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MAGNETIC PUMPS FOR USE IN REFRIGERATION SYSTEMS

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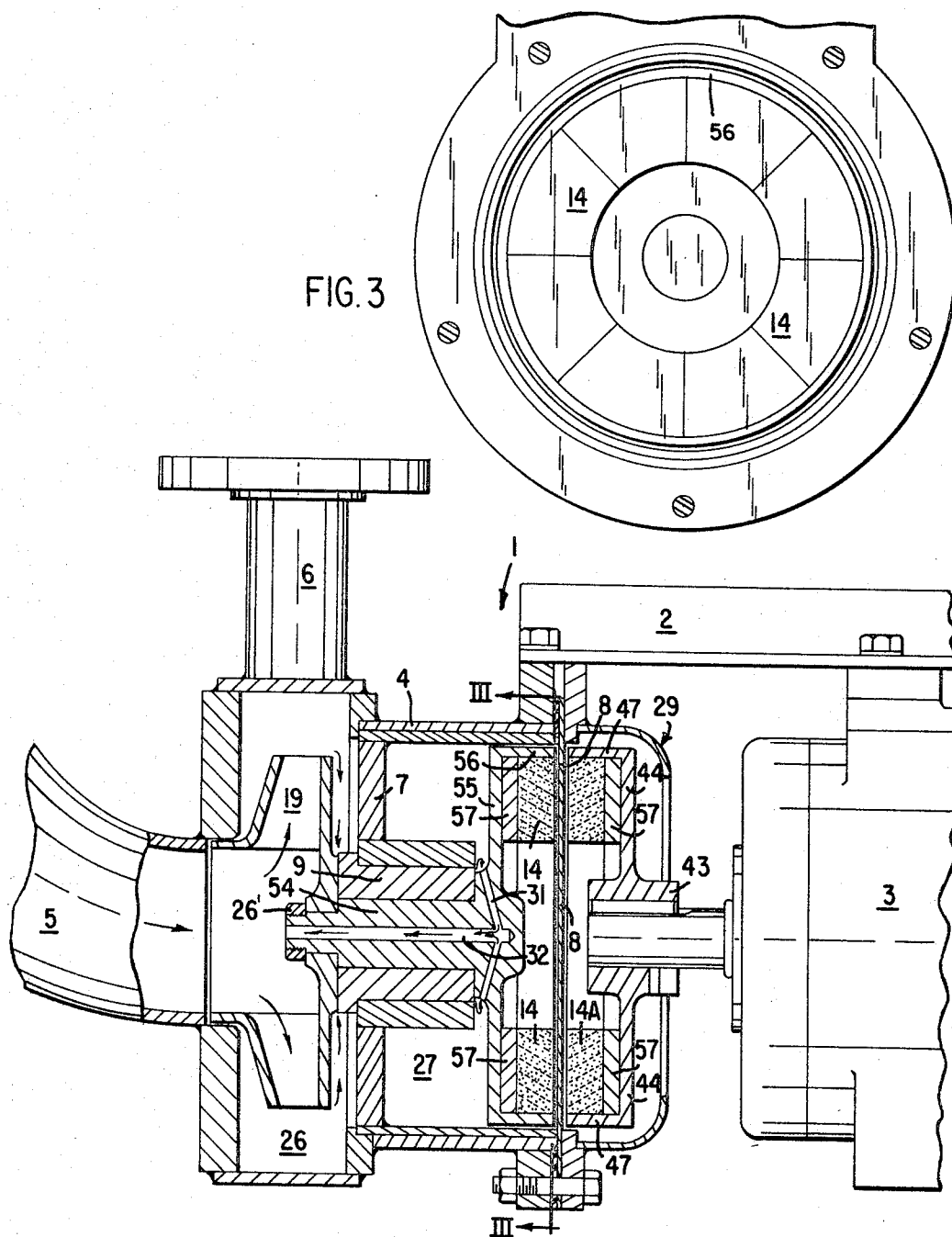


FIG. 2

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MAGNETIC PUMPS FOR USE IN REFRIGERATION SYSTEMS**Kenneth H. Miller, Syracuse, and Edward F. Russ, Baldwinsville, N.Y., assignors to Carrier Corporation, Syracuse, N.Y.**

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4 Claims. (Cl. 62—476)

This invention relates to absorption refrigeration systems and more particularly to pumps for use in absorption refrigeration systems for circulating fluids therein.

In absorption refrigeration systems employing saline solution, such as a mixture of water and lithium bromide as an absorbent and water as a refrigerant, circulation of the water-lithium bromide solution and circulation of the refrigerant water throughout the system is usually effected by means of a solution pump and a refrigerant pump. Common practice utilizes the fluids pumped to lubricate and cool the moving parts of the pump such as the bearings, thereby eliminating the higher cost of, and the sealing problems incident to, the use of a pump having a separate lubrication and cooling system. To increase the reliability of the fluid pumps used in an absorption refrigeration system, magnetically driven pumps have been proposed to eliminate shaft seals or packing. Ordinarily, magnetically driven pumps have a pump impeller with magnets affixed thereto. Driving magnets positioned on the outside of the pump casing opposite the back face of the impeller are magnetically coupled to the impeller magnets. When the drive magnets are rotated by a prime mover such as an electric motor, the pump impeller rotates therewith. Process fluid which is being pumped, completely fills the pump casing including the space between the magnets and the casing or diaphragm separating the pumps from the prime mover. Any solid magnetic impurities in the fluid being pumped are attracted by the magnets and collect in the space between the impeller magnets and the casing or diaphragm, decreasing the running clearance therebetween causing excessive wear of the casing or diaphragm and the magnet surfaces. This problem is exaggerated in an absorption refrigeration system in that as the system operates, the solution becomes increasingly contaminated with foreign matter such as rust, dirt and abrasives.

The chief object of the present invention is to provide an absorption refrigeration system including magnetically driven pump means for circulating the fluids therein.

A further object of this invention is to provide a magnetically driven pump for pumping fluids, such as absorption refrigeration system fluids, contaminated with foreign matter such as rust, dirt, and abrasives. Other objects of the invention will be readily perceived from the following description.

This invention relates to an absorption refrigeration system which comprises, in combination, an absorber, an evaporator, vapor from the evaporator flowing to the absorber to be absorbed by solution therein, a condenser, a generator, vapor from the generator flowing to the condenser to be condensed therein, condensate from the condenser passing to the evaporator, and a magnetically driven pump assembly to circulate solution and condensate, the pump assembly including a mounting plate, an electric motor mounted on the plate, a refrigerant pump and solution pump mounted thereon, each pump having a casing with an inlet and an outlet, and a central partition therein adapted for mounting an impeller shaft bearing, and an impeller shaft mounted in the bearing with provision for supporting an impeller wheel on one end thereof and for mounting the impeller drive magnets in the other end thereof. A small quantity of the fluid being pumped is utilized as a bearing lubricant, the

fluid passing from the impeller side of the casing partition through the bearing clearance to the drive magnet section of the casing. Fluid passages in the shaft between the drive magnet section of the casing and the inlet section of the impeller provide a return fluid passage. Since the process fluid in the drive magnet section of the housing must flow through the bearing clearance where foreign particles are effectively strained, the process fluid in contact with the magnets is free of solid impurities and the magnet-casing clearance is likewise maintained free of foreign particles.

This invention further relates to a magnetically driven pump for pumping fluids such as absorption refrigeration system fluids contaminated with foreign matter such as rust, dirt, and abrasives, the pump having a casing with an inlet, an outlet, and a central partition therein for mounting an impeller shaft bearing. The impeller shaft mounted in this bearing has provisions for mounting an impeller wheel on one end thereof and for mounting the impeller drive magnets on the other end thereof. A small quantity of the fluid being pumped is utilized as a bearing lubricant, the fluid passing from the impeller side of the casing partition through the bearing clearance to the drive magnet section of the casing. Fluid passages in the shaft between the drive magnet section of the casing and the inlet section of the impeller provide a return fluid passage. Since the process fluid in the drive magnet section of the housing must flow through the bearing clearance where foreign particles are effectively strained, the process fluid in contact with the magnets is free of solid impurities and the magnet-casing clearance is likewise maintained free of foreign particles.

Other objects and features of our invention will become apparent upon consideration of the ensuing specification and drawings in which:

FIGURE 1 is a flow diagram of an absorption refrigeration system incorporating the present invention;

FIGURE 2 is a sectional view of the pump structure; and

FIGURE 3 is an enlarged view of a magnetic ring utilized in the magnetic pump drives.

Referring particularly to FIGURE 1, there is shown an absorption refrigeration machine having a generator 10, a condenser 11, an evaporator 12, and an absorber 13.

Generator 10 comprises a shell 15 having a plurality of fire tubes 16 passing therethrough. Gas jets 17 supply an ignited mixture of gas and air into fire tubes 16 to heat weak solution which is supplied to the generator ("weak solution" as used herein referring to a dilute solution of lithium bromide which is weak in absorbing power). A vapor lift tube 18 extends from the top of shell 15. Weak solution is heated in generator 10 to boil off refrigerant vapor and to thereby concentrate the weak solution. A mixture of concentrated absorbent solution and refrigerant vapor bubbles rises upwardly into separator 20. An equalizer line 21 is provided between the bottom of generator 10 and separator 20 to assist in stabilizing the generator boiling.

Condenser 11 is conveniently contained in the same shell as separator 20 and comprises a plurality of heat exchange tubes 23. A cooling medium from a suitable source, such as a cooling tower, passes through condenser tubes 23. Refrigerant vapor separates from the mixture of absorbent solution passed to separator 20 and passes to condenser 11 through eliminator 22. The refrigerant vapor is condensed in condenser 11. Liquid refrigerant thus formed passes from condenser 11 through condensate line 24 to spray nozzles 25 in evaporator 12.

Evaporator 12 comprises a plurality of heat exchange or evaporator tubes 30 disposed in a tube bundle located in a portion of shell 33. Water or other heat exchange fluid to be cooled is passed through evaporator tubes 30.

Liquid refrigerant is distributed over evaporator tubes 30 by refrigerant spray nozzles 25 and 38. Discharge of the refrigerant from the spray nozzles flash cools the refrigerant, a portion of which vaporizes and passes through eliminator 39 into absorber 13. The chilled refrigerant in the evaporator extracts heat from the water passing through evaporator tubes 30 resulting in further vaporization of the refrigerant. This vapor also passes into absorber 13 through eliminator 39, carrying with it the heat absorbed from the water passing through tubes 30. The chilled water may be circulated to suitable remote heat exchangers (not shown) to provide cooling or air conditioning as desired.

Shell 33 includes an evaporator sump 34 containing unevaporated refrigerant liquid which drips off the lower rows of evaporator tubes 30. A refrigerant recirculation line 35 is connected to receive refrigerant from sump 34. The refrigerant is pumped through refrigerant pump 36 and recirculation line 37 to spray nozzles 38 where it again is discharged over the top of the tube bundle in the evaporator.

As previously explained, refrigerant vapor and absorbent solution from generator 10 is separated in separator 20. The concentrate absorbent solution, or strong solution ("strong solution" as used herein refers to a concentrated solution of lithium bromide which is strong in absorbing power) is passed from the lower portion of separator 20 through strong solution line 40, through one side of heat exchanger 41, from which it flows through strong solution line 42 and is distributed by spray nozzles 45 over absorber tubes 46 to wet the absorber tubes.

Absorber 13 is preferably also contained in shell 33 and comprises a plurality of heat exchange tubes 46 disposed in a tube bundle. Cooling water from a suitable source, such as a cooling tower, is passed through heat exchange tubes 46 to cool the hot refrigerant vapor from the evaporator and the absorbent solution sprayed into the absorber from spray nozzle 45. The refrigerant vapor from the evaporator is absorbed by the absorbent solution. The cooling water may be circulated so as to flow from absorber heat exchange tubes 46, through condenser tubes 23 to a cooling tower (not shown) where the cooling water is recooled and returned to the absorber tubes. Preferably, the cooling water is circulated first through the lower tubes so as to maintain a more uniform temperature difference throughout the tube bundle.

An absorber pan 48 is arranged around the sides and bottom of the tube bundle in the absorber to separate absorber 13 from evaporator 12 and to prevent absorbent solution from spray nozzles 45 from passing into the evaporator. Eliminators 39 may or may not be provided in the vapor path between the absorber and evaporator. Absorber pan 48 also prevents refrigerant vapor from entering the sides of the tube bundle and confines the vapor flow to the region about the tubes. An absorber discharge conduit 49 collects absorbent solution which drips from the absorber tubes and discharges it into inlet 64 of solution storage sump 50, which is formed in the lower portion of the shell 33 by a partition 51.

A purge line 52 having an opening adjacent the lower portion of the tube bundle in absorber 13 is connected to a suitable purge unit 53. Purge unit 53 may be jet purge of the general type shown in United States Letters Patent No. 2,940,273, granted June 14, 1960, to Louis H. Leonard, Jr., or it may be a vacuum pump type, or any other suitable type of purge.

A baffle 60 is provided between absorber pan 48 and evaporator 12 to prevent unwanted refrigerant draining into the absorber. Absorbent solution is withdrawn from the absorber through line 65 and passed by pump 66 through line 67, heat exchanger 41, and line 69 to equalizer line 21 where it is forwarded to the generator for reconcentration. A portion of the solution from pump 66 may be passed through solution recirculating line 58 so as to mix with concentrated absorbent solution in

line 42 and recirculate through spray nozzle 45. The recirculating line 58 has an orifice 58' therein so that fluid entering line 42 is at the same pressure as the concentrated absorbent solution from heat exchanger 41.

A solution loop line 70 is provided between equalizer line 21 at an appropriate height, and the lower portion of absorber pan 48. Line 70 serves to maintain the proper solution level in generator 10 on start-up.

The pump assembly 1 consists of the aforementioned pumps 36 and 66 attached to mounting plate 2 having a motor 3 positioned therebetween. The pumps are basically identical except that one impeller and casing are designed for clockwise rotation while the other impeller and casing are designed for counterclockwise rotation.

FIGURE 2, which is a sectional view of one of the pumps and a portion of the drive motor 3, illustrates the preferred embodiment of our pump.

A pump casing 4 having an inlet 5 and an outlet 6 is provided with a combination central partition and bearing support member 7. A diaphragm 8 mounted on casing 4 serves as an end closure therefor and forms and enclosure with partition 7. The diaphragm is preferably formed of a non-magnetic, non-conducting material, such as fiberglass-reinforced epoxy, to eliminate eddy current losses, which reduce the torque transmitting capability of the magnetic coupling employed. However, in some applications, the pressure differential across the diaphragm is great enough to cause excessive deflection of diaphragms of most non-conducting materials. For absorption refrigeration pump applications, pressure differential across the diaphragm necessitates the use of a high stiffness diaphragm material, such as Inconel, which results in a somewhat lower torque transmitting capability of the coupling due to the eddy current losses induced thereby. The central partition 7 divides the housing into an impeller section 26 and enclosure 27. A bearing 9 is suitably affixed to central partition 7 and has a shaft 54 journaled therein.

An impeller 19 is suitably affixed to one end of the shaft in the impeller section of the housing as by nut 26'. The end of shaft 54 in the coupling section of casing 4 has a radially extending flange 55 formed thereon. An axial flange 56 projecting from the periphery of flange 55 is provided so as to enable the drive magnet 14 to be mounted therein in a manner to be explained hereinafter. Radial fluid ducts 31 communicating with axial fluid duct 32 in shaft 54 are provided to pass process fluid from enclosure 27 to the inlet portion of the impeller to provide a constant flow of process fluid (which is utilized as lubricant for bearing 9) from the high pressure side of the pump through the bearing clearance into the enclosure 27, and back to the low pressure side of the pump. Foreign matter in the process fluid is strained at the thrust bearing entry (surface between bearing 9 and back of impeller 19, FIGURE 2), assuming the thrust load is toward the magnet end of shaft 54 (rearward). This straining effect reduces bearing wear in addition to effectively preventing solid foreign particles from entering enclosure 27. Once the coupling section is filled with fluid, the fluid circulating through the bearing clearance will be drawn out of the enclosure through passages 31 and 32 with very little circulation occurring throughout the enclosure. Any minute foreign particles that do manage to pass through the bearing clearance will therefore be immediately withdrawn from the enclosure.

Motor 3 is provided with identical magnetic drivers 29 affixed to the motor shaft on each end thereof which form a coupling with the magnetic rings 14 within the pump casings. Referring to FIGURE 2 there is illustrated a hub 43 having a radially extending portion 44 thereon with an axially extending flange 47 formed on the periphery of portion 44. A ceramic magnetic rings 14A is affixed to magnetic backing plate 57 which is in turn affixed to the portion 44 of hub 43 within flange 47 oppo-

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site the magnetic ring 14 in the enclosure 27 of the pump to provide a magnetic coupling therebetween.

Particular attention must be given to the mounting of the ceramic magnetic rings 14 and 14A. The ceramic rings must be mounted on a magnetic material, such as soft iron, before they can be magnetized. A further requirement is that an air gap or non-magnetic material be provided around the periphery of the ring.

In FIGURE 2, the illustrated shaft 54, with flanges 55 and 56 formed thereon, and the hub 43, with portions 44 and 47 thereon, are constructed of a material such as non-magnetic stainless steel. If it is desired to provide a magnetic coupling without flanges 56 and 47, the shaft 54 with flange 55 and hub 43 with portion 44 could be formed of a magnetic material such as soft iron or other magnetic material compatible with the fluid being pumped. With such construction, the ceramic rings could be bonded directly to flange 55 and hub portion 44 and then magnetized, the magnetic plate 57 being unnecessary.

FIGURE 3 is a plan view of one of the magnetized ceramic rings utilized in the magnetic coupling showing the orientation of poles therein. In the preferred embodiment of our invention, the rings are magnetized so as to contain eight magnetic poles.

The present invention provides a simplified absorption refrigeration system through the use of a pump having no running seals therein which can utilize pumped fluid, contaminated with foreign particles, as a lubricant and coolant.

While we have described a preferred embodiment of our invention, it will be understood that the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

We claim:

1. In a magnetic drive pump utilizing a portion of the pumped fluid as a coolant and a lubricant for use in a location in which the pumped fluid may be contaminated with foreign materials such as an absorption refrigeration system, the combination of a pump casing, said casing having an inlet and an outlet and a central partition therein, a bearing mounted in the central partition of said casing, an impeller shaft operatively associated with said bearing, said shaft having a radially extending flange on one end thereof, an impeller wheel suitably affixed to the other end of said shaft, first magnetic means mounted on the radially extending portion of said shaft, a diaphragm mounted on said casing serving as an end closure therefor and forming with said partition an enclosure, said first magnetic means being in close proximity thereto, a motor, second magnetic means mounted on one end of said motor magnetically coupled to said first magnetic means for driving said shaft, said shaft having fluid passages therein communicating between the casing inlet and the enclosure formed between the central partition of said casing and said diaphragm so that a portion of the fluid being pumped may flow through the clearance between said bearing and said shaft into the aforementioned enclosure and then through the shaft passages to the casing inlet.

2. In a magnetic drive pump according to claim 1 further including a second pump assembly including a second casing with an inlet and an outlet, said second casing having a central partition therein, a bearing mounted in the central partition of said second casing, a second impeller shaft operatively associated with said bearing, said second shaft having a radially extending flange on one end thereof, a second impeller wheel affixed to the other end of said second shaft, third magnetic means mounted on the radially extending portion of said second shaft, a second diaphragm mounted on said second casing serving as an end closure therefor and forming

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with said partition an enclosure, said third magnetic means being in close proximity thereto, fourth magnetic means mounted on the other end of said motor magnetically coupled to said third magnetic means for driving said second shaft, said second shaft having fluid passages therein communicating between the second casing inlet and the enclosure formed between the central partition of said second casing and said second diaphragm so that a portion of the fluid being pumped may flow through the clearance between said bearing and said second shaft into the aforementioned enclosure and then through the passages in said second shaft to the second casing inlet.

3. In an absorption refrigeration system, the combination of an absorber, an evaporator, vapor from the evaporator flowing to the absorber to be absorbed by solution therein, a condenser, a generator, vapor from the generator flowing to the condenser and passing to the evaporator, and means to circulate fluid in said system, said means comprising a pump assembly including a casing, said casing having an inlet and outlet and a central partition therein, a bearing mounted in the central partition of said casing, an impeller shaft operatively associated with said bearing, said shaft having a radially extending flange on one end thereof, an impeller wheel affixed to the other end of said shaft, first magnetic means mounted on the radially extending portion of said shaft, a diaphragm mounted on said casing serving as an end closure therefor and forming with said partition an enclosure, said first magnetic means being in close proximity thereto, a motor, second magnetic means mounted on one end of said motor magnetically coupled to said first magnetic means for driving said shaft, said shaft having fluid passages therein communicating between the casing inlet and the enclosure formed between the central partition of said casing and said diaphragm so that a portion of the fluid being pumped may flow through the clearance between said bearing and said shaft into the aforementioned enclosure and then through the shaft passages to the casing inlet.

4. An absorption refrigeration system according to claim 3 further including a second pump assembly comprising a second casing having an inlet and outlet and a central partition therein, a bearing mounted in the central partition of said second casing, a second impeller shaft operably associated with said bearing, said second shaft having a radially extending flange on one end thereof, a second impeller wheel affixed to the other end of said second shaft, third magnetic means mounted on the radially extending portion of said second shaft, a second diaphragm mounted on said second casing serving as an end closure therefor and forming with said partition an enclosure, said third magnetic means being in close proximity thereto, fourth magnetic means mounted on the other end of said motor magnetically coupled to said third magnetic means for driving said second shaft, said second shaft having fluid passages therein communicating between the second casing inlet and the enclosure formed between the central partition of said casing and said second diaphragm so that a portion of the fluid being pumped may flow through the clearance between said bearing and said second shaft into the enclosure in said second casing and then through the passages in said second shaft to the second casing inlet.

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