amount or volume of cooling fluid, the required fluid flow, the amount of energy consumed by the required fluid circulation system, and the complexity of the circulation system necessary to circulate the cooling fluid.

[0007] As seismic data processing requires a large number of electronic systems contained in High Performance Computing centers, improving the efficiency, redundancy and operational flexibility of the cooling systems is a desirable outcome for that activity.

SUMMARY

[0008] Exemplary embodiments are directed to systems for immersion cooling electronic components such as computing system equipment using cylindrical containers having a circular cross section such as metal barrels used to transport and store immersion cooling fluids. These systems include two cooling elements disposed within the cylindrical container to provide for a flow of a first or primary cooling fluid into and out of the cylindrical container, and a volume of second cooling fluid disposed in the container and surrounding the two cooling elements disposed within the container. The second cooling fluid is an immersion cooling fluid such as the immersion cooling fluid supplied in the container. A plurality of heat generating electronic component is disposed within the cylindrical container in the volume of immersion cooling fluid, and at least one micropump is disposed in the plurality of heat generating electronic component. The micropump provides for the flow of the secondary cooling fluid through the electronic component and the two cooling elements to remove heat from the at least heat generating electronic component and to transfer heat between the secondary cooling fluid and the primary cooling fluid. The plurality of electronic components are arranged in the cylindrical container as a stack with sides of all of the plurality of electronic components aligned. Each cooling element is located between the electronic components and an interior wall of the

cylindrical container, and the two cooling elements are arranged on diametrically opposed sides of the electronic components.

[0009] Exemplary embodiments are also directed to methods for immersion cooling heat generating electronic components. The lid of a cylindrical barrel, such as a cylindrical barrel used to transport and store an immersion cooling fluid, is removed, and one or more cooling elements are

placed within the cylindrical barrel. The cooling elements are connected to a source of primary cooling fluid such as water. The cylindrical barrel is filled with a volume of second cooling fluid sufficient to surround the one or more cooling elements disposed within the container. The second cooling fluid is an immersion cooling fluid, and in one embodiment, the second cooling fluid is the immersion cooling fluid shipped in the cylindrical barrel. Therefore, the second cooling fluid is already contained within the cylindrical barrel and does not need to be added. In one embodiment, a portion of the volume of the second cooling fluid is removed to accommodate insertion of the other components.

[0010] At least one heat generating electronic component is placed within the cylindrical barrel in the volume of immersion cooling fluid. The first or primary cooling fluid is circulated through the one or more cooling elements and into and out of the cylindrical barrel, and a micropump, for example, disposed in the at least one heat generating electronic component is used to circulate the second cooling fluid through the electronic component and the one or more cooling elements to remove heat from the at least heat generating electronic component and to transfer heat between the second cooling fluid and the first cooling fluid.

[0011] Exemplary embodiments are directed to a system for immersion cooling electronic components that includes a cylindrical container having a circular cross section, two cooling elements disposed in the cylindrical container and containing a first cooling fluid, a volume of a second cooling fluid disposed in the cylindrical container and in contact with the cooling elements for exchange of heat between the second cooling fluid and the first cooling fluid, where the second cooling fluid is an immersion cooling fluid, a plurality of heat generating electronic components disposed within the cylindrical container and at least partially immersed in the second cooling fluid for exchange of heat between the electronic components and the second cooling fluid, and a fluid circulating device

disposed in the second cooling fluid to direct a flow of the second cooling fluid through the electronic components and over the cooling elements. The plurality of electronic components are arranged in the cylindrical container as a stack with sides of all of the plurality of electronic components aligned. Each cooling element is located between the electronic components and an interior wall of the cylindrical container, and the two cooling elements are arranged on diametrically opposed sides of the electronic components..

[0012] In one embodiment, the cylindrical container is a metal barrel used to ship the second cooling fluid. In one embodiment, the cooling element includes an inlet for introducing the first cooling fluid into the cooling element from a source external to the cylindrical container and an outlet, separate from the inlet, for removing heated first cooling fluid from the cooling element. In one embodiment, the system further includes two cooling elements. Each cooling element is located between the electronic component and an interior wall of the cylindrical container, and the two cooling elements are arranged on diametrically opposed sides of the electronic component. In one embodiment, the first cooling fluid is water, and the second cooling fluid is a dielectric oil. In one embodiment, the electronic component is completely immersed in the second cooling fluid.

[0013] In one embodiment, the electronic component includes a face containing power and communication connections and a depth extending back from the face. The electronic component is disposed in the cylindrical container with the face accessible through an open top of the cylindrical container and the depth extending vertically in the cylindrical container. In one embodiment, the face has two opposing side edges, a top edge and a bottom edge opposite the top edge. The top and bottom edges extend between the side edges. The electronic component has two sides extending along the depth from the two side edges, a top extending along the depth from the top edge and a bottom extending along the depth from the bottom edge, and the cooling element is disposed adjacent one of the side edges. In one embodiment, the system includes a plurality of electronic

components arranged in the cylindrical container as a stack with the sides of all electronic components aligned. The cooling element is position between one of the aligned sides of the plurality of electronic components and an interior wall of the cylindrical container.

components. The support platform has cooling element opening positioned between one of the opposing support rails and an interior wall of the cylindrical container, and the cooling element is disposed in the cooling element opening. In one application, the support platform further includes a containment section having a deck, and the central opening and the cooling element opening are disposed in the deck. A lip extends up from the deck in a direction opposite the base around an entire periphery of the deck. The deck and lip direct a flow of second cooling fluid emerging from the face of the electronic component through the cooling element opening and along the cooling element.

[0023] In one embodiment, the system for immersion cooling computer system components includes a cylindrical container having a circular cross section, and a cooling element containing a first cooling fluid disposed in the cylindrical container. A volume of a second cooling fluid is disposed in the cylindrical container in contact with the cooling element for exchange of heat between the second cooling fluid and the first cooling fluid. In one embodiment, the second cooling fluid is an immersion cooling fluid. A heat generating electronic component is disposed within the cylindrical container and completely immersed in the second cooling fluid for exchange of heat between the electronic component and the second cooling fluid, and a micropump is disposed in the second cooling fluid and integrated into the heat generating electronic component to direct a flow of the second cooling fluid through the electronic component and over the of cooling element.

[0024] In another embodiment, there is a method for immersion cooling electronic components that includes opening a top of a cylindrical barrel containing an immersion cooling fluid, placing a support within the cylindrical barrel, using the support to hold a plurality of heat generating electronic component in the cylindrical barrel such that the electronic components are completely immersed in the immersion cooling fluid, arranging the plurality of electronic components in the cylindrical barrel as a stack with sides of all of the plurality of electronic components aligned, immersing two cooling elements in the immersion cooling fluid

within the cylindrical barrel adjacent the electronic components, arranging the two cooling elements on diametrically opposed sides of the electronic components such that each cooling element is located between the electronic components and an interior wall of the cylindrical barrel, circulating cooling fluid from a source external to the cylindrical barrel through the

cooling elements, and using at least one micropump integrated into each electronic component of the electronic components and deriving power from the electronic component to direct a flow of the immersion cooling fluid vertically up through the electronic component and vertically down over the one of the two cooling elements to transfer heat from the electronic component through the immersion cooling fluid and to the cooling fluid from the source external to the cylindrical barrel for removal from the cylindrical barrel.

FIGURES

[0025] The accompanying drawings, which are incorporated in and constitute a part of the specifications, illustrate one or more embodiments and, together with the description, explain these embodiments.

[0026] Fig. 1 is an illustration of an embodiment of an electronic component cooling system having a cylindrical container;

[0027] Fig. 2 is an illustration of an embodiment of an electronic component cooling system containing a plurality of cylindrical containers manifolded together;

[0028] Fig. 3 is an illustration of a side cutout view of an embodiment of a system for immersion cooling of electronic systems;

[0029] Fig. 4 is an illustration of a side cutout view of an embodiment of the position and positioning system for the electronic systems;

[0030] Fig. 5 is an illustration of a side cutout view of an embodiment of the position and positioning system for the cooling plates;

[0031] Fig. 6 is an illustration of an embodiment of a cylindrical barrel containing components of an electronic component cooling system;

[0032] Fig. 7 is a plan view from the top of a cylindrical barrel;

CLAIMS

1. A system for immersion cooling electronic components, the system comprising:

a cylindrical container having a circular cross section;

two cooling elements disposed in the cylindrical container, the cooling elements containing a first cooling fluid;

a volume of a second cooling fluid disposed in the cylindrical container and in contact with the cooling elements for exchange of heat between the second cooling fluid and the first cooling fluid, the second cooling fluid comprising an immersion cooling fluid;

a plurality of heat generating electronic components disposed within the cylindrical container and at least partially immersed in the second cooling fluid for exchange of heat between the electronic components and the second cooling fluid; and

a fluid circulating device disposed in the second cooling fluid to direct a flow of the second cooling fluid through the electronic components and over the cooling elements,

wherein the plurality of electronic components are arranged in the cylindrical container as a stack with sides of all of the plurality of electronic components aligned;

wherein each cooling element is located between the electronic components and an interior wall of the cylindrical container, and

wherein the two cooling elements are arranged on diametrically opposed sides of the electronic components.

2. The system of claim 1, wherein the cylindrical container comprises a metal barrel used to ship the second cooling fluid.

3. The system of claim 1 or 2, wherein each cooling element comprises:

an inlet for introducing the first cooling fluid into the cooling element from a source external to the cylindrical container; and

an outlet, separate from the inlet, for removing heated first cooling fluid from the cooling elements.

4. The system of any one of the preceding claims, wherein the first cooling fluid comprises water.

5. The system of any one of the preceding claims, wherein the second cooling fluid comprises a dielectric oil.

6. The system of any one of the preceding claims, wherein the electronic components are completely immersed in the second cooling fluid.

7. The system of any one of the preceding claims, wherein:

each electronic component comprises a face comprising power and communication connections and a depth extending back from the face; and

each electronic component is disposed in the cylindrical container with the face accessible through an open top of the cylindrical container and the depth extending vertically in the cylindrical container.

8. The system of claim 7, wherein:

the face comprises two opposing side edges, a top edge and a bottom edge opposite the top edge, the top and bottom edges extending between the side edges;

the electronic components each comprise two sides extending along the depth from the two side edges, a top extending along the depth from the top edge and a bottom extending along the depth from the bottom edge; and

the cooling elements are disposed adjacent one of the side edges.

9. The system of claim 8, wherein the cooling elements are positioned between one of the aligned sides of the plurality of electronic components and an interior wall of the cylindrical container.

10. The system of any one of the preceding claims, wherein the fluid circulating device comprises a micropump integrated into one of the electronic components and receives power from the electronic component.

11. The system of any one of claims 1 to 6, wherein:

the electronic components comprise a face comprising power and communication connections and a depth extending back from the face;

the system further comprises a support disposed in the cylindrical container, the support comprising a support platform spaced from a bottom of the cylindrical container along a height of the cylindrical container a distance at least equal to the depth;

wherein the support platform is arranged to hold the electronic component in the cylindrical container with the depth positioned vertically in the cylindrical container.

12. The system of claim 11, wherein:

the face comprises two opposing side edges, a top edge, and a bottom edge spaced from the top edge, the top edge and bottom edge extending between the opposing side edges;

each electronic component further comprises two sides extending along the depth from the two side edges, a top extending along the depth from the top edge and a bottom extending along the depth from the bottom edge; and

the support platform comprises a central opening comprising opposing support rails engaging the opposing side edges of the face and supporting each of the electronic components.

13 The system of claim 12, wherein:

the support platform comprises cooling element openings positioned between one of the opposing support rails and an interior wall of the cylindrical container; and

the cooling elements are disposed in the cooling element openings.

14. The system of claim 13, wherein the support platform further comprises a containment section comprising:

a deck, the central opening and the cooling element openings disposed in the deck; and

a lip extending up from the deck in a direction opposite a base of the cylindrical container around an entire periphery of the deck, the deck and lip directing a flow of second cooling fluid emerging from the face of the electronic component through the cooling element openings and along the cooling elements.

15. A system for immersion cooling computer system components, the system comprising:

a cylindrical container having a circular cross section;

two cooling elements disposed in the cylindrical container, the cooling elements containing a first cooling fluid;

a volume of a second cooling fluid disposed in the cylindrical container and in contact with the cooling elements for exchange of heat between the second cooling fluid and the first cooling fluid, the second cooling fluid comprising an immersion cooling fluid;

a plurality of heat generating electronic components disposed within the cylindrical container and completely immersed in the second cooling fluid for exchange of heat between the electronic component and the second cooling fluid; and

a micropump disposed in the second cooling fluid and integrated into the heat generating electronic component to direct a flow of the second cooling fluid through the electronic component and over the cooling elements,

wherein the plurality of electronic components are arranged in the cylindrical container as a stack with sides of all of the plurality of electronic components aligned;

wherein each cooling element is located between the electronic components and an interior wall of the cylindrical container , and

wherein the two cooling elements are arranged on diametrically opposed sides of the electronic components.

16. The system of claim 15, wherein:

the cylindrical container comprises a metal barrel used to ship the second cooling fluid; and

the micropump receives power from the electronic components.

17. The system of claim 16, wherein:

each electronic component comprises:

a face comprising two opposing side edges, a top edge, and a bottom edge spaced from the top edge, the top edge and bottom edge extending between the opposing side edges;

a depth extending back from the face; and

two sides extending along the depth from the two side edges; and

the system further comprises a support disposed in the cylindrical container, the support comprising:

a support platform spaced from a bottom of the cylindrical container along a height of the cylindrical container a distance at least equal to the depth, the support platform comprising a containment section comprising:

a deck comprising:

a central opening comprising opposing support rails engaging the opposing side edges of the face and supporting the electronic components in the cylindrical container with the depth positioned vertically in the cylindrical container;

cooling element openings positioned between one of the opposing support rails and an interior wall of the cylindrical container, the cooling elements disposed in the cooling element openings; and

a lip extending up from the deck in a direction opposite the base around an entire periphery of the deck, the deck and lip directing a flow of second cooling fluid emerging from the faces of the electronic components through the cooling element openings and along the cooling elements.

18. A method for immersion cooling electronic components, the method comprising:

opening a top of a cylindrical barrel containing an immersion cooling fluid;

placing a support within the cylindrical barrel;

using the support to hold a plurality of heat generating electronic components in the cylindrical barrel such that the electronic components are completely immersed in the immersion cooling fluid;

arranging the plurality of electronic components in the cylindrical barrel as a stack with sides of all of the plurality of electronic components aligned;

immersing two cooling elements in the immersion cooling fluid within the cylindrical barrel adjacent the electronic components;

arranging the two cooling elements on diametrically opposed sides of the electronic components such that each cooling element is located between the electronic components and an interior wall of the cylindrical barrel;

circulating cooling fluid from a source external to the cylindrical barrel through the cooling elements; and

using at least one micropump integrated into each electronic component of the electronic components and deriving power from the electronic component to direct a flow of the immersion cooling fluid vertically up through the electronic component and vertically down over one of the two cooling elements to transfer heat from the electronic component through the immersion cooling fluid and to the cooling fluid from the source external to the cylindrical barrel for removal from the cylindrical barrel.