, or alternatively, heat-pump hot water supply systems employing CO₂ refrigerant provided with a plurality of at least one of compressors, heat sinks, depressurizing means, heat absorbers, hot-water supplying heat exchangers provided with water channels for performing heat exchange with the heat sinks, water channels, and so on, have been proposed for method (2).

{Citation List}

{Patent Literature}

[0004]

{PTL 1} Publication of Patent No. 4016875
 {PTL 2} Japanese Unexamined Patent Application, Publication No. 2003-343914

[0005] However, as disclosed in Patent Literature 1, in the case of the configuration in which the plurality of compressors are simply connected in parallel, the design pressure thereof is high at 8.5 MPa even on the low-pressure side, and thus, there is a problem in that it is necessary to increase the plate thickness of containers for the compressors, oil separators, receivers, accumulators, and so forth, and that, because this tendency increases with increasing capacity, this is a major cause of increasing cost, and it also causes increased difficulties related to manufacturing. In particular, when the refrigerating capacity is three tons or greater, compliance with the High Pressure Gas Safety Law is required, and because containers with inner diameters of 160 mm or greater correspond to containers regulated by the High Pressure Gas Safety Law, manufacturing costs and testing costs considerably increase, which is an obstacle to increasing the capacity.

[0006] On the other hand, even in the in which a plurality of compressors are provided, as disclosed in Patent Literature 2, the capacity can be increased without considerably increasing the size of container for oil separators, receivers, accumulators, and so forth, if refrigerant circulation circuits are formed as multiple independent systems for individual compressors without merging the refrigerant (see Fig. 9). However, when the refrigerating capacities of individual heat pumps are increased, thus increasing the required amount of refrigerant, because the sizes of the individual containers are inevitably increased to 160 mm or greater in terms of inner diameters and compliance with the High Pressure Gas Safety Law is required, one problem has been how to increase the capacities of heat-pump hot water supply systems employing CO₂ refrigerant, including increasing the size of the heat exchangers.

[0007] The present invention has been conceived in light of the above-described circumstances, and an object thereof is to provide a heat-pump hot water supply system employing CO₂ refrigerant whose capacity can be increased while keeping the size of containers for constituent devices at or below a certain size regulated by the High Pressure Gas Safety Law.

{Solution to Problem}

[0008] In order to solve the above-described problems, a heat-pump hot water supply system employing CO₂ refrigerant of the present invention employs the following solutions.

A heat-pump hot water supply system employing CO₂ refrigerant according to an aspect of the present invention is a heat-pump hot water supply system employing CO₂ refrigerant provided with a refrigerant circulation circuit employing CO₂ refrigerant, which includes a com-

pressor, a heat sink, depressurizing means, and a heat absorber, and a hot-water supplying heat exchanger having a water channel for performing heat exchange with the heat sink; and in which multiple systems of the refrigerant circulation circuits are provided in parallel for the hot-water supplying heat exchanger, wherein container sizes for all individual constituent devices of individual heat pumps formed in the multiple systems of the refrigerant circulation circuits are 160 mm or below in terms of inner diameters, and the total refrigerating capacity thereof is three refrigerating tons or greater.

[0009] With the heat-pump hot water supply system employing CO₂ refrigerant according to the aspect of the present invention described above, in the heat-pump hot water supply system employing CO₂ refrigerant in which the multiple systems of the refrigerant circulation circuits are provided in parallel for the hot-water supplying heat exchanger, the container sizes for all individual constituent devices of individual heat-pumps formed in the multiple systems of the refrigerant circulation circuits are 160 mm or below in terms of inner diameters, and total refrigerating capacity thereof is three refrigerating tons or greater. Because of this, when increasing the capacity of the heat-pump hot water supply system employing CO₂ refrigerant, it is possible to form a large-capacity heat-pump hot water supply system employing CO₂ refrigerant whose total refrigerating capacity is three refrigerating tons or greater by employing the configuration in which two or more systems of heat-pumps are connected in parallel for the hot-water supplying heat exchanger, in which containers for devices that form the refrigerant circulation circuits all have container sizes of 160 mm or below in terms of inner diameters. Therefore, it is possible to increase the capacity of the heat-pump hot water supply system employing CO₂ refrigerant while keeping the containers for devices that form the heat pumps employing CO₂ refrigerant, whose design pressures are high at 14 MPa on the high-pressure side and 8.5 MPa on the low-pressure side, at a certain size or below, and it is possible to eliminate various problems associated with increasing the sizes of the containers. Moreover, because the containers for the devices that form the individual heat pumps all have container sizes of 160 mm or below in terms of inner diameters, they do not correspond to containers regulated by the High Pressure Gas Safety Law, and it is possible to reduce manufacturing costs considerably by simplifying the manufacturing process, omitting various tests, and so fourth. Furthermore, because the multiple systems of the refrigerant circulation circuits are provided in parallel, an oil equalization mechanism, oil equalization control, etc. are not required among the plurality of compressors, thus making it possible to simplify the configuration thereof and to enhance the reliability of the individual heat pumps.

[0010] In the heat pump hot water supply system employing CO₂ refrigerant according to the aspect of the present invention described above, two-stage compressors

may be individually employed as the compressors in the multiple systems of the refrigerant circulation circuits; and a gas injection circuit may be provided which injects gaseous refrigerant separated at an intermediate-pressure receiver provided downstream of the heat sink into refrigerant that is compressed to intermediate pressure.

[0011] With this configuration, two-stage compressors are employed as the individual compressors in the multiple systems of the refrigerant, circulation circuits, and the gas injection circuits, which inject the gaseous refrigerant separated at the intermediate-pressure receivers provided downstream of the heat sinks into the refrigerant compressed to intermediate pressure, are provided. Because of this, the heating capacities and the coefficients of performance (COP) of the heat pumps can be enhanced due to the enhanced compression efficiency achieved by the two-stage compression of the CO₂ refrigerant and the economizer effect of the gas injection circuits, and therefore, the hot water supplying performance can be further enhanced. In addition, because the gas injection circuits are also provided individually for the individual refrigerant circulation circuits, the gas injection can be performed substantially equally for the individual compressors, and thus, it is possible to eliminate any imbalance in gas injection levels between the compressors.

[0012] In the heat-pump hot water supply system employing CO₂ refrigerant according to an aspect of the present invention described above, of the multiple systems of the refrigerant circulation circuits, the hot-water supplying heat exchanger and heat pumps formed in the two systems of the refrigerant circulation circuits may be integrated, thereby being modularized as a main unit, and heat pumps in a third and subsequent system may be individually modularized as subunits, which are employed in combination with the main unit in accordance with a required refrigerating capacity.

[0013] With this configuration, of the multiple systems of refrigerant circulation circuits, the hot-water supplying heat exchanger and the heat pumps formed in two systems of the refrigerant circulation circuits are integrated, thereby being modularized as the main unit; and the heat pumps of the third and subsequent systems are modularized as the subunits, which are employed by being combined with the main unit in accordance with the required refrigerating capacity. Accordingly, when developing a series of hot water supply systems in accordance with the refrigerating capacities, a series with a different refrigerating capacity can be developed merely by changing the number of subunits to be combined. Therefore, it is possible to easily increase the capacity, and productivity can be enhanced.

[0014] In the heat-pump hot water supply system employing CO₂ refrigerant according to an aspect of the present invention described above, the main unit may have a configuration in which two heat absorbers formed of air heat exchangers having flat shapes or formed by

being bent into L-shapes or angular U-shapes are assembled into a tetragon by being disposed to face each other on top of a bottom unit in which other devices are accommodated; the subunits may have configurations in which heat absorbers formed of air heat exchangers formed by being bent into angular U-shapes are disposed above bottom units in which other devices are accommodated; and the main unit and the subunits, may be employed by being arranged next to each other in appropriate numbers.

[0015] With this configuration, the main unit has a configuration in which two heat absorbers formed of the air heat exchangers having flat shapes or formed by being bent into L-shapes or angular U-shapes are assembled into a tetragon by being disposed to face each other on top of the bottom unit in which other devices are accommodated; the subunits have configurations in which the heat absorbers formed of air heat exchangers formed by being bent into U-shapes are disposed above bottom units in which other devices are accommodated; and the main unit and the subunits are employed by being arranged next to each other in appropriate numbers. Accordingly, it is possible to modularize individual units by setting the widthwise sizes of the subunits to be about half the size of the widthwise size of the main unit. Therefore, the size of the hot water supply system can be predefined in accordance with the refrigerating capacities, thus making it possible to facilitate securing installation space as well as installation thereof.

{Advantageous Effects of Invention}

[0016] With the present invention, increasing the capacity of a heat-pump hot water supply system employing CO₂ refrigerant, it is possible to form a large-capacity heat-pump hot water supply system employing CO₂ refrigerant whose total refrigerating capacity is three refrigerating tons or greater by employing a configuration in which two or more systems of heat pumps are connected in parallel for the hot-water supplying heat exchanger, in which containers for devices that form the refrigerant circulation circuits all have container sizes of 160 mm or below in terms of inner diameters. Because of this, it is possible to increase the capacity of the heat-pump hot water supply system employing CO₂ refrigerant while keeping the containers at a certain size or below for devices that form the heat pumps employing CO₂ refrigerant whose design pressures are high at 14 MPa on the high-pressure side and 8.5 MPa on the low-pressure side, and it is possible to eliminate various problems associated with increasing the sizes of the containers. Moreover, because containers for the devices that form the individual heat pumps all have container sizes of 160 mm or below in terms of inner diameters, they do not correspond to containers regulated by the High Pressure Gas Safety Law, and it is possible to reduce manufacturing costs considerably by simplifying the manufacturing process, omitting various tests, so forth. Furthermore, because

the multiple systems of the refrigerant circulation circuits are provided in parallel, an oil equalization mechanism, oil equalization control, etc. are not required among the plurality of compressors, thus making it possible to simplify the configuration thereof and to enhance the reliability of the individual heat pumps.

{Brief Description of Drawings}

10 **[0017]**

Fig. 1 is a circuit configuration diagram of a heat-pump hot water supply system employing CO₂ refrigerant according to a first embodiment of the present invention.

15 Fig. 2 is an exploded perspective view of an example unit configuration for a heat-pump hot water supply system employing CO₂ refrigerant according to a second embodiment of the present invention.

20 Fig. 3 is an exploded perspective view of a modification of the example unit configuration shown in Fig. 2.

25 Fig. 4 is an exploded perspective view of another modification of the example unit configuration shown in Fig.

{Description of Embodiments}

30 **[0018]** Embodiments according to the present invention will be described below with reverence to the drawings.

{First Embodiment}

35 **[0019]** A first embodiment of the present invention will be described below by using Fig. 1.

Fig. 1 a circuit configuration diagram of a heat-pump hot water supply system employing CO₂ refrigerant according to the first embodiment of the present invention.

40 A heat-pump hot water supply system 1 employing CO₂ refrigerant according to this embodiment is provided with supercritical cycle heat pumps 2A and 2B employing CO₂ refrigerant formed in refrigerant circulation circuits 3A and 3B that multiple independent systems.

45 **[0020]** The individual heat pumps 2A 2B formed of the closed-cycle refrigerant circulation circuits 3A and 3B in which refrigerant pipes connect, in the following order, two-stage compressors 4A and 4B having, for example, rotary compression mechanisms at lower stages and scroll compression mechanisms at higher stages; oil separators 5A and 5B that separate lubricant in refrigerant gas; heat sinks (gas coolers) 6A and 6B that release the heat of the refrigerant gas; first electronic expansion valves (depressurizing means) 7A and 7B that control outlet-side refrigerant temperature of the heat sinks 6A and 6B; intermediate-pressure receivers 8A and 8B that perform gas-liquid separation of the refrigerant; intercoolers 9A and 9B that perform heat exchange between in-

intermediate-pressure refrigerant and intake refrigerant gas for the compressors 4A and 4B; second electronic expansion valves (depressurizing means) 10A and 10B that depressurize the intermediate-pressure refrigerant; supercooling coils 11A and 11B; and heat absorbers (air exchangers) 13A and 13B that perform heat exchange between the external air from fans 12A and 12B and refrigerant.

[0021] The individual heat pumps 2A and 2B provided with oil returning circuits 14A and 14B that return oil separated at the oil separators 5A and 5B to the two-stage compressors 4A and 4B; hot-gas bypass circuits 16A and 16B provided with electromagnetic valves 15A and 15B that, when the external air temperature is low, remove frost accumulated on the heat absorbers (air heat exchangers) 13A and 13B by introducing hot gas refrigerant discharged from the two-stage compressors 4A and 4B to the heat absorbers (air heat exchangers) 13A and 13B; and gas injection circuits 18A and 18B provided with electromagnetic valves 17A and 17B that perform injection of (inject) the intermediate-pressure refrigerant gas separated at the intermediate-pressure receivers 8A and 8B into the intermediate-pressure refrigerant gas to be taken into the scroll compression mechanisms at the higher stages of the two-stage compressors 4A and 4B.

[0022] The heat sinks (gas coolers) 6A and 6B of the above-described heat pumps 2A and 2B form a hot-water supplying heat exchanger 19 that performs heat exchange between water flowing in the water channel 19A and the refrigerant, thereby producing hot water by heating the water. This hot-water supplying heat exchanger 19 is configured so that the water channel 19A thereof is connected with a hot-water storage tank 20 via a water circulation circuit 23 provided with a water circulation pump 21 and an electromagnetic valve 22, and water circulated from the hot-water storage tank 20 via the water circulation pump 21 is heated to form hot water of a predetermined temperature and is stored in the hot-water storage tank 20. Note that a water supply pipe (not shown) for drinking water or the like is connected to the water circulation circuit 23, and a hot-water supply pipe (not shown) for supplying hot water to required locations is connected to the hot-water storage tank 20.

[0023] In this way, the heat-pump hot water supply system 1 of this embodiment has a configuration in which the individual heat pumps 2A and 2B, which are multiple independent systems, in the individual refrigerant circulation circuits 3A and 3B are connected in parallel to the hot-water supplying heat exchanger 19, such that water can be heated at the hot-water supplying heat exchanger 19 by means of the heat sinks 6A and 6B of the individual heat pumps 2A and 2B. In addition, for the individual heat pumps 2A and 2B, containers for the two-stage compressors 4A and 4B, oil separators 5A and 5B, the intermediate-pressure receivers 8A and 8B, accumulators (not shown), and so forth that form the refrigerant circulation circuits 3A and 3B all have container sizes of 160 mm or below in terms of inner diameters. Then, if the refrigerating capacity is made

three refrigerating tons or greater when increasing the capacity of the heat-pump hot water supply system 1, at least two or more heat pumps 2A and 2B, in which containers for devices that form the individual refrigerant circulation circuits 3A and 3B all have container sizes of 160 mm or below in terms of inner diameters, are connected in parallel to form a large-capacity heat-pump hot water supply system 1.

[0024] This embodiment with the above-described configuration affords the following operational advantages.

In the above-described heat-pump hot water supply system 1 employing CO₂ refrigerant, the refrigerant that has undergone the two-stage compression at the two-stage compressors 4A and 4B is introduced to the heat sinks (gas coolers) 6A and 6B after the oil in the refrigerant is separated at the oil separators 5A and 5B, and the refrigerant undergoes heat exchange here with the water flowing in the water channel 19A of the hot-water supplying heat exchanger 19. This water is heated by the heat released from the refrigerant, thus being increased in temperature, is subsequently returned to the hot-water storage tank 20, and is circulated between the hot-water storage tank 20 and the hot-water supplying heat exchangers 19 until the hot water temperature in the hot-water storage tank 20 reaches a predetermined temperature; a hot-water storing operation is ended at the point when the hot water temperature reaches the predetermined temperature.

[0025] The refrigerant that has been cooled by undergoing heat exchange with water at the hot-water supplying heat exchanger 19 is depressurized at the first electronic expansion valves (depressurizing means) 7A and 7B, reaches the intermediate pressure-receivers 8A and 8B, and undergoes gas-liquid separation thereat. The gaseous refrigerant that has been separated here is injected into the refrigerant gas compressed to intermediate pressure by the lower-stage compression mechanisms of the two-stage compressors 4A and 4B via the electromagnetic valves 17A and 17B and the gas injection circuits 18A and 18B. On the other hand, the liquid refrigerant, after being cooled, passes through the intercoolers 9A and 9B, is depressurized at the second electronic expansion valves (depressurizing means) 10A and 10B, and flows into the heat absorbers (air heat exchangers) 13A and 13B in the form of low-temperature, low-pressure refrigerant. Due to the economizer effect of this gas injection, the heating capacities and coefficients of performance (COP) of the individual heat pumps 2A and 2B can be enhanced, and thus, the hot-water supplying performance can be enhanced.

[0026] The refrigerant that has flowed into the heat absorbers (air heat exchangers) 13A and 13B undergoes heat exchange with the external air blown by the fans 12A and 12B, thereby forming vaporized gas by adsorbing heat from the external air. This gasified refrigerant is taken into the two-stage compressors 4A and 4B via the intercoolers 9A and 9B and is recompressed. Thereafter,

it is supplied for hot water production by repeating the same operations. Note that, in the case in which a low external air temperature causes frost to accumulate on the heat absorbers 13A and 13B during the hot water storing operation, the defrost operation is performed by opening the electromagnetic valves 15A and 15B and by introducing the high-temperature, high-pressure hot gas compressed at the two-stage compressors 4A and 4B to the heat absorbers 13A and 13B via the hot-gas bypass circuits 16A and 16B.

[0027] When increasing the capacity of the above-described heat-pump hot water supply system 1 employing CO₂ refrigerant, it is possible to form the large-capacity heat-pump hot water supply systems 1 whose total refrigerating capacity is three refrigerating tons or greater by employing the configuration in which two or more systems of the heat pumps 2A and 2B are connected in parallel for the hot-water supplying heat exchanger, in which containers for devices that form the refrigerant circulation circuits 3A and 3B all have container sizes of 160 mm or below in terms of inner diameters. By doing so, it is possible to increase the capacity of the heat-pump hot water supply system employing CO₂ refrigerant while keeping the containers for the devices that form the heat pumps 2A and 2B employing CO₂ refrigerant, whose design pressures are high at 14 MPa on the high-pressure side and 8.5 MPa on the low-pressure side, at or below a certain size, and it is possible to eliminate various problems associated with increasing the sizes of individual containers, such as increasing pressure resistance by means of increasing the plate thickness, etc., difficulties related to manufacturing, increased costs, and so on.

[0028] Moreover, because the containers for the devices that form the individual heat pumps 2A and 2B all have container sizes of 160 mm or below in terms of inner diameters, they do not correspond to containers regulated by the High Pressure Gas Safety Law, and it is possible to reduce manufacturing costs considerably by simplifying the manufacturing process, omitting various tests, and so forth. Furthermore, because the multiple systems of the refrigerant circulation circuits 3A and 3B are connected in parallel, an oil equalization mechanism, oil equalization control, etc. are not required between the plurality of two-stage compressors 4A and 4B, thus making it possible to simplify the configuration thereof and to enhance the reliability of the individual heat pumps 2A and 2B.

[0029] In addition, because the multiple systems of the refrigerant circulation circuits 3A and 3B are individually provided with the gas injection circuits 18A and 18B that inject the gaseous refrigerant separated at the intermediate-pressure receivers 8A and 8B into the intermediate-pressure refrigerant gas at the two-stage compressors 4A and 4B, the heating capacities and the coefficients of performance (COP) of the heat pumps 2A and 2B can be enhanced due to the enhanced compression efficiency achieved by the two-stage compression of the CO₂ refrigerant and the economizer effect of the gas injection

circuits 18A and 18B. Therefore, the hot-water supplying performance can be further enhanced, and, because the gas injection circuits 18A and 18B are also provided in the individual refrigerant circulation circuits 3A and 3B, the gas injection can be performed substantially equally for the individual two-stage compressors 4A and 4B, and thus, it is possible to eliminate any imbalance in gas injection levels between the individual compressors.

10 {Second Embodiment}

[0030] Next a second embodiment of the present invention will be described by using Figs. 2 to 4.

15 This embodiment differs from the first embodiment described above, in that the heat-pump hot water supply system 1 employing CO₂ refrigerant, is specifically configured for the case where it is formed as a unit. Because other points are the same as those in the first embodiment, descriptions thereof will be omitted.

20 In this embodiment, by integrating the hot-water supplying heat exchangers 19 and the heat pumps 2A and 2B formed in two systems of the refrigerant circulation circuits 3A and 3B, in which the containers for the individual constituent devices are containers with inner diameters of 160 mm or below, they are modularized as a main unit 30, as shown in Figs. 2 to 4; and a third system, that is, a heat pump 3C (not shown) subsequent systems, in which containers for constituent devices are containers with inner diameters of 160 mm or below, are modularized as subunits 31, which are combined with the main unit 30 in appropriate numbers in accordance with the required refrigerating capacity.

25 **[0031]** The main unit 30 has a configuration in which the two heat absorbers 13A and 13B formed of air heat exchangers formed by being bent into L-shapes, as shown in Fig. 2, or two heat absorbers 13A' and 13B' formed of flat air heat exchangers, as shown in Fig. 3, or two heat absorbers 13A'' and 13B'' formed of air heat exchangers formed by being bent into angular U-shapes, as shown in Fig. 4, are assembled into a tetragon by being disposed to face each other in a top unit 30A along with the fans 12A and 12B, and a bottom unit 30B placed therebelow accommodates other devices therein. In addition, the subunits 31 have configurations in which heat absorbers 13C formed of air heat exchangers formed by being bent into angular U-shapes are accommodated in top units 31.A along with fans 12C (not shown), and bottom units 30B placed therebelow accommodate other devices therein.

30 **[0032]** As described above, the system is configured such that, of the multiple systems of the refrigerant circulation circuits 3A and 3B, the hot-water supplying heat exchanger 19 and the heat pumps 2A and 2B, in which the containers for the individual constituent devices are containers with inner diameters of 160 mm or below, formed in the two systems of the refrigerant circulation circuits 3A and 3B are integrated thereby being modularized as the main unit 30; and a third system, that is,

the heat pump 2C (not shown), and subsequent systems in which containers for constituent devices are containers with inner diameters of 160 mm or below are modularized as the subunits 31, which are employed by being combined with the main unit 30 in accordance with the required refrigerating capacity; by doing so, when developing a series of the heat-pump hot water supply systems 1 in accordance with the refrigerating capacities, a series with a different refrigerating capacity can be developed merely by changing the number of subunits 31 to be combined. Accordingly, it is possible to easily increase the capacity, and productivity can be enhanced.

[0033] In addition, because the main unit 30 has the configuration in which two heat absorbers 13A and 13B, 13A' and 13B' or 13A'' and 13B'' formed of air heat exchanger having flat shapes or formed by being bent into L-shapes or angular U-shapes are assembled into a tetragon by being disposed to face each other on top of the bottom unit 31B in which other devices are accommodated; because the subunits 31 have the configurations in which the heat absorbers 13C formed of air heat exchangers formed by being bent into angular U-shapes are disposed above the bottom unit 30B in which other devices are accommodated; and because the main unit 30 and the subunits 31 are employed by being arranged next to each other in appropriate numbers, it is possible to form modules of individual units 30 and 31 by setting the widthwise sizes of the subunits 31 to be about half the size of the widthwise size of the main unit 30. Therefore, the size of the heat-pump hot water supply system 1 can be predefined in accordance with the refrigerating capacities, thus making it possible to facilitate securing installation space as well as installation thereof.

[0034] Note that the present invention is not limited to the inventions according to the embodiments described above, and appropriate modifications are possible within a range that does not depart from the spirit thereof. For example, although examples in which the two-stage compressors 4A and 4B are employed in the individual heat pumps 2A and 2B have been described in the embodiments described above, the compressors may be single-stage compressors. In addition, the gas injection circuits 18A and 18B are not essential, and a configuration without the gas injection circuits may be employed. Furthermore, although examples in which gas-liquid separators (intermediate-pressure receivers 8A and 8B) are employed as the gas injection circuits 18A and 18B have been described, alternatively, a configuration in which intermediate heat exchangers are employed is permissible.

{Reference Signs List}

[0035]

1 heat-pump hot water supply system employing CO₂ refrigerant
2A, 2B heat pump

3A, 3B refrigerant circulation circuit
4A, 4B two-stage compressor
6A, 6B heat sink
7A, 7B first electronic expansion valve (depressurizing means)
8A, 8B intermediate-pressure receiver
10A, 10B second electronic expansion valve (depressurizing means)
13A, 13A', 13A'', 13B, 13B', 13B'', 13C heat absorber
18A, 18B gas injection circuit
19 hot-water supplying heat exchanger
19A water channel
30 main unit
30B bottom unit
31 subunit
31D bottom unit

Claims

1. A heat-pump hot water supply system employing CO₂ refrigerant provided with a refrigerant circulation circuit employing CO₂ refrigerant, which includes a compressor, a heat sink, depressurizing means, and a heat absorber, and a hot-water supplying heat exchanger having a water channel for performing heat exchange with the heat sink; and in which multiple systems of the refrigerant circulation circuits are provided in parallel for the hot-water supplying heat exchanger, wherein container sizes for all individual constituent devices of individual heat pumps formed in the multiple systems of the refrigerant circulation circuits are 160 mm or below in terms of inner diameters, and the total refrigerating capacity thereof is three refrigerating tons or greater.
2. A heat-pump hot water supply system employing CO₂ refrigerant according to Claim 1, wherein two-stage compressors are individually employed as the compressors in the multiple systems of the refrigerant circulation circuits; and a gas injection circuit is provided which injects gaseous refrigerant separated at an intermediate-pressure receiver provided downstream of the heat sink into refrigerant that is compressed to intermediate pressure.
3. A heat-pump hot water supply system employing CO₂ refrigerant according to claim 1 or 2, wherein, of the multiple systems of the refrigerant circulation circuits, the hot-water supplying heat exchanger and heat pumps formed in the two systems of the refrigerant circulation circuits are integrated, thereby being modularized as a main unit, and heat pumps in a third and subsequent system are individually modularized as subunits, which are employed in combination with the main unit in accordance with a required refrigerating capacity.

4. A heat-pump hot water supply system employing CO₂ refrigerant according to Claim 3, wherein the main unit has a configuration in which two heat absorbers formed of air heat exchangers having flat shapes or formed by being bent into L-shapes or angular U-shapes are assembled into a tetragon by being disposed to face each other on top of a bottom unit in which other devices are accommodated; the subunits have configurations in which heat absorbers formed of air heat exchangers formed by being bent into angular U-shapes are disposed above bottom units in which other devices are accommodated; and the main unit and the subunits are employed by being arranged next to each other in appropriate numbers.

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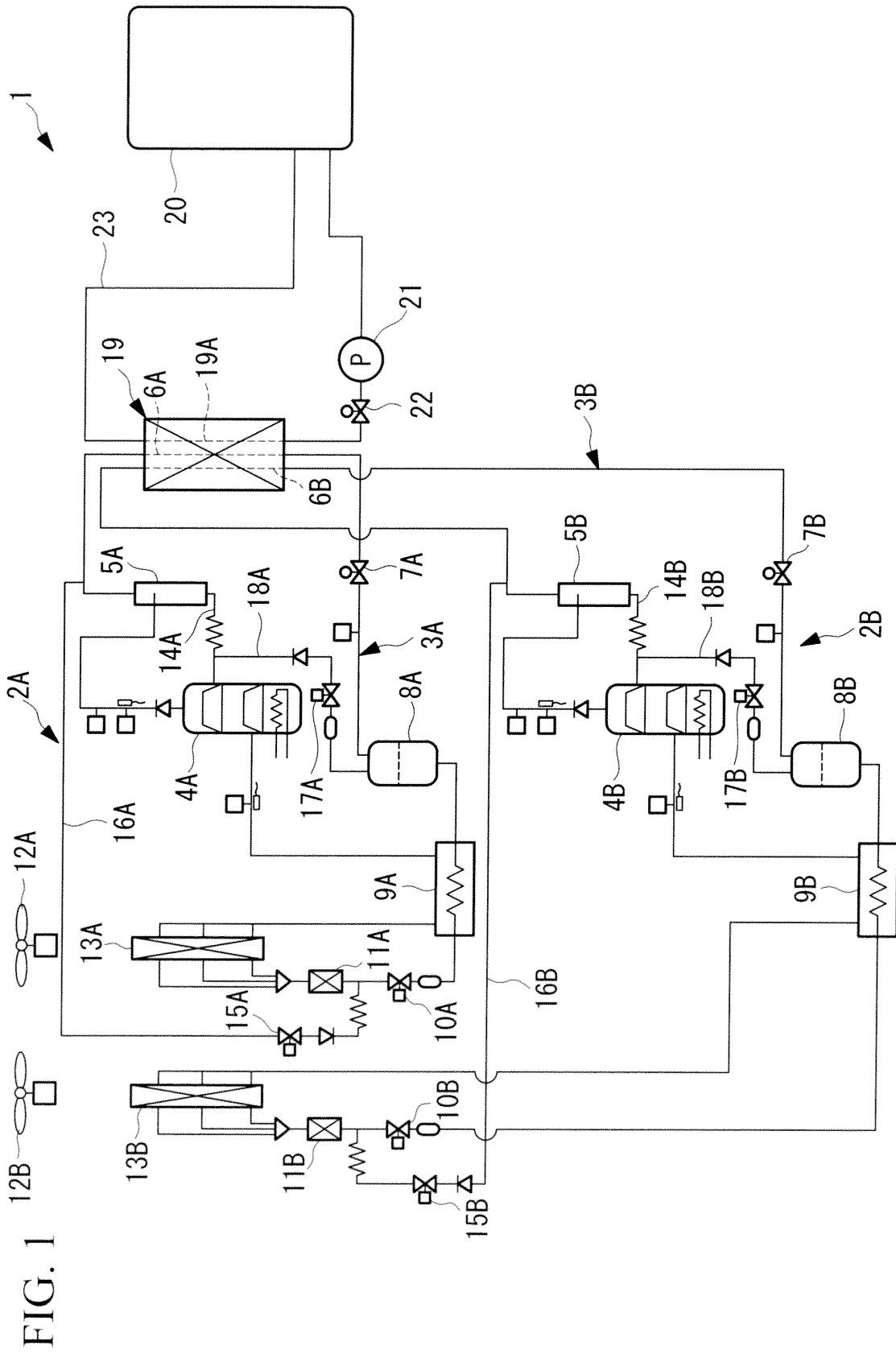
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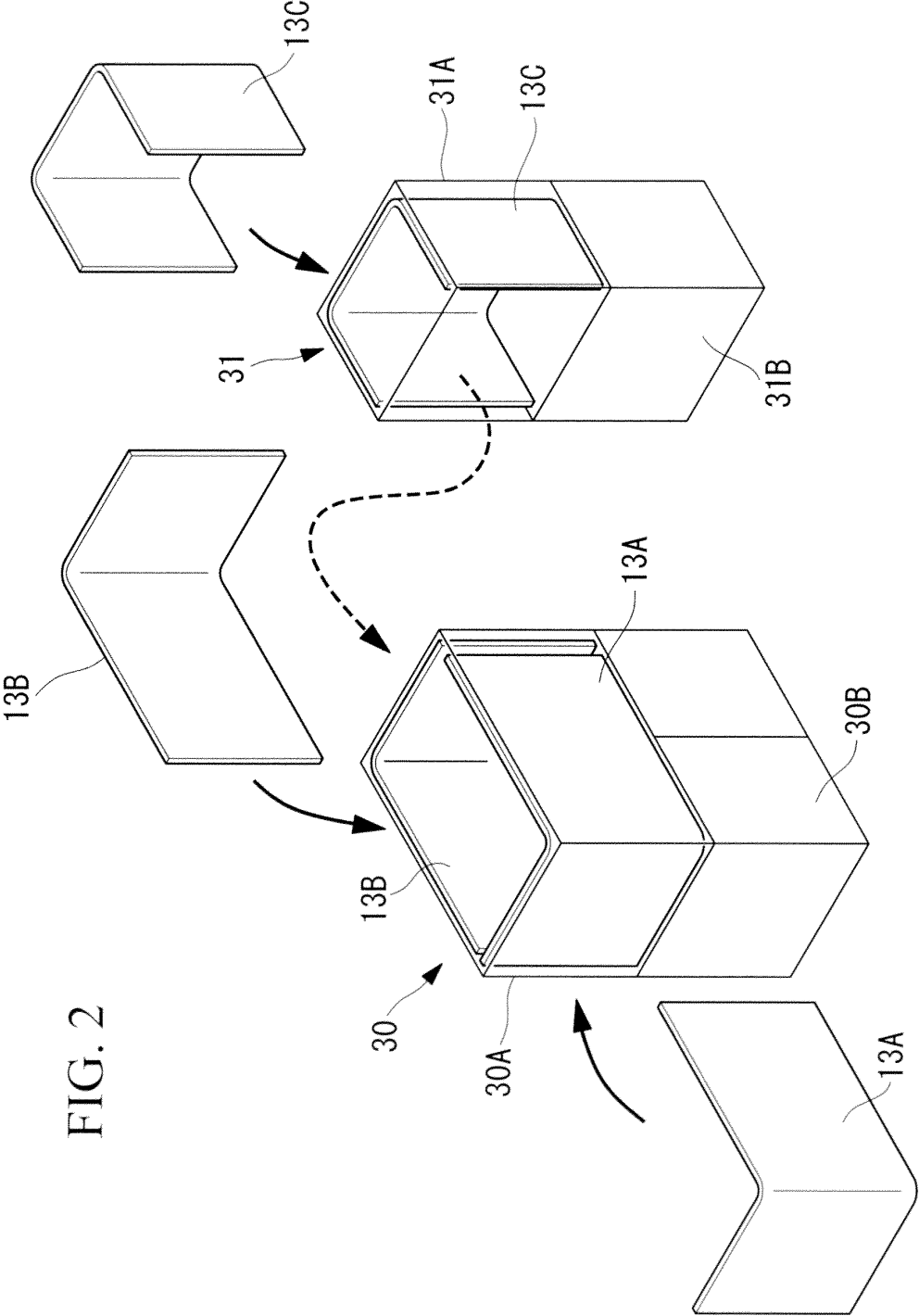
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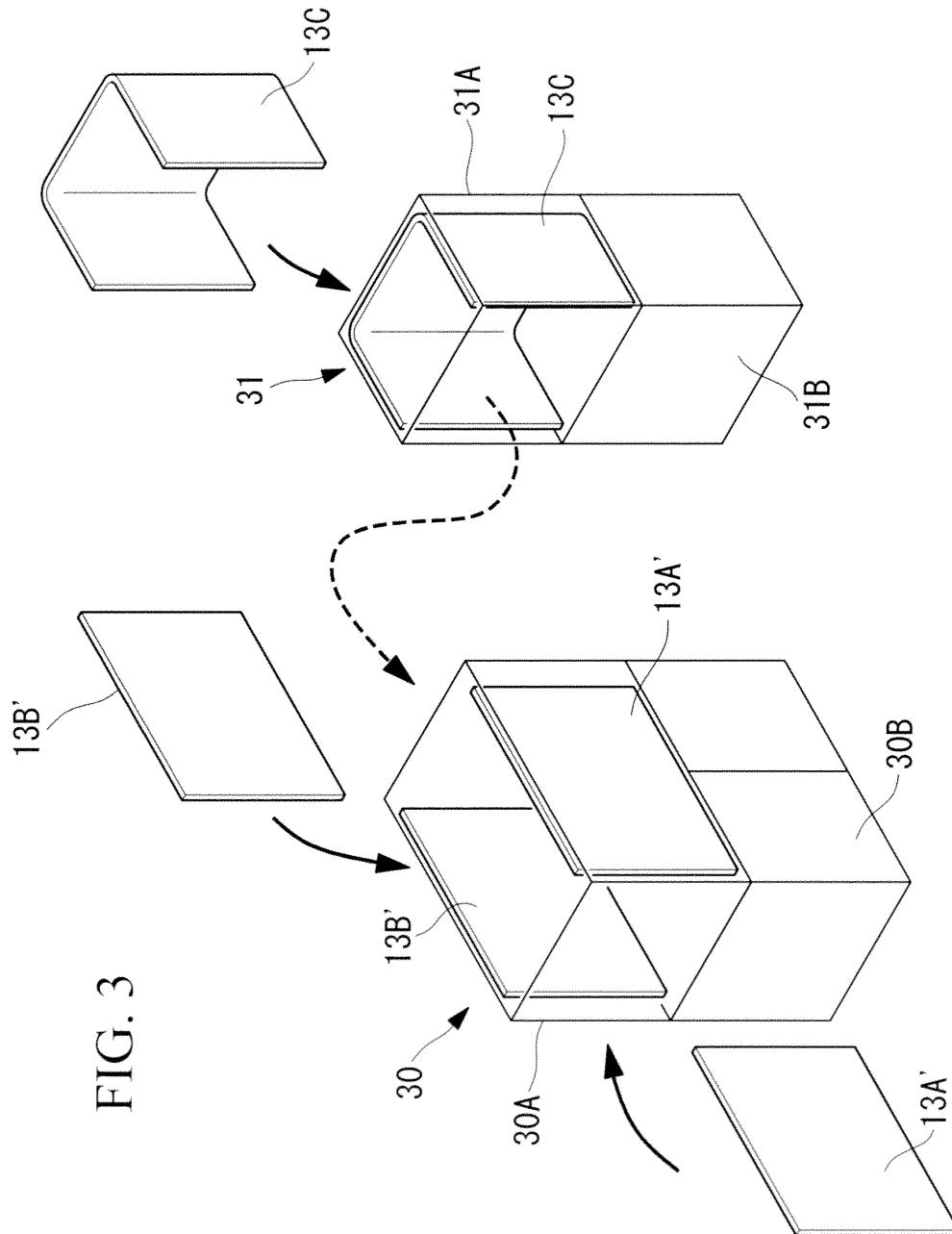
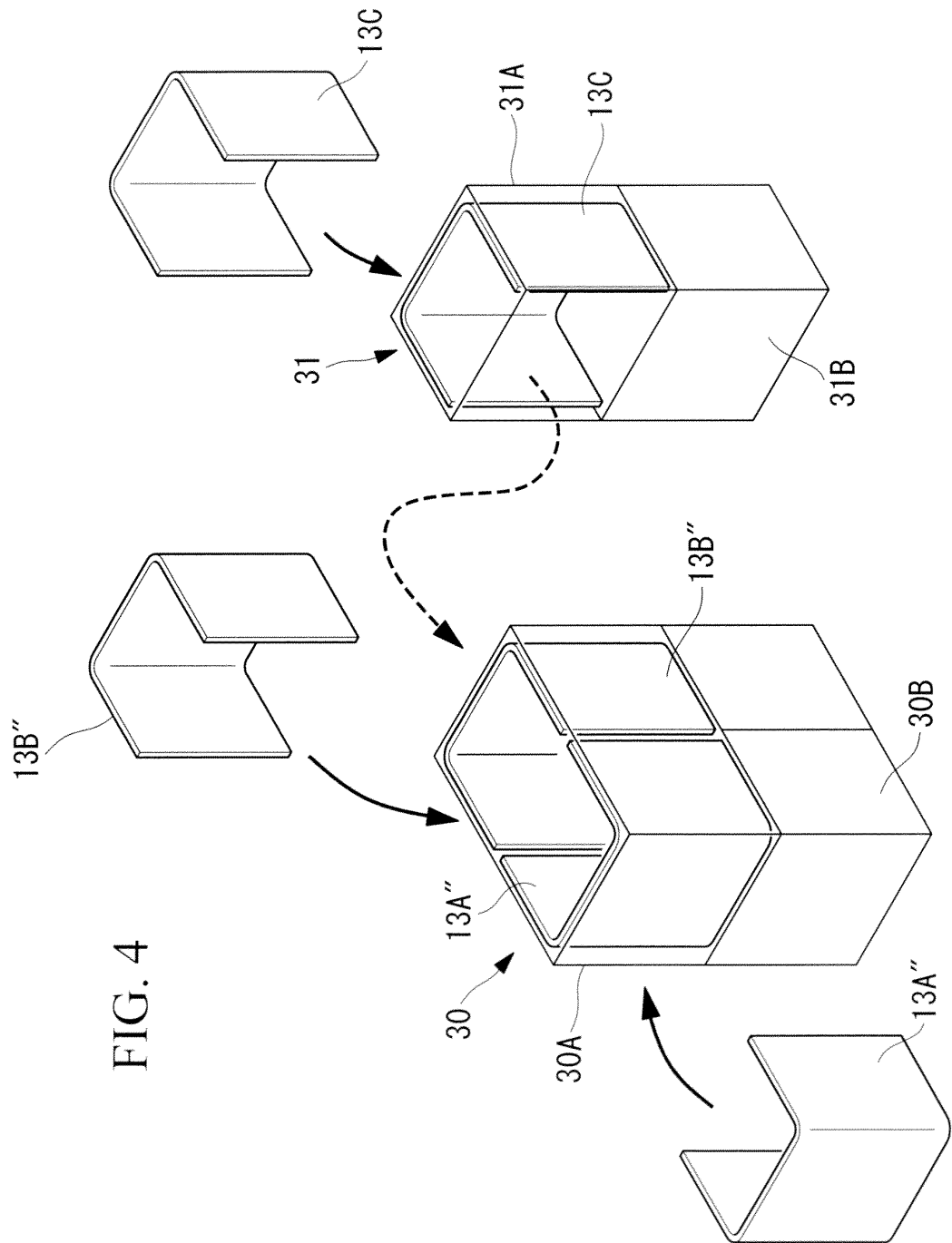


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/059492

A. CLASSIFICATION OF SUBJECT MATTER

F24H1/00(2006.01) i, F25B1/00(2006.01) i, F25B30/02(2006.01) i

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)

F24H1/00, F25B1/00, F25B30/02

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2011

Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-040590 A (Hitachi Appliances, Inc.), 15 February 2007 (15.02.2007), paragraphs [0016] to [0017], [0051]; fig. 1 (Family: none)	1-4
Y	JP 09-236357 A (Denso Corp.), 09 September 1997 (09.09.1997), paragraph [0026] (Family: none)	1-4
Y	JP 05-231724 A (Thermo King Corp.), 07 September 1993 (07.09.1993), paragraph [0023]; fig. 1 & US 5174123 A & EP 529882 A2	2-4

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

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
24 May, 2011 (24.05.11)Date of mailing of the international search report
07 June, 2011 (07.06.11)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/059492

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2006-009713 A (Hitachi, Ltd.), 12 January 2006 (12.01.2006), front page & US 2005/0284946 A1 & CN 1721771 A	3, 4
Y	JP 2008-076014 A (Noritz Corp.), 03 April 2008 (03.04.2008), front page (Family: none)	3, 4

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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