

Claims

1. Liquid cooling apparatus for an electronic device comprising:
a primary housing defining a chamber to accommodate at least one electronic
5 device having at least one heat-generating electronic component;
at least one liquid flow inlet and at least one liquid flow outlet provided at the
housing to allow a flow of a dielectric cooling liquid to enter and exit the chamber in direct
contact with the electronic device;
a second housing located within the chamber defining an enclosure to at least
10 partially accommodate the at least one heat-generating electronic component of the device;
at least one liquid flow inlet and at least one liquid flow outlet provided at the
second housing to allow a flow of the liquid to enter and exit the enclosure in direct contact
with the heat-generating electronic component; and
a cooling unit having an inlet and an outlet, the at least one of the outlet of the
15 second housing connected in fluid communication with the inlet of the cooling unit and the
outlet of the cooling unit connected in fluid communication with the at least one inlet of
the primary housing forming part of a fluid flow network to transfer heat energy from the
liquid;
wherein the at least one outlet of the primary housing is connected in fluid
20 communication to the at least one inlet of the second housing;
wherein the chamber is connected in fluid communication in-series with the
enclosure such that the liquid is configured to flow through the chamber, then through the
enclosure and then through the cooling unit;
wherein the second housing is smaller in size than the primary housing and is
25 located within the chamber.
2. The apparatus as claimed in claim 1 comprising an electronic device having:
at least one first heat-generating electronic component at least partially
accommodated within the chamber for immersion in the liquid within the chamber; and
30 at least one second heat-generating electronic component at least partially
accommodated within the enclosure for immersion in the liquid within the enclosure.

3. The apparatus as claimed in claim 2 wherein the second heat-generating electronic component is capable of comprises a higher operating temperature than the first heat-generating electronic component.

5 4. The apparatus as claimed in claim 1 further comprising:

at least one electronically controllable valve provided in fluid communication with the inlet and/or the outlet of the primary housing and/or the second housing; and
a control unit to control the valve and a flow of the liquid to enter and exit the primary housing and/or the second housing via the respective inlet and outlet;

10 wherein the control unit is configured to control the liquid flow through the chamber for a first heat energy exchange with the first heat-generating electronic component and then to control the liquid flow through the enclosure for a second heat energy exchange with the second heat-generating electronic component, the second heat energy exchange being supplemental and additional to the first heat energy exchange such
15 that an increase in a temperature of the liquid at the outlet of the enclosure is a sum of a temperature increase of the liquid having passed through the chamber and the enclosure.

5. The apparatus as claimed in any preceding claim comprising a dielectric cooling liquid contained within the chamber of the primary housing and wherein the second
20 housing is at least partially immersed in or completely submerged by the liquid within the chamber of the primary housing; and

wherein at least a part of the second heat-generating electronic component is positioned in direct contact with the liquid within the enclosure defined by the second housing and/or at least a part of the first heat-generating electronic component is
25 positioned in direct contact with the liquid within the chamber.

6. The apparatus as claimed in any preceding claim when dependant on claim 2 wherein the electronic device comprises any one or a combination of:

- a computer entity;
- 30 • a server;
- a motherboard;

- a printed circuit board comprising a plurality of electronic components;
and

wherein the first heat-generating electronic component and/or the second heat-generating electronic component comprise any one or a combination of:

- 5
- a motherboard;
 - random access memory (RAM);
 - a graphics processing unit (GPU);
 - a central processing unit (CPU).

10 7. The apparatus as claimed in claim 1 wherein the inlet of the second housing is defined by at least a perimeter of an opening by which the second housing is positionable to receive and envelope the heat-generating electronic component at the enclosure.

15 8. The apparatus as claimed in any preceding claim wherein the second housing comprises an opening to enable the second housing to receive and envelope the heat-generating electronic component at the enclosure and a roof positioned opposite the opening.

20 9. The apparatus as claimed in any preceding claim further comprising an actuator connected to the second housing to actuate a movement of the second housing, the actuator configured to change any one or a combination of:

- an internal volume of the enclosure;
- a position of the enclosure relative to the housing and/or the heat-generating electronic component;
- 25 • a separation distance between the second housing and the heat-generating electronic component;
- an extent to which the second housing encapsulates or accommodates the heat-generating electronic component within the enclosure.

10. The apparatus as claimed in any preceding claim further comprising a pump connected in fluid communication to the inlet and/or the outlet of the second housing to drive a flow of the liquid through the enclosure.

5 11. The apparatus as claimed in any preceding claim comprising:
a first electronically controllable valve connected in fluid communication to the inlet and/or the outlet of the chamber and a second electronically controllable valve connected in fluid communication to the inlet and/or the outlet of the enclosure; or
at least one electronically controllable valve provided in fluid communication
10 with the inlet and/or the outlet of the second housing.

12. The apparatus as claimed in any preceding claim comprising at least one temperature sensor to determine a temperature or relative temperature difference of the liquid and/or the heat-generating electronic component, the temperature sensor provided in
15 electronic communication with the control unit.

13. The apparatus as claimed in any preceding claim further comprising a liquid return conduit connecting in fluid communication the outlet of the chamber and the inlet of the enclosure to circulate the liquid that exits the chamber into the enclosure.

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14. The apparatus as claimed in claim 13 further comprising a temporary storage reservoir connected in fluid communication between the outlet of the chamber and the inlet of the enclosure to temporarily store a volume of the liquid for circulation from the chamber to the enclosure.

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15. The apparatus as claimed in claims 13 or 14 wherein an inlet of the chamber comprises a plenum to distribute a flow of the liquid into the chamber.

16. The apparatus as claimed in any preceding claim comprising a plurality of second
30 housings, each having a respective inlet and outlet connected in fluid communication to the cooling unit; and

wherein at least some of the second housings are connected in-series with one another as part of a liquid flow network including the cooling unit; or

wherein at least some of the second housings are connected in-parallel with one another as part of a liquid flow network including the cooling unit.

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17. The apparatus as claimed in any preceding claim comprising a dielectric cooling liquid contained within the chamber and capable of flowing through the enclosure; and

wherein at least a part of the electronic device and/or the at least a part of first heat-generating electronic component is positioned within the chamber and immersed in direct contact with the liquid within the chamber and at least a part of the at least one second heat-generating electronic component is positioned within the enclosure and immersed in direct contact with the liquid within the enclosure.

18. A method of cooling at least part of an electronic device comprising:
immersing an electronic device having at least one heat-generating electronic component within a dielectric cooling liquid contained within a chamber defined by a primary housing;

immersing the heat-generating electronic component within the liquid within an enclosure defined by a second housing located within the chamber, wherein the second housing is smaller in size than the primary housing and is located within the chamber;

providing a first flow of the liquid through the chamber via at least one inlet and at least one outlet provided at the primary housing;

providing a second flow of the liquid through the enclosure via at least one inlet and at least one outlet provided at the second housing;

cooling the liquid heated by the electronic device and/or the heat-generating electronic component using a cooling device forming part of a fluid flow network connected in fluid communication to at least one of the inlets and at least one of the outlets;

wherein the liquid is configured to flow from the outlet of the chamber to the inlet of the enclosure via a return flow conduit and then the liquid is configured to flow from the at least one outlet of the enclosure to a fluid flow network that includes the cooling unit;

wherein the electronic device comprises at least a first heat-generating electronic component and at least one second heat-generating electronic component that is capable of or comprises a higher operating temperature than the first heat-generating electronic component, wherein at least a part of the second heat-generating electronic component is positioned in direct contact with the liquid within the enclosure defined by the second housing and at least a part of the first heat-generating electronic component is positioned in direct contact with the liquid within the chamber;

wherein the chamber is connected in fluid communication in-series with the enclosure such that the liquid is configured to flow through the chamber and then to flow through the enclosure; and

directing the flow of the liquid from the outlet of the enclosure to the cooling unit to reduce the temperature of the liquid; and

providing a return flow of the liquid cooled by the cooling unit to the inlet of the primary housing.

19. The method as claimed in any one of claim 18 comprising:

plurality of enclosures defined by respective second housings each enclosing a respective heat-generating electronic component provided at the electronic device;

wherein the plurality of enclosures are connected in liquid flow in-series with one another; and

wherein the respective heat-generating electronic components comprise substantially the same operating temperature or comprise different operating temperatures arranged within respective second housings in order of increasing operating temperature such that the liquid is configured to flow through the respective enclosures in contact with the respective heat-generating electronic components in-series from the relative low to high operating temperature.

20. The method as claimed in claim 18 comprising controlling a flow of the liquid to flow along the first pathway through the chamber in direct contact with at least a part of the first heat-generating electronic component and then along a second flow pathway through the enclosure in direct contact with at least a part of the second heat-generating electronic component such that heat energy transferred to the liquid is a sum of a heat

energy transferred from the first heat-generating electronic component and the second heat-generating electronic component.

21. The method as claimed in any one of claims 18 to 20 further comprising driving a
5 flow of the liquid through the chamber and/or the enclosure using a pump.

22. The method as claimed in claim 20 comprising directing a return flow of the liquid from the outlet of the chamber at an end of the first flow pathway to the inlet of the enclosure at a start of the second flow pathway.

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23. The method as claimed in any one of claims 18 to 22 comprising temporarily storing the liquid received from the outlet of the chamber at the end of the first flow pathway at a temperature storage reservoir prior to the step of directing the return flow of the liquid to the inlet of the enclosure.

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24. A liquid immersion cooling bath to cool an electronic device having at least one heat-generating electronic component, the bath comprising the apparatus as claimed in any one of claims 1 to 17; and

an electronic device having at least one heat-generating electronic component, the
20 device and the heat-generating electronic component immersed respectively within the dielectric cooling liquid contained within the chamber as defined by the primary housing and/or the enclosure as defined by the second housing.