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(54) DETECTION APPARATUS AND METHOD FOR REFRIGERANT LEAKAGE OF AIR SOURCE COOLING ONLY SYSTEM

(57) The present invention relates to a device and a method for detecting a refrigerant leakage of an air source cooling-only system, wherein the detection method comprises S1: obtaining an operating parameter of an air-cooled cooling-only air source cooling-only system, wherein the operating parameter comprises at least a compressor speed or capacity; S2: comparing the operating parameter with a preset operating parameter interval; S3: updating a cumulative score when the operating parameter falls within the preset operating parameter interval; and S4: determining that a refrigerant leakage has occurred when the cumulative score exceeds a predefined cumulative score, and returning to step S1 when the cumulative score does not exceed the predefined cumulative score. The device and the method for detecting a refrigerant leakage of an air source cooling-only system according to the present invention are simple and reliable, easy in implementation, convenient in application and so on, and can provide automatic detection of a refrigerant leakage, improving the operating efficiency and safety of modules.

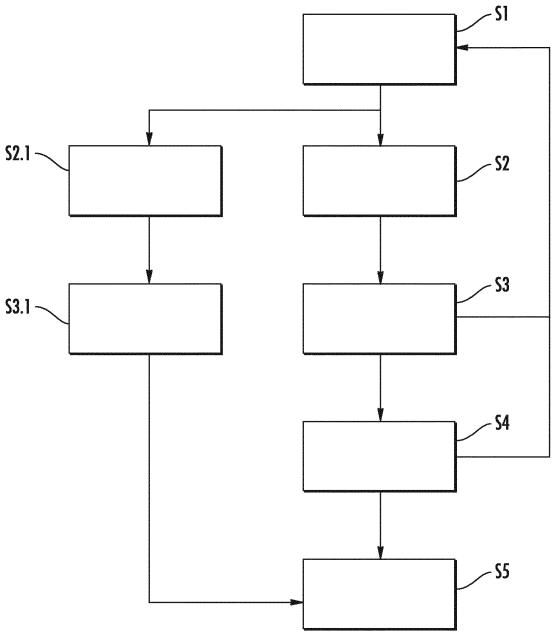

FIG. 2

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Description

[0001] The present invention relates to a method and a device for detecting a refrigerant leakage of an air source cooling-only system, which is used for monitoring whether a leakage has occurred in a cooling system.

[0002] It is known that an air source cooling-only system generally uses a refrigerant to perform a refrigeration cycle operation. During operation, the refrigerant may leak from pipelines for a variety of reasons. A cooling-only module may probably shut down due to a leakage, thereby resulting in economic losses, air pollution, and repair costs.

[0003] The existing air source cooling-only system is not capable of automatically detecting a refrigerant leakage. Although a special-purpose apparatus can be used to detect whether a leakage has occurred, such detection is time-consuming and expensive.

[0004] Accordingly, it is desirable to provide a device and a method for detecting a refrigerant leakage of an air source cooling-only system, which is capable of automatically detecting an occurrence of a refrigerant leakage and reducing operating costs.

[0005] Viewed from a first aspect, the present invention provides

a device for detecting a refrigerant leakage of an air source cooling-only system comprising:

a data obtaining module, configured to obtain an operating parameter of the air source cooling-only system;

a data comparison module, configured to compare the operating parameter with a preset operating parameter interval;

a cumulative score updating module, configured to update a cumulative score when the operating parameter falls within the preset operating parameter interval; and

a refrigerant leakage determination module, configured to determine that a refrigerant leakage has occurred when the cumulative score exceeds a predefined cumulative score, and to continue to operate the data obtaining module when the cumulative score does not exceed the predefined cumulative score.

[0006] Optionally, the data comparison module comprises a compressor speed or capacity comparison module;

the compressor speed or capacity comparison module is configured to compare the compressor speed or capacity with a minimum speed or capacity when the air source cooling-only system has been continuously operated for a first predefined period of time and an absolute value of a temperature difference between inlet and outlet water is less than a first predefined value; and

the cumulative score updating module is configured to increase the cumulative score by a first score when the compressor speed or capacity is greater than or equal to the minimum speed or capacity.

[0007] Optionally, the data comparison module comprises a superheat comparison module;

the superheat comparison module is configured to compare a superheat degree with a sum of a superheat degree setting value and a third predefined value when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, a supercooling degree is less than a second predefined value, and an expansion valve opening degree is equal to a predefined opening degree;

the cumulative score updating module is configured to continue to operate the data obtaining module when the superheat degree is not greater than the sum of the superheat degree setting value and the third predefined value; and

the cumulative score updating module is further configured to increase the cumulative score by a second score when the superheat degree is greater than the sum of the superheat degree setting value and the third predefined value.

[0008] Optionally, the data comparison module comprises a first pressure comparison module;

the first pressure comparison module is configured to compare a compressor discharge pressure with a first predefined pressure when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, the supercooling degree is less than the second predefined value, and the expansion valve opening degree is not equal to the predefined opening degree;

the cumulative score updating module is configured to continue to operate the data obtaining module when the compressor discharge pressure is not less than the first predefined pressure; and

the cumulative score updating module is further configured to increase the cumulative score by a third score when the compressor discharge pressure is less than the first predefined pressure.

[0009] Optionally, the data comparison module comprises a supercooling degree comparison module;

the supercooling degree comparison module is configured to compare the supercooling degree with a predefined supercooling degree when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, and the supercooling degree is not less than the second predefined value;

the cumulative score updating module is configured to continue to operate the data obtaining module when the supercooling degree is not less than the predefined supercooling degree; and

the cumulative score updating module is further configured to increase the cumulative score by a fourth score when the supercooling degree is less than the predefined supercooling degree.

[0010] Optionally, the data comparison module comprises a second pressure comparison module and/or a reservoir level comparison module;

the second pressure comparison module and/or the reservoir level comparison module is configured to operate when a second predefined period of time elapses after the air source cooling-only system is shut down; and wherein the second pressure comparison module is configured to compare the compressor discharge pressure of the air source cooling-only system with a second predefined pressure, and/or the reservoir level comparison module is configured to compare a reservoir level with a predefined reservoir level; and

the refrigerant leakage determination module is configured to determine that the refrigerant leakage has occurred when the compressor discharge pressure of the air source cooling-only cycle system is less than the second predefined pressure and/or the reservoir level is below the predefined reservoir level.

[0011] Optionally, the preset operating parameter interval is a preset value, a preset table, or a preset diagram.

[0012] Optionally, the device further comprises a warning module configured to send a leakage warning signal when it is determined that the refrigerant leakage has occurred.

[0013] Optionally, the first predefined value is 1 degree Celsius.

[0014] Optionally, the operating parameter comprises one or more of the following: an operating state of the air source cooling-only system, a shutdown state of the air source cooling-only system, time elapsed since the air source cooling-only system is shut down, time elapsed since the air source cooling-only system operates, a water outlet temperature, a water inlet temperature, an expansion valve opening degree, a supercooling degree, a superheat degree, a compressor discharge pressure, and a reservoir level.

[0015] Viewed from a second aspect, the present invention provides a method for detecting a refrigerant leakage of an air source cooling-only system comprising the following steps:

(i): obtaining an operating parameter of the air source cooling-only system;

(ii): comparing the operating parameter with a preset operating parameter interval;

(iii): updating a cumulative score when the operating parameter falls within the preset operating parameter interval;

(iv): determining that a refrigerant leakage has occurred when the cumulative score exceeds a predefined cumulative score, and returning to step (i) when the cumulative score does not exceed the predefined cumulative score.

[0016] Optionally, in step (ii), the compressor speed or capacity is compared with a minimum speed or capacity when the air source cooling-only system has been continuously operated for a first predefined period of time and an absolute value of a temperature difference between inlet and outlet water is less than a first predefined value;

in step (iii), the cumulative score is increased by a first score when the compressor speed or capacity is greater than or equal to the minimum speed or capacity, and the method returns to step S1 when the compressor speed or capacity is less than the predefined speed or capacity.

[0017] Optionally, in step (ii), a superheat degree is compared with a sum of a superheat degree setting value and a third predefined value when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, a supercooling degree is less than a second predefined value, and an expansion valve opening degree is equal to a predefined opening degree; and

in step (iii), the cumulative score is increased by a second score when the superheat degree is greater than the sum of the superheat degree setting value and the third predefined value, and the method returns to step (i) when the superheat degree is not greater than the sum of the superheat degree setting value and the third predefined value.

[0018] Optionally, in step (ii), a compressor discharge pressure is compared with a first predefined pressure when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, the supercooling degree is less than the second predefined value, and the expansion valve opening degree is not equal to the predefined opening degree; and

in step (iii), the cumulative score is increased by a third score when the compressor discharge pressure is less than the first predefined pressure, and the method returns to step (i) when the compressor discharge pressure is not less than the first predefined pressure.

[0019] Optionally, in step (ii), the supercooling degree is compared with a predefined supercooling degree when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, and the supercooling degree is not less than the second predefined value; and

in step (iii), the cumulative score is increased by a fourth score when the supercooling degree is less than the predefined supercooling degree, and the method returns to step (i) when the supercooling degree is not less than the predefined supercooling degree.

[0020] Optionally, the method further comprises the following steps:

(iib): when a second predefined period of time elapses after the air source cooling-only system is shut down, comparing the compressor discharge pressure of the air source cooling-only system with a second predefined pressure, and/or comparing a reservoir level with a predefined reservoir level;

(iiib): determining that the refrigerant leakage has occurred when the compressor discharge pressure of the air source cooling-only system is less than the second predefined pressure and/or the reservoir level is below the predefined reservoir level.

[0021] Optionally, in step (ii), the preset operating parameter interval is a preset value, a preset table, or a preset diagram.

[0022] Optionally, the method further comprises step (v): sending a warning signal if it is determined that the refrigerant leakage has occurred.

[0023] Optionally, the first predefined value is 1 degree Celsius.

[0024] Optionally, step (i) comprises obtaining one or more of the following operating parameters: whether the air source cooling-only system is operating, time elapsed since the air source cooling-only system is shut down, time elapsed since the air source cooling-only system operates, a water outlet temperature, a water inlet temperature, the expansion valve opening degree, the supercooling degree, the superheat degree, the compressor discharge pressure, and the reservoir level.

[0025] The device and the method for detecting a refrigerant leakage of an air source cooling-only system according to at least the preferred embodiments of the present invention are simple and reliable, easy in implementation, convenient in application and so on, and can provide automatic detection of a refrigerant leakage, improving the operating efficiency and safety of modules.

[0026] The present invention will be described in further details below with reference to the accompanying drawings and preferred embodiments. However, those skilled in the art will understand that the drawings are drawn only for explaining the preferred embodiments and thus should not be taken as limiting the scope of the present invention. Moreover, unless expressly specified otherwise, the drawings are only intended to conceptually illustrate compositions or a construction of a described object and may comprise an exaggerated display, and the drawings are not necessarily drawn to scale.

FIG. 1 is a schematic view of a device for detecting a refrigerant leakage of an air source cooling-only system.

FIG. 2 is a flowchart of a method for detecting a refrigerant leakage of an air source cooling-only system.

FIG. 3 is a detailed flowchart of the device shown in FIG. 1.

[0027] The preferred embodiments of the present invention will be described in detail below with reference to the accompanying drawings. Those skilled in the art will understand that the description is only illustrative and exemplary, and should not be construed as limiting the scope of the present invention.

[0028] First of all, it is noted that positional terms such as top, bottom, upward, and downward mentioned herein are defined with respect to directions in each of the drawings, they are relative concepts and thus can vary according to different locations and different practical states thereof. Therefore, these or other positional terms should not be construed as limiting terms.

[0029] In addition, it is also noted that any single technical feature described or implied in the embodiments herein or any single technical feature shown or implied in the drawings can still continue to be combined among these technical features (or equivalents thereof), so as to obtain other embodiments of the present invention that are not directly mentioned herein.

[0030] It should be noted that the same reference numbers in different figures refer to the same or substantially the same assemblies.

[0031] FIG. 1 is a schematic view of a device for detecting a refrigerant leakage of an air source cooling-only system. Herein, the device for detecting a refrigerant leakage of an air source cooling-only system comprises a data obtaining module 100, configured to obtain an operating parameter of the air source cooling-only system; a data comparison module 200, configured to compare the operating parameter with a preset operating parameter interval; a cumulative score updating module 300, configured to update a cumulative score when the operating parameter falls within the preset operating parameter interval; and a refrigerant leakage determination module 400, configured to determine that a refrigerant leakage has occurred when the cumulative score exceeds a predefined cumulative score, and to continue to operate the data obtaining module 100 when the cumulative score does not exceed the predefined cumulative score.

[0032] In one example, the data comparison module 200 comprises a compressor speed or capacity comparison module 210. The compressor speed or capacity comparison module 210 is configured to compare a compressor speed (compresser_spd) or capacity with a minimum speed (minimum_spd) or capacity when the air source cooling-only system has been continuously operated for a first predefined period of time and an absolute value of a temperature difference between inlet and outlet water is less than a first predefined value; and the cumulative score updating module 300 is configured to increase the cumulative score by a first score when the compressor speed or capacity is greater than or equal to the minimum speed or capacity (as shown at module 310).

[0033] In another example, the data comparison module 200 comprises a superheat comparison module 220; the superheat comparison module 220 is configured to compare a superheat degree (SH) with a sum of a superheat degree setting value (SH_sp) and a third predefined value (DT3) when the air source cooling-only system has been continuously operated for the first predefined period of time (N2), the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value (DT1), a supercooling degree is less than a second predefined value (DT2), and an expansion valve opening degree (EXV_open) is equal to a predefined opening degree; the cumulative score updating module 300 is configured to continue to operate the data obtaining module 100 when the superheat degree is not greater than the sum of the superheat degree setting value and the third predefined value; and the cumulative score updating module 300 is further configured to increase the cumulative score by a second score when the superheat degree is greater than the sum of the superheat degree setting value and the third predefined value (as shown at module 320).

[0034] In another example, the data comparison module 200 comprises a first pressure comparison module 230; the first pressure comparison module 230 is configured to compare a compressor discharge pressure (HP) with a first predefined pressure (HP_predefined) when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, the supercooling degree is less than the second predefined value, and the expansion valve opening degree is not equal to the predefined opening degree; the cumulative score updating module 300 is configured to continue to operate the data obtaining module 100 when the compressor discharge pressure (HP) is not less than the first predefined pressure; and the cumulative score updating module 300 is further configured to increase the cumulative score by a third score when the compressor discharge pressure (HP) is less than the first predefined pressure (as shown at module 330).

[0035] In another example, the data comparison module 200 comprises a supercooling degree comparison module 240; the supercooling degree comparison module 240 is configured to compare the supercooling degree (SC) with a predefined supercooling degree (SC_predefined) when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, and the supercooling degree is not less than the second predefined value; the cumulative score updating module 300 is configured to continue to operate the data obtaining module 100 when the supercooling degree is not less than the predefined supercooling degree; and the cumulative score updating module 300 is further configured to increase the cumulative score by a fourth score when the supercooling degree is less than the predefined supercooling degree (as shown at module 340).

[0036] In another example, the data comparison module 200 comprises a second pressure comparison module and/or a reservoir level comparison module 250; the second pressure comparison module and/or the reservoir level comparison module 250 is configured to operate when a second predefined period of time (N1) elapses after the air source cooling-only system is shut down; and wherein the second pressure comparison module is configured to compare the compressor discharge pressure of the air source cooling-only system with a second predefined pressure, and/or the reservoir level comparison module is configured to compare a reservoir level with a predefined reservoir level; and the refrigerant leakage determination module 400 is configured to determine that the refrigerant leakage has occurred when the compressor discharge pressure of the air source cooling-only system is less than the second predefined pressure and/or the reservoir level is below the predefined reservoir level.

[0037] The preset operating parameter interval may be a preset value, a preset table, or a preset diagram. The preset value, preset table, or preset diagram can be prestored in a memory.

[0038] The device for detecting a refrigerant leakage can further comprise a warning module 500 configured to send a leakage warning signal when the refrigerant leakage determination module 400 determines that the refrigerant leakage has occurred. The warning signal can be an image signal, a sound signal, or a combination thereof.

[0039] The first predefined value may be 1 degree Celsius.

[0040] The predefined opening degree may be 100%.

[0041] In one example, the operating parameter comprises one or more of the following: an operating state of the air source cooling-only system, a shutdown state of the air source cooling-only system, time elapsed since the air source cooling-only system is shut down, time elapsed since the air source cooling-only system operates, a water outlet temperature, a water inlet temperature, an expansion valve opening degree, a supercooling degree, a superheat degree, a compressor discharge pressure, and a reservoir level.

[0042] FIG. 2 is a flowchart of a method for detecting a refrigerant leakage of an air source cooling-only system. Herein, the method for detecting a refrigerant leakage of an air source cooling-only system comprises the following steps:

S1: obtaining an operating parameter of the air source cooling-only system;

S2: comparing the operating parameter with a preset operating parameter interval;

S3: updating a cumulative score when the operating parameter falls within the preset operating parame-

ter interval;

S4: determining that a refrigerant leakage has occurred when the cumulative score exceeds a predefined cumulative score, and returning to step S1 when the cumulative score does not exceed the predefined cumulative score.

[0043] In one example, in step S2, the compressor speed or capacity is compared with a minimum speed or capacity when the air source cooling-only system has been continuously operated for a first predefined period of time and an absolute value of a temperature difference between inlet and outlet water is less than a first predefined value; and in step S3, the cumulative score is increased by a first score when the compressor speed or capacity is greater than or equal to the minimum speed or capacity, and the method returns to step S1 when the compressor speed or capacity is less than the predefined speed or capacity.

[0044] In another example, in step S2, a superheat degree is compared with a sum of a superheat degree setting value and a third predefined value when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, a supercooling degree is less than a second predefined value, and an expansion valve opening degree is equal to a predefined opening degree; and in step S3, the cumulative score is increased by a second score when the superheat degree is greater than the sum of the superheat degree setting value and the third predefined value, and the method returns to step S1 when the superheat degree is not greater than the sum of the superheat degree setting value and the third predefined value.

[0045] In another example, in step S2, a compressor discharge pressure is compared with a first predefined pressure when the air source cooling-only system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, the supercooling degree is less than the second predefined value, and the expansion valve opening degree is not equal to the predefined opening degree; and in step S3, the cumulative score is increased by a third score when the compressor discharge pressure is less than the first predefined pressure, and the method returns to step S1 when the compressor discharge pressure is not less than the first predefined pressure.

[0046] In another example, in step S2, the supercooling degree is compared with a predefined supercooling degree when the air source cooling-only cycle system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, and the supercooling degree is not less than the second predefined value; and in step S3, the cumulative score is increased by a fourth score when the supercooling degree is less than the predefined supercooling degree, and the method returns to step S1 when the supercooling degree is not less than the predefined supercooling degree.

[0047] In some examples, the method further comprises the following steps:

S2.1: when a second predefined period of time elapses after the air source cooling-only system is shut down, comparing the compressor discharge pressure of the air source cooling-only system with a second predefined pressure, and/or comparing a reservoir level with a predefined reservoir level; and

S3.1: determining that the refrigerant leakage has occurred when the compressor discharge pressure of the air source cooling-only system is less than the second predefined pressure and/or the reservoir level is below the predefined reservoir level.

[0048] The preset operating parameter interval described in step S2 may be a preset value, a preset table, or a preset diagram. The preset value, preset table, or preset diagram can be stored in an accessible memory.

[0049] In some examples, the method further comprises step S5 in which a warning signal is sent if it is determined that the refrigerant leakage has occurred. The warning signal can be an image signal, a sound signal, or a combination thereof.

[0050] The first predefined value may be 1 degree Celsius.

[0051] The predefined opening degree may be 100%.

[0052] In one example, step S1 comprises obtaining one or more of the following operating parameters: whether the air source cooling-only system is operating, time elapsed since the air source cooling-only system is shut down, time elapsed since the air source cooling-only system operates, a water outlet temperature, a water inlet temperature, an expansion valve opening degree, a supercooling degree, a superheat degree, a compressor discharge pressure, and a reservoir level.

[0053] FIG. 3 is a detailed flowchart of the device shown in FIG. 1. Herein, when a cooling system is in a cooling mode, whether the cooling system is operating is continuously monitored. If it is found that the system has been shut down for a longer duration than a second predefined period of time, steps S2.1 and S3.1 described above are performed; and when it is determined that a refrigerant leakage has occurred, a warning signal is sent.

[0054] If it is found that the system has been operated for a longer duration than a first predefined period of time, then whether an absolute value of a temperature difference between inlet and outlet water is less than a first predefined value is detected. If the absolute value of the temperature difference between inlet and outlet water is less than the first predefined value, then a compressor speed or capacity check is performed.

[0055] If the absolute value of the temperature differ-

ence between inlet and outlet water is not less than the first predefined value, then an operating parameter of an air-cooled heat pump system is obtained, including reading an expansion valve opening degree, a supercooling degree, and a superheat degree from the air-cooled heat pump system; and whether the supercooling degree is less than a second predefined value is determined. If the supercooling degree is not less than the second predefined value, then a supercooling degree check is performed.

[0056] If the supercooling degree is less than the second predefined value, then whether the expansion valve opening degree is equal to a predefined opening degree is determined continuously; if the expansion valve opening degree is equal to the predefined opening degree, then a superheat degree check is performed; and if the expansion valve opening degree is not equal to the predefined opening degree, then a compressor discharge pressure check is performed.

[0057] In each of the checking steps described above, if a checked operating parameter falls within a predefined range, then a cumulative score is respectively increased by a different value. When the cumulative score reaches a predefined cumulative score, it is determined that a refrigerant leakage has occurred and a warning signal is sent. Herein, in the compressor speed or capacity check, if a compressor speed or capacity is greater than or equal to a minimum speed or capacity, the cumulative score is increased by a first score; in the superheat degree check, if a superheat degree is greater than a sum of a superheat degree setting value and a third predefined value, the cumulative score is increased by a second score; in the compressor discharge pressure check, if a compressor discharge pressure is less than a first predefined pressure, the cumulative score is increased by a third score; and in the supercooling degree check, if a supercooling degree is less than a predefined supercooling degree, the cumulative score is increased by a fourth score. Herein, each of the checking steps described above can be used alone or in combination; and when a combination is performed, two or more than two or all of the checking steps can be used.

[0058] In one example, an initial value of the cumulative score is 0; the first score is 5; the second score is 3; the third score is 2; and the fourth score is 1. When the cumulative score reaches 15 (i.e., the predefined cumulative score), it is determined that a refrigerant leakage has occurred and a leakage warning signal is sent.

[0059] The device and the method for detecting a refrigerant leakage are applicable to an air source cooling-only cycle cooling system which is preferably air-cooled. The device and the method for detecting a refrigerant leakage can automatically detect whether a refrigerant leakage has occurred in a cooling system without using other apparatuses for manual detection, which effectively improves the operating efficiency of the cooling system and has good economic benefits.

[0060] The specification discloses example embodiments of the present invention with reference to the drawings, and also allows those skilled in the art to implement the present invention, including making and using any device or module, selecting a suitable material, and using any combined method. The scope of the present invention is defined by the claims.

Claims

1. A device for detecting a refrigerant leakage of an air source cooling-only cycle system, comprising:

   a data obtaining module (100), configured to obtain an operating parameter of the air source cooling-only cycle system, wherein the operating parameter comprises at least a compressor speed or capacity;
   a data comparison module (200), configured to compare the operating parameter with a preset operating parameter interval;
   a cumulative score updating module (300), configured to update a cumulative score when the operating parameter falls within the preset operating parameter interval; and
   a refrigerant leakage determination module (400), configured to determine that a refrigerant leakage has occurred when the cumulative score exceeds a predefined cumulative score, and to continue to operate the data obtaining module when the cumulative score does not exceed the predefined cumulative score.

2. The device for detecting a refrigerant leakage according to claim 1, wherein
   the data comparison module (200) comprises a compressor speed or capacity comparison module (210);
   the compressor speed or capacity comparison module is configured to compare the compressor speed or capacity with a predefined speed or capacity when the air source cooling-only cycle system has been continuously operated for a first predefined period of time and an absolute value of a temperature difference between inlet and outlet water is less than a first predefined value; and
   the cumulative score updating module (300) is configured to increase the cumulative score by a first score when the compressor speed or capacity is greater than or equal to the predefined speed or capacity;
   optionally wherein the first predefined value is 1 degree Celsius.

3. The device for detecting a refrigerant leakage according to claim 2, wherein
   the data comparison module (200) comprises a superheat comparison module (220);
   the superheat comparison module is configured to

compare a superheat degree with a sum of a superheat degree setting value and a third predefined value when the air source cooling-only cycle system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, a supercooling degree is less than a second predefined value, and an expansion valve opening degree reaches a predefined opening degree;
the cumulative score updating module is configured to continue to operate the data obtaining module when the superheat degree is not greater than the sum of the superheat degree setting value and the third predefined value; and
the cumulative score updating module is further configured to increase the cumulative score by a second score when the superheat degree is greater than the sum of the superheat degree setting value and the third predefined value.

4. The device for detecting a refrigerant leakage according to claim 3, wherein
the data comparison module (200) comprises a first pressure comparison module (230);
the first pressure comparison module (300) is configured to compare a compressor discharge pressure with a first predefined pressure when the air source cooling-only cycle system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, the supercooling degree is less than the second predefined value, and the expansion valve opening degree is not equal to the predefined opening degree;
the cumulative score updating module (300) is configured to continue to operate the data obtaining module when the compressor discharge pressure is not less than the first predefined pressure; and
the cumulative score updating module is further configured to increase the cumulative score by a third score when the compressor discharge pressure is less than the first predefined pressure; optionally wherein
the data comparison module (200) comprises a supercooling degree comparison module (240);
the supercooling degree comparison module is configured to compare the supercooling degree with a predefined supercooling degree when the air source cooling-only cycle system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, and the supercooling degree is not less than the second predefined value;
the cumulative score updating module (300) is configured to continue to operate the data obtaining module when the supercooling degree is not less than the predefined supercooling degree; and
the cumulative score updating module (300) is further configured to increase the cumulative score by a fourth score when the supercooling degree is less than the predefined supercooling degree.

5. The device for detecting a refrigerant leakage according to any preceding claim, wherein the device further comprises:

the data comparison module (200) comprising a second pressure comparison module and/or a reservoir level comparison module (250);
the second pressure comparison module and/or the reservoir level comparison module is configured to operate when a second predefined period of time elapses after the air source cooling-only cycle system is shut down; and wherein the second pressure comparison module is configured to compare the compressor discharge pressure with a second predefined pressure, and/or the reservoir level comparison module is configured to compare a reservoir level with a predefined reservoir level; and
the refrigerant leakage determination module (400) is configured to determine that the refrigerant leakage has occurred when the compressor discharge pressure of the air source cooling-only cycle system is less than the second predefined pressure and/or the reservoir level is below the predefined reservoir level.

6. The device for detecting a refrigerant leakage according to any preceding claim, wherein the preset operating parameter interval is a preset value, a preset table, or a preset diagram.

7. The device for detecting a refrigerant leakage according to any preceding claim, wherein the device further comprises:
a warning module (500), configured to send a leakage warning signal when it is determined that the refrigerant leakage has occurred.

8. The device for detecting a refrigerant leakage according to any preceding claim, wherein the operating parameter comprises one or more of the following: an operating state of the air source cooling-only cycle system, a shutdown state of the air source cooling-only cycle system, time elapsed since the air source cooling-only cycle system is shut down, time elapsed since the air source cooling-only cycle system operates, a water outlet temperature, a water inlet temperature, an expansion valve opening degree, a supercooling degree, a superheat degree, a compressor discharge pressure, and a reservoir level.

9. A method for detecting a refrigerant leakage of an air source cooling-only cycle system, comprising the following steps:

(i): obtaining an operating parameter of the air source cooling-only cycle system, wherein the operating parameter comprises at least a compressor speed or capacity;
(ii): comparing the operating parameter with a preset operating parameter interval;
(iii): updating a cumulative score when the operating parameter falls within the preset operating parameter interval;
(iv): determining that a refrigerant leakage has occurred when the cumulative score exceeds a predefined cumulative score, and returning to step (i) when the cumulative score does not exceed the predefined cumulative score.

10. The method for detecting a refrigerant leakage according to claim 9, wherein
in step (ii), the compressor speed or capacity is compared with a predefined speed or capacity when the air source cooling-only cycle system has been continuously operated for a first predefined period of time and an absolute value of a temperature difference between inlet and outlet water is less than a first predefined value; and
in step (iii), the cumulative score is increased by a first score when the compressor speed or capacity is greater than or equal to the predefined speed or capacity, and the method returns to step (i) when the compressor speed or capacity is less than the predefined speed or capacity,
optionally wherein the first predefined value is 1 degree Celsius.

11. The method for detecting a refrigerant leakage according to claim 10, wherein
in step (ii), a superheat degree is compared with a sum of a superheat degree setting value and a third predefined value when the air source cooling-only cycle system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, a supercooling degree is less than a second predefined value, and an expansion valve opening degree is equal to a predefined opening degree; and
in step (iii), the cumulative score is increased by a second score when the superheat degree is greater than the sum of the superheat degree setting value and the third predefined value, and the method returns to step (i) when the superheat degree is not greater than the sum of the superheat degree setting value and the third predefined value.

12. The method for detecting a refrigerant leakage according to claim 11, wherein
in step (ii), a compressor discharge pressure is compared with a first predefined pressure when the air source cooling-only cycle system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, the supercooling degree is less than the second predefined value, and the expansion valve opening degree is not equal to the predefined opening degree; and
in step (iii), the cumulative score is increased by a third score when the compressor discharge pressure is less than the first predefined pressure, and the method returns to step (i) when the compressor discharge pressure is not less than the first predefined pressure, optionally wherein:

in step (ii), the supercooling degree is compared with a predefined supercooling degree when the air source cooling-only cycle system has been continuously operated for the first predefined period of time, the absolute value of the temperature difference between inlet and outlet water is not less than the first predefined value, and the supercooling degree is not less than the second predefined value; and
in step (iii), the cumulative score is increased by a fourth score when the supercooling degree is less than the predefined supercooling degree, and the method returns to step (i) when the supercooling degree is not less than the predefined supercooling degree.

13. The method for detecting a refrigerant leakage according to any of claims 9 to 12, wherein the method further comprises:

(iib) when a second predefined period of time elapses after the air source cooling-only cycle system is shut down, comparing the compressor discharge pressure of the air source cooling-only cycle system with a second predefined pressure, and/or comparing a reservoir level with a predefined reservoir level; and
(iiib) determining that the refrigerant leakage has occurred when the compressor discharge pressure of the air source cooling-only cycle system is less than the second predefined pressure and/or the reservoir level is below the predefined reservoir level;
and/or wherein the method further comprises:
(v) sending a warning signal if it is determined that the refrigerant leakage has occurred.

14. The method for detecting a refrigerant leakage according to any of claims 9 to 13, wherein in step (ii), the preset operating parameter interval is a preset

value, a preset table, or a preset diagram.

15. The method for detecting a refrigerant leakage according to any of claims 9 to 14, wherein step (i) comprises obtaining one or more of the following operating parameters: whether the air source cooling-only cycle system is operating, time elapsed since the air source cooling-only cycle system is shut down, time elapsed since the air source cooling-only cycle system operates, a water outlet temperature, a water inlet temperature, an expansion valve opening degree, a supercooling degree, a superheat degree, a compressor discharge pressure, and a reservoir level.

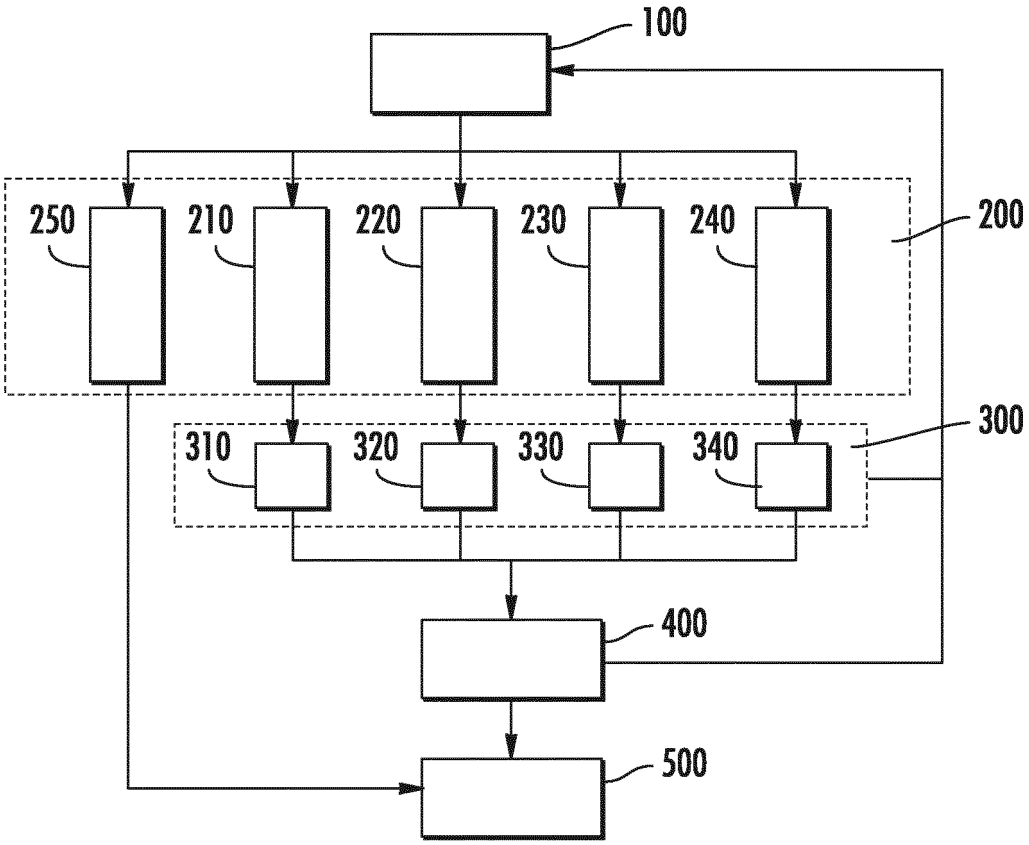

FIG. 1

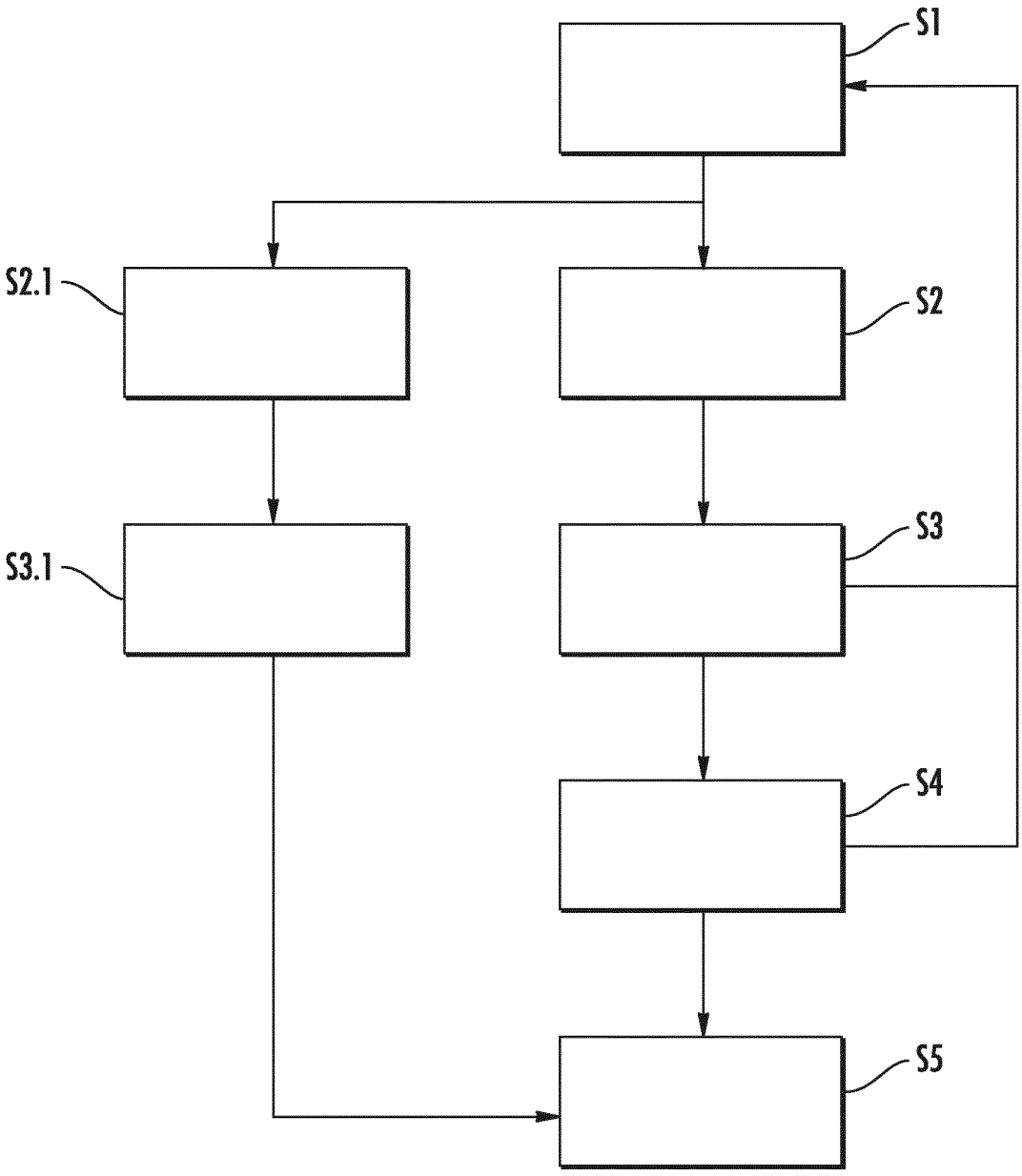

FIG. 2

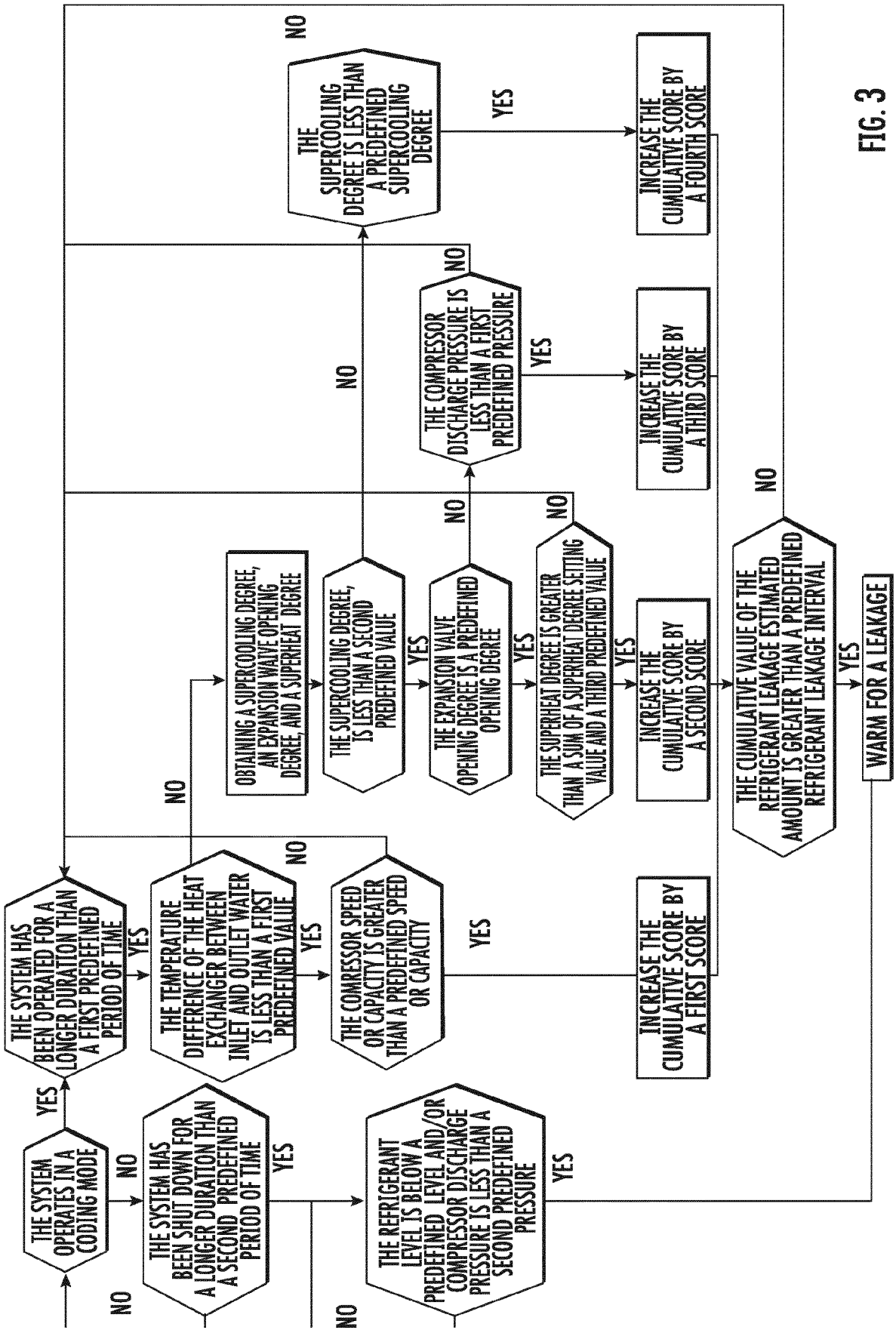
THE SYSTEM OPERATES IN A COOLING MODE
YES
NO
THE SYSTEM HAS BEEN SHUT DOWN FOR A LONGER DURATION THAN A SECOND PREDEFINED PERIOD OF TIME
YES
NO
THE REFRIGERANT LEVEL IS BELOW A PREDEFINED LEVEL AND/OR COMPRESSOR DISCHARGE PRESSURE IS LESS THAN A SECOND PREDEFINED PRESSURE
YES
NO
THE SYSTEM HAS BEEN OPERATED FOR A LONGER DURATION THAN A FIRST PREDEFINED PERIOD OF TIME
YES
NO
THE TEMPERATURE DIFFERENCE OF THE HEAT EXCHANGER BETWEEN INLET AND OUTLET WATER IS LESS THAN A FIRST PREDEFINED VALUE
YES
NO
THE COMRESSOR SPEED OR CAPACITY IS GREATER THAN A PREDEFINED SPEED OR CAPACITY
YES
NO
INCREASE THE CUMULATIVE SCORE BY A FIRST SCORE
OBTAINING A SUPERCOOLING DEGREE, AN EXPANSION WAIVE OPENING DEGREE, AND A SUPERHEAT DEGREE
THE SUPERCOOLING DEGREE, IS LESS THAN A SECOND PREDEFINED VALUE
YES
NO
INCREASE THE CUMULATIVE SCORE BY A SECOND SCORE
THE EXPANSION VALVE OPENING DEGREE IS A PREDEFINED OPENING DEGREE
YES
NO
INCREASE THE CUMULATIVE SCORE BY A THIRD SCORE
THE SUPERHEAT DEGREE IS GREATER THAN A SUM OF A SUPERHEAT DEGREE SETTING VALUE AND A THIRD PREDEFINED VALUE
YES
NO
INCREASE THE CUMULATIVE SCORE BY A FOURTH SCORE
THE SUPERCOOLING DEGREE IS LESS THAN A PREDEFINED SUPERCOOLING DEGREE
YES
NO
THE COMPRESSOR DISCHARGE PRESSURE IS LESS THAN A FIRST PREDEFINED PRESSURE
YES
NO
THE CUMULATIVE VALUE OF THE REFRIGERANT LEAKAGE ESTIMATED AMOUNT IS GREATER THAN A PREDEFINED REFRIGERANT LEAKAGE INTERVAL
YES
WARM FOR A LEAKAGE

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 19 16 7627

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	JP 2017 053566 A (JOHNSON CONTROLS HITACHI AIR CONDITIONING TECH LTD) 16 March 2017 (2017-03-16) * paragraphs [0047] - [0057]; figures 1,6 * -----	1,6,7,9, 14 2-5,8, 10-13,15	INV. F25B30/00 F25B49/00
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Place of search	Date of completion of the search	Examiner
Munich	14 June 2019	Amous, Moez

CATEGORY OF CITED DOCUMENTS

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