

Claims

1. Liquid cooling apparatus for an electronic device comprising:
a housing defining a chamber to at least partially accommodate at least one
5 electronic device having at least one heat-generating electronic component, the housing
having at least one inlet to enable a dielectric cooling liquid to enter the chamber;
at least one cover at least partially within the chamber and positionable over the
heat-generating electronic component, the cover configured with at least one inlet to allow
the dielectric cooling liquid to enter an enclosure defined by the cover and in direct contact
10 with the heat-generating electronic component, and at least one outlet to allow the liquid to
exit the enclosure;
a cooling unit connected in fluid communication with the at least one of the inlet
of the housing and the at least one of the outlet of the cover to receive the liquid from the at
least one of the outlet and to deliver the liquid to the at least one of inlet;
15 wherein the inlet of the cover is defined by at least a perimeter of an opening by
which the least one cover is positionable to receive and envelope the heat-generating
electronic component at the enclosure.
2. The apparatus as claimed preceding claim 1 comprising an electronic device
20 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
at least one second heat-generating electronic component at least partially
accommodated within the enclosure for immersion in the liquid within the enclosure.
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3. The apparatus as claimed in claims 2 wherein the second heat-generating
electronic component is capable of or comprises a higher operating temperature than the
first heat-generating electronic component.
- 30 4. The apparatus as claimed in any preceding claim wherein the housing comprises
at least one outlet to enable the liquid to exit the chamber.

5. The apparatus as claimed in any preceding claim wherein the inlet and outlet of the cover are separate from one another and/or positioned at different regions of the cover.

6. The apparatus as claimed in any one of claims 1 to 4 wherein the cover comprises an opening to enable the cover to receive and envelope the heat-generating electronic component at the enclosure and a roof positioned opposite the opening.

7. The apparatus as claimed in claim 6 wherein the inlet of the cover is positioned at the roof of the cover.

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8. The apparatus as claimed in claims 6 or 7 wherein the outlet of the cover is defined, in part by the opening.

9. The apparatus as claimed in any preceding claim further comprising an actuator connected to the cover to actuate a movement of the cover towards and away from the housing and/or the heat-generating electronic component.

10. The apparatus as claimed in any one of claims 1 to 8 wherein the cover is adjustably mounted at the apparatus via an actuator that by actuation is configured to change any one or a combination of:

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

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11. The apparatus as claimed in any preceding claim 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.

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12. The apparatus as claimed in claim 11 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.

13. The apparatus as claimed in claim 12 wherein the chamber is connected in fluid communication in-series with the enclosure.

14. The apparatus as claimed in any preceding claim comprising at least one electronically controllable valve provided in fluid communication with the inlet and/or the outlet of the cover.

15. The apparatus as claimed in claim 14 further comprising a control unit to control the valve and a flow of the liquid to enter and exit the enclosure via the inlet and outlet.

16. The apparatus as claimed in claim 15 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 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.

17. The apparatus as claimed in any preceding claim comprising a plurality of covers, each having a respective inlet and outlet connected in fluid communication to the cooling unit.

18. The apparatus as claimed in claim 17 wherein at least some of the covers are connected in-series with one another as part of a liquid flow of network including the cooling unit; or

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

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

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

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wherein the heat-generating electronic component comprises any one or a combination of:

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

20. The apparatus as claimed in any preceding claim when dependant on claim 2 comprising a dielectric cooling liquid contained within the chamber and capable of flowing through the enclosure; and

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

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21. The apparatus as claimed in any one of claim 20 further comprising a temperature sensor to determine a temperature or a temperature difference of the liquid and/or the heat-generating electronic component within the enclosure.

30 22. The apparatus as claimed in any preceding claim when dependant on claim 4 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; and

wherein the chamber is connected in fluid communication in-series with the enclosure.

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23. The apparatus as claimed in any preceding claim when dependant on claim 15 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 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.

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

25. A method of cooling a heat-generating electronic component of an electronic device comprising:

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at least partially accommodating an electronic device having at least one heat-generating electronic component within a chamber defined by a housing, the housing having at least one inlet to enable a dielectric cooling liquid to enter the chamber;

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positioning a cover over the heat-generating electronic component to define an enclosure containing the heat-generating electronic component, at least one liquid flow inlet and at least one liquid flow outlet provided at the cover;

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providing a flow of a dielectric cooling liquid within the enclosure between the at least one inlet and the at least one outlet, the liquid in direct contact with the heat-generating electronic component so as to receive directly heat energy from the heat-generating electronic component;

cooling the liquid heated by the heat-generating electronic component using a cooling device forming part of a fluid flow network connected in fluid communication to the at least one inlet of the housing and the at least one outlet of the cover;

wherein the inlet of the cover is defined by at least a perimeter of an opening by which the least one cover is positionable to receive and envelope the heat-generating electronic component at the enclosure; and

controlling the 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 is a sum of a temperature increase of the liquid having passed through the chamber and then the enclosure.

26. The method as claimed in claim 25 comprising providing a flow of the liquid through the chamber via at least one liquid flow inlet and at least one liquid flow outlet at the housing, the electronic device at least partially immersed within the liquid within the chamber.

27. The method as claimed in claims 25 or 26 wherein the electronic device comprises at least one first heat-generating electronic component and at least one second heat-generating electronic component capable of or having a higher operating temperature than the first heat-generating electronic component, wherein the second heat-generating electronic component is positioned in direct contact with the liquid within the enclosure defined by the cover and the first heat-generating electronic component is positioned in direct contact with the liquid within the chamber.

28. The method as claimed in any one of claims 25 to 27 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.

29. The method as claimed in any one of claims 25 to 28 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.

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30. The method as claimed in any one of claims 25 to 29 wherein a flow of the liquid within the enclosure is fed from the liquid within the chamber via the inlet of the cover; or wherein a flow of the liquid within the enclosure is fed from the fluid flow network via the inlet of the cover.

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31. The method as claimed in any one of claims 25 to 30 comprising:
providing an in-series flow of the liquid through a plurality of enclosures defined by respective covers each enclosing a respective heat-generating electronic component provided at the electronic device;

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

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32. 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 apparatus as claimed in any one of claims 1 to 23; and

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an electronic device having at least one heat-generating electronic component immersed within the dielectric cooling liquid contained within the housing.

33. An electronic device rack to store electronic devices, each having a heat-generating electronic component, the rack comprising the apparatus as claimed in any one of claims 1 to 23; and

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an electronic device having at least one heat-generating electronic component and mounted at the rack at least in part via the housing;

the heat-generating electronic component at least partially immersed in the dielectric cooling liquid within the enclosure defined by the cover.

34. The electronic device rack as claimed in claim 33 comprising a plurality of
5 electronic devices each having at least one heat-generating electronic component.

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

10 a plurality of covers 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
contained within the respectively chambers and the at least one heat-generating electronic
15 components are immersed within the liquid contained within the respectively enclosures.