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Tindale et al.(10) **Pub. No.: US 2010/0242530 A1**(43) **Pub. Date: Sep. 30, 2010**(54) **CONDENSER HEATSINK**(30) **Foreign Application Priority Data**(75) Inventors: **Patrick Tindale**, Nottingham (GB);
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(GB)(57) **ABSTRACT**(21) Appl. No.: **12/601,122**(22) PCT Filed: **May 22, 2008**(86) PCT No.: **PCT/GB08/01746**§ 371 (c)(1),
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A diffusion-absorption refrigerator system (1) comprising a condenser pipe (6) passing through and surrounded by a heatsink (2), the heatsink comprising a sealed enclosure defining an internal cavity surrounding the condenser pipe for containing a heat transfer liquid, a cross-section of the heat-sink transverse the condenser pipe tapering to a minimum thickness towards an upper end when oriented for use of the refrigerator system.

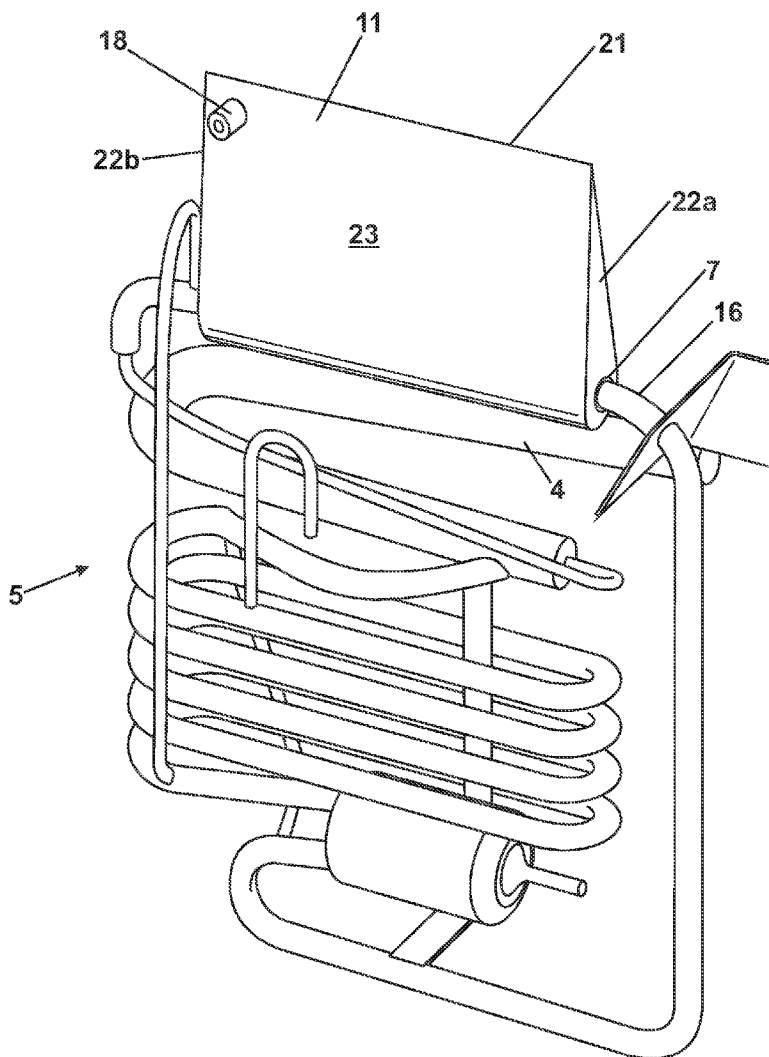


Fig. 1

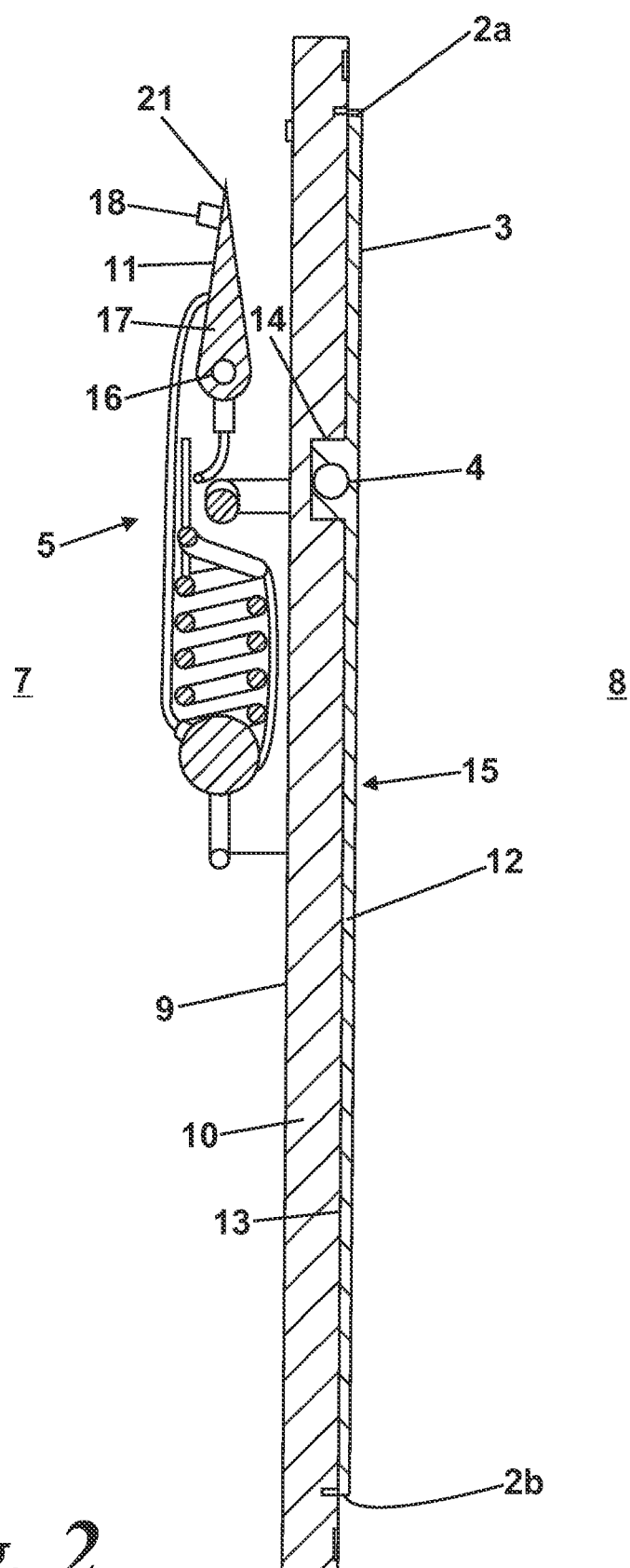


Fig. 2

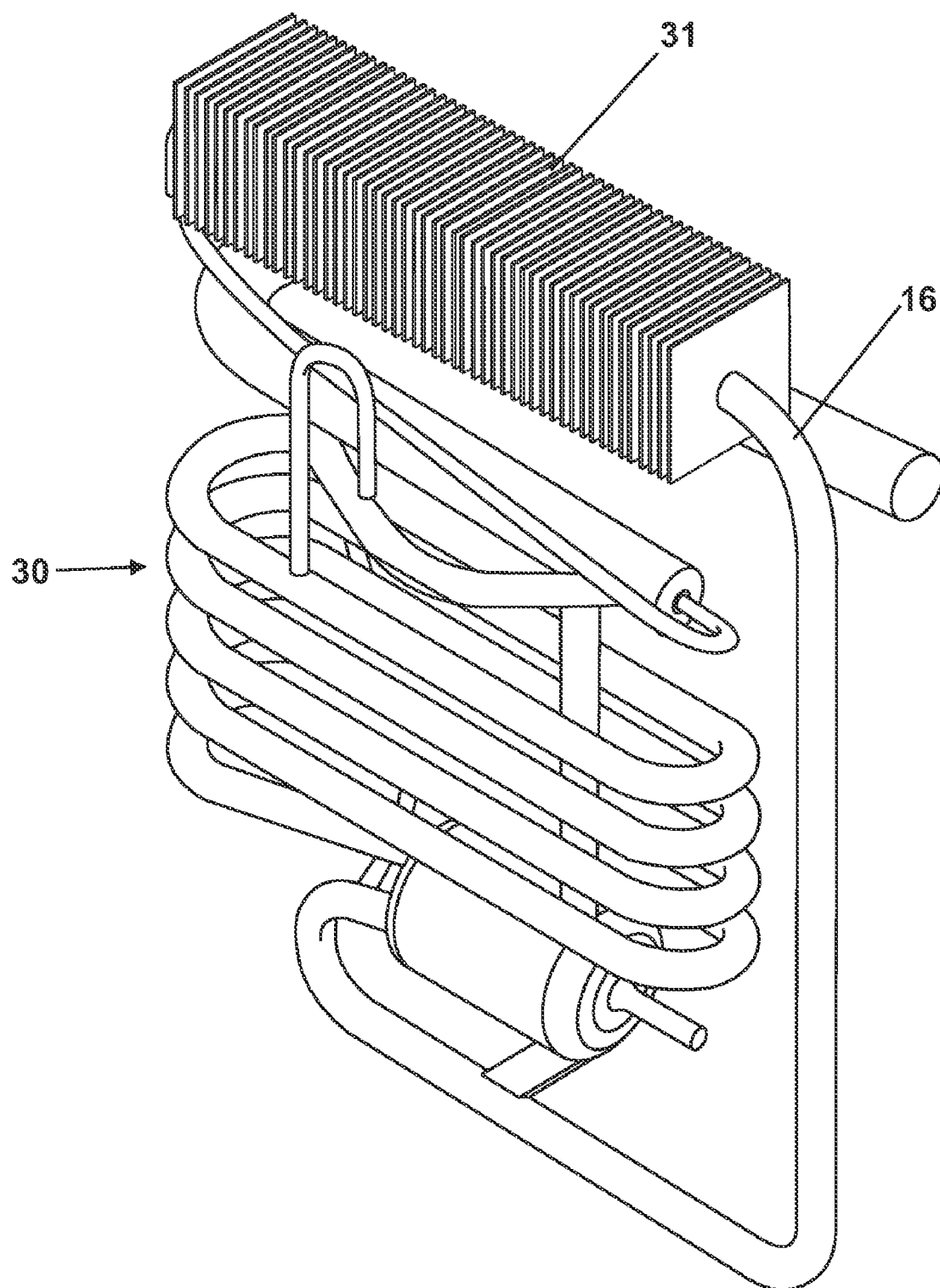
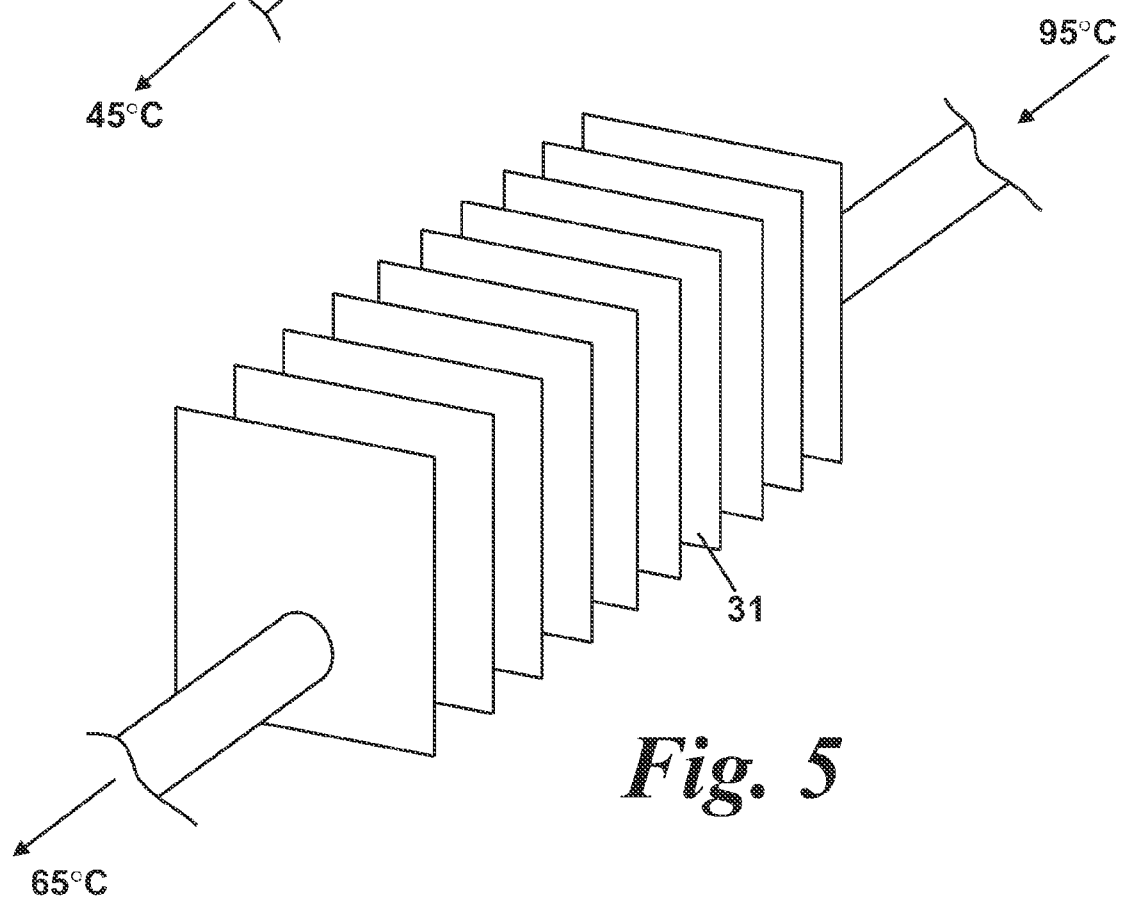
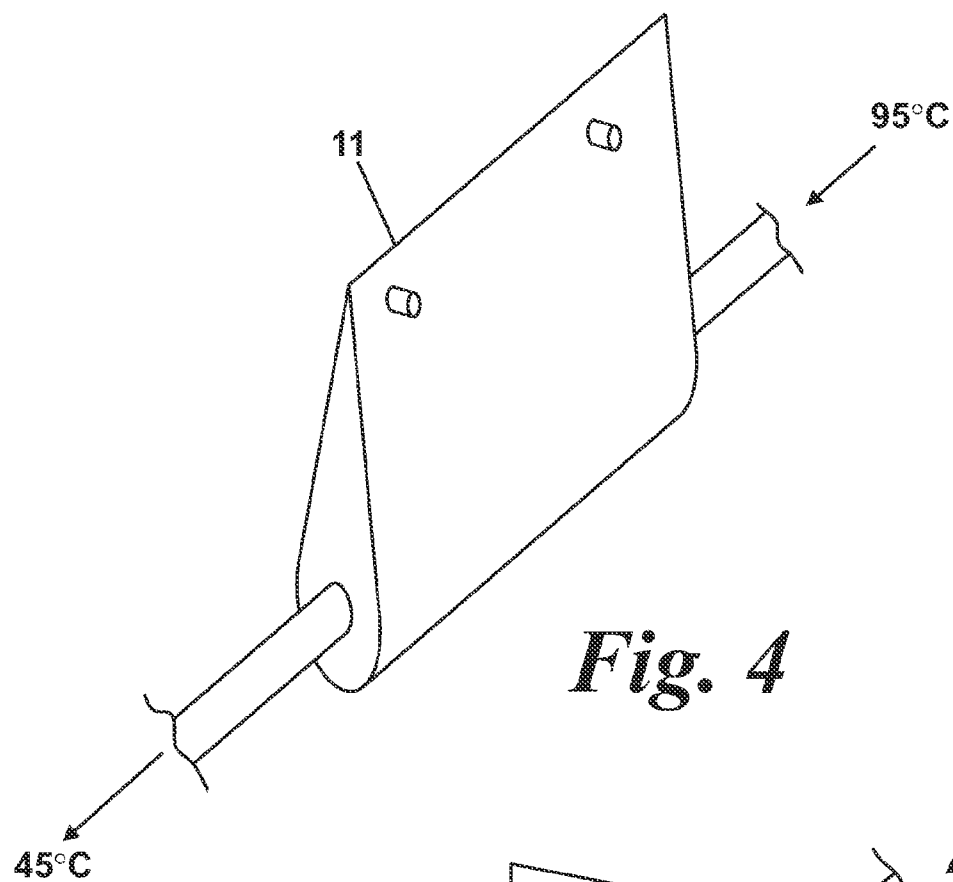


Fig. 3



CONDENSER HEATSINK

FIELD OF THE INVENTION

[0001] The invention relates to improvements in performance of diffusion-absorption cycle refrigerator systems, in particular for use with temperature controlled enclosures for containing temperature-sensitive electrical and electronic equipment.

BACKGROUND

[0002] Many items of electrical and electronic equipment have increased susceptibility to failure, malfunction or generally accelerated degradation and shortened lifespan when exposed to large variations in temperature, humidity and other ambient conditions. The problem is particularly significant for items of equipment that must be left for extended periods of time in environments that are relatively unprotected from atmospheric conditions.

[0003] One example is items of control equipment, and in particular, the standby or backup battery power supplies thereof. Such control equipment may be found in power distribution, telecommunication, transport and security systems and may often be situated in isolated and exposed outdoor and indoor locations. Installing such equipment in an enclosure for protection from rain or other precipitation can often increase temperature variations, in that sunlight on the enclosure will tend to heat the contents of the enclosure to far higher temperatures than would otherwise be the case. Additionally, in some applications, heat emitting equipment situated close to the sensitive equipment may add to the thermal stress. Thus, there is a requirement to provide cooling or air conditioning to the most temperature sensitive items.

[0004] In particular, battery back-up power supplies for power distribution control systems and telecommunication systems in the field have been observed to have a service life substantially lower than expected largely due to degradation caused by temperature and/or humidity variation. Solutions in the prior art have provided temperature controlled enclosures for the sensitive equipment ranging from a simple ventilated enclosure through to complete air conditioning systems. These solutions and systems incorporate technologies such as thermoelectric devices, forced convection, heat pipes, phase change material and vapour compression cycles.

[0005] A problem to be addressed in such temperature controlled enclosures is to make them as thermally efficient as possible, whilst at the same time developing devices that have no moving components which removes the need for regular and expensive maintenance due to the failure of those components as a result of mechanical wear and tear. Components which can be removed include mechanical parts such as fans, pumps and compressors and consumables such as filters.

[0006] An alternative refrigeration cycle or cooling mechanism to those noted which can be adapted to be used with electronic and electrical equipment is the diffusion absorption cycle. This cycle completely avoids the use of mechanical energy and instead it relies on direct thermal energy as a power source. They also use environmentally benign fluids, are reliable, silent and relatively inexpensive to build and have no moving parts. However they have a relatively low refrigeration Coefficient of Performance ('COP'), which needs to be improved so that electronic and electrical equipment such as industrial reserve power batteries can efficiently be cooled.

[0007] One of key reasons for poor performance of existing diffusion-absorption cycle refrigerator systems is the poor heat transfer from heatsink fins on the condenser to the external ambient environment. In general heatsink fin geometries, the region of the fins further from the base plays less of a role in the total heat transfer rate compared with the region closest to the fin base, which dominates the rate of heat transfer. In typical traditional diffusion absorption cycle systems the condenser fin arrangement leads to sub optimal heat transfer away from the condenser, meaning that the cycle runs at higher temperatures and lower efficiencies.

[0008] It is an object of this present invention to provide more efficient diffusion-absorption refrigerator systems for use with temperature controlled enclosures for electrical and electronic components such as industrial reserve power batteries.

SUMMARY OF THE INVENTION

[0009] In accordance with the invention there is provided a diffusion-absorption refrigerator system comprising a condenser pipe passing through and surrounded by a heatsink, the heatsink comprising a sealed enclosure defining an internal cavity surrounding the condenser pipe for containing a heat transfer liquid, a cross-section of the heatsink transverse the condenser pipe tapering to a minimum thickness towards an upper end when oriented for use of the refrigerator system.

[0010] Using improved diffusion absorption refrigeration cycle systems in accordance with the invention leads to a lower cost and higher efficiency for a wider range of ambient temperatures than with existing solutions. The temperature of industrial batteries can then be cooled more effectively, as the batteries can easily be thermally separated from other items of equipment in small enclosures that emit only a small amount of heat when on trickle charge. With adaptations to the systems as described herein, cooling performance can be enhanced and COPs improved.

[0011] Using a heatsink in the form of the liquid-filled sealed enclosure of the invention results in various improvements in performance of the diffusion absorption cycle system, including that of an improved thermal performance in dissipating heat from the condenser pipe into a heat transfer liquid within the enclosure. The heat transfer liquid is preferably a mixture of water and glycol, used due to its high heat capacity.

[0012] Aspects of the invention can be obtained at low cost by modification of a standard diffusion absorption system through the addition of the sealed enclosure by 'wrapping' the enclosure around the condenser pipe.

[0013] The sealed enclosure may be formed from one or a limited number of pieces of material, which improves the ease of manufacture of the enclosure and the ease of installation around an existing condenser pipe.

[0014] No moving parts such as fans are required, which would increase maintenance costs of the equipment. Instead, heat dissipation from the condenser pipe is achieved more effectively without the need for forced convection. A fan may optionally be added to the system to further enhance cooling performance, but at the cost of increased complexity.

[0015] Testing has indicated that a temperature difference (ΔT) in the region of 15°C. , between the inside of a temperature-controlled enclosure (e.g. for industrial batteries) and an external ambient environment, can be obtained using a standard 80 W diffusion absorption cycle system. Using a modified system with a heatsink according to the invention results

in an enhancement of typically over 5° C. in this temperature difference. This enables the system to be used at higher ambient temperatures, while still keeping the contents of the enclosure within their ideal operating temperature range. The modified system is therefore typically able to operate effectively in ambient temperatures of up to 60° C. while maintaining the contents of the enclosure below 45° C., and is able to maintain an effective ΔT of 15° C. down to room temperature.

DETAILED DESCRIPTION

[0016] The invention will now be described by way of example, and with reference to the enclosed drawings in which:

[0017] FIG. 1 is a perspective view of a diffusion absorption refrigeration cycle system having a fluid filled enclosure on the condenser pipe;

[0018] FIG. 2 is a cross-sectional view of the diffusion absorption refrigeration cycle system of FIG. 1, when attached to a wall of an equipment enclosure;

[0019] FIG. 3 is a perspective view of a standard diffusion absorption refrigeration cycle system having a heatsink comprising metal fins on the condenser pipe;

[0020] FIG. 4 is an isometric sketch view of an exemplary heatsink; and

[0021] FIG. 5 is an isometric sketch view of a standard finned condenser pipe heatsink.

[0022] FIG. 1 illustrates an exemplary diffusion absorption refrigeration cycle system 5 according to an aspect of the invention. The system 5 comprises an evaporator pipe 4 for extracting heat from a connected system, as described further in relation to FIG. 2, and a condenser pipe 16 for transporting this heat to an external environment. A heatsink 11 is attached around the condenser pipe 16, described in more detail below.

[0023] With reference to FIG. 2, the diffusion absorption refrigeration cycle system 5 of FIG. 1 is illustrated in cross-section. The system 5 is attached to a wall 9 of a temperature-controllable cabinet such that the interior 8 of the cabinet is cooled by the evaporator pipe 4 of the system 5, and heat extracted from the interior 8 is pumped by the system 5 to the exterior 7 of the cabinet. The wall 9 comprises a layer of insulation 10, which may itself form the external surface of the wall 9 or be further enclosed by another layer of material such as a metal sheet or casing. The cabinet is preferably configured and used for containing temperature-sensitive electrical and electronic equipment, so as to maintain the equipment within a desired temperature range by operation of the refrigeration system. A typical temperature range is around room temperature (i.e. 20-25° C.) or above, within which equipment such as lead-acid batteries tend to operate most efficiently.

[0024] A liquid-filled enclosure, or thermo-siphon 3, is attached to the inside of the wall 9, forming a sealed vessel surrounding the evaporator pipe 4. The enclosure 3 comprises one or more filling points for introducing liquid 12 into the enclosure once it has been fixed in place around the evaporator pipe 4. The liquid filled enclosure 3 may be attached to the structural insulation 10, or to a material enclosing the insulation, by way of welding, gluing or other mechanical fixing methods, for example at fixing points 2a, 2b on the edge of the enclosure 3.

[0025] The enclosure 3 may have one or more sides or faces in common with the structural insulation 10 or a material enclosing the insulation, for example along an interface 13

between the internal volume of the enclosure 6 and the insulation 10. The external surface 15 of the enclosure 3 may be in direct contact with the contents of the temperature controlled enclosure, or may act as a cooling element across the internal wall 15 for cooling air within the cabinet.

[0026] The size of the thermo-siphon is preferably optimised to provide a balance between thermal efficiency in heat transfer, cost of manufacture, fit with the refrigeration cycle and weight of fluid. The embodiment shown illustrates a particular preferred embodiment, where the enclosure 3 is in a substantially planar form extending across the internal surface of the wall, so as to maximise the cooling effect within the cabinet and minimise the quantity of heat transfer liquid required.

[0027] Preferably, the evaporator pipe 4 is located towards an upper end of the enclosure 3, extending through the enclosure in a substantially horizontal direction. The upper location of the pipe 4 allows for the convection effect to be optimised, since cool liquid within the enclosure 3 in contact with the evaporator pipe 4 will sink away from the pipe 4. As the liquid 3 absorbs heat from the internal volume 8 of the cabinet, the liquid rises and is then cooled again by the evaporator pipe 4, creating a convection cycle between the evaporator pipe 4 and the bottom of the enclosure 3. Any volume of liquid above the evaporator pipe 4, however, is not able to contribute to the convection cycle, due to a thermocline being set up within the liquid 12 around the level of the evaporator pipe 4. The evaporator pipe 4 therefore preferably passes through an upper portion of the enclosure 3, and more preferably as near to the top of the enclosure as practical, so as to maximise the efficiency of the thermo-siphon effect.

[0028] The liquid-filled sealed enclosure 6 surrounding the evaporator pipe 4 has the advantage of preventing ice forming on the evaporator pipe in use, and allows a more even temperature distribution throughout the interior of the cabinet. The use of the first sealed enclosure in the form of a heatsink 11 around the condenser pipe together with a second sealed enclosure 6 around the evaporator pipe 4 allows for an improved refrigerator system that operates more efficiently and requires less maintenance.

[0029] The heatsink 11 is configured to facilitate heat flow away from the condenser pipe 16 around which it is attached. The heatsink 11 is preferably formed by a metal sheet being wrapped around the condenser pipe 16, and sealed at the upper edge 21 and opposing side portions 21a, 21b (FIG. 1). This forms a sealed cavity for containing a heat transfer liquid 17 within. A filling port 18 is provided for introducing the heat transfer liquid, which may comprise water or another suitable liquid such as a water-glycol mixture. Expansion of the heat transfer liquid due to heating can be accommodated by flexing of the side walls 23 of the heatsink 11. Introduction of the heat transfer liquid can be carried out once the heatsink 11 is fixed in place around the condenser pipe 16. In the embodiment shown in FIG. 1, the heatsink fins normally present on the condenser pipe 16 (see FIGS. 3 and 5) have been removed, although this is not a prerequisite for improving the system 5.

[0030] The heatsink 11 may be attached to the condenser pipe 16 by way of welding, gluing or other mechanical fixing means, provided a liquid seal is made to prevent any liquid being lost to the environment. In FIG. 1, the side portions 21a, 21b are shown attached to the condenser pipe 16 along a weld line 7. The enclosure formed by the heatsink 11 is preferably widest in cross-section at the point where the heatsink 11

wraps around the condenser pipe 16, so as to encourage convective flow in the liquid 17 around the hot condenser pipe 16.

[0031] For comparison, FIG. 3 illustrates a standard diffusion absorption refrigeration cycle system 30 comprising a condenser pipe 16 having a heatsink 31 in the form of solid metal fins, configured to increase the available surface area for improving heat dissipation away from the condenser pipe 16. Such heatsinks rely mainly on thermal conduction through the metal fins to dissipate heat away from the condenser pipe 16. By comparison, the heatsink 11 in the form of the liquid-filled enclosure of the present invention has the benefit of liquid convection to accelerate heat transport away from the condenser pipe 16.

[0032] As shown in sketch form in FIG. 4 and FIG. 5, a temperature difference across the liquid filled heatsink 11 of 40° C. (95° C. to 45° C.: FIG. 4) is possible, compared with 30° C. (95° C. to 65° C.: FIG. 5) for the conventional solid metal heatsink 30.

[0033] The general preferred shape of the enclosure 2 is that of a wing, i.e. having the form of a substantially uniform cross-section with a rounded lower end and a tapering upper end. Such a cross-sectional shape results in a further benefit from convective flow of air around the enclosure 2, thereby further improving heat dissipation from the condenser pipe 16.

[0034] The size of the heatsink is preferably optimised to provide a balance between: i) thermal efficiency in dissipating heat; ii) cost of manufacture; iii) fit with the refrigeration cycle system to which it is to be attached; and iv) weight of the heat transfer liquid. For example, the heatsink may be required to fit within the available footprint around the equipment enclosure.

[0035] The heatsink being shaped in the form of a wing orientated vertically allows the most effective and uninterrupted hot air flow up the side of the equipment cabinet, from the base of the system to the external ambient environment. A typical heatsink will have a surface area of a sufficient size to reduce the temperature at the end of the condenser pipe by 20° C. when compared to an equivalent finned condenser pipe.

[0036] Because the equipment cabinet to which the system of the invention is configured to be attached is required to be thermally isolated from the external environment, a vent may be added to the cabinet to ensure that noxious or explosive gases (such as hydrogen) are dissipated to the external environment, thus avoiding any explosive build up of gas within the cabinet, which could be generated during operation of the equipment therein.

[0037] Other embodiments are intentionally within the scope of the invention, as defined by the appended claims.

1. A diffusion-absorption refrigerator system comprising:
 - a heatsink;
 - a condenser pipe passing through and surrounded by the heatsink, the heatsink comprising a sealed enclosure defining an internal cavity surrounding the condenser pipe for containing a heat transfer liquid, a cross-section of the heatsink transverse the condenser pipe tapering to a minimum thickness towards an upper end when oriented for use of the refrigerator system.
2. The system of claim 1 wherein the heatsink is shaped in the form of a wing comprising a substantially uniform cross-section with a rounded lower end and a tapering upper end.

3. The system of claim 2 wherein the heatsink comprises a section sealed at opposing ends by first and second end portions defining the cross-section, the middle section wrapping around the condenser pipe.

4. The system of claim 3 wherein the heatsink comprises a filling port for introducing the heat transfer liquid into the cavity.

5. The system of claim 4 wherein the cross-section of the heatsink is substantially uniform along a length direction parallel to the condenser pipe.

6. A temperature-controlled system comprising:
 - an enclosure;
 - a diffusion-absorption refrigerator system operatively connected to the enclosure, the diffusion-absorption refrigerator system comprising:
 - a heatsink;
 - a condenser pipe passing through and surrounded by the heatsink, the heatsink comprising a sealed enclosure defining an internal cavity surrounding the condenser pipe for containing a heat transfer liquid, a cross-section of the heatsink transverse the condenser pipe tapering to a minimum thickness towards an upper end when oriented for use of the refrigerator system.

7. A temperature-controllable equipment cabinet comprising:
 - a wall;
 - a diffusion-absorption refrigeration cycle system comprising:
 - a heatsink;
 - a condenser pipe passing through and surrounded by the heatsink, the heatsink comprising a sealed enclosure defining an internal cavity surrounding the condenser pipe for containing a heat transfer liquid, a cross-section of the heatsink transverse the condenser pipe tapering to a minimum thickness towards an upper end when oriented for use of the refrigerator system; and
 - a evaporator pipe,
 - wherein the evaporator pipe of the refrigeration system extends through the wall of the cabinet and passes through a second sealed enclosure for containing a heat transfer liquid, the sealed enclosure extending across and forming part of an internal surface of the cabinet such that the refrigeration system in use extracts heat from within the cabinet to an external environment.

8. The equipment cabinet of claim 7 wherein the wall of the cabinet comprises a layer of thermal insulation through which the evaporator pipe extends.

9. The equipment cabinet of claim 8 wherein the evaporator pipe passes through a recess provided in the wall.

10. The equipment cabinet of claim 9 wherein the second sealed enclosure is substantially planar in construction across the internal surface of the wall.

11. The equipment cabinet of claim 10 wherein the evaporator pipe passes in a horizontal direction through an upper portion of the second sealed enclosure when the cabinet is oriented for use such that, in use, convective flow of the heat transfer liquid aids heat transfer from within the cabinet.

12. The system of any of claim 5 wherein the internal cavity of the sealed enclosure contains a mixture of water and glycol as the heat transfer liquid.

13. (canceled)

14. The system of claim 1, wherein the heatsink comprises a section sealed at opposing ends by first and second end

portions defining the cross-section, the middle section wrapping around the condenser pipe.

15. The system of claim 1, wherein the heatsink comprises a filling port for introducing the heat transfer liquid into the cavity.

16. The system of claim 1, wherein the cross-section of the heatsink is substantially uniform along a length direction parallel to the condenser pipe.

17. The system of claim 1 wherein the internal cavity of the sealed enclosure contains a mixture of water and glycol as the heat transfer liquid.

18. The equipment cabinet of claim 7, wherein the evaporator pipe passes through a recess provided in the wall.

19. The equipment cabinet of claim 7, wherein the second sealed enclosure is substantially planar in construction across the internal surface of the wall.

20. The equipment cabinet of claim 7, wherein the evaporator pipe passes in a horizontal direction through an upper portion of the second sealed enclosure when the cabinet is oriented for use such that, in use, convective flow of the heat transfer liquid aids heat transfer from within the cabinet.

21. The system of claim 6, wherein the heatsink is shaped in the form of a wing comprising a substantially uniform cross-section with a rounded lower end and a tapering upper end, wherein the heatsink comprises a section sealed at opposing ends by first and second end portions defining the cross-section, the middle section wrapping around the condenser pipe, wherein the heatsink comprises a filling port for introducing the heat transfer liquid into the cavity, and wherein the cross-section of the heatsink is substantially uniform along a length direction parallel to the condenser pipe.

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