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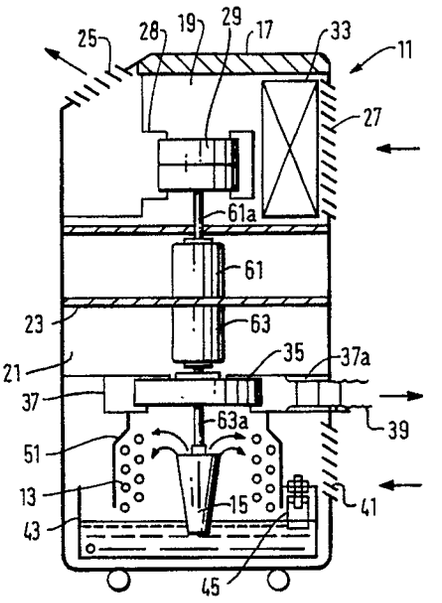
(54) Portable air conditioning apparatus and method for controlling the same.

(57) An exhaustion fan device of a portable air conditioning apparatus, which includes an evaporation type condenser cooled by water and air discharged to the outside of a defined space to be cooled, is stopped when the actual temperature Ta in the defined space reaches a prescribed value Ts to decrease an amount of water conveyed by air exhausted from the defined space to the outside of the defined space through the condenser. In addition, the stopping of the exhaustion fan device prevents the actual temperature Ta in the defined space from fluctuating after the actual temperature Ta reaches the prescribed value Ts by decreasing the amount of air entering into the defined space from the outside of the defined space.

FIG. 3



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PORTABLE AIR CONDITIONING APPARATUS AND METHOD FOR CONTROLLING THE SAME

This invention relates, in general, to air conditioning apparatus. In particular, the invention relates to a portable air conditioning apparatus which includes a refrigerating circuit unit having a compressor, a condenser and an exhaustion fan device, and an air conditioning unit having an evaporator and a circulation fan device in a common casing. The portable air conditioning apparatus usually is disposed in a room to be air-conditioned.

As shown in FIGURES 1 and 2, a well known portable air conditioning apparatus 11 typically includes an evaporation type condenser 13 and a spray device 15, which sprays water onto evaporation type condenser 13 to cool condenser 13. A casing 17 of air conditioning apparatus 11 is partitioned into an upper chamber 19 and a lower chamber 21 with a partition plate 23. A conditioned air discharging opening 25 is formed in the front surface of casing 17. An air intake opening 27 is formed in the rear surface of casing 17. A fan casing 28 is arranged in upper chamber 19 and opens to conditioned air discharge opening 25. A circulation fan 29 is rotatably disposed in fan casing 28, and is supported by one of the rotatable shafts 31a of a two-shaft motor 31 arranged in lower chamber 21. An evaporator 33 is disposed in upper chamber 19 so as to be opposite to air intake opening 27.

An exhaustion fan 35 and the above-described spray device 15 are coaxially supported by the other rotatable shaft 31b of two-shaft motor 31 in lower chamber 21. Exhaustion fan 35 is a centrifugal fan device, and is disposed between two-shaft motor 31 and spray device 15. An exhaustion fan casing 37 is disposed around exhaustion fan 35. A flexible guide hose 39 is inserted into an outlet 37a of exhaustion fan casing 37 to guide air from exhaustion fan 35 to the external atmosphere (outside of the room). A second air intake opening 41 is formed in the rear surface of casing 17 close to outlet 37a of exhaustion fan casing 37 to take air from the room into lower chamber 21 of casing 17.

Spray device 15 includes a cylinder 15a, the diameter of which gradually increases from the lower end toward the upper end. A plurality of fins 15b extend from the inner peripheral wall of cylinder 15a toward rotatable shaft 31b, and each extended end of fins 15b is fixed to a hub (Not shown) which is firmly fixed to rotatable shaft 31b of motor 31. The lower end of cylinder 15a of spray device 15 is dipped into water in a water tank 43 disposed on the bottom surface of casing 17. Water tank 43 is provided with a float switch 45 to detect the level of water stored in water tank 43. A water supply tank 47 is disposed in casing 17, as shown in FIGURE 1. The lower portion 47a of water supply tank 47 is connected to water tank 43 through a pipe 49 to supply water stored in water supply tank 47 to water tank 43. A compressor 51 is located parallel to water supply tank 47 in casing 17.

As shown in FIGURE 2, evaporation type condenser 13 is coiled around the periphery of cylinder 15a of spray device 15 so as to maintain a predetermined distance between coiled condenser 13 and cylinder 15a. A cylindrical cover 51 is disposed outside condenser 13 to prevent water sprayed by spray device 15 from being scattered to lower chamber 21.

The refrigerating circuit unit of the above-described air conditioning apparatus 11 includes compressor 51, evaporation type condenser 13, spray device 15, water supply tank 47 and exhaustion fan 35. The air conditioning unit of the above-described air conditioning apparatus 11 includes evaporator 33 and circulation fan 29. Compressor 51, evaporation type condenser 13, a capillary tube (not shown), and evaporator 33 are connected serially to perform a refrigerating cycle operation.

When the cooling operation is executed by the above-described conventional air conditioning apparatus, compressor 51 and two-shaft motor 31 are operated. Thus, circulation fan 29, exhaustion fan 35 and spray device 15 are driven by motor 31. Internal air is taken into upper chamber 19 of casing 17 through air intake opening 27, and is cooled by evaporator 33. The cooled air is discharged to the room. Thus, air in the room is circulated by circulation fan 29 through evaporator 33 during the air conditioning operation. When exhaustion fan 35 is driven, the internal air also is taken into lower chamber 21 of casing 17 through second air intake opening 41 to cool condenser 13. After cooling condenser 13, the air is exhausted to the outside of the room through exhaustion fan 35 and air guide hose 39.

At this time, spray device 15 also cools condenser 13. Water in water tank 43 is drawn up by spray device 15, and is sprayed from the upper end portion of spray device 15 in the centrifugal direction. Thus, the sprayed water falls on condenser 13 to cool condenser 13. Condensation of refrigerant in condenser 13 is promoted by the evaporation of the water on condenser 13, resulting in the enhancement of heat-exchange efficiency of condenser 13.

In the above-described conventional air conditioning apparatus, compressor 51 is stopped when the actual room temperature detected by a temperature sensor (not shown) is below the pre-

scribed set temperature. However, the circulation fan 29 is continuously operated to circulate air in the room. Exhaustion fan 35 also continues to operate because of the rotation of two-shaft motor 31. Thus, the spray of water to condenser 13 by spray device 15 and the exhaustion of air to the ourside of the room by exhaustion fan 35 continue even if compressor 51 is stopped and the flow of refrigerant is stopped. As a result, water scattered by spray device 15 and water spontaneously evaporated from water tank 43 are exhausted together with the air discharged by the exhaustion fan 35. This results in an increase in the consumption of water stored in water tank 43. It is rather troublesome to frequently replenish the water supply tank 47 with water.

In addition, in the above-described conventional air oonditioning apparatus, since air is constantly exhausted from the room through exhaustion fan 35 and air guide hose 39, an amount of hot air corresponding to the amount of exhausted air must enter the room from the outside. Thus, the actual room temperature tends to fluctuate and a comfortable air conditioning can not be achieved.

The present invention seeks to provide an apparatus which alleviates the problems of the known apparatus.

Accordingly to the present invention, there is provided a portable air conditioning apparatus including a compressor which is stopped when the actual temperature Ta in a defined space reaches a set temperature Ts, the apparatus comprising:
means for conditioning air in the defined space, the conditioning means having a condenser cooled by air and water, a part of the water being subject to evaporation;
exhaustion fan means operating at a prescribed rotational speed Es for exhausting air through the condenser to the outside of the defined space, the exhausted air conveying the evaporated water to the outside of the defined space;
means for driving the exhaustion fan means; and
means for controlling the driving mans to decrease the amount of water conveyed by the exhausted air to the outside of the defined space when the actual temperature Ta reaches the set temperature Ts.

The controlling section may include an operation section for decreasing the rotational speed of the exhaustion fan device through the driving device when the actual temperature Ta reaches the set temperature Ts.

The operation section may include an air exhaustion regulator section for regulating the rotational speed of the exhaustion fan device at a predetermined rotational speed El lower than the prescribed rotational speed Es when the actual temperature Ta reaches the set temperature Ts.

According to a second aspect of the present invention, there is provided a portable air conditioning apparatus including a compressor which is stopped when the actual temperature Ta in a defined space reaches a set temperature Ts, the apparatus comprising:
an outer casing for defining an inner space;
an evaporator disposed in the outer casing;
circulation fan means for taking air into the inner space from the defined space through the evaporator;
a condenser disposed in the outer casing;
water tank means, arranged in the outer casing, for storing water;
spray means for supplying water from the water tank means to the condenser to cool the condenser;
exhaustion fan means rotating at a predetermined rotational speed Es for taking air from the outside of the casing and for exhausting the air to the outside of the defined space through the condenser, wherein air from outside the defined space enters into the defined space as air in the defined space is exhausted to the outside of the defined space; and
control means for decreasing the amount of air entering the defined space from outside the defined space when the compressor is stopped in comparison with the amount that enters when the compressor operates.

According to the a third aspect of the present invention, there is provided a method for controlling a portable air conditioning apparatus wherein a condenser is cooled by both water and air which are exhausted by an exhaustion fan to the outside of a defined space through the condenser, and a compressor is stopped when an actual temperature Ta in the defined space reaches a set temperature Ts, including the step of:
decreasing the rotational speed of the exhaustion fan to a prescribed rotational speed when the actual temperature Ta reaches the set temperature Ts.

For a better understanding of the present invention, and to show how it may be brought into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

FIGURE 1 is a partial cross sectional view in perspective of a conventional air conditioning apparatus;

FIGURE 2 is a sectional side view illustrating the air conditioning apparatus shown in FIGURE 1;

FIGURE 3 is a sectional side view illustrating the air conditioning apparatus of one embodiment of the present invention;

FIGURE 4 is a block diagram illustrating the refrigerating circuit and the control circuit of the air conditioning apparatus shown in FIGURE 3; and

FIGURE 5 is a flow chart showing the operation of the air conditioning apparatus shown in FIGURE 3.

A preferred embodiment of the present invention will be described in more detail with reference to the accompanying drawings. However, in the drawings, the same numerals are applied to like structural elements, and therefore the detailed descriptions thereof are not repeated.

As shown in FIGURE 3, first and second driving motors 61 and 63 are arranged on partition plate 23, instead of a single motor 31 as shown in FIGURE 2. First driving motor 61 is disposed on the surface of partition plate 23 which is exposed to upper chamber 19. The top of the rotation shaft 61a of first driving motor 61 is connected to circulation fan 29. Second driving motor 63 is arranged on the surface of partition plate 23 exposed to lower chamber 19. The rotation shaft 63a of second driving motor 63 is connected to exhaustion fan 35 and spray device 15.

As shown in FIGURE 4, compressor 51, evaporation type condenser 13, capillary tube 65 and evaporator 33 are serially connected to perform a refrigerating cycle operation. The output of a setting section 67 is input into a control section 69, which preferably includes a microcomputer and its peripheral circuits. Thus, when a user inputs a desired room temperature into setting section 67, setting section outputs a set signal indicating the desired room temperature (set temperature) to control section 69. A temperature detection section 71 detects an actual room temperature and outputs a detection signal indicating the actual room temperature to control section 69. Control section 69 compares the set signal fed from setting section 67 with the detection signal fed from temperature detection section 71, and independently controls the rotational speed of first and second driving motors 61 and 63 in accordance with the comparison result. Control section 69 also controls the compressing operation of compressor 51 based on the above-described comparison result. Compressor 51 and second driving motor 63 are operated until the actual room temperature is below the desired room temperature. When the actual room temperature is below the desired room temperature compressor 51 is stopped and the rotational speed of second driving motor 35 is decreased to a prescribed value lower than that of its normal operational state.

The rotational speed of first driving motor 61 is decreased to a predetermined value lower than that of its normal operational state when the difference between the actual room temperature and the set temperature is greater than one degree centigrade ($^{\circ}$C) after the actual room temperature reaches the set temperature.

The cooling operation of the above-described embodiment will now be described referring to FIGURE 5.

In step a, if the power of the air conditioning apparatus 11 is on, the YES-path is taken. Otherwise, the NO-path is taken. When the YES-path is taken in step a, the set temperature Ts set through setting section 67 is read into control section 69 in step b. In step c, the actual room temperature Ta detected by temperature detection section 71 also is read into control section 69. In step d, set temperature Ts is compared with actual room temperature Ta. If actual room temperature Ta is greater than set temperature Ts, the YES-path is taken. Otherwise, the NO-path is taken. When the YES-path is taken in step d, compressor 51 is driven in step e. Second driving motor 63 is driven to rotate exhaustion fan 35 and spray device 13 at a predetermined rotation value Es in step f. First driving motor 61 also is driven to rotate circulation fan 29 at a prescribed rotation speed Cs in step g. The above-described steps a, b, c, d, e, f, and g are repeatedly executed until the actual room temperature Ta is equal to or smaller than the set temperature Ts in step d. When the actual room temperature Ta is equal to or lower than the set temperature Ts in step d, the NO-path is taken. Compressor 51 is stopped in step h. Second driving motor 63 is de- energized to stop exhaustion fan 35 in step i. Thus, spray device 15 also is stopped. In step j, the actual room temperature Ta is further compared with a value calculated by subtracting one degree centigrade ($^{\circ}$C) from the set temperature Ts. When the actual room temperature Ta is equal to or lower than the value (Ts - 1], the YES-path is taken. First driving motor 61 is de-energized to stop circulation fan 29 in step k. Otherwise, the NO-path is taken in step j. The rotational speed of first driving motor 61 is maintained to keep the rotational speed of circulation fan 29 at the prescribed rotation value Cs in step 1. After the execution of step k or l, the above-described step a is reexecuted.

With the above-described embodiment, since exhaustion fan 35 is stopped when the actual room temperature Ts reaches the set temperature Ts, discharge of the water scattered by spray device 15 and the spontaneously evaporated water from water tank 43 to the outside the room are avoided. Thus, the frequency of water replenishment to water supply tank 47 can be reduced. In addition, since external hot air entering into the room also is avoided while compressor 51 stops, a comfortable air conditioning can be achieved. Furthermore, after the actual room temperature Ta is equal to or lower than the set temperature Ts, the difference between the actual room temperature Ta and the set temperature Ts is compared with a prescribed value and circulation fan 39 is stopped in accordance

with the result of this comparison. Thus, the comfortable air conditioning can be ensured.

In the above-described embodiment, exhaustion fan 35 is stopped when compressor 51 is stopped because the actual room temperature Ta is below the set temperature Ts. However, the rotational speed of exhaustion fan 35 may be decreased by control section to a predetermined value El smaller than the prescribed value Es at which exhaustion fan 35 rotates during the cooling operation to regulate air exhausted to the outside the room. Circulation fan 29 is stopped when the difference between the actual room temperature Ta and the set temperature Ts is greater than one degree centigrade (° C) after the actual room temperature Ta reaches the set temperature Ts. However, rather than stopping circulation fan 39, the rotational speed of circulation fan 39 may be decreased to a predetermined value Cl smaller than the prescribed value Cs at which circulation fan 39 rotates in the cooling operation to regulate air circulated in the room.

The present invention has been described with respect to a specific embodiment. However, other embodiments based on the principles of the present invention should be obvious to those of ordinary skill in the art. Such embodiments are intended to be covered by the claims.

Claims

1. A portable air conditioning apparatus including a compressor which is stopped when the actual temperature Ta in a defined space reaches a set temperature Ts, the apparatus comprising:
means for conditioning air in the defined space, the conditioning means having a condenser cooled by air and water, a part of the water being subject to evaporation;
exhaustion fan means operating at a prescribed rotational speed Es for exhausting air through the condenser to the outside of the defined space, the exhausted air conveying the evaporated water to the outside of the defined space;
means for driving the exhaustion fan means; and
means for controlling the driving means to decrease the amount of water conveyed by the exhausted air to the outside of the defined space when the actual temperature Ta reaches the set temperature Ts.

2. An apparatus according to claim 1, wherein the controlling means includes operation means for decreasing the rotational speed of the exhaustion fan means through the driving means when the actual temperature Ta reaches the set temperature Ts.

3. An apparatus according to claim 2, wherein the operation means includes air exhaustion regulator means for regulating the rotational speed of the exhaustion fan means at a predetermined rotational speed El lower than the prescribed rotational speed Es when the actual temperature Ta reaches the set temperature Ts.

4. An apparatus according to any preceding claim, wherein the conditioning means includes circulation fan means operating at a prescribed rotational speed Cs for circulating the conditioned air in the defined space.

5. An apparatus according to claim 4, wherein the driving means includes second driving means for driving the circulation fan means.

6. An apparatus according to claim 5, wherein the controlling means includes operation means for controlling the second driving means to decrease the rotational speed of the circulation fan means after the actual temperature Ta reaches the set temperature Ts.

7. An apparatus according to claim 6, wherein the operation means includes air circulation regulator means for regulating the rotational speed of the circulation fan means at a predetermined rotational speed Cl lower than the prescribed rotational speed Cs when the actual temperature Ta reaches a prescribed value below the set temperature Ts.

8. An apparatus according to claim 4, wherein the conditioning means includes water tank means for storing water supplied to the condenser.

9. An apparatus according to claim 8, wherein the conditioning means also includes spray means for spraying water in the water tank means to the condenser.

10. An apparatus according to claim 9, wherein the driving means includes means for independently driving the exhaustion fan means and the circulation fan means.

11. An apparatus according to claim 10, wherein the independently driving means includes first motor means for driving the exhaustion fan means and the spray means and second motor means for driving the circulation fan means.

12. An apparatus according to claim 11, wherein the controlling means includes operation means for independently controlling the first and the second motor means.

13. An apparatus according to claim 12, wherein the operation means includes air circulation regulator means for regulating the rotational speed of the circulation fan means at a predetermined rotational speed Cl lower than the prescribed rotational speed Cs when the actual temperature Ta reaches a prescribed value below the set temperature Ts.

14. A portable air conditioning apparatus including a compressor which is stopped when the actual temperature Ta in a defined space reaches a set temperature Ts, the apparatus comprising:
an outer casing for defining an inner space;

an evaporator disposed in the outer casing;
circulation fan means for taking air into the inner space from the defined space through the evaporator;
a condenser disposed in the outer casing;
water tank means, arranged in the outer casing, for storing water;
spray means for supplying water from the water tank means to the condenser to cool the condenser;
exhaustion fan means rotating at a predetermined rotational value Es for taking air from the outside of the casing and for exhausting the air to the outside of the defined space through the condenser, wherein air from outside the defined space enters into the defined space as air in the defined space is exhausted to the outside of the defined space; and
control means for decreasing the amount of air entering the defined space from outside the defined space when the compressor is stopped in comparison with the amount that enters when the compressor operates.

15. An apparatus according to claim 14, wherein the control means includes means for decreasing the rotational speed of the exhaustion fan means when the compressor is stopped.

16. An apparatus according to claim 15, wherein the decreasing means includes air exhaustion regulator means for regulating the rotational speed of the exhaustion fan means at a prescribed rotational speed El lower than the predetermined rotational speed Es when the compressor is stopped.

17. A method for controlling a portable air conditioning apparatus wherein a condenser is cooled by both water and air which are exhausted by an exhaustion fan to the outside of a defined space through the condenser, and a compressor is stopped when an actual temperature Ta in the defined space reaches a set temperature Ts, including the step of:
decreasing the rotational speed of the exhaustion fan to a prescribed rotational speed when the actual temperature Ta reaches the set temperature Ts.

18. A method according to claim 17 further including the step of decreasing the rotational speed of a circulation fan to a prescribed rotational speed when the actual temperature Ta reaches a prescribed value below the set temperature Ts.

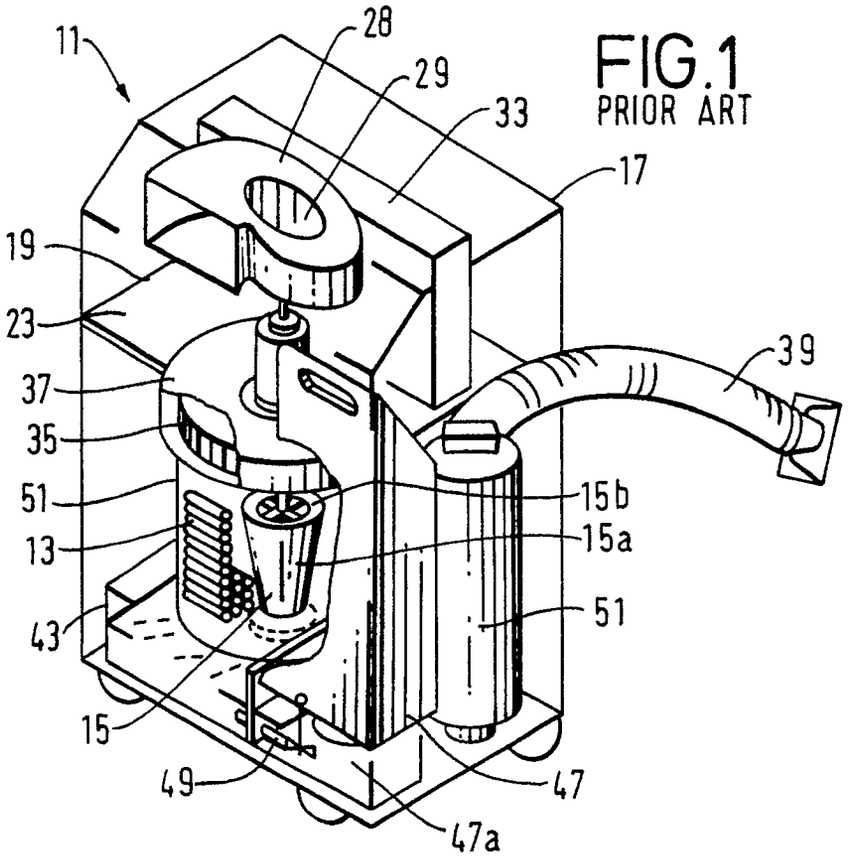

FIG.1
PRIOR ART

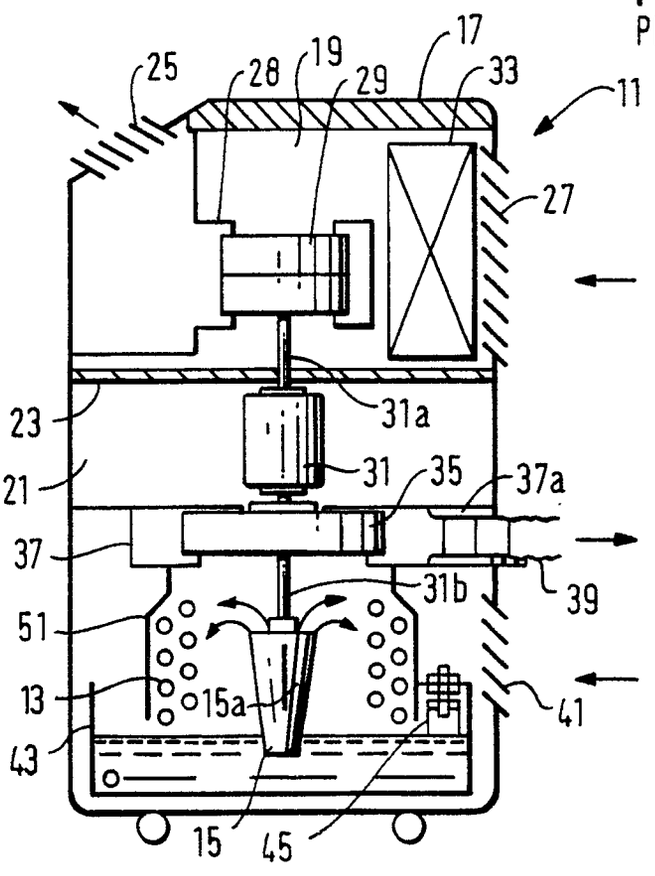

FIG.2
PRIOR ART

FIG. 3

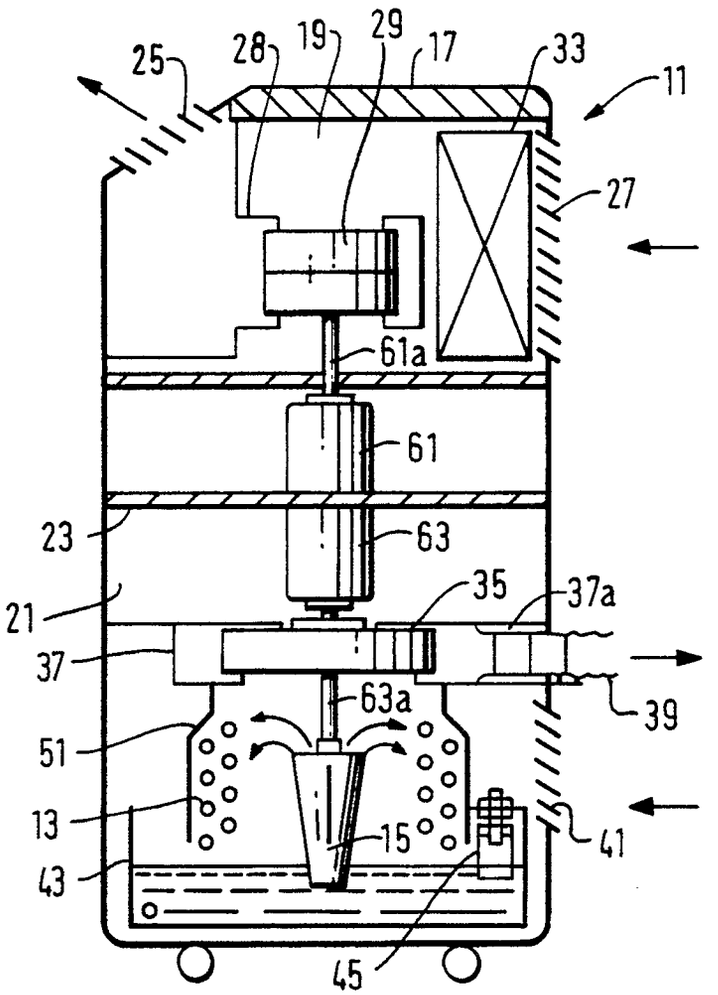
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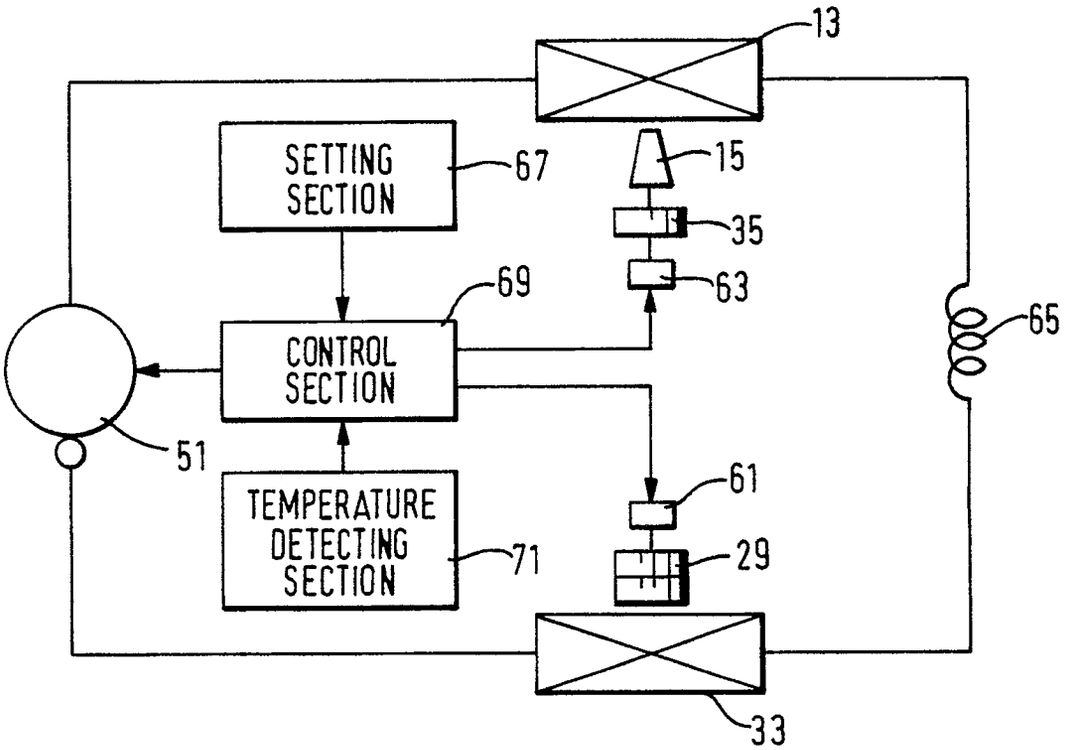
FIG.4


13
SETTING SECTION
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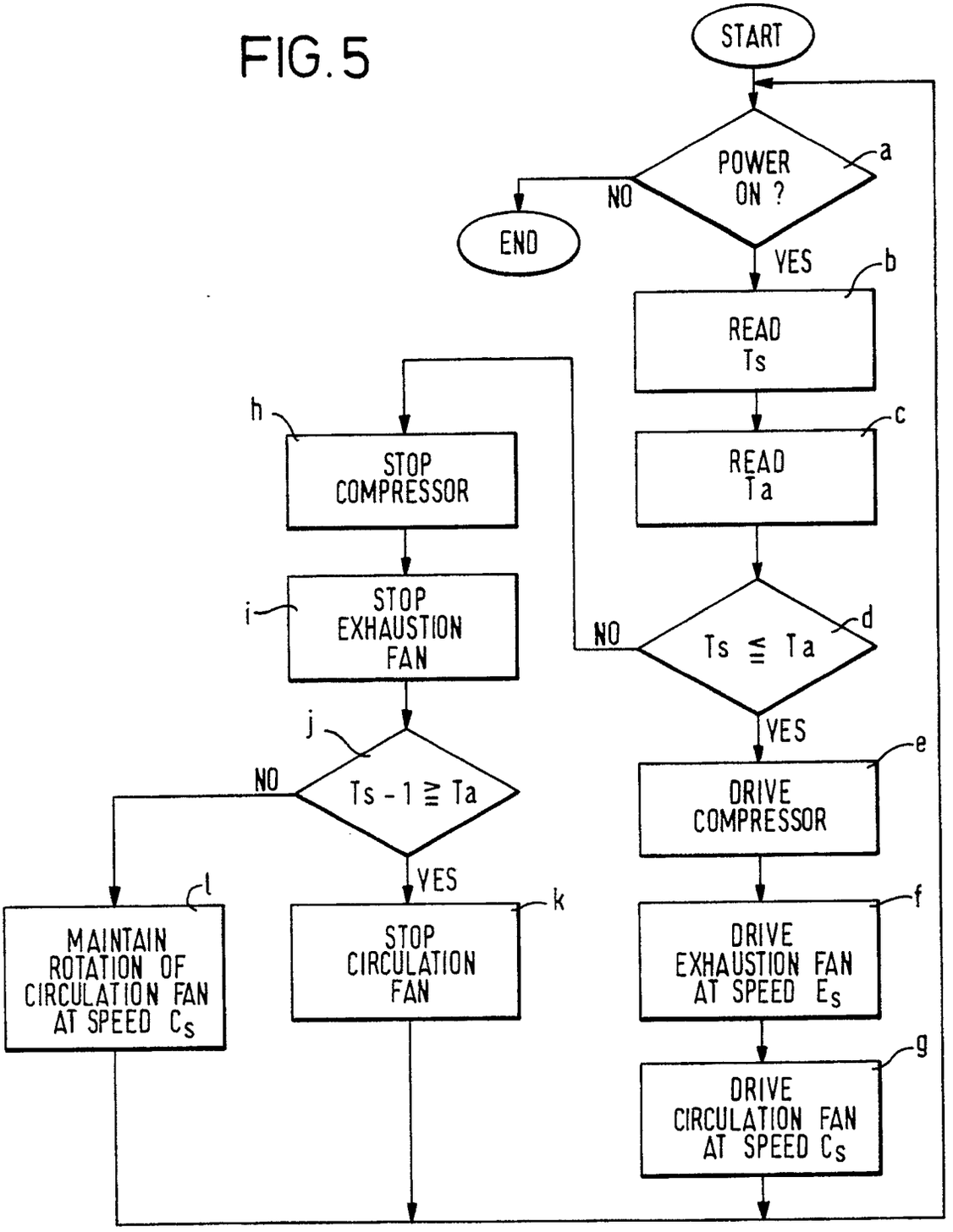
63
69
65
CONTROL SECTION
51
TEMPERATURE DETECTING SECTION
71
61
29
33

FIG.5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END
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c
READ Ta
d
NO
Ts ≦ Ta
YES
e
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f
DRIVE EXHAUSTION FAN AT SPEED Es
g
DRIVE CIRCULATION FAN AT SPEED Cs
h
STOP COMPRESSOR
i
STOP EXHAUSTION FAN
j
NO
Ts - 1 ≧ Ta
YES
k
STOP CIRCULATION FAN
l
MAINTAIN ROTATION OF CIRCULATION FAN AT SPEED Cs