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CONDENSING UNITS FOR REFRIGERATION SYSTEMS

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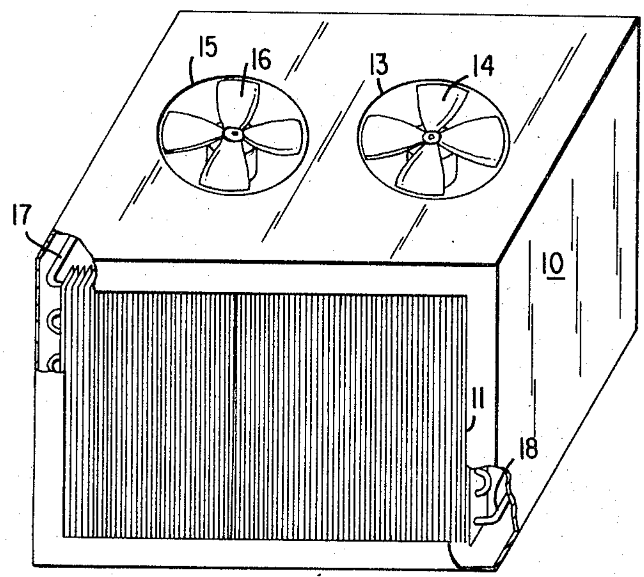

FIG. 1

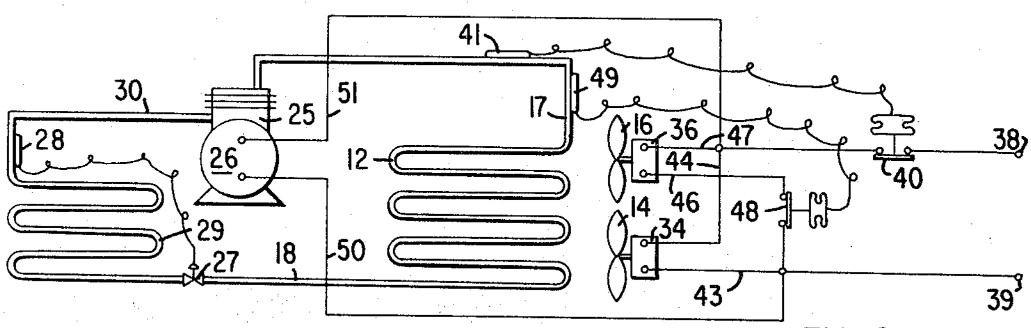

FIG. 2

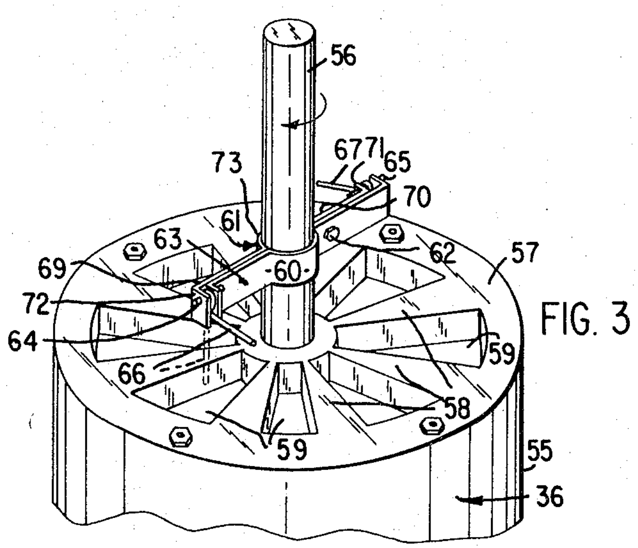

FIG. 3

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CONDENSING UNITS FOR REFRIGERATION SYSTEMS

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This invention relates to condensing units for use in refrigeration systems, and more particularly, to a condensing unit of the type which employs multiple fans, at least one of which may be turned off to prevent the occurrence of an undesirably low condensing pressure.

The components of a typical reciprocating refrigeration system are normally designed to operate between specified design conditions. It is frequently observed that when the condensing temperature drops substantially below normal design conditions, as when the ambient temperature drops in winter-time, the refrigeration system is likely to malfunction due to insufficient head pressure. Under these conditions, the condensing pressure may not be high enough to force sufficient refrigerant through the thermal expansion valve to satisfy the cooling load requirement of the evaporator. Since the compressor attempts to remove a constant volume of refrigerant from the evaporator, and the evaporator is starved for refrigerant, the evaporator pressure drops. This in turn results in an undersirably low evaporator temperature which may cause the evaporator to condense moisture from the air being cooled, and to freeze the moisture on the outside of the excessively cold evaporator coil. The icing of the evaporator coil, in turn, reduces the heat transfer effectiveness of the evaporator coil by insulating it from the air being cooled, thus rendering the refrigeration system ineffective, and further contributing to a drop in evaporator temperature due to the reduced heat transferred to the refrigerant.

A common solution to the problem of excessively low ambient condenser temperatures is to employ a condensing unit having a plurality of condenser fans for passing air over the condenser. Suitable head pressure control means is employed to turn off one or more of the fans when the condensing temperature drops below a predetermined desired low temperature. When one of the fans is turned off, the quantity of air passing over the condenser is decreased, and the condensing temperature rises sufficiently to provide sufficient refrigerant to the evaporator coil to prevent loss of capacity and icing thereof.

While the solution described can be fully satisfactory in a properly designed condensing unit, it is necessary to provide internal baffles within the condensing unit to prevent the air from passing from one condenser fan directly to the other fan. If the condensing unit is not properly baffled, when one fan is turned off, air will be admitted into the aperture in the unit in which the nonoperating fan is located, and will pass directly out of the unit through the fan or fans which are in operation. Consequently, the inoperative fan is caused to turn backwards as air rushes in the aperture in the condensing unit in which the fan is located. This commonly results in two problems occurring. First, the bearings of the fan motor are often not properly lubricated at slow speeds, so that the slow reverse rotation of the fan may cause severe damage to the motor bearings. Second, it is desirable to use inexpensive electric motors of the permanent split capacitor type to operate the condenser fans. If power is subsequently applied to the fan motor while it is turning backwards, a fan motor of the permanent split capacitor type will generally continue to operate backwards. The backward operation of the fan results in poor and inadequate air distribution over the condenser coil, and unsatisfactory operation of the refrigeration system.

Accordingly, it is an object of this invention to provide improved condensing units of the multiple fan type which eliminates many of the shortcomings of previously employed multiple fan condensing units.

It is a further object of this invention to provide a satisfactory condensing unit of the multiple fan type which does not require internal baffles to separate the fans.

These and other features of this invention are achieved in the illustrated embodiment thereof by providing a brake arrangement on one or more fans of a multiple fan condensing unit. The brake is constructed so as to freely permit rotation of the fan in its normal direction with respect to the other fans in the unit but to prevent reverse rotation of the fan during periods of time when its motor is de-energized. Thus, the fan motor cannot turn in a backward direction, and it is always started in the proper direction upon re-energization of its motor. Likewise, backward rotation of the fan, either because of operation of the other fans in the condensing unit pulling air through the aperture in which the fan is located, or because of wind impinging on the fan, is not permitted. Consequently, the brake prevents injury to the fan motor bearings by slow backward rotation of the motor under these conditions. For these reasons, the necessity for providing an expensive internal baffle between the fans in the condensing unit is eliminated, and a consequent cost saving is achieved.

These and other features of this invention will become more readily apparent by referring to the attached specification and drawings wherein:

FIGURE 1 is a perspective view of a multiple fan condensing unit of a type to which this invention is applied;

FIGURE 2 is a schematic diagram of a refrigeration system employing a multiple fan condensing unit, and illustrating a suitable control arrangement for use in conjunction therewith; and

FIGURE 3 shows a fan motor assembly provided with a brake in accordance with this invention.

Referring to FIGURE 1, there is shown a condensing unit such as might be located on a roof of an air conditioned building. The condensing unit includes a casing **10** having an aperture **11** in one side thereof to admit ambient air through the spaces between fins of a condenser **12** into the interior of the casing. Condenser **12** comprises a heat exchanger which may suitably be a plate fin heat exchange coil having multiple passes joined by return bends as shown in the drawing. The top side of the casing **10** has a first aperture **13** formed therein in which is disposed a first fan **14** and a second aperture **15** having a second fan **16** disposed therein. Casing **10** suitably may be a single undivided compartment having no partition between the fan sections which are housed by said casing.

Fans **14** and **16** are preferably arranged to draw air into casing **10** through aperture **11** and condenser **12** and exhaust the air through apertures **13** and **15**. The passage of air over condenser **12** cools and condenses refrigerant vapor passing through an internal heat exchange passage of the condenser. A hot gas line **17** is provided for admitting the refrigerant vapor into condenser **12** and a refrigerant liquid line **18** is provided for discharging the liquefied refrigerant from the condenser.

A schematic diagram of the refrigeration system and associated electrical circuitry is shown in FIGURE 2. A compressor **25** is driven by an electric motor **26**. The compressed gaseous refrigerant is discharged from compressor **25** through hot gas line **17** into condenser **12** where it is cooled and condensed to a liquid. The liquefied refrigerant passes from condenser **12** through liquid line **18** and thermal expansion valve **27** into refrigerant evaporator **29**. Thermal expansion valve **27** is provided with a suitable gas-filled bulb 28 disposed in the outlet of evaporator 29 to control refrigerant flow to the evaporator in response to superheat sensed at the evaporator outlet. Evaporated refrigerant is passed from evaporator 29, through suction line 30, back to compressor 25 to complete the refrigeration circuit.

First fan 14 is driven by a first electric fan motor 34 and second fan 16 is driven by second fan motor 36. Motors 34 and 36 may desirably be of the permanent split capacitor type. Line current terminals 38 and 39 supply current to energize the fan and compressor motors. Conductors 43 and 44 supply current from terminals 39 and 38 respectively to energize fan motor 34. Conductors 46 and 47 supply current from line terminals 39 and 38 respectively to energize fan motor 36. Conductors 50 and 51 supply current from terminals 39 and 38 respectively to energize compressor motor 26.

A high head pressure switch 40 is provided in series with line terminal 38 and has a gas-filled bulb 41 to sense head pressure or condensing temperature at condenser 12. Alternatively, the sensor for high pressure switch 40 could be located at any suitable location on the high pressure side of the system. High head pressure switch 40 is normally closed and upon the occurrence of an excessively high head pressure sensed by bulb 41, switch 40 opens to de-energize fan motors 34, 36 and compressor motor 26. Opening of high head pressure switch 40 therefore shuts down the refrigeration system and prevents an excessively high head pressure from occurring which might damage the refrigeration circuit by bursting the refrigerant passages.

A low head pressure switch 48 is disposed in conductor 46 to selectively energize and de-energize second fan motor 36. Low head pressure switch 48 is provided with a gas-filled bulb 49 to sense the temperature of hot gas passing through hot gas line 17 which corresponds to the head pressure of the refrigeration system. Low head pressure sensor 49 may be located at any suitable point on the high pressure side of the refrigeration system so as to respond to condensing or condenser pressure or temperature or any function thereof. Low head pressure switch 48 is closed during periods of time when the head pressure of the refrigeration system is above a predetermined excessively low pressure. Low head pressure switch 48 opens when the head pressure in the refrigeration system drops below the predetermined desired minimum pressure thereby de-energizing fan motor 36.

In normal operation, both high head pressure switch 40 and low head pressure switch 48 are closed and both fan motors 34 and 36 and compressor motor 26 are energized so that both fans are operative to pass air over condenser 12. If the head pressure sensed by bulb 49 drops below the predetermined desired minimum head pressure necessary to properly feed refrigerant to evaporator 29, low head pressure switch 48 opens and de-energizes fan motor 36. When fan motor 36 is de-energized, less air is passed over condenser 12, which results in raising the condensing temperature and thereby restoring sufficient head pressure to adequate feed evaporator 29. When the head pressure sensed by bulb 49 rises sufficiently, low head pressure switch 48 will again close an energize fan motor 36 to restore normal air circulation over the condenser.

As previously explained, the selective energization and de-energization of second fan 16 prevents the head pressure from dropping under conditions of low ambient condensing temperature to an extent that refrigeration capacity is lost due to insufficient refrigerant flow to evaporator 29. Likewise, by preventing evaporator 29 from being starved for refrigerant, ice formation on the evaporator coil can be prevented which overcomes another problem which causes loss of refrigeration capacity. On the other hand, energization of fan 16 under conditions such as higher ambient condenser temperatures will reduce the head pressure by causing proper cooling of condenser 12 so that high head pressure switch 40 will not de-energize the entire refrigeration system.

In accordance with this invention, a sutiable brake is provided on at least second fan 16 to prevent reverse rotation thereof, as shown in greater detail in FIGURE 3. It is also desirable to provide a similar brake on fan 14. Fan motor 36 comprises a vertical stator member 55 and a rotor member 56. Stator member 55 may be of standard commercially available construction which includes a peripheral boss 57 and a number of radial ribs 58 extending radially outwardly from a central hub through which rotor 56 passes. In the motor construction described, ribs 58 also extend axially outwardly from end 59 of the motor casing thereby forming shoulder portions which may provide heat transfer surface to assist in cooling the motor.

The brake assembly comprises a pair of similar brackets 60 and 61. Brackets 60 and 61 are drawn together by self-tapping sheet metal screws 62 and 63 to clamp the bracket about rotor shaft 56.

Bracket 61 has a pair of traverse portions 69 and 70 which are joined by a semicircular clamping portion 73. An angular portion 71 extends from traverse portion 70 in a direction opposite to that of the intended direction of rotation of rotor shaft 56, and traverse portions 69 has an angular portion 72 extending therefrom in a direction opposite that of the intended rotation of rotor shaft 56. Bracket 60 is similarly constructed so as to cooperate with bracket 61 when clamped around rotor 56, as shown in the drawing.

Traverse pivot pins 64 and 65 extend between and are secured to the spaced angular portions 72 and 73 respectively of the clamping bracket. A brake pin 66 is pivotally secured to pivot pin 64 so that it depends from angular portion 72. Brake pin 66 may be suitably formed of stiff metal wire having a loop at one end surrounding pivot pin 64 in pivotal engagement therewith. Brake pin 67 is similarly pivotally secured to pivot pin 65.

The brake assembly is secured on rotor shaft 56 by tightening screws 62 and 63 sufficiently to cause clamping portions 61 to securely engage the rotor shaft. The brake assembly is axially positioned on the rotor shaft so that brake pins 66 and 67 normally extend axially below the upper edges of the shoulders forming ribs 58 when the motor is at rest but at the same time so that brake pins 66 and 67 can swing axially upwardly and outwardly when the motor is turning in the desired direction. Preferably, the ends of the pivot pins are just above end 59 of the motor casing when the motor is at rest.

Brackets 60 and 61 have sufficient axial thickness so that pivot pins 66 and 67 can swing outwardly away from the desired direction of rotation of shaft 56 but are prevented from swinging in the opposite direction by engagement of the pivot pin with the transverse portions of the brackets.

When motor 36 is started in the proper direction, brake pins 66 and 67 engage ribs 58 of the motor and swing upwardly out of engagement with the ribs. They are held by centrifugal force in the upward position, shown in full lines in the drawing, while the motor rotates. When motor 36 is de-energized, brake pins 66 and 67 are no longer subjected to centrifugal force and they again pivot or swing downwardly into engagement with ribs 58 as shown in broken lines in the drawing. Wind or air pressure acting on fan 16 tends to cause reverse rotation of the fan and rotor shaft 56. However, reverse rotation of shaft 56 is prevented by locking engagement of brake pins 66 and 67 with ribs 58 due to the thickness of brackets 60 and 61 which prevent the pins from swinging in the opposite direction.

In operation, when fan motor 36 is de-energized, the brake arrangement described effectively prevents reverse rotation of fan 16. Consequently, when fan motor 36 is again energized, the fan motor can only start in the proper direction. Also, during the period of time fan motor 36 is de-energized, low speed reverse rotation of the motor is prevented, and consequent injury to the bearings due to improper lubrication at low speed is prevented. Also, the tendency of air to freely bypass the condenser, by passing inwardly through reverse rotating fan **16** and outwardly through operating fan **15** is substantially reduced thereby eliminating the need for a baffle between the fans in casing **10**.

Any number of fans may be employed in a condensing unit and one or all of them may be selectively energized and de-energized in accordance with the requirements of the condensing unit. It is desirable to provide each of the fans with a reverse rotation brake in accodance with this invention. Also, various other types of systems, controls and sensors may be used in conjunction with this invention instead of those shown in the illustrated preferred embodiment thereof.

Accordingly, it will be appreciated that this invention may be otherwise embodied within the scope of the following claims.

I claim:

1. A condensing unit for use in a refrigeration system comprising:

(1) a casing having a plurality of apertures formed therein for admitting and exhausting air from said housing;

(2) a heat exchanger disposed in one of said apertures in said housing, said heat exchanger being adapted to condensate refrigerant vapor therein;

(3) a first fan driven by a first electric fan motor disposed in another of said apertures in said housing for passing air over said heat exchanger;

(4) a second fan driven by a second electric fan motor disposed in another of said apertures in said housing for passing additional air over said heat exchanger;

(5) circuit means for energizing said first and said second fan motors including circuit means for selectively energizing and de-energizing one of said fan motors independently of the other fan motor upon the occurrence of a predetermined condition; and

(6) brake means to prevent reverse rotation of said one fan motor when in a de-energized condition at times when said other fan motor is in an energized condition.

2. A condensing unit as defined in claim **1** wherein said one fan motor comprises a permanent split capacitor motor and said brake means serves to prevent reverse rotation of said one fan motor relative to said other fan motor upon energization of said one fan motor.

3. A condensing unit as defined in claim **1** wherein said brake means comprises pivoted means carried by the rotor shaft of said one motor adapted to pivot out of engagement with a relatively stationary portion of said condensing unit when said rotor is turning in the desired direction and to pivot into engagement with said stationary portion of said condensing unit when said rotor is turning in the opposite direction.

4. A condensing unit as defined in claim **1** wherein said brake means comprises a clamping bracket secured to the rotor shaft of said one motor, said bracket having a brake pin pivotally secured thereto, said brake pin having a portion thereof engaging both said clamping bracket and the stator portion of said one motor when said braking pin is urged in a direction opposite the desired direction of rotation thereof, and said braking pin being free to pivot out of engagement with said stator portion of said one motor when said rotor portion is turned in the desired direction of rotation.

5. A condensing unit as defined in claim **1** wherein said predetermined condition comprises a function of condenser pressure, said circuit means being arranged to deenergize said one fan motor when said function of condenser pressure drops below a predetermined minimum pressure to thereby reduce the air passing over said heat exchanger and to thereby raise the condenser pressure.

6. A condensing unit as defined in claim **5** wherein said brake means comprises a pair of clamping brackets mounted about the rotor shaft of the rotor portion of said one motor, fastening means for drawing said clamping brackets toward each other to clamp them into secure engagement with said rotor shaft of said one motor, said clamping brackets having a portion extending transversely of said rotor shaft and having an angular portion extending away from the transverse portion thereof in a direction away from the desired direction of rotation of said rotor member, the angular portions of said clamping brackets being spaced apart, a pivot pin extending between and engaging said spaced angular portions of said clamping brackets, and a brake pin engaging said pivot pin, said brake pin being free for limited pivotal motion with respect to said clamping bracket and normally depending therefrom axially toward the stator portion of said motor a distance sufficient to engage said stator portion, said clamping brackets having an axial width sufficient to engage and prevent pivotal movement of said brake pin in one direction to prevent rotation of said rotor portion of said motor in a direction opposite to the desired direction of rotation thereof, and said brake pin being free to pivot out of engagement with said stator portion of said motor when said rotor is rotated in the desired direction.

7. A condensing unit as defined in claim **6** wherein said casing comprises a single undivided compartment housing both of said fans.

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