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CIRCULATING MEANS FOR ENCLOSED LIQUID-VAPOR SYSTEMS

Filed Aug. 14, 1959

2 Sheets-Sheet 1

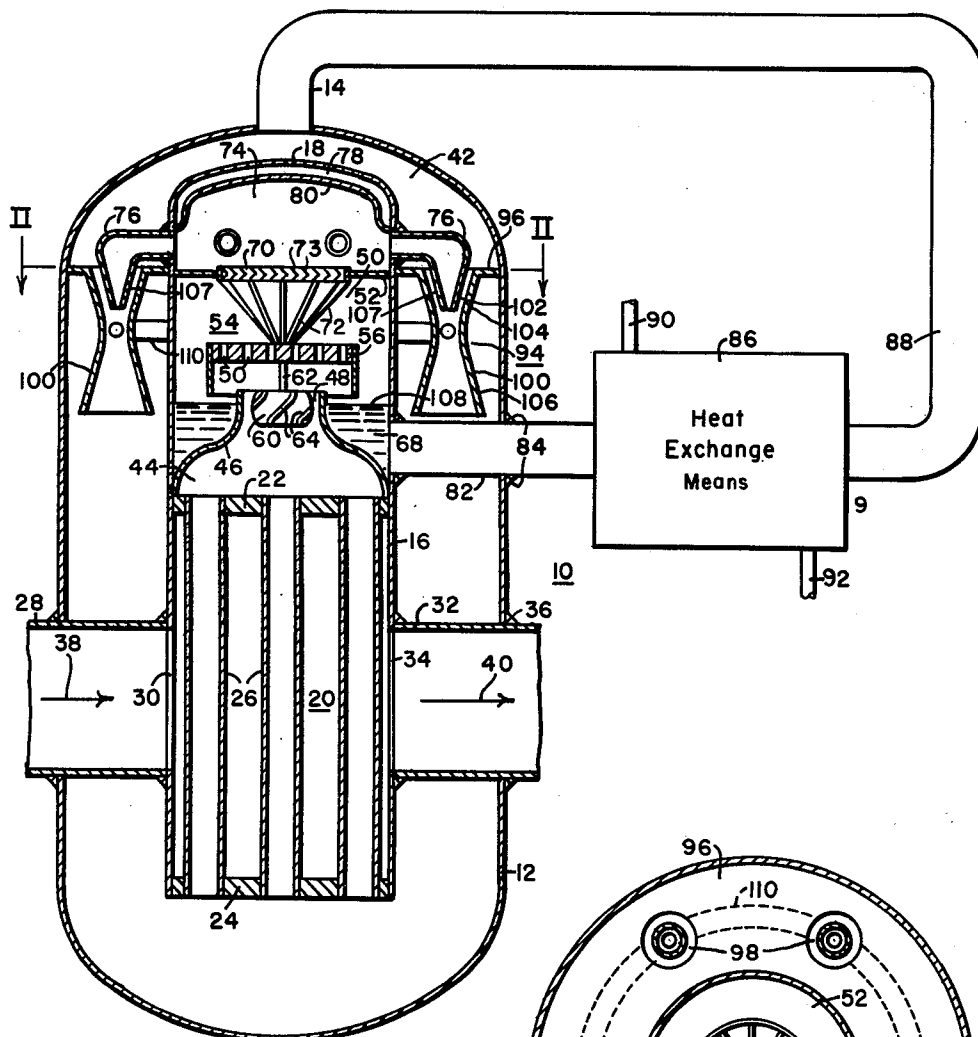


Fig. 1.

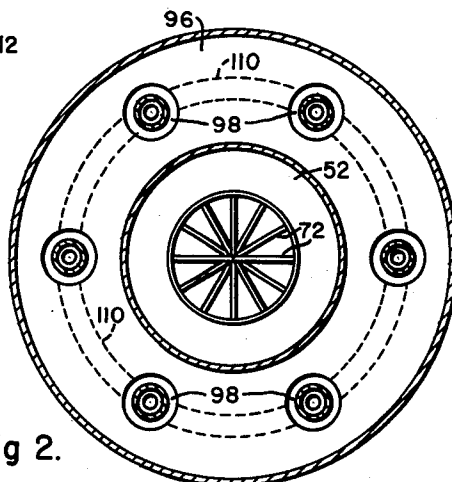


Fig 2.

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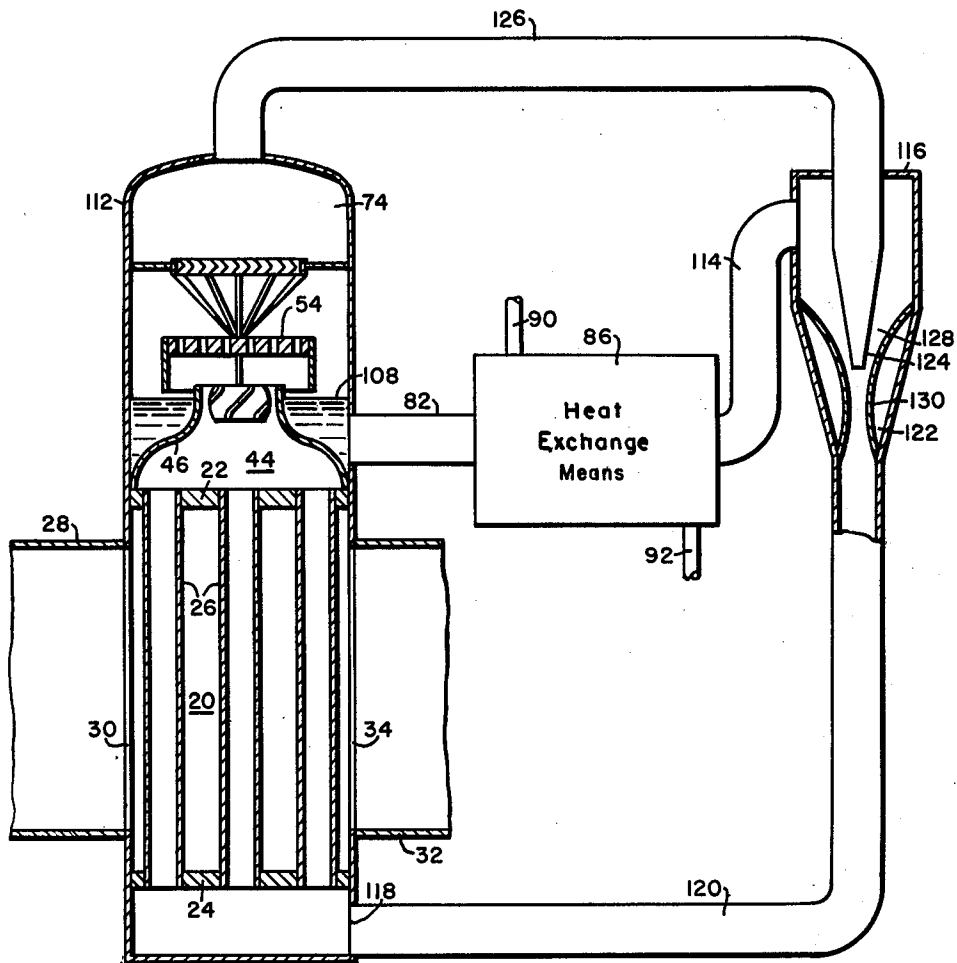


Fig. 3.

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CIRCULATING MEANS FOR ENCLOSED LIQUID-VAPOR SYSTEMS

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14 Claims. (Cl. 165-106)

The present invention relates generally to a new and improved circulating means for enclosed recirculating liquid-vapor systems and is more particularly directed to the use of vapor jet pumps as the circulating means.

Still more particularly, the present invention contemplates the use of vapor jet pumps for causing the circulation of a liquid in a recycling system which may be at extremely high pressures and temperatures.

Present systems wherein a liquid is to be circulated contemplate the use of conventional pumps for producing the motive means for the liquids. In systems wherein high pressures and high temperatures are encountered, these electric pumps must be constructed to withstand the system conditions. In totally enclosed systems which operate under high pressures and high temperatures wherein highly corrosive liquids are utilized, it has been found necessary to select liquid circulating means which can withstand not only these system conditions but in addition, the corrosive effects of the liquid. In many applications, it has been found that it is necessary to provide a leak-tight system inasmuch as the escape of certain liquids would be quite hazardous. Liquid circulating means have been developed in the past to motivate liquids in such systems and normally comprise the use of a totally enclosed or "canned" pump wherein a leak-tight enclosure separates the rotor of the pump from the stator. Of course, the use of a canned motor pump requires certain moving parts to be located in the liquid system which parts are subjected to the high temperatures and pressures of the system as well as the corrosive effects of the liquid. In addition, a great deal of difficulty has been encountered in providing means for lubricating bearings and the like which are required in such pumps. Thus, it may be seen that the use of a canned motor pump for circulating corrosive liquids results in a system wherein failure of the moving parts of the pump creates a difficult maintenance problem in that personnel may be exposed to hazardous materials and a lengthy shut-down of the system may be required.

The present invention contemplates the use of a single or a number of vapor jet pumps located in the liquid-vapor system for providing circulating means for the liquid. Our invention contemplates the use of vapor jet pumps in high pressure, high temperature systems wherein a corrosive liquid may be located. The use of vapor jet pumps in this application eliminates the disadvantages of previously-employed circulating means inasmuch as a vapor jet pump includes no moving parts, whereby maintenance problems for the pumps are substantially eliminated. Vapor jet pumps have been found to be of simple and rugged construction and can be produced at substantially reduced costs when compared to the costs of canned motor pumps or other specialized pumps.

Another aspect of the present invention contemplates the location of the vapor jet pumps entirely within the closed liquid system so that for pressurized systems, the vapor jet pump sees only the system pressure, and the pressure difference of the pump head, rather than a differential between system and atmosphere pressure across the pump casing.

Another feature of the invention contemplates the

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use of a plurality of vapor jet pumps connected in parallel to provide greater flow in response to system requirements. In furtherance of this purpose, a pair of interfitting or coaxial vessels may be provided with the incoming liquid flowing from the top of the outer vessel through the annular space between the vessels to the bottom of the outer vessel and then upwardly into the inner vessel whereupon the liquid encounters heating means which provides substantial heat to boil a portion of the liquid. The vapor produced by such boiling may be separated from the heated liquid and is preferably transmitted to the upper region of the inner vessel with the heated liquid being removed from the inner vessel at a point lower than the liquid level so that the fluid is passed to a suitable heat sink. Nozzles for the vapor jet pumps are provided in the upper region of the inner vessel and extend outwardly from the side walls of the inner vessel into the annular space between the vessels. Thus, these nozzles are supplied with the vapor which is located in the upper region of the inner vessel and jet pumping action is provided by the nozzles in the annular region between the vessels.

Accordingly, it is one object of this invention to provide a new and improved liquid circulating means for totally enclosed liquid-vapor systems.

Another object of this invention is to provide a new and improved liquid circulating means for totally enclosed recycling systems which operate under high temperature and pressures.

A further object of this invention is to provide a totally enclosed recycling flow system for a liquid-vapor medium having a vapor jet pump located therein for circulating the liquid.

Still another object of this invention is to provide a new and improved totally enclosed flow system for a liquid-vapor medium having a plurality of parallelly connected vapor jet pumps for circulating the liquid.

Another object of this invention is to provide a new and improved liquid-vapor flow system capable of operating at high pressures and temperatures with the liquid being of a corrosive nature and having a vapor jet pump located completely within the system to circulate the liquid.

Still another object of this invention is to provide a new and improved totally enclosed recycling flow system for a corrosive vapor-liquid medium having a vapor jet pump located entirely within the system for circulating the liquid therethrough so that the pump is not subjected to a high pressure differential thereacross.

These and other objects of this invention will become more readily apparent upon review of the following detailed descriptions of illustrative embodiments of this invention wherein:

FIGURE 1 is a schematic flow circuit of a totally enclosed system incorporating this invention and having portions thereof shown in section for clarity;

FIG. 2 is a sectional view of the vessels shown in FIG. 1 and taken along the lines II-II of FIG. 1;

FIG. 3 is a schematic flow diagram of another embodiment of this invention and having portions thereof shown in section to clearly illustrate the operation of the invention.

Viewing the apparatus shown in FIGS. 1 and 2 the invention as utilized with the apparatus is located in a completely sealed system which is preferably operated at a pressure greater than atmospheric. The sealed system is denoted generally by the reference character 10 and includes an enlarged pressure vessel 12 formed from a suitable material having strength characteristics capable of withstanding the system pressure, such as steel. The vessel 12 is provided with an inlet 14 which extends into the

vessel 12 from the upper surface thereof. An inverted cup shaped inner vessel 16 is concentrically located within the vessel 12 and is supported therein by suitable means (not shown). The upper end of the inner vessel 16 is enclosed by a barrier or cover 18 with the lower end of the inner vessel 16 being opened. A sealed chamber 20 is provided in the inner vessel 16 and is formed therein by a pair of baffle plates 22 and 24 which are secured to the side walls of the inner vessel 16 by suitable means, such as by welding. A plurality of flow tubes 26 extend through the chamber 20 and are secured to the baffles 22 and 24 by conventional means such as by welding. An inlet 28 is provided for the chamber 20 with the inlet comprising a suitable flow conduit extending through the side wall of the outer vessel 12 and being secured to an opening 30 of the inner vessel 16 adjacent the periphery of the opening 30. Similarly, outlet means 32 are provided for the chamber 20 with the outlet means 32 being secured to the inner vessel 16 along the periphery of an opening 34 therein. The outlet means 32 in addition extends through the side wall of the outer vessel 12 with a hermetic seal being formed between the vessel 12 and the outlet means 32 by suitable means, for example by welding at 36.

In this example of the invention, the chamber 20 and the inlet and outlet 28 and 32, respectively, are provided so that they are completely sealed from the remainder of the flow system. The chamber 20 is adapted to be utilized as a heat exchange means whereby a heated means, such as a liquid or vapor, may be passed therethrough. In the present embodiment of this invention, it is contemplated that hot combustion gases will enter the chamber 20 through the inlet 28 as indicated by the flow arrows 38. The gases will then circulate throughout the chamber 20 and will be located in heat exchange relation with the flow tubes 26 which pass through the chamber 20. Thus, any liquid flowing through the tubes 26 will absorb a portion of the heat of the combustion gases. The combustion gases exit from the chamber 20 through the outlet means 32 as indicated by the flow arrows 40. Suitable means such as a pump (not shown), may be utilized to ensure the continuous flow of combustion gases through the chamber 20. Inasmuch as the chamber 20 is sealed from the remainder of the flow system, it is to be noted that none of the combustion gases will leak into the main system. Furthermore, such sealing contemplates the heat exchange fluids to be at different pressures inasmuch as the pressure in the chamber 20 may differ substantially from the pressure in the remainder of the system. Obviously, any heating means well known in the art may be substituted for the heating means illustrated in this embodiment of the invention.

As described herein the flow system 10 is contemplated to comprise a partially boiling liquid system wherein any suitable liquid is propelled therethrough in the manner hereinafter described with a portion of the liquid being transformed to the vapor state. Thus, the liquid enters the vessel 12 through the inlet 14 and is passed through the annular space 42 formed between the outer vessel 12 and the inner vessel 16. The liquid flows downwardly through the annular space 42 and then flows upwardly through the heat exchange tubes 26 whereby the liquid is placed in heat exchange relation with the combustion gases located in the chamber 20. The heat exchange system is formed so that a portion of the liquid is boiled as it passes through the tubes 26 with the remainder of the liquids being substantially elevated in temperature. At the upper end of the tubes 26 there is provided a collection chamber 44 which is defined by the upper baffle plate 22 and an inwardly extending annular baffle 46. The baffle 46 is provided at its upper end with an opening 48 which leads to a separating chamber 50. The separating chamber 50 is defined at its lower end by the baffle 46 and at its upper end by a wall 52. A suitable vapor-liquid separator 54 is located in the separating chamber 50 and

may be formed as any conventional structure well known in the art. In this embodiment of the invention, the separator 54 is shown to comprise a separating plate 56 having a plurality of openings 58 extending therethrough.

A portion of the separator 54 includes a lower vane structure 60 disposed in the opening 48 of the barrier 46 and secured to the baffle plate 54 by a shaft 62. The vane structure 60 is designed to impart a whirling motion on the liquid-vapor flowing therepast. Thus, the vane structure 60 includes a plurality of aligned, outwardly extending arcuate projections 64 located on the side surface of the vane structure 60. An annular ring 66 extends outwardly from the underside of the separating plate 56 and cooperates therewith to ensure that liquid being separated from the liquid-vapor passing through the separator will be deposited in the annular space 68 formed by the baffle 46 and the inner side wall of the inner vessel 16. The separator, in addition, includes an upper vapor drying structure noted generally by the reference character 70 which may comprise a plurality of spokes 72 secured at one end to the baffle 56 and extending radially outwardly therefrom to additionally cooperate to separate the liquid and vapor. The vapor drying structure 70 in addition includes a plurality of chevrons 73 which are located in the path of vapor flow to reduce the moisture content of the vapor, in a manner well known in the art. It is to be noted, of course, that the separating means shown in this embodiment of the invention is exemplary and does not form a part of this invention. Thus, any suitable separating means may be utilized to attain the results created by the structure shown in the drawings.

It may be noted that the inner vessel 16 contains in the space 44 defined by the upper plate 22 and the baffle 46 is a liquid-vapor mixture. In the region of the inner vessel 16 defined by the plate 52 the baffle 46 and the inner side wall of the vessel 16, there is contained a vapor-liquid mixture wherein the vapor and liquid are partially separated so that a liquid level is provided in the annular space 68 defined by the barrier 46 and the inner side wall of the inner vessel 16. Above the liquid level in the aforementioned space there is provided substantially all vapor wherein any liquid contained therein is removed by the separating means 70 located therein. The chamber 74 defined by the cover 18 of the inner vessel 16 and the baffle plate 52 encloses only dry vapor, which vapor is utilized to circulate the liquid in the system by means of the vapor jet pumps 76 presently to be described. In order to limit the condensation of the dry vapor located in the vapor chamber 74 caused by the proximity of the relatively cool incoming liquid from the inlet 14, there is provided insulating means denoted generally by the reference character 78 located on the inward side of the dome 18. The insulation 78 may comprise any well-known insulating means and may, for example, comprise an enclosed space containing a suitable gas having a low heat transfer coefficient or containing low heat transfer coefficients such as are well known in the art. In FIG. 1, the insulating means 78 is generally depicted as a thermal barrier having an inert air space defined by the cover 18 and by an enlarged plate 80 secured to the inner vessel 16 by suitable means, such for example, as by welding.

The annular space 68 containing the liquid is provided with an outlet fluid transfer means 82 secured to an opening (not shown) in the inner vessel 16 and passing through the annular space defined by the inner vessel 16 and outer vessel 12 and through an opening (not shown) in the outer vessel 12 in a leak-tight manner, for example by welding at 84. The fluid transfer means 82 connects the annular region 68 with a suitable heat exchange means denoted generally by the reference character 86 which does not form a part of this invention and may comprise many suitable structures well known in the art. A conduit 88 connects the outlet of the heat exchange means to the inlet 14 of the outer vessel 12. Thus, the liquid

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located in the region 68 of the inner vessel 16 is transported by the conduit 82 to the heat exchange means 86 or heat sink whereby it is placed in heat exchange relation with a suitable energy absorbing device which may enter the heat exchange means 86 through the conduit 90 and exit therefrom through the conduit 92.

It is to be noted that the heat exchange means 86 when utilized with the instant invention is formed so that the integrity of the pressurized recycling closed loop is not destroyed. Thus, the heat exchange means 86 isolates the fluid transported thereto by the conduit 82 from the external coolant or heat removal means which enters the heat exchange means 86 through the conduit 90. This may be accomplished by means well known in the art, such as by the utilization of a plurality of tubes through which the liquid flowing through the conduit 82 is passed. The tubes (not shown) may be coupled to the conduits 82 and 88 in a leak-tight manner so that the liquid in the recycling system is maintained at system pressure. The isolation means or tubes are located in heat exchange relationship with the coolant which enters the heat exchange means 86 through the conduit 90. In this way heat may be removed from the liquid flowing through the conduit 82 without affecting the integrity of the recycling pressurized system.

A conduit 88 is provided to couple the outlet of the heat exchange means 86 to the inlet 14 of the vessel 12. Thus, the liquid flowing through the conduit 82 passes through the heat exchange means 86 and exits therefrom through the conduit 88 to be recirculated to the vessel 12 through the inlet 14 thereof.

In the annular region defined by the outer vessel 12 and inner vessel 16 and adjacent the vapor nozzles 76, there is provided a diffuser structure denoted generally by the reference character 94. The diffuser structure 94, in this example of the invention, includes an annular plate 96 disposed horizontally in the annular space 42 and is provided with a plurality of openings 98 there-through, in this embodiment of the invention the number being six. Adjacent each of the openings 98 in the plate 96 there is provided a combined water nozzle and diffuser 100 which has an arcuate cross section so that it conforms in shape substantially to a pair of opposed frustoconical portions with their longitudinal axes being aligned and in the vertical direction. Each of these diffuser portions 100 may be formed from a thin walled member secured at its upper edge to the plate 96 by suitable means, such as by welding. The diffuser members 100 are preferably formed from a material having sufficient structural strength to withstand deformation when subjected to system pressures and system flow requirements. Each of the vapor nozzles 76 is provided at its outward end with a hollow frustoconical section 102 with its narrow end being located within the upper frustoconical portion 104 of the diffuser 100. It is to be noted that the frustoconical portion 102 is correspondingly smaller in diameter than the upper frustoconical section 104 of the diffuser 100. The frustoconical portions 102 and 104 define an annular space 107 therebetween which forms a liquid nozzle for the vapor jet pump combination. The lower frustoconical portion 106 of the diffuser 100 defines a region for the vapor jet pump. It is to be noted that each of the vapor jet pumps 76 is located in the path of flow of the inlet liquid for the pressure vessel 12. Thus, all of the inlet liquid must pass through the liquid nozzles 106 wherein the liquid is subjected to the vapor exiting from the vapor nozzle 76. As well known in the art, a jet pumping action is imparted to the liquid passing through the liquid nozzle 107 wherein the flow of liquid therepast is substantially increased. It is to be noted that the particular shape and sizings of the vapor nozzle 76, the liquid nozzle 104 and the diffuser portion 106 is directly dependent upon the particular parameters of any given fluid flow system. Once the flow parameters of the system have been determined it is

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within the scope of those skilled in the art to determine the sizings and shapes of the aforementioned elements.

The operation of the recycling system 10 is as follows. The entire system 10 is filled with a desired working liquid and the heating means is passed through the inlet 28 into the heat exchange chamber 20 as indicated by the flow arrows 38. The liquid located in the flow tubes 26 is in heat transfer relation with the heating means and is increased in temperature thereby. The heating means maintains heat transfer relation with the liquid for a period of time depending upon the flow rate in the heat transfer system whereby the heating means exits therefrom through the conduit 32 as indicated by the flow arrows 40. During this time, of course, additional heat is imparted to the liquid through continuous subjection of the liquid to additional heating means of gases. While the system liquid is being initially heated up, it is to be noted that the liquid located in the tubes 26 is at a higher temperature than the liquid located in the remaining portions of the system. The liquid located in the heat exchange means or heat sink 86 is at the lowest temperature so that natural circulation of the system liquid is created and initial flow of the system liquid occurs. The flow path for such circulation commences with the tubes 26 into the chamber 44 into the annular space 68 through conduit 82, heat exchange means 86, conduit 88, inlet 14, annular space 42 and then into the tubes 26.

While initially some flow may exist in the circuit defined by the tubes 26, chamber 44, chamber 74, nozzles 76, annular space 42 and tubes 26, it is to be noted that this flow will continue only until the liquid in the entire pressure vessel 12 is approximately at the same temperature. From that point, it is to be noted that heat must be removed from the liquid by suitable external means, which means may only comprise the heat sink 86 so that eventually the initially mentioned flow path will result. As the liquid continues to be heated some vapor will be formed thereby which vapor will be collected in the vapor chamber 74 adjacent the top of the inner vessel 16. The vapor level in the chamber 74 will decrease the liquid level in the chamber 74 until the lower end of the steam nozzle 76 is above the liquid level. Depending upon the flow rate of the vapor through the nozzle 76, the liquid level will be lower until it reaches a suitable stable point such as the level 108.

When the liquid level in the inner vessel 16 is below the lower end of the nozzle 76, vapor will initially flow through the nozzle 76 into the diffuser structure 94. Since all of the vapor nozzles 76 are connected in parallel and are located at the same level, it is expected that each of the vapor nozzles will impart vapor to the diffuser 94 at the same time. In order to ensure start-up of each of the vapor jet pumps at the same time, means are provided to ensure that the pressure differential between each nozzle 76 and its corresponding diffuser structure 94 is the same. In furtherance of this purpose, each diffuser structure 94 is connected to the adjacent diffuser structures by fluid conduit means, such as piping 110. In this manner the possibility of start-up of one of the vapor jet pumps 76 without start-up of the remainder of the jet pumps 76 and resulting in backflow through the remaining nozzles 76 is prevented.

It is to be noted that the pumping action created by each of the vapor jet pumps 76 is dependent upon the temperature differential between the vapor and the liquid flowing therepast. Thus, each vapor jet pump 76 is located in the inlet stream of the pressure vessel 12 to ensure that relatively cool liquid flows therepast. While a vapor jet pump may be located in the outlet stream adjacent the conduit 82, it is to be noted that the flow imparted to the liquid would be substantially reduced since the liquid in the conduit 82 is at a temperature higher than the inlet liquid.

It is to be noted, in addition, that the present system

contemplates that a positive pressure differential exists initially between the vapor located in the chamber 74 and the inlet liquid, so that each of the vapor jet pumps will properly start up. The present invention will also operate under conditions wherein all of the liquid passing through the flow tubes 26 is boiled, provided, of course, that at least a portion of this liquid is condensed in the heat exchange means 86 so that the nozzles 76 are exposed to an exterior portion of the liquid at a lower temperature than that of the vapor located in the nozzles 76. It is to be noted that vapor jet pumps are rather inefficient; but that any heat losses are imparted to the inlet liquid for the pressure vessel 12 which losses serve to heat this liquid and thereby aid the heat exchange means located in the chamber 20. Each of the diffuser structures 94 is formed from relatively thin generally venturi-shaped members which are cooled by the inlet coolant for the vessel 12. The placing of the vapor jet pump entirely within the system minimizes maintenance thereof since the pump is exposed only to system pressure and need not be constructed to withstand large pressure differentials so that the possibility of failure of a pump is decreased.

Referring now to the embodiment of this invention shown in FIG. 3, it will be noted that like parts of each embodiment will be denoted by the same reference characters. In this embodiment of the invention, the vapor jet pump nozzle is not located within the outer pressure vessel 12, but rather is located on the cold side of the heat exchange means 86. In this embodiment of the invention, an enclosed pressure vessel 112 is provided with a heat source which may comprise upper and lower baffle plates 22 and 24, respectively, having flow tubes 26 extending therebetween and therethrough to define a heat exchange chamber 20 thereby. The heat source is provided with a suitable inlet 28 and an outlet 32 wherein heat transfer means, such as heated combustion gases enter and exit from the chamber 20. An annular baffle plate 46 is provided within the vessel 112 above the upper plate 32 to define a chamber 44 thereby. The vessel 112 includes in addition a liquid-vapor separator 54 and a vapor chamber 74 adjacent the top of the vessel 112. The heat exchange means or heat sink 86 is coupled to the vessel 112 by a conduit 82 and includes an inlet conduit 90 and an outlet conduit 92 which permits a suitable energy absorbing device to enter and exit from the heat exchange means 86.

The system liquid exits from the heat exchange means 86 through a conduit 114 which lead to an enlarged liquid plenum chamber 116. The plenum chamber 116 is coupled to an inlet 118 for the pressure vessel 112 by fluid transfer means 120. A diffuser structure denoted generally by the reference character 122 is located between the plenum chamber 116 and the conduit 120 and is shaped similarly to the diffuser structure 94 of the first embodiment of this invention. The vapor chamber 74 is coupled through the plenum chamber 116 to a vapor nozzle 124 by a vapor carrying conduit 126. The nozzle 124 is located adjacent the diffuser structure 122 in the manner described heretofore to provide a liquid nozzle or annular space 128 between the vapor nozzle 124 and the diffuser structure 122. In this embodiment of the invention the diffuser structure 122 may comprise an inwardly extending annular cylindrical member being arcuate in cross section to provide an elongated throat or water nozzle in the upward portion thereof and a diffuser of expansion portion along the lower portion thereof. It is contemplated that the diffuser structure 122 is spaced from the adjacent portions of the conduit 120 so that a dead space 130 is provided therebetween to insulate the diffuser structure from the exterior whereby the latter may be cooled by the liquid flowing therepast.

It is to be noted that the lower edge of the nozzle 124 is designed to be located at an elevation higher than the liquid level 108 in the pressure vessel 112 so that vapor

may be transmitted thereto for jet pumping action. In addition, it is to be noted that the vapor jet pump is located on the cold side of the heat exchange means 86 so that the greatest possible temperature differential exists between the vapor at the vapor jet pump and the liquid flowing therepast. In this embodiment of the invention, it is to be noted that a single vapor jet pump is utilized so that start-up problems therefor are eliminated.

Having now described an operative embodiment of the instant invention, we note that a great number of modifications may be made thereto without departing from the broad spirit and scope of the invention. Accordingly, it is specifically intended that the aforesaid descriptions of operative embodiments of the invention be interpreted in an illustrative rather than in a limiting sense.

We claim as our invention:

1. In a closed recycling pressurized system, the combination comprising a pressure vessel having an inlet flow path means and an outlet flow path means, a liquid flowing through said pressure vessel, heat exchange means located in said pressure vessel between said inlet and said outlet flow path means for heating incoming liquid and causing at least a portion of said liquid to boil, said pressure vessel including a chamber therein communicating with the outlet side of said heat exchange means for accommodating the vaporized portion of said liquid, a vapor jet pump located in said inlet flow path means for said pressure vessel for enhancing the flow of liquid in said inlet flow path means toward said heat exchange means, and means for coupling the vapor nozzle of said vapor jet pump to said chamber for providing vapor to said nozzle.

2. In a closed recycling pressurized system, the combination comprising a pressure vessel having an inlet conduit and an outlet conduit, a liquid flowing through said pressure vessel from said inlet conduit to said outlet conduit, heating means having an inlet side and an outlet side and located in said pressure vessel for heating said liquid and causing at least a portion of said liquid to boil, said inlet side of said heating means communicating directly with said inlet conduit, said pressure vessel including a chamber therein for accommodating the vaporized portion of said liquid, said outlet conduit being coupled to said inlet conduit through a heat sink means whereby heat is removed from said liquid, a vapor jet pump disposed in said inlet conduit between said heat sink and said heating means, and another conduit means coupling said chamber to the vapor nozzle of said vapor jet pump for providing vapor to said nozzle, so that said vapor jet pump enhances the flow through said inlet flow path means.

3. In a closed recycling system containing a liquid therein, the combination comprising a heat source and a heat sink located in said system and each having an inlet and an outlet, conduit means coupling the inlet of said source to the outlet of said sink and coupling the inlet of said sink to the outlet of said liquid to form a recycling flow path for said liquid whereby said liquid is heated by said heat source and cooled by said heat sink, said heat source being formed to impart sufficient heat to said liquid to boil at least a portion thereof, said system including a chamber for accommodating the vaporized portion of said liquid, said system having a portion thereof normally at a temperature lower than the temperature of the remainder of said system, a vapor jet pump located in said system at said low temperature portion thereof for imparting motion to said liquid for circulating the latter throughout said system, and another conduit means coupling said chamber to the vapor nozzle of said vapor jet pump to provide vapor for said nozzle.

4. In a closed recycling system containing a liquid therein, the combination comprising, a vessel containing a heat source, a heat sink, conduit means coupled between said vessel and said heat sink to form a recycling flow path between said heat source and said heat sink whereby

said liquid is heated by said heat source and cooled by said heat sink, said heat source being formed to impart sufficient heat to said liquid to boil at least a portion thereof, said vessel including a chamber for accommodating the vaporized portion of said liquid, a vapor jet pump located entirely within said vessel for circulating said liquid therethrough, and another conduit means disposed entirely in said vessel coupling said chamber to the vapor nozzle of said vapor jet pump.

5. A sealed recycling flow system for a liquid medium comprising a sealed vessel having an inlet and an outlet conduit, annular wall means located within said vessel and spaced therefrom to define an annular space therebetween, a heat source located within said wall means capable of imparting sufficient heat to said liquid for boiling at least a portion thereof, said wall means in addition defining a vapor chamber disposed to collect the vapor formed from said liquid, said outlet conduit being coupled to said wall means and located between said heat source and said vapor chamber, conduit means coupling said outlet conduit to a heat sink whereby the heated liquid is transported to said heat sink, said inlet conduit being coupled to said annular space whereby liquid entering said vessel from said inlet conduit flows through said annular space, additional conduit means coupling the outlet of said heat sink to said inlet conduit, a vapor jet pump located in said annular space adjacent said inlet conduit, and the vapor nozzle of said vapor jet pump being coupled directly to said vapor chamber.

6. A sealed recycling flow system for a liquid medium comprising a sealed vessel having an inlet and an outlet conduit, annular wall means located within said vessel and spaced therefrom to define an annular space therebetween, a heat source located within said wall means capable of imparting sufficient heat to said liquid for boiling at least a portion thereof, said wall means in addition defining a vapor chamber disposed to collect the vapor formed from said liquid, separating means disposed within said wall means between said vapor chamber and said heat source for separating at least a portion of said vapor from said liquid, said outlet conduit communicating with the interior of said wall means at a position between said heat source and said vapor chamber, conduit means coupling said outlet conduit to a heat sink whereby the heated liquid is transported to said heat sink, said inlet conduit communicating with said annular space whereby liquid entering said vessel from said inlet conduit flows through said annular space, additional conduit means coupling the outlet of said heat sink to said inlet conduit, a vapor jet pump located in said annular space between said inlet conduit and said heat source, and the vapor nozzle of said vapor jet pump being coupled directly to said vapor chamber.

7. A sealed recycling flow system for a liquid medium comprising a sealed vessel having an inlet and an outlet conduit, annular wall means located within said vessel and spaced therefrom to define an annular space therebetween, a heat source located within said wall means capable of imparting sufficient heat to said liquid for boiling at least a portion thereof, said wall means in addition defining a vapor chamber disposed to collect the vapor formed from said liquid, said outlet conduit communicating with the interior of said wall means at a position between said heat source and said vapor chamber, conduit means coupling to said outlet conduit to a heat sink whereby the heated liquid is transported to said heat sink, said inlet communicating with said annular space whereby liquid entering said vessel from said inlet conduit flows through said annular space, additional conduit means coupling the outlet of said heat sink to said inlet conduit, a plurality of vapor jet pumps located in said annular space and disposed between said inlet conduit and said heat source, and means coupling the vapor nozzles of each of said vapor jet pumps to said vapor chamber.

8. A sealed recycling flow system for a liquid medium

comprising a sealed vessel having an inlet and an outlet conduit, annular wall means located within said vessel and spaced therefrom to define an annular space therebetween, a heat source located within said wall means capable of imparting sufficient heat to said liquid for boiling at least a portion thereof, said wall means in addition defining a vapor chamber disposed to collect the vapor formed from said liquid, said outlet conduit communicating with the interior of said wall means at a position between said heat source and said vapor chamber, conduit means coupling said outlet conduit to a heat sink whereby the heated liquid is transported to said heat sink, said inlet conduit communicating with said annular space whereby liquid entering said vessel from said inlet conduit flows through said annular space, additional conduit means coupling the outlet of said heat sink to said inlet conduit, an annular ring structure disposed in said annular space between said inlet conduit and said heat source and engaging the inner surface of said vessel and said wall means, said ring structure having a plurality of openings therethrough, a diffuser structure mounted in said annular space adjacent each of said openings respectively, a vapor nozzle disposed in said annular space adjacent each of said diffuser structures, and each of said vapor nozzles being coupled directly to said vapor chamber.

9. A sealed recycling flow system for a liquid medium comprising a sealed vessel having an inlet and an outlet conduit, annular wall means located within said vessel and spaced therefrom to define an annular space therebetween, a heat source located within said wall means capable of imparting sufficient heat to said liquid for boiling at least a portion thereof, said wall means in addition defining a vapor chamber disposed to collect the vapor formed from said liquid, said outlet conduit communicating with the interior of said wall means at a position between said heat source and said vapor chamber, conduit means coupling said outlet conduit to a heat sink whereby the heated liquid is transported to said heat sink, said inlet conduit communicating with said annular space whereby liquid entering said vessel from said inlet conduit flows through said annular space, additional conduit means coupling the outlet of said heat sink to said inlet conduit, an annular ring structure disposed in said annular space between said inlet conduit and said heat source and engaging the inner surface of said vessel and said wall means, said ring structure having a plurality of openings therethrough, a diffuser structure mounted in said annular space adjacent each of said openings respectively, a vapor nozzle disposed in said annular space adjacent each of said diffuser structures, each of said vapor nozzles being coupled directly to said vapor chamber, and pressure equalizing means serially connected between each of said diffuser structures.

10. A sealed recycling flow system for a liquid medium comprising a sealed vessel having an inlet and an outlet conduit, annular wall means located within said vessel and spaced therefrom to define an annular space therebetween, a heat source located within said wall means capable of imparting sufficient heat to said liquid for boiling at least a portion thereof, said wall means in addition defining a vapor chamber disposed to collect the vapor formed from said liquid, separating means disposed within said wall means between said vapor chamber and said heat source for separating at least a portion of said vapor from said liquid, said outlet conduit communicating with the interior of said wall means at a position between said heat source and said vapor chamber, conduit means coupling said outlet conduit to a heat sink whereby the heated liquid is transported to said heat sink, said inlet conduit being coupled to said annular space whereby liquid entering said vessel from said inlet conduit flows through said annular space, additional conduit means coupling the outlet of said heat sink to said inlet conduit, a plurality of vapor jet pumps located in said annular space and disposed between said inlet conduit and said heat source,

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and means coupling the vapor nozzles of each of said vapor jet pumps to said vapor chamber.

11. A sealed recycling flow system for a liquid medium comprising a sealed vessel having an inlet and an outlet conduit, annular wall means located within said vessel and spaced therefrom to define an annular space therebetween, a heat source located within said wall means capable of imparting sufficient heat to said liquid for boiling at least a portion thereof, said wall means in addition defining a vapor chamber disposed to collect the vapor formed from said liquid, separating means disposed within said wall means between said vapor chamber and said heat source for separating at least a portion of said vapor from said liquid, said outlet conduit communicating with the interior of said wall means at a position between said heat source and said vapor chamber, conduit means coupling said outlet conduit to a heat sink whereby the heated liquid is transported to said heat sink, said inlet conduit being coupled to said annular space whereby liquid entering said vessel from said inlet conduit flows through said annular space, additional conduit means coupling the outlet of said heat sink to said inlet conduit, an annular ring structure disposed in said annular space between said inlet conduit and said heat source and engaging the inner surface of said vessel and said wall means, said ring structure having a plurality of openings therethrough, a diffuser structure mounted in said annular space adjacent each of said openings respectively, a vapor nozzle disposed in said annular space adjacent each of said diffuser structures, and each of said vapor nozzles being coupled directly to said vapor chamber.

12. A sealed recycling flow system for a liquid medium comprising a sealed vessel having an inlet and an outlet conduit, annular wall means located within said vessel and spaced therefrom to define an annular space therebetween, a heat source located within said wall means capable of imparting sufficient heat to said liquid for boiling at least a portion thereof, said wall means in addition defining a vapor chamber disposed to collect the vapor formed from said liquid, separating means disposed within said wall means between said vapor chamber and said heat source for separating at least a portion of said vapor from said liquid, said outlet conduit communicating with the interior of said wall means at a position between said heat source and said vapor chamber, conduit means coupling said outlet conduit to a heat sink whereby the heated liquid is transported to said heat sink, said inlet conduit being coupled to said annular space whereby liquid entering said vessel from said inlet conduit flows through said annular space, additional conduit means coupling the outlet of said heat sink to said inlet conduit, an annular ring structure disposed in said annular space

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between said inlet and said heat source and engaging the inner surface of said vessel and said wall means, said ring structure having a plurality of openings therethrough, a diffuser structure secured to said ring structure adjacent each of said openings respectively, a vapor nozzle disposed in said annular space adjacent each of said diffuser structures, each of said vapor nozzles being coupled directly to said vapor chamber, and pressure equalizing means serially connected between each of said diffuser structures.

13. In a closed recycling system containing a liquid therein, the combination comprising a heat source and a heat sink located in said system whereby said liquid is heated by said heat source and cooled by said heat sink, said heat source being formed to impart sufficient heat to said liquid to boil at least a portion thereof, said system including a chamber communicating with said heat source for accommodating the vaporized portion of said liquid, separating means disposed between said vapor chamber and said heat source for separating at least a portion of said vapor from said liquid, a vapor jet pump located in said system for imparting motion to said liquid for circulating the latter throughout said system, and conduit means coupling said chamber to the vapor nozzle of said vapor jet pump.

14. In a sealed recycling flow system including a vessel and having a liquid flowing through said system, the combination comprising inlet and outlet means coupled to said vessel for transporting said liquid into and out of said vessel; means for imparting heat to said liquid, when located in said vessel, in a quantity sufficient to boil at least a portion of said liquid; a chamber coupled to said system for collecting at least a portion of the vapor formed by said heating; a heat sink, having inlet and outlet means coupled thereto and capable of removing heat from said liquid; first conduit means coupling the inlet means of said heat sink to the outlet means of said vessel, second conduit means coupling the outlet means of said heat sink to the inlet means of said vessel; a vapor jet pump located in said second conduit means to enhance liquid flow therethrough; and means coupling the vapor nozzle of said vapor jet pump to said chamber.

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