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Jeding et al.

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[54] **COOLING PUMP SYSTEM**

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[51] **Int. Cl.** **F25b 31/00**

[58] **Field of Search** 62/196, 505, 229; 417/513

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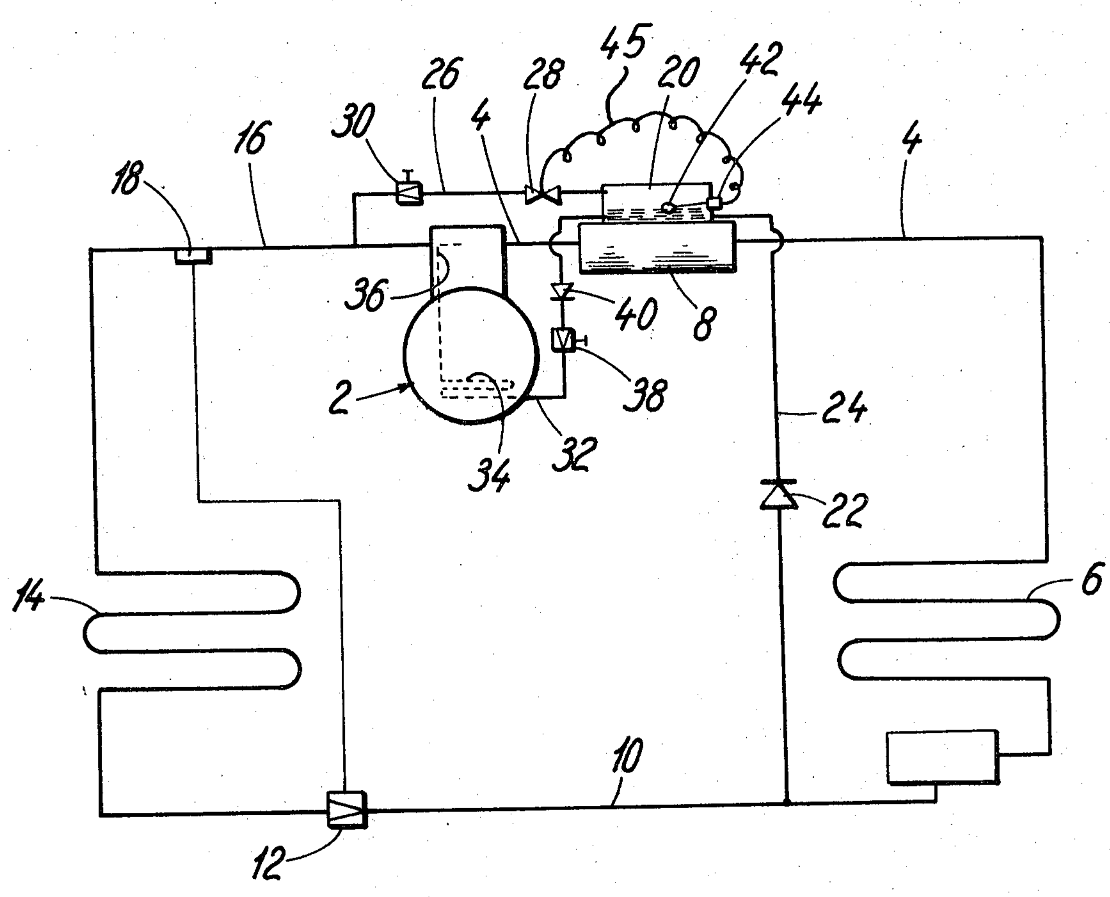
[57] **ABSTRACT**

An apparatus having a heat developing part such as a compressor in a refrigeration system, said part being adapted to be cooled by a cooling medium supplied thereto by means of a pump, control means being provided for regulating the supply of cooling medium in response to actual cooling requirements of the heat developing part characterized in that the pump is at least partly constituted by a thermal positive displacement pump of the type comprising a closed container partly filled with a liquid pumping medium, said container having a lower outlet pipe for said pumping liquid and an inlet pipe connected to a pumping liquid reservoir through inlet control means operable to effect refilling of pumping liquid into the container the container being in heat conducting connection with a heating source operable to heat the container so as to increase the vapour pressure in the container sufficiently to cause liquid to be pressed out through said outlet pipe for thereby causing said cooling medium to be supplied to said heat developing part, the pumping liquid and the cooling medium preferably being identical whereas the container is placed in heat conducting connection with the heat developing part which thus at least partly constitutes the said heating source.

13 Claims, 6 Drawing Figures



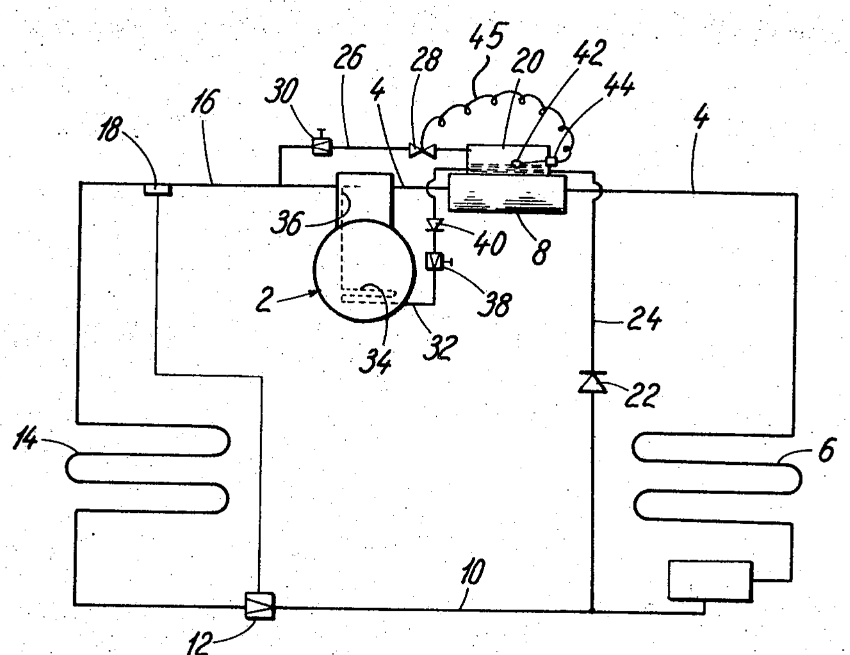


Fig. 1.

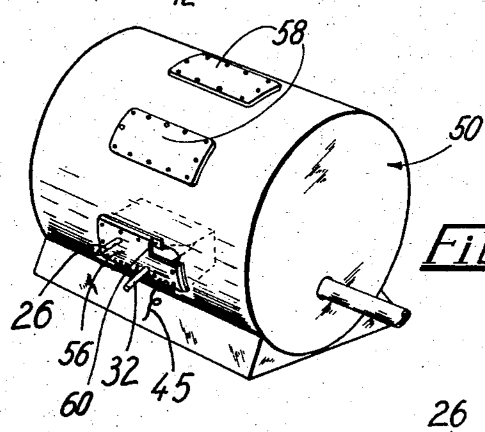


Fig. 2.

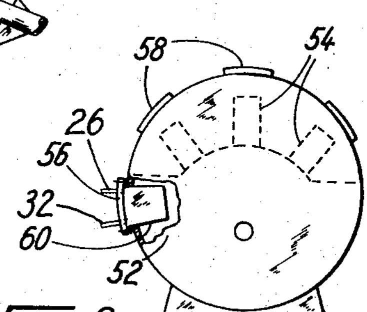
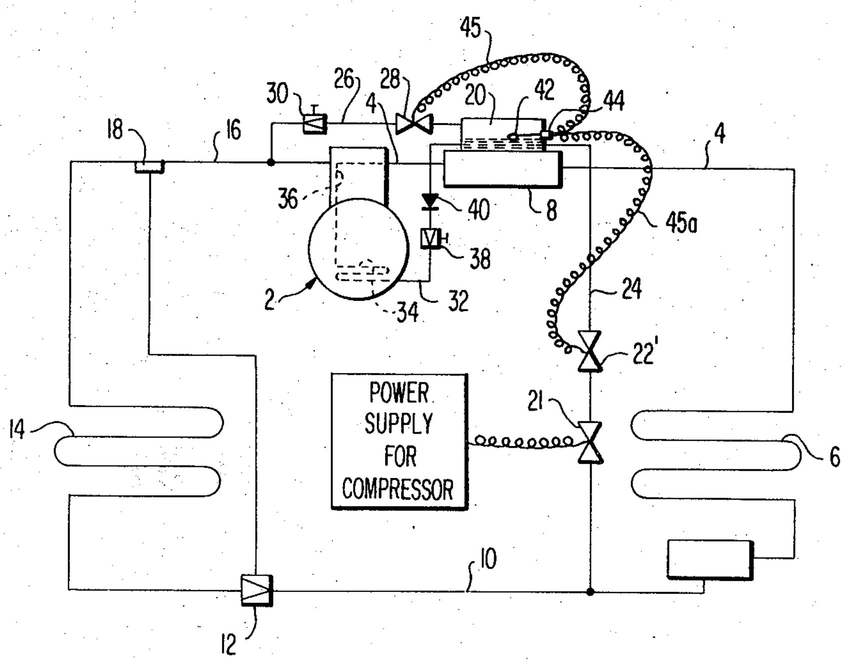


Fig. 3.

FIG. 1a


45
30
26
28
4
20
42
44
18
16
4
36
40
8
45a
38
2
34
32
24
22'
POWER SUPPLY FOR COMPRESSOR
21
14
6
10
12

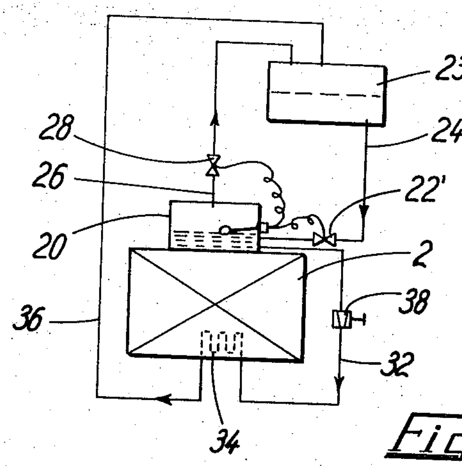

23
28
24
26
22'
20
2
38
36
32
34

Fig. 4.

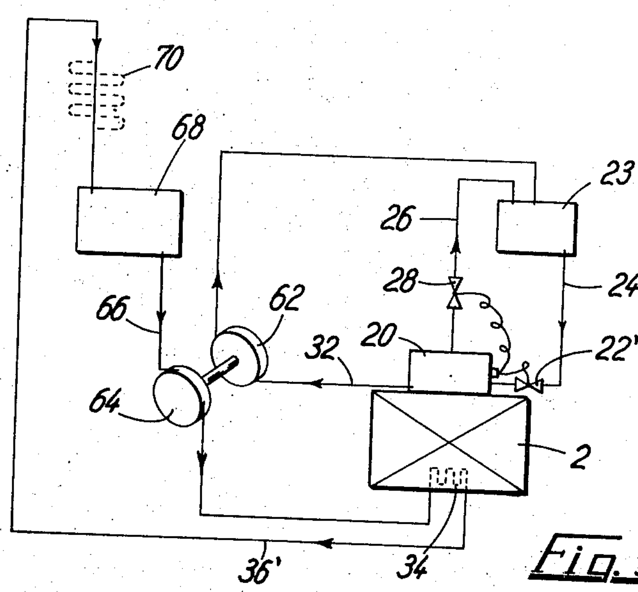

70
68
23
26
28
24
66
62
20
32
22'
64
2
36'
34

Fig. 5.

COOLING PUMP SYSTEM

The present invention relates to an apparatus having a heat developing part such as a compressor in a refrigeration system, said part being adapted to be cooled by a cooling medium supplied thereto by means of a pump, control means being provided for regulating the supply of cooling medium in response to actual cooling requirements of the heat developing part.

Especially in large-size refrigeration plants the development of heat in the refrigerating compressor will often be so considerable that there will be a need for direct cooling of the compressor by means of a cooling medium which may well be the same cooling medium as that already employed in the plant. At varying loads of the compressor the cooling requirement will vary correspondingly, and there is actually no problem in principle in using thermostatic sensing and regulating devices to control the pumped supply of cooling medium in such a way that the cooling adapts itself in relation to the variations in the development of heat in order to achieve a cooling effect according to the need for cooling. However, in practice this involves various drawbacks, because ordinary mechanical pumps develop a heat of their own and consume extra energy, just as the sensing and regulating devices can be rather expensive and at times not fully dependable.

The object of the present invention is to provide an apparatus of the type mentioned in which the supply of cooling medium can be effected in an extremely simple manner and with negligible extra power consumption.

According to the invention the pump is at least partly constituted by a thermal positive displacement pump of the type comprising a closed container partly filled with a liquid pumping medium, said container having a lower outlet pipe for said pumping liquid and an inlet pipe connected to a pumping liquid reservoir through inlet control means preferably for intermittent admission of pumping liquid into the container, the container being in heat conducting connection with a heating source operable to heat the container so as to increase the vapour pressure in the container sufficiently to cause liquid to be pressed out through said outlet pipe for thereby causing said cooling medium to be supplied to said heat developing part, the pumping liquid and the cooling medium preferably being identical, whereas the container is placed in heat conducting connection with the heat developing part which thus at least partly constitutes the said heating source.

It will be appreciated that hereby it is the heat from the heat developing part which is used directly to produce the energy necessary for the pumping of the cooling medium, i.e., a part of the heat surplus is utilized for the heating of the pump container so that this use in itself means that a certain amount of heat is conducted away from the compressor, and so that it will not be necessary to supply extra energy in order to perform the required pumping. Compared with conventional pumping systems the operational economy will thus be improved, and besides the thermal pump itself is of simple construction, e.g., with no moving parts. A further and very important advantage of the apparatus according to the invention is that the cooling pump may automatically adjust its output to suit the directly ascertained cooling requirement, namely as expressed by the actual heat influence on the pump container so that the supply of cooling medium will be regulated as desired

without any kind of special sensing and regulating devices.

It should be mentioned that the principle of pumping liquid by thermal positive displacement is not novel per se see for example, U.S. Pat. No. 2,892,416, but it will be appreciated that the use of this pumping principle in the connection according to the invention offers quite specific and remarkable advantages.

Especially when used in a refrigeration system the arrangement according to the invention will be extremely simple and advantageous, because a part of the liquid coolant in the system may be used directly as the cooling medium for the compressor, i.e., the cooling medium may be taken from the coolant system without the use of any special reservoir, and after its use it may simply be reintroduced into the coolant system. Furthermore, the liquid coolant is well suited to constitute the medium handled by the thermal pump.

In the following the invention is described in more detail with reference to the drawing, in which:

FIG. **1** is a schematic diagram of a refrigerating plant made according to the invention,

FIG. **1***a* is a schematic diagram of another embodiment of the refrigerating plant of FIG. **1**,

FIG. **2** is a perspective view of the compressor of the refrigerating plant,

FIG. **3** is a plan end view, partly in cross-section, of the compressor,

FIG. **4** is a schematic diagram of a modified embodiment of the systems according to the invention, and

FIG. **5** is a corresponding view of still a further embodiment.

In FIG. **1** the numeral **2** designates a refrigerating compressor which through a pressure pipe **4** sends a compressed gaseous coolant to a condenser **6** thereby sending the gas through an oil seperator **8.** From the condensor **6** in which the gas is condensed into its liquid state the cooling medium is conducted through a pipe **10** past a thermostatic expansion valve **12** to an evaporator **14** from which a pipe **16** leads back to the suction side of the compressor **2.** On the pipe **16** is placed in a conventional manner a temperature sensor **18** which controls the valve **12**; the system so far described is a conventional refrigeration system.

On the oil separator **8** (or directly on the compressor **2** as mentioned below) is placed a container **20** which through a non-return valve **22** in a pipe **24** is connected to the pipe **10** between the condenser **6** and the expansion valve **12,** and which at the top is connected to the suction pipe **16** by means of a pipe **26** in which is placed a solenoid valve **28** and a pressure control valve **30.** At the bottom the container **20** is connected via a pipe **32** to a heat exchanger **34** in direct connection with the compressor **2,** the outlet from this heat exchanger being connected to the discharge side of the compressor through a pipe **36.** Such heat exchangers in compressors are well known. In the pipe **32** there is interposed a throttle valve **38** and a non-return valve **40.** In the container **20** there is provided a liquid-level detector **42** represented by a float which is controlling an electric switch **44** connected to the solenoid valve **28** through a wire **45** in the way that the switch **44** at a relatively low liquid level in the container **20** causes an opening of the solenoid valve **28** in the pipe **26,** and at a relatively high liquid level it causes a closing of the said valve.

The mode of the operation is as follows:

When the container **20** is empty the float **42** will open the valve **28** whereby the container is connected to the suction side of the compressor through the pipe **26.** The result will be that cooling liquid will be sent from the pipe **10** through the non-return valve **22** into the container until the float at an upper liquid level causes the valve **28** to close. After this point there will be a further, slight inflow until the space above the liquid is narrowed down so much that the correspondingly increasing pressure in it will counterbalance the charging pressure in the pipe **10.**

On account of this pressure there will then from the container be sent a certain amount of cooling medium through the throttle valve **38** into the cooling section **34** in the compressor.

The flow of cooling medium to this section will thus be determined by the pressure or pressure development in the container **20,** and as the container is placed in heat conducting connection with the oil separator, which in its turn receives heat from the compressor by way of the hot gaseous cooling medium, the vapour pressure in the container will fluctuate with the compressor temperature so that this pressure tends to increase with the temperature of the compressor and thereby cause a graduated flow of liquid to be pressed through the cooling section **34.** Actually, neither the temperature nor the pressure inside the container **20** will vary very much since the medium will merely boil more or less so as to be pressed out according to the rate of boiling. It will be seen that the cooling in this way will regulate itself according to requirement and that no external power is used for the forward pumping of the cooling medium.

When the liquid level has dropped to a lower level the float **42** will cause an opening of the valve **28** whereby new liquid will be charged into the container as described above, and the described working cycle will then be repeated automatically.

During the charging of liquid into the container **20** the pressure pipe **10** is connected to the suction pipe **16** of the compressor through the pipes **24** and **26,** but the pressure regulating valve **30** is set at a pressure which is only slightly lower than the condensing pressure so that the pressure drop in the pressure pipe will not be more than strictly necessary i.e., in practice of no special significance.

The cooling section **34** in the compressor may - as already mentioned - be a regular heat exchanger, but the cooling may also be effected by direct injection of the cooling medium into a cooling compartment connected to the discharge side of the high side of the compressor.

The pump container **20** may be installed in connection with any part of the compressor system or the refrigerating plant whose temperature during operation is higher than the condensing temperature and besides fluctuates with the development of heat in the compressor. FIGS. **2** and **3** show a preferred location on a piston type compressor **50** with cylinders **54** protruding from a crankcase **52** in well known manner. In the wall of the crankcase is in the usual way provided an admission opening, which is closed with a cover **56.** Corresponding covers **58** may be placed over openings in the compressor house in order to give admission to the top of the cylinders. To make it possible in connection with such a standard type compressor to mount the pump container in an easy manner and not visible from the outside the container may, according to the present invention, be mounted as a box **60** protruding into the interior of the crankcase under the cover **56,** whereby the cover itself may even constitute the front side of the box. This mounting arrangement is simple to perform and will offer no obstruction to the servicing of the crankcase as the box **60** is easily removed for that purpose by unscrewing the cover **56.**

Instead of the non-return valve **22** in the pipe **24** it is possible, if desired, to employ a solenoid valve **22'** controlled by the float switch **44** through a wire **45*a*** as shown in FIG. 1a. Instead of the solenoid valve **28** may be employed a needle valve or similar type of valve located in connection with the container **20** and in a manner not shown controlled directly by the float **42.** As already mentioned it may also be possible instead of the said float to employ any suitable type of level detector arrangement for controlling the valve **28** or the valve **22.** As here described it is possible in the case of a refrigerating plant to employ the cooling medium of the plant as a cooling medium for the heat developing part, but it is perfectly possible to circulate the cooling medium in a separate system with a reservoir to which the medium is conducted from the refrigerating section, and from which it is conducted to the container **20** controlled e.g., by the float valve.

A system of this type is shown in FIG. **5** where parts similar to the different parts of FIG. **1** are designated with the same reference mumerals. Instead of the cooling medium being taken from the refrigerating system as in FIG. **1** there is provided a special reservoir **23** from which the combined pumping and cooling medium is conducted to the pump container through the pipe **24** and through the valve **22'** which is here a solenoid valve controlled by the level detector switch **44.** The return pipe **36** from the cooling element **34** is connected to the top of the reservoir **23.** The pipe **26** serving to permit exhaust of the vapour or steam from the pump container **20** during refilling thereof is likewise connected to the top of the reservoir **23,** as in FIG. **1** through a solenoid valve **28.**

The mode of the operation of the system will be equivalent to that described in connection with FIG. **1** with the exception that the coolant is supplied to the pump container by the action of the gravity as long as the valve **22'** is kept open, whereby the vapour or steam above the liquid in the container **20** will be pressed up into the reservoir through the valve **28.** This vapour or steam could be let out into the atmosphere, but of course, it would then be necessary to supply new liquid to the reservoir from time to time.

In the described arrangement the pump **20** will be able to continue to be active some time after the compressor is stopped, and especially in the case of direct injection of the cooling medium into the compressor as described in connection with FIG. **1** this may result in an unwanted accumulation of cooling medium in it; in order to counter this effect there should be provided means to stop the pumping when the compressor stops, e.g., a solenoid valve **21** located in the supply pipe **24** to the pump container **20,** and operatively connected with the power supply to the compressor so as to be open when the compressor is working and close as soon as the compressor is stopped, as illustrated, for example, in FIG. **1.**

An essential feature of the present invention is that the use of the thermal pump gives automatic control of the pump output when the pump is heated from the part which is to be cooled, and for that matter it would be of minor importance if it was necessary to use a small external source of energy, for instance to produce a direct pumping of cooling medium into the container **20** against an unrelieved pressure in it so that the filling operation does not necessarily have to be intermittent; in this case the feeding pump should be controlled by the level detector so as to be operative when the liquid level in the container **20** is below a predetermined maximum level. It is true that it would then instead be possible to use a pump which simply pumps the liquid up to the cooling section, but by omitting the container **20** the automatic regulation would get lost.

As also disclosed in the said U.S. Pat. No. 2,892,416 the driving agent in thermal pumping does not necessarily have to be identical with the medium to be pumped, and it will be understood that the present invention is not limited to the situation where driving medium, pumping medium and possibly also the coolant in a refrigeration system are identical. For example, as shown in FIG. **5**, the output liquid from the container **20** may be used for driving a hydraulic motor **62** of the positive displacement type instead of - as shown in FIG. **4** - being supplied to the cooling section **34**; otherwise the pump circuit in connection with the pump container **20** is identical with that shown in FIG. **4**, and the same reference numerals are used. The hydraulic motor **62** drives a rotary pump **64** of the positive displacement type, this pump serving to supply cooling liquid through a pipe **66** from a reservoir **68** to the cooling section **34** from which the return pipe **36'** leads back to the reservoir, if necessary through an external heat exchanger **70** in which the cooling medium may be cooled or condenced. It will be appreciated that in this manner there is provided full separation between the pumping medium and the cooling medium so that if desired it is possible to use different media each of optimal properties for the particular purposes, e.g., Freon and cold water, respectively. The cooling medium is not heated in the pump container whereby it may have a very high cooling capacity and the proportion between the rate of flow of the two media need not be one to one. i.e., the cooling medium may be supplied in a proportional manner with twice or more the flow rate of the pumping medium.

It is a specific feature of the invention that the liquid to be heated in the pump container for pumping purposes may be liquid coolant such as Freon having a boiling point substantially below 100°C, since the automatic control of the pumping may thereby be accomplished in an effective and easy manner at relatively low temperatures. It will be understood that this advantage is entirely independent of the possible additional use of the coolant for cooling purposes. However, it is of course a further advantage that a medium having optimal properties for acting as the pumping medium may thus additionally - as described in connection with FIG. **1** and **4** - be used for the actual cooling, likewise with optimal properties for this purpose.

When the cooling medium is of the type such as Freon which provided cooling by evaporation in the cooling section the actual cooling temperature will be much lower than the temperature of the liquid in the pump container **20** (FIGS. **1** and **4**). On the other hand, if the cooling medium is used for cooling without evaporation, then of course the pump container should not be placed adjacent the hottest zone of the heat developing part, since the cooling medium could then itself be heated too much to be effective for cooling purposes, especially of course if the medium has a relatively high boiling point; preferably there should not be built up any excessive overpressure in the pump container, so the temperature of the liquid therein will not normally be able to exceed the normal boiling point of the liquid.

Should the liquid be too hot anyway it is possible to let the outlet pipe **32** be long enough to enable the medium to cool down before it is actually supplied to the part to be cooled, or it can pass an external heat exchanger.

The invention is not restricted to cooling of compressors, since other heat developing parts such as motor cylinders may be cooled in this manner.

What is claimed is:

1. An apparatus having a heat developing part comprising:

pump means for supplying a cooling medium to the heat developing part, said heat developing part being cooled by said cooling medium;

control means for regulating the supply of said cooling medium in response to heat generated by said heat developing part,

said pump means including a thermal positive displacement pump of the type having a closed container partly filled with a liquid pumping medium,

said closed container including an outlet pipe for said liquid pumping medium, an inlet pipe for refilling said liquid pumping medium into said closed container, said inlet pipe being connected to a reservoir of said liquid pumping medium, and inlet control means for regulating said refilling of said closed container; and

a heating source in heat conduction connection with said closed container for heating said closed container sufficiently to cause said liquid pumping medium in said closed container to boil so that the vapour pressure in said closed container is sufficiently increased to cause the liquid pumping medium to be forced out through said outlet pipe for supplying said cooling medium to said heat developing part,

wherein said heat developing part at least partly constitutes said heating source in heat conduction connection with said closed container so as to effectively cause the supply of the cooling liquid to be adjusted in direct response to the temperature variations of the heat developing part.

2. An apparatus according to claim **1**, wherein said liquid pumping medium is a liquid coolant of the type having a boiling point substantially below 100°C.

3. An apparatus according to claim **1**, wherein said liquid pumping medium is said cooling medium.

4. An apparatus according to claim **3**, wherein said heat developing part is a compressor in a refrigerating system of the type working with a cooling medium which in a gaseous phase is compressed in the compressor, thereafter condensed into a liquid phase at the pressure side of the compressor then evaporated after passage of an expansion valve and finally returned to the suction side of the compressor, and in which the pumping and cooling medium is constituted by the cooling medium circulating in the refrigerating system, characterized in that said closed container is in heat conducting connection with the compressor having a temperature which is equal to or bigger than the condensing temperature of the refrigeration system and fluctuates with the working conditions of the compressor, whereas the inlet pipe of said closed container is connected to that part of the refrigeration system in which the cooling medium is present as a liquid under pressure, while the top of said closed container is connected to a point of relatively lower pressure of said refrigeration system through intermittently operating valve means.

5. An apparatus according to claim **4**, further comprising an oil separator unit mounted in the discharge pipe from the compressor, wherein said closed container is mounted in direct heat exchanging connection with said oil separator unit.

6. An apparatus according to claim **3**, wherein said liquid pumping medium is fed to said closed container from said reservoir, said outlet pipe being connected to an inlet of a flow-through heat exchanger in heat conductive connection with said heat developing part and an outlet of said heat exchanger being connected to said reservoir through a return pipe.

7. An apparatus according to claim **6**, wherein the upper space of said closed container is connected to the upper space of said reservoir through a vent pipe including valve means operable to open this connection for effecting venting of said closed container.

8. An apparatus according to claim **1**, wherein said inlet control means are operable to effect intermittent refilling of said closed container, and in which the upper space of said closed container is connected to venting means operable to relieve the pressure inside said closed container during said refilling.

9. An apparatus according to claim **8**, wherein detector means for detecting the level of the liquid in said closed container are operatively connected with said inlet control means so as to cause refilling in response to said liquid pumping medium falling below a predetermined level.

10. An apparatus according to claim **8**, wherein said inlet control means comprise valve means operable to actuate the said venting means, said liquid pumping medium being supplied to said closed container through a one-way valve under a pressure which is higher than the relieved pressure in said closed container but lower than the vapour pressure of said liquid pumping medium.

11. An apparatus according to claim **8**, wherein said inlet control means comprise valve means operable to actuate said venting means and inlet valve means operable concurrently therewith to introduce liquid into said closed container.

12. An apparatus according to claim **1**, wherein said outlet pipe of said closed container is connected with flow sensing means operatively connected with means for controlling the flow of said cooling medium to said heat developing part in such a manner that an increased flow of said cooling medium is produced in response to an increased outlet flow of liquid pumping

medium from said closed container.

13. An apparatus comprising:

a compressor in a refrigerating system of the type in which a cooling medium in the gaseous phase is compressed in said compressor, thereafter condensed into a liquid phase at the pressure side of said compressor, then evaporated after passage through an expansion valve, and finally returned to the suction side of the compressor,

said compressor being a piston type compressor having a crankcase and cylinders protruding from said crankcase, said piston type compressor having a detachable cover mounted over an admission opening of said crankcase;

pump means for supplying a cooling medium to said compressor, said compressor being cooled by said cooling medium;

control means for regulating the supply of said cooling medium in response to heat generated by said compressor,

said pump means including a thermal positive displacement pump of the type having a closed container partly filled with a liquid pumping medium and mounted protruding inwardly into said crankcase at the back of said cover, said liquid pumping medium constituting said cooling medium circulating in said refrigeration system and having a boiling point substantially below 100°C,

said closed container including a lower outlet pipe for said liquid pumping medium, an inlet pipe for refilling said liquid pumping medium into said closed container, said inlet pipe being connected to a reservoir of said liquid pumping medium at a portion of said refrigeration system in which said liquid pumping medium is under pressure, an inlet control means for regulating said refilling of said closed container, said closed container being connected to the suction side of said compressor through intermittently operating valve means; and

a heating source including at least partly said compressor in heat conduction connection with said closed container for heating said closed container at a temperature equal to or larger than the condensing temperature of said refrigeration system, said temperature fluctuating with the working conditions of said compressor, sufficiently to cause said liquid pumping medium in said closed container to boil so that the vapour pressure in said closed container is sufficiently increased to cause the liquid pumping medium to be forced out through said lower outlet pipe for supplying said cooling medium to said compressor,

wherein said heating source including at least partly said compressor in heat conduction connection with said closed container effectively causes the supply of the cooling liquid to be adjusted in direct response to the fluctuations of temperature of the compressor.

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