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(54) Title: THERMOELECTRIC COOLER WITH PHASE CHANGE MATERIAL

(57) Abstract: The present disclosure discloses a thermoelectric cooler. The thermoelectric cooler (100) includes a housing (102) defining a first chamber (10) and a second chamber (20). The second chamber is adjoining to the first chamber and the second chamber is configured to accommodate a phase change material (PCM) (30). The thermoelectric cooler includes a thermoelectric module (40) configured between the first chamber and the second chamber. The thermoelectric module includes a cold side (42) towards the first chamber and a hot side (44) towards the second chamber. The PCM in the second chamber is configured to absorb heat from the hot side and maintain the hot side of the thermoelectric module within a predetermined temperature limit without getting impeded by the changing ambient temperature. The thermoelectric module 40 with PCM in second chamber aids in less consumption of energy and power.

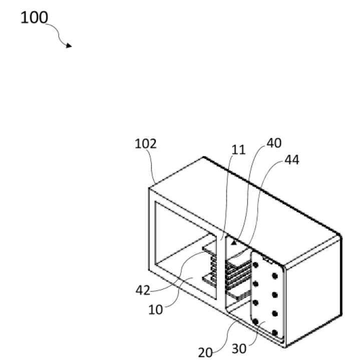

Figure 1

FORM 2

THE PATENTS ACT 1970
(39 OF 1970)
&
The Patent Rules, 2003

Complete Specification

(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

THERMOELECTRIC COOLER WITH PHASE CHANGE MATERIAL

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification describes the invention and the manner in which it is to be performed

DESCRIPTION

Technical Field

[001] This disclosure relates generally to thermoelectric devices, and more particularly to a thermoelectric cooler having a thermoelectric module to maintain a temperature of enclosed chamber within a desired temperature range.

BACKGROUND

[002] Generally, thermoelectric devices have been used in wide range of applications, especially in appliances like refrigerators, coolers or air conditioners and containers or enclosed structures to be maintained within a selected temperature range. The thermoelectric device typically includes at least one thermoelectric module that operate based on a Peltier effect. Thermoelectric devices may be a heat pump used to transfer heat energy and operate with solid state electrical components (thermocouples) as compared to more traditional mechanical/fluid heating and cooling components. Each of the thermoelectric module includes an array of thermocouples. Further, the thermoelectric module is arranged such that one side faces a cold side of the thermoelectric device and another side faces a hot side of the thermoelectric device. During operation, an electrical power is applied to the thermoelectric device having at least one thermoelectric module, such that heat is absorbed from the cold side of the thermocouples and passes through the thermocouples and is dissipated to the hot side of the thermocouples. Further, typically, a heat sink is provided in the hot side of the thermoelectric device to allow in dissipation of heat from the thermocouples to an ambient surrounding / any nearby environment. Similarly, a cold sink may also be provided to the cold side of the thermoelectric device to aid in a cooling effect in functioning of the coolers or air conditioners.

[003] Conventional thermoelectric modules with heat sinks are mostly subjected to varying ambient temperatures, which result in variation in/ the temperature in the hot side, thereby affecting a performance of the heat sink. Usually, to address this variation in the hot side, additional heat exchangers or coolants are provided to maintain a desired temperature range. Thus, the conventional devices have complex construction that leads to increased manufacturing and operational costs. Furthermore, these conventional devices require increased usage of power to maintain the desired temperature range in the cold side and the hot side of the thermoelectric module.

SUMMARY OF THE INVENTION

[004] In an embodiment, a thermoelectric cooler is disclosed. The thermoelectric cooler includes a housing defining a first chamber and a second chamber. The second chamber is adjoining to the first chamber and the second chamber is configured to accommodate a phase change material (PCM). The thermoelectric cooler may include a thermoelectric module configured between the first chamber and the second chamber. The thermoelectric module is having a cold side towards the first chamber and a hot side towards the second chamber. The PCM in the second chamber is configured to absorb heat from the hot side and maintain the hot side of the thermoelectric module within a predetermined temperature limit.

[005] In an embodiment, each of the first chamber and the second chamber are thermally insulated.

[006] In an embodiment, the first chamber defines a storage compartment for storing items and a thermally insulated cover to selectively provide access for storage or removal of the items. This facilitates maintaining required temperature in the first chamber, without any temperature losses.

[007] In an embodiment, the second chamber comprises a thermally insulated door to access and replace the PCM. This configuration of the insulated door prevents temperature variation due to ambient conditions.

[008] In an embodiment, the PCM is encapsulated in shell.

[009] In an embodiment, a power source is electrically coupled to the thermoelectric module.

[010] In an embodiment, PCM is at least one of organic, inorganic, and eutectic.

[011] In an embodiment, the thermoelectric module includes at least one conductor interposed between the hot side and the cold side. Further, one or more thermocouples are secured to at least one conductor on the hot side and the cold side such that one or more thermocouples detects temperature in hot side and cold side. A plurality of fins extending from at least one conductor the cold side and the hot side to increase heat transfer area of the cold side and the hot side. Further, a fan is adjacent to at least one the hot side and cold side for forced convection heat transfer. At least one control circuit is in electrical communication with the power source for operating the hot side, cold side and the fan.

BRIEF DESCRIPTION OF THE DRAWINGS

[012] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, explain the disclosed principles.

[013] **Figure 1** illustrates a schematic isometric view of a thermoelectric cooler, in accordance with an embodiment of the present disclosure;

[014] **Figure 2** illustrates a schematic front view of the thermoelectric cooler of Figure. 1;

[015] **Figure 3** illustrates a schematic front view the thermoelectric cooler indicating flow of heat of Figure. 1, in accordance with an embodiment of the present disclosure; and

[016] **Figure 4** illustrates a plot of heat pumping capacity Vs temperature difference (Delta T) of a thermoelectric module, in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE DRAWINGS

[017] Exemplary embodiments are described with reference to the accompanying drawings. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope being indicated by the following claims. Additional illustrative embodiments are listed.

[018] Embodiment of the present disclosure discloses thermoelectric cooler which is efficient and use less power from the power source for maintaining a temperature of enclosed chamber/structure within a desired temperature range. The thermoelectric cooler is also simple in construction and work efficiently in varying ambient temperatures. The thermoelectric cooler includes less number of components and is inexpensive to maintain the desired temperature range.

[019] The following paragraphs describe the present disclosure with reference to Figures.1 to 4. In the figures, the same element or elements which have similar functions are indicated by the same reference signs.

[020] Referring to **Figure 1** to **Figure 3** which are exemplary embodiments of the present disclosure illustrating a thermoelectric cooler 100 [also referred as "cooler" 100]. As shown in Figure. 1, the cooler 100 includes a housing 102 defining a first chamber 10 and a second chamber 20. In an embodiment, the housing 102 may include a body defined with a chamber or cavity having the first chamber 10 and the second chamber 20. The second chamber 10 is adjoining the first chamber 10. In an embodiment, the first chamber 10 and the second chamber 10 are separated by at least one wall 11. The housing 102 is formed by at least one wall structures having a rear wall. The wall structure is formed around each edge of the rear wall having a surface area with the interior chamber. In an embodiment, the wall structure includes an upper wall, a bottom wall, a rear wall, and two side walls. In an embodiment, the housing 102 may be cube-shaped, or any suitable shape that meets the requirement. In some embodiments, the housing may be cylindrical in shape.

[021] As show in Figure.1, the housing 102 may be rectangular in shape having the first chamber 10 and the second chamber 20. Although, it is within the purview of a person skilled in the art to modify the shape of the housing 102. The size of the housing 102 may also vary depending on the application. Further, each of the first chamber 10 and the second chamber 20 are thermally insulated. In an embodiment, the first 10 and the second chamber 20 may be manufacturing using any suitable thermal insulating material.

[022] Referring to Figure 1 and 2, the first chamber 10 defines a storage compartment for storing items that have to be maintained at a desired temperature. Further, a thermally insulated cover (not shown in figures) may be provided in the first chamber 10 to selectively provide access for storage or removal of the items. In an embodiment, the thermally insulated cover is configured to at least one portion of the top wall, bottom wall, side wall of the housing 102. The thermally insulated cover may be removably secured to the housing 102 with by a hinge assembly, or the thermally insulated cover may slider cover having a sliding movement relative to the housing 102. Further, sealing [not shown] may be provided along the periphery of the cover to thermally seal the first chamber 10. The second chamber 20 also defines a compartment and configured to accommodate a phase change material (PCM) 30. The second chamber 20 may include at least one provision to removably support the PCM 30. In an embodiment, the PCM is encapsulated in a shell. Further, the second chamber 20 includes a thermally insulated door [not shown] removably secured to the housing 102. The thermally insulated door provides access to second chamber 20 for replacing the PCM 30. The door may be removably secured to the second chamber 20 with by a hinge assembly or slide relative to the housing 102. Further, one or more sealing members [not shown] may be provided along the periphery of the door to thermally seal the second chamber 20. Further, the PCM 30 being encapsulate in shell can be recharged or swapped at any external charging stations and PCM storage hubs. The PCM 30 provided in the second chamber 20 is configured to release/ absorb heat at constant temperature, by storing energy in the form of latent heat. In an embodiment, the PCM 30 is at least one of organic, inorganic, and eutectic. The PCM 30 may be encapsulated in various types of encapsulated shell to effectively reduce leakage of PCMs 30 during a solid-liquid phase transition and avoid a reaction of the PCMs 30 with the ambient environment. In an embodiment, the PCM 30 may be encapsulated by different types of material such as organic, inorganic and hybrid materials.

[023] The cooler 100 further includes a thermoelectric module 40 configured between the first chamber 10 and the second chamber 20. The thermoelectric module 40 is having a cold side 42 towards the first chamber 10 and a hot side 44 towards the second chamber 20. In an embodiment, a plurality of fins 45a, 45b extend from the cold side 42 and the hot side 44 to increase heat transfer area of the cold side 42 and the hot side 44 as shown in Figure 3. The plurality of fins 45a and 45b are disposed on opposite sides of the wall defined between the first chamber 10 and the second chamber 20. The plurality of fins 45a, 45b are configured to dissipate heat from first chamber 10 to a surrounding environment or to the second chamber 20 and vice-versa. In an embodiment, a heat exchanger may be mounted on the hot side 44 and cold side 42 of the thermoelectric module 40. Each heat exchanger may be positioned within an area enclosed by the housing 102 and the housing 102 is vented through slots, for allowing the air to circulate around the heat exchangers dissipating heat to the ambient atmosphere. In an embodiment, the plurality of fins 45a, 45b extends from the heat exchanger provided in hot side 44 and cold side 42 to improve heat dissipation.

[024] The thermoelectric module 40 may preferably include a plurality of thermocouples or thermoelectric member (not shown in Figures) disposed between the first 10 and the second chamber 20. At least one conductor is interposed between the hot side 44 and the cold side 42. In an embodiment, at least one conductor is thermally conductive plates may be provided on opposite sides of the wall 11 to securely support the thermoelectric members such as one or more thermocouples. The one or more thermocouples are secured to at least one conductor on the hot side 44 and the cold side 42 such that one or more thermocouples detects temperature in hot side and cold side.. For example, the thermally conductive plates may be formed from ceramic and/or composite materials as desired. The thermoelectric elements may be selected from materials such as bismuth telluride to provide an array of P-N junctions with the desired thermoelectric characteristics to allow thermoelectric module to operate as a heat pump. Thus, withdrawing heat from the cold side 42 and transferring it to the hot side 44.

[025] In an embodiment, at least one fan is 46 adjacently secured to at least one the hot side 44 and cold side 42. The fan is coupled to an electric motor. A rotating shaft (not shown in figures) may extend through electrical motor to couple with at least one fan 46 to rotate the fan 46. The at least one fan 46 at the hot side 44 and cold side 42 enables a forced convection heat transfer within each of the first chamber 10 and the second chamber 20. A hot air present at the hot side 44 is dissipated via the fins 45b and is circulated using the fan 46 in the second chamber 20. This hot air comes in contact with the PCM 30 provided in the second chamber 20 resulting in forced convection, this causes the PCM 30 to absorb the heat of the hot air and generate a latent heat, thereby reducing a temperature of the hot air initially generated in the hot side 44. Thus, this reduced temperature is circulated within the second chamber 20 to maintain a predetermined temperature of the second chamber 20. Similarly, the cold air dissipated in the cold side 42 using the fins 45a is circulated in the first chamber 10 using the fan 46 causing forced convection. Thus, the cold side 42 is maintained at desired temperature thereby cooling the first chamber 10 and the items stored or present in it. The configuration of the fan 46 adjacent to its associated fin 45a, 45b aids in increasing circulation of air over the respective chambers 10, 20, thereby improving efficiency of thermoelectric module 40. Further, the PCM 30 in the second chamber 20 is configured to absorb heat from the hot side 44 and maintain the hot side 44 of the thermoelectric module 40 within a predetermined temperature limit without altering due to varying the ambient temperatures. This cascading of PCM 30 with hot side 44 of the thermoelectric module 40 and keeping both hot side 44 and cold 42 and PCM 30 in insulated first and second chambers 10,20 results in two stage cooling of the cooler 100.

[026] The thermoelectric module 40 includes at least one control circuit is communicatively coupled to the hot side 44, cold side 42, and the fan 46 to operate them. The thermoelectric module 40 comprises a power source electrically coupled to the thermoelectric module 40. The at least one control circuit is electrically connected with the power source for operating the hot side 44, cold side 42, and the fan 46.

[027] Referring now to **Figure. 4**, a thermoelectric module 40 performing at different temperatures is recorded. Accordingly, a graph is plotted for a heat pumping capacity Vs Delta T. Delta T is the temperature difference between the cold side 42 and hot side 44. For example, if the Delta T is maintained at 10°C due to presence of the PCM in the hot side 44, the power consumed for 20 Watts cooling capacity at the cold side 42 is approximately 24 Watts, as the current and voltage required is dropped 2 Amps and 12 V. Whereas, the conventional thermoelectric module without any PCM in the hot side, the power consumption may reach up-to 61.2 Watts for the thermoelectric module 40 with 20 Watts cooling capacity. Therefore, the power consumption by the thermoelectric cooler 100 of the present disclosure is substantially decreased due to presence of PCM 30 at the hot side 44. Moreover, power utilized for recharging the PCM 30, is considerably less, therefore eliminating the need for additional systems / apparatus required to maintain the temperature in the cold side 42 and the hot side 44.

[028] The above subject matter discloses a thermoelectric cooler 100 which is capable of operating based on Peltier effect by cooling the cold side 42 in the first chamber 10 and heating the hot side 44 in the second chamber 20. Further, cooler 100 includes a fewer number of moving parts, by providing PCM 30 in the hot side 44, thus enabling ease to assemble, thereby reducing the overall manufacturing and operating cost. Further, the PCM 30 can eliminate the need of additional system to maintain desired temperatures of the second chamber 20 without getting impeded by the changing ambient temperature. Moreover, by employing the thermoelectric module 40 for operation of the cooler 100 enables less consumption of energy and power.

[029] It is intended that the disclosure and examples be considered as exemplary only, with a true scope of disclosed embodiments being indicated by the following claims.

List of reference numerals

Reference number	**Description**
100	Thermoelectric cooler
102	Housing
10	First chamber
11	Wall
20	Second chamber
30	PCM
40	Thermoelectric module
42	Cold side
44	Hot side
45a, 45b	Fins
46	Fan

WE CLAIM:

1. A thermoelectric cooler (100), comprising:
   a housing (102), defining:
   a first chamber (10);
   a second chamber (20), adjoining the first chamber (10), wherein the second chamber (20) being configured to accommodate a phase change material (PCM) (30); and
   a thermoelectric module (40) between the first chamber (10) and the second chamber (20), the thermoelectric module (40) having a cold side (42) towards the first chamber (10) and a hot side (44) towards the second chamber (20),
   wherein the PCM (30) being configured to absorb heat from the hot side (44) and maintain the hot side (44) of the thermoelectric module (40) within a predetermined temperature limit.
2. The thermoelectric cooler (100) as claimed in claim 1, wherein each of the first chamber (10) and the second chamber (20) are thermally insulated.

3. The thermoelectric cooler (100) as claimed in claim 1, wherein the first chamber (10) defines a storage compartment for storing items and a thermally insulated cover to selectively provide access for storage or removal of the items.

4. The thermoelectric cooler (100) as claimed in claim 1, wherein the second chamber (20) comprises a thermally insulated door to access and replace the PCM (30).

5. The thermoelectric cooler (100) as claimed in claim 1, wherein the PCM (30) is encapsulated in shell.

6. The thermoelectric cooler (100) as claimed in claim 1, comprises a power source electrically coupled to the thermoelectric module (40).

7. The thermoelectric cooler (100) as claimed in claim 1, wherein PCM (30) is at least one of organic, inorganic, and eutectic.

8. The thermoelectric cooler (100) as claimed in claim 1, wherein the thermoelectric module (40) comprises:

at least one conductor interposed between the hot side (44) and the cold side (42);

one or more thermocouples are secured to at least one conductor on the hot side (44) and the cold side (42), wherein one or more thermocouples detects temperature in hot side (44) and cold side (42);

a plurality of fins (45a, 45b) extending from at least one conductor of the cold side (42) and the hot side (44) to increase heat transfer area of the cold side (42) and the hot side (44); and

a fan (46) adjacent to at least one the hot side (44) and cold side (42) for forced convection heat transfer; and

at least one control circuit in electrical communication with the power source for operating the hot side (44), cold side (42), and the fan (46).

Dated this 08th day of June 2022

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ABSTRACT

THERMOELECTRIC COOLER WITH PHASE CHANGE MATERIAL

The present disclosure discloses a thermoelectric cooler. The thermoelectric cooler (100) includes a housing (102) defining a first chamber (10) and a second chamber (20). The second chamber is adjoining to the first chamber and the second chamber is configured to accommodate a phase change material (PCM) (30). The thermoelectric cooler includes a thermoelectric module (40) configured between the first chamber and the second chamber. The thermoelectric module includes a cold side (42) towards the first chamber and a hot side (44) towards the second chamber. The PCM in the second chamber is configured to absorb heat from the hot side and maintain the hot side of the thermoelectric module within a predetermined temperature limit without getting impeded by the changing ambient temperature. The thermoelectric module 40 with PCM in second chamber aids in less consumption of energy and power.

[To be published with Figure. 2]

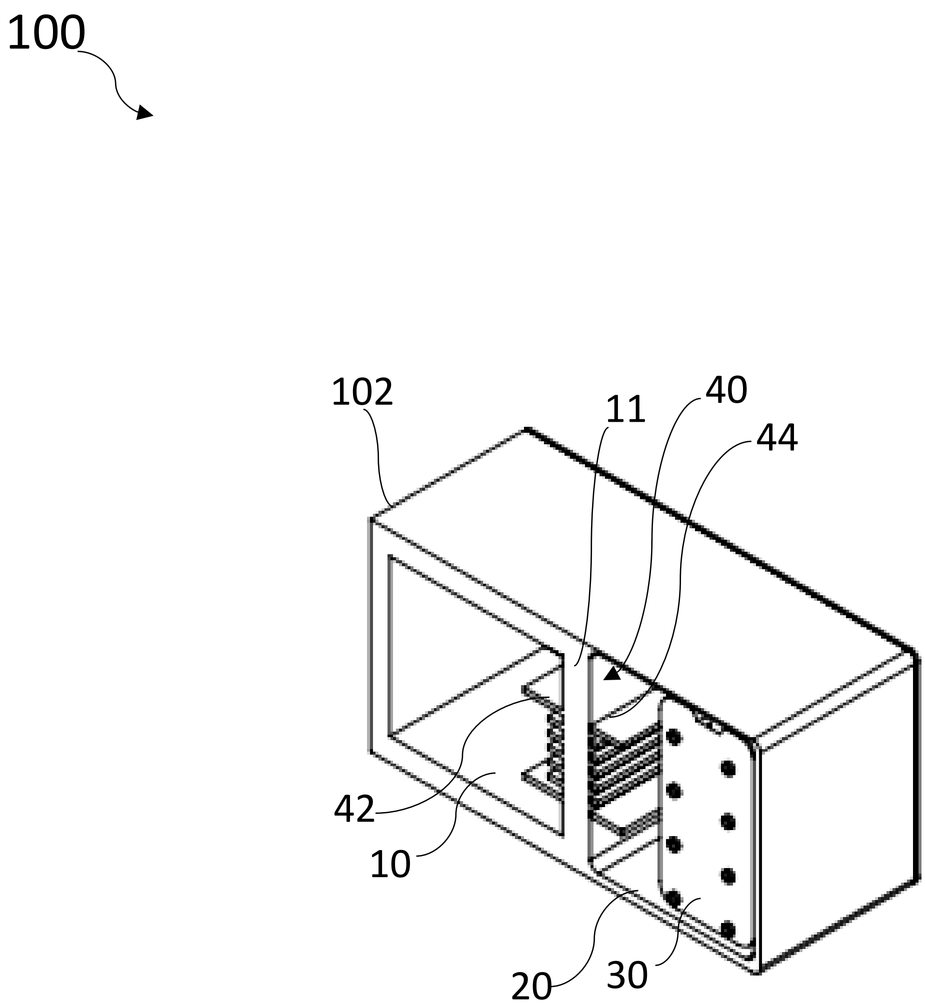

Figure 1

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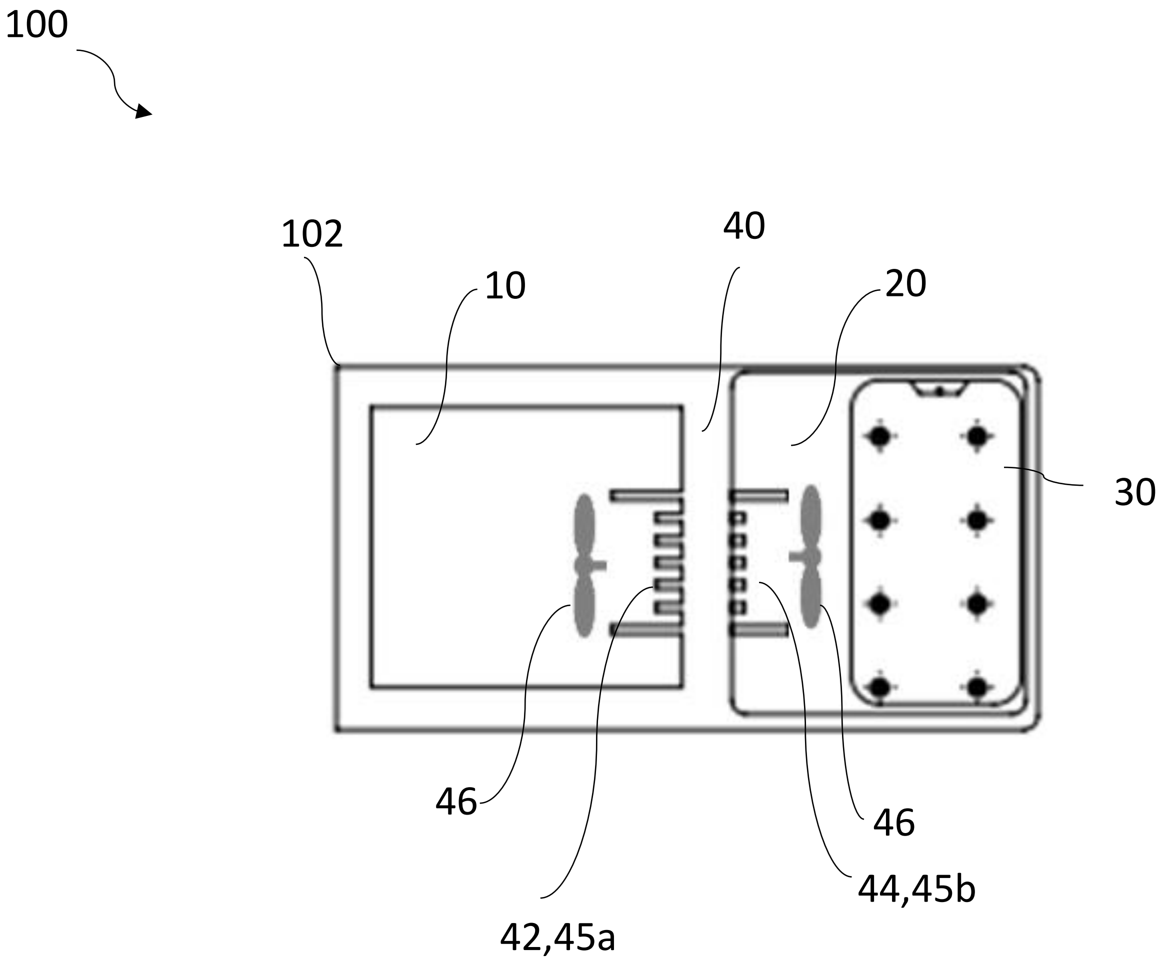

Figure 2

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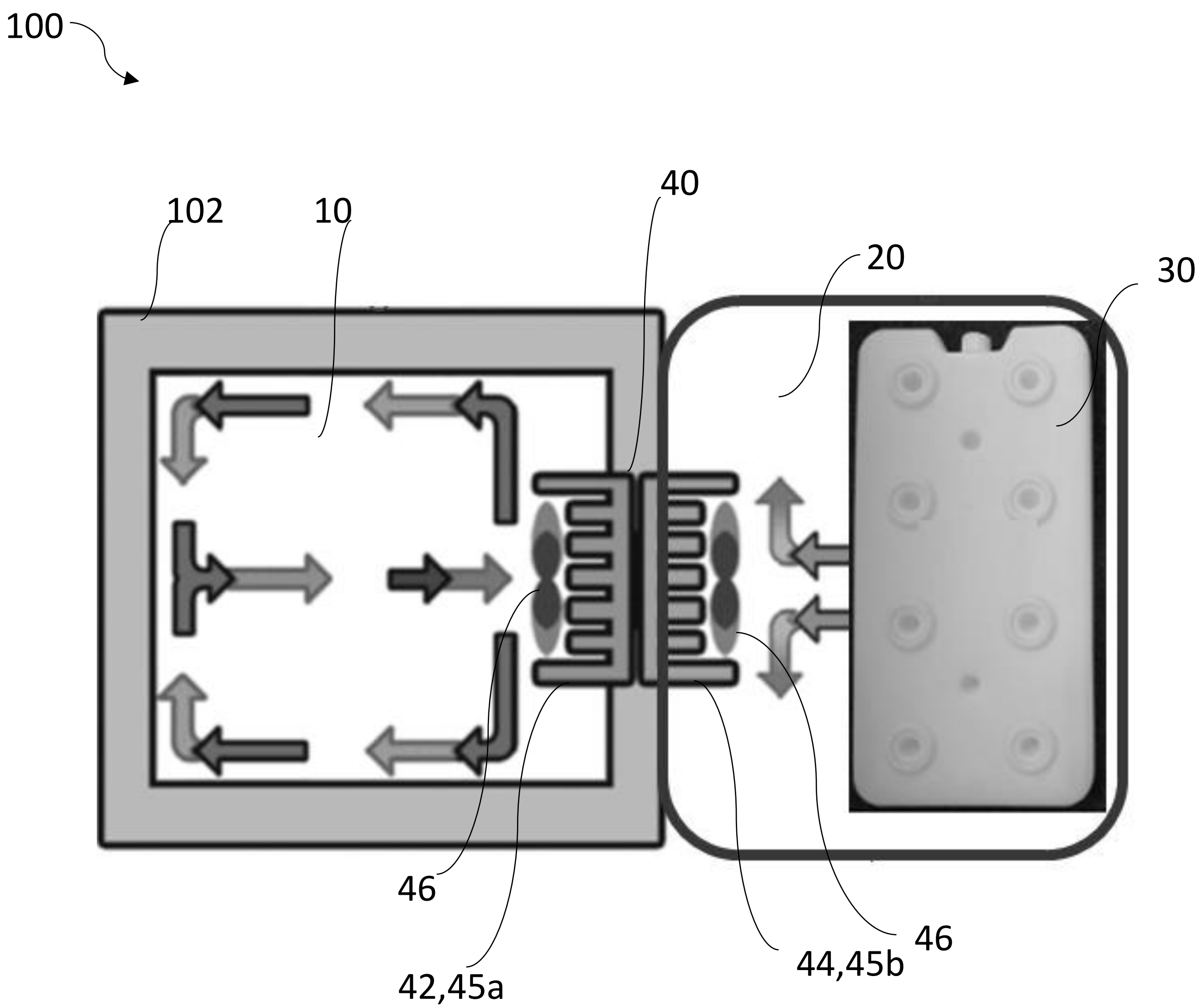

Figure 3

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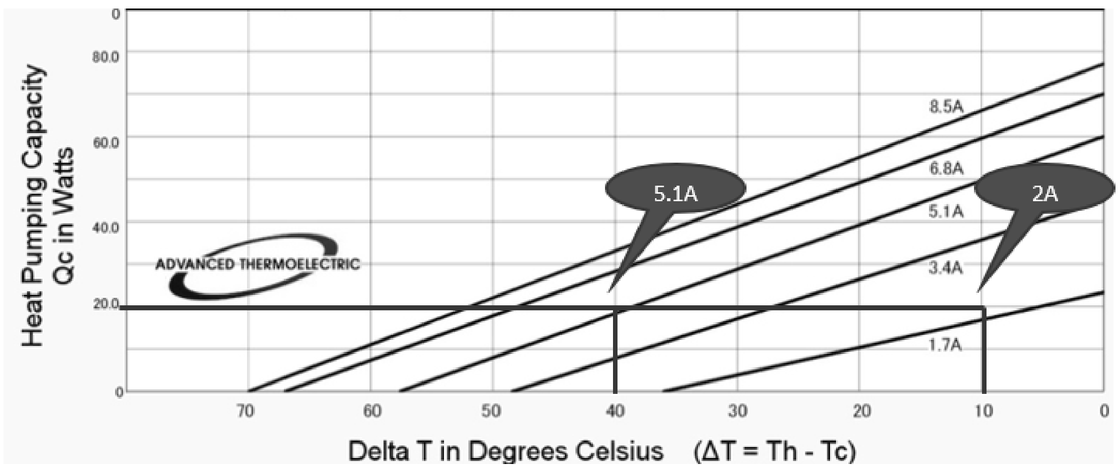

Figure 4

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