(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 677 058 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.07.2006 Bulletin 2006/27

(51) Int Cl.:
F25B 49/02 *(2006.01)* ***F24F 11/00*** *(2006.01)*

(21) Application number: **05028036.1**

(22) Date of filing: **21.12.2005**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: **28.12.2004 KR 2004113566**

(71) Applicant: **LG Electronics, Inc.**
Seoul 150-010 (KR)

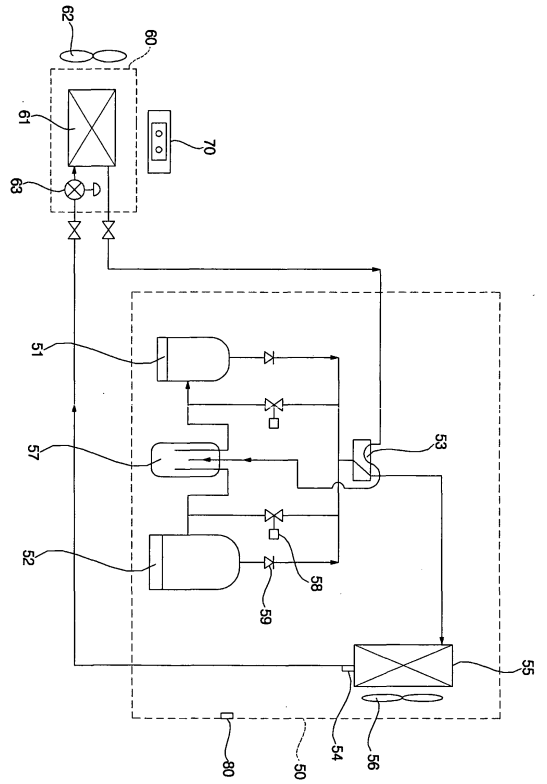
(72) Inventors:
- **Lee, Won Hee**
  Seodaemun-ku
  Seoul 120-080 (KR)
- **Hyun, Seung Youp**
  Guro-ku
  Seoul 152-056 (KR)
- **Sim, Jae Hoon**
  Seoul 152-082 (KR)
- **Hwang, Yoon Jei**
  Seoul 140-031 (KR)

(74) Representative: **Vossius & Partner**
Siebertstrasse 4
81675 München (DE)

(54) Method of controlling over-load cooling operation of air conditioner

(57) A method of controlling an over-load cooling operation of an air conditioner includes over-load operation mode in which, when an outdoor pipe temperature and an outdoor temperature exceeds reference temperatures, respectively, the operation capacity is changed to a low-level operation capacity, which is lower than the current operation capacity, the low-level operation capacity being one of plural operation capacities set according to the operation capacities of compressors (51, 52), and the operation is performed, and normal operation mode in which the outdoor pipe temperature is measured every predetermined period of time after the operation is performed in the over-load operation mode, and, when the measured outdoor pipe temperature is below the reference temperature, the operation is performed according to a signal from a thermostat (70). The continuous cooling operation is possible even under the over-load condition during the cooling operation of the air conditioner, and the air conditioner system is protected through the variable-capacity operation. Consequently, the present invention has the effect of improving user comfort and improving operational reliability of the air conditioner.

FIG. 2



EP 1 677 058 A2

Description

[0001] The present invention relates to a method of controlling an operation of an air conditioner, and, more particularly, to a method of controlling an over-load cooling operation of an air conditioner that is capable of enabling the cooling operation of the air conditioner to be performed without interruption, while protecting the air conditioner system, when over load is generated during the cooling operation of the air conditioner.

[0002] Generally, a heat-pump type air conditioner is a kind of air conditioner that is capable of performing a simultaneous cooling and heating operation. The heat-pump type air conditioner includes an evaporator and a compressor, by which the heat-pump type air conditioner is used as a cooling apparatus or a heating apparatus. Switching between the cooling apparatus and the heating apparatus is accomplished by reversing flow of coolant in a cooling cycle.

[0003] FIG. 1 is a perspective view schematically showing a conventional unitary air conditioner, which is one form of the above-mentioned heat-pump type air conditioner. The unitary air conditioner is constructed such that an operation or stop signal is transmitted to an indoor unit 20 and an outdoor unit 10 from a thermostat 20, which is mounted in a room, to operate the indoor unit 20 and the outdoor unit 10.

[0004] Generally, unitary air conditioners each having a 1-stage thermostat, which transmits only an ON/OFF signal, are widely used in ordinary houses. Recently, however, energy saving and more convenient cooling and heating operations have been increasingly required, and therefore, unitary air conditioners each having a 2-stage thermostat, by which change in capacity is possible, have been used.

[0005] If the 2-stage thermostat is applied to the unitary air conditioner, a 2-stage variable compressor, whose capacity is variable, or a plurality of constant-speed compressors are used. Based on a signal from the thermostat, the cooling or heating operation is performed while the capacity of the compressor is changed.

[0006] When the outdoor temperature increases or the temperature of a pipe exceeds a predetermined temperature (approximately 46 °C according to regulations of AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI) in USA) due to lack of heat transfer at the condenser during the cooling operation of the air conditioner, it is determined that the air conditioner is operated under an over-load condition, and therefore, the compressor is stopped, by which the air conditioner system is effectively protected.

[0007] According to the method of controlling the over load of the conventional air conditioner as described above, however, the outdoor temperature increases under the over-load operation condition. As a result, users rather requires higher cooling operation of the air conditioner. When the air conditioner is stopped to protect the air conditioner system at this time, the indoor temperature increases, and therefore, the users feel discomfort.

[0008] Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a method of controlling an over-load cooling operation of an air conditioner that is capable of enabling the cooling operation of the air conditioner to be performed without interruption, while protecting the air conditioner system, when over load is generated during the cooling operation of the air conditioner, thereby improving user comfort and improving operational reliability of the air conditioner.

[0009] In accordance with the present invention, the above and other objects can be accomplished by the provision of a method of controlling an over-load cooling operation of an air conditioner including: an over-load operation mode in which, when an outdoor pipe temperature and an outdoor temperature exceeds reference temperatures, respectively, the operation capacity is changed to a low-level operation capacity, which is lower than the current operation capacity, the low-level operation capacity being one of plural operation capacities set according to the operation capacities of compressors, and the operation is performed; and a normal operation mode in which the outdoor pipe temperature is measured every predetermined period of time after the operation is performed in the over-load operation mode, and, when the measured outdoor pipe temperature is below the reference temperature, the operation is performed according to a signal from a thermostat.

[0010] Preferably, the reference temperature of the outdoor pipe temperature is set to be higher than the reference temperature of the outdoor temperature.

[0011] At the beginning in the over-load operation mode, the operation capacity is changed to a first low-level operation capacity, which is lower than the current operation capacity, and, if the outdoor pipe temperature or the outdoor temperature exceeds the reference temperatures when a predetermined period of time elapses after the operation is performed in the over-load operation mode, the operation capacity is changed to a second low-level operation capacity, which is lower than the first low-level operation capacity, and then the operation is performed in the second low-level operation capacity.

[0012] On the assumption that the operation capacities of the compressors are set to X%, Y%, and Z% in order of operation capacities of the compressors in the over-load operation mode, when the operation capacity is the X% operation capacity, the compressors are operated with the Y% operation capacity, which is lower than the X% operation capacity, when the operation capacity is the Y% operation capacity, the compressors are operated with the Z% operation capacity, which is lower than the Y% operation capacity, and when the operation capacity is the Z% operation capacity, the compressors are stopped.

[0013] When the compressors are operated in the over-load operation mode, an outdoor fan, by which an outdoor heat exchanger is cooled, is operated with high

airflow, and, when the compressors are stopped in the over-load operation mode, the outdoor fan is stopped.

[0014] If the signal from the thermostat, which controls operation stages of the air conditioner, is changed from a high-level operation signal to a low-level operation signal during operation in the over-load operation mode, the compressors are returned to the normal operation mode.

[0015] If the signal from the thermostat is changed from a low-level operation signal to a high-level operation signal during operation in the over-load operation mode, the operation is still performed in the over-load operation mode.

[0016] When the outdoor pipe temperature or the outdoor temperature exceeds the reference temperature after the compressors are returned to the normal operation mode, the operation mode is not changed to the over-load operation mode for a predetermined period of time.

[0017] If the outdoor pipe temperature is a specific temperature, which is higher than the reference temperature, when a predetermined period of time elapses after the compressors are started, both the compressors are stopped.

[0018] When a predetermined period time elapses after the compressors are stopped, the compressors are restarted in the normal operation mode.

[0019] According to the present invention, the method of controlling the over-load cooling operation of the air conditioner is capable of performing the controlling operation such that the continuous cooling operation is possible even under the over-load condition during the cooling operation of the air conditioner, and the air conditioner system is protected through the variable-capacity operation. Consequently, the present invention has the effect of improving user comfort and improving operational reliability of the air conditioner.

[0020] The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view schematically showing a conventional unitary air conditioner system;

FIG. 2 is a view showing the structure of an air conditioner system, to which a method of controlling an over-load cooling operation of an air conditioner according to the present invention is applied;

FIG. 3 is a flow chart illustrating the method of controlling the over-load cooling operation of the air conditioner according to the present invention; and

FIG. 4 is a graph illustrating the method of controlling the over-load cooling operation of the air conditioner according to the present invention.

[0021] Now, a preferred embodiment of the present invention will be described in detail with reference to the accompanying drawings.

[0022] FIG. 2 is a view showing the structure of an air conditioner system, to which a method of controlling an over-load cooling operation of an air conditioner according to the present invention is applied.

[0023] FIG. 2 shows the operational state of the air conditioner during the cooling operation. As shown in FIG. 2, a small-capacity compressor 51 and a large-capacity compressor 52 are mounted in an outdoor unit 50. At the inlet sides of the compressors 51 and 52 is mounted an accumulator 57. At the outlet sides of the compressors 51 and 52 are mounted check valves 59, respectively, for preventing backward-flow of refrigerant. Between the inlet and outlet sides of the compressors 51 and 52 are mounted flat pressure valves 58, respectively, for performing a flat pressure function when the compressors are stopped.

[0024] In the outdoor unit 50 is also mounted a four-way valve 53 for performing a switching operation between cooling and heating operations. Furthermore, an outdoor heat exchanger 55, which serves as an evaporator when the heating operation is performed, and an outdoor fan 56 for blowing air are mounted in the outdoor unit 50.

[0025] Especially, a pipe temperature sensor 54 for measuring the temperature of a pipe and an outdoor temperature sensor 80 for measuring the temperature of outdoor air are mounted in the outdoor unit 50. In the illustrated embodiment, the pipe temperature sensor 54 is mounted at the outdoor heat exchanger 55, although the pipe temperature sensor 54 may be mounted at the pipe between the outlet sides of the compressors 51 and 52 and the outdoor heat exchanger 55.

[0026] In an indoor unit 60 is mounted an indoor heat exchanger 61, which is connected to the four-way valve 53 and the outdoor heat exchanger 55 via a refrigerant line. The indoor heat exchanger 61 serves as a condenser during the heating operation of the air conditioner. In the indoor unit 60 is also mounted an indoor fan 62 for blowing air. At the refrigerant line between the indoor heat exchanger 61 and the outdoor heat exchanger 55 is mounted an expansion device 63.

[0027] In a room, where the indoor unit 60 is installed, is mounted a 2-stage thermostat 70 for manipulating the operation of the heat-pump type air conditioner with the above-stated construction. The 2-stage thermostat 70 is configured to generate an off signal, a low operation signal Y1, and a high operation signal Y2. Specifically, the 2-stage thermostat 70 is configured such that the variable operation of the air conditioner is possible. Based on indoor-side load, the 2-stage thermostat 70 transmits the high operation signal Y2 or the low operation signal Y1 to the indoor fan 62 of the indoor unit 60 and the compressors 51 and 52 of the outdoor unit 50.

[0028] During cooling operation of the air conditioner with the above-stated construction, at least one of the compressors 51 and 52, which have different capacities, is operated. According to the operation of the compressors 51 and 52, the refrigerant is circulated via the four-way valve 53, the outdoor heat exchanger 55, the expansion device 63, the indoor heat exchanger 61, the four-

way valve 53, the accumulator 57, and the compressors 51 and 52. Consequently, the cooling operation is performed.

[0029] In the following description, a 60% operation is performed when only the large-capacity compressor 52 is operated, a 40% operation is performed when only the small-capacity compressor 51 is operated, and a 100% operation is performed when both the large-capacity compressor 52 and the small-capacity compressor 51 are operated. It should be noted, however, that the above-mentioned percentages are classified only for the purpose of more convenient description of the illustrated embodiment of the present invention. Consequently, the compressors 51 and 52 may be applied with various capacities under different conditions.

[0030] The operations of the large-capacity compressor 52 and the small-capacity compressor 51 of the air conditioner according to the present invention are operated in 3 stage modes, for example, in 100% operation mode, 60% operation mode, and 40% operation mode according to the signal from the 2-stage thermostat 70. Specifically, when the high operation signal Y2 is transmitted to the compressors 51 and 52 from the thermostat 70, the 100 % operation is performed, i.e., both the large-capacity compressor 52 and the small-capacity compressor 51 are operated. When the low operation signal Y1 is transmitted to the compressors 51 and 52 from the thermostat 70, on the other hand, the large-capacity compressor 52 or the small-capacity compressor 51 is operated according to the operating condition.

[0031] Now, a method of controlling the cooling operation of the air conditioner having the above-stated operation modes when over load is generated will be described with reference to FIGS. 3 and 4.

[0032] FIG. 3 is a flow chart illustrating the method of controlling the over-load cooling operation of the air conditioner according to the present invention, and FIG. 4 is a graph illustrating the method of controlling the over-load cooling operation of the air conditioner according to the present invention.

[0033] Referring first to FIG. 3, the compressors 51 and 52 are started according to the cooling operation of the air conditioner. If the outdoor pipe temperature measured by the pipe temperature sensor 54 is a specific temperature (for example, 65 °C), which is higher than a reference temperature (for example, 60 °C), when a predetermined period of time elapses, for example, when 30 seconds elapses, after the compressors are started or when 10 minutes elapses after the air conditioner is operated in the over-load operation mode, it is determined that the air conditioner is under the pipe over-load condition. As a result, the compressors 51 and 52 and the outdoor fan 56 are all stopped.

[0034] When a predetermined period time elapses, for example, when 3 minutes elapses, after both the compressors are stopped, the compressors 51 and 52 are restarted in the normal operation mode.

[0035] If the outdoor pipe temperature measured by the pipe temperature sensor 54 is the reference temperature (for example, 60 °C), which is lower than the specific temperature, or the outdoor temperature measured by the outdoor temperature sensor 80 exceeds a reference temperature (for example, 55 °C), the compressors are operated in the over-load operation mode, in which the operation capacity is changed to a first low-level operation capacity, which is lower than the current operation capacity. The first low-level operation capacity is one of plural operation capacities set according to the operation capacities of the compressors 51 and 52.

[0036] In the case that an X% operation capacity (100% operation capacity), in which both the compressors 51 and 52 are operated, a Y% operation capacity (60% operation capacity), in which only the large-capacity compressor 52 is operated, and a Z% operation capacity (40% operation capacity), in which only the small-capacity compressor 51 is operated, are set in order of operation capacities of the compressors in the over-load operation mode, when the operation capacity is the 100% operation capacity, the compressors are operated with the 60% operation capacity, which is lower than the 100% operation capacity. When the operation capacity is the 60% operation capacity, the compressors are operated with the 40% operation capacity, which is lower than the 60% operation capacity. When the operation capacity is the 40% operation capacity, the compressors are stopped.

[0037] When the compressors 51 and 52 are operated with the 60% operation capacity and the 40% operation capacity, respectively, the outdoor fan 56, by which the outdoor heat exchanger 55 is cooled, is operated in high airflow mode if the outdoor fan 56 can be operated in high/middle/low airflow mode. When the compressors 51 and 52 are stopped, the outdoor fan 56 is also stopped.

[0038] However, if the outdoor pipe temperature exceeds 60 °C or the outdoor temperature exceeds 55 °C even when a predetermined period of time, for example, 10 minutes elapses after the compressors are operated in the over-load operation mode, the operation capacity is changed to a second low-level operation capacity, which is lower than the first low-level operation capacity, and then the operation is performed in the second low-level operation capacity.

[0039] If the operation capacity is changed to the 60% operation capacity from the 100% operation capacity, and the compressors are operated with the changed 60% operation capacity in the first section, for example, in the A section, after entry into the over-load operation mode, as illustrated in FIG. 4, and the outdoor pipe temperature exceeds 60 °C even after 10 minutes elapses, the compressors are operated with the 40% operation capacity.

[0040] If the outdoor pipe temperature exceeds 60 °C even after another 10 minutes elapses, the compressors 51 and 52 are stopped as in the B section.

[0041] When approximately 3 minutes elapses after the compressors 51 and 52 are stopped, the compressors 51 and 52 are restarted in the normal operation

mode.

[0042] If the signal from the thermostat 70 is changed from the high-level operation signal to the low-level operation signal during operation in the over-load operation mode, i.e., if the signal is changed from the high operation signal Y2 to the low operation signal Y1, the control signal is changed from the 100% operation capacity to the 60% operation capacity. Consequently, the over-load operation mode is automatically released, and the compressors are returned to the normal operation mode. When the signal is changed from the low operation signal Y1 to the OFF signal, both the compressors 51 and 52 are stopped.

[0043] If the signal from the thermostat 70 is changed from the low-level operation signal to the high-level operation signal during operation in the over-load operation mode, on the other hand, if the signal is changed from the OFF signal to the low operation signal Y1 or from the low operation signal Y1 to the high operation signal Y2, the operation is still performed in the over-load operation mode.

[0044] As described above, the outdoor pipe temperature or the outdoor temperature is measured every 10 minutes after the operation is performed in the over-load operation mode. When the measured outdoor pipe temperature or the measure outdoor temperature is below the reference temperature (60 °C or 55 °C), the operation is performed in the normal operation mode, in which the operation is performed according to the signal from the thermostat 70.

[0045] When the outdoor pipe temperature or the outdoor temperature exceeds the reference temperature (60 °C or 55 °C) after the compressors are returned to the normal operation mode, the operation mode is not changed to the over-load operation mode for a predetermined period of time, by which abrupt change in capacities of the compressors is prevented, and therefore, the air conditioner system is protected.

[0046] As apparent from the above description, the method of controlling the over-load cooling operation of the air conditioner is capable of performing the controlling operation such that the continuous cooling operation is possible even under the over-load condition during the cooling operation of the air conditioner, and the air conditioner system is protected through the variable-capacity operation. Consequently, the present invention has the effect of improving user comfort and improving operational reliability of the air conditioner.

[0047] Although the preferred embodiment of the present invention has been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Claims

1. A method of controlling an over-load cooling operation of an air conditioner including:

   an over-load operation mode in which, when an outdoor pipe temperature and an outdoor temperature exceeds reference temperatures, respectively, the operation capacity is changed to a low-level operation capacity, which is lower than the current operation capacity, the low-level operation capacity being one of plural operation capacities set according to the operation capacities of compressors (51, 52), and the operation is performed; and
   a normal operation mode in which the outdoor pipe temperature is measured every predetermined period of time after the operation is performed in the over-load operation mode, and, when the measured outdoor pipe temperature is below the reference temperature, the operation is performed according to a signal from a thermostat (70).

2. The method as set forth in claim 1, wherein the reference temperature of the outdoor pipe temperature is set to be higher than the reference temperature of the outdoor temperature.

3. The method as set forth in claim 1 or 2, wherein
   at the beginning in the over-load operation mode, the operation capacity is changed to a first low-level operation capacity, which is lower than the current operation capacity, and
   if the outdoor pipe temperature or the outdoor temperature exceeds the reference temperatures when a predetermined period of time elapses after the operation is performed in the over-load operation mode, the operation capacity is changed to a second low-level operation capacity, which is lower than the first low-level operation capacity, and then the operation is performed in the second low-level operation capacity. '

4. The method as set forth in any of claims 1 to 3, wherein
   on the assumption that the operation capacities of the compressors (51, 52) are set to X%, Y%, and Z% in order of operation capacities of the compressors in the over-load operation mode,
   when the operation capacity is the X% operation capacity, the compressors (51, 52) are operated with the Y% operation capacity, which is lower than the X% operation capacity,
   when the operation capacity is the Y% operation capacity, the compressors (51, 52) are operated with the Z% operation capacity, which is lower than the Y% operation capacity, and

when the operation capacity is the Z% operation capacity, the compressors (51, 52) are stopped.

5. The method as set forth in any of claims 1 to 4, wherein
when the compressors (51, 52) are operated in the over-load operation mode, an outdoor fan (56), by which an outdoor heat exchanger (55) is cooled, is operated with high airflow, and
when the compressors (51, 52) are stopped in the over-load operation mode, the outdoor fan (56) is stopped.

6. The method as set forth in any of claims 1 to 5, wherein, if the signal from the thermostat (70), which controls operation stages of the air conditioner, is changed from a high-level operation signal to a low-level operation signal during operation in the over-load operation mode, the compressors (51, 52) are returned to the normal operation mode.

7. The method as set forth in any of claims 1 to 6, wherein, if the signal from the thermostat (70) is changed from a low-level operation signal to a high-level operation signal during operation in the over-load operation mode, the operation is still performed in the over-load operation mode.

8. The method as set forth in any of claims 1 to 7, wherein, when the outdoor pipe temperature or the outdoor temperature exceeds the reference temperature after the compressors (51, 52) are returned to the normal operation mode, the operation mode is not changed to the over-load operation mode for a predetermined period of time.

9. The method as set forth in any of claims 1 to 8, wherein, if the outdoor pipe temperature is a specific temperature, which is higher than the reference temperature, when a predetermined period of time elapses after the compressors (51, 52) are started, both the compressors (51, 52) are stopped.

10. The method as set forth in claim 9, wherein, when a predetermined period time elapses after the compressors (51, 52) are stopped, the compressors (51, 52) are restarted in the normal operation mode.

11. An apparatus for performing the method according to any of claims 1 to 10.

FIG. 1 (Prior Art)

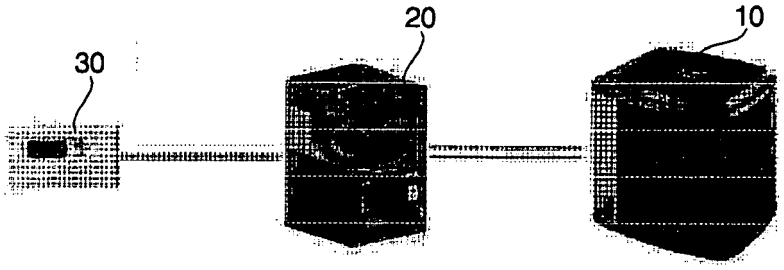


FIG. 2

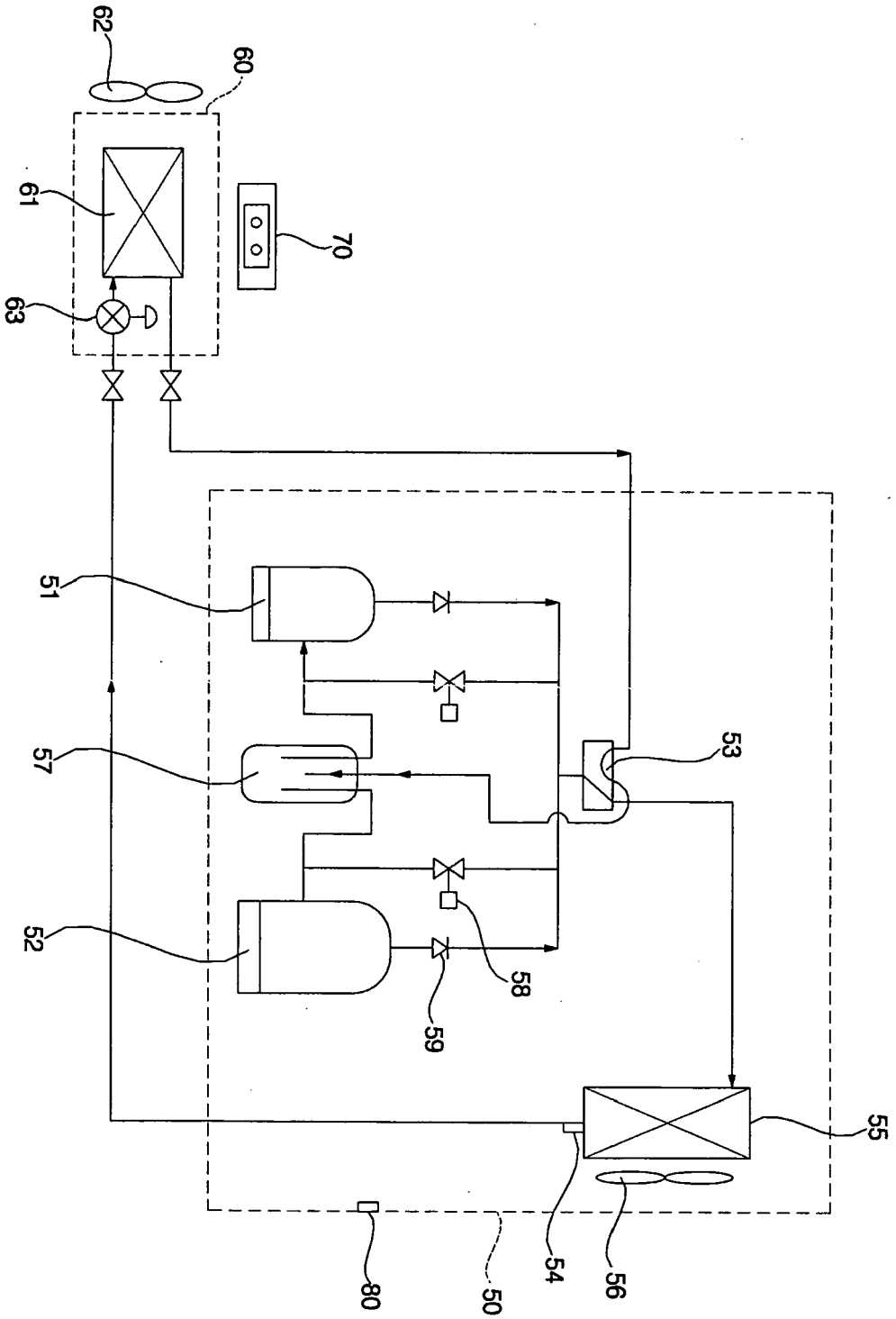


FIG. 3

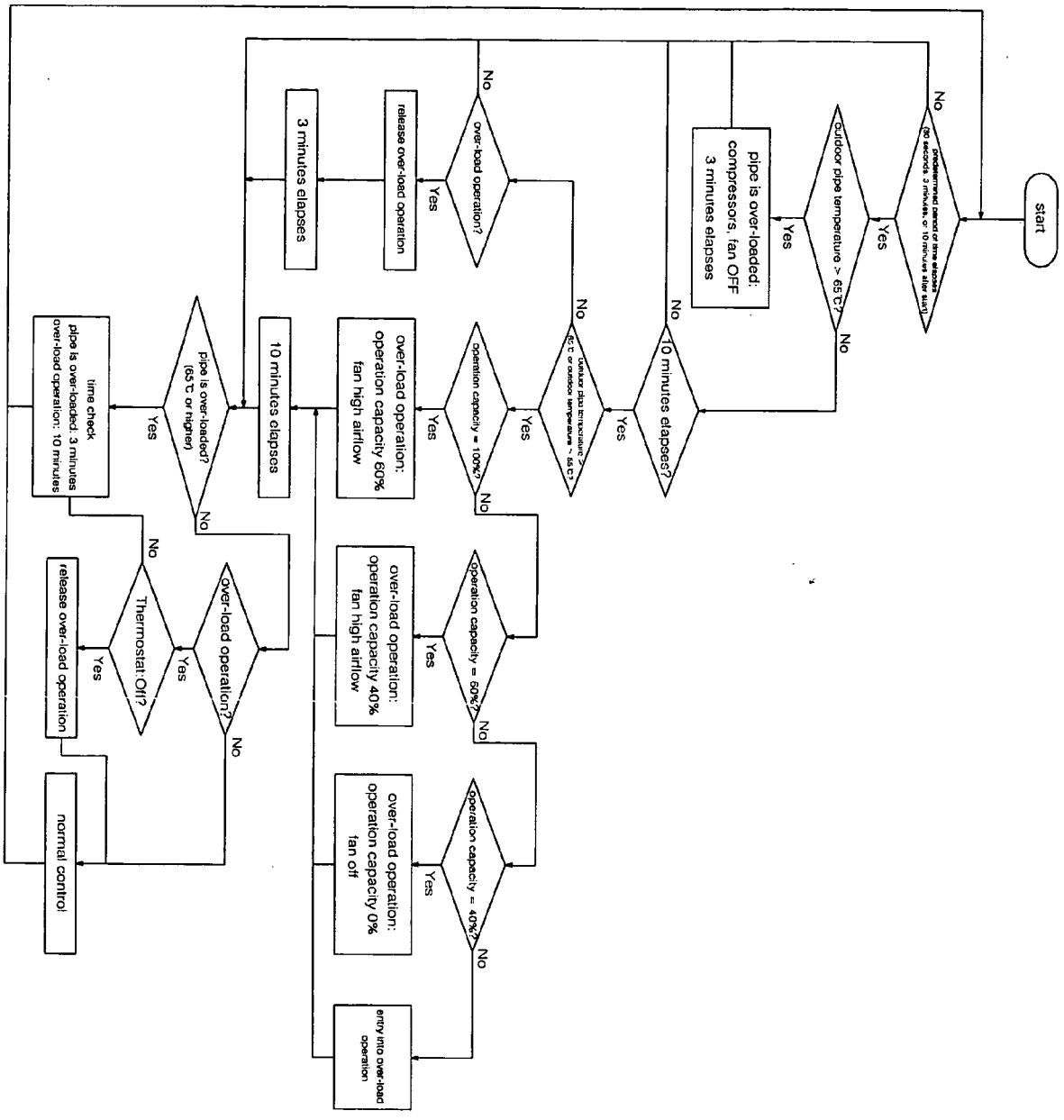
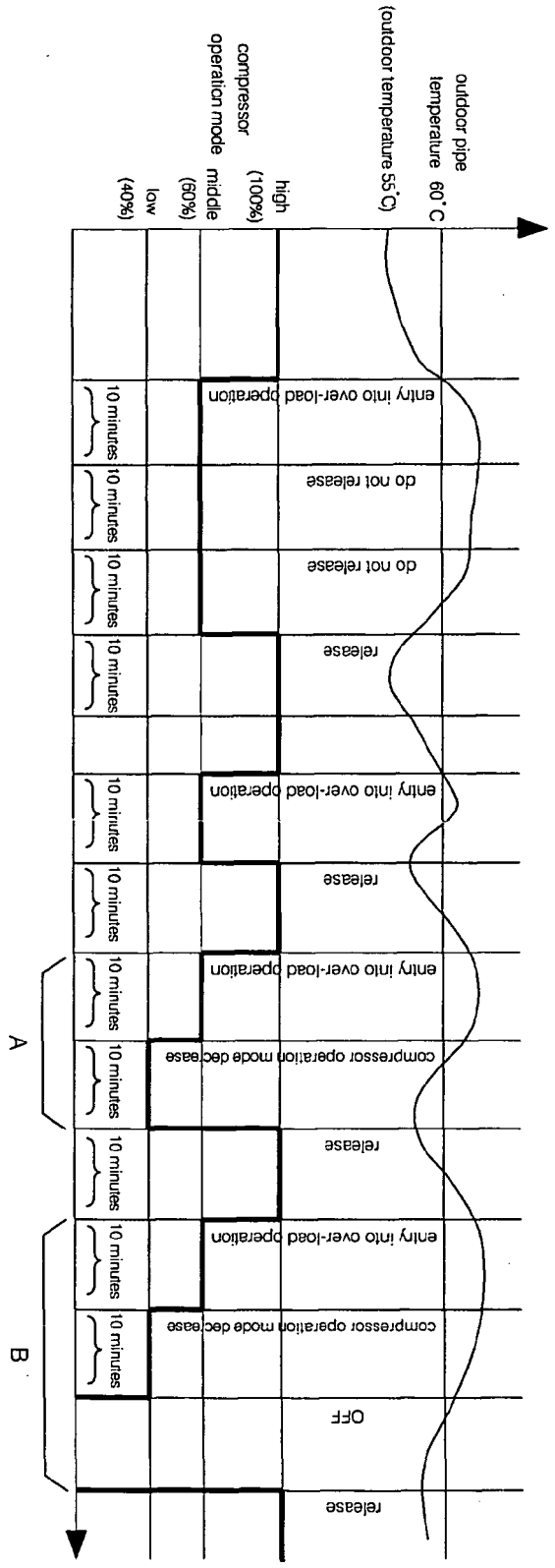

Start
predetermined period of time elapses (90 seconds, 3 minutes, or 10 minutes after start)
No
Yes
outdoor pipe temperature >= 65°C?
Yes
No
pipe is over-loaded: compressors, fan OFF 3 minutes elapses
10 minutes elapses?
Yes
No
compressor pipe temperature >= 65°C or outdoor temperature >= 65°C?
Yes
No
operation capacity = 100%?
Yes
No
over-load operation: operation capacity 60% fan high airflow
operation capacity = 60%?
Yes
No
over-load operation: operation capacity 40% fan high airflow
operation capacity = 40%?
Yes
No
over-load operation: operation capacity 0% fan off
entry into over-load operation
over-load operation?
Yes
No
release over-load operation
3 minutes elapses
over-load operation?
Yes
No
release over-load operation
10 minutes elapses
pipe is over-loaded? (65°C or higher)
Yes
No
time check
pipe is over-loaded: 3 minutes
over-load operation: 10 minutes
Thermostat Off?
Yes
No
normal control

FIG. 4


outdoor pipe temperature 60°C
(outdoor temperature 55°C)
compressor operation mode
high (100%)
middle (60%)
low (40%)
entry into over-load operation
do not release
do not release
release
entry into over-load operation
release
entry into over-load operation
compressor operation mode decrease
release
entry into over-load operation
compressor operation mode decrease
OFF
release
10 minutes
A
B