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SELF-SUSTAINED LIQUID CIRCULATING SEAL SYSTEM

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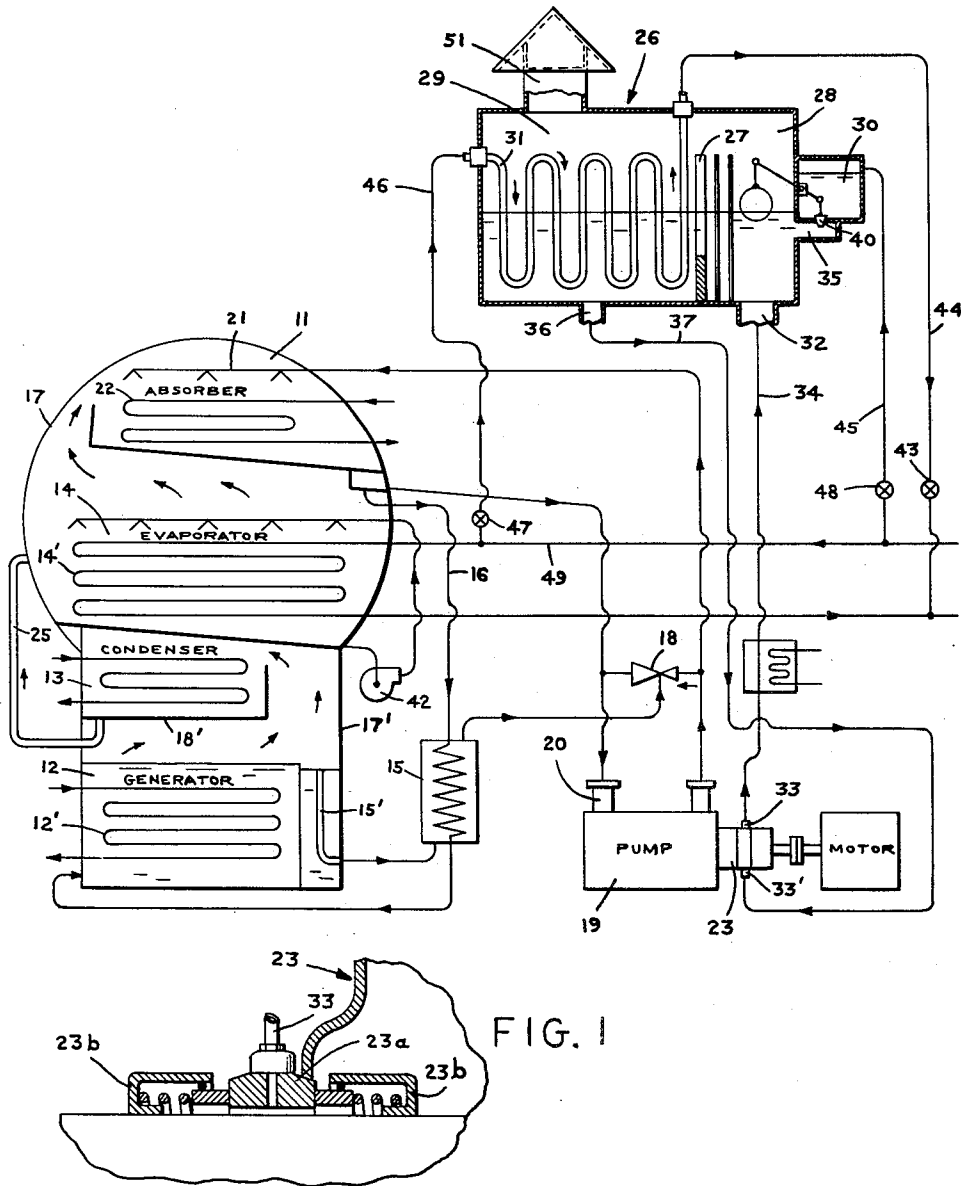


FIG. 2

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SELF-SUSTAINED LIQUID CIRCULATING SEAL SYSTEM

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The present invention relates to a liquid seal arrangement. It relates in particular to seal cooling and flushing means in a refrigeration system including a pump circulating a refrigerant or absorbent mixture through the system at sub-atmospheric conditions.

Refrigeration systems of the type contemplated consist of elements connected to circulate a solution made up of an absorbent such as a brine, and a refrigerant such as water. Characteristic of the normal absorption circuit is the circulation of solution in various degrees of concentration. To provide such circulation, generally a liquid pumping means is provided especially when related machine elements are disposed at different levels.

Absorption machines often employ two and frequently three or more liquid moving pumps. Because the major portion of the system is operated at sub-atmospheric pressure it is essential that the entire apparatus be sufficiently air-tight to prohibit inleaked air which would lead to greatly reduced efficiency. Normally, inleaked air is removed by a purging arrangement. However, where the amount of leaked air becomes excessive, the purger may be of inadequate capacity to properly remove air and other non-condensibles which have penetrated the system.

The simplicity of the normal absorption unit as contrasted with other types of refrigeration systems makes it commercially attractive. These machines are particularly advantageous since they may be run continuously, are self-regulatory in capacity adjustment, and consequently require only a minimum degree of maintenance. Thus, equipment operated in conjunction with the basic absorption unit embodies of necessity a construction requiring little or no maintenance while functioning over long periods of time.

It is therefore an object of the present invention to provide a self-sustaining liquid circulatory system for cooling and flushing seal joints.

It is a further object to provide a self induced liquid circulating system for effectively removing heat from cooperating seal faces operating under sub-atmospheric conditions.

It is a still further object to provide a refrigeration system operable under reduced pressure and normally pumping an absorbent solution, and means cooperative with the system for liquid cooling pump seal faces which otherwise become heated due to rubbing of the rotating seal face against a stationary face.

These and other objectives of the invention will become clear to those skilled in the art from the following description of the invention made in conjunction with the appended drawings, in which:

FIGURE 1 is a diagrammatic representation of the present seal cooling arrangement incorporated into an absorption refrigeration system operating at a pressure less than atmospheric.

FIGURE 2 is an enlarged view in cross-section of a liquid seal of the type presently contemplated.

In accomplishing the aforementioned objectives, the invention in brief contemplates a refrigeration system operative at sub-atmospheric pressure and interconnected with a cooling arrangement for cooperating pump seal faces. Such seals pass a liquid between slidably engaged

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faces to function as a lubricant and as a fluid-tight barrier about a pump shaft.

The instant cooling arrangement includes a reservoir or tank having at least a pair of interconnected chambers holding a supply of sealant liquid to be circulated. Separating means disposed between the respective chambers acts to maintain a substantially equal level of liquid in both chambers and permits unidirectional flow of the sealant medium from hot side to cold side of the reservoir.

One of the chambers is connected by a first line to the seal faces to be chilled and carries a column of liquid which is cooled by means of a liquid circulating cooling coil normally submerged in the sealant liquid.

The cooled liquid flows under a gravity head to the seal assembly to lubricate and cool the seal faces. Liquid then passes to a heat exchanger which may use the ambient air as heat source, and which warms the sealant liquid causing the latter to rise in the upgoing pipe or line and enter the hot side of the reservoir.

Natural circulation of sealant liquid under normal operating conditions is maintained by virtue of a temperature differential existing between the respective inlet and outlet lines to the reservoir. This temperature difference effectuates a sufficient pressure differential in coolant carrying columns to induce an adequate flow for lubricating and cooling seal faces without an appreciable rise in the temperature of the sealant liquid in its passage across the seal faces.

A further requirement of the instant system is that it affords ample warning of incipient failure at either of two seal face assemblies. Following normal seal construction, and as illustrated in FIGURE 2, one seal face assembly prevents sealant liquid from leaking to the ambient, while the other assembly prevents the sealant liquid from leaking into the pump. Should either seal begin to deteriorate and increase its miniscule leak flow rate, liquid in the reservoir will be depleted and by means of a suitable alarm system associated with the liquid level, will alert operating personnel to the possible danger.

Concurrently, it is necessary to assure that the extremely small though continuous leakage does not lead to a drop in liquid level which could cause a false alarm. A degree of liquid makeup is provided by extracting moisture from the atmosphere condensing liquid on the cooling coil and so raising the liquid level. As liquid level in the reservoir builds up, the cooling coil is gradually immersed and in so doing restricts the rate of condensation from the atmosphere and thus is self-regulating, avoiding any overflow.

Normally when water chilling is required for air conditioning applications the humidity is sufficiently high to cause the condensation described above. There may of course be instances where this condition does not exist and in such arid locations, any of the several types of well known humidifiers may be placed in communication with the air space above the cooling coil to supply relatively high humidity air. Because of extremely low water makeup rates, no forced circulation is required, but diffusion or natural convection is sufficient to convey the water vapor to the cooling coils on which it condenses.

Where the signalling or alarm feature of this invention is deemed to be unnecessary, makeup water may be supplied by a simple form of liquid level controller.

While the novel features of the invention are not entirely contingent on a particular disposition of absorber elements, the instant arrangement illustrates an embodiment in which the invention has been operatively assimilated to great advantage.

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Referring to FIGURE 1, the absorption unit consists of basic elements including an absorber 11, a generator 12 having a coil 12' connected to a source of heating fluid, a condenser 13, an evaporator 14 and a heat exchanger 15. These elements are connected by piping and associated control means to define a closed refrigeration system. The circulated solution in the system as previously mentioned may consist of refrigerant and absorbent material such as water and lithium bromide. Circulation of the solution in varying concentrations is motivated either by gravity flow or by the pumping means hereinafter described in greater detail.

Absorber 11 and evaporator 14 are disposed within a first low pressure shell enclosure 17 whereby heated water vapors may rise into the absorber and be contacted by sprayed streams of concentrated brine solution. Condenser 13 and generator 12 are positioned in a high pressure second shell enclosure 17' and relatively disposed with respect to each other to pass vaporized refrigerant to the condenser. In the generator 12, refrigerant vapors are boiled from weak brine solution for the purpose of concentrating the latter. Vapor thus driven from the brine solution being concentrated is condensed in the indirectly cooled condenser located in the higher pressure shell. Condensate is then passed upward through conduit 25 from the high pressure shell to the low pressure portion of the system.

Liquid formed in condenser pan 18' is directed through conduit 25 to the low pressure side of the system into which it flashes for cooling chiller coils 14' by evaporation. The quantity of refrigerant circulated over water carrying heat transfer tubes in the chiller, and the quantity of brine circulated over tubes in the absorber are normally in excess of that required for proper functioning of the respective units.

Liquid in the system is circulated from the uppermost positioned absorber to the lowermost positioned generator and vice versa. In the present arrangement, conduit means 16 is provided for gravity feeding a stream of weak solution from absorber 11 through the tube side of heat exchanger 15 and to the generator 12 for concentrating the solution. After being concentrated by removal of water vapor, strong solution flows from the generator through line 15', passes through heat exchanger 15 shell, and thence to the suction of ejector 18. The ejector as shown is interconnected with a pump 19 normally disposed at the lower part of the machine receiving a gravity flow of solution at its suction 20 and redirecting the same under pressure to spray nozzles 21 located at the upper part of absorber 11 for spraying streams of concentrated solution onto the absorber tubes 22.

Pump 19, carrying concentrated brine, is normally provided with a liquid seal 23 as shown in FIGURE 2 to prevent inleak of air to the fluid system by way of the rotating pump shaft. Because the closed refrigeration system normally operates continuously for long periods of time, the pump seal and other similar seals are constructed and arranged with cooperating faces to circulate sealant medium to absorb heat from the seal, and to maintain a substantially low constant pressure between seal components.

Seal 23 as shown in FIGURE 2 is carried on the pump about the pump shaft, is exemplified by a commercially available type in which adjacently disposed rotating and non-rotating members 23 and 23b define a sealing face therebetween consisting of a thin liquid layer formed along the interface of said members.

The seal cooling arrangement illustrated consists in general of a reservoir or tank 26 defining a fluid enclosure and having a panel 27 dividing the enclosure into adjacently positioned storage and cooling chambers 28 and 29 respectively. These chambers are interconnected permitting unidirectional flow of liquid from 28 to 29.

Weir 27 is intended to operate partially submerged so that the warm liquid entering at 32 can rise and flow over

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the weir. Cooled liquid leaving contact with the cooling coil 31, sinks because of its higher density, and cannot flow backwards across the weir 27, but can only leave through opening 36 thus assuring continuous and unidirectional flow.

Reservoir 26 is vented to the atmosphere so that the cooling circuit is in effect an open system, and as will be hereinafter described this feature permits automatic replenishment of cooling water from the atmosphere when the supply of coolant is reduced.

Tank 26 is preferably positioned at an elevation above the elevation of pump seal 23. As a matter of convenience, the tank may be disposed adjacent to or in heat exchange contact with evaporator 14 of the absorption system when water chilled by the system is circulated through the tank cooling coil 31.

Storage chamber 28 is provided with at least one inlet 32 and conduit means 34 communicated with the outlet 33 of liquid seal 23. Conduit 34 extending between said openings may be rigid piping or of flexible tubing as best suited to the apparatus.

Also cooperative with storage chamber 28 there may be a liquid level control means maintaining a predetermined amount of liquid within the system. The control means may consist of any of several commercial arrangements such as the present device which includes a float assembly actuated by the level of liquid contained in storage chamber 28 between predetermined upper and lower limits. At the lower extremity when the supply of water is below a predetermined minimum level, the control means will actuate a secondary supply mechanism or source such as water contained in a secondary tank 30 which is communicated to the storage chamber 28 through conduit 35 including valve 40. Valve 40 is operably responsive to liquid level control means to open and introduce a flow of liquid to the storage chamber 28 when the control means indicates a low level.

Chilled or unchilled water is supplied to secondary tank 30 through a conduit 45 and valve 48 connected to the upstream side of chiller coil 14'.

While the liquid level control means is described in terms of introduction of liquid from the supplementary source, it is not intended that this embodiment should constitute a limitation to the invention. For example, a suitable water control means might consist of commercially available electrically operated elements connected to a source of water such as city water or refrigerant circulated in the absorber unit when said refrigerant is also circulated in the seal 23 cooling circuit.

Secondary or cooling chamber 29 in tank 26 is provided with at least one outlet 36 connected to line 37, which carries cooled liquid to inlet 33' of seal 23. Chamber 29 is also provided with coil 31 positioned in such manner as to be at least partially immersed in liquid sealant held in chamber 29 prior to introduction of the sealant to inlet 33' of seal 23.

Coil 31 circulates cooling medium which may be loop process water, or is interconnected into a separate refrigeration system. In the present arrangement it is convenient to connect the upstream side of cooling coil 31 through line 46 and valve 47 with the upstream leg of chiller coil 14'. Thus a small amount of loop water to be processed by the absorption refrigeration system will be used for seal cooling. Interconnection of the evaporator and the seal cooling circuit includes valve 43 and line 44 connecting the outlet leg of coil 31 to the downstream leg of chiller coil 14'.

Tank 26 is provided with a vent 51 or similar means permitting communication of the tank interior with the atmosphere. This not only maintains the system in an open condition but also permits replenishing the supply of sealant liquid contained in the system which may become decreased or depleted due to evaporation. Thus, coil 31 is so disposed in chamber 39, preferably in a vertical position, to cool a pool of liquid sealant contained

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in the cooling chamber at all times. When the pool level drops sufficiently to uncover the upper turns of coil 31, depending on the prevalent atmospheric conditions, an amount of water from the air will be condensed on the coil exposed surface and be deposited in the cooling chamber. This replenishment of the water supply is continuous and at a rate depending on ambient conditions and on the temperature of water circulated through coil 31. When of course the level of water in the cooling chamber becomes excessive, coil 31 will be completely immersed and automatically discontinue further condensation.

Thus, the described system may be largely self-regulating in that both the minimum level of water in the system and the maximum level are controlled and automatically maintained.

Operation of the seal cooling system or loop will be described in conjunction with the absorption arrangement shown in FIGURE 1. The system is provided with a supply of water which is initially charged to a predetermined level in tank 26, both input line 34 and output line 37 being connected to the reservoir to fill said lines. To avoid bubble formation within the seal circuit, and to preclude the possibility of airlock, the system may be charged in a manner familiar to commercial practice as by filling through one leg of the closed loop formed by both legs and the seal until water overflows from the other leg.

Thus, with the system fully charged and no temperature differential existing between the respective water columns there will be no appreciable movement of water through the system. As the absorber unit commences to operate, concentrated solution carried from the system heat exchanger 15 and into pump 19 through ejector 18 will be in a heated condition. Much of the heat generated at pump seal faces will be transferred to the seal 23 cooling jacket and to the sealant water circulated therein. As the absorber continues to operate, the seal cooling system liquid will gradually become heated by direct contact with the seal engaging faces.

The hot and cold sides of the cooling system defined by panel 27 in the reservoir and seal 23 respectively, will be at slightly different temperatures depending on the amount of heat transferred to the water sealant from seal heated faces. Chilled water in the colder leg 37 of the loop, having a slightly greater density than water in the heated return leg 34, will in effect be under a slightly greater head than water in the latter line. Theoretically this differential will prompt a sufficient amount of circulation to provide a continuous passage through seal passages for both cooling and flushing.

To induce circulation through seal 23 at a greater rate than would be caused by the normal seal temperature differential, the return leg of the sealant circulating loop may be subjected to additional heating from an external source. One means to accomplish heat addition in the return leg 34 or hot side is to position return leg 34 in heat exchange contact with an external heating element utilizing electricity, steam or other source. Alternately, leg 34 may be positioned in heat exchange contact with normally heated elements of the absorber unit such as the outer surface of generator 12 or heat exchanger 14.

Also, in accordance with the invention, it is understood that chilling fluid passed through coil 31 may be supplied from a source other than that presently shown. For example, this portion of the seal circuit may receive a flow of cooling fluid from a source external to the absorption unit such as a sink or may be interconnected with another portion of the absorber unit itself.

Where, as shown in the drawings, the absorber unit includes a plurality of pumps moving both hot and cooled solution, the respective pump seals may be interconnected in series or parallel. Since the chiller pump 42 will ordinarily move cooled liquid, when a series connection is used the chiller pump seal will be connected upstream of absorber pump seal 23.

It is also practical to connect the respective seals in

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parallel whereby each seal receives coolant liquid at approximately the same temperature. Since both arrangements function to provide the sealing and cooling desired, the particular connection employed is optional.

From the foregoing description it may be appreciated that the invention constitutes features which are highly desirable and advantageous to an absorption or similar refrigeration type apparatus. For example, by eliminating the need for a pump in the seal cooling arrangement, not only is there a saving in the initial installation but also subsequent maintenance to the apparatus is reduced. Further, by interconnecting cooling coil 31 with evaporator coil 14', cooling of pump seal 23 is accomplished by drawing off only so much of the cooled water from the evaporator as is actually required.

While I have confined the foregoing description to an absorption unit of a particular design for the purpose of illustrating the invention, it is not intended to so limit the scope of the cooling arrangement. For example, the relative disposition of a main absorber apparatus with the seal cooling circuit carries certain limitations which are included in a preferred embodiment of the invention, which limitations may be modified and changed without departing from the spirit and scope of the invention.

What is claimed is:

1. In a closed refrigeration system circulating absorbent solution incorporating a refrigerant in liquid and vapor phase at pressure below atmospheric and comprising; an evaporator having a coil including upstream and downstream sides and carrying chilled liquid, a generator, a condenser and an absorber, a motor driven pump pumping at least a portion of the absorbent solution in liquid phase, said motor driven pump including a liquid seal associated therewith preventing leakage of air to the closed system, a liquid seal cooling circuit comprising:

(a) a reservoir forming separate chambers for storage and cooling of a liquid sealant,

(b) said respective storage and cooling chambers being communicated to pass liquid therebetween and being positioned substantially equidistant above the pump liquid seal,

(c) a coil carried in the cooling chamber having inlet and outlet openings and circulating a chilled medium,

(d) a sealant liquid carrying loop having conduit legs communicating the pump liquid seal with the respective storage and cooling chambers,

(e) liquid sealant flowing in one of the conduit legs in communication with the cooling chamber being normally at a lower temperature than liquid sealant flowing in the other of said legs,

(f) whereby chilled sealant flowing in said one leg having a greater density than warmer coolant in the other leg will induce continuous liquid circulation in the liquid carrying loop.

2. In a closed absorption refrigeration system substantially as defined in claim 1 wherein the coil positioned in the cooling chamber is communicably connected with means circulating chilled liquid through the absorber.

3. In a closed absorption refrigeration system substantially as defined in claim 1 wherein the coil positioned in the cooling chamber is in communication with the coil in the evaporator carrying chilled liquid.

4. In an absorption refrigeration system substantially as defined in claim 3 wherein the coil positioned in the reservoir cooling chamber includes an inlet communicated to the upstream side of the coil in said evaporator and receiving liquid therefrom, the cooling chamber coil outlet being in communication with the downstream side of the coil in said evaporator.

5. In an absorption refrigeration system substantially as defined in claim 3 including flow control means cooperative with said reservoir and responsive to the level of liquid therein for controlling the amount of liquid held in the reservoir storage and cooling chambers within

predetermined limits and containing means associated with the flow control means holding a supply of sealant for addition to the reservoir chambers.

6. In an absorption apparatus substantially as defined in claim 3 wherein the leg in said loop carrying warmed liquid sealant is disposed in heat exchange relation with a heat source and receiving heat from the latter to induce circulation of sealant liquid in the loop regardless of temperature differential of liquid between the seal inlet and outlet.

7. In an absorption apparatus substantially as defined in claim 6 wherein the said loop leg carrying warm liquid sealant is disposed in heat exchange contact with a surface of the absorption apparatus normally having a temperature above the temperature of liquid in the other leg of the loop.

8. In combination with an absorption apparatus circulating an absorbent solution, a liquid carrying pump for said solution having a liquid seal including a liquid sealant conducting passage disposed in heat exchange relationship with normally heated seal engaging faces, said sealant conducting passage having inlet and outlet passing liquid sealant therethrough, of a system cooperative with said apparatus circulating liquid sealant through said passage including:

(a) a reservoir positioned above said seal defining a plurality of communicated chambers holding a supply of liquid sealant,

(b) a cooling element disposed in at least one of said communicated reservoir chambers and positioned in contact with liquid contained therein to maintain the liquid in said one chamber at a temperature lower than liquid held in the other of said plurality of communicated chambers,

(c) first conduit means communicating said one chamber containing liquid at a lower temperature with the sealant conducting passage inlet, to direct a stream of chilled coolant to seal engaging faces,

(d) second conduit means communicating the outlet of said sealant conducting passage with the other of the plurality of chambers, said second conduit means carrying heated liquid from the seal engaging faces, to induce circulation of liquid through said

system when sealant flowing in said first and second conduit means is at a temperature differential.

9. In the combination substantially as defined in claim 8 wherein said respective plurality of chambers in the reservoir are adjacently disposed one to the other to hold sealant liquid at substantially the same elevation above the seal.

10. In an apparatus substantially as defined in claim 8 including means communicating the reservoir with a source of sealant liquid for introducing a flow of said liquid to the cooling system to maintain a predetermined quantity of sealant in the system.

11. In a system substantially as defined in claim 8 including flow control means disposed in at least one of said plurality of chambers and communicated to a source of liquid for addition of said liquid to the reservoir, said flow control means being operable to introduce said liquid to the system at a predetermined minimum level.

12. In an absorption system substantially as defined in claim 8 including flow control means disposed in at least one of said plurality of chambers; an auxiliary tank holding a supply of liquid sealant for addition to the reservoir and in communication therewith, valve means communicating with the auxiliary tank controlling the flow of said liquid sealant to the system, said valve means being responsive to the flow control means to introduce liquid to the system in response to the liquid level in at least one of said reservoir chambers.

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