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(72) Inventors:
• **KATO, Takahiro**
Tokyo 108-8215 (JP)
• **ENYA, Atsushi**
Tokyo 108-8215 (JP)

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(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo 108-8215 (JP)

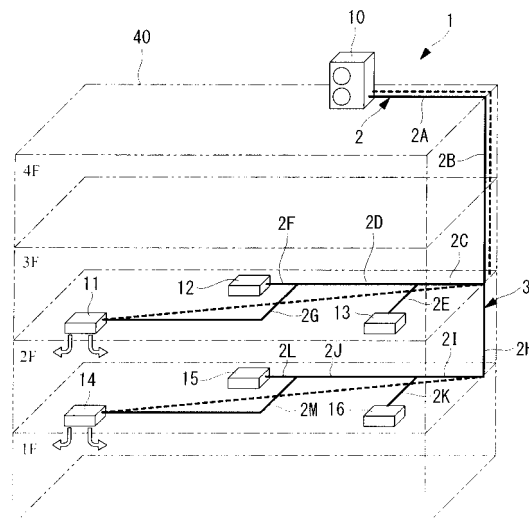
(74) Representative: **Intès, Didier Gérard André et al**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cedex 07 (FR)

(54) **AIR CONDITIONER REFRIGERANT FILLING METHOD**

(57) Provided is an air-conditioner refrigerant injecting method that enables precise and quick injection of an optimum amount of refrigerant. In an air-conditioner (1) refrigerant injecting method of injecting a specified amount of refrigerant into a closed-cycle refrigerant circuit (3) in which an outdoor unit (10) and a plurality of indoor units (11) to (16) are connected via refrigerant pipes (2), the pipe lengths and pipe diameters of the refrigerant pipes (2A) to (2M) connecting the outdoor unit

(10) and the plurality of indoor units (11) to (16) installed on the respective floors of a structure (40) are identified insofar as they can be reliably measured or estimated, the minimum required refrigerant amount required by the air conditioner (1) is calculated on the basis of the pipe lengths and pipe diameters, the resulting amount of refrigerant is additionally injected in advance, and then the refrigerant is automatically injected by an automatic refrigerant injection function until a specified injection amount is reached.

FIG. 1



Description

{Technical Field}

5 **[0001]** The present invention relates to an air-conditioner refrigerant injecting method that enables precise and quick additional injection of an optimum amount of refrigerant into a refrigerant circuit of an air conditioner.

{Background Art}

10 **[0002]** Multi-type air conditioners used for air conditioning of buildings etc. are configured such that a plurality of indoor units are connected to a single outdoor unit. In such air conditioners, because the lengths of refrigerant pipes (crossover pipes) connecting, the outdoor unit and a plurality of indoor units vary from site to site or vary depending on the number of indoor units connected, refrigerant of an amount corresponding to the specifications, i.e., pipe length and pipe diameter of the crossover pipes needs to be additionally injected at the site. Usually, when additionally injecting refrigerant at the
15 site, a specified refrigerant amount is calculated on the basis of the pipe lengths and pipe diameters of the crossover pipe and the specified amount of refrigerant is additionally injected.

[0003] In a typical method like this, the amount of refrigerant to be additionally injected is determined at the site by calculation based on the specifications of the crossover pipes. Thus, at a site where a new air conditioner is installed, because the detailed specifications of the crossover pipes can be obtained, a specified refrigerant amount can be easily
20 and correctly calculated by humans or machines based on the data. However, at a site where an air conditioner is renewed by replacing the outdoor unit and indoor units of the existing air conditioner and reusing the crossover pipes, the specifications of the crossover pipes are sometimes unknown, resulting in situations where the amount of refrigerant to be additionally injected cannot be correctly calculated.

[0004] To overcome this problem, an air conditioner having an automatic refrigerant injection function that enables a
25 specified amount of refrigerant to be automatically injected into a refrigerant circuit, and an air conditioner that enables refrigerant to be automatically injected into a refrigerant circuit while eliminating the work of inputting information about crossover pipes that enables precise determination of the adequacy of the amount of the refrigerant have been proposed (for example, see PTLS 1 to 3).

30 Citation List

Patent Literature

[0005]

35 PTL 1 Japanese Unexamined Patent Application, Publication No. 2002-350014
PTL 2 The Publication of Japanese Patent No. 3719246
PTL 3 Japanese Unexamined Patent Application, Publication No. 2007-292429

40 Summary of Invention

Technical Problem

[0006] However, even an air conditioner having an automatic refrigerant injection function, as described above, requires
45 an amount of refrigerant corresponding to the crossover pipes, which should basically be additionally injected, to be injected from the beginning, if the specifications (pipe length and pipe diameter) of the crossover pipes are unknown. Therefore, there has been a problem in that it takes a long time to inject the specified amount of refrigerant. The reason for this is that the refrigerant injection speed achieved by the automatic refrigerant injection function is slow, and this is a cause of long installation work for installing air conditioners.

50 **[0007]** The present invention has been in view of these circumstances and provides an air-conditioner refrigerant injecting method that enables precise and quick additional injection of an optimum amount of refrigerant into a refrigerant circuit.

Solution to Problem

55 **[0008]** To solve the above-described problems, an air-conditioner refrigerant injecting method of the present invention employs the following solutions.
Specifically, an air-conditioner refrigerant injecting method according to a first aspect of the present invention is an air-

conditioner refrigerant injecting method of injecting a specified amount of refrigerant into a closed-cycle refrigerant circuit in which an outdoor unit and a plurality of indoor units are connected via refrigerant pipes. The pipe lengths and pipe diameters of the refrigerant pipes connecting the outdoor unit and the plurality of indoor units installed on the respective floors of a structure are identified insofar as they can be reliably measured or estimated, the minimum required refrigerant amount required by the air conditioner is calculated on the basis of the pipe lengths and the pipe diameters, the resulting amount of refrigerant is additionally injected in advance, and then the refrigerant is automatically injected by an automatic refrigerant injection function until a specified injection amount is reached.

[0009] According to the first aspect of the present invention, even if the specifications of the refrigerant, pipes connecting the outdoor unit and the plurality of indoor units installed on the respective floors of the structure are unknown, because the pipe lengths and pipe diameters are identified insofar as they can be reliably measured or estimated, the minimum required refrigerant amount is calculated on the basis thereof, the resulting amount of refrigerant is additionally injected in advance, and then the refrigerant is automatically injected by the automatic refrigerant injection function until the specified injection amount is reached, the specified amount of refrigerant, i.e., the amount that eventually needs to be injected, can be correctly injected without any excess or shortfall. Accordingly, an optimum amount of refrigerant can be precisely injected, and the air conditioner can be stably operated. Furthermore, because the need for automatically injecting, from the beginning, the amount of refrigerant that should basically be additionally injected is eliminated, it is possible to reduce the time for injecting refrigerant, to reduce the time for installation work, and to simplify the installation work.

[0010] in the air-conditioner refrigerant, injecting method according to the first aspect of the present invention, the minimum required refrigerant amount may be calculated on the basis of, at least, the horizontal pipe length and pipe diameter of the refrigerant pipe extending from the installation position of the outdoor unit to the position of a vertical pipe extending along the floors of the structure, the vertical pipe lengths and pipe diameters, of the refrigerant pipe to the positions of branched portions on the respective floors of the structure, and the lengths and pipe diameters of branch pipes connecting, in straight lines, the positions of the vertical pipe on the respective floors and the indoor units located farthest therefrom among the plurality of indoor units.

[0011] In this method, the minimum required refrigerant amount is calculated on the basis of the horizontal pipe length and pipe diameter of the refrigerant pipe extending from the installation position of the outdoor unit to the position of the vertical pipe extending along the floors of the structure, the vertical pipe lengths and pipe diameters of the refrigerant pipe to the positions of the branched portions on the respective floors of the structure, and the lengths and pipe diameters of the branch pipes connecting, in straight lines, the positions of the vertical pipe on the respective floors and the indoor units located farthest therefrom among the plurality of indoor units. Therefore, even if the detailed specifications of the refrigerant pipes connecting the outdoor unit and the plurality of indoor units installed on the respective floors of the structure are unknown, the minimum required refrigerant amount not exceeding the refrigerant amount that should basically be additionally injected can be calculated on the basis of the pipe lengths and pipe diameters that can be reliably measured or estimated, and the refrigerant can be additionally injected in advance. More specifically, the length and diameter of the horizontal pipe (main pipe) connected to the outdoor unit can be reliably measured, and the length and pipe diameter of the vertical pipe extending along the floors of the structure to the position of the first branched portion can be estimated from the height of the structure and the diameter of the horizontal pipe, even if the actual pipe length is unknown or cannot be measured. Moreover, the lengths and diameters of the branch pipes connected to the plurality of indoor units installed on the respective floors can be estimated from the straight-line distances between the positions of the vertical pipe on the respective floors and the indoor units located farthest therefrom and from the diameters of the branch pipes, even if the actual pipe lengths are unknown or cannot be measured. Accordingly, by calculating the refrigerant amount on the basis of the pipe lengths and pipe diameters, the minimum required refrigerant amount not exceeding the refrigerant amount that should basically be additionally injected can be reliably calculated.

[0012] In the air-conditioner refrigerant injecting method according to the first aspect of the present invention, the amount of refrigerant may be calculated by assuming the pipe diameter of the horizontal pipe and the pipe diameter of the vertical pipe to the position of the first branched portion to be the diameters determined from the model of the outdoor unit or from the measurement value of the refrigerant pipe closest thereto.

[0013] In this method, the amount of refrigerant is calculated by assuming the pipe diameter of the horizontal pipe and the pipe diameter of the vertical pipe to the position of the first branched portion to be the diameter determined from the model of the outdoor unit or from the measurement value of the refrigerant pipe closest thereto. Therefore, even if the pipe diameter of the horizontal pipe and the pipe diameter of the vertical pipe to the position of the first branched portion are unknown, because the horizontal pipe and the vertical pipe are so-called main pipes, it can be reliably assumed that the refrigerant pipe closest to the outdoor unit is expended and serves as these pipes. Accordingly, by assuming the pipe diameter determined from the model of the outdoor unit or from the measurement value of the refrigerant pipe closest thereto to be the pipe diameters of the horizontal pipe and the vertical pipe, the minimum required refrigerant amount can be precisely calculated.

[0014] In the air-conditioner refrigerant injecting method according to the first aspect of the present invention, the

amount of refrigerant may be calculated by assuming the pipe diameters of the branch pipes and/or the pipe diameter of the vertical pipe beyond the first branched portion to be the diameters determined from the models of the indoor units located farthest from the vertical pipe or from the measurement values of the refrigerant pipes closest thereto.

[0015] In this method, because the amount of refrigerant may be calculated by assuming the pipe diameters of the branch pipes and/or the pipe diameter of the vertical pipe beyond the first branched portion to be the diameters determined from the models of the indoor units located farthest from the vertical pipe or from the measurement values of the refrigerant pipes closest thereto, even if the pipe diameters of the branch pipes and/or the pipe diameter of the vertical pipe beyond the first branched portion are unknown, the pipe diameters of the branch pipes and/or the pipe diameter of the vertical pipe can be reliably assumed to be, at least, those of the model of the indoor units located farthest from the vertical pipe or the pipe diameter of the refrigerant pipes connected to such indoor units. Accordingly, by assuming the pipe diameters determined from the model of the farthest indoor units or from the measurement values of the refrigerant pipes closest thereto to be the pipe diameters of the branch pipes and/or the pipe diameter of the vertical pipe beyond the first branched portion, the minimum required refrigerant amount can be precisely calculated.

[0016] An air-conditioner refrigerant injecting method according to a second aspect of the present invention is an air-conditioner refrigerant injecting method, in which refrigerant is injected by using any one of the above-described methods when renewing the air conditioner by replacing the outdoor unit and indoor units of the existing air conditioner and by connecting the replaced outdoor unit and indoor units with the existing refrigerant pipes.

[0017] In the air-conditioner refrigerant injecting method according to the second aspect of the present invention, refrigerant is injected by using any one of the above-described methods when renewing the air conditioner by replacing the outdoor unit and indoor units of the existing air conditioner and by connecting the replaced outdoor unit and indoor units with the existing refrigerant pipes. Therefore, even if the detailed specifications of the existing refrigerant pipes are unknown, by identifying their pipe lengths and pipe diameters insofar as they can be correctly measured or estimated and by calculating the minimum required refrigerant amount on the basis thereof, the resulting amount of refrigerant can be additionally injected in advance, and then the refrigerant can be automatically injected by an automatic refrigerant injection function until a specified injection amount is reached. Accordingly, the specified amount of refrigerant can be reliably and quickly injected into an air conditioner renewed by reusing the existing refrigerant pipe without any excess or shortfall.

{Advantageous Effects of Invention}

[0018] With the present invention, the minimum required refrigerant amount is calculated on the basis of the pipe lengths and pipe diameters of the refrigerant, pipes identified insofar as they can be reliably measured or estimated, the resulting amount of refrigerant is additionally injected in advance, and the specified amount of refrigerant, is automatically injected by the automatic refrigerant injection function. Thus, the specified amount of refrigerant can be correctly injected without any excess or shortfall. Accordingly, an optimum amount of refrigerant can be precisely injected, and the air conditioner can be stably operated. Furthermore, because the need for automatically injecting, from the beginning, the amount of refrigerant that should basically be additionally injected is eliminated, it is possible to reduce the time for injecting refrigerant, to reduce the time for installation work, and to simplify the installation work.

Brief Description of Drawings

[0019]

FIG. 1 FIG. 1 is a schematic perspective view showing an installation example of an air conditioner to which a refrigerant injecting method according to an embodiment of the present invention is applied and the concept of a method of estimating the pipe lengths and pipe diameters of refrigerant pipes.

FIG. 2 FIG. 2 is a conceptual diagram of a method of estimating the pipe length of a branch pipe of the air conditioner in each floor shown in FIG. 1.

FIG. 3 FIG. 3 is a flowchart of a determination procedure performed when the refrigerant injecting method according to the embodiment of the present invention is applied.

FIG. 4 FIG. 4 is a refrigerant circuit diagram of an air conditioner having an automatic refrigerant injection function that is applied to the refrigerant injecting method according to the embodiment of the present invention.

{Description of Embodiments}

[0020] Referring to FIGS. 1 to 4, an embodiment of the present invention will be described bellow.

FIG. 1 shows a schematic perspective view showing an installation example of an air conditioner to which a refrigerant injecting method according to an embodiment of the present invention is applied and the concept of a method of estimating

the pipe lengths and pipe diameters of refrigerant pipes.

A multi-type air conditioner 1 for a building, serving as an air conditioner 1 of this embodiment, is shown. This air conditioner 1 is configured such that three indoor units 11 to 13 and three indoor units 14 to 16, which are installed on the ceilings on a first floor and a second floor, respectively, are connected to one outdoor unit 10 installed on a roof of a building (structure) 40 via refrigerant pipes (gas-side pipes and liquid-side pipes) 2, forming a single closed-cycle refrigerant circuit 3.

[0021] The specifications (the gas-side pipe diameter (mm), the liquid-side pipe diameter (mm), and their pipe length (m)) of the refrigerant pipes (crossover pipes) 2 constituting this refrigerant circuit 3 are as follows: For example, as shown in FIG. 1, a horizontal pipe 2A extending horizontally from the outdoor unit 10, installed on the roof of the building 40 or the like, along the roof has a gas-side pipe diameter of 28.58 mm, a liquid-side pipe diameter of 12.7 mm, and a pipe length of 10 m; a vertical pipe 2B extending from the horizontal pipe 2A to a ceiling on the second floor in the height direction of the building 40 has a gas-side pipe diameter of 28.58 mm, a liquid-side pipe diameter of 12.7 mm, and a pipe length of 20 m; a branch pipe 2C branched off from the vertical pipe 2B toward the indoor units 11 to 13 installed on the ceiling on the second floor has a gas-side pipe diameter of 19.05 mm, a liquid-side pipe diameter of 9.52 mm, and a pipe length of 2 m; a branch pipe 2D extending from the branch pipe 2C has a gas-side pipe diameter of 15.88 mm, a liquid-side pipe diameter of 9.52 mm, and a pipe length of 4 m; a branch pipe 2E extending from the tip of the branch pipe 2C to the indoor unit 13 has a gas-side pipe diameter of 12.7 mm, a liquid-side pipe diameter of 6.35 mm, and a pipe length of 2 m; a branch pipe 2F extending from the tip of the branch pipe 2D to the indoor unit 12 has a gas-side pipe diameter of 12.7 mm, a liquid-side pipe diameter of 6.35 mm, and a pipe length of 2 m; and a branch pipe 2G extending from the tip of the branch pipe 2D to the indoor unit 11 has a gas-side pipe diameter of 12.7 mm, a liquid-side pipe diameter of 6.35 mm, and a pipe length of 8 m.

[0022] Furthermore, a vertical pipe 2H extending from the vertical pipe 2B to a ceiling on the first floor in the weight direction of the building 40 has a gas-side pipe diameter of 19.05 mm, a liquid-side pipe diameter of 9.52 mm, and a pipe length of 4 m; and branch pipes 2I, 2J, 2K, 2L, and 2M, which are installed on the ceiling on the first floor and branched toward the indoor units 14 to 16, are configured as follows, similarly to the branch pipes 2C, 2D, 2E, 2F, and 2G, respectively: the branch pipe 2I has a gas-side pipe diameter of 19.05 mm, a liquid-side pipe diameter of 9.52 mm, and a pipe length of 2 m; the branch pipe 2J has a gas-side pipe diameter of 15.88 mm, a liquid-side pipe diameter of 9.52 mm, and a pipe length of 4 m; the branch pipe 2K has a gas-side pipe diameter of 12.7 mm, a liquid-side pipe diameter of 6.35 mm, and a pipe length of 2 m; the branch pipe 2L has a gas-side pipe diameter of 12.7 mm, a liquid-side pipe diameter of 6.35 mm, and a pipe length of 2 m; and the branch pipe 2M has a gas-side pipe diameter of 12.7 mm, a liquid-side pipe diameter of 6.35 mm, and a pipe length of 8 m.

[0023] In the case of the air conditioner 1, basically, the amount of refrigerant corresponding to the refrigerant pipes (crossover pipes) 2, which should be additionally injected, needs to be calculated on the basis of the pipe specifications (pipe diameters and pipe lengths) of the refrigerant pipes 2 (the refrigerant pipes 2 as used herein mean the liquid-side pipes that determine the amount of refrigerant to be added). In this air conditioner 1, the lengths of the liquid-side pipes corresponding to the respective pipe diameters are as follows:

the length of the liquid-side pipes having a diameter of 12.7 mm = the pipe 2A: 10 m + the pipe 2B: 20 m = 30 m;
the length of the liquid-side pipes having a diameter of 9.52 mm = the pipe 2C: 2 m + the pipe 2D: 4 m + the pipe 2H: 4 m + the pipe 2I: 2 m + the pipe 2J: 4 m = 16 m; and
the length of the liquid-side pipes having a diameter of 6.35 mm = the pipe 2E: 2 m + the pipe 2F: 2 m + the pipe 2G: 8 m + the pipe 2K: 2 m + the pipe 2L: 2 m + the pipe 2M: 8 m = 24 m.

[0024] Thus, the amount of refrigerant (kg) that should basically be additionally injected is calculated as follows:

the amount of refrigerant to be added = $0.12 \text{ kg} \times 30 \text{ m} + 0.059 \text{ kg} \times 16 \text{ m} + 0.022 \text{ kg} \times 24 \text{ m} = 5.072 \text{ kg}$

where the weights are exemplary amounts of refrigerant to be added per 1 m length for the respective pipe diameters. Note that the amounts of refrigerant to be added per 1 m length for the respective pipe diameters are just exemplary, and they slightly vary depending on the manufacturer.

[0025] sometimes the air conditioner 1 is renewed by replacing the outdoor unit 10 and the indoor units 11 to 16 with new models and reusing the existing refrigerant pipes (crossover pipes) 2. In such cases, the pipe specifications are often completely unknown because the data storing the pipe specifications of the refrigerant pipes (crossover pipes) 2 are lost. Many air conditioners 1 today have an automatic refrigerant injection function, and the refrigerant is supposed to be additionally injected by automatic injection. However, if the amount of refrigerant corresponding to the crossover pipes, which should basically be injected, is injected from the beginning, a disadvantage occurs in that it takes a very long time to inject refrigerant because the injecting speed achieved by the automatic refrigerant injection function is slow.

[0026] Hence, in this embodiment, refrigerant is additionally injected according to the procedure below.

First, as shown in FIG. 3, in step S1, it is determined whether or not a piping diagram or the pipe size, pipe length, etc. of the installation site has been acquired. If YES, the procedure proceeds to step S2, and if NO, the procedure proceeds to step S3. In step S3, it is determined whether or not a piping diagram or the pipe size, pipe length, etc. of the installation site can be immediately acquired. If YES, the procedure proceeds to step S4, and if NO, the procedure proceeds to step S5.

[0027] Steps S2 and S4 (after acquisition of the diagram) are intended for the people who can perfectly estimate the pipe size, length, etc.; the amount of refrigerant to be additionally injected is calculated on the basis thereof, and the specified amount of refrigerant is additionally charged (injected). On the other hand, step S5 is intended for people who have not yet determined or cannot determine the pipe size, length, etc.; the pipe size, pipe length, and the like are estimated using the method described below, the minimum required refrigerant amount is calculated on the basis thereof, and the resulting amount of refrigerant is additionally charged. When the minimum required amount of refrigerant is injected in step S5, the procedure proceeds to step S6, where an automatic operation is performed to additionally inject the refrigerant until the specified amount is reached, using the automatic refrigerant injection function of the air conditioner 1 described below.

[0028] After the specified amount of refrigerant corresponding to the capacity of the refrigerant pipes (crossover pipes) 2 is additionally injected in step S2, S4, and S6, cooling and heating operation and various other test operations are performed in step S7. Once it is confirmed that there are no abnormalities by going through the test operations, the installation construction and work are completed, and then the procedure proceeds to step S8, where the system is delivered to the client.

[0029] Here, a method for calculating the minimum required refrigerant amount when the specifications, such as the pipe diameter and pipe length, of the refrigerant pipes (crossover pipes) 2 are unknown will be described below with reference to FIGS. 1 and 2.

(1) Estimation regarding the horizontal pipe 2A connected to the outdoor unit 10

[0030] Concerning the pipe diameter of the horizontal pipe 2A, the diameter of the horizontal pipe 2A, serving as the main pipe, can be confirmed from the model of the existing air conditioner or by measuring the pipe. Note that the measurement of the pipe may be performed by measuring the pipe closest to the existing outdoor unit 10. Furthermore, the pipe length may be confirmed by measuring or estimating the distance between the installation position of the outdoor unit 10 and the position of the vertical pipe 2B that extends in the height direction of the building 40. Note that the estimated length is estimated as a straight-line distance because it should be the minimum length over which the pipe actually exists (this is the same in the following descriptions).

(2) Estimation regarding the vertical pipe 2B extending from the horizontal pipe 2A in the height direction of the building 40

[0031] This vertical pipe 2B is the main pipe, similar to the horizontal pipe 2A, and, similarly to the horizontal pipe 2A, the diameter thereof can be confirmed from the model of the existing air conditioner or by measuring the pipe. Furthermore, the pipe length may be confirmed by measuring or estimating the vertical pipe length up to the position of the first branched portion, that is, the position of the ceiling on the second floors. Note that the estimated length may be estimated by multiplying the height of one floor of the building 40 (measured or visually determined) by the number of stories (measured). For example, if the height of one floor is 3 m and the number of stories is three, the estimated length is $3 \text{ m} \times 3 = 9 \text{ m}$.

(3) Estimation regarding the branch pipes 2C to 2M on the respective floors

[0032] These branch pipes 2C to 2M are often installed inside the ceilings, and it is difficult to actually confirm the pipe paths. Hence, to estimate the actually existing minimum pipe length, as shown in FIG. 2, confirmation is performed by measuring or estimating the straight-line distances between the positions of the vertical pipes 2B and 2H and the indoor units 11 and 14 located farthest therefrom on the respective floors. Furthermore, the pipe diameters may be confirmed from the model of the existing indoor units 11 to 16 or by measuring the pipe diameters closest thereto.

[0033] Then, the minimum required refrigerant amount can be calculated on the basis of the pipe lengths and pipe diameters confirmed by (1), (2), and (3) above. The minimum required refrigerant amount in the example shown in FIG. 1 is calculated as follows.

Amount of refrigerant for the horizontal pipe 2A having a diameter of 12.7 mm = $10 \text{ m} \times 0.12 = 1.2 \text{ kg}$

Amount of refrigerant for the vertical pipe 2B having a diameter of 12.7 mm = $20 \text{ m} \times 0.12 = 2.4 \text{ kg}$

Amount of refrigerant for the branch pipes 2C to 2M in the respective floor, having a diameter of 6.35 mm = $12 \text{ m (measurement valve)} \times 2 \text{ (number of stories)} \times 0.022 = 0.528 \text{ kg}$

Thus, the calculated minimum required refrigerant amount is $1.2 + 2.4 + 0.528 = 4.128 \text{ kg}$.

[0034] Although the vertical pipe 2H is excluded from the calculation of the refrigerant amount in the above-described

example because the estimation of the pipe diameter is difficult, the vertical pipe 2H may of course be included in the calculation of the minimum required refrigerant amount by assuming the pipe length to be the height of one floor and by assuming the pipe diameter to be 6.35 mm, which is equivalent to the pipe diameter of the narrowest branch pipe.

[0035] As has been described, the amount of refrigerant that should basically be additionally injected in the air conditioner 1, which is the amount corresponding to the refrigerant pipes (crossover pipes) 2A to 2M illustrated in bold solid lines in FIG. 1, is 5.072 kg. On the other hand, even if the pipe specifications are unknown, by identifying the refrigerant pipes that can be reliably measured or estimated, as illustrated in bold dashed lines FIG. 1, and by roughly calculating the minimum required refrigerant amount on the basis of the pipe specifications, 4.128 kg of that refrigerant can be additionally injected into the refrigerant, circuit 3 in advance, before the automatic injection. This minimum required refrigerant amount exceeds 80% of the amount of refrigerant that should basically be additionally injected, and thus, the amount of refrigerant to be automatically injected is the remaining amount of just less than 20%.

[0036] Meanwhile, automatic refrigerant injection is performed in the following way, as an example.

FIG. 4 shows a refrigerant, circuit diagram of the air conditioner 1 having the automatic refrigerant injection function.

This air conditioner 1 is a multi-type air conditioner 1 in which a plurality of indoor units 11 to 16 (only the indoor unit 11 is illustrated) are connected to the outdoor unit 10 via the refrigerant pipe (the gas-side pipe and the liquid-side pipe) 2. The outdoor unit 10 is configured to include a compressor 20, a four-way switching valve 21, an outdoor heat exchanger 22, an outdoor expansion valve 23, a receiver 24, an outdoor fan 25, a refrigerant detecting circuit 28 having decompression means 26 and a solenoid valve 27 connected between a certain height position in the receiver 24 and an intake pipe of the compressor 20, and injected-refrigerant-amount detecting means 30 that detects whether the specified amount of refrigerant has been injected, on the basis of the detection value of a temperature sensor 29 provided on the downstream side of the solenoid valve 27 of the refrigerant detecting circuit 28.

[0037] The indoor unit 11 (and also the indoor units 12 to 16) is configured to include an indoor heat exchanger 31, an indoor expansion valve 32, and an indoor fan 33, and is configured to form a closed-cycle refrigerant, circuit 3 by connecting a plurality of indoor units in parallel to the outdoor unit 10 via the refrigerant pipes 2, branching devices (not shown), and the like.

[0038] The automatic injection of refrigerant into the air conditioner 1 is performed by the air conditioner 1 operating in a cooling cycle, while taking in the refrigerant from a refrigerant cylinder connected to the refrigerant circuit 3 at the intake side of the compressor 20. The refrigerant additionally injected by this refrigerant injection operation is gradually accumulated in the receiver 24, and the liquid level rises. Until the liquid level of the refrigerant in the receiver 24 reaches the position of an open end of the refrigerant detecting circuit 28, saturated gas refrigerant is taken out into the refrigerant detecting circuit 28, and the temperature of the refrigerant after having been decompressed in the decompression means 26 is detected by the temperature sensor 29. On the other hand, when the liquid level of the refrigerant has reached the position of the open end of the refrigerant detecting circuit 28, saturated liquid refrigerant is taken out, and the temperature of the refrigerant after having been decompressed in the decompression means 26 is detected by the temperature sensor 29.

[0039] From the temperature difference between the thus-detected temperature of the refrigerant when decompressed from the saturated gas state and the temperature of the refrigerant when decompressed from the saturated liquid state, the injected-refrigerant-amount detecting means 30 detects that the refrigerant has been accumulated in the receiver 24 to a preset liquid level, and thus, it can be detected that the specified amount of refrigerant has been injected into the refrigerant circuit 3. Accordingly, by additionally injecting, in advance, about 80% of the specified amount of refrigerant that should be additionally injected, which serves as the minimum required amount of refrigerant, and by automatically injecting the remaining about 20% of the refrigerant using the above-described method, the specified amount of refrigerant can be precisely and quickly injected.

[0040] This embodiment provides the following advantages.

Even if the specifications (pipe length and pipe diameter) of the pipes 2A to 2M connecting, the outdoor unit 10 and the plurality of indoor units 11 to 16 installed on the respective floors of the building 40 are unknown, by identifying the pipe lengths and pipe diameters thereof insofar as they can be reliably measured or estimated, the minimum required refrigerant amount can be calculated on the basis thereof, the resulting amount of refrigerant can be additionally injected in advance, and the refrigerant, can be automatically injected by the automatic refrigerant injection function until the specified amount is reached. Thus, the specified amount of refrigerant, i.e., the amount that eventually needs to be injected, can be correctly injected without any excess or shortfall. As a result, an optimum amount of refrigerant can be precisely injected, and the air conditioner can be stably operated. Furthermore, because the need for automatically injecting, from the beginning, the amount of refrigerant that should basically be additionally injected is eliminated, it is possible to reduce the time for injecting refrigerant, to reduce the time for installation work, and to simplify the installation work.

[0041] Moreover, the minimum required refrigerant amount is calculated on the basis of the pipe length and pipe diameter of the horizontal pipe 2A, which extends from the installation position of the outdoor unit 10 to the position of the vertical pipes 2B and 2H extending along the floors of the building 40; the pipe lengths and pipe diameters of the vertical pipes 2B and 2H, extending to the branched portions of the refrigerant pipes 2 on the respective floors of the

building 40; and the lengths and pipe diameters of the branch pipes connecting, by straight lines, the positions of the vertical pipes on the respective floors and the indoor units 11 and 14, which are located farthest therefrom among the plurality of indoor units 11 to 16 installed on the respective floors. Therefore, even if the detailed specifications of the refrigerant pipes 2 connecting the outdoor unit 10 and the plurality of indoor units 11 to 16 installed on the respective floors of the building 40 are unknown, the refrigerant can be additionally injected in advance by calculating the minimum required refrigerant amount not exceeding the refrigerant amount that should basically be additionally injected on the basis of the pipe lengths and pipe diameters that can be reliably measured or estimated. Although a rough estimation, this minimum required refrigerant amount corresponds to about 80% of the amount of refrigerant that should basically be additionally injected, leading to a significant reduction in the refrigerant injection time.

[0042] More specifically, the length and diameter of the horizontal pipe (main pipe) 2A connected to the outdoor unit 10 can be reliably measured, and the length and pipe diameter of the vertical pipe 2B, which extends along the floors of the building 40, to the position of the first branched portion can be estimated from the height of the building 40 and the diameter of the horizontal pipe 2A, even if the actual pipe lengths is unknown or cannot be measured. Moreover, the lengths and diameters of the branch pipes 2C to 2M connected to the plurality of indoor units 11 to 16 disposed on the respective floors can be estimated from the straight-line distances between the positions of the vertical pipes 2B and 2H on the respective floors and the indoor units 11 and 14 located farthest therefrom and from the branch pipe diameters, even if the actual pipe lengths are unknown or cannot be measured. Accordingly, by calculating the refrigerant amount on the basis of the pipe lengths and pipe diameters, the minimum required refrigerant amount to an extent not exceeding the regular refrigerant amount that should basically be additionally injected, i.e., about 80%, can be reliably calculated.

[0043] Furthermore, the amount of refrigerant is calculated by assuming the pipe diameter of the horizontal pipe 2A and the pipe diameter of the vertical pipe to the position of the first branched portion to be the diameters determined from the model of the outdoor unit 10 or from the measurement value of the refrigerant pipe closest thereto, and moreover, the amount of refrigerant is calculated by assuming the pipe diameters of the branch pipes 2C to 2M and/or the pipe diameter of the vertical pipe 2H to be the diameters determined from the model of the indoor units located farthest from the vertical pipes 2B and 2H or from the measurement values of the refrigerant pipes closest thereto. Therefore, even if the pipe diameters of the pipes are unknown, the pipe diameters can be reliably estimated. As a result, the minimum required refrigerant amount closer to the specified refrigerant amount can be precisely calculated.

[0044] Moreover, even if the detailed specifications of the existing pipes 2A to 2M are unknown when the air conditioner 1 is renewed by replacing the outdoor unit 10 and the indoor units 11 to 16 of the existing air conditioner 1 and connecting the replaced outdoor unit 10 and the indoor units 11 to 16 using the existing refrigerant pipes 2, by identifying the pipe lengths and pipe diameters insofar as they can be correctly measured or estimated and by calculating the minimum required refrigerant amount on the basis thereof, it is possible to inject the resulting amount of refrigerant in advance and then automatically inject the specified amount of refrigerant using the automatic refrigerant injection function of the air conditioner 1. Accordingly, the specified amount of refrigerant can be reliably and quickly injected, without any excess or shortfall, into the air conditioner 1 which is renewed by reusing the existing refrigerant pipes 2.

[0045] Note that the present invention is not limited to the invention according to the above-described embodiment, and it may be appropriately modified within a scope not departing from the spirit thereof. For example, although an example in which the outdoor unit 10 is installed on the roof of the building 40 has been described in the above-described embodiment, the outdoor unit 10 may be installed on the ground or the like, and the installation site is not limited. The pipe lengths and pipe diameters of the refrigerant pipes can be estimated in the same way no matter where they are installed. Furthermore, the number of indoor units 11 to 16 connected is not specifically limited.

[0046] Furthermore, although an example in which automatic refrigerant injection is performed by using a method in which the refrigerant liquid level in the receiver 24 is detected by the refrigerant detecting circuit 28 has been described in the above-described embodiment, it is of course not limited thereto, and any method may be employed as long as automatic injection is performed by checking the operating conditions of the air conditioner 1 and detecting that the specified amount of refrigerant has been injected. Furthermore, although an example of a case where the air conditioner 1 is renewed has been described in the above-described embodiment, the present invention may of course be applied to the case where a new air conditioner 1 is installed.

Reference Signs List

[0047]

1:	air conditioner
2:	refrigerant pipe
2A:	horizontal pipe
2B,	2H: vertical pipe

2C, 2D, 2E, 2F, 2G, 2I, 2J, 2K, 2L, 2M:	branch pipe
3:	refrigerant circuit
10:	outdoor unit
11, 12, 13, 14, 15, 16:	indoor unit
28:	refrigerant detecting circuit
30:	injected-refrigerant-amount detecting means
40:	building (structure)

Claims

1. An air-conditioner refrigerant, injecting method of injecting, a specified amount of refrigerant into a closed-cycle refrigerant circuit in which an outdoor unit and a plurality of indoor units are connected via refrigerant pipes, wherein the pipe lengths and pipe diameters of the refrigerant pipes connecting the outdoor unit and the plurality of indoor units installed on the respective floors of a structure are identified insofar as they can be reliably measured or estimated, the minimum required refrigerant amount required by the air conditioner is calculated on the basis of the pipe lengths and the pipe diameters, the resulting amount of refrigerant is additionally injected in advance, and then the refrigerant is automatically injected by an automatic refrigerant injection function until a specified injection amount is reached.
2. The air-conditioner refrigerant injecting method according to Claim 1, wherein the minimum required refrigerant amount is calculated on the basis of, at least, the horizontal pipe length and pipe diameter of the refrigerant pipe extending from the installation position of the outdoor unit to the position of a vertical pipe extending along the floors of the structure, the vertical pipe lengths and pipe diameters of the refrigerant pipe to the positions of branched portions on the respective floors of the structure, and the lengths and pipe diameters of branch pipes connecting, in straight lines, the positions of the vertical pipe on the respective floors and the indoor units located farthest therefrom among the plurality of indoor units.
3. The air-conditioner refrigerant injecting method according to Claim 2, wherein the amount of refrigerant is calculated by assuming the pipe diameter of the horizontal pipe and the pipe diameter of the vertical pipe to the position of the first branched portion to be the diameters determined from the model of the outdoor unit or from the measurement value of the refrigerant pipe closest thereto.
4. The air-conditioner refrigerant injecting method according to Claim 2 or 3, wherein the amount of refrigerant is calculated by assuming the pipe diameters of the branch pipes and/or the pipe diameter of the vertical pipe beyond the first branched portion to be the diameters determined from the models of the indoor units located farthest from the vertical pipe or from the measurement values of the refrigerant pipes closest thereto.
5. An air-conditioner refrigerant injecting method, wherein refrigerant is injected by using the method according to any one of Claims 1 to 4 when renewing the air conditioner by replacing the outdoor unit and indoor units of the existing air conditioner and by connecting the replaced outdoor unit and indoor units with the existing refrigerant pipes.

FIG. 1

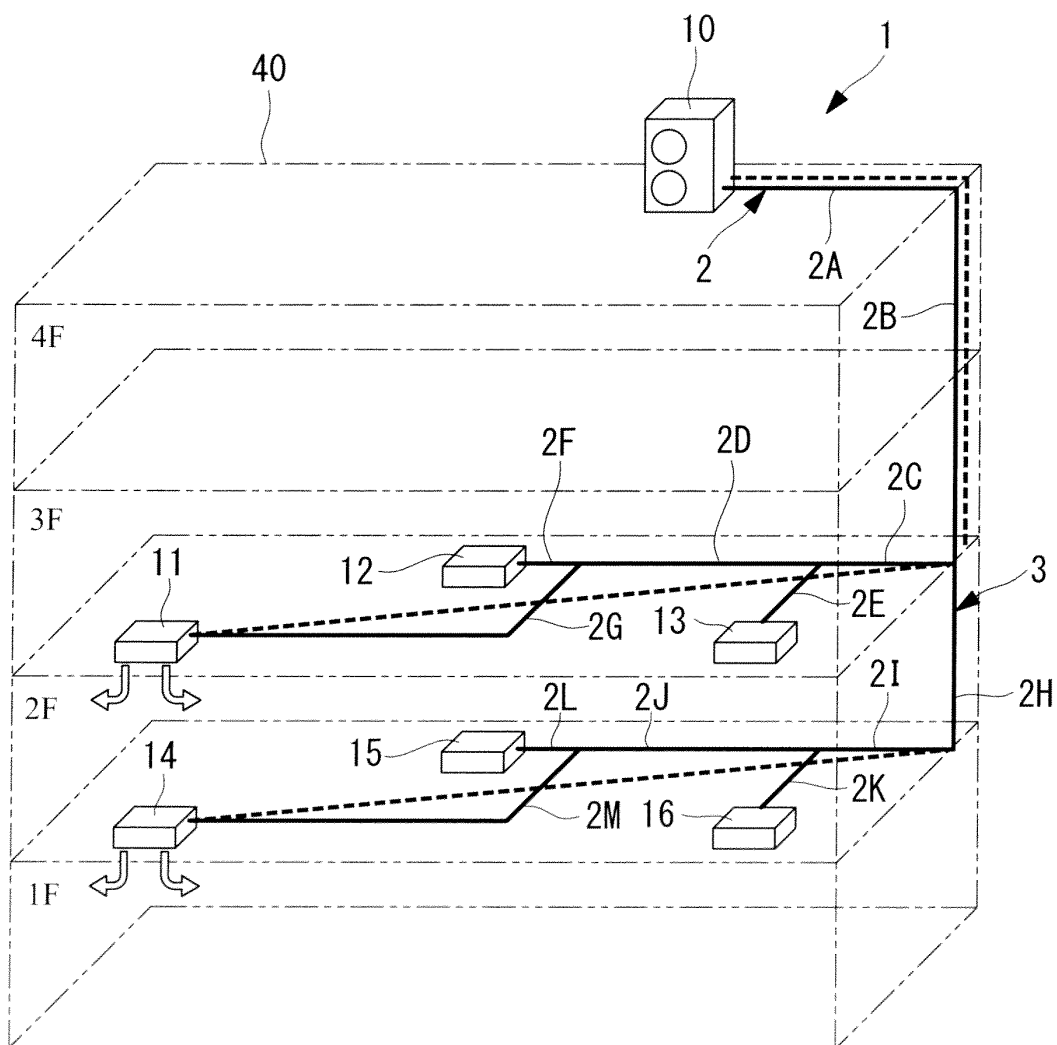
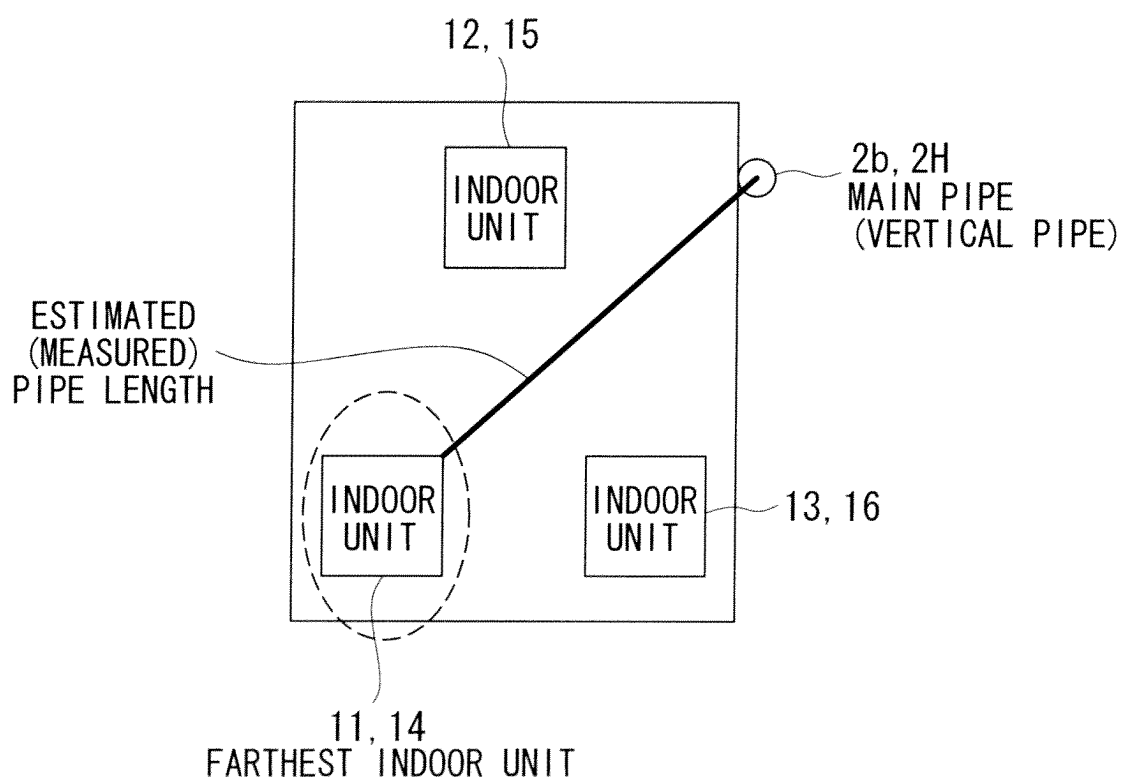


FIG. 2



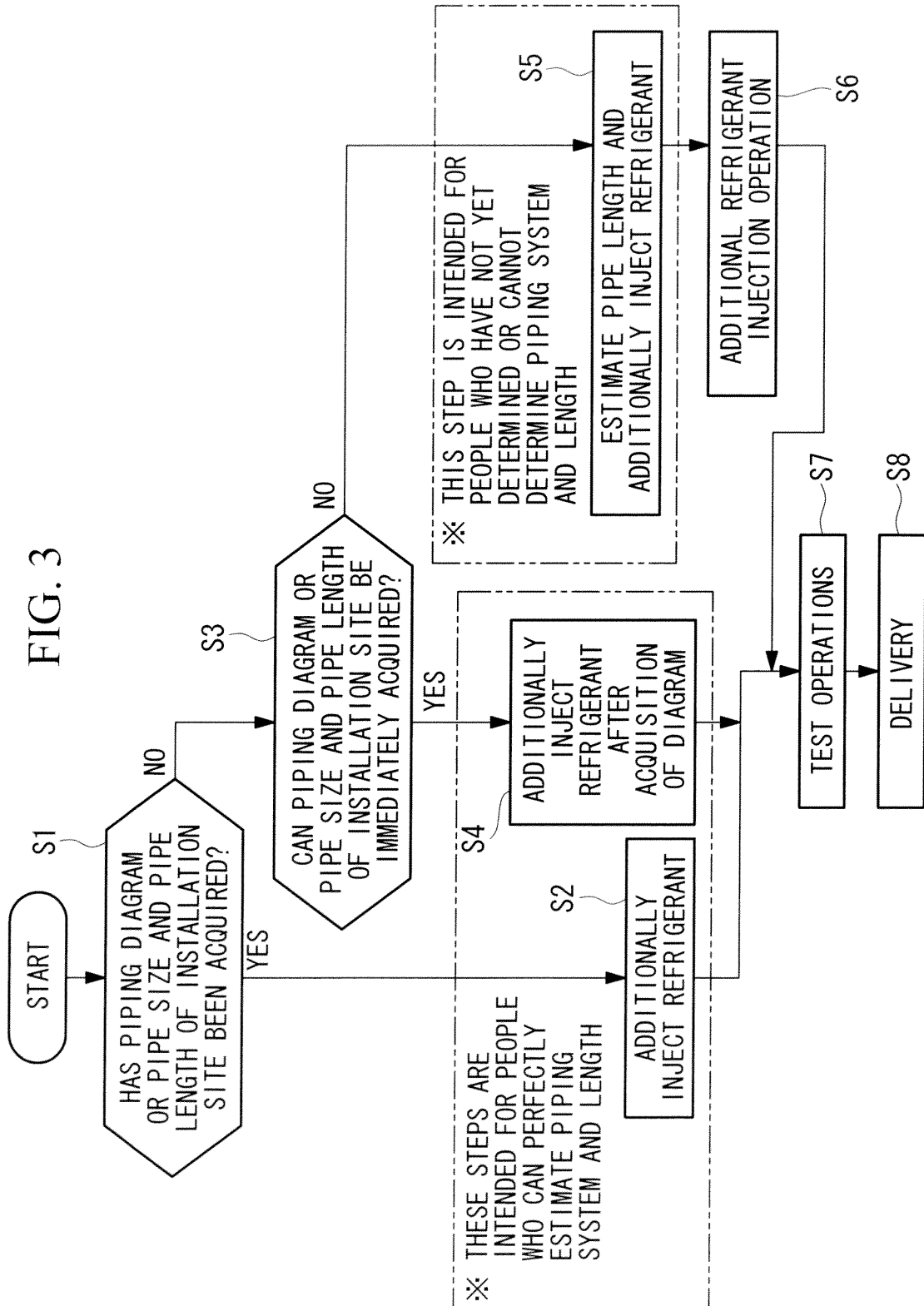
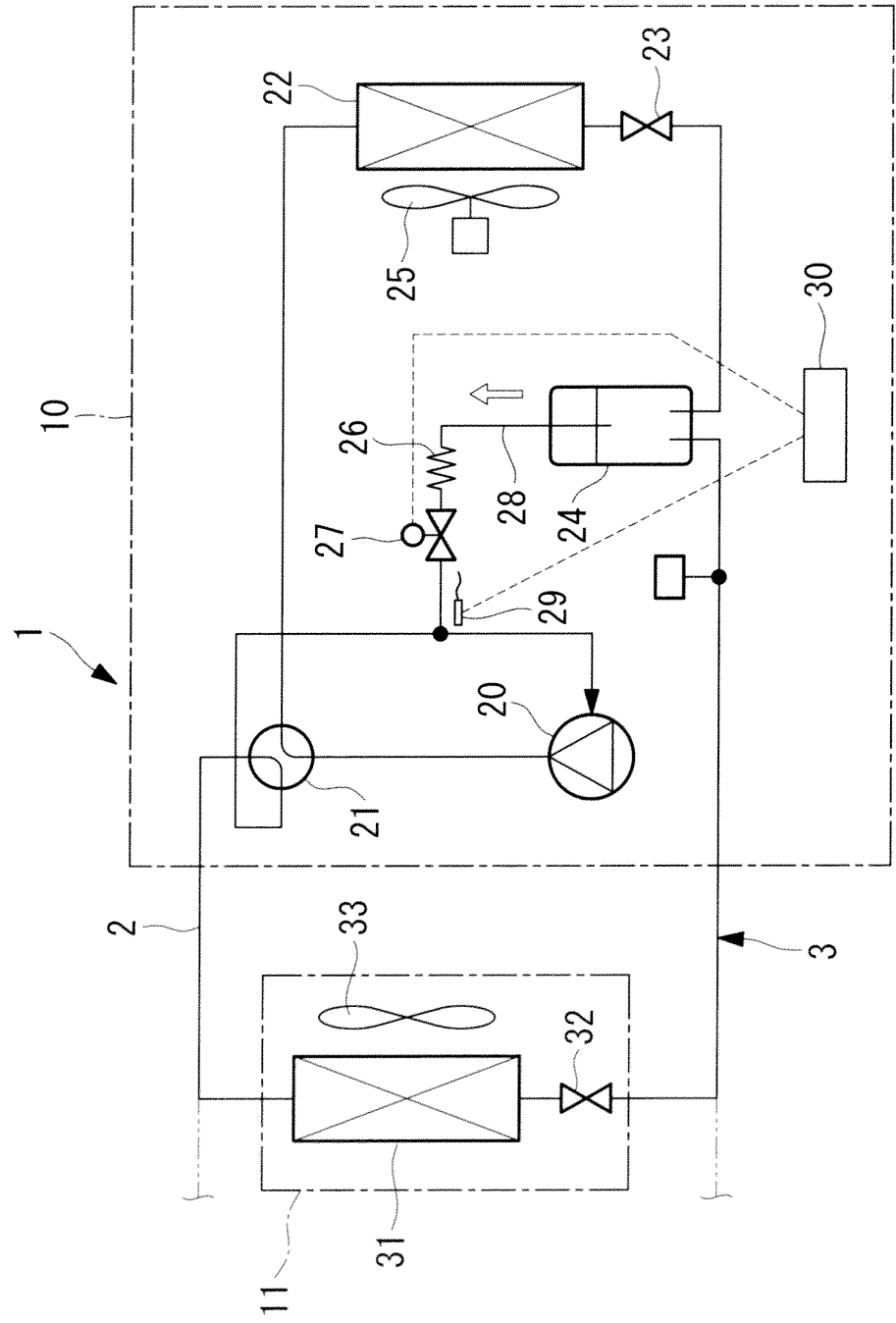


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/059061

A. CLASSIFICATION OF SUBJECT MATTER

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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)

F25B45/00, F25B49/02

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 8-21675 A (Hitachi, Ltd.), 23 January 1996 (23.01.1996), paragraphs [0020], [0021] (Family: none)	1-5
Y	JP 8-200905 A (Hitachi, Ltd.), 09 August 1996 (09.08.1996), paragraphs [0021] to [0032] (Family: none)	1-5
Y	JP 11-63745 A (Hitachi, Ltd.), 05 March 1999 (05.03.1999), paragraphs [0021] to [0023] (Family: none)	1-5

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

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Date of the actual completion of the international search
09 May, 2011 (09.05.11)Date of mailing of the international search report
24 May, 2011 (24.05.11)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/059061

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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REFERENCES CITED IN THE DESCRIPTION

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