Refrigeration system for a chilled product vending system.

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Description

The invention relates to a refrigeration system for a chilled product vending machine which includes a refrigeration compressor, temperature sensing means for controlling the compressor, an evaporator coil and evaporator fan means for blowing air across the evaporator coil and circulating said air throughout the vending machine.

Such a refrigeration system in accordance with the prior art portion of the sole claim is known from US-A-2,529,470 wherein the evaporator fan runs continuously. The unnecessary high energy usage and waste caused by the continuous running of the evaporator fan has become a problem with the high costs of energy. One logical solution to reducing the consumption of energy is to cycle the evaporator fan motor ON and OFF with the compressor thus decreasing the running time of the evaporator fan. When the vending machine is off, the period that the evaporator fan may, however, permit the chilled products to freeze. That is, when the evaporator fan is running and blowing air over the evaporator coil and throughout the vending machine, this flow of air dissipates heat generated by the evaporator fan motors thus acting as a heater to prevent the storage products from freezing. Thus, the aforementioned problem exists when the evaporator fan is permitted to cycle ON and OFF with the compressor, even though a substantial reduction in energy consumption results.

The invention as claimed in the sole claim solves the problem of how to avoid product freezing up in blow freezing environmental conditions without necessary high energy usage.

The advantages offered by the invention are mainly that the vended products dispensed are within acceptable and predictable temperature ranges and that temperature fluctuations throughout the volume of the vending machine are kept to a minimum.

In the refrigeration system according to the sole claim, the timer means is provided to preclude freezing of the vended products and/or the evaporator coil when a vending machine is disposed in a below freezing environment. This timer is enabled when the thermostatic temperature switch which controls the compressor opens, and will time out to cycle on the evaporator fans for continuous operation for a predetermined period of time if the temperature switch remains open in excess of a predetermined period of time, for example four hours. That is, by sensing the compressor off period, (the period that the temperature switch is open), the evaporator fans are cycled on for a continuous period of operation to preclude freeze up of the products when the off period of the compressor (the temperature switch open) exceeds a predetermined limit such as four hours.

A refrigeration system for a chilled product vending machine including a refrigeration compressor, temperature sensing means for detecting the temperature within said vending machine and turning said compressor ON and OFF to define a compressor cycle in response to the detection of predetermined temperature limits, an evaporator coil and evaporator fan means for blowing air across said evaporator coil and circulating said air throughout said vending machine, characterized by first timer means responsive to said temperature sensing means for cycling said evaporator fan means ON simultaneously with said compressor or for enabling it to be maintained ON for a time period longer than said compressor cycle and for cycling said evaporator fan means OFF a predetermined period of time after said compressor is turned OFF, said point in time being long enough after said compressor is turned OFF to permit the temperature of said evaporator coil to stabilize above the freezing point of water; and cycle timer means for intermittently turning said evaporator fan means ON and OFF for predetermined periods between said compressor cycles after said first timer means turns said evaporator fan means OFF to thereby maintain an even distribution of chilled air within said machine and minimize temperature fluctuations of the chilled products, is the subject-matter of parent EP-A-0 050 333.

The present invention will become readily appreciated by reference to the following detailed description when considered in conjunction with the accompanying drawings in which:

Figure 1 is a cross sectional view of the inside of a typical chilled-product vending machine having a convection cooling system;

Figure 2 is an electrical schematic diagram of the control circuitry for operating the convection cooling system within the vending machine of Figure 1;

Figure 3 is a timing diagram of the electrical signals present at selected terminals of the circuit diagram of Figure 2 to be referenced hereinafter; and

Figure 4 is another timing diagram of electrical signals present at other terminals in the circuit of Figure 2 to be referenced hereinafter.

Referring in detail to Figure 1, there is generally illustrated in cut away view a typical product vending machine wherein a plurality of products such as soft drink cans or bottles are stored in product stacks PS, from which they are sequentially dispensed on demand through appropriate vend slots in the bottom of the vending machine. As illustrated in Figure 1, the vending machine thereof also includes a convection refrigeration system which includes the conventional components of a refrigeration circuit, having a cycle denser CD, a fan CF and a compressor CP, an evaporator coil EC, an evaporator fan motor EFM, and a thermostatic temperature switch TS (not shown), for controlling the operation of the refrigeration system in response to the temperatures sensed within the vending machine. The conventional convection refrigeration system illustrated in Figure 1 operates to chill the products in product stacks PS, by blowing air by means of
evaporator fan motor EFM over evaporator coil EC to thereby circulate chilled air between and throughout the product stacks PS. Air returns from the stacks as indicated by arrows AR. In conventional prior art convection refrigeration systems of vending machines known heretofore, the compressor CP is cycled on and off under control of thermostatic temperature switch TS, while the evaporator fan motor EFM runs continuously, even during the periods that compressor CP is de-energized. This continuous running of the evaporator fan motor EFM obviously expends a lot of unnecessary electrical energy and generates heat leading to unnecessary energy waste. Accordingly, as described in EP—A—0 050 333, the control circuit of Figure 2 was designed to energize the evaporator fan motor EFM only during optimum times when its operation is clearly needed. For example, the evaporator fan EFM operates continuously during the period that the compressor CP is operating, operates for a predetermined delay period following the cycle OFF of the compressor in order to preclude freeze up of the evaporator coil EC, and operates intermittently for predetermined periods when the compressor CP is cycled OFF. In accordance with the present invention, the evaporator fan EFM is cycled ON to run continuously for a period following an interval when the compressor has not operated for an extended period of time, to preclude freezing of the products in the vending machine in sub-freezing environmental locations.

Referring in detail to Figure 2, there is illustrated an electrical circuit diagram of the control circuitry as described in EP—A—0 050 333 for operating the convection refrigeration system illustrated in Figure 1. A pair of main power lines PL1, PL2 are provided across which a conventional 120 volt, 60 Hz power source is connected. Also connected in parallel between power lines PL1, PL2 are a plurality of timers E, fp, D, Cy. Because these respective timers are connected in parallel, they are effectively hardwired in OR logic with respect to evaporator fan motors EFM. Thus, each of the respective timers E, fp, D and Cy can effect a time control function over evaporator fan motors EFM to be described in more detail hereinafter.

Beginning at the top of Figure 2, the first timer E, may be a 24 hour clock controller for cycling the refrigeration system ON and OFF at predetermined times of day. That is, by means of timer E, the refrigeration system can be enabled or disabled for any specified period of a daily basis. Timer E is coupled to power line PL1 through a temperature switch TS at terminal C thereof. Included within timer E is time control switch S1 between terminals C and NC and a timer motor TM1 between terminals L1 and L2. Terminal NC is also coupled to the compressor and the condenser fan motors of the refrigeration system of Figure 1 and terminals L1 and L2 are coupled to power lines PL1 and PL2, respectively. Timer E in one embodiment, is a multi-pulse cam timer manufactured by Eagle Signal Corporation, and identified as "multi-pulse timer catalog number MP-1-A6-32-MP5-48".

According to the present invention, timer fp is provided in the control circuit of Figure 2 to energize evaporator fans EFM continuously when the compressor CP of the refrigeration system has not operated for an extended period of time, for example four (4) hours or more. The failure of the compressor CP to operate for such an extended period of time would normally occur when the vending machine is placed in a sub-freezing environment which eliminates the need for internal cooling of the machine. However, this sub-freezing environment also may create a problem in that the chilled products may freeze up when the machine is placed in extremely cold external environment conditions. Accordingly, the timer fp is utilized to sense these extended periods in which the compressor CP does not run and turn ON the evaporator fans EFM to run continuously and thereby blow air over the products to preclude freeze up thereof. Timer fp includes external terminals 1, 2, 3, 4, and 11. Terminal 1 of timer fp is connected to terminal C of timer E. Terminal 2 of timer fp is externally connected to power line PL2. Terminal 3 of timer fp is connected to the terminal 5 of timer D and through junction FJ to fans EFM. Terminal 4 of timer fp is hardwired to terminal 11 thereof which in turn is coupled to power line PL1. Timer fp also includes a timer motor TM2 which is coupled at one end to a wire connecting terminals 1 and 2 thereof, and at an opposite end through a switch S2 to terminal 11. Also provided in the wire connection between terminals 1 and 2 of timer fp is a clutch coil C1. In addition, a switch S3 is coupled between terminals 3 and 4 of timer fp. Timer fp may, for example, be an electromechanical cam timer manufactured by Eagle Signal Corporation under the description "Cycle-Flex timer catalogue number HP 58-A6-01".

As described in EP—A—0 050 333, timer D is provided to maintain evaporator fans EFM ON for a predetermined time or delay period after the compressor CP is turned OFF. This delay period is necessary in some environmental conditions to preclude freeze up of the evaporator coil EC. That is, since evaporator fan motors EFM will continue to run at the end of a compressor cycle for a predetermined period of time, the temperature of the evaporator coil due to this moving air is elevated to a safe temperature above the freezing point of water before the evaporator fans EFM are turned OFF under the control of timer D. Timer D includes a plurality of external terminals numbered 1, 2, 3, 4, 5, and 11, in the same manner as the like terminals of timer fp. Timer D is in the preferred embodiment of the present invention, similar to timer fp with the exception of the specific function it performs, the addition of terminal 5, and the manner in which it is connected in the circuit of Figure 2. Terminal 1 of timer D is connected to terminal NC of timer E. Terminal 2 of timer D is connected to power line PL2. Terminal 3
of timer D is connected to terminal L2 of timer Cy to be described hereinafter. Terminal 4 of timer D is hardwired to terminal 11 of timer D which is in turn, coupled to power line PL1. Terminal 5 of timer D is as stated hereinbefore, connected directly to terminal 3 of timer fp and through junction FJ to fans EFM. Timer D also includes a clutch coil C2 coupled between terminals 1 and 2 thereof, a timer motor TM3 connected between clutch coil C2 and terminal 2 at one end thereof, and an opposite end thereof coupled through a switch S4 to terminal 11. A switch S5 is also provided in timer D for completing a circuit between terminals 3 and 4 or terminals 4 and 5 as controlled by timer motor TM3 in a manner to be described hereinafter.

A cycle timer Cy is provided to intermittently energize evaporator fans EFM during periods in which the compressor CP is de-energized. This is desirable in order to provide a more even temperature distribution throughout the vending machine during the off period of the compressor in order to enable more accurate temperature sensing within the vending machine during that period and a more limited fluctuation of the temperature of the chilled products in product stacks PS. Timer Cy includes a plurality of external terminals L1, L2, 2 and 3. Terminal L1 of timer Cy is coupled to power line PL2. Terminal L2 of timer Cy as stated hereinbefore, is coupled directly to terminal 3 of timer D. Terminal 2 of timer Cy is hardwired to terminal L2 of timer Cy. Terminal 3 of timer Cy is coupled through junction FJ to the evaporator fan motors of the refrigeration system of the present invention. A timer motor TM4 is provided within timer Cy between terminals L1 and L2 for the timed operation of a switch S6, coupled between terminals 2 and 3, in a manner to be more fully described hereinafter. Timer Cy in one embodiment of the present invention is electromechanical cam timer manufactured by Eagle Signal Corporation under the description "Flexopulse timer number HG-94-A6".

The operation of the control circuit of Figure 2 can best be understood in conjunction with the timing diagrams of Figures 3 and 4 as described hereinafter.

Referring in detail to Figure 3, waveform E' represents the output at terminal NC of timer E. Waveform TS' represents the ON-OFF state of thermostatic temperature switch TS. Waveform D represents the output at terminal 5 of timer D over the control period illustrated in Figure 3. Waveform FJ represents the intermittent timing pulse output generated by timer Cy at output terminal 3 over the control period. The remaining waveform of Figure 3 labeled FAN(S)' illustrates the cycle of operation of the evaporator fan motors EFM in response to the timing controls provided by the waveforms E', TS', D' and Cy'.

Referring in detail to Figure 4, there is illustrated a plurality of timing waveforms illustrating the function of timer fp. Waveform TS' represents the ON-OFF periods of temperature switch TS.

Waveform fp represents the output with respect to temperature at terminal 3 of timer fp and the waveform labeled FAN(S)' illustrates the control periods of the evaporator fans EFM in response to the combined control of temperature switch TS and timer fp.

Having now generally described the content of the timing diagrams of Figures 3 and 4, the detailed operation of the control circuitry of Figure 2 may now be explained by reference to Figure 2 in conjunction with Figures 3 and 4.

In normal operation the compressor CP of the refrigeration system illustrated in Figure 1 is turned on in response to the closing of temperature switch TS when the temperature within the vending machine rises above a predetermined level. However, temperature switch TS will not turn the compressor CP on unless switch S1 of timer E is closed providing a closed circuit path between power line PL1, the compressor and power line PL2. The function of switch S1 will be explained further hereinafter. The closing of temperature switch TS also provides a circuit path through clutch coil C1 of timer fp and power lines PL1 and PL2. That is, the closing of temperature switch TS energizes the clutch coil C1. With clutch coil C1 energized, timer motor TM2 of timer fp can not rotate. Timer E is an optional 24 hour clock/ controller which may be utilized to turn the refrigeration system of the present invention ON and OFF for any specified period daily. For example, as illustrated in Figure 3 by waveform E', the refrigeration system may be turned ON at 9:00 AM and OFF at 5:00 PM, by means of timer E. This ON-OFF period is controlled by timer E by the opening and closing of switch S1 which is controlled by timer motor TM1 in conjunction with appropriate timing cams. If this option is not required, switch S1 may be locked in a closed position to effectively short terminals C and NC and open terminals L1 and L2, thus eliminating the function of timer E. In this position, with switch S1 continuously closed, the enablement of the refrigeration system and compressor C are under the control of temperature switch TS.

The delay timer D is provided with a clutch coil C2 which is energized when temperature switch TS is closed. When clutch coil C2 is energized, timer motor TM3 does not run. However, at the end of a compressor cycle, when temperature switch TS opens, clutch C2 becomes de-energized timer motor TM3 begins to run, and runs until it times out. Switch S5 remains in the position shown between terminals 4 and 5 until timer motor TM3 is timed out, thus completing a circuit from power line PL1 through junction FJ, to evaporator fan motor EFM. At the beginning of any cycle of operation of the compressor C, switch S5 is normally in the position shown connecting terminals 4 and 5 of timer D, and therefore, power is supplied to evaporator fan motors EFM from power line PL1 via terminals 4, 5 of timer D, and junction FJ. Timer D determines how long power is to be applied to the evaporator fan motors following the cut-off time of the
compressor determined by temperature switch TS. That is, as temperature switch TS opens, clutch coil C2 becomes de-energized permitting timer TM3 to time out, at which time switch S5 switches from terminal 5 to terminal 3, thus interrupting the supply of power to evaporator fan motors EFM. With switch S5 coupling terminals 4 and 3 of timer D together, the cycle timer CY is enabled.

Thus, the cycle timer CY, timer motor TM4 runs continuously following each delay period generated by timer D, until reset by the ending of another delay period. The cycle timer alternately opens and closes the contacts between terminal 2 and 3 of timer CY at a selectable rate to create the small pulse waveform illustrated as CY in Figure 3. Thus, as shown in the bottom waveform FAN(S) of Figure 3, the evaporator fans EFM intermittently cycle ON and OFF following each delay period controlled by timer D. Thus, the evaporator fan motors EFM, as illustrated in Figure 3 are turned ON for the entire period that the compressor is turned ON, remain ON for a delay period determined by timer D, and are intermittently turned ON following each delay period and during the period preceding the next compressor ON time. The compressor ON and compressor OFF times are labeled C\text{ON} and C\text{OFF}, respectively in Figure 3. Thus, the operation of timers E, D, and CY have now been described with reference to Figure 3.

The operation of the timer fp, according to the present invention, which prevents freeze up of vended products in sub-freezing environments may now be understood with reference to Figure 4 and in conjunction with Figure 2. As illustrated by the top waveform TS in Figure 4, the temperature switch TS is closed and opens to turn the compressor OFF at the time indicated C\text{OFF} in Figure 4, at which time power is removed from clutch coil C1 of timer fp. When this occurs, timer motor TM2 is permitted to rotate to begin its timing function. If the temperature switch TS remains open for a predetermined period, for example, four (4) continuous hours, timer fp will time out closing the contacts between terminals 3 and 4 thereof by switch S3. The closure of switch S3 completes the circuit to the evaporator fan motors EFM between power lines PL1 and PL2. The evaporator fans will then run continuously until such time that the temperature switch again closes which energizes clutch coil C1 to stop the operation of the timer motor. When this occurs, timer fp is automatically reset to its initial condition in readiness for subsequent actuation in response to a compressor OFF period in excess of said predetermined period of four (4) hours. It should be understood that the period of four (4) hours is exemplary only, and that the predetermined time period selected will vary depending on the type of vending machine being controlled.

Thus, by the continuous operation of the evaporator fan motors following a long compressor OFF period indicative of sub-freezing conditions in the environment, freeze up of products in the vending machine are precluded by the heating effect of the moving air circulating throughout the vending machine.

**Claim**

In a refrigeration system for a chilled product vending machine including a refrigeration compressor (C), temperature sensing means (TS) for detecting the temperature within said vending machine and turning said compressor ON and OFF to define a compressor cycle in response to the detection of predetermined temperature limits, an evaporator coil and evaporator fan means (EFM) for blowing air across said evaporator coil (EC) and circulating said air throughout said vending machine, characterized by:

- sensor means (C1) for detecting when said compressor is cycled OFF;
- timer means (fp) responsive to said sensor means for measuring the length of time that said compressor is cycled OFF and for generating an enabling signal when said length of time exceeds a predetermined duration; and
- circuit means (S3) responsive to said enabling signal for cycling said evaporator fan means ON continuously until said compressor turns ON.

**Patentanspruch**

Kühlsystem für einen Verkaufsautomaten für gekühlte Waren mit einem Kälteverdichter (C), Temperaturfühlerinrichtungen (TS) zum Messen der Temperatur innerhalb des Verkaufsautomaten und zum Ein- und Ausschalten des Verdichters, so daß ein Verdichterzyklus unter Ansprechen auf die Messung vorgegebener Temperaturgrenzwerte festgelegt wird, einer Verdampfungskolonne und Verdampfergeräte in den Verdampferkolonne (EFM) zum Blasen von Luft über die Verdampfungskolonne (EC) und zum Zirkulieren der Luft durch den Verkaufsautomaten, gekennzeichnet durch:

- Fühlerinrichtungen (C1) zum Erkennen, wann der Verdichter ausgeschaltet ist;
- ZeitschaltEinrichtungen (fp), die auf die Fühlerinrichtungen ansprechen, um die Länge der Zeit zu messen, die der Verdichter ausgeschaltet ist und zur Erzeugung eines Einschaltsignals, wenn die Länge der Zeit eine vorgegebene Zeitdauer übersteigt;
- SchaltEinrichtungen (S3), die auf das Einschaltsignal ansprechen, um die VerdampfergeräteEinrichtung kontinuierlich einzuschalten, bis der Verdichter eingeschaltet wird.

**Revendication**

Dans un système de refroidissement pour une machine de vente de produits réfrigérés comportant un compresseur de réfrigération (C), un moyen de détection de température (TS) pour détecter la température à l'intérieur de ladite machine de vente et pour faire fonctionner ledit compresseur en marche-arrêt afin de définir un
cycle de compresseur en réponse à la détection de limites prédéterminées de la température, en serpentin d'évaporateur et un ensemble de ventilateurs d'évaporateur (EFM) pour insuffler de l'air au travers dudit serpentin d'évaporateur (EC) et pour faire circuler cet air dans ladite machine de vente, caractérisé par :
— un moyen de détection (C1) pour détecter quand ledit compresseur est à l'arrêt ;
— une minuterie (fP répondant audit moyen de détection pour mesurer la durée de la période pendant laquelle ledit compresseur est à l'arrêt et pour produire un signal d'autorisation de fonctionnement quand ladite période dépasse une durée prédéterminée ; et
— un composant de circuit (S3) réagissant audit signal d'autorisation de fonctionnement pour faire fonctionner ledit ensemble de ventilateurs d'évaporateur en marche continue jusqu'à ce que ledit compresseur soit enclenché.