Oct. 13, 1964 C. D. WARE 3,152,455

REFRIGERATION CONTROL SYSTEM

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FIG. 2.

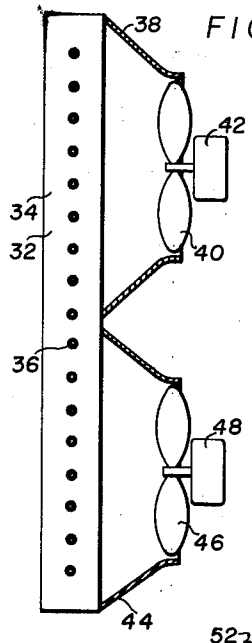
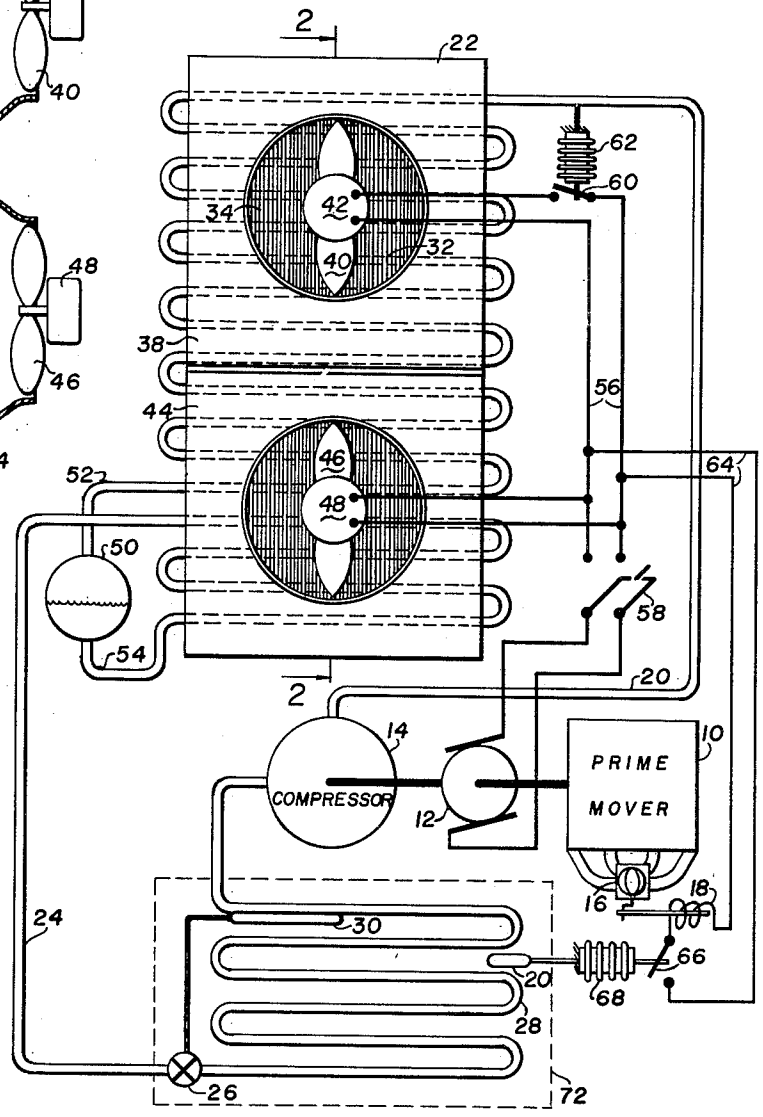


FIG. 1.



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REFRIGERATION CONTROL SYSTEM

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This invention relates to mechanical refrigeration systems and the apparatus for the control thereof.

Refrigeration systems employed in the transportation of refrigerated goods such as frozen foods and produce frequently use a continuously operating internal combustion engine for driving mechanical refrigeration apparatus including a compressor, air cooled condenser, expansion means and evaporator. The engine or prime mover is cycled between a high and low speed to obtain control of the conditioned space.

An object of this invention is to provide apparatus for the refrigeration system control which will enable the prime mover to operate a greater portion of its cycle at low speed.

Another object of my invention is to provide means for reducing the frequency of cycling of the compressor-engine to the full-speed position.

A further object of my invention is to provide a control means which permits a refrigeration system to operate with greater economy and efficiency.

Still another object of my invention is to provide with a single air cooled heat exchange means for obtaining maximum subcooling while simultaneously controlling the head pressure.

An additional object of my invention is to provide in a refrigeration system means which tends to reduce the rate at which frost is built up on the heat exchange surfaces of the evaporator.

Other objects and advantages will become apparent as this specification proceeds to describe the invention with reference to the accompanying drawing in which:

FIGURE 1 is a schematic view of a refrigeration system embodying my invention and showing the air cooled heat exchanger thereof in greater detail; and

FIGURE 2 is a sectional view of the air cooled heat exchanger taken at line 2—2 of FIGURE 1.

Now looking to FIGURE 1, it will be seen that a two-speed prime mover 10 is drivingly connected to an electrical generator 12 and a refrigerant compressor 14. The prime mover 10 may be of the internal combustion type having a throttle or speed control 16 such as for example a carburetor. The speed control 16 is moved from low to a high speed operating position via energization of solenoid actuator 18. The particulars of such a control will vary with the type of prime mover employed and do not constitute part of my invention.

During operation, compressor 14 discharges hot gaseous refrigerant through conduit 20 to an air cooled heat exchanger 22 wherein the gaseous refrigerant is condensed and subcooled. Subcooled refrigerant condensate is discharged from heat exchanger 22 through conduit 24 to expansion valve 26 from whence it passes through evaporator 28 on its return to the suction inlet of compressor 14. Expansion valve 26 may be thermostatically controlled in response to the temperature of the evaporator outlet as by sensing bulb 30.

Referring now to FIGURES 1 and 2 it will be seen that heat exchanger 22 is comprised of a single core 32. Core 32 includes a plurality of vertically extending parallel juxtaposed elongated cooling fins 34 which are traversed by a plurality of horizontally extending fluid conducting tubes 36 contiguous therewith. The upper half portion of core 32 is provided with a first shroud 38 for distributing cooling air from a first fan 40 which is driven

by an electric motor 42. The lower half portion of core 32 is similarly provided with a second shroud 44 for distributing cooling air from a second fan 46 driven by an electric motor 48.

The tubes disposed in the upper portion of core 32 and a portion of the tubes in the lower portion of core 32 are serially connected so as to define a condenser portion of heat exchanger 22. The condenser portion is connected to and discharges refrigerant condensate into a refrigerant receiver 50 by way of conduit 52. The other tubes 36 in the lower portion of core 22 are connected in series to define a subcooler portion thereof, the lower end of which is connected to the liquid discharge of receiver 50 via conduit 54 and the upper end of which is connected to expansion valve 26 via conduit 24 aforementioned.

Fan motors 42 and 48 are arranged to be energized by generator 12 through an electrical circuit 56. Electric circuit 56 includes a main power switch 58 for interrupting power to fan motors 42 and 48. A fan switch 60 having a bellows actuator 62 responsive to condenser pressure is arranged in series with fan motor 42 and in parallel relation with fan motor 48.

Electric circuit 56 also includes a branch circuit 64 which include speed control solenoid 18 aforementioned and in series therewith a thermostatic switch 66 which is actuated by bellows 68 connected to a conventional temperature sensing bulb 20 disposed within the space 72 conidtioned by evaporator 28.

Operation

The primer mover remains in operation during the entire period while the refrigeration system is in use. However, the prime mover will cycle between a high and a low speed to accommodate varying load conditions in the conditioned space. As the temperature in the conditioned space 72 rises, bellows 68 expands and closes switch 66 to energize solenoid actuator 18 thereby actuating speed control 16 of prime mover 10 to the high speed operating position. Conversely, when the temperature in the conditioned space is satisfied, switch 66 opens to de-energize solenoid actuator 18 allowing speed control 16 to return to its low speed position.

In the refrigerant circuit, compressor 14 continuously supplies refrigerant gas to the condenser portion of the air cooled heat exchanger 22 where it is condensed and passes to receiver 50. The liquid condensate from receiver 50 flows through the subcooler portion of exchanger 22 and passes on to the expansion valve 26 and hence is evaporated in evaporator 26. The evaporated refrigerant gas is then compressed and again delivered to the condenser. The amount of fluid so circulated will of course depend on the position of expansion valve 26 and the head pressure of the refrigerant.

It is thus necessary to maintain sufficient head pressure in the refrigerant circuit at the inlet of the expansion valve in order that adequate refrigerant be delivered by expansion valve 26 to the evaporator 28. As the pressure falls in the high pressure side of the circuit, due to lower temperature of cooling air, pressure actuator 62 will open switch 60 to shut off fan 42 while permitting fan 46 to continue to deliver cooling air through the subcooler portion of core 32. While a portion of the condenser extends into the lower half portion of the core 32 it will be seen that the ratio of condensing to subcooling by the heat exchanger is reduced. Upon a rise in high side pressure, the fan 40 will again be energized. During this cycling fan 46 continues to run and has the effect of limiting the cycling of prime mover 10 as will hereinafter be explained. It further has the effect of permitting the prime mover to run for longer periods

at low speed thus increasing the economy of operation and reducing maintenance.

It will thus be seen that in the single heat exchanger **22**, pressure is maintained by controllably limiting condensing therein while simultaneously maintaining maximum subcooling.

Since the pressure is so maintained at the expansion valve **26** and since the refrigerant delivered to valve **26** is subcooled to a maximum, expansion valve **26** is capable of delivering the maximum cooling effect to evaporator **28** for any compressor speed which in turn permits prime mover **10** to operate a greater portion of its cycle at low speed.

By operating a refrigeration system in this manner in accordance with my invention, it follows that economy of operation is improved and maintenance due to prime mover speed cycling and wear is reduced. Further, the refrigeration system will run at the highest practical suction temperature which in turn tends to reduce the rate of frost buildup in the evaporator.

Although I have 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 desire to be limited only by the claims.

I claim:

1. A refrigeration apparatus comprising in combination: a closed refrigerant circuit including a compressor, a heat exchange means for condensing and subcooling refrigerant, refrigerant flow control means and an evaporator serially connected, that portion of said circuit from said compressor to said refrigerant flow control means in the direction of refrigerant flow defining a high pressure side of said circuit; said heat exchange means having a first portion for condensing refrigerant gas from said compressor and a second portion for subcooling refrigerant condensate from said first portion; cooling means for passing a cooling fluid in heat exchange relation with said first and second portions of said heat exchange means; and control means for maintaining the flow of cooling fluid in heat exchange relation with said second portion while reducing the flow of cooling fluid to said first portion in response to a condition of the refrigerant within the high pressure side of said refrigerant circuit thereby controlling the refrigerant pressure in the high side of said circuit and simultaneously maintaining effective subcooling of the refrigerant prior to entry into said refrigerant flow regulating means.

2. The apparatus as defined by claim 1 wherein said control means is responsive to refrigerant pressure in the high pressure side of the refrigerant circuit.

3. The apparatus as defined by claim 1 wherein said heat exchange means is comprised of a heat exchange core having a first portion with fluid passages for condensing gaseous refrigerant, a second portion with fluid passages for subcooling liquid refrigerant and a plurality of heat exchange fins each of which spans fluid passages

of each of said heat exchange core portions and wherein said cooling means comprises a separate fan for each of said core portions.

4. The apparatus as defined by claim 1 wherein said cooling means includes a first motor driven fan operably associated with said first portion and a second motor driven fan operably associated with said second portion and wherein said control means includes an electrical power source, means for conducting electrical current to each of said motor driven fans from said power source and a switch responsive to a condition of the refrigerant in said high pressure side of said circuit and disposed in series with said first motor driven fan and in parallel with said second motor driven fan.

5. A refrigeration apparatus comprising the combination of a refrigerant compressor; an electrical generator; a prime mover drivingly connected to said compressor and generator; a refrigerant condenser connected to the discharge of said compressor; a refrigerant receiver connected to the discharge of said condenser; a subcooler connected to the receiver; a refrigerant flow regulating means connected to said subcooler; a refrigerant evaporator connected to said flow regulating means and the suction side of said compressor; a first motor driven fan means for passing cooling air over said condenser; a second motor driven fan means for passing cooling air over said subcooler; conductor means for conducting electrical current from said generator to each of said fan means; said last mentioned means including a switch responsive to a condition of the refrigerant between the discharge side of said compressor and said flow regulating means and connected in series with said first fan means.

6. A refrigeration apparatus comprising the combination of a refrigerant compressor, an air cooled heat exchanger for removing heat from gaseous and liquid refrigerant therein, an expansion valve and an evaporator serially connected; means for continuously driving said compressor while said refrigeration apparatus is in use; means for shifting the speed of said driving means from a high speed operating condition to a low speed operating condition and vice versa in response to the refrigerant load at the evaporator; and means for varying the ratio of heat removed from gaseous refrigerant to that removed from liquid refrigerant by said heat exchanger in response to a condition of the refrigerant passing from the compressor to the expansion valve to thereby increase the operating time of said driving means at the low speed operating condition.

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