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(71) Applicant: **Vestel Beyaz Esya Sanayi Ve Ticaret A.S.**
45030 Manisa (TR)

(72) Inventors:
- **Turan, Halil**
  35030, IZMIR (TR)
- **Özkiliç, Sibel**
  35030 Izmir (TR)

(74) Representative: **Cayli, Hülya**
Paragon Consultancy Inc.
Koza Sokak No: 60/6
GOP
06700 Ankara (TR)

(54) **Heat exchanger**

(57) The present heat exchanger (A) comprises a thermal element (1), one side of which becomes cold and the other side becomes hot once energized with electricity, a high heat-conductive intermediate plate (2) in contact with one surface of this element (1); a high heat-conductive porous material (3) in contact with the other surface of the intermediate plate (2); and an upper plate (4) provided on the other side of this material (3). Once the thermal element (1) is activated in the heat exchanger (A), the intermediate plate (2) and the porous material (3) are rapidly cooled or heated. Meanwhile, since the temperature of fluid passing through within the porous material (3) is different than the temperature of the material itself (3), heat exchange is ensured between the fluid and the porous material.

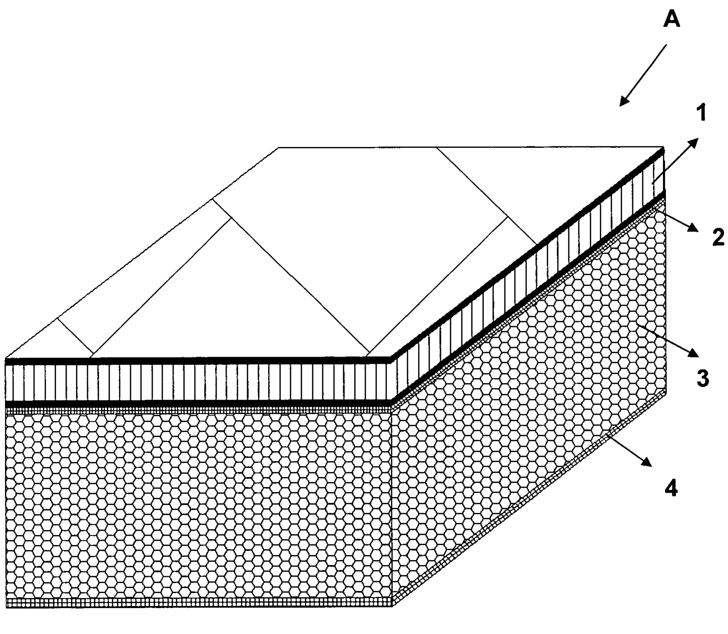

Figure – 1

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Description

Technical Field

[0001] The present invention relates to small-sized heat exchangers with high heat transfer capacity for both heating and cooling purposes.

Prior Art

[0002] The method of cooling in currently-used household cooling devices is based on heat exchange between the air of the exterior (i.e. external ambiance) and the air within the refrigerator, during the cycling of the refrigerant fluid compressed by means of the compressor. As an alternative to such vapor-compression cycle, however, the use of such systems as thermoelectric and thermo acoustic cooling systems - though the cooling performance obtained by means of such cooling systems has yet to reach the performance of systems employed in household refrigerators in current use, they have many other advantages -has become discussible as well. The small size of heat transfer surfaces in such kind of cooling systems plays a significant role in their efficiency. As is known, the larger the size of such surfaces, the greater is the heat rate dissipated away from the system. Therefore, it is intended to enhance the contact surface between the cooling system and the refrigerant fluid to provide cooling, by making use of porous structures as heat transfer surfaces in such devices. The surfaces of such porous structures exposed to heat transfer are substantially larger than the heat transfer fins which have been employed frequently in the prior art.

[0003] In addition to cooling devices, different means are used as heating units in places where heating is required. For instance, electric resistance and fans are used in heating many devices with a limited internal volume, and fins are employed together with such elements to increase the heating efficiency.

[0004] There are cooling approaches in the prior art, wherein finned-porous structures and motor-fan mechanisms are employed. In the published patent application US2005243515, for example, a finned and porous material is placed on an electronic circuit to dissipate the radiating heat and to provide cooling, such that the heat energy transferred to this finned and porous material from said circuit is removed by means of a fan and forced air circulation.

[0005] Concerning the published patent application WO0169160, a different type of heat exchanger structure is obtained by filling in between the fins with a porous material to increase the surface area there. Another approach making use of a porous material with the fins is disclosed in the published patent application RU2115869.

[0006] As for the present heat exchanger, a small-volume unit is embodied with a high heat transfer capacity. The present embodiment may be used in place of compressor-based cooling systems, for example, often used in refrigerators. In the present invention, porous materials, in which the rate of the heat transfer area to the volume (or the heat exchange area) is larger as compared to finned systems, are used together with an electrically-energized thermal element (thermoelectric and thermo acoustic coolers). In another embodiment, forced convection is applied additionally by means of a motor-fan unit to enhance the cooling performance. In a representative application of the present invention on a cooling device, the refrigerating gas or liquid circulated within the device is passed through the porous structure continually cooled with the thermoelectric and thermo acoustic cooling element.

Aim of Invention

[0007] The aim of the present invention is to make use of porous materials with high thermal conductivity in order to enhance the heating and cooling efficiency in heat exchangers formed by using electrically-energized thermal elements.

[0008] Another aim of the present invention is to meet the heating or cooling requirements of devices with limited internal volume, by making use of small-volume heat exchangers.

[0009] A further aim of the present invention is to reduce the utilization of environment-polluting CFC (chlorofluorocarbon) gases, by means of applied thermoelectric and thermo acoustic cooling methods.

Description of Drawings

[0010] The subject heat exchanger is illustrated in annexed figures briefly described hereunder.

Figure 1 is a perspective view of an illustrative heat exchanger.
Figure 2 is a cross-sectional view of an illustrative heat exchanger.
Figure 3 illustrates the use of a heat exchanger together with a fan.
Figure 4 is a perspective view of an illustrative heat exchanger which can be used with both heating and cooling purposes.
Figure 5 is a side cross-sectional view of an illustrative embodiment of the present invention.

[0011] The parts in said figures are individually enumerated as described below.

Heat exchanger (A)
Thermal element (1, 1')
Intermediate plate (2, 2', 2")
Porous material (3, 3', 3")
Upper plate (4, 4', 4")
Fan (5)

Disclosure of Invention

[0012] In Figure 1 to 4 are given perspective and cross-sectional views of illustrative heat exchangers (A) with differing layers. The subject heat exchanger (A) -employable both with heating and cooling purposes- can both be used with cooling purposes in household refrigerators, and be used in many places requiring heating. The fact that they occupy relatively less space as compared to current cooling units used in refrigerators brings an advantage in their use in units with limited internal volume, such as refrigerators.

[0013] The heat exchanger (A) shown in figures 1 and 2 comprises at least one thermal element (1) energized with electricity; a thermally-conductive intermediate plate (2) in contact with one surface of this element (1); and a thermally-conductive porous material (3) in contact with the other surface of said intermediate plate. In an illustrative embodiment of the present invention, an upper plate (4) is located on the other side of said material (3).

[0014] Said thermal element (1) may be a thermoelectric or thermo acoustic unit. Both units can be used both with cooling and heating purposes. When the thermoelectric element is electrically energized, cooling and heating is achieved by making use of the "Peltier" effect. As for the thermo acoustic cooler, it is the sound waves which are benefited from. Thus when the thermal element (1) is energized by means of electricity or sound, while a surface of this element (1) is heated, the other surface is cooled.

[0015] Once the thermal element (1) is activated in the heat exchanger (A), the intermediate plate (2) and the porous material (3) are rapidly cooled or heated based on their higher heat conductivity. Meanwhile, since the temperature of the fluid passed through the porous material (3) is different than the temperature of the material (3) itself, heat exchange is ensured between the fluid and the porous material. If it is used in a cooling unit such as a refrigerator, for instance, the fluid is circulated within the unit so that the parts of the unit located far from the heat exchanger (A) are cooled as well.

[0016] In the heat exchanger (A) shown in figures 1 and 2, the upper plate (4) provided at the outer surface of the porous material (3) is employed for isolating the heat exchanger (A) from the external ambiance. The fluid passed through this heat exchanger (A) may be air, or any other liquid or gas material enhancing the convectional heat transfer. And the purpose of the intermediate plate (2) is to ensure a homogeneous heat transfer from the thermal element (1) onto the porous material (3). This homogeneous heat transfer is achieved by providing a large contact surface between the thermal element (1) and the intermediate plate (2). While the intermediate plate (2) can be made from the same, heat conductive material with the porous material (3), it may also be produced from different materials that can be joined so as to provide heat conductivity between them. While the porous material (3) can be formed from a single layer with a homogeneous pore composition, as illustrated in Figure 1, it may also be formed from multiple layers with differing pore sizes and densities, as illustrated in Figure 2, provided that heat conductivity is not diminished and no barrier is built against the fluid flow.

[0017] In another illustrative heat exchanger (A) shown in Figure 3, a fan (5) and/or a plate with heat conductance may be used in place of said upper plate (4) to let the heat exchanger conduct heat exchange directly with its periphery. (Additionally, a pump can also be used in place of this fan depending on the required fluid transfer conditions.) While the fan (5) is run, convectional heat exchange is ensured, resulting in an increase in the efficiency and rate of cooling or heating. Especially if the fluid is circulated rapidly, it becomes a necessity to conduct forced convection with such a fan (5).

[0018] As pointed out above, the heat exchanger can be used both with cooling and heating purposes. In the heat exchanger (A) shown in Figure 4, one heat conductive intermediate plate (2, 2') is contacted to each side of the thermal element (1), and the other surfaces of the intermediate plates (2, 2') are coupled to materials (3, 3') with heat conducting pores. There may be either provided an upper plate (4, 4'), or one each fan and/or one each plate with heat conductance on the outer surfaces of porous materials (here as well, can a pump be used in place of the fan). When the thermal element (1) is energized by means of electricity in this heat exchanger (A), the porous material (3) on one side becomes heated, while at the same time the porous material (3') on the other side becomes cooled. Thereby, heating and cooling are performed simultaneously by means of the fluid passed between the porous materials (3, 3'). With respect to this heat exchanger (A) configuration as well, the porous materials (3, 3') can be formed from a single layer with a homogeneous pore composition, or they may be formed from multiple layers with different pore sizes and densities, provided that heat conductivity is not diminished and no barrier is built against the fluid flow.

[0019] Figure 5, is a side cross-sectional view of an illustrative embodiment of the present invention. The heat exchanger shown in Figure 5 is developed to increase the efficiency of the exchanger shown in Figure 4. In this type of heat exchanger (A), an intermediate plate (2") is provided on the upper surface of the porous material (3') located upside of the thermoelectric element (1), a second thermoelectric element (1') is placed on the upper surface of this intermediate plate (2"), and another intermediate plate (2") on the upper surface of this element (1'). A porous material (3") is provided on the upper surface of this intermediate plate (2"), and an upper plate (4") is positioned on the upper surface of this material (3"). This configuration is designated also as a "cascade system". Accordingly, the lower the temperature difference between one each surfaces of the thermoelectric elements (1, 1') the higher becomes the performance of the thermoelectric system. It becomes possible to increase the heat transfer efficiency by means of the cascade system, obtained by communicating one surface of the porous material (3') with the hot side of the first thermoelectric element (1'), and the other surface of the porous material with the cold side of the second thermoelectric element (1). In this instance, the temperatures of fluids passing through the porous materials (3, 3', 3") are altered in cascade. Put differently, the temperature of fluid passing through the utmost porous material (3") is higher than that of the fluid passing through the central porous material (3'), whereas the temperature of fluid passing through the central porous material (3') is higher than that of the fluid passing through the undermost porous material (3'). Thanks to this gradual temperature change, the heat exchanger (A) is run at a relatively higher efficiency.

[0020] It is also feasible to increase the number of layers in this cascade system. In this context, hot and cold surfaces of thermoelectric elements in use must be intercommunicated so as to achieve a gradual temperature change for ensuring an increase in efficiency.

[0021] The intermediate plate (2) and the porous material (3) can be joined either by means of high heat-conductive materials such as thermal paste, or by means of methods such as mechanical pressing, welding, hot adhering etc. such that the heat transfer is maintained at maximum.

[0022] The fact that the thermal elements (1) (thermoelectric and thermo acoustic elements) used in the present heat exchanger (A) have rather smaller volumes as compared to cooling units currently used in refrigerators ensures an advantage for the use of said heat exchanger. (A)

[0023] In addition, the upper plates (4, 4', 4") used in the present heat exchanger (A) may find other applications as well. For instance, they may either be used on the outer surfaces of the exchanger (A) for heat insulation purposes, or in transferring heat between the exchanger (A) and its periphery, provided that such plates are made from a heat conductive material.

Claims

1. A heat exchanger (A) used for heating and cooling and comprising at least one thermal element (1) with one surface becoming relatively cooler and the other surface relatively hotter once energized by means of electricity or sound waves, said heat exchanger (A) being **characterized by** comprising a thermally-conductive intermediate plate (2) in contact with one surface of this element (1); a thermally-conductive porous material (3) in contact with the other surface of said intermediate plate(2); and an upper plate (4) provided on the other side of said porous material (3).

2. A heat exchanger (A) according to Claim 1, **characterized in that** said thermal element (1) is a thermoelectric material.

3. A heat exchanger (A) according to Claim 1, **characterized in that** said thermal element (1) is a thermo acoustic material.

4. A heat exchanger (A) according to Claim 1, **characterized in that** said porous material (3) is composed of a single layer with a homogeneous pore composition.

5. A heat exchanger (A) according to Claim 1, **characterized in that** said porous material (3) is composed of multiple layers having differing pore sizes and relative densities.

6. A heat exchanger (A) according to Claim 1, **characterized by** comprising here a fan (5) and/or a heat-conductive plate as well, which is/are located at the other side of the porous material (3), in place of said upper plate (4).

7. A heat exchanger (A) according to Claim 6, **characterized in that** a pump is used here as well, in place of said fan.

8. A heat exchanger (A) according to Claim 1, **characterized by** further comprising a heat-conductive intermediate plate (2') contacting the other surface of the thermal element (1); a heat-conductive porous material (3') contacting the other surface of the intermediate plate; and an upper plate (4') located at the other side of the porous material (3').

9. A heat exchanger (A) according to Claim 8, **characterized in that** said porous material (3') is composed of a single layer with a homogeneous pore composition.

10. A heat exchanger (A) according to Claim 8, **characterized in that** said porous material (3') is composed of multiple layers having differing pore sizes and relative densities.

11. A heat exchanger (A) according to Claim 8, **characterized by** comprising here a fan and/or a heat-conductive plate as well, which is/are located at the other side of the porous material (3'), in place of said upper plate (4').

12. A heat exchanger (A) according to Claim 11, **characterized in that** a pump is used here as well, in place of said fan.

13. A heat exchanger (A) according to Claim 8, **characterized by** comprising an intermediate plate (2") provided on the upper surface of the porous material (3') located upside of said thermoelectric element (1); a second thermoelectric element (1') placed on the upper surface of this intermediate plate (2"); an-

other intermediate plate (2") on the upper surface of this element (1'); a porous material (3") on the supper surface of this intermediate plate (2"); and an upper plate (4") provided on the upper surface of this material (3").

14. A heat exchanger (A) according to Claim 13, **characterized in that** one surface of the porous material (3') is communicated with the hotter side of the first thermoelectric element (1') and the other surface of the porous material with the colder side of the second thermoelectric element (1) in order to enhance the heat transfer efficiency.

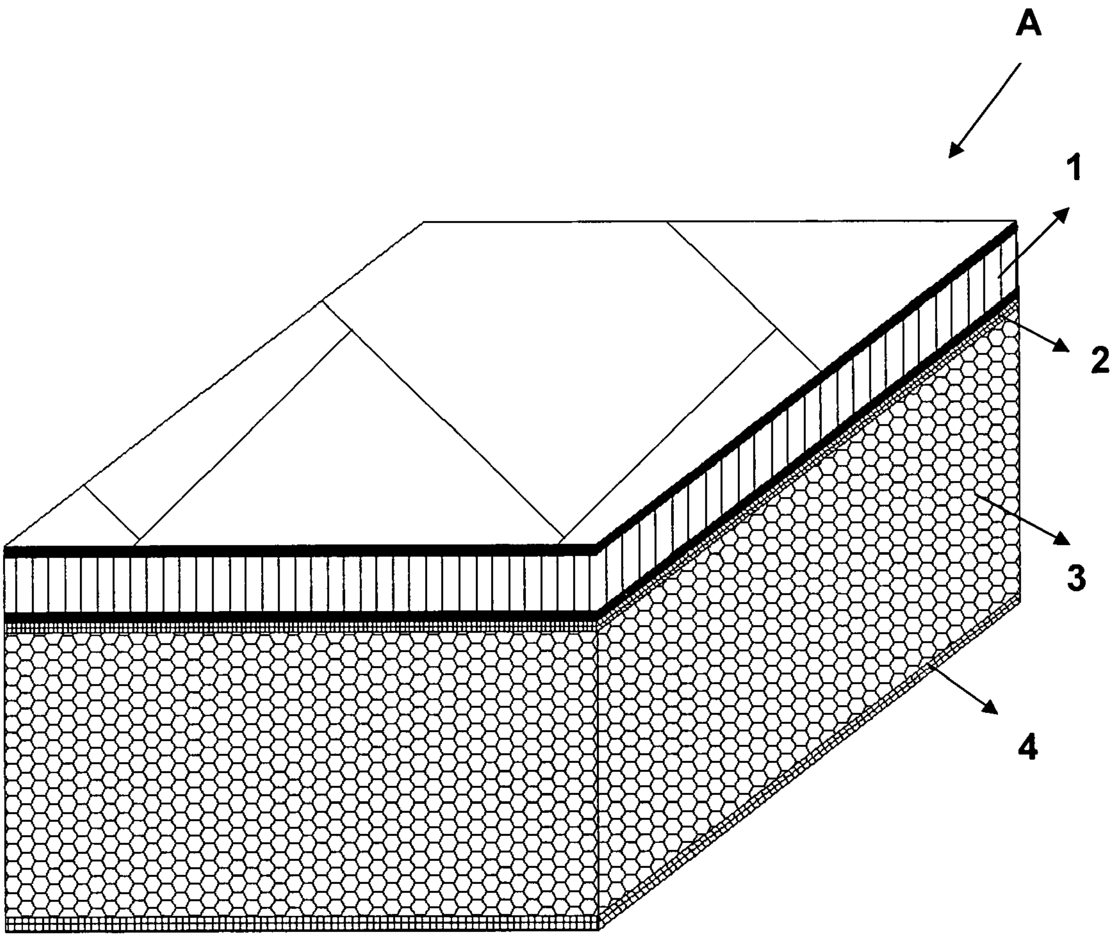

Figure – 1

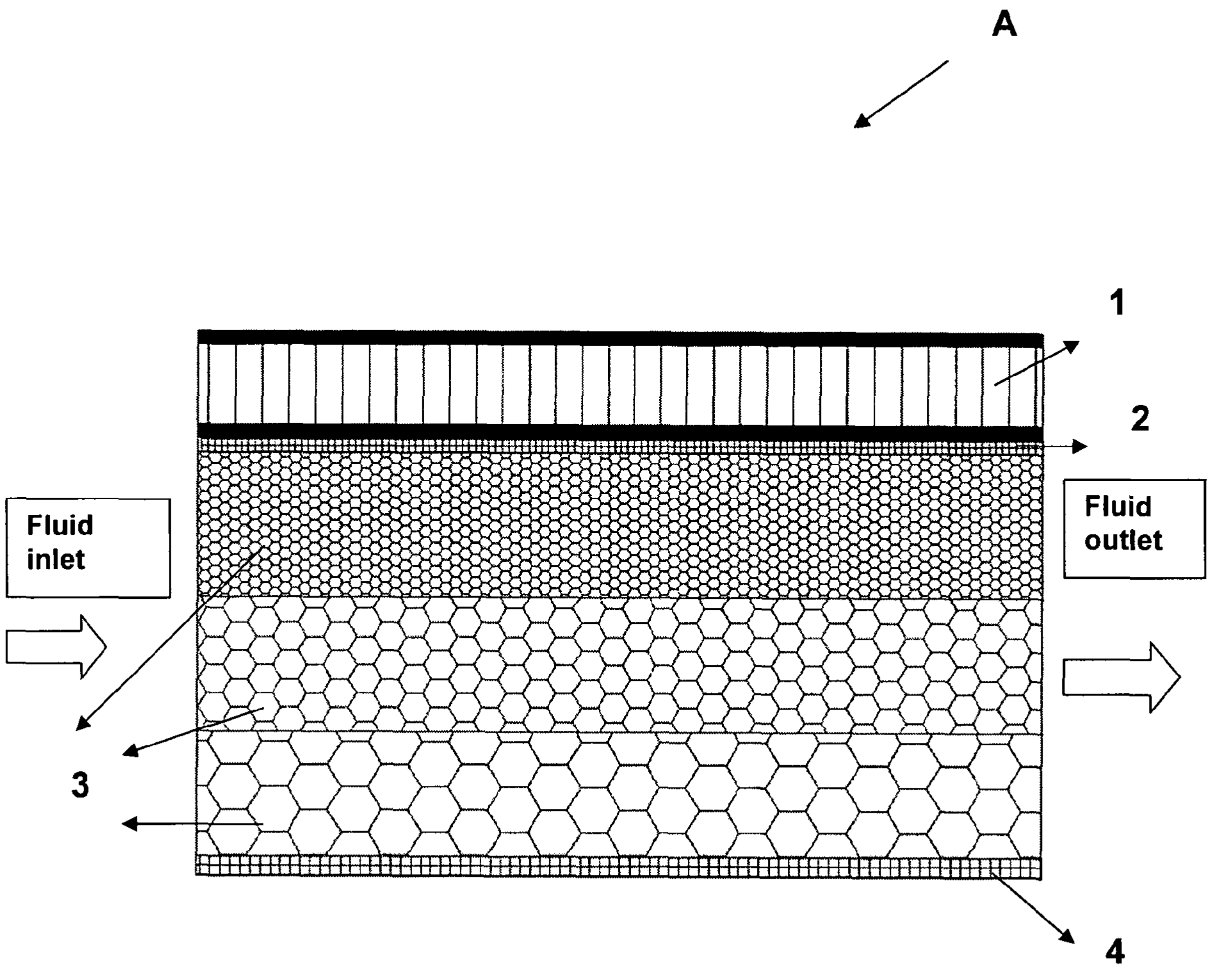

Figure – 2

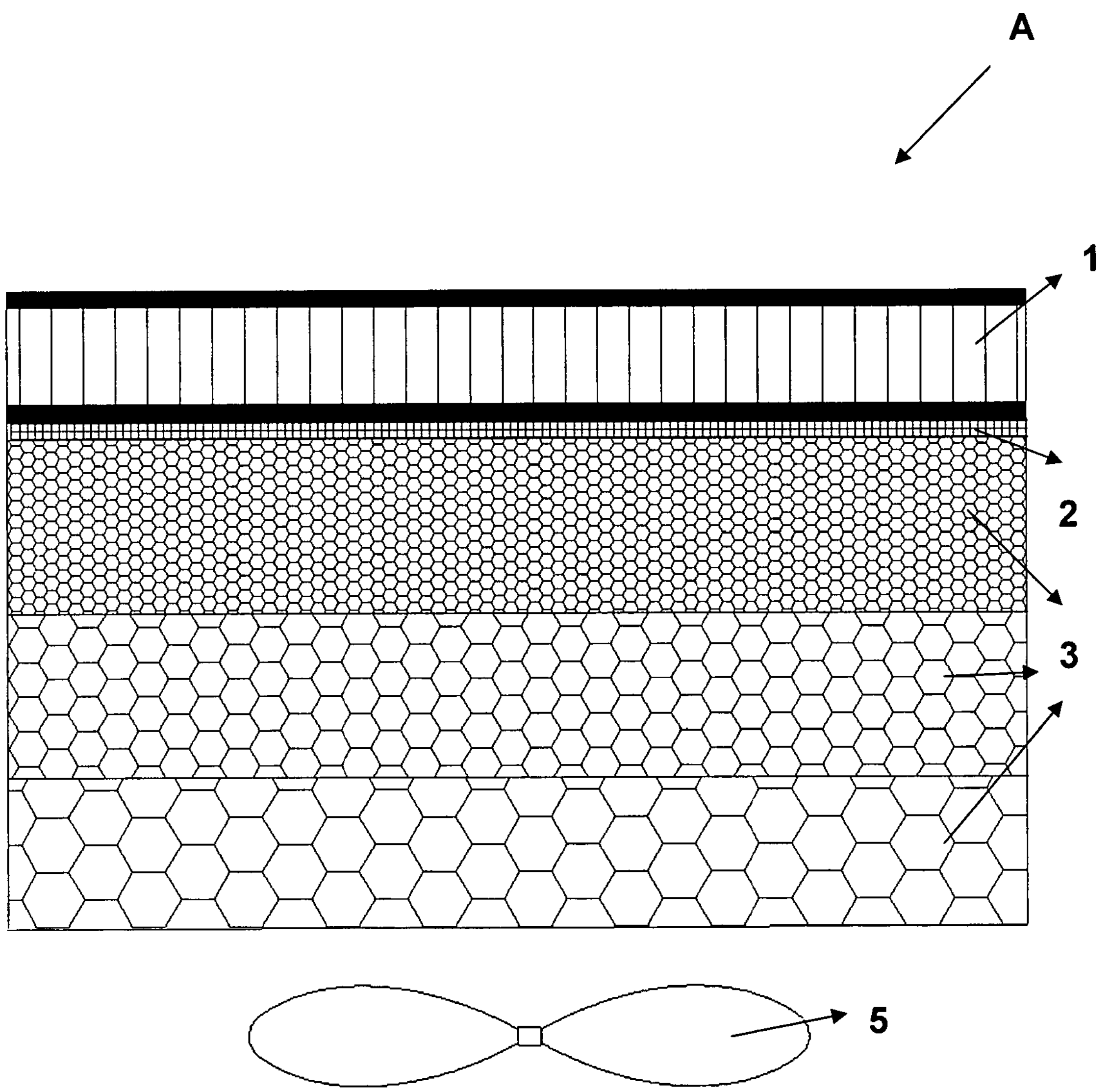

Figure – 3

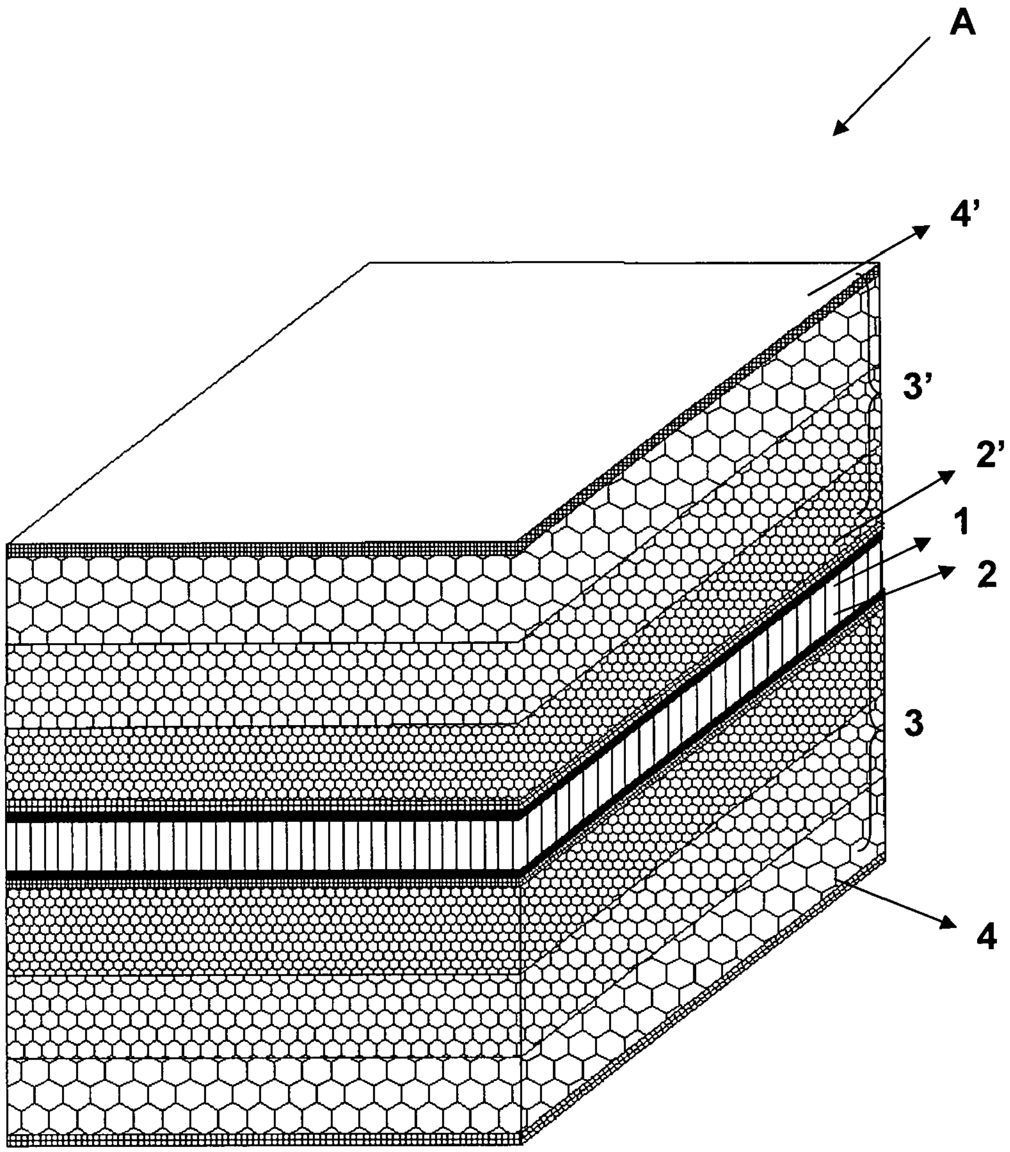

Figure – 4

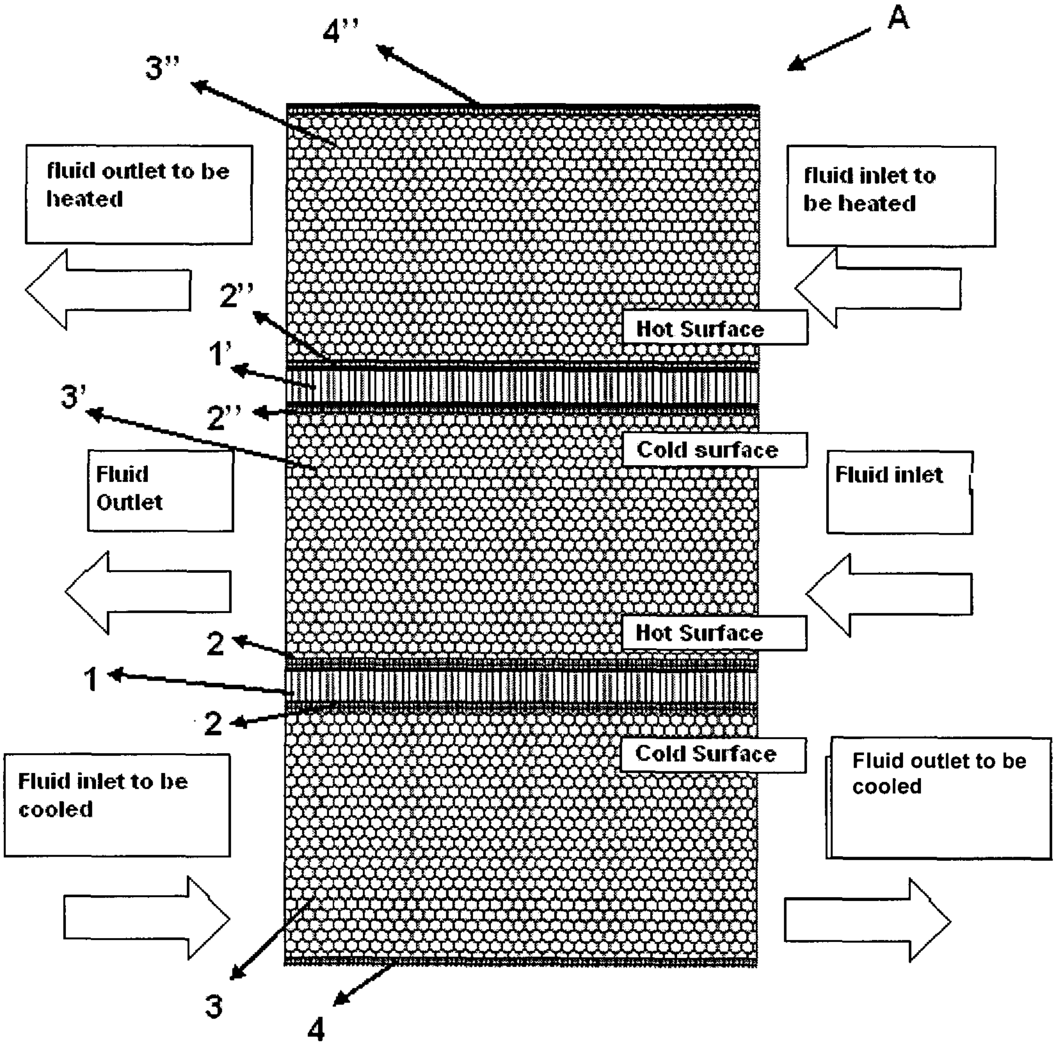
A
4''
3''
fluid outlet to be heated
fluid inlet to be heated
2''
Hot Surface
1'
3'
2''
Cold surface
Fluid Outlet
Fluid inlet
2
Hot Surface
1
2
Cold Surface
Fluid inlet to be cooled
Fluid outlet to be cooled
3
4

Figure – 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2005243515 A **[0004]**
- WO 0169160 A **[0005]**
- RU 2115869 **[0005]**