REFRIGERATION MACHINE WITH LIQUID REFRIGERANT COOLED MOTOR

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References Cited
UNITED STATES PATENTS
2,184,285 12/1939 Codling 62/505
3,150,277 9/1964 Chubb 62/505
3,217,193 11/1965 Rayner 62/505

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ABSTRACT
A centrifugal compressor type refrigeration machine is shown with a liquid refrigerant cooled electric motor for driving the compressor. The liquid refrigerant for motor cooling is derived from the refrigeration machine refrigerant circuit at refrigerant circuit pressure but is applied directly to the stator-rotor gap of the motor at a relatively uniform elevationally controlled hydrostatic pressure. Prior to entering the stator-rotor gap, liquid refrigerant is separated from refrigerant vaporized by heat exchange with the stator.

9 Claims, 2 Drawing Figures
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BACKGROUND OF THE INVENTION

Heretofor many advancements have been made in the art of cooling compressor motors for refrigeration machines to thereby reduce their size, weight, cost and increase their reliability. The art has advanced from a state of using solely refrigerant gas for cooling to using liquid sprays directed at both the moving and fixed parts of the ends of the motor.

SUMMARY OF THE INVENTION

This invention pertains to refrigeration machines of the compression type wherein a refrigerant is advanced through a closed circuit of widely varying pressures and temperatures to effect changes in state of the refrigerant medium.

More particularly this invention pertains to the method of utilizing the refrigeration effect of the refrigerating medium of the circuit to effectively cool the compressor motor. In this invention refrigerant liquid is derived from the closed refrigerant circuit under circuit pressure. The liquid refrigerant is then delivered across the stator-rotor gap of the motor via an annular stator cooling chamber at a relatively low pressure of substantially fixed elevational head. The stator cooling chamber also functions as a separator to remove substantial quantities of vaporized refrigerant from the refrigerant liquid prior to the refrigerant passing to the stator-rotor gap. The refrigerant then passes axially outwardly from the stator-rotor gap and with some tangential velocity imparted thereto by the rotor is impelled over the motor end turns and finally is returned to the closed refrigerant circuit at a second lower circuit pressure.

The invention eliminates small internal jets and orifices commonly used in liquid spray cooled refrigerant compressor motors.

It eliminates the hazards of clogged motor cooling passages in the motor.

It further reduces the likelihood of erosion due to high velocity refrigerant impingement.

Other objects and advantages will become apparent as this specification describes the invention with reference to the accompanying drawings in which:

FIG. 1 is a semi-schematic vertical section of a refrigeration machine employing the invention; and

FIG. 2 is a section of the compressor motor taken at line 2—2 of FIG. 1.

Now referring to the drawing it will be seen that the refrigeration machine 10 has a shell-and-tube type evaporator 12 for cooling water, such as from a building chilled water system, which water is passed through a series of interconnected tubes 14. By indirect heat exchange with the water in tubes 14, refrigerant liquid within the shell of the evaporator 12 is vaporized and passes to the inlet 16 of centrifugal compressor 18 which may be provided with capacity control adjustable inlet vanes 20. The refrigerant gas is centrifugally impelled by rotation of compressor impeller 22 to a high pressure and collected in the compressor volute 24 for discharge at 26 to the shell-and-tube condenser 28.

In the condenser the refrigerant gas under high pressure is cooled by indirect heat exchange with cooling water passed through the tubes 29 thereof. The condensed refrigerant falls to and collects in the condenser well 30 where upon it returns to the evaporator 12 through a refrigerant throttling means such as pressure reducing valve 32 which may be constructed in accordance with the teachings of U.S. Pat. No. 3,260,067 regarding valve 52 thereof.

The refrigerant is then conducted through a closed refrigerant circuit or loop including evaporator 12, compressor 18, condenser 28, and refrigerant throttling means 32.

The compressor impeller 22 is rotatably driven by an electric motor 34 via a speed increasing gear drive assembly 36. The compressor 18, gear drive assembly 36 and motor 34 are preferably hermetically constructed, i.e., with no sliding or rotating seals in the exterior walls.

The motor has a rotor 38, the shaft 40 of which is journaled in suitable bearings 42 carried by the ends 44 of motor housing 46. One end of shaft 40 extends into the casing of the gear drive assembly 36 and has mounted thereon for rotation therewith a large bull gear 48 which is disposed in driving mesh with a small pinion gear 52 mounted on and in driving relationship with the impeller shaft 54 of the impeller 22 which is journaled in bearings 56. The gears 52 and 48 are provided with a suitable lubrication system which is not shown for purposes of simplicity.

The motor has an annular stator 58 disposed about rotor 38 which stator is comprised of a stack of annular plates 59 provided in the conventional manner with axially extending interior grooves or slots 61 for receiving the stator windings the end turns 60 of which extend axially therefrom at each end. The axially inner laminations or plates are constructed so as to provide a substantially annular chamber 62 between their radial outer edge and the inner surface of the motor housing 46. The stator 58 has a plurality of circumferentially spaced radially extending passages or bores 64 disposed intermediate the ends of the stator which communicate chamber 62 with the stator-rotor radial gap 66. A conduit 68 is provided to communicate the lower portion of the condenser well 30 through a fixed orifice valve 70 to chamber 62. Valve 70 may be similar to valve 32. Axially extending bores 72 extend through the ends of the stator 58 adjacent the top to communicate chamber 62 with the motor end chambers 74 and 76 which are located between the stator ends and the motor housing end walls 44. The motor end chambers 74 and 76 are connected at their bottoms by conduits 78 and 80 to evaporator 12.

During operation of the refrigeration machine refrigerant is circulated through the closed refrigerant circuit afore described. During this operation liquid refrigerant also passes from the condenser well 30 at a relatively high condenser pressure through pressure reducing valve 70 into the motor 34 to chamber 62 at a rate in excess of that required to adequately cool the motor. Except for bores 64, 72 and inlet conduit 68, chamber 72 is sealed and is maintained during operation full to the level of bores 72 so liquid refrigerant is circumferentially distributed under hydrostatic pressure within the motor housing completely around the outside of stator 58 and to radial passages 64. During operation sufficient heat passes from stator 58 to chamber 62 to vaporize a portion of the refrigerant therein. A substantial portion of refrigerant liquid which may have vapor-
ized in chamber 62 or by reason of the reduction in pressure at valve 70 will separate by rising to the top of chamber 62 whereby predominately liquid refrigerant enters passages 64. Excess liquid refrigerant in chamber 62 rising above apertures 72 passes into end chambers 74 and 76 along with the vaporized refrigerant collected at the top of chamber 62.

Liquid refrigerant entering passages 64 passes directly to the center of the stator-rotor gap 66 where it impinges upon the rotor. The elevation hydrostatic head impelling the refrigerant through passages 64 is limited by the elevation of the refrigerant in chamber 62 as determined by the position of apertures 72. Sufficient heat is passed from the rotor 38 and stator 58 to at least partially vaporize the refrigerant in the stator-rotor gap to cool the rotor and internal surface of the stator. Vaporized and any unvaporized refrigerant passes axially from each end of the stator-rotor gap 66 from whence it passes along with refrigerant passing through apertures 72 over the motor winding end turns 60 in the motor end chambers 74 and 76. The rotational or tangential velocities imparted to the vapors by the rotor in passing axially outwardly through the stator-rotor gap 66 and by the rotor fan blades 39 causes the refrigerant to pass radially outwardly in intimate heat exchange relationship with the motor end turns for improved cooling thereof.

Refrigerant gas and any unvaporized refrigerant liquid is withdrawn from motor end chambers 74 and 76 and passes through conduits 78 and 80 to evaporator 12 thereby maintaining chambers 62, 74 and 76 close to relatively low evaporator pressure. However, it should be appreciated that where a two stage compressor is employed conduit 80 could be connected to the interstage such as by an interstage economizer rather than to the evaporator. In such case chambers 62, 74 and 76 would be maintained at relatively low economizer pressure.

Thus it will be seen that while refrigerant for motor cooling is taken from and returned to the closed refrigerant circuit at variable system pressures which exist within such circuit, the differential pressure forcing the liquid refrigerant through the stator passages 64 is substantially fixed by the hydrostatic gravitational or elevation pressure head of the liquid refrigerant in chamber 62, it being appreciated that excess liquid exceeding the predetermined level established by apertures 72 overflows into chambers 74 and 76. Since this pressure differential is relatively small and constant during operation, the orifices defined by passages 64 may be made relatively large whereby they cannot easily become clogged. The system operates in a simple reliable manner with minimum structure to provide direct liquid cooling to both the outside of the stator and the surfaces defining the stator-rotor gap.

Having now described the preferred embodiment of the invention, it is contemplated that any changes may be made without departing from the scope or spirit of the invention as limited only by the claims.

What is claimed is:

1. In a refrigeration machine having a refrigerant compressor, a refrigerant condenser, and a refrigerant evaporator respectively serially connected in a closed refrigerant circuit, and an electric motor drivingly connected to the compressor and having a stator formed of a stack of plates and a rotor spaced by a stator-rotor ra-
F. passing sufficient heat from said rotor to the liquid portion of refrigerant in said stator-rotor gap to thereby vaporize a second portion thereof; and
G. returning said first and second vaporized portions of refrigerant to said closed refrigerant circuit.

6. The method as defined by claim 5 further including the step of limiting the pressure differential on said refrigerant in passing through said stator.

7. The method as defined by claim 6 wherein the step of limiting the pressure differential includes the step of limiting the hydrostatic elevational head pressure applied to the refrigerant passing about said stator.

8. The method defined by claim 7 wherein step A includes the step of delivering refrigerant liquid into said motor at a rate in excess of that required to adequately cool said motor and wherein said step of limiting the hydrostatic elevational head pressure includes the step of passing an overflow portion of liquid refrigerant exceeding a predetermined height relative to said chamber from said chamber.

9. The method as defined by claim 8 including the steps of passing said first and second vaporized portions and said liquid overflow portion of refrigerant simultaneously in heat exchange relation with the end turns of said stator.

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