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(54) **HEATING SYSTEM**

HEIZSYSTEM

SYSTÈME DE CHAUFFAGE

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Description

[0001] The present invention relates to a heating system in a cooling device such as a flooded cooler and in particular to a heating system for preventing water in the cooler from freezing.

[0002] Prior art air-conditioning systems, such as air-cooled chillers for example, contain a cooler, such as a flooded cooler. Often these chillers are installed outside the building to which they supply air-conditioning and during cold periods the ambient temperature may be around or below the freezing point of the medium flooding the cooler. In such situations, if the cooled medium is water and if the ambient temperature is about or below 0° C, then it is necessary to prevent the water from freezing. This is particularly important when the cooler is not operating, which may occur for example when the chiller is not required to provide cooling or when a fault occurs in the chiller.

[0003] When a chiller stops due to an unexpected event or emergency, such as a power shortage or a safety cut-out, and if the ambient temperature is low, then just after the compressor of the system stops, the condenser cools down very quickly to reach the ambient temperature level. Consequently the pressure inside the condenser also drops very quickly to reach a saturated pressure corresponding to the ambient air temperature. The refrigerant, which just prior to the chiller stopping was located in the cooler, is subject to a reduction in pressure and therefore boils at a temperature level corresponding with the ambient air temperature whilst migrating to the coldest chiller system point, i.e. the condenser. Before all the refrigerant in the cooler evaporates, a significant amount of cooling is provided to the water in the cooler and, particularly if that water is not circulating (for example if the power shortage or safety cut-out stops the entire chiller and/or the water pumps etc.), it will rapidly freeze, forming ice. Even an operating cooler can be susceptible to freezing if the ambient temperature is low and particularly if it remains low for a prolonged period.

[0004] There are typically two types of cooler used in chillers; direct expansion evaporators in which refrigerant evaporates inside a plurality of tubes and water circulates around the outside of the tubes and flooded coolers in which water circulates inside the tubes and refrigerant surrounds the tubes. The above described situation in which water freezes inside a chiller is particularly detrimental to the flooded type of cooler since, as water freezes to form ice, the volume occupied by the fluid increases by approximately 10% (compared with the volume occupied by the water alone). This volume increase significantly increases the pressure within the tubes causing high stresses in the tube body and thus splitting or bursting the tubes and allowing refrigerant and water to mix.

[0005] Prior art solutions to overcome the above problem have been suggested. For example, one common solution is to provide dedicated electrical heaters, which deliver energy to portions of the cooler when the ambient

temperature is sufficiently low, particularly if the chiller or the cooler is not operating. The heaters increase the temperature of the portions of the cooler that are heated and thus increase the temperature of the water in the cooler (or whatever coolant is employed) to a temperature above its freezing point. The heaters can comprise resistive wires applied to the cooler housing or shell, and/or immersion heaters directly immersed in the water supply at a suitable location, such as at the water inlet and/or the water outlet manifolds.

[0006] However, the above heating solutions are expensive and complicated to install, operate and maintain. In particular, in the resistive wire type heating systems, it is typically the shell that is heated by the wires and the heat is delivered to the pipes in the cooler, which carry the water, only by conduction and convection of heat from the shell. Therefore it is necessary to provide sufficient heat to the shell to ensure enough heat reaches all regions of the tubes, otherwise frozen sections could occur, say, in the centre of the pipes which are furthest from the shell. Furthermore, a good thermal connection must be made between the resistive wires and the shell in order to conduct sufficient heat to the shell and therefore installation of these systems is complicated, time-consuming and subject to failure if the connections weaken with time.

[0007] Whilst immersion heating systems apply heat directly to the water, these systems are typically installed in the water inlet or outlet, since they cannot reside in the pipes without interfering with the flow of the water and thus reducing the efficiency of the chiller. Furthermore, immersion systems are complicated to install, since they must be immersed in the water requiring inlets to be cut into the shell, which must be water-tight once closed. Immersion heater systems are also expensive to operate due to their high power requirements, particularly over prolonged periods of time.

[0008] Therefore it is desirable to provide a heating system for a cooler, particularly although not exclusively a flooded type cooler, for conditions when the medium in the cooler is susceptible to freezing and that is cost effective, easy to install and does not unduly affect the cooler efficiency or performance.

[0009] It is an object of the present invention to provide a system and method for protecting a cooler against freeze damage.

[0010] A cooler having the features of the preamble of claim 1 is disclosed in FR-A-1199108.

[0011] In accordance with a first aspect of the present invention, there is provided a cooler for an air-conditioning system as set forth in claim 1.

[0012] Therefore there is provided a cooler in which electricity, preferably very low voltage, high current electricity is applied across at least a part of the cooler, which generates heat in the part or parts of the cooler in which the current flows thereby maintaining or raising the temperature of the medium in the tubes. Heat is preferably generated in the part or parts of the cooler through which

the current flows by means of impedance heating, which is known in the art and generally speaking is a combination of heat generated by the resistance of the parts of the cooler through which the current flows and also the various effects of the magnetic fields generated in the region of the cooler. The impedance heating directly heats the parts of the cooler through which the current flows and conduction and convection of the generated heat also provides dissipated heating to other regions of the cooler which are thermally connected to the heated parts of the cooler, thereby providing heating over most of or substantially all of the cooler and, thus providing an effective and uniform heating system.

[0013] In a preferred embodiment of the present invention, the cooler comprises a plurality of tubes. The medium in the tubes is therefore distributed across the cooler providing a large surface area for contacting the medium with the tubes and a large surface area that can be subjected to the impedance heating mechanism.

[0014] Preferably the medium in the cooler comprises water. Water is well known in the art for its suitability in conventional coolers and is particularly suitable for the preferred cooling systems of the present invention, such as air-cooled chillers.

[0015] As mentioned above, whilst heat can be generated by impedance heating in parts of the cooler, it is desirable for that heat to be at least partially transferable to any or all regions of the cooler in which the current does not flow. Therefore it is preferable for the shell and the tube or tubes to be thermally coupled such that heat generated in one is transferable to the other, typically by conduction and/or convection. The tubes comprise an electrically and thermally conductive material and the shell also preferably comprises an electrically and thermally conductive material. Conduction of the heat from one region of the cooler, such as the shell, readily occurs to other regions of the cooler such as each of the tubes. The material of the shell is less electrically and less thermally conductive than the material of the tubes. This is particularly beneficial because this arrangement allows more heat to be generated and/or transferred to the more conductive material (i.e. the tube material) than to the less conductive material (i.e. the shell) and it is desirable to heat the tubes rather than the shell because the medium is more susceptible to freezing in the tubes rather than in the shell. In a particularly preferred embodiment, the tubes comprises copper or a copper based alloy. Further, it is preferable for the shell to comprise steel or a steel based alloy.

[0016] The electrical current provided to the cooler may comprise direct current (DC). However, supplying DC electricity to the cooler may cause corrosion of the components over a prolonged period of use. Preferably therefore, the electrical current provided to the cooler comprises an alternating current (AC). Furthermore, it is preferred that the electrical current has a relatively high current and a relatively low voltage (compared, for example with the conventional mains supply in the US and/or Eu-

rope etc.) to provide effective impedance heating. Preferably the electrical current is from 50 to 1000 Amperes. Preferably the electrical voltage corresponding with the electrical current is from about 0.1 to about 24 Volts.

Therefore it is preferable for the heating system for the cooler to further comprise a transformer, preferably a step down transformer that is suitable for connecting to a building mains supply or to a dedicated electrical supply for the system, said electrical current provided by a secondary side of the transformer.

[0017] As discussed above, it is desirable to regulate the temperature of the medium within the cooler, and particularly within the tubes to prevent the medium freezing in low ambient temperatures. The heating system is therefore preferably controllable such that the medium temperature is monitored and/or the ambient temperature is monitored and one or both of these temperatures is used to control activation and deactivation of the impedance heating system of the present invention.

[0018] The above-mentioned and other features of the various embodiments of the present invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 shows a cross-section of a prior art flooded cooler for a chiller having a plurality of tubes for carrying water and a refrigerant in the cooler surrounding the tubes;

Figure 2 shows a cross-section of a prior art flooded cooler for a chiller similar to the cooler of Figure 1 but having conventional water heating systems; and Figure 3 shows a cross-section of flooded cooler for a chiller in accordance with an embodiment of the present invention having an impedance heating system.

[0019] With reference to Figure 1, a prior art cooler 10 for a chiller, such as an air-cooled chiller, is shown. The cooler 10 comprises a shell 12 which holds a liquid 30, which is typically a refrigerant as is known in the art. A refrigerant inlet 32 and a refrigerant outlet 34 are provided in the shell 12. The cooler also contains a plurality of tubes 20 which are immersed in the refrigerant 30 and are arranged in this embodiment such that the refrigerant completely surrounds each of the tubes 20. The tubes 20 are connected to an associated inlet 22 for a supply for providing a medium to be cooled 40 through the tubes 20 via a manifold 14 at a first side of the shell 12. The medium 40 passes through the tubes 20 to a manifold 16 at the other side of the shell 12 where it leaves the cooler via an outlet 24. The medium in an air-cooled chiller is typically water. Heat transfer between the water 40 flowing through the tubes 20 and the refrigerant 30 surrounding the tubes 20 occurs during normal operation of the cooler 10 to cool or heat the water 40. However, when the ambient temperature of the environment in which the chiller is situated falls below the freezing point of water, and particularly if the water 40 is not circulating through

the tubes 20 due, for example, to a power failure, then the water 40 begins to freeze thus forming ice which begins to build in the tubes 20 and which can cause damage to the tubes due to the increased volume frozen water compared to unfrozen water.

[0020] The prior art cooler 10 of Figure 2 shows a conventional arrangement for compensating for low ambient temperatures of a water filled chiller. Like reference numerals are used for like components in this arrangement. The prior art cooler 10 of Figure 2 is identical to the cooler 10 of Figure 1 except that several heaters 50, 52 are provided in and around the cooler 10. In particular, immersion heaters 50 are inserted into manifolds 14, 16 in order to warm the water 40 entering from the inlet 22 and passing to the outlet 24 respectively. These heaters 50 each require an electrical power source 54 which typically would consume high levels of power when operational. Installing the immersion heaters 50 in the water 40 inlet 22 and outlet 24 regions of the shell requires holes to be cut in the manifolds 14, 16 and water tight seals to preventing leaking. Furthermore, these heaters 50 are not effective at preventing water 40 in other parts of the cooler 10 from freezing, particularly in regions such as the central portion 26 of the tubes 20. Therefore further heating is required and this is provided by resistive wire heating systems 52 in which wires are applied to the cooler shell 12, for example as wires or sheets wrapped around the shell. Electrical power sources 54 provide the high levels of power required to warm the shell via the wires, which heat not only the shell 12, but also the refrigerant 30. It is still difficult to provide sufficient heat to tubes 20a in the centre of the cooler 10 since they are furthest spaced from the heat sources 50, 52. Since the tubes 20 themselves are not heated, there may be regions of the cooler 10 that are still susceptible to freezing, thereby having an increased risk of damage or requiring increased power consumption to reduce the damage risk.

[0021] Figure 3 shows a preferred embodiment of the present invention. A conventional cooler 10 is shown, like the coolers of Figures 1 and 2. However, in this embodiment of the present invention, heating is provided to the cooler 10 by an impedance heating system 60, 62, 63, 64, 65. A conventional power source 54, such as alternating current mains voltage or a dedicated electricity supply is connected to a step-down transformer 60 on the primary side 66, which reduces the voltage and increases the current of the alternating current supply. The transformer secondary 68 is connected via cable 62 to terminal 63 which makes electrical contact with the manifold 14 on a first side of the shell 12. The transformer secondary 68 is also connected via cable 64 to terminal 65 which makes electrical contact with the manifold 16 on the second side 16 of the shell 12. This completes an electrical loop or circuit and therefore alternating is passed through the circuit, generating heat in all of the metallic components of the cooler 10 that are electrically connected to the terminals 63, 65 via the manifolds 14, 16 and shell 12 which is electrically connected to the man-

ifolds. In this embodiment, the shell 12 comprises steel and each tube 20 comprises copper and therefore current can flow through each of these connected components, thus generating heat in each of them. This is a particularly advantageous arrangement because the tubes 20 themselves are heated thus leaving no regions, such as the centre of the tubes as shown at 26 in Figure 2, that do not receive heat.

[0022] Although described above in the context of an air-cooled chiller system, the principles of the present invention can be incorporated into any system in which water or another medium passes through tubing or the like and which may be caused to freeze. Furthermore, although not discussed in detail above, it is contemplated that the heating system need not be connected to the shell, but could be connected to the tubes or to other metallic parts of the cooler.

Claims

1. A cooler (10) for an air-conditioning system, said cooler comprising:

a shell (12);
at least one tube (20) within the shell (12), said tube (20) extending between said first manifold (14) and said second manifold (16) capable of carrying a first medium; and
heating means (60...65), said heating means comprising means for providing an electrical current to at least one of the shell (12) and the tube (20) so as to generate heat therein; **characterised by** further comprising:

a first manifold (14); and
a second manifold (16); and in that:

said tube (20) extends between said first manifold (14) and said second manifold (16), said heating means providing said electric current to said tube via said first and second manifolds (14, 16); and
the tube (20) comprises an electrically and thermally conductive material, and the shell (12) comprises an electrically and thermally conductive material that is less electrically and less thermally conductive than the material of the tube (20).

2. The cooler of claim 1, comprising a plurality of said tubes (20).
3. The cooler of claim 1 or 2, wherein the medium comprises water.

4. The cooler of claim 1, 2 or 3, wherein the shell (12) and the tube (20) are thermally and/or electrically coupled such that heat generated in one is transferable to the other. 5
5. The cooler of any preceding claim, wherein the electrical current comprises an alternating current. 5
6. The cooler of any preceding claim, further comprising a transformer (60), said electrical current provided by a secondary side of the transformer (60). 10
7. The cooler of any preceding claim, wherein the electrical current is from 50 to about 1000 Amperes 15
8. The cooler of any preceding claim, wherein an electrical voltage corresponding with the electrical current is from about 0.1 to about 24 Volts.
9. The cooler of any preceding claim, wherein the tube (20) comprises copper or a copper based alloy. 20
10. The cooler of any preceding claim, wherein the shell (12) comprises steel or a steel based alloy. 25
11. The cooler of any preceding claim, further comprising a second medium within the shell (12), said second medium at least partially surrounding the tube. 30
12. The cooler of claim 11, wherein the second medium comprises refrigerant.
13. The cooler of claim 11 or 12, further comprising:
 - a first inlet in said first manifold (14) at a first side of the shell (12) and a first outlet in said second manifold (16) at a second side of the shell (12); and 35
 - a second inlet and a second outlet in the shell (12) for the second medium. 40
14. The cooler of claim 13, wherein the first medium enters the shell (12) via the first inlet in the first manifold (14) at the first side of the shell (12), passes through the tube (20) and exits the shell via the first outlet in the second manifold (14) at the second side of the shell (12). 45
15. The cooler of any preceding claim, further comprising controlling means for measuring the temperature of the medium and/or an ambient temperature and for controlling the heating means depending upon one or both said temperatures. 50
16. The cooler of claim 1 being an air air-cooled chiller (10) and comprising: 55
 - a plurality of said tubes (20);

said shell (12) being capable of containing a second medium and having the tubes (20) arranged therein such that said second medium at least partially surrounds the plurality of tubes (20); and
said heating means comprising:

a transformer (60);

means for providing an electrical current from the transformer (60) to at least one of the shell (12) and the tubes (20).

17. The cooler of claim 16 wherein the shell (12) comprises steel and the tubes comprise copper.

18. The cooler of claim 16 or 17 wherein the transformer (60) comprises a step-down transformer capable of connection to a conventional mains supply.

Patentansprüche

1. Kühleinrichtung (10) für ein Klimatisierungssystem, wobei die Kühleinrichtung Folgendes umfasst:

einen Mantel (12);
wenigstens eine Röhre (20) in dem Mantel (12), wobei sich die Röhre (20) zwischen dem ersten Verteiler (14) und dem zweiten Verteiler (16) erstreckt und ein erstes Medium fördern kann; und Heizmittel (60...65), wobei die Heizmittel Mittel zum Bereitstellen eines elektrischen Stroms an wenigstens eins von dem Mantel (12) und der Röhre (20) umfassen, um Wärme darin zu erzeugen; **dadurch gekennzeichnet, dass** sie ferner Folgendes umfasst:

einen ersten Verteiler (14); und
einen zweiten Verteiler (16); und dadurch, dass:

die Röhre (20) sich zwischen dem ersten Verteiler (14) und dem zweiten Verteiler (16) erstreckt, wobei die Heizmittel den elektrischen Strom über den ersten und zweiten Verteiler (14, 16) an die Röhre bereitstellen; und
die Röhre (20) ein elektrisch leitendes und wärmeleitendes Material umfasst und der Mantel (12) ein elektrisch leitendes und wärmeleitendes Material umfasst, das weniger elektrisch leitend und wärmeleitend ist als das Material der Röhre (20).

2. Kühleinrichtung nach Anspruch 1, umfassend eine Vielzahl von Röhren (20).

3. Kühleinrichtung nach Anspruch 1 oder 2, wobei das Medium Wasser umfasst.
4. Kühleinrichtung nach Anspruch 1, 2 oder 3, wobei der Mantel (12) und die Röhre (20) thermisch und/oder elektrisch gekoppelt sind, derart, dass Wärme, die in einem davon erzeugt wird, an das andere übertragbar ist.
5. Kühleinrichtung nach einem der vorangehenden Ansprüche, wobei der elektrische Strom einen Wechselstrom umfasst.
6. Kühleinrichtung nach einem der vorangehenden Ansprüche, ferner umfassend einen Transformator (60), wobei der elektrische Strom von einer Sekundärseite des Transformators (60) bereitgestellt wird.
7. Kühleinrichtung nach einem der vorangehenden Ansprüche, wobei der elektrische Strom zwischen 50 und 1000 Ampere beträgt.
8. Kühleinrichtung nach einem der vorangehenden Ansprüche, wobei eine elektrische Spannung, die dem elektrischen Strom entspricht, zwischen etwa 0,1 und etwa 24 Volt liegt.
9. Kühleinrichtung nach einem der vorangehenden Ansprüche, wobei die Röhre (20) Kupfer oder eine Legierung auf Kupferbasis umfasst.
10. Kühleinrichtung nach einem der vorangehenden Ansprüche, wobei der Mantel (12) Stahl oder eine Legierung auf Stahlbasis umfasst.
11. Kühleinrichtung nach einem der vorangehenden Ansprüche, ferner umfassend ein zweites Medium in dem Mantel (12), wobei das zweite Medium die Röhre wenigstens teilweise umgibt.
12. Kühleinrichtung nach Anspruch 11, wobei das zweite Medium Kältemittel umfasst.
13. Kühleinrichtung nach Anspruch 11 oder 12, ferner umfassend:
einen ersten Einlass in dem ersten Verteiler (14) auf einer ersten Seite des Mantels (12) und einen ersten Auslass in dem zweiten Verteiler (16) auf einer zweiten Seite des Mantels (12); und einen zweiten Einlass und einen zweiten Auslass in dem Mantel (12) für das zweite Medium.
14. Kühleinrichtung nach Anspruch 13, wobei das erste Medium über den ersten Einlass in dem ersten Verteiler (14) auf der ersten Seite des Mantels (12) in den Mantel (12) eintritt, die Röhre (20) durchläuft und den Mantel über den ersten Auslass in dem zweiten Verteiler (14) auf der zweiten Seite des Mantels (12) verlässt.
15. Kühleinrichtung nach einem der vorangehenden Ansprüche, ferner umfassend Steuermittel zum Messen der Temperatur des Mediums und/oder einer Umgebungstemperatur und zum Steuern der Heizmittel abhängig von einer oder beiden Temperaturen.
16. Kühleinrichtung nach Anspruch 1, die eine luftgekühlte Kälteanlage (10) ist und Folgendes umfasst:
eine Vielzahl der Röhren (20);
den Mantel (12), der ein zweites Medium enthalten kann und in dem die Röhren (20) angeordnet sind, derart, dass das zweite Medium die Vielzahl von Röhren (20) wenigstens teilweise umgibt; und
die Heizmittel, umfassend:
einen Transformator (60);
Mittel zum Bereitstellen eines elektrischen Stroms von dem Transformator (60) an wenigstens eins von dem Mantel (12) und den Röhren (20).
17. Kühleinrichtung nach Anspruch 16, wobei der Mantel (12) Stahl umfasst und die Röhren (20) Kupfer umfassen.
18. Kühleinrichtung nach Anspruch 16 oder 17, wobei der Transformator (60) einen Abwärtstransformator umfasst, der mit einem üblichen Netzanschluss verbunden werden kann.

Revendications

1. Refroidisseur (10) pour un système de climatisation, ledit refroidisseur comprenant :
- une enveloppe (12) ;
au moins un tube (20) à l'intérieur de l'enveloppe (12), ledit tube (20) s'étendant entre ledit premier collecteur (14) et ledit second collecteur (16) capable de transporter un premier fluide ; et
un moyen de chauffage (60...65), ledit moyen de chauffage comprenant un moyen pour la fourniture d'un courant électrique à au moins un de l'enveloppe (12) et du tube (20) afin de générer de la chaleur dans celui-ci ; **caractérisé en ce qu'il comprend en outre :**
un premier collecteur (14) ; et
un second collecteur (16) ; et **en ce que :**

ledit tube (20) s'étend entre ledit premier collecteur (14) et ledit second collecteur (16), ledit moyen de chauffage fournissant ledit courant électrique audit tube via lesdits premier et second collecteurs (14, 16) ; et le tube (20) comprend un matériau conducteur électriquement et thermiquement, et l'enveloppe (12) comprend un matériau conducteur électriquement et thermiquement qui est moins conducteur électriquement et thermiquement que le matériau du tube (20).

2. Refroidisseur selon la revendication 1, comprenant une pluralité desdits tubes (20). 5
3. Refroidisseur selon la revendication 1 ou 2, dans lequel le fluide comprend de l'eau. 10
4. Refroidisseur selon la revendication 1, 2 ou 3, dans lequel l'enveloppe (12) et le tube (20) sont couplés thermiquement et/ou électriquement de telle sorte que la chaleur générée dans l'un est transférable vers l'autre. 15
5. Refroidisseur selon une quelconque revendication précédente, dans lequel le courant électrique comprend un courant alternatif. 20
6. Refroidisseur selon une quelconque revendication précédente, comprenant en outre un transformateur (60), ledit courant électrique fourni par un côté secondaire du transformateur (60). 25
7. Refroidisseur selon une quelconque revendication précédente, dans lequel le courant électrique est compris entre 50 et environ 1 000 ampères. 30
8. Refroidisseur selon une quelconque revendication précédente, dans lequel une tension électrique correspondant au courant électrique est comprise entre environ 0,1 et environ 24 volts. 35
9. Refroidisseur selon une quelconque revendication précédente, dans lequel le tube (20) comprend du cuivre ou un alliage à base de cuivre. 40
10. Refroidisseur selon une quelconque revendication précédente, dans lequel l'enveloppe (12) comprend de l'acier ou un alliage à base d'acier. 45
11. Refroidisseur selon une quelconque revendication précédente, comprenant en outre un second fluide à l'intérieur de l'enveloppe (12), ledit second fluide entourant au moins partiellement le tube. 50
12. Refroidisseur selon la revendication 11, dans lequel

le second fluide comprend du réfrigérant.

13. Refroidisseur selon la revendication 11 ou 12, comprenant en outre :
 - une première entrée dans ledit premier collecteur (14) au niveau d'un premier côté de l'enveloppe (12) et une première sortie dans ledit second collecteur (16) au niveau d'un second côté de l'enveloppe (12) ; et
 - une seconde entrée et une seconde sortie dans l'enveloppe (12) pour le second fluide.
14. Refroidisseur selon la revendication 13, dans lequel le premier fluide pénètre l'enveloppe (12) via la première entrée dans le premier collecteur (14) au niveau d'un premier côté de l'enveloppe (12), traverse le tube (20) et ressort de l'enveloppe via la première sortie dans le second collecteur (14) au niveau du second côté de l'enveloppe (12).
15. Refroidisseur selon une quelconque revendication précédente, comprenant en outre un moyen de contrôle pour la mesure de la température du fluide et/ou d'une température ambiante et pour le contrôle du moyen de chauffage en fonction de l'une ou des deux desdites températures.
16. Refroidisseur selon la revendication 1 étant un refroidisseur refroidi par air (10) et comprenant :
 - une pluralité desdits tubes (20) ;
 - ladite enveloppe (12) étant capable de contenir un second fluide et ayant les tubes (20) agencés dans celle-ci de telle sorte que ledit second fluide entoure au moins partiellement la pluralité de tubes (20) ; et
 - ledit moyen de chauffage comprenant :
 - un transformateur (60) ;
 - un moyen pour la fourniture d'un courant électrique du transformateur (60) à au moins un de l'enveloppe (12) et des tubes (20).
17. Refroidisseur selon la revendication 16 dans lequel l'enveloppe (12) comprend de l'acier et les tubes comprennent du cuivre.
18. Refroidisseur selon la revendication 16 ou 17 dans lequel le transformateur (60) comprend un transformateur abaisseur capable de se connecter à une alimentation secteur conventionnelle.

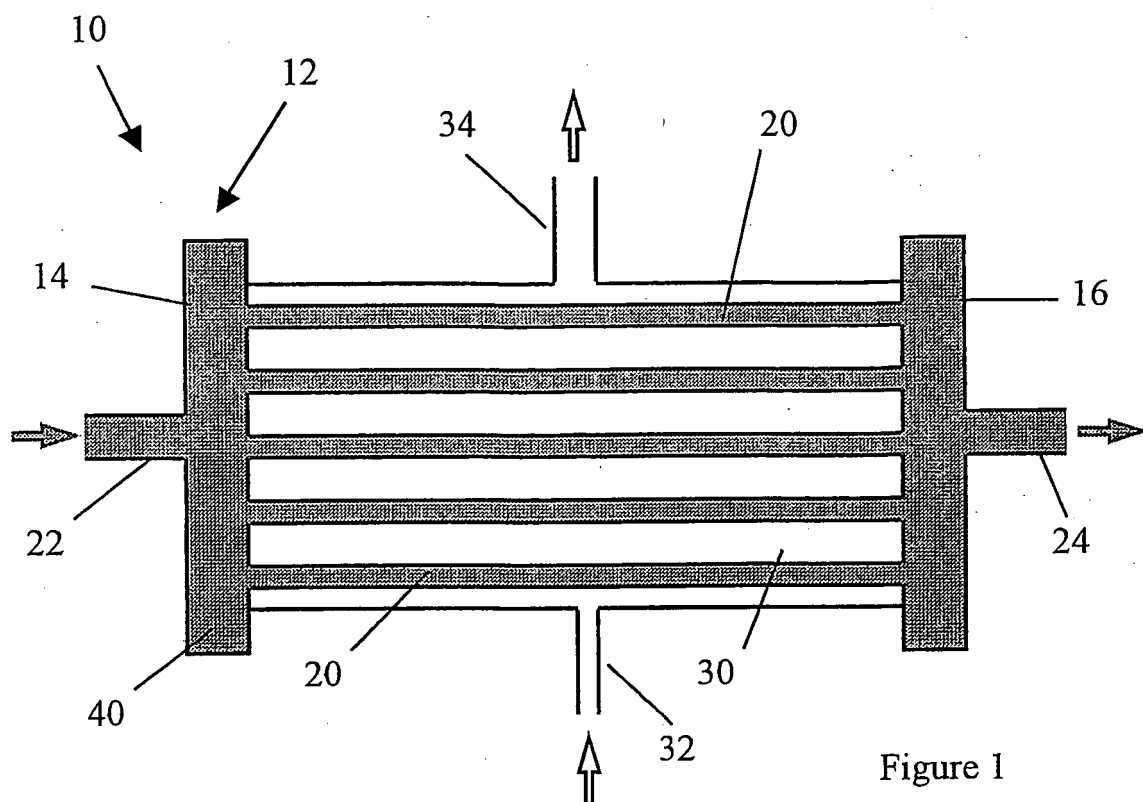


Figure 1

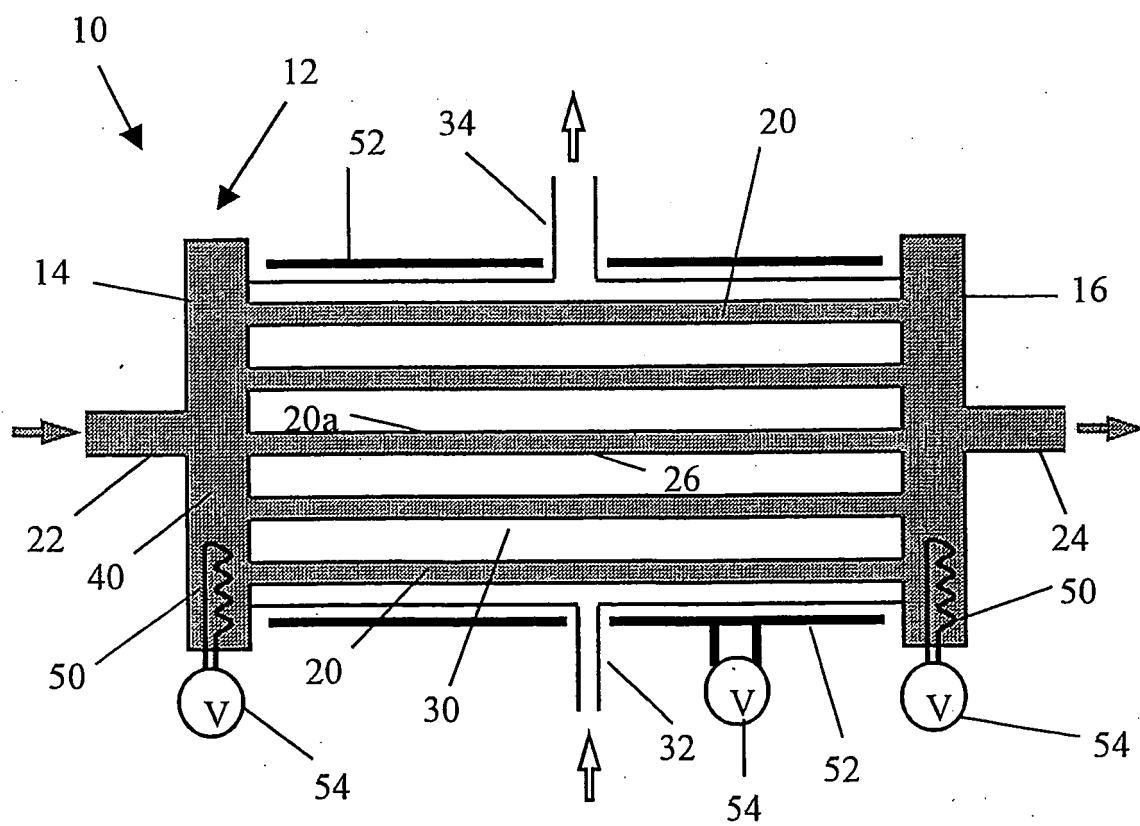


Figure 2

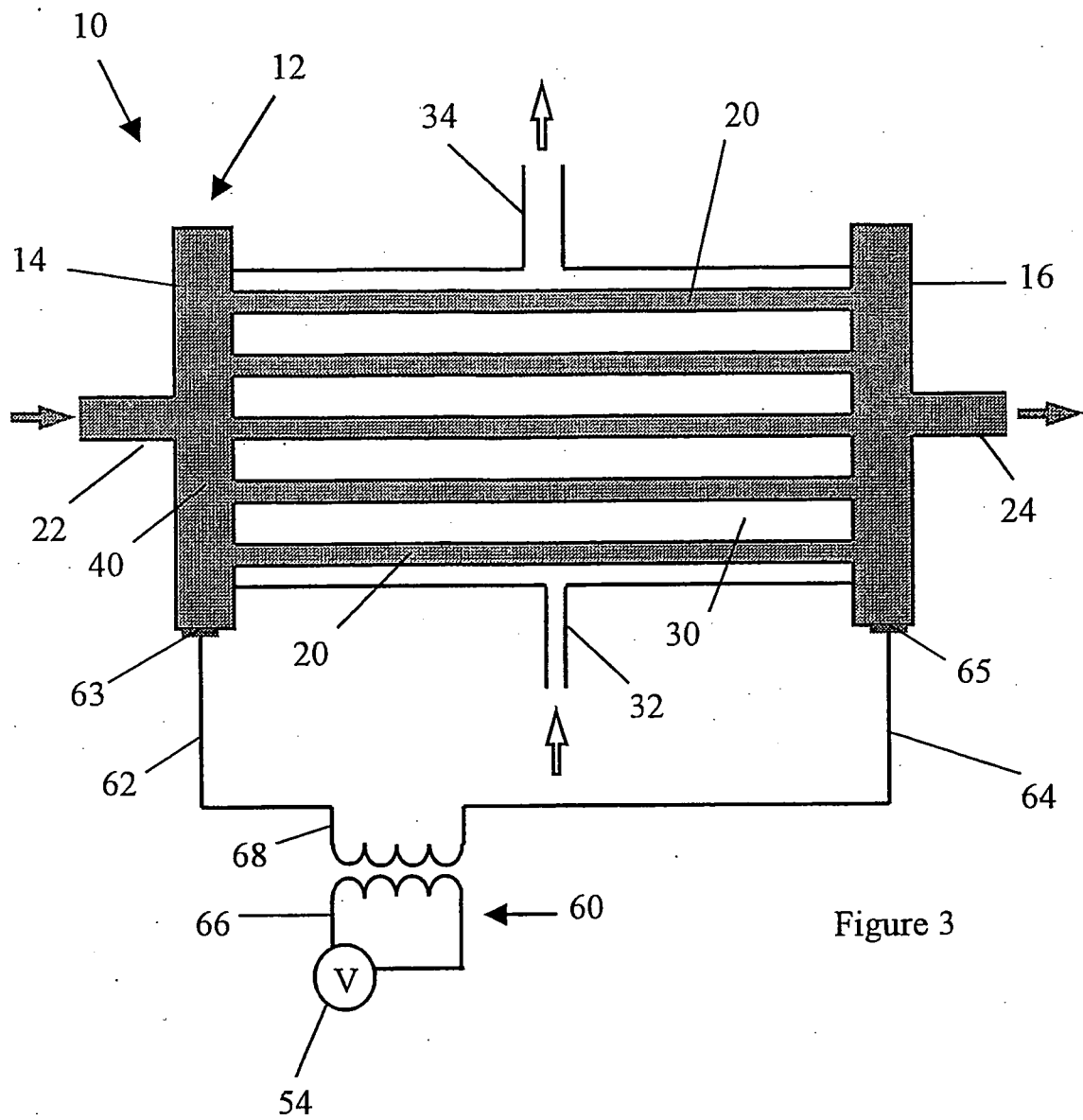


Figure 3

REFERENCES CITED IN THE DESCRIPTION

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