

Claims

1. Liquid cooling apparatus for an electronic device comprising:
 - a first housing defining a chamber to at least partially accommodate at least one
 - 5 first heat-generating electronic component of an electronic device;
 - at least one inlet and at least one outlet provided at the first housing to enable a dielectric cooling liquid to enter and exit the chamber in direct contact with the first heat-generating electronic component;
 - a second housing defining an enclosure to at least partially accommodate at least
 - 10 one second heat-generating electronic component of an electronic device;
 - at least one inlet and at least one outlet provided at the second housing to enable the dielectric cooling liquid to enter and exit the enclosure in direct contact with the second heat-generating electronic component;
 - at least one cooling unit connected in fluid communication to at least one of the
 - 15 inlets and at least one of the outlets to cool the dielectric liquid received from at least one of the outlets and to deliver the liquid to at least one of inlets; and
 - a control unit to control a flow of the liquid through the chamber and enclosure;
 - wherein the at least one outlet of the chamber is connected in fluid
 - communication to the at least one inlet of the enclosure such that the liquid is configured to
 - 20 flow through the chamber and then through the enclosure
 - wherein the at least one outlet of the enclosure is connected in fluid
 - communication to an inlet of the cooling unit and an outlet of the cooling unit is connected in fluid communication to the at least one inlet of the chamber;
 - wherein the chamber is connected in fluid communication in-series with the
 - 25 enclosure.
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 or comprises a higher operating temperature than the first heat-generating electronic component.

5 4. The apparatus as claimed in claim 1 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
10 heat energy exchange such 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 in any preceding claim when dependant on claim 1 comprising:
15 a plurality of enclosures defined by respective second housings each enclosing a respective heat-generating electronic component provided at the electronic device;
the plurality of enclosures connected in fluid communication in-series with one another;
wherein the respective heat-generating electronic components comprise
20 substantially the same operating temperature or comprise different operating temperatures arranged within respective second housings in order of increasing operating temperature;
wherein the liquid is capable of flowing through the respective second housings in contact with the respective heat-generating electronic components in-series from the relative low to high operating temperature.

25

6. The method as claimed in any one of claims 1 to 5 comprising:
a plurality of enclosures defined by respective second housings each enclosing a respective heat-generating electronic component provided at the electronic device;
the plurality of enclosures arranged in a fluid flow direction in parallel with one
30 another;

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;

wherein the liquid is capable of flowing through the respective second housings in contact with the respective heat-generating electronic components in parallel.

7. The apparatus as claimed in any preceding claim wherein the first housing comprises a liquid immersion tank and the second housing is smaller in size than the first housing and is located within the chamber.

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

9. The apparatus as claimed in claim 8 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 positioned in direct contact with the liquid within the chamber.

10. The apparatus as claimed in any preceding claim wherein the electronic device comprises any one or a combination of:

- a computer entity;
- a server;
- a motherboard;
- a printed circuit board comprising a plurality of electronic components.

11. The apparatus as claimed in any preceding claim wherein the first heat-generating electronic component and/or the second heat-generating electronic component comprise any one or a combination of:

- a motherboard;
- random access memory (RAM);

- a graphic processing unit (GPU);
- a central processing unit (CPU).

12. The apparatus as claimed in any preceding claim further comprising a pump
5 connected in fluid communication with the chamber and enclosure to drive the flow of the liquid through the first chamber and the enclosure.

13. The apparatus as claimed in any preceding claim wherein the cooling unit
comprises a heat exchanger to transfer heat energy from the liquid to a heat transfer fluid.
10

14. The apparatus as claimed in any preceding claim wherein the first housing is
larger than the second housing such that the chamber contains the enclosure.

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

16. The apparatus as claimed in any preceding claim and dependant on claim 3
20 wherein the electronic device of the first and/or second heat-generating electronic components comprise a temperature sensor to determine a temperature or a temperature difference of the liquid and the first and/or second heat-generating electronic components.

17. The apparatus as claimed in any preceding claim comprising at least one
25 electronically controllable valve connected in fluid communication with at least one of the inlets and outlets and controllable by the control unit.

18. The apparatus as claimed in claim 17 comprising a first electronically controllable
valve connected in fluid communication to the inlet and/or the outlet of the chamber and a
30 second electronically controllable valve connected in fluid communication to the inlet and/or the outlet of the enclosure.

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

5 20. The apparatus as claimed in claim 19 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.

10 21. The apparatus as claimed in claims 19 or 20 wherein an inlet of the chamber comprises a plenum to distribute a flow of the liquid into the chamber.

22. A method of cooling at least part of an electronic device comprising:
delivering a dielectric cooling liquid to flow into a chamber via at least one inlet
15 of a first housing, the chamber at least partially accommodating an electronic device having at least one first heat-generating electronic component and allowing the liquid to flow out of the chamber via at least one outlet of the first housing, the first heat-generating electronic component positioned in direct contact with the liquid within the chamber;
delivering a flow of the dielectric cooling liquid into an enclosure via at least one
20 inlet of a second housing, the enclosure at least partially accommodating at least one second heat-generating electronic component of the electronic device and allowing the liquid to flow out of the enclosure via at least one outlet of the second housing, the second heat-generating electronic component positioned in direct contact with the liquid within the enclosure;
25 routing the liquid from at least one of the outlets of the chamber and/or the enclosure to at least one cooling unit to reduce a temperature of the liquid received from the chamber and/or enclosure;
controlling a flow of the liquid through the chamber and enclosure using a control unit;
30 wherein the at least one outlet of the chamber is connected in fluid communication to the at least one inlet of the enclosure such that the liquid is configured to flow through the chamber and then through the enclosure

wherein the at least one outlet of the enclosure is connected in fluid communication to an inlet of the cooling unit and an outlet of the cooling unit is connected in fluid communication to the at least one inlet of the chamber;

5 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.

23. The method as claimed in claim 22 comprising controlling the flow of the liquid through the chamber and enclosure using at least one electronically controllable valve
10 provided in a fluid flow pathway of the liquid.

24. The method as claimed in claims 22 or 23 comprising controlling a flow of the liquid to flow along a first flow pathway through the chamber in direct contact with the first heat-generating electronic component and then to flow along a second flow pathway
15 through the enclosure in direct contact with the second heat-generating electronic component such that heat energy transferred to a liquid is a sum of a heat energy transferred to the liquid from the first heat-generating electronic component and the second heat-generating electronic component.

20 25. The method as claimed in any one of claims 22 to 24 wherein the second heat-generating electronic component is capable of or comprises a higher operating temperature than the first heat-generating electronic component.

26. The method as claimed in any one of claims 22 to 25 comprising:
25 providing an in-series flow of the liquid through a plurality of enclosures defined by respective second housings each enclosing a respective heat-generating electronic component provided at the electronic device;

wherein the respective heat-generating electronic components comprise substantially the same operating temperature or comprise different operating temperatures
30 arranged within respective second housings in order of increasing operating temperature such that the liquid is configured to flow through the respective second housings in contact

with the respective heat-generating electronic components in-series from the relative low to high operating temperature.

27. The method as claimed in any one of claims 22 to 26 comprising controlling the
5 flow of the liquid to flow through the chamber for a first heat energy exchange with the first heat-generating electronic component and then to 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 that an increase in a temperature of the liquid at the outlet of the enclosure
10 is a sum of a temperature increase of the liquid having passed through the chamber and then the enclosure.

28. The method as claimed in any one of claims 22 to 26 further comprising driving the flow of the liquid through the chamber and/or the enclosure using a pump.

15

29. 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 the any one of claims 1 to 21; 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 liquid contained within the chamber and/or the enclosure.

30. The liquid immersion cooling bath as claimed in claim 29 comprising a plurality of electronic devices each having first and second heat-generating electronic components,
25 the devices and the heat-generating electronic components at least partially immersed respectively within the liquid contained within the chamber and the enclosure.

31. The liquid immersion cooling bath as claimed in claim 30 comprising:
at least one first housing defining the chamber to accommodate the electronic
30 devices; and

a plurality of second housings located within the chamber defining respective enclosures to at least partially accommodate the respective second heat-generating electronic components of the devices;

wherein the devices are immersed within the liquid contained within the chamber
5 and the second heat-generating electronic components are immersed within the liquid contained within the respectively enclosures.

32. An electronic device rack to store electronic devices, each having at least one heat-generating electronic component, the rack comprising the apparatus as claimed in any
10 one of claims 1 to 21; and

an electronic device having at least one heat-generating electronic component, the device and the heat-generating electronic component at least partially immersed within the dielectric cooling liquid contained respectively within the chamber and the enclosure;

wherein the electronic device is mounted at the rack at least in part via the first
15 housing.

33. The electronic device rack as claimed in claim 32 comprising a plurality of electronic devices each having at least one heat-generating electronic component, the devices immersed within the liquid contained within the chamber and the one heat-
20 generating electronic components immersed within the liquid contained respectively within the enclosures.

34. The electronic device rack as claimed in claim 33 comprising:
a plurality of first housings defining the respective chambers to accommodate the
25 respective electronic devices; and

a plurality of second housings defining enclosures and located respectively within the chambers to accommodate respectively the at least one heat-generating electronic components;

wherein the plurality of electronic devices are immersed within the liquid
30 contained within the respectively chambers and the at least one heat-generating electronic components are immersed within the liquid contained within the respectively enclosures.

35. The electronic device rack as claimed in claim 33 wherein the plurality of electronic devices each have first and second heat-generating electronic components, the devices and the first heat-generating electronic components at least partially immersed or completely submerged within the liquid contained within the first housings and the second
- 5 heat-generating electronic components at least partially immersed within the liquid contained within the enclosures.