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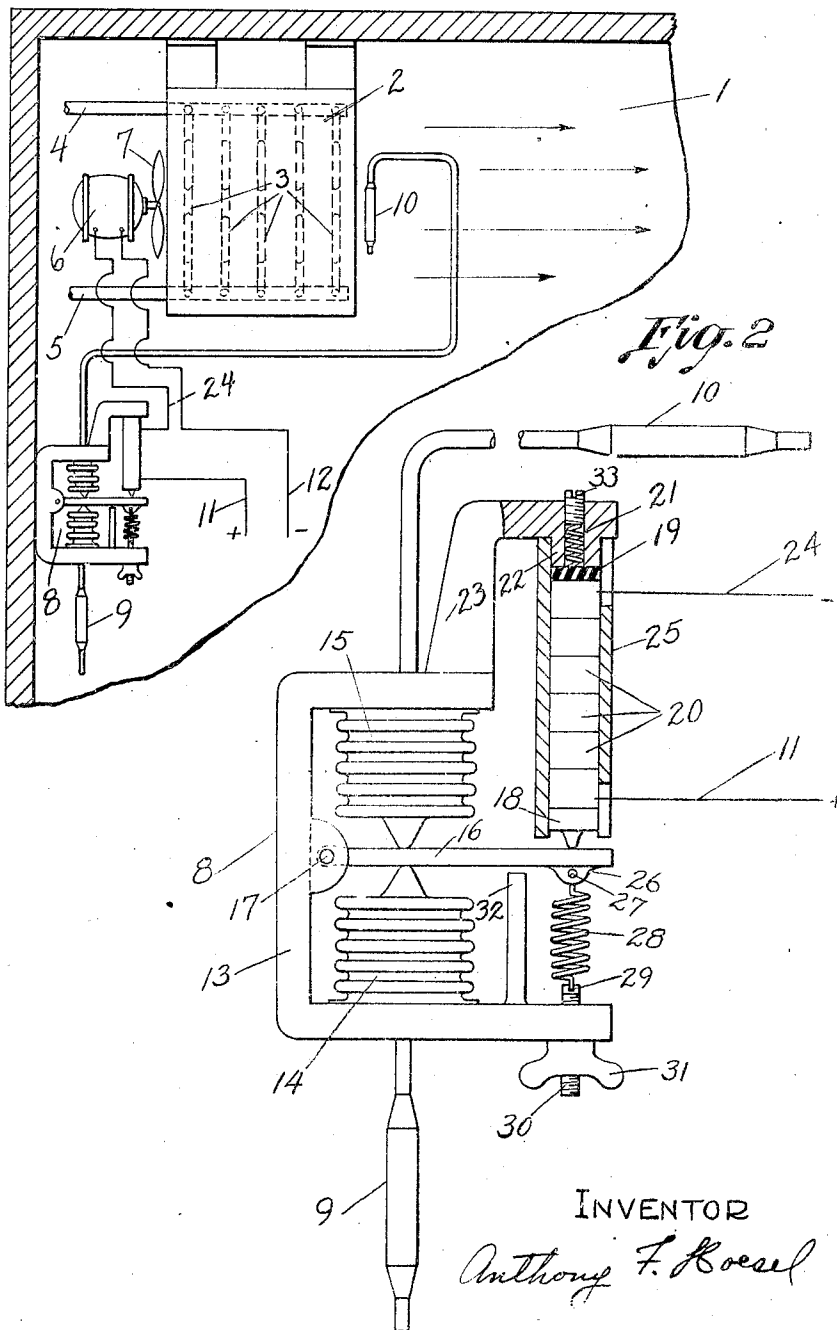
A. F. HOESEL

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REFRIGERATING SYSTEM

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Fig. 1



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REFRIGERATING SYSTEM

Anthony F. Hoesel, Chicago, Ill., assignor to
Peerless Ice Machine Company, Chicago, Ill.

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Forced convection circulation type coolers, prior to my invention, operating on alternate on-time and off-time cycles in respect to the refrigerant circulation through the cooler, had their fans operating either continuously at a given speed or else the fan was stopped whenever the cooled compartment reached its desired minimum temperature. The fan, whenever the compartment reached the desired maximum temperature, was again started. Whenever the fan was cyclically operated, it was controlled either by a room thermostat or else in conjunction with the cyclical operation of the compressor circulating the refrigerant fluid. Both of these methods, of cyclically operating the fan, are so well known in the art that it is presumed unnecessary to elaborate upon the details thereof.

Whenever the fan operates continuously, at a given rate of speed, the velocity of the air, passing through the cooling coil, is so great that the frost condensed upon the cooling coil surfaces defrosts so rapidly, during the off-time cycle of the compressor, that the air cannot pick up the maximum quantity of moisture, which it is capable of at slower velocities; also due to the high velocity of the air circulation, in the cooled compartment, sweeping the walls of the cooled compartment, there is an increased heat input.

With an intermittently operated fan, the temperatures, throughout the cooled compartment, vary to a considerable extent during the off-time period of the fan; also all of the disadvantages of the continuously operated fan, as outlined in the preceding paragraph, also persist.

One of the objects of my invention is to provide a forced circulation of air, through a cooling unit, of such volume as will maintain a definite temperature differential between the comparatively warm air, prior to its circulation through the cooling unit, and the cooled air issuing from the cooling unit. In this manner, I am enabled to control the moisture content of the circulated air.

Another object is to provide a decreased circulation of air, during the compressor off-time cycle, thereby allowing the circulated air to more readily pick up moisture from the cooling unit surfaces, upon which the moisture is condensed and frozen during the compressor on-time cycle.

A further object is to provide a decreased circulation of air, during the compressor off-time cycle, of such volume as to minimize temperature variation at different points of the cooled space.

Another object is to provide a control means, which accomplishes the aforementioned objects.

In the drawing:

Figure 1 is an elevational cross-sectional view of a portion of a refrigerated space containing the elements of the invention.

Figure 2 is an elevational view, partly in sec-

tion, of a temperature differential control used in the invention.

Referring to the drawing:

In Figure 1, a refrigerated space 1 contains a casing 2 in which a suitable cooling unit 3 is encased. The conduits 4 and 5 serve as conductors of the refrigerant, to and from the cooling unit 3, and are connected to a refrigerant compressor-condenser system, not shown.

An electric motor 6 operates the fan 7, forcing the air through the encased cooling unit 3 and in the direction indicated by the arrows.

A temperature differential control 8, of which the temperature responsive bulb 9 is subject to the temperature of the refrigerated space, and of which the temperature responsive bulb 10 is subject to the temperature of the air forced through the cooling unit 3, controls the resistance of the electrical circuit 11 and 12, connected to a suitable source of electrical energy, and which energize the electric motor 6, thereby rotating the fan 7.

In Figure 2, the temperature differential control 8 comprises a base 13, upon which is mounted a flexible bellows member 14, which, with its associated temperature responsive bulb 9, forms a closed system charged with a temperature-pressure responsive fluid.

A lever 16, pivoted at point 17 and oscillating thereabout, subject to the movements of the flexible bellows members 14 and 15; presses against an insulator disc 18 between which and the insulator disc 19, a multiplicity of carbon discs 20 are placed. A spring 21 is recessed into the flange 22 of the leg 23 of the base 13.

The extreme end discs, of the carbon pile 20, are connected to the leads 11 and 24 of an electrical circuit.

An insulating bushing 25, mounted upon the flange 22, and slotted at its upper end and at its lower end for the passage of the electrical circuit conduits 24 and 10 to their respective carbon end discs of the carbon disc pile 20, serves to keep the carbon discs 20, insulators 18 and 19 in alignment.

The lever 16, at its free end, has a boss 26 having a bore 27 engaging an end of the tension spring 28, the other end of which engages a bore 29 of the adjusting screw 30, positioned within a suitable opening in the base 13. The adjusting nut 31 serves to lengthen or shorten the tension spring 28, thereby increasing or decreasing the pressure of the lever 16 upon the carbon disc pile assembly, thereby decreasing or increasing, respectively, the electrical resistance of the carbon pile assembly.

The downward movement, of the lever 16, is limited by the abutment stop 32 integral with the base 13.

Having described the details of the invention,

I shall now describe its operation. Assuming the space 1 at an elevated temperature and the starting of the refrigerant circulation through the refrigerant conduits 4 and 5 and the cooling unit 3, thereby reducing the temperature of the cooling unit 3 in the casing 2, the cooled air passing by the temperature responsive bulb 10 reduces the pressure within the flexible bellows member 15, thereby tending to allow the flexible bellows member 14, which contains a greater pressure, due to the higher temperature of the temperature responsive bulb 9, to exert a greater force against the lever 16, which, increasing the pressure exerted upon the carbon discs 20, decreases the resistance to the electrical current flow through the carbon discs 20 and, in consequence, the motor 6, becoming more highly energized through the increased electrical current flow in the circuit conduits 11 and 12, the fan 7 is operated at an increased speed.

With a given temperature of the cooling unit 3 in the casing 2, and a certain increased temperature of the air prior to its passage through the cooling unit, it follows that a decrease in the rate of the air circulated through the cooling unit must result in the lower volume of air being at a lower temperature at the exit from the cooling unit. Conversely, an increase in the rate of the air circulated through the cooling unit must result in the increased volume of air, passing through the cooling unit, being at a higher temperature at the exit from the cooling unit.

As the temperature of the cooled space 1 drops, the pressure in the bellows member 14 decreases. This tends to decrease the pressure upon the carbon disc 20, increase the resistance of the electrical circuit and decrease the speed of the motor 6 and fan 7; however, the temperature of the air, passing through the cooling unit 3 and passing by the temperature responsive bulb 10, also drops, and this, reducing the temperature of the temperature responsive bulb 10, decreases the pressure in the bellows member 15, which tends to allow the bellows member 14 to press with greater force upon the lever 16 and, thereby increase the pressure upon the carbon discs 20, decreasing their electrical resistance, and thereby increasing the speed of the motor 6 and fan 7. Since these opposing tendencies practically balance each other, the net result is that the fan tends to operate at a continuous speed during the flow of refrigerant through the cooling unit.

Assuming the system in operation as previously described and the circulation of refrigerant, in the cooling unit, greatly increased. This results in the air, passing by the temperature responsive bulb 10, being reduced in temperature below that previously. The temperature responsive bulb 10 drops in temperature and the flexible bellows member 15 presses, with decreased force, against the lever 16 and the pressure of the carbon discs 20 is increased, thereby decreasing their electrical resistance and speeding up the electric motor 6 and fan 7 to such speed as will force sufficient air through the cooling unit 3, so that the cooled air passing by the temperature responsive bulb 10 again reaches approximately its same temperature as existed before the increased circulation of the refrigerant.

Assuming the system in operation, and the compressor-condenser system then closed down. The circulation of refrigerant ceases. The cooling unit 3 increases in temperature and the air, passing by the temperature responsive bulb 10, raises the temperature of the temperature responsive

bulb 10, thereby increasing the force with which the flexible bellows 15 presses against the lever 16 and decreasing the pressure of the carbon discs 20, increases their electrical resistance and slows down the motor 6 and fan 7 to the point where the decreased volume of air passing by the bulb 10 is again of approximately the same temperature as before the stoppage of the refrigerant circulation.

Since the differential temperature control 8 operates to maintain a constant temperature differential between the temperature responsive bulbs 9 and 10, the bulb 9 being at the higher or refrigerated space temperature, and the bulb 10 being at the lower or cooled air temperature, it is very desirable to vary the temperature differential in order to get certain desired conditions of moisture content of the air, also to regulate the normal maximum volume of air circulated by the fan 7. For this purpose, I have incorporated an adjustment by means of the tension spring 28, adjusting screw 30 and the adjusting nut 31. By proper manipulation, the force exerted by the tension spring 28 upon the lever 16, is so regulated that the temperature bulb 9 must be the desired temperature differential, above the temperature of the temperature responsive bulb 10, so that the pressure of the bellows member 14 will sufficiently counter-balance the pressure of the bellows member 15 plus the force of the tension spring 28, and compress the carbon discs 20 sufficiently to maintain the speed of the fan 7 at the desired condition of operation.

It is obvious that, since the control is operated by temperature difference, and since there may occur times when there is no temperature difference of the bulbs 9 and 10, some means must be employed to energize the system until such time as a controlling temperature difference occurs. For this purpose, I employ the compression spring 21, which, at all times, maintains a certain minimum compression of the carbon discs 20, depending upon the amount of the compression of the spring 21 by means of adjustment of the adjusting screw 33, which is in threaded engagement, as indicated, with the bore in which the spring 21 plays, and thereby maintains a certain maximum resistance to the electric current flow through the carbon discs 20, whereby the fan 7, at all times, is never rotated below a certain minimum speed.

From the above, it is evident that I am enabled to maintain a certain temperature difference between the air prior to and subsequent to its passage through a cooling unit. If the temperature difference tends to decrease, the amount of air circulated tends to decrease. If the temperature difference tends to increase, the amount of air circulated tends to increase.

With this method of operating a forced convection cooling system, I maintain a definite balance between the heat absorption capacity of a cooling unit, the amount of air circulated, the temperature difference between the cooled air and the main body of air; also I maintain, during the circulation of the refrigerant, a definite relationship between the temperature of the cooling unit and the circulated air cooled thereby and, furthermore, I maintain a certain minimum air circulation at all times. All of these features are highly desirable and result in the better preservation of perishable foods, etc., especially those of a dehumidifiable nature.

Assuming that we have a compartment to be maintained within the temperature limits of 34°

F. and 38° F., then the compressor would start the refrigerant circulation whenever the compartment reached 38° F. temperature and, after a sufficient circulation of the refrigerant, the compartment temperature would reach 34° F., at which time the compressor would stop the circulation of refrigerant.

Just prior to the stopping of the refrigerant circulation, the temperature of the compartment would be 34° F. and the temperature of the air discharged from the cooling unit would be approximately 22° F. This would be a temperature differential of 12° F.

Just prior to the starting of the refrigerant circulation, the temperature of the compartment would be 38° F. and the temperature of the air discharged from the cooling unit would be approximately 37° F. This would be a temperature differential of 1° F.

Assuming the temperature differential control to be so adjusted as to operate the fan motor at its maximum speed with an 11° F. differential and to operate the fan motor at its minimum speed with a 1° F. temperature differential, then the temperature differential control would tend to gradually increase and decrease the fan motor speed during the refrigerant circulation on-time cycle and off-time cycle, respectively.

Under certain circumstances, it might prove advisable that the fan motor speed decrease very rapidly from the beginning of the refrigerant circulation off-time cycle and, in that case, I would adjust the temperature differential control to operate the fan motor between its minimum and maximum speeds with a very low temperature differential variation.

Assuming the same conditions of temperature differentials between the cooling unit discharge air and the compartment air, as explained above, if I adjust the temperature differential control to operate the fan motor between its maximum and minimum speed with a temperature differential variation of 2° F., then whenever the refrigerant circulation ceases the temperature differential would quickly decrease 1° F. since the air entering the cooling unit, at the start of the refrigerant circulation off-time cycle is 12° F. higher in temperature than the temperature of the air discharged from the cooling unit at that time, and, therefore, the cooling unit would warm up sufficiently to slow the fan motor to its minimum speed in a very short period of time.

While the above is a specific concept of the invention, it is understood that I may employ variations from the same without departing from the spirit and scope of the invention, which is limited only by the claims hereto appended.

I claim:

1. In a refrigerating system the combination of a cooling unit, means to circulate air through the cooling unit and means responsive to the temperature differential between the circulated air entering and the air leaving the cooling unit to control the air circulating means.

2. In a refrigerating system the combination of a cooling unit, means to circulate air through the cooling unit and means responsive to the temperature differential between the circulated air entering and the air leaving the cooling unit to control the air circulating means so as to increase the volume of the circulated air upon an increase of the temperature differential.

3. In a refrigerating system the combination of a cooling unit, means to circulate air through the cooling unit and means responsive to the temperature differential between the circulated air entering and the air leaving the cooling unit to control the air circulating means so as to decrease the volume of the circulated air upon a decrease of the temperature differential.

4. In a refrigerating system the combination of a cooling unit, means to circulate air through the cooling unit and means responsive to the temperature differential between the circulated air entering and the air leaving the cooling unit to control the air circulating means so as to increase or decrease the volume of the circulated air upon an increase or decrease, respectively, of the temperature differential.

5. In a refrigerating system the combination of a cooling unit, means to continuously circulate air through the cooling unit and means responsive to the temperature differential between the circulated air entering and the air leaving the cooling unit to control the air circulating means, the said temperature differential responsive means being so limited, in its control of the said air circulating means, as to maintain at least a certain minimum volume of air circulation under any condition of temperatures.

6. In a refrigerating system the combination of a cooling unit, means to continuously circulate air through the cooling unit and means controlling the air circulating means to a predetermined minimum volume of circulation whenever the cooling unit temperature increases above that of its normal operating temperature.

7. In a refrigerating system, the combination of a fan to circulate air through a cooling unit, control means, responsive to the temperature differential between the temperature of the air leaving the cooling unit and the temperature of the air prior to its circulation through the cooling unit, to increase the speed of the fan upon an increase of the temperature differential.

8. In a refrigerating system, the combination of a fan to circulate air through a cooling unit, control means, responsive to the temperature differential between the temperature of the air leaving the cooling unit and the temperature of the air prior to its circulation through the cooling unit, to decrease the speed of the fan upon a decrease of the temperature differential.

9. In a refrigerating system, the combination of a fan to circulate air, past surfaces cooled by a circulating refrigerant at some predetermined maximum volume during the circulation of refrigerant and means to decrease the air circulation to some predetermined minimum volume during the stoppage of the refrigerant circulation.

10. In a forced air circulation refrigerating system, an automatic control, responsive to temperature variations, and which tends to increase the air circulation upon a decrease in temperature of the circulated air.

11. In a forced air circulation refrigerating system, an automatic control, responsive to temperature variations, and which tends to decrease the air circulation upon an increase in temperature of the circulated air.

ANTHONY F. HOESSEL.