

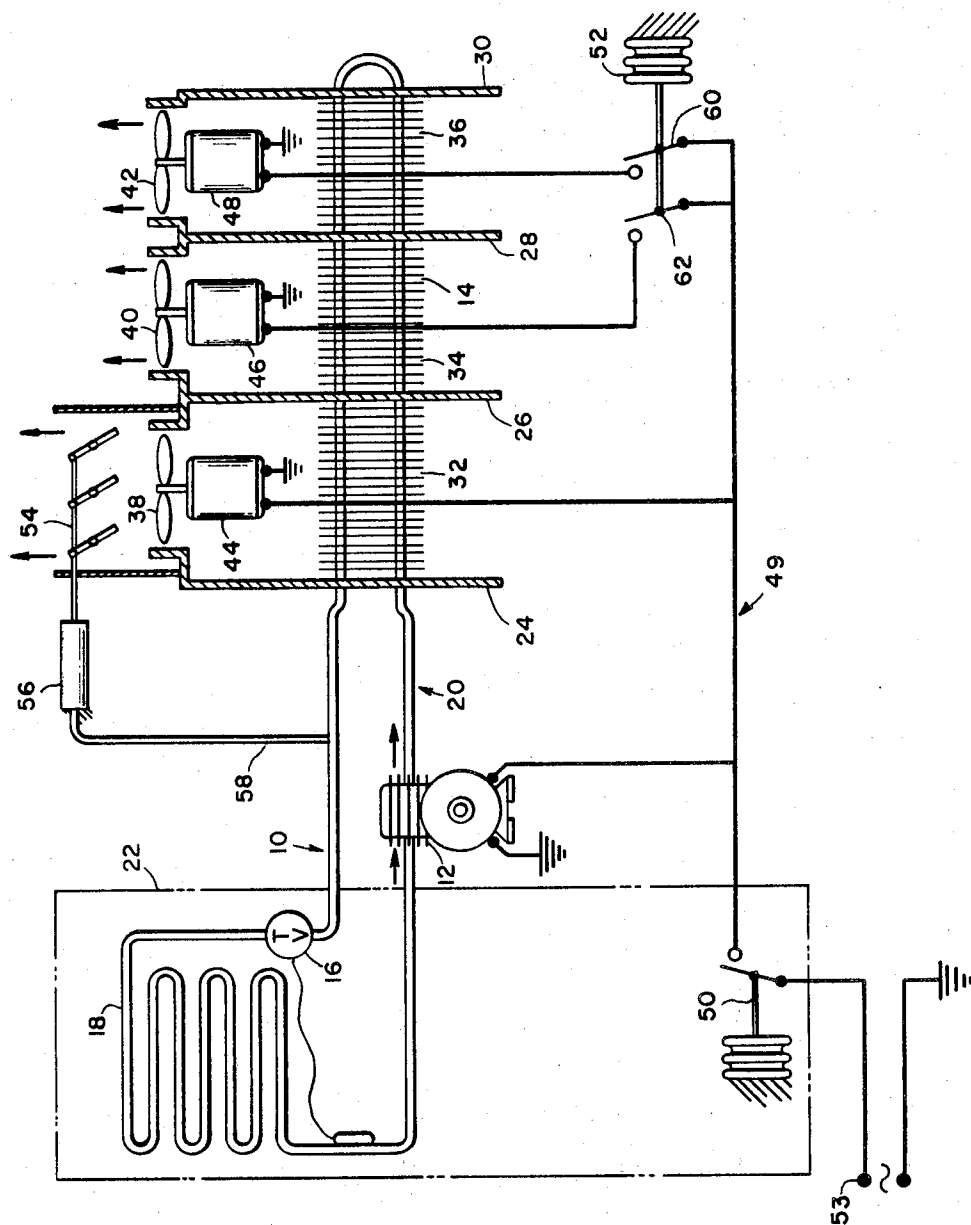
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REFRIGERATION SYSTEM

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REFRIGERATION SYSTEM

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ABSTRACT OF THE DISCLOSURE

A refrigeration system having multiple fans for the condenser thereof and controls for throttling the air passing from a portion of the condenser served by one of the fans while the other fans are cycled between operating and nonoperating positions to thereby obtain total air flow modulation despite the sharp fluctuations in air flow at said other fans.

Summary of the invention

This invention relates to refrigeration systems of the vapor compression cycle type utilizing an air cooled condenser to condense compressed refrigerant. More specifically, this invention relates to such systems using multiple fans for passing cooling air over the condenser and the apparatus for controlling such air flow in response to atmospheric temperature conditions.

In such refrigeration systems it is desirable that the throttling means pass an amount of liquid refrigerant which is commensurate with the heat load placed upon the evaporator. To vary the amount of liquid refrigerant passing through the throttling means with respect to the load, the throttling means is usually constructed in the form of a capillary tube or variable orifice expansion valve, the latter which may be responsive to evaporator outlet temperature and/or pressure.

While these devices have provided satisfactory results in most systems, they have not proved to be entirely satisfactory in systems using atmospheric air to cool the condenser. The reason for their somewhat unsatisfactory operation is that the condensing pressure varies considerably depending upon the load on the condenser, i.e., the amount of refrigerant to be condensed, the temperature of the cooling air, and the amount of cooling air. Such variation in pressure obviously affects the amount of refrigerant passing through the throttling means without regard to the actual load placed on the evaporator. Thus, for example, if the condenser cooling air is relatively cold, the condenser pressure may be excessively low with the result that insufficient refrigerant is delivered to the evaporator to meet the cooling load placed thereon. On the other hand, should the load on the evaporator be relatively small, and the cooling air temperature relatively high, an excessive amount of refrigerant may pass the throttling means which may not be vaporized in the evaporator thereby possibly causing liquid refrigerant slugging in the compressor which is quite damaging to the compressing mechanism. Thus it will be seen that improper condensing capacity caused by wide variations in condenser cooling air temperature is undesirable and should be controlled.

It is an object of this invention to provide a means for controlling the condenser capacity throughout a wide range of cooling air temperatures. More specifically, it is an object of this invention to modulate the total air moved by multiple condenser fans throughout a range which exceeds the full capacity of any one of the multiple fans.

It is a further object to modulate the total air moved by multiple condenser fans throughout a range which exceeds the full capacity of any one of the multiple fans by modulating air flow at only one of the fans.

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It is another object of this invention to provide a multi-fan condenser unit with the minimum damper structure for complete modulation of the air flow therethrough.

It is still a further object of this invention to provide a single damper assembly only at the air discharge side of that portion of an air cooled condenser served by only one of a plurality of fans whereby said damper assembly throttles high velocity air thus minimizing the damper size for complete modulation of the air flow through the condenser.

More specifically, this invention involves a refrigeration system comprising: a refrigerant compressor; an air cooled refrigerant condenser; a refrigerant throttling means; and a refrigerant evaporator respectively serially connected in a closed refrigerant circuit; that portion of said circuit between said compressor and said throttling means including said condenser constituting the high pressure side thereof; means disposing said evaporator in heat exchange relation with a conditioned space; a first fan means arranged to draw atmospheric cooling air through said condenser, a second fan means arranged to draw atmospheric cooling air through said condenser; means for activating and deactivating said second fan means in response to the load on said condenser; an air flow damper means disposed on the downstream side of said condenser in series flow relation with said first fan means for limiting the air flow passing said first fan means without substantially limiting the air flow passing said second fan means in response to the load on said condenser whereby said damper means associated with said first fan means serves to modulate the total air flow through said condenser despite sharp fluctuations in air flow resulting from activating and deactivating of said second fan means.

Other objects and advantages will become apparent as this specification proceeds to describe the invention in detail with reference to the accompanying drawing showing a schematic of a refrigeration system incorporating the invention.

The refrigeration system 10 includes an electrically driven refrigerant compressor 12, an air cooled refrigerant condenser 14, a refrigerant throttling means such as thermostatic expansion valve 16 and evaporator 18 respectively serially connected in a closed refrigerant circuit 20. Evaporator 18 is disposed in heat exchange relation with conditioned space 22 for cooling the same.

Condenser 14 is arranged to be cooled by atmospheric cooling air. Toward this end, baffles 24, 26, 28, and 30 separate condenser 14 into first, second and third portions 32, 34 and 36 for three separate cooling air streams.

First, second and third condenser portions are provided with fans 38, 40 and 42 respectively for passing atmospheric cooling air over the respective portions of condenser 14 as indicated by arrows. Fans 38, 40 and 42 are respectively drivingly connected to fan motors 44, 46 and 48.

An electric control circuit 49 for fan motors 44, 46 and 48 and compressor 12 includes a conditioned space responsive electric thermostat 50, an atmospheric cooling air responsive electric thermostat 52 and an electric power source 53. Thermostat 52 is of the two stage type. The operational relation of thermostats 50 and 52, fan motors 44, 46 and 48, and compressor 12 will be fully described in connection with the operation of the refrigeration system.

Portion 32 of condenser 14 is provided with an air flow damper assembly 54 for controllably restricting the air flow from portion 32. Damper assembly 54 does not throttle the air flow from portions 34 and 36 of condenser 14. The dampers of damper assembly 54 are modulated by a damper motor 56 which may be of the type shown and described in U.S. Patent 2,958,208. Damper motor 56 is

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powered by fluid pressure to open the dampers of assembly 54 upon high fluid pressure and to close the dampers of assembly 54 upon low fluid pressure. The fluid pressure at damper motor 54 is provided by conduit 58 which connects damper motor 54 to the refrigerant circuit 20 between condenser 14 and expansion valve 16. The dampers of assembly 54 are thus positioned in response to refrigerant pressure in the high side of the circuit.

Operation

Assume electric power is supplied at source 53. When the temperature of conditioned space 22 rises above a predetermined level, electric thermostat 50 closes to energize via electric circuit 49, compressor 12 and fan motor 44. Electric power is also supplied via circuit 49 to two stage electric thermostat 52. Assuming the atmospheric cooling air to be high in temperature, the switches 60 and 62 of both stages of thermostat 52 will be closed, thus connecting both fan motors 46 and 48 to power source 53. Under these conditions, compressor 12 and fans 38, 40 and 42 are all in operation. The dampers of assembly 54 will assume a position which is determined by the pressure in the high side of the refrigerant circuit. Compressor 12 compresses refrigerant gas and delivers the high pressure refrigerant gas to the condenser 14 where it is cooled by the cooling air delivered to the condenser by fans 38, 40, and 42. Cooling of the refrigerant gas causes it to condense to a liquid whereupon the liquid refrigerant flows to expansion valve 16. Expansion valve 16 throttles the liquid refrigerant into evaporator 18 under low pressure in the usual manner. The low pressure refrigerant in evaporator 18 is vaporized by heat absorbed from the conditioned space 22 and the resulting vapor is once again returned to the compressor.

If the outdoor or atmospheric cooling air temperature drops, the pressure at the condenser also begins to drop. Damper motor 56 senses this drop in refrigerant pressure and accordingly moves the dampers of assembly 54 to a restricting position thus reducing the air flow from portion 32 of condenser 14 thereby maintaining sufficient condenser pressure for expansion valve 16 to operate effectively in supplying evaporator 18 with an amount of refrigerant commensurate with the cooling load in the conditioned space.

Should the temperature of the atmospheric cooling air decline further the first stage switch 60 associated with fan 42 and fan motor 48 will be opened by thermostat 52, thereby terminating the air flow through portion 36 of condenser 14. With the resulting reduced quantity of air passing over condenser 14, the refrigerant pressure therein may tend to rise. Damper motor 56 immediately senses this change in pressure and causes dampers 54 to open wider and allow a larger quantity of cooling air through portion 32 of condenser 14 to maintain a stable pressure at the expansion valve.

Should the temperature of the atmospheric cooling air drop even further, the second stage switch 62 associated with fan 40 and fan motor 46 will be opened by thermostat 52, thereby terminating the air flow through portion 34 of condenser 14. Damper motor 56 will again move to a less restricting position to compensate for this sharp fluctuation in air flow through the condenser.

Of course it will be understood that the control system will act in reverse upon rising atmospheric temperature. Thus, each time fans 40 and 42 are made operative upon closure of switches 62 and 60 by thermostat 52, damper motor 56 moves the dampers of assembly 54 toward a more restricting position.

It will thus be seen that while the dampers 54 are associated with only a portion of the condenser, they effectively modulate the total air flow over the condenser despite the sharp fluctuation in air flow caused by the cycling of condenser fans 40 and 42. This control thus has the effect of maintaining substantially uniform high side pressure in the refrigeration system throughout a wide range of cooling air temperatures by using a small damper assembly

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which is associated with only a portion of the condenser. Since only a portion of the downstream side of the condenser need be associated with dampers, the cost for providing complete air modulation at the condenser can be substantially reduced. These dampers are relatively small as they are located at a point of high air velocity adjacent the outlet of fan 38.

Having thus described in detail the preferred embodiment of my invention, I contemplate that many changes may be made without departing from the scope or spirit of my invention and I accordingly desire to be limited only by the claims.

I claim:

1. A refrigeration system comprising: a refrigerant compressor; an air cooled refrigerant condenser; a refrigerant throttling means; and a refrigerant evaporator respectively serially connected in a closed refrigerant circuit; that portion of said circuit between said compressor and said throttling means including said condenser constituting the high pressure side thereof; means disposing said evaporator in heat exchange relation with a conditioned space; a first fan means arranged to draw atmospheric cooling air through said condenser, a second fan means arranged to draw atmospheric cooling air through said condenser; means for activating and deactivating said second fan means in response to the load on said condenser; an air flow damper means disposed on the downstream side of said condenser in series flow relation with said first fan means for limiting the air flow passing said first fan means without substantially limiting the air flow passing said second fan means in response to the load on said condenser whereby said damper means associated with said first fan means serves to modulate the total air flow through said condenser despite sharp fluctuations in air flow resulting from activating and deactivating of said second fan means.

2. The apparatus as defined by claim 1 including means for operating said first fan means and said compressor in response to the load on said refrigeration system.

3. The apparatus as defined by claim 2 including a third fan means arranged for passing atmospheric cooling air through said condenser and wherein said means for activating and deactivating said second fan means is a two stage thermostat connected to operate said second fan means from one stage and said third fan means from the other stage thereof.

4. The apparatus as defined in claim 1 wherein said damper means is responsive to a condition of the refrigerant in said high side.

5. The apparatus as defined by claim 4 wherein said damper means is responsive to refrigerant pressure in said high side and operates to increase air flow at said first fan means in response to increased pressure and operates to decrease air flow at said first fan in response to decreased pressure.

6. The apparatus as defined by claim 5 wherein said damper means includes a damper assembly arranged to limit air flow substantially only at said first fan means; a refrigerant powered damper motor; and conduit means connecting said refrigerant circuit high side to said damper motor.

7. The apparatus as defined by claim 1 wherein said means for activating and deactivating said second fan means is responsive to a temperature condition.

8. The apparatus as defined by claim 7 wherein said temperature condition is atmospheric cooling air temperature.

9. The apparatus as defined by claim 4 wherein said means for activating and deactivating said second fan means is responsive to a temperature condition.

10. The apparatus as defined by claim 9 wherein said temperature condition is atmospheric cooling air temperature.

11. The apparatus as defined by claim 5 wherein said means for activating and deactivating said second fan means is responsive to a temperature condition.

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12. The apparatus as defined by claim 11 wherein said temperature condition is atmospheric cooling air temperature.

13. The apparatus as defined by claim 6 wherein said means for activating and deactivating said second fan means is responsive to a temperature condition. 5

14. The apparatus as defined by claim 13 wherein said temperature condition is atmospheric cooling air temperature.

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