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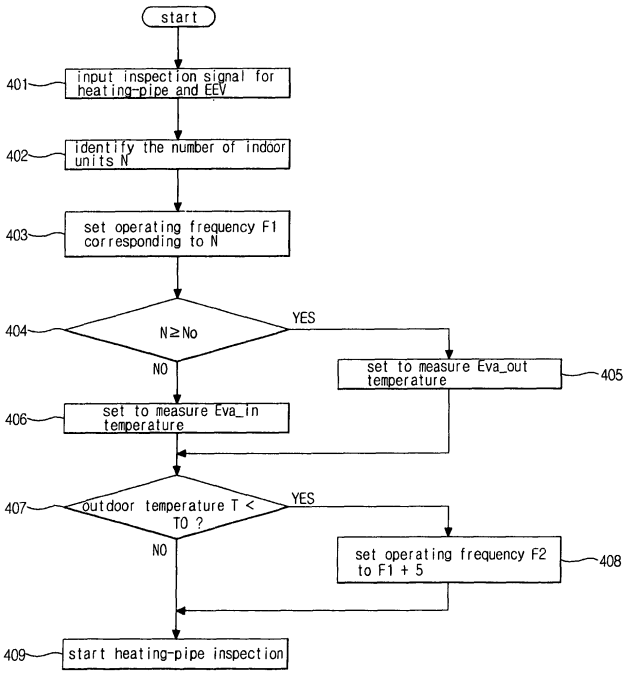
(54) Pipe inspection method and pipe-inspection operation method of multi-air conditioner

(57) Disclosed herein are a pipe-inspection operation method and a pipe inspection method of a multi-air conditioner system, wherein an operating frequency of a compressor and a temperature-sensing reference location are altered according to the number of indoor units connected to an outdoor unit to inspect pipes and expansion valves. The pipe-inspection operation method operates the multi-air conditioner system including an outdoor unit and a plurality of indoor units (16) such that an operating frequency of a compressor (11) of the outdoor unit and a temperature-sensing reference location (17,18) of each of the indoor units (16) are altered according to the number of the indoor units connected to the outdoor unit to inspect pipes and expansion valves accurately and easily.

FIG. 4



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Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Patent Application No. 2005-72031, filed on Aug. 08, 2005 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to pipe inspection of a multi-air conditioner system, and more particularly, to a pipe-inspection operation method and a pipe inspection method of a multi-air conditioner system wherein the operating frequency of a compressor and a temperature-sensing reference location are altered according to the number of indoor units connected to an outdoor unit to inspect pipes and expansion valves.

2. Description of the Related Art

[0003] In general, a multi-air conditioner system is an air conditioning system which comprises an outdoor unit and a plurality of indoor units connected to the outdoor unit. Recently, the multi-air conditioner system is mainly installed in a building or a plurality of rooms to cool or heat air therein. In this multi-air conditioner system, a connection configuration of pipes between the plurality of indoor units and the outdoor unit is more complicated than that of a single-type air conditioner. In addition, a controller of the outdoor unit or a separate integrated controller needs to match a pipe to an address of each indoor unit connected with the pipe to control the indoor units.

[0004] This pipe-to-indoor unit matching may be performed through identifying an address assigned to each indoor unit and manually inputting the address to the controller of the outdoor unit. However, this manual input approach is currently rarely used because the number of installed indoor units has become large in recent years, and the address of each indoor unit is assigned through an internal communication line, thus the address thereof cannot be identified externally.

[0005] In recent years, for the pipe-to-indoor unit matching in the multi-air conditioner system, there have been developed various pipe inspection methods, in which valves of respective pipes are opened or closed during a cooling or other mode operation to check temperature changes of the indoor units, and then one of the indoor units exhibiting a significant temperature change is matched with the corresponding pipe.

[0006] FIG. 2 shows a time chart of a conventional pipe-inspection mode operation of a multi-air conditioner system. In a heating operation, as shown in FIG. 1, indoor heat exchangers 16a to 16d are adapted to serve as condensers and an outdoor heat exchanger 12 is adapted to serve as an evaporator. When a pipe inspection signal for heating is inputted, a fan of an outdoor unit and a 4-way valve thereof are initialized, the fan of the outdoor unit and fans of indoor units are activated, and a compressor 11 is operated at a predetermined frequency (40Hz). At this time, expansion valves 15a to 15d are fully open to set a reference point for valve opening control. That is, the valve opening degree of an expansion valve is controlled in 500 steps from a fully open position of the expansion valve to a fully closed position thereof, and the reference point is set corresponding to the fully open position. After the reference point for control of the valve opening is set, the multi-air conditioner system is activated to raise temperatures of the indoor units to a certain temperature. At this time, the expansion valves 15a to 15d are opened at a small valve opening degree (80-step) to rapidly raise the temperatures of the indoor units. This is because a temperature difference between before and after an expansion valve becomes larger with a smaller valve opening degree of the expansion valve. Afterwards, for pipe inspection, the expansion valves 15a to 15d are opened at a valve opening degree of 120 step, the multi-air conditioner system is operated for 5 minutes, and then temperatures of the respective indoor units are measured. One of the expansion valves 15a to 15d under inspection is fully closed, and the temperatures of the respective indoor units are measured again. If the expansion valve under inspection is closed, the temperature of an indoor unit connected with the expansion valve under inspection drops. This temperature change is utilized to inspect normality of a pipe and match the pipe to the address of an indoor unit. If there exists an indoor unit whose temperature difference between before and after the closure of the expansion valve under inspection is greater than or equal to a predetermined value and whose temperature is the lowest among those of the indoor units, the indoor unit is selected as one being connected with the expansion valve under inspection, and the above operations are repeated to continue pipe inspection by manipulating a next expansion valve. If there is no indoor unit whose temperature difference between before and after the closure of the expansion valve under inspection is greater than or equal to the predetermined value and whose temperature is the lowest among those of the indoor units, the expansion valve under inspection is determined to have malfunctioned and this result is registered, and the above operations are repeated to continue the pipe inspection.

[0007] However, in this conventional pipe inspection method, the compressor is operated at a constant operating frequency irrespective of the number of indoor units. Although cooling load is low if the number of indoor units is small, the compressor is operated at an excessive operating frequency, causing frequent occurrences of compressor trips where the compressor is forcibly stopped by the controller. These compressor trips may obstruct a smooth pipe inspection process.

SUMMARY OF THE INVENTION

[0008] Therefore, it is an aspect of the invention to provide a pipe-inspection operation method and a pipe inspection method of a multi-air conditioner system wherein an operating frequency of a compressor for pipe inspection is altered according to the number of indoor units connected to an outdoor unit to prevent a compressor trip, and a temperature-sensing reference location is changed according to the number of indoor units for accurate and rapid pipe inspection.

[0009] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0010] In accordance with an aspect of the invention, there is provided a pipe-inspection operation method of a multi-air conditioner system comprising: operating the multi-air conditioner system including an outdoor unit and a plurality of indoor units such that an operating frequency of a compressor of the outdoor unit and a temperature-sensing reference location of each of the indoor units are altered according to the number of the indoor units connected to the outdoor unit to inspect pipes and expansion valves.

[0011] The operating frequency of the compressor may become higher with increasing number of the indoor units connected to the outdoor unit.

[0012] The temperature-sensing reference location may be determined on the basis of a comparison result between the number of the indoor units connected to the outdoor unit and a preset reference number.

[0013] Preferably, the temperature-sensing reference location is an evaporator inlet if the number of the indoor units connected to the outdoor unit is greater than or equal to the preset reference number, and is an evaporator outlet if the number of the indoor units connected to the outdoor unit is less than the preset reference number.

[0014] The operating frequency of the compressor may be increased by a constant frequency if outdoor air temperature is lower than a preset temperature.

[0015] In accordance with another aspect of the invention, there is provided a pipe inspection method of a multi-air conditioner system comprising: inputting a pipe inspection signal; setting an operating frequency of a compressor according to the number of indoor units connected to an outdoor unit and determining a temperature-sensing reference location of each of the indoor units according to the number of the indoor units connected to the outdoor unit; operating the compressor at the set operating frequency and measuring temperatures at the determined temperature-sensing reference location; and inspecting pipes and expansion valves on the basis of the measured temperatures.

[0016] The operating frequency of the compressor may become higher with increasing number of the indoor units connected to the outdoor unit at the setting an operating frequency of a compressor.

[0017] The temperature-sensing reference location may be determined on the basis of a comparison result between the number of the indoor units connected to the outdoor unit and a preset reference number.

[0018] Preferably, the temperature-sensing reference location is an evaporator inlet if the number of the indoor units connected to the outdoor unit is greater than or equal to the preset reference number, and is an evaporator outlet if the number of the indoor units connected to the outdoor unit is less than the preset reference number.

[0019] The operating frequency of the compressor may be increased by a constant frequency if outdoor air temperature is lower than a preset temperature.

[0020] Preferably, the inspecting pipes includes: opening all of the expansion valves at a certain valve opening degree and operating the multi-air conditioner system; measuring a first temperature at the determined temperature-sensing reference location; closing one of the expansion valves under inspection and measuring a second temperature at the determined temperature-sensing reference location after a predetermined time from closure of the expansion valve under inspection; determining if there is one of the indoor units whose temperature difference between the first measured temperature and the second measured temperature is greater than or equal to a certain value and whose second temperature is the lowest among those of the indoor units; selecting, if there is an indoor unit satisfying the above two conditions, the indoor unit as an associated indoor unit with the expansion valve under inspection, or otherwise, registering the expansion valve under inspection as a defective expansion valve; and manipulating remaining expansion values through the above operations to inspect the pipes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a schematic diagram showing the configuration of a typical multi-air conditioner system;
FIG. 2 is a time chart illustrating a conventional pipe-inspection mode operation;
FIG. 3 is a time chart illustrating a pipe-inspection mode operation according to the present invention;
FIG. 4 is a flow chart illustrating a pipe-inspection operation method according to the present invention; and
FIG. 5 is a flow chart illustrating a pipe inspection method according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below to explain the present invention by referring to the figures.

[0023] FIG. 1 is a diagram showing the overall configuration of a typical multi-air conditioner system comprising an outdoor unit and a plurality of indoor units. The outdoor unit includes a compressor 11 to compress a coolant, a 4-way valve 14 to switch the flow of the coolant depending upon a cooling or heating operation, a condenser 12 to condense the compressed coolant, and an accumulator 13 to prevent a direct inflow of the liquid coolant to the compressor 11. Each of the indoor units includes one of expansion valves 15a to 15d to expand the condensed coolant into the coolant of low pressure and low temperature, and one of evaporators 16a to 16d to exchange heat with indoor air, and two ones of temperature sensors 17a to 17d and 18a to 18d provided at an inlet of the one of the evaporators 16a to 16d and an outlet thereof, respectively, to sense temperatures of the coolant.

[0024] A description will hereinafter be given of the operation of the multi-air conditioner system having the above-stated configuration. In a heating operation, the condenser 12 of the outdoor unit acts as an evaporator, and the evaporators 16a to 16d of the indoor units act as condensers. A high-temperature and high-pressure coolant compressed by the compressor 11 flows through the 4-way valve 14, without passing through the condenser 12, to the evaporators 16a to 16d of the respective indoor units acting as condensers. The coolant condensed through heat exchange with indoor air at the evaporators 16a to 16d is expanded through the expansion valves 15a to 15d into the low-temperature and low-pressure coolant, which flows to the condenser 12 of the outdoor unit acting as an evaporator. The coolant of low-temperature and low-pressure exchanges heat with outdoor air at the condenser 12 of the outdoor unit, and flows through the 4-way valve 14 to the accumulator 13, in which a liquid portion of the coolant is then filtered off and only a gaseous portion of the coolant flows to the compressor 11. The indoor air is heated via this heating cycle. In a cooling operation, the coolant flows in a direction opposite to the case of the heating operation described above. That is, the coolant flows from the compressor 11, through the condenser 12, the expansion valves 15a to 15d, and the evaporators 16a to 16d, and back to the compressor 11 in order, cooling the indoor air. An air conditioning system having both heating and cooling capabilities, as the case of FIG. 1, is sometimes termed a heat pump. In FIG. 1, the flow of the coolant in the heating operation is denoted by solid arrows, and that in the cooling operation is denoted by dotted arrows.

[0025] FIG. 3 is a time chart illustrating a pipe-inspection mode operation according to the present invention. In principle, the pipe-inspection mode operation is almost the same as the conventional one, and thus repeated description of the same parts as those of FIG. 2 is omitted. In the pipe-inspection mode operation according to the present invention, the number of the installed indoor units connected to the outdoor unit is identified and used for setting the operating frequency of the compressor 11. The following table is an example showing how the operating frequency of the compressor 11 is varied with the number of the installed indoor units.

number of installed indoor units	operating frequency of compressor and temperature-sensing reference location
1	18Hz, EVA_in
2	25, 30, 33Hz, EVA_in
3	35Hz, EVA_in
4	40Hz, EVA_out

It can be understood from the above table that the operating frequency of the compressor 11 becomes higher with increasing number of the installed indoor units. When the number of the installed indoor units is two, various operating frequencies of the compressor 11 are used. This indicates that the operating frequency of the compressor 11 can be varied according to cooling capacity demand such as an indoor area to be cooled. In addition, a temperature-sensing reference location is changed to distinctively identify a temperature difference between before and after closure of an expansion valve under inspection. That is, in the case of a small number of the installed indoor units, if the compressor 11 is operated at a low operating frequency, the coolant may be not sufficiently compressed to exhibit a meaningful temperature difference. This can cause an error in pipe inspection because the temperature difference between before

and after closure of the expansion valve under inspection is less than a predetermined temperature Tc. Thus, to obtain a temperature difference greater than or equal to the predetermined temperature Tc, the temperature-sensing reference location is EVA_in (evaporator inlet) if the operating frequency is low. In the above table, the temperature-sensing reference location is changed when the number of the installed indoor units is four. However, this value is changeable according to installation environments.

[0026] After the operating frequency of the compressor 11 and the temperature-sensing reference location are set according to the number of the installed indoor units, pipe inspection, as shown in FIG. 3, is started. In the present invention, compared to the conventional pipe inspection method, the time needed to inspect an expansion valve is increased from 3 minutes of the conventional case to 10 minutes to reduce errors in inspection of pipes and expansion valves and enhance accuracy therein. This is to prevent errors of the pipe inspection due to a failure of expansion valve inspection within a short time allocated thereto as the case of the conventional pipe inspection method. If inspection of a pipe is successful, a next pipe is immediately inspected, and thus the overall time needed for the pipe inspection is not increased.

[0027] FIG. 4 is a flow chart illustrating a pipe-inspection operation method according to the present invention. When an inspection signal for pipes and expansion valves (EEVs) is inputted through a controller (not shown) of an outdoor unit or an integrated controller (not shown) (S401), the number of indoor units N connected to the outdoor unit is identified (S402). After identification of the number of indoor units N, an operating frequency F_1 of a compressor is set on the basis of the identified number of indoor units N (S403). Next, if the number of the indoor units N connected to the outdoor unit is greater than or equal to a predetermined number No (S404), a temperature-sensing reference location is EVA_out (evaporator outlet) (S405), or otherwise, the temperature-sensing reference location is EVA_in (evaporator inlet) (S406). This is to obtain a meaningful temperature difference for pipe inspection, as described before, when the compressor is operated at a low operating frequency because of a small number of the installed indoor units. Next, outdoor temperature is measured. If the measured outdoor temperature is lower than or equal to a predetermined temperature T_0 (for example, 5°C) (S407), a constant frequency is added to the operating frequency to give a new operating frequency F_2 for smooth pipe inspection (S408). This is because a larger heating capacity is needed when the outdoor temperature is low. As described above, after the operating frequency of the compressor and the temperature-sensing reference location are determined according to the number of the installed indoor units connected to the outdoor unit, the pipe inspection operation begins (S409).

[0028] FIG. 5 is a flow chart illustrating a pipe inspection method according to the present invention. The operating frequency of the compressor and the temperature-sensing reference location are determined as shown in FIG. 4 (S501), the fan of the outdoor unit and the like are initialized (S502), and then the multi-air conditioner system is operated according to a time chart as shown in FIG. 3 (S503). The expansion valves (EEVs) are opened at a certain valve opening degree for a predetermined time (7 minutes in FIG. 3) to raise the temperature of the pipes. To inspect the pipes and the EEVs, an EEV under inspection is fully closed (S504). It is determined if there is an indoor unit whose temperature difference between a first temperature T1 before and a second temperature T2 after the closure of the EEV under inspection is greater than or equal to Tc°C (S505) and whose second temperature T2 is the lowest among those of the indoor units (S506). Satisfaction of these two conditions is tested to increase accuracy of a pipe inspection result. If there is an indoor unit satisfying both the conditions, the indoor unit is selected as one being connected with the EEV under inspection. Then, the EEV under inspection is opened to the certain valve opening degree, that before the full closure thereof (S508), and after a predetermined time, a next EEV under inspection is fully closed to start inspection of the next EEV. If there is no indoor unit satisfying both the conditions, the EEV under inspection is registered as a badly connected EEV (S507), and inspection of a next EEV is started. At this time, an indoor unit which has been matched with an associated EEV is naturally excluded from the subsequent inspection operations. If all the EEVs are inspected (S509), a list of defective EEVs disconnecting pipes is displayed to the user (S510), and the pipe inspection process is completed.

[0029] As apparent from the above description, the present invention provides a pipe-inspection operation method and a pipe inspection method of a multi-air conditioner system wherein an operating frequency of a compressor and a temperature-sensing reference location are altered according to the number of indoor units connected to an outdoor unit to prevent a compressor trip which can occur during the pipe inspection and make the pipe inspection more accurate and easier.

[0030] Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

Claims

1. A pipe-inspection operation method of a multi-air conditioner system, comprising:

operating the multi-air conditioner system including an outdoor unit and a plurality of indoor units such that an operating frequency of a compressor of the outdoor unit and a temperature-sensing reference location of each of the indoor units are altered according to the number of the indoor units connected to the outdoor unit to inspect pipes and expansion valves.

2. The pipe-inspection operation method as set forth in claim 1, wherein the operating frequency of the compressor becomes higher with increasing number of the indoor units connected to the outdoor unit.

3. The pipe-inspection operation method as set forth in claim 2, wherein the temperature-sensing reference location is determined on the basis of a comparison result between the number of the indoor units connected to the outdoor unit and a preset reference number.

4. The pipe-inspection operation method as set forth in claim 3, wherein the temperature-sensing reference location is an evaporator inlet if the number of the indoor units connected to the outdoor unit is greater than or equal to the preset reference number, and is an evaporator outlet if the number of the indoor units connected to the outdoor unit is less than the preset reference number.

5. The pipe-inspection operation method as set forth in claim 2, wherein the operating frequency of the compressor is increased by a constant frequency if outdoor air temperature is lower than a preset temperature.

6. A pipe inspection method of a multi-air conditioner system, comprising:

inputting a pipe inspection signal;
setting an operating frequency of a compressor according to the number of indoor units connected to an outdoor unit and determining a temperature-sensing reference location of each of the indoor units according to the number of the indoor units connected to the outdoor unit;
operating the compressor at the set operating frequency and measuring temperatures at the determined temperature-sensing reference location; and
inspecting pipes and expansion valves on the basis of the measured temperatures.

7. The pipe inspection method as set forth in claim 6, wherein the operating frequency of the compressor becomes higher with increasing number of the indoor units connected to the outdoor unit at the setting an operating frequency of a compressor.

8. The pipe inspection method as set forth in claim 7, wherein the temperature-sensing reference location is determined on the basis of a comparison result between the number of the indoor units connected to the outdoor unit and a preset reference number.

9. The pipe inspection method as set forth in claim 8, wherein the temperature-sensing reference location is an evaporator inlet if the number of the indoor units connected to the outdoor unit is greater than or equal to the preset reference number, and is an evaporator outlet if the number of the indoor units connected to the outdoor unit is less than the preset reference number.

10. The pipe inspection method as set forth in claim 7, wherein the operating frequency of the compressor is increased by a constant frequency if outdoor air temperature is lower than a preset temperature.

11. The pipe inspection method as set forth in claim 6, wherein the inspecting pipes includes:

opening all of the expansion valves to a certain valve opening degree and operating the multi-air conditioner system;
measuring a first temperature at the determined temperature-sensing reference location;
closing one of the expansion valves under inspection and measuring a second temperature at the determined temperature-sensing reference location after a predetermined time from closure of the expansion valve under-inspection;
determining if there is one of the indoor units whose temperature difference between the first measured temperature and the second measured temperature is greater than or equal to a certain value and whose second temperature is the lowest among those of the indoor units;
selecting, if there is an indoor unit satisfying the above two conditions, the indoor unit as an associated indoor

unit with the expansion valve under inspection, or otherwise, registering the expansion valve under inspection as a defective expansion valve; and
manipulating remaining expansion values through the above operations to inspect the pipes.

FIG. 1

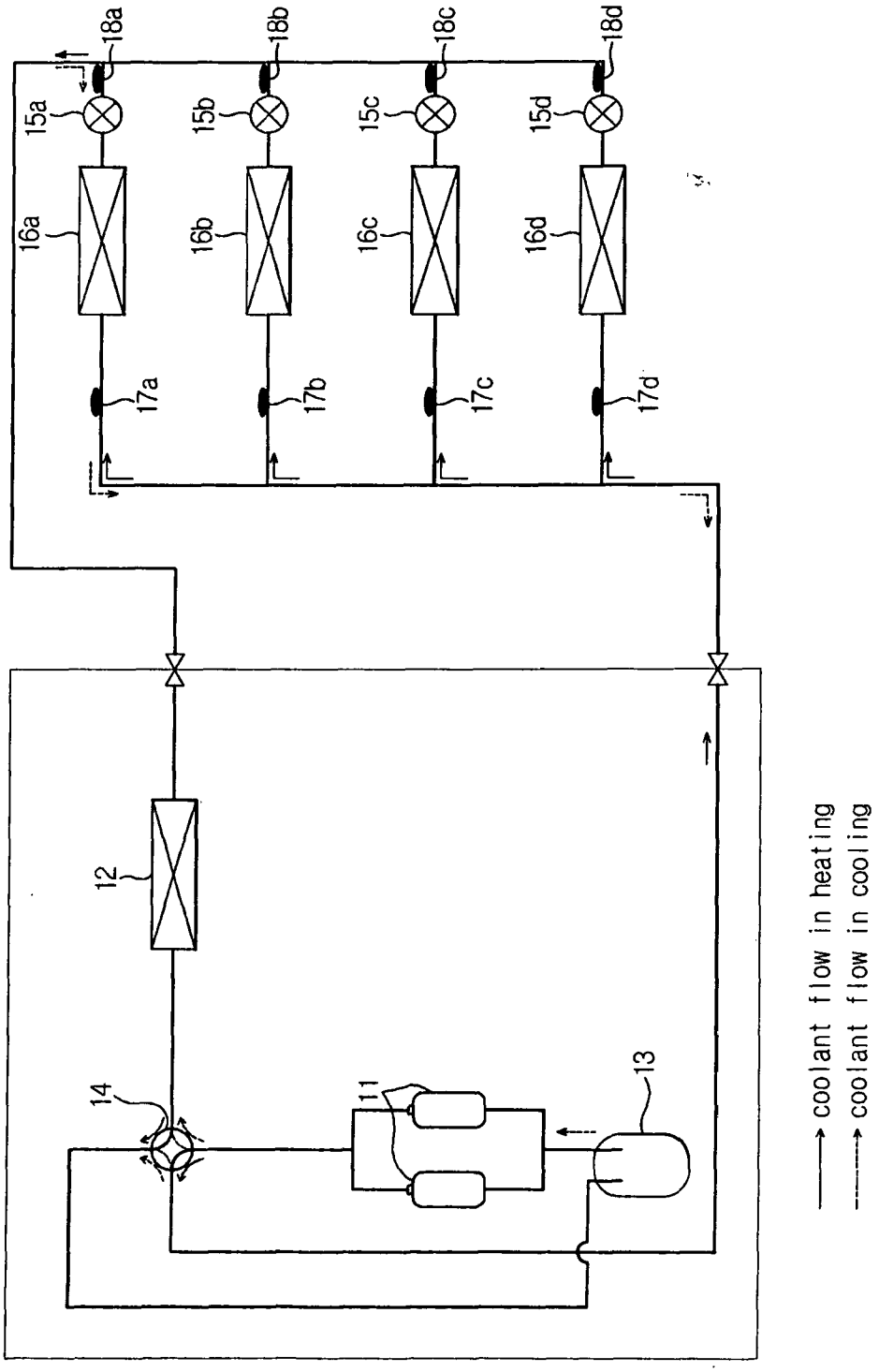

18a
18b
18c
18d
15a
15b
15c
15d
16a
16b
16c
16d
17a
17b
17c
17d
12
14
11
13
coolant flow in heating
coolant flow in cooling

FIG. 2

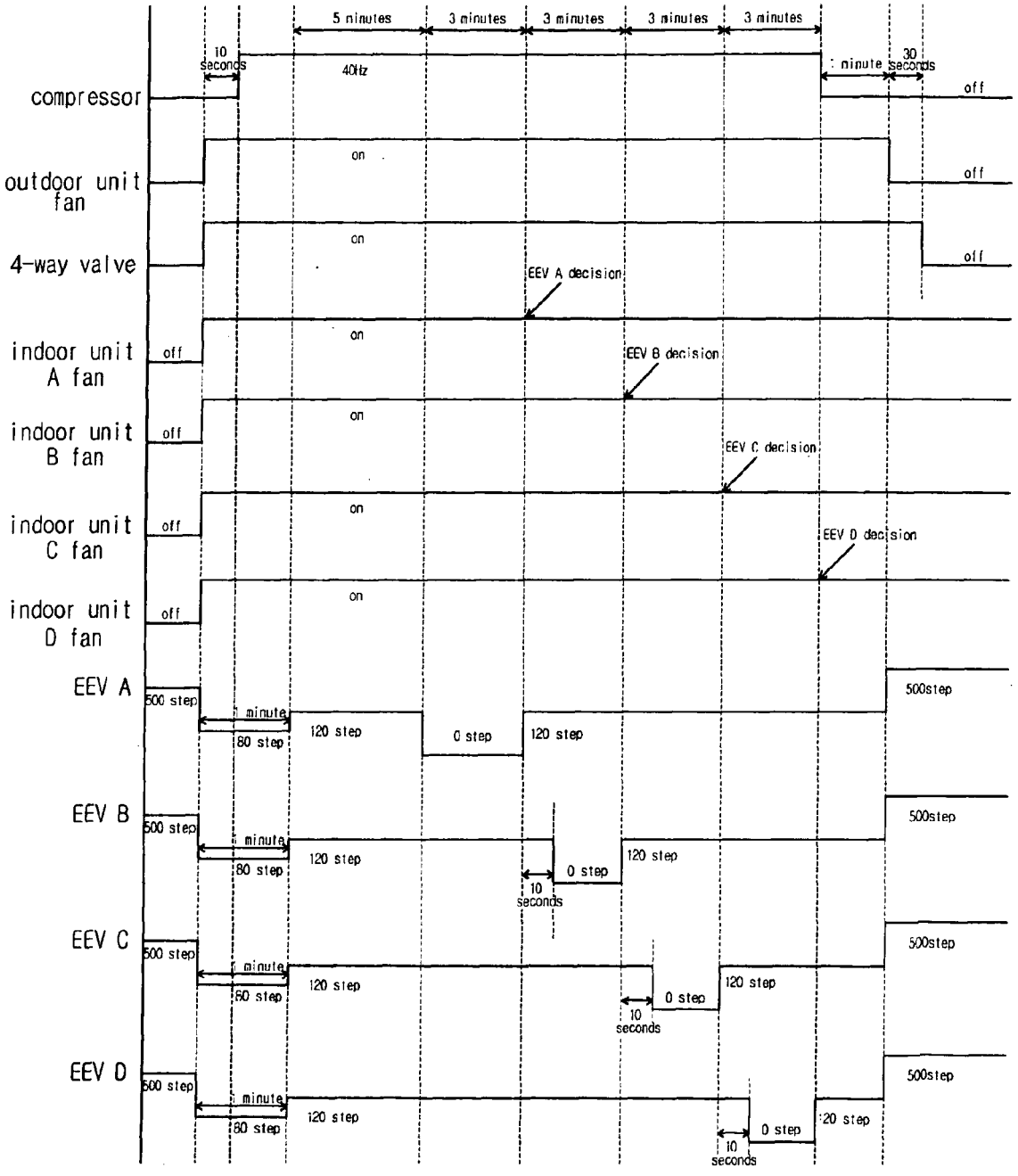

5 minutes
3 minutes
3 minutes
3 minutes
3 minutes
10 seconds
40Hz
1 minute
30 seconds
compressor
off
outdoor unit fan
on
off
4-way valve
on
off
EEV A decision
indoor unit A fan
off
on
EEV B decision
indoor unit B fan
off
on
EEV C decision
indoor unit C fan
off
on
EEV D decision
indoor unit D fan
off
on
EEV A
500 step
1 minute
80 step
120 step
0 step
120 step
500step
EEV B
500 step
1 minute
80 step
120 step
0 step
10 seconds
120 step
500step
EEV C
500 step
1 minute
60 step
120 step
0 step
10 seconds
120 step
500step
EEV D
500 step
1 minute
80 step
120 step
0 step
10 seconds
120 step
500step

FIG. 3

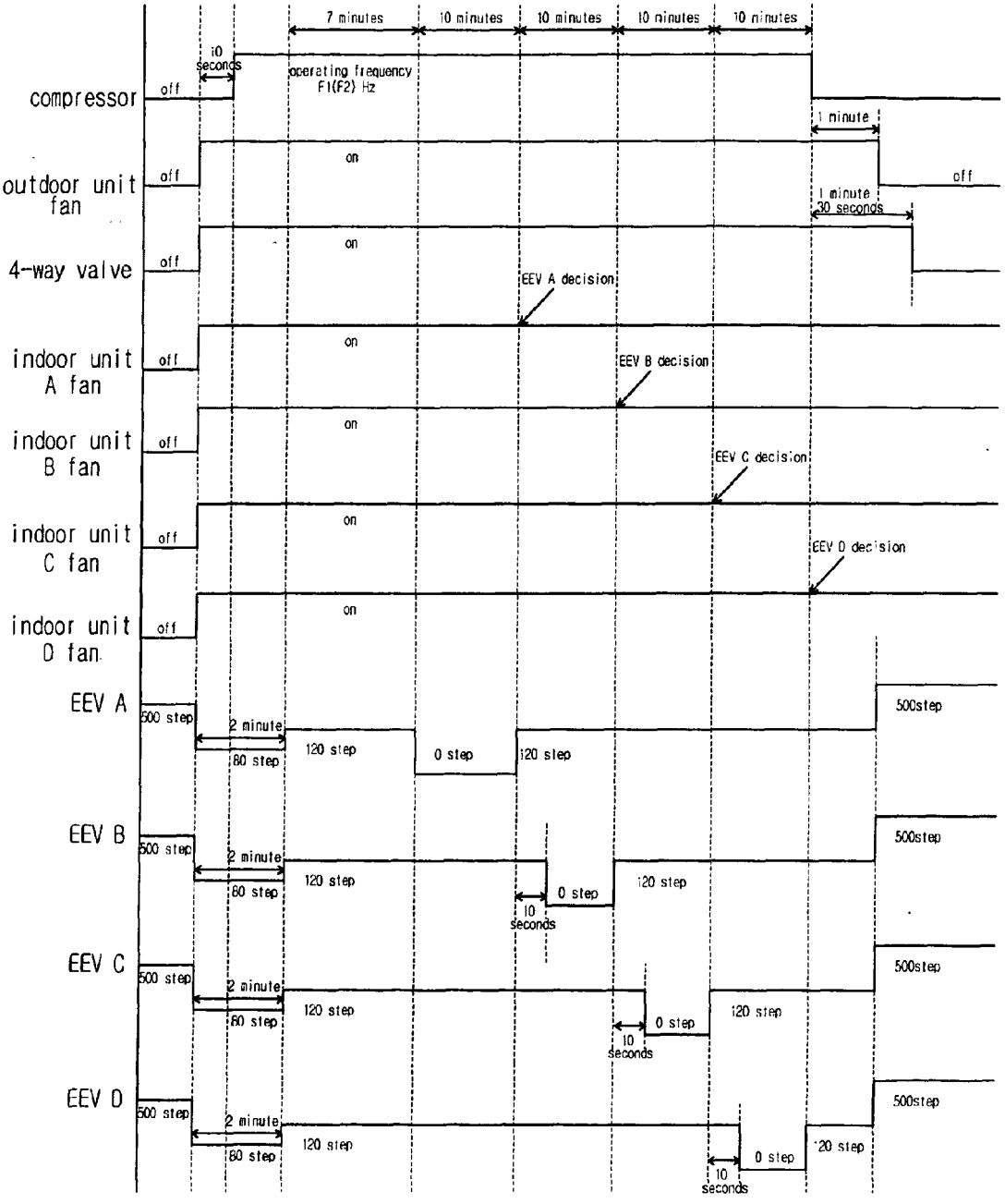

7 minutes
10 minutes
10 minutes
10 minutes
10 minutes
10 seconds
operating frequency F1(F2) Hz
compressor
off
1 minute
outdoor unit fan
on
off
1 minute 30 seconds
4-way valve
EEV A decision
indoor unit A fan
EEV B decision
indoor unit B fan
EEV C decision
indoor unit C fan
EEV D decision
indoor unit D fan
EEV A
500 step
2 minute
80 step
120 step
0 step
500step
EEV B
EEV C
EEV D
10 seconds

FIG. 4

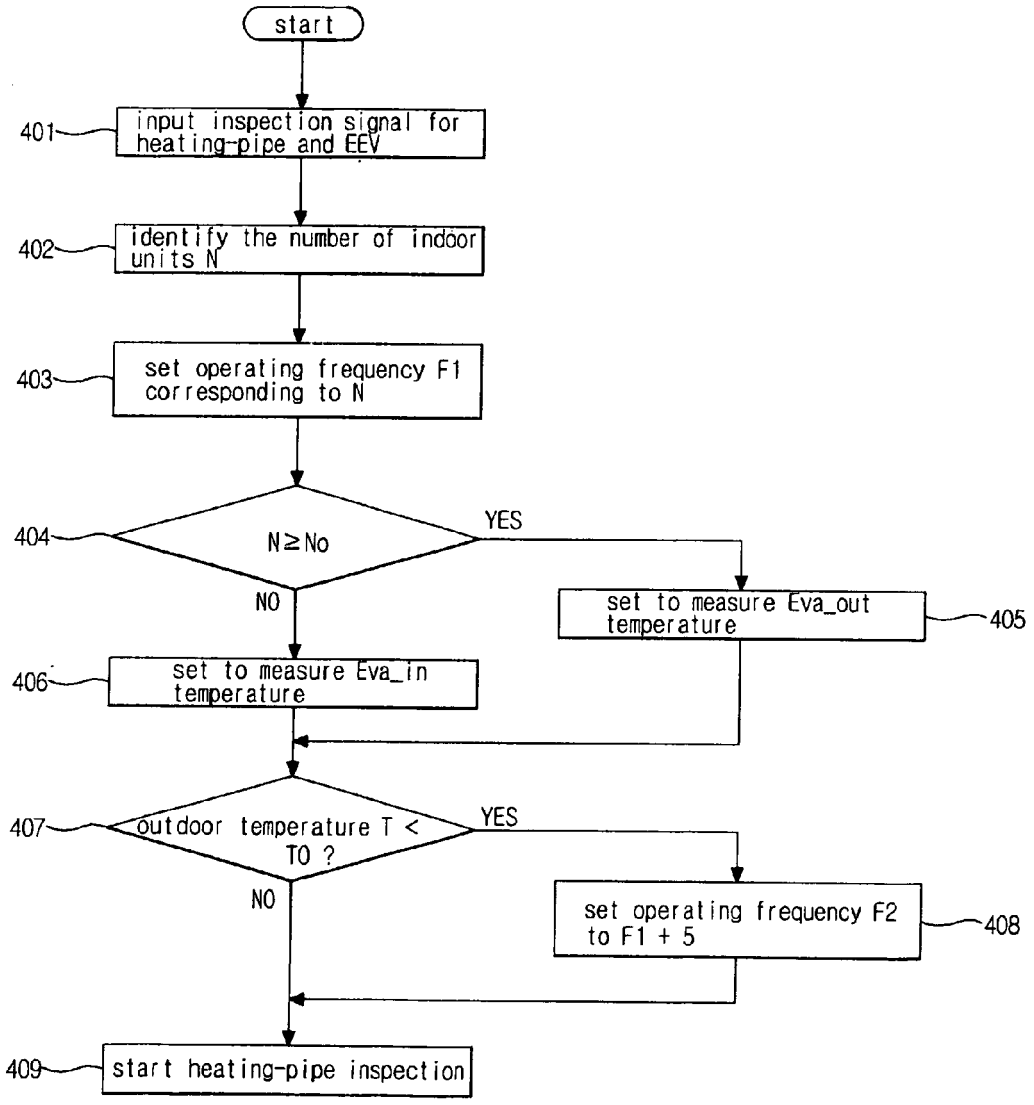
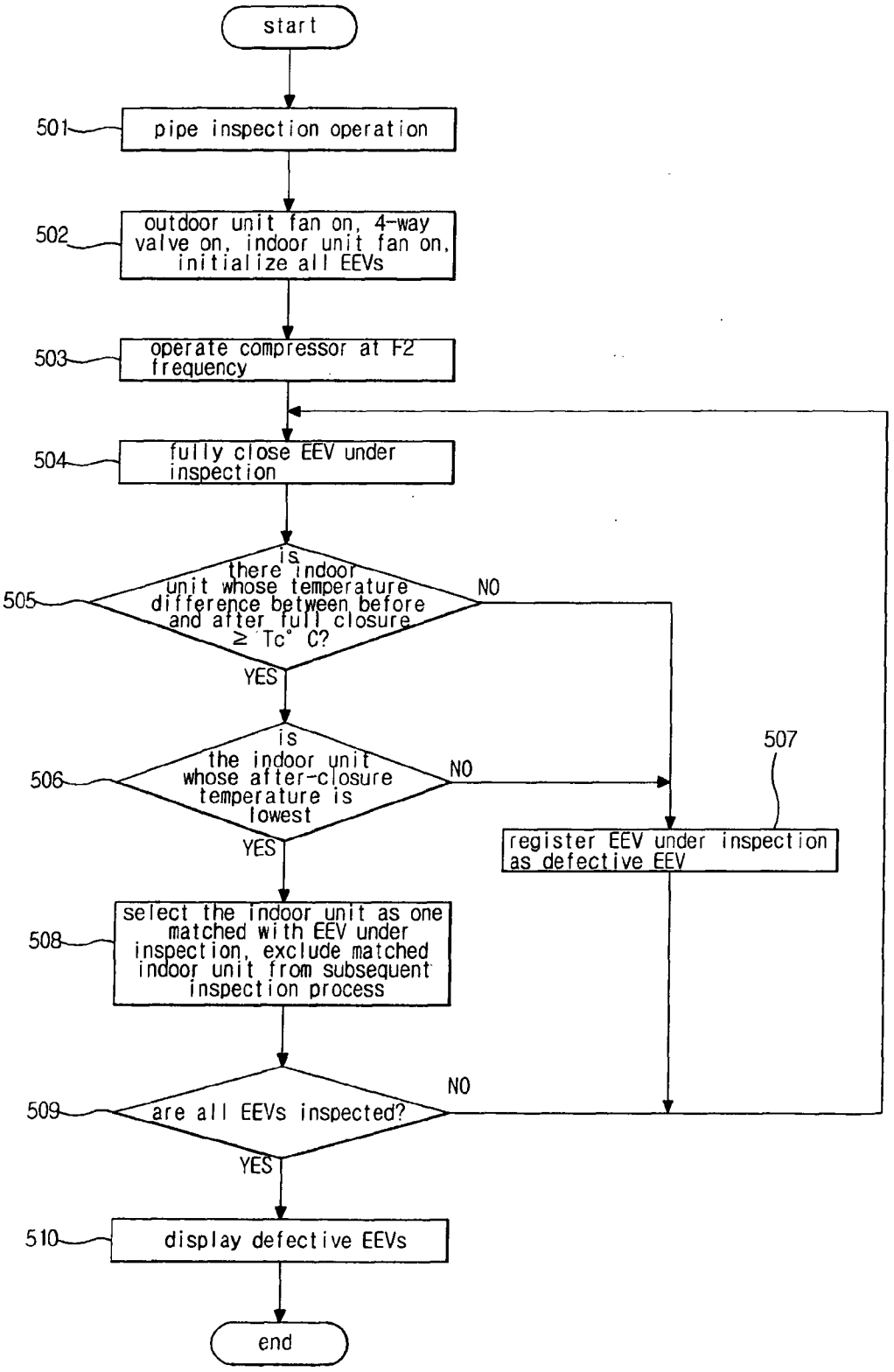

start
401
input inspection signal for heating-pipe and EEV
402
identify the number of indoor units N
403
set operating frequency F1 corresponding to N
404
N≥No
YES
NO
405
set to measure Eva_out temperature
406
set to measure Eva_in temperature
407
outdoor temperature T < TO ?
YES
NO
408
set operating frequency F2 to F1 + 5
409
start heating-pipe inspection

FIG 5


start
501
pipe inspection operation
502
outdoor unit fan on, 4-way valve on, indoor unit fan on, initialize all EEVs
503
operate compressor at F2 frequency
504
fully close EEV under inspection
505
is there indoor unit whose temperature difference between before and after full closure ≥ Tc° C?
NO
YES
506
is the indoor unit whose after-closure temperature is lowest
NO
YES
507
register EEV under inspection as defective EEV
508
select the indoor unit as one matched with EEV under inspection, exclude matched indoor unit from subsequent inspection process
509
are all EEVs inspected?
NO
YES
510
display defective EEVs
end

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 200572031 **[0001]**