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SELF-COOLING CANNED PUMP AND REFRIGERATION
SYSTEM CONTAINING THE SAME

3,306,074

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2 Sheets-Sheet 1

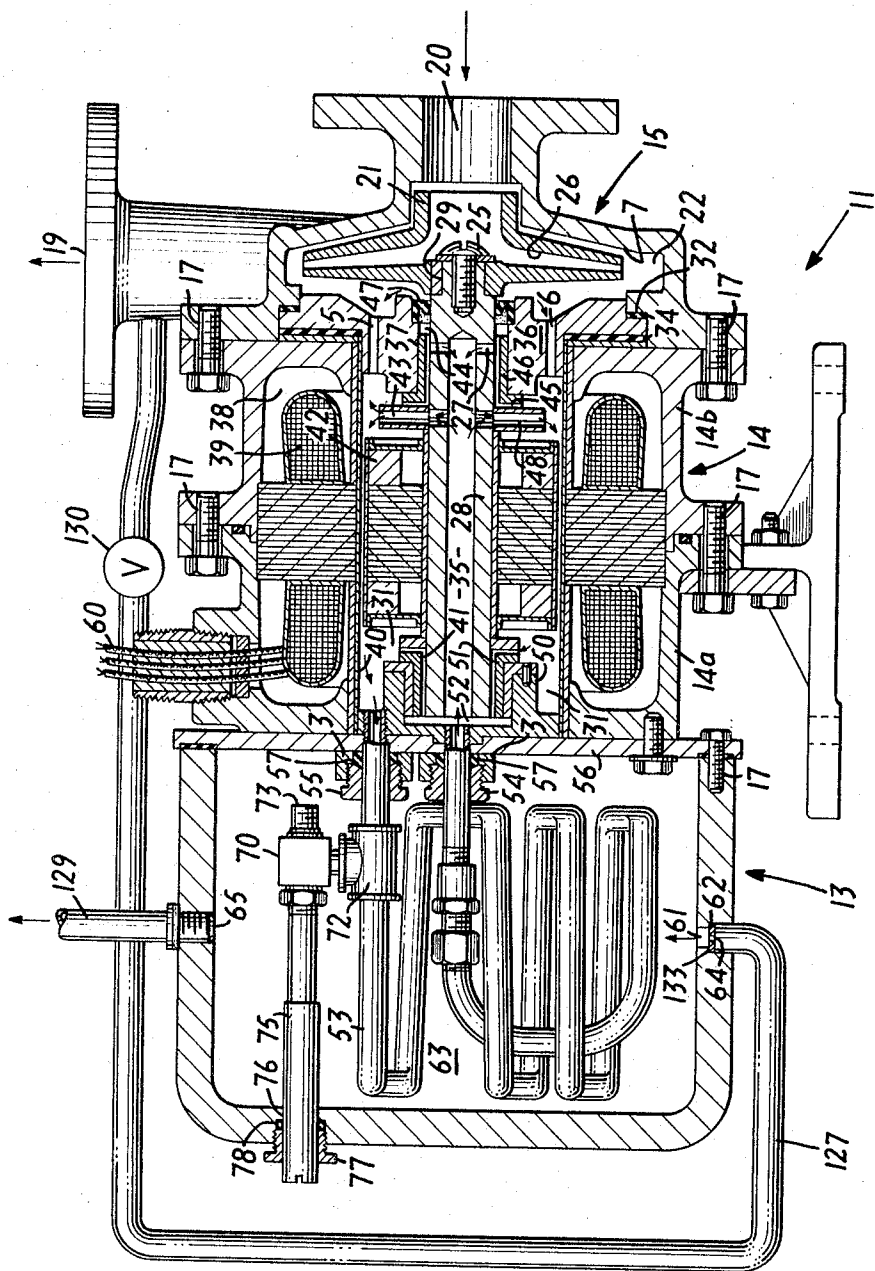


FIG. 1

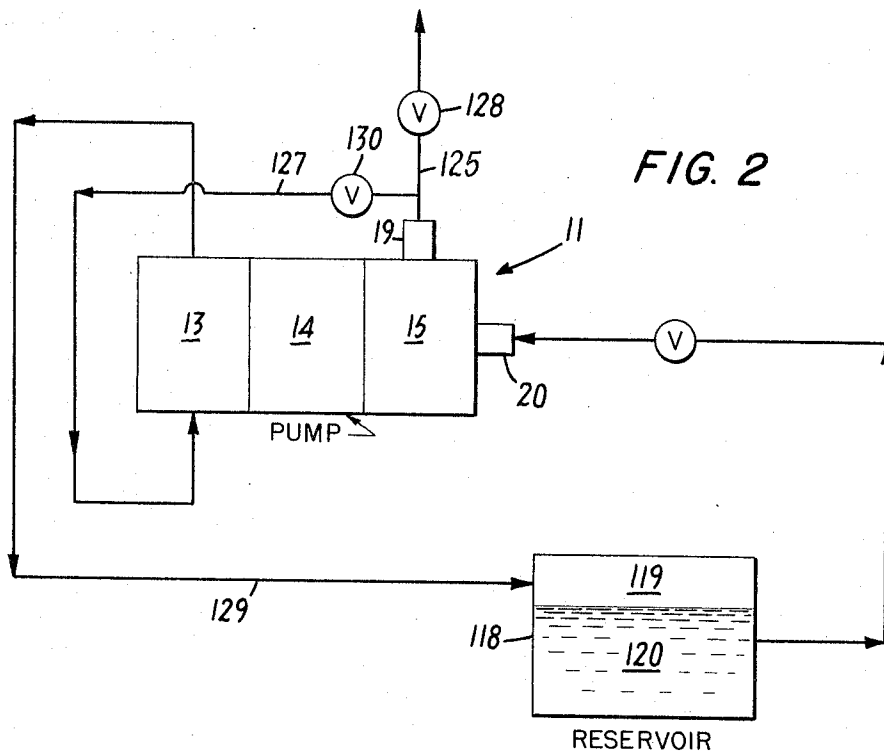
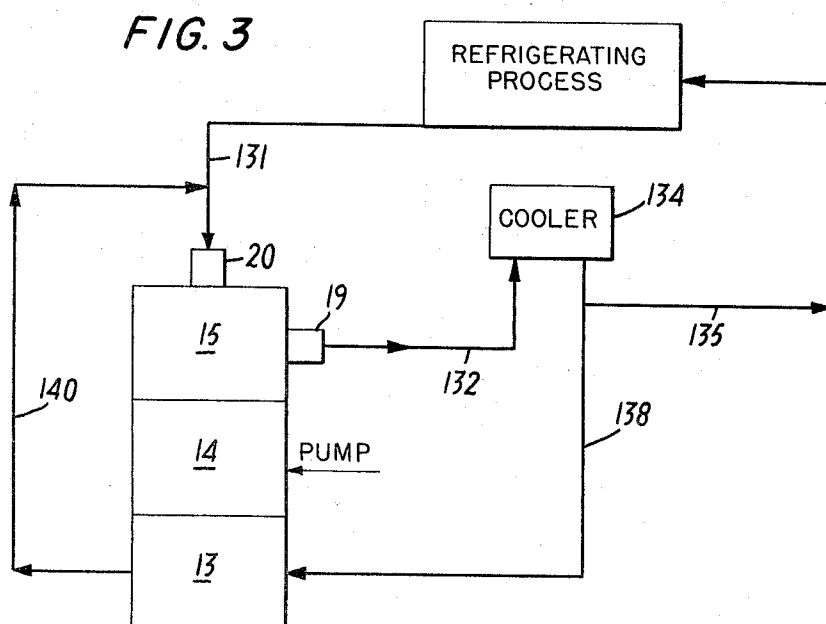
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SELF-COOLING CANNED PUMP AND REFRIGERATION SYSTEM CONTAINING THE SAME

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9 Claims. (Cl. 62—505)

This invention relates to a canned or close-coupled pump provided with a heat exchanger as the pumping means for a refrigeration system especially designed for use in which the refrigerant fluid is the cooling fluid for the pump heat exchanger. More particularly, it relates to a canned pump having a motor chamber in close-coupled relationship to the impeller chamber and cooling means for indirectly cooling the cooling and lubricating fluid within the rotor chamber with a refrigerant itself pumped by the pump in a refrigeration system and to refrigerant systems including such pumps in combination therewith.

In most canned pumps, the motor parts, e.g., the shaft bearings for the rotor drive shaft, are lubricated by the fluid being pumped. When utilizing a canned pump for the pumping of a compressed vapor-type of refrigerant, however, it is generally necessary to have a separate fluid system for lubricating the motor parts, since the refrigerating liquid is usually pumped at its vapor pressure, and accordingly would vaporize immediately upon being subjected to any additional heat if it were allowed to flow through the motor. This of course renders it unsuitable as a lubricating fluid for the motor parts. Hence, in such a canned pump, the motor chamber is separated from the impeller chamber so that pumped fluid cannot circulate through the motor chamber. Thus, the motor chamber fluid is cooled either by heat transfer through the motor chamber walls to the outside air, or by a separate heat exchanger, one side of which is in fluid-flow connection with the motor chamber. Through the second side of the heat exchanger is passed a separate coolant fluid in heat exchange relationship with the motor chamber fluid. This use of a separate external coolant will, of course, require a separate circulating system and a separate pump, and thus two additional liquids are required for lubrication and cooling.

There have been canned pumps, such as shown in U.S. Patent No. 2,986,905 to Kocher et al., dated June 6, 1961, which have a refrigerant system wherein the pumped compressed vapor-type refrigerant, such as Freon, is passed through the interior of the motor chamber to directly cool the motor. This necessitates the use of sealed lubricated bearings for the motor shaft, as the evaporating refrigerant of course provides no lubrication. The oil in the lubricated bearings often leaks into the pump system and Kocher discloses a separator unit, 25 in FIGURE 1, for removing the lubricating oil from the refrigerant fluid.

The use of external cooling coils for cooling the motor chamber liquid with a separate coolant is well-known to the prior art, and is exemplified by U.S. Patents Nos. 2,687,695 to Blom et al., dated August 31, 1954, and 3,013,500 to Bollibon et al., dated December 19, 1961. In both of these cases a cooling coil is in fluid flow relationship with the interior of the motor chamber such that motor fluid passes out from the motor chamber through the coil and back to the motor chamber. The coil is disposed in a cooling chamber through which is passed the coolant liquid.

The canned pump of this invention comprises a housing defining an impeller chamber and a motor chamber, an impeller in the impeller chamber, an inlet and an outlet in the impeller chamber for circulation of fluid to be

pumped therethrough and an inlet and an outlet in the motor chamber, for circulation of lubricating and cooling fluid therethrough, a heat exchanger having a heat exchanging surface separating the heat exchanger into two sides, fluid connections connecting one side thereof with the motor chamber and a fluid connection connecting the other side with the impeller chamber for heat exchange between fluid circulating in the motor chamber with fluid passing through the impeller chamber. It should be understood that the term "pump" includes a compressor, as well.

This pump makes it possible to utilize the pumped fluid, to cool the lubricating and cooling fluid in the motor chamber, and also to pump a compressed vapor-type refrigerating liquid and use this pumped fluid as the cooling and lubricating fluid for the motor chamber, without the need for sealed lubricated bearings.

When pumping the vapor-type refrigerant at its vapor pressure, it is necessary to prevent the fluid in the motor chamber from vaporizing as a result of the heat generated by the motor. This is accomplished in the pump of the invention by providing pressure connections between the motor chamber and a high pressure portion of the impeller chamber to pressurize the motor chamber fluid above its vapor pressure, while preventing it from becoming too warm by cooling it in the heat exchanger, where it is passed in heat exchange relationship with a portion of the fluid being pumped. The refrigerant fluid leaving the heat exchanger after cooling the motor chamber liquid is returned to the refrigerating system.

The pumps of the invention introduce canned pumps for the first time to refrigerant systems, which could not utilize canned pumps, without considerable modifications. The canned pump of the invention possesses the usual attributes of such pumps: compactness, and a generally leakproof design, which is obtainable at a minimum of expense and trouble. Leakproofness is accomplished by eliminating the need for a moving seal, e.g., at the bearings or at the juncture between the rotating drive shaft and the casing of the pump. Heretofore, because of the low boiling point of refrigerant fluids, it has been necessary to use sealed lubricated bearings, or a separate lubricating and cooling fluid for the motor compartment, which would require special seals to prevent contamination of the refrigerant fluid by the lubricating fluid, thus increasing substantially the initial expense as well as the cost of upkeep. Kocher et al., for example use a special separator tank for removing entrained oil from the pumped refrigerant liquid. This is an added expense which would not be necessary with a pump of the new type herein described. This invention now makes it possible to pump a material at its boiling point and utilize the same fluid as the motor lubricating and cooling fluid thereby doing away with the additional expense and trouble inherent in using a different lubricating fluid.

However, in the circumstances where the liquid refrigerant is itself incapable of acting as a suitable lubricating and cooling fluid, as where it is corrosive or abrasive, it is possible to utilize a separate fluid in the motor chamber cooled by the pump fluid in the heat exchanger. This would usually require, however, a seal between the motor and impeller chambers of the pump to prevent leakage.

The refrigerant system of this invention comprises, in combination, a refrigerant reservoir, which preferably contains a refrigerant in the liquid phase at its boiling point and in the vapor phase in contact with the liquid phase, a pump having a housing defining an impeller chamber and a motor chamber, an impeller in the impeller chamber, an inlet and an outlet in the impeller chamber for circulation of fluid to be pumped therethrough and an inlet and an outlet in the motor cham-

ber for circulation of lubricating and cooling fluid there-through, a heat exchanger having a heat exchanging surface separating the heat exchanger into two sides, fluid connections connecting one side thereof with the motor chamber and fluid connections connecting the other side with the impeller chamber and the reservoir for heat exchange between fluid circulating in the motor chamber with fluid passing through the impeller chamber and conduit means for flow of refrigerant liquid between the reservoir and the impeller chamber.

It is preferred to utilize the pumped fluid as the cooling and lubricating fluid within the motor chamber, to eliminate the need for expensive and troublesome fluid-tight seals between the impeller and motor chamber. When the fluid in reservoir is at its boiling point, however, as in the case of a refrigerant liquid of the compressed vapor type, it is necessary to pressurize the fluid in the motor chamber to prevent it from boiling immediately upon absorbing the motor heat. This is accomplished by providing a pressure connection between a high pressure portion of the impeller chamber and the motor chamber, which transmits pressure from the impeller chamber. It is preferable that this connection have means to prevent the flow of fluid from the motor chamber into the impeller chamber, and vice versa.

Preferably, the pumped refrigerant is tapped for heat exchange purposes at the exhaust from the impeller chamber. This eliminates the necessity for having a separate pump solely for circulating the refrigerant. Where the refrigerant is of the compressed vapor type, to obtain the most effective cooling, the liquid will be bled into the second side of the heat exchanger so as to flash upon coming into contact with the relatively hot heat exchange surface separating the two sides of the heat exchanger. To insure the flashing of the refrigerant immediately upon entering the heat exchanger a flow restrictor can be inserted in the inlet to the second side of the heat exchanger such that the pump refrigerant passing into the heat exchanger from the outlet of the pump will immediately experience a pressure drop and will flash. An alternative method would be to allow the refrigerant to pass into the heat exchanger and then to allow the refrigerant liquid to boil therein as it passes through. The refrigerant vapors passing out from the heat exchanger are returned to the main refrigerating system.

The position of the heat exchanger vis-a-vis the pump, as well as the type of heat exchanger chosen, are not critical to the invention. Their position and the type will be determined by the amount of heat exchange surface necessary for providing sufficient cooling capacity for the motor fluid, space requirements for the particular pump, and any other factors peculiar to a given situation. For example, the heat exchanger can be of the shell-and-tube type wherein the motor chamber fluid will pass through the tube side of the heat exchanger, or the heat exchanger can be of the coiled tube type wherein the motor chamber fluid will pass through the coil of the heat exchanger. When using a vapor-type of refrigerant, it is preferred to pass the pumped liquid into a large housing, such as the shell side of a tube-and-shell, or coiled tube, heat exchanger.

The heat exchanger may be located at a distance from the canned pump or it can be attached to the pump housing. It can be attached to the motor chamber end of the pump, as is shown in the drawing, or it can be located in an annular jacket around the pump. Various embodiments are known in the prior art, and a preferred embodiment is described in the drawings.

FIGURE 1 is a sectional view of an embodiment of a canned pump of this invention,

FIGURE 2 is a flow sheet of a refrigeration system utilizing the canned pump of FIGURE 1, and

FIGURE 3 is a flow sheet of a second type of refrigeration system wherein a canned pump of the type shown

in FIGURE 1 acts as the compressor for the refrigeration system.

The pump of FIGURE 1 comprises a housing 11 which is formed in three sections, the heat exchanger section 13, the motor section 14, and the impeller section 15. The sections are bolted together by bolts 17. The motor section is formed in two parts 14a and 14b which are also bolted together for ease of maintenance. The motor section has an open end, which is closed off by end plate 56, also bolted on.

The impeller section 15 includes an impeller chamber 22 having an outlet 19, an inlet 20 and an impeller 21 rotatably supported therein, in fluid flow impelling relationship between the inlet and outlet. The impeller has an internal volute 26. The pump section 15 also has a volute 7 formed in the impeller chamber 22, complementing the impeller volute 26. Although the impeller in this embodiment is of the centrifugal type, the invention is equally applicable to any other type of motor pump, such as a turbine pump or a gear pump.

The motor section contains a motor rotor chamber 31, which is separated from the impeller chamber 22 by the end plate 36. Plate 36 at its external periphery, is held by the ledge 32 on the pump section housing 15 against the thrust plate gasket 34, and the entire assembly of plate 36 and gasket 34 are held in a fluid-tight seal between housing sections 14 and 15 by bolts 17. Pressure ports 5 and 6 extend through plate 36 and connect the impeller chamber 22 to the motor rotor chamber 31 at a position close to the outer circumference of the motor rotor chamber 31, to tap the high pressure at this portion of the impeller chamber.

A support bearing 46 is press-fitted into a central passage 37 in end plate 36. The front end of rotor shaft 28 passes through and is rotatably supported by the bearing 46. A bearing retainer 50 is connected to the end of stator cup 40 abutting the end plate 36 and holds therein bearing 51 which supports the back end of shaft 28. A barrier seal, in this embodiment, a lip seal 47, is located between the shaft 28 and an indentation in the passage 37 of the end plate 36 sealing off flow of fluid in the motor rotor chamber along the shaft into the impeller chamber 22. Bearing lubrication space 44 is defined in passage 37 between the front end of bearing 46 and lip seal 47.

The impeller 21 is attached to drive shaft 28 by bolt 25, which is threaded into the end of shaft 28. A necked-down portion of the shaft 28 extends through an opening 29 in the back side of the impeller 21. The rotor 42 is fixed to the shaft 28, to rotate therewith.

The shaft 28 has a central channel 35 running from the rear of the shaft to a position adjacent the front end of the shaft, beyond the bearing 46. Radial channel 27 in the shaft 28 connects the central channel 35 to the bearing lubrication space 44. A secondary impeller in the form of two radial arms 43 is attached to the shaft 28. The arms have central channels 48 connecting the central channel 35 of the shaft with the motor rotor chamber 31. The back end of the central channel 35 opens into bearing lubrication space 52 formed within bearing holder 50.

The lubrication spaces 44 and 52 communicate directly with the motor rotor chamber 31 through the dogleg longitudinal and radial channels 45 and 41, respectively.

Stator chamber 38 is annularly disposed just inside of the motor section housing 14, defined by stator cup 40, and contains the stator 39. The stator 39 is connected to a source of electrical power (not shown) via electrical wires 60. In this embodiment, the stator chamber is sealed off from the rotor chamber 31. However, under certain conditions this may not be desirable, and the rotor and stator chambers may be in fluid flow connection.

Cooling coil 53 is contained within the heat exchanger chamber 63. One end of the coil is in fluid connection with lubrication space 52 and is held in place by the gland nut 54. The other end of the coil is in fluid connection with the motor rotor chamber 31 through coil inlet 58

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and is held in place by the gland nut 55. The gland nuts 54 and 55 are threadedly connected to raised bosses 3 on the end plate 56. The gland nuts 54 and 55 hold sealing glands 57 in place around the cooling coil ends to prevent leakage between the motor rotor chamber 31 and heat exchanger chamber 63.

A vent valve 70 is attached to the cooling coil 53 through T 72 to allow venting of the coil through nipple 73 to the heat exchanger chamber 63. The slot-headed control leg 75 for the vent valve 70 extends through aperture 76 in the housing section 13. Gland nut 77 and sealing gland 78 prevent leakage from the heat exchanger chamber 63. The manually operated vent valve described above can be readily replaced with any of the conventional automatic vent valves now commonly used.

Conduit 127 is thread-fitted into the pump section 15 at the outlet 19 at one end and into the heat exchanger section 13 at its other end through the inlet 61. A plate 62 having an orifice 64 is placed in the inlet 61 and held between the end of conduit 127 and shoulder 133 in the housing 13. Valve 130 is attached into conduit 127, and is normally open. The chamber 63 has an outlet 65 in which is similarly fitted a conduit 129 leading to the main refrigeration system.

In this type of canned pump, the motor operates in a fluid bath, i.e., the motor rotor chamber 31 and cooling coil 53 are filled with a cooling and lubricating fluid. The bearings 46 and 51 are thus lubricated and cooled by the fluid, and the rotor 42 and shaft 28 are also cooled by the same fluid. Similarly, by having the fluid flowing through the motor rotor chamber, the stator compartment 38 is also cooled.

The motor rotor chamber 31 is filled with pumped fluid through ports 5 and 6 from the impeller chamber 22. The fluid is allowed to fill the cooling coil 53, shaft channel 35 and the motor rotor chamber itself before the pump is turned on. The vent valve 70 is open to permit venting while the motor rotor chamber and coil are being filled. When these spaces are filled the vent valve 70 is closed by turning the slot-headed control leg 75.

After these spaces are full, the pump is turned on, and as the impeller 21 rotates, the secondary impeller 43 also rotates, forcing circulation of fluid up through the central shaft, out through the secondary impeller arms 43, around the motor rotor chamber 31, down through inlet 58, into the cooling coil 53 and finally back to the motor rotor chamber 31 through space 52, whence it is recirculated via the central shaft impeller 43. A portion of the fluid is also passed through bearings 46 and 51 for lubricating and cooling. The liquid in the motor rotor chamber 31 is pressurized above the pressure in the pump inlet by putting the ports 5 and 6 at the outermost portion of the motor rotor chamber 31, as far from the center of the impeller 21 as possible and by preventing fluid flow along the shaft 28 with the lip seal 47.

The pumped compressed vapor refrigerant fluid enters the impeller chamber through inlet 20, passes through the eye of the impeller, is spun out through the volute 26 of the impeller 21, into the volute 22 in the impeller housing section 15 and then out through the outlet 19 at the required pressure. A portion of the pumped refrigerant is diverted through conduit 127 to the heat exchanger housing section 13. The refrigerant passes through the orifice 64 and flashes upon entering the relatively hot and lower pressure heat exchanger chamber 63. The lubricating liquid in coil 53 is cooled thereby, and the refrigerant vapor exits through outlet 65, and conduit 129, returning thence to the main refrigeration system.

The orifice plate 62 can be omitted, and the refrigerant fluid can be allowed to pass as a liquid into the heat exchanger chamber 63, within which it will boil off, and exit through outlet 65. It is preferable that the inlet be located at or near the lower portion of the chamber 63, i.e., when the pump is horizontal, as shown in FIGURE 1, the inlet 61 is at the bottom and the outlet 65 is at the top of the heat exchanger housing section 13.

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In the embodiment shown in FIGURE 1, the refrigerant is passed through the shell side of a coil-and-shell heat exchanger. Although it would be possible to pass the rotor fluid through the shell side and the refrigerant through the cooling coil, when utilizing a vaporizing refrigerant it is considered preferable to allow the refrigerant to vaporize in the open shell space, and cool a liquid carried in a coil or in tubes passing therethrough. However, when the refrigerant used is of the non-evaporating type, the lubricating fluid and the refrigerant liquids can be passed through either side of the heat exchanger. However, even in that situation it is advantageous to pass the motor chamber liquid through the tubes or coil rather than through the shell space, as it improves the circulation of the motor chamber liquid. It will be appreciated that the pumping power of the secondary impeller in the rotor chamber is generally relatively small, compared to the power of the primary pump impeller and it requires less power to obtain a suitable circulation through a tube than through a relatively large chamber.

The various portions of the housing 11 are shown in FIGURE 1 as being bolted together for ease of maintenance and breaking down the entire unit. However, it is also possible to weld the sections together, or to cast the housing into two axial halves, as opposed to the vertical sections shown herein, and either weld or bolt the sections together.

The material of construction will depend upon the fluid pumped and the temperature at which it is operated. For highly corrosive materials, the preferred material would be stainless steel. When using a different motor chamber fluid, the motor chamber can be sealed off completely from the impeller chamber by closing ports 5 and 6 and the material of construction of the motor housing section may be different.

In the refrigeration system of FIGURE 2 the pump, generally designated as 11, is divided into three sections, the impeller section 15, the motor section 14 and the heat exchange section 13 as shown in FIGURE 1. Reservoir 118 which includes an upper portion 119 for vapor phase above the liquid refrigerant in the lower portion 120 is connected at its lower portion 120 through conduit 122 to the inlet 20 of the impeller section 15. Conduit 125 leads from the outlet 19 from the impeller section, and includes gate valve 128. Conduit 127 connects to the interior of the heat exchange section 13, and includes valve 130. Conduit 129 connects the section 13 to the vapor space 119 in reservoir 118. The refrigerant liquid pumped through conduit 125 goes through a refrigerating system (not shown), where it vaporizes while refrigerating, and the vapors are eventually recompressed and returned to the reservoir 118 in the liquid phase.

Alternatively, when the canned pump acts as the compressor for the refrigerating system, as shown in FIGURE 3, refrigerant vapor from the refrigerating process enters the impeller chamber 15 from conduit 131. The refrigerant is compressed and exhausts through outlet 19 into conduit 132 to cooler 134, where its temperature is reduced. Conduit 135 carries the cooled liquid refrigerant to the refrigerating process area. Conduit 138 taps a portion of the cooled refrigerant, and connects into the heat exchange section 13, from which the vaporized refrigerant then passes through conduit 140 to conduit 131 and then into the impeller chamber, where it is recompressed.

As stated above, the refrigerant material need not be of the compressed vapor type and may be of a material such as brine or other high heat capacity refrigerant liquid. However, for the most efficient cooling, high latent heat vaporizable materials, such as the Freons, are preferred.

When pumping such materials as the Freons at their vapor pressure, it is important to prevent any boiling of the material in the impeller chamber. Accordingly, if the motor must be operated at a temperature very much

above the temperature of the Freon, such that a different lubricating fluid must be used in the motor, it would be necessary to include a thermal barrier, or insulating layer, in the end plate 36 to prevent excessive heat exchange across the end plate 36, which may cause boiling of the Freon in the impeller chamber. This would result in cavitation in the pump and uneven pumping.

What is claimed is:

1. A motor pump for the pumping of compressed vapor refrigerants, comprising a housing defining an impeller chamber, a motor chamber and a heat exchanger; an impeller in the impeller chamber, and a motor in the motor chamber; an inlet and an outlet in the impeller chamber for circulation of fluid to be pumped there-through, and an inlet and outlet in the motor chamber for circulation of pumped fluid therethrough for lubricating and cooling; a pressure relief connection between a high pressure portion of the impeller chamber and the motor chamber to relieve any increase in fluid volume in the motor chamber due to heat from the motor; a heat exchanging separator member in the heat exchanger separating the heat exchanger into two compartments, one compartment being in fluid flow connection with the inlet and outlet of the motor chamber so as to form a fluid flow circuit with the motor chamber, and the other compartment of the heat exchanger being in fluid flow connection with a high pressure portion of the impeller chamber, for heat exchange between pumped fluid passing through the impeller chamber and pumped fluid circulating in the motor chamber.

2. The motor pump of claim 1 wherein the heat exchanger comprises an outer housing defining a shell space having an inlet and an outlet, and a tube disposed within the shell space and having an inlet and an outlet, the inlets and outlets of both tube and shell being attached in a manner separating the fluids passed therethrough for heat exchange.

3. The motor pump of claim 1 comprising a vent valve between the first and second sides of the heat exchanger.

4. The motor pump of claim 2 wherein the tube defines the first side of the heat exchanger and comprises in addition a pressure-reducing flow restriction placed in the inlet to the second side, whereby a pumped refrigerant liquid at its boiling point will flash immediately upon entering the second side.

5. A closed circuit compressed vapor type of refrigerating system comprising, in combination, in a closed fluid circuit interconnected by fluid lines, a refrigerant reservoir for a compressed vapor refrigerant held therein partially in a lower liquid phase and partially in an upper vapor phase, an element to be refrigerated by refrigerant fluid circulated in the circuit, and a canned motor pump for pumping refrigerant fluid in the circuit, the pump comprising a housing defining an impeller chamber and a motor chamber; an impeller in the impeller chamber, and a motor in the motor chamber; pressure ports between the motor chamber and a high pressure portion of the impeller chamber; an inlet and an outlet in the impeller

chamber for circulation of refrigerant fluid to be pumped therethrough, and an inlet and an outlet in the motor chamber for circulation of refrigerant liquid therethrough for lubrication and cooling; a heat exchanger having a heat exchanging surface separating the heat exchanger into two sides; fluid connections connecting one side thereof with the inlet and outlet in the motor chamber, and second fluid connections connecting the other side thereof with the impeller chamber and with the closed fluid circuit for heat exchange between refrigerant liquid circulating in the motor chamber and refrigerant fluid passing through the impeller chamber and the fluid circuit.

6. The refrigerating system of claim 5 wherein the heat exchanger includes an outer shell defining a shell space having an inlet and an outlet and a tube disposed within the shell having an inlet and an outlet, the inlets and outlets of both tube and shell being connected to the fluid connections in a manner separating the fluids passed therethrough for heat exchange.

7. The refrigerating system of claim 6 wherein the tube defines the first side of the heat exchanger and the outlet from the shell side of the exchanger is in fluid flow connection with the upper portion of the reservoir.

8. The refrigerating system of claim 5 comprising a vent valve between the two sides of the heat exchanger.

9. A compressed vapor type of refrigeration system comprising a closed fluid circuit interconnected by fluid lines, a compressor comprising a housing defining a compressor chamber and a motor chamber, a compressor in the compressor chamber, a motor in the motor chamber, an inlet and an outlet in the compressor chamber for circulation of fluid to be compressed therein, and an inlet and an outlet in the motor chamber for circulation of refrigerant liquid therethrough for lubricating and cooling, pressure ports connecting the motor chamber to a high pressure portion of the compressor chamber; a heat exchanger having a heat exchanging surface separating the heat exchanger into two sides, one side thereof being in fluid connection with the inlet and the outlet of the motor chamber, and the other side thereof being in fluid flow connection with the compressor chamber for heat exchange between refrigerant liquid circulating in the motor chamber with refrigerant fluid passing through the compressor chamber and the refrigeration system circuit; means for cooling the effluent from the compressor, and an element to be refrigerated by refrigerant fluid circulated in the circuit.

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MEYER PERLIN, *Primary Examiner.*