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- 1 -

Providing Connection Elements For Connecting
Fluid Pipes To Carry Cooling Fluid In A System

Background

[0001] In modern electronic systems, a relatively large amount of heat is generated due to operation of electronic devices in such systems. Various approaches have been used for cooling electronic devices of systems.

[0002] Traditionally, air flow generators, such as fans, are provided within a system to generate air flow for cooling electronic devices in the system. However, as operating speeds of electronic devices, such as microprocessors, have dramatically increased, the use of just air flow cooling techniques have generally not been sufficient for cooling electronic devices of certain types of systems, such as high-end computer servers, storage systems, or communications systems.

[0003] Enhanced cooling can be provided by provision of fluid pipes inside the chassis of a system, where the fluid pipes are used for carrying a cooling fluid. The challenge of employing fluid pipes within a system is that the fluid pipes may have to be routed to many different points inside the system. The presence of such pipes may make it difficult to access certain components in the system, such as to perform repair or replacement tasks. Also, during servicing, possible leakage of fluids from fluid pipes is also an issue when a component is disconnected and removed from the system.

Brief Description Of The Drawings

[0004] Some embodiments of the invention are described, by way of example, with respect to the following figures:

Fig. 1 is a front view of an exemplary system having rigid and flexible fluid pipes that are connected by quick-connect mechanisms, in accordance with some embodiments;

Fig. 2 is a schematic diagram of portions of a flexible fluid pipe and a rigid fluid pipe, and associated connection elements that are part of a quick-connect mechanism, according to an embodiment;

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Fig. 3 is a perspective view of the connection elements of a quick-connect mechanism in a separated position, wherein the quick-connect mechanism is used to connect a flexible fluid pipe and a rigid fluid pipe according to an embodiment;

Fig. 4 is an enlarged perspective view of a portion of the system of Fig. 1 that incorporates an embodiment; and

Fig. 5 is a rear view of the system of Fig. 1.

Detailed Description

[0005] Fig. 1 is a front view of an exemplary system that includes housing (or outer chassis) 100 (note that portions of the housing 100 have been omitted to enable depiction of components within the housing) for containing the components of the system. The “housing” can be formed of multiple segments attached or otherwise connected together to define an inner space or chamber for containing the system components, or alternatively, the housing can be formed of segments integrally connected together.

[0006] The system depicted in Fig. 1 can be a computer system, a storage system, a communications system, and so forth. Certain of the components within the system produce heat during operation. Some of the components produce more heat than other components. An example of a component that produces a relatively elevated amount of heat during operation is a microprocessor.

[0007] In the ensuing discussion, reference is also made to Figs. 4 and 5, which depict perspective views and rear views, respectively, of the system.

[0008] Fig. 1 illustrates a heat-generating assembly 102, which includes a heat sink 104 and an electronic device 106 (*e.g.*, a microprocessor or other type of electronic device) thermally attached to the heat sink 104. In the example depicted in Fig. 1, the heat-generating assembly 102 is mounted in the system on mounting brackets 160 and 162. A heat sink is formed of a thermally conductive material, such as metal (*e.g.*, copper or other metal of relatively high thermal conductivity), that conducts heat away from the electronic device 106 during operation of the electronic device 106. The heat sink 104 includes internal fluid passages (not shown in Fig. 1) for carrying a cooling fluid. A flow of cooling fluid is induced in the fluid passages of the heat sink 104 to carry heat away from the heat sink.

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[0009] In accordance with some embodiments, rigid fluid pipes are fixedly mounted inside the housing 100 of the system. A “rigid” fluid pipe refers to a fluid pipe formed of a relatively sturdy material that would make bending of the fluid pipe relatively difficult. For example, the rigid fluid pipe can be formed of a metal or plastic material. A “pipe” can be a generally cylindrical conduit or can be any other type of conduit having other geometries (*e.g.*, rectangular cross-section, square cross-section, etc.). The fluid pipe has an inner longitudinal bore enclosed by the wall of the pipe, where the inner longitudinal bore is used for carrying cooling fluid.

[0010] In the example depicted in Figs. 1, 4, and 5, rigid fluid pipes 108, 110, 111, 112, 114, and 115 are provided. An additional rigid fluid pipe 113 (not visible in Fig. 1) is depicted in Fig. 4, which is a perspective view of the system. The fixedly mounted, rigid fluid pipes 108, 110, 111, 112, 113, 114, and 115 are positioned according to a desired organization. The positions of the rigid fluid pipes can be arranged to allow for relatively easy access (insertion or removal) of certain components in the system, such as for purposes of repair or replacement. For example, the rigid fluid pipes can be positioned such that the heat-generating assembly 102 can be easily inserted or removed inside the housing 100. Being able to fix the positions of the rigid fluid pipes inside the housing 100 of the system enables a manufacturer to achieve better organization of components inside the housing.

[0011] The heat sink 104 of the heat-generating assembly 102 has various ports connected to respective flexible fluid pipes 118, 120, 122, 124, 126, and 128. A “flexible” fluid pipe is a pipe formed of a relatively soft elastic material that allows the flexible fluid pipe to be flexed or bent relatively easily. The ports of the heat sink 104 include input ports and output ports. An input port is to receive input cooling fluid for routing through the inner fluid passages of the heat sink 104, and the output ports are used for outputting heated cooling fluid for carrying such heated fluid away from the heat sink 104.

[0012] The flexible fluid pipes 118, 120, 122, 124, 126, and 128 are attached to the heat-generating assembly 102 such that the assembly 102 with the attached flexible fluid pipes can be mounted or dismounted from the system housing 100 as a unit. The flexible fluid pipes are easily manipulated by a user for ease of connection of the flexible fluid pipes to the corresponding rigid fluid pipes.

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[0013] A heat exchanger 130 is also provided in the system housing 100. The heat exchanger 130 also has internal fluid passages (not shown) that are connected to corresponding fluid pipes, including flexible fluid pipes 116 and 152 (*see* Figs. 1 and 4). The heat exchanger 130 has fins 150 over which air flow can be provided to carry heat away from the heat exchanger. As depicted in Fig. 4, fans 131 are provided as part of the heat exchanger 130 to generate the air flow to dissipate heat away from the heat fins 150. Heated cooling fluid from the heat sink 104 can be carried from output ports of the heat sink 104 to the heat exchanger 130 (*e.g.*, through flexible fluid pipe 116), where air flow can remove heat from the heat exchanger 130. Fluid that is cooled due to passage through the heat exchanger 130 can then be returned back to the heat sink 104 (*e.g.*, through flexible fluid pipe 152) for cooling the heat-generating assembly 102.

[0014] The flexible fluid pipes 116 and 152 connected to ports of the heat exchanger 130 are connected to respective rigid fluid pipes 111 and 113. Note that the heat exchanger 130 is another example of a heat-generating assembly that can be removably mounted in the system. The use of the flexible fluid pipes 116 and 152 attached to the heat exchanger 130 enables convenient connection of the heat exchanger 130 to the rigid pipes 111 and 113.

[0015] Fig. 1 also shows the rigid fluid pipes 108 and 115 connected to respective flexible fluid pipes 119 and 117, which are in turn connected to a manifold 121.

[0016] In accordance with some embodiments, quick-connect mechanisms 140 are provided for connecting each flexible fluid pipe to a corresponding rigid fluid pipe. The quick-connect mechanism 140 includes a first connection element attached to an end portion of the rigid fluid pipe, and a second connection element attached to an end portion of the corresponding flexible fluid pipe. The quick-connect mechanism has a sealing element to automatically provide a fluid seal when the first and second connection elements are disconnected. The sealing element can be in the form of a valve (*e.g.*, a ball valve that is released from a sealing position when the first and second connection elements are connected, but that is allowed to move to a sealing position when the first and second connection elements are disconnected). The sealing elements of the quick-connect mechanisms allow for heat-generating assemblies to be disconnected from the rigid fluid pipes while reducing the likelihood of leaking cooling fluids.

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[0017] A quick-connect mechanism is a connection mechanism that enables relatively easy snap-on connection and snap-off disconnection such that a user can connect or disconnect components without the use of tools. The flexible fluid pipes further enhance convenience when connecting or disconnecting since the flexible fluid pipes are easily manipulated when connecting the flexible fluid pipes to corresponding rigid pipes using the quick-connect mechanisms.

[0018] Fig. 2 is a schematic diagram of a portion of a rigid fluid pipe 200 (which can be any of rigid fluid pipes depicted in Figs. 1, 4, and 5), and a portion of a flexible fluid pipe 202 (which can be any one of flexible fluid pipes in Figs. 1, 4, and 5). Fig. 2 also shows a quick-connect mechanism 140 for releasably connecting the fluid pipes 200 and 202. The quick-connect mechanism 140 includes a first connection element 204 (attached to the rigid fluid pipe 200) and a second connection element 206 (attached to the flexible fluid pipe 202). One of the first and second connection elements can be a female connection element, and the other of the first and second connection elements can be a male connection element. The first connection element 204 has a sealing element 208 that provides an automatic seal when the first and second connection elements 204 and 206 are disconnected. As noted above, the sealing element 208 can be a valve, such as a ball valve.

[0019] Fig. 3 is a perspective view of the quick-connect mechanism 140 with the first and second connection elements 204 and 206 separated from each other. The first connection element 204 has a receptacle 302 to receive a male element 300 of the second connection element 206. The first connection element 204 includes a fitting for sealingly attaching the first connection element 204 to a rigid fluid pipe. Similarly, the second connection element 206 has a fitting 304 for sealingly engaging a flexible fluid pipe.

[0020] In operation, a user mounts the heat-generating assembly (102 or 130 in Fig. 1, for example) into the system housing, with the first and second connection elements 204 and 206 disconnected. Once the heat-generating assembly is mounted, a user can manipulate each flexible fluid pipe to position the second connection element 206 such that the user can push the second connection element 206 into the first connection element 204 to provide a snap-on connection.

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[0021] In the disconnected position depicted in Fig. 3, the valve (208 in Fig. 2) inside the first connection element 204 is in a sealing position, such that any cooling fluid in the rigid fluid pipe does not leak from the first connection element 204. Once the male element 130 of the second connection element 206 is pushed into the receptacle 302 of the first connection element 204, the valve inside the first connection element 204 is actuated to an open position.

[0022] Although the first connection element 204 is depicted as a female connection element, and the second connection element 206 is depicted as a male connection element, an alternative embodiment can implement the reverse, with the first connection element 204 implemented as a male connection element, whereas the second connection element 206 is implemented as a female connection element.

[0023] By employing the cooling assembly including flexible fluid pipes, rigid fluid pipes, and quick-connect mechanisms, in accordance with some embodiments, a solution is provided to enable easy installation or removal of heat-generating assemblies from a system housing, and to provide leak resistance when connecting/disconnecting fluid pipes.

[0024] In the foregoing description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these details. While the invention has been disclosed with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover such modifications and variations as fall within the true spirit and scope of the invention.

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What is claimed is:

- 1 1. A system comprising:
2 a housing;
3 a rigid fluid pipe fixedly mounted inside the housing to carry cooling fluid;
4 a first connection element attached to an end portion of the rigid fluid pipe;
5 a heat-generating assembly mounted inside the housing, wherein the heat-generating
6 assembly has a flexible fluid pipe; and
7 a second connection element attached to an end portion of the flexible fluid pipe,
8 wherein the first and second connection elements are removably connectable together and
9 provide an automatic sealing mechanism when the first and second connection elements are
10 disconnected.
- 1 2. The system of claim 1, wherein the first and second connection elements form a fluid
2 quick-connect mechanism.
- 1 3. The system of claim 1, wherein the first connection element has a sealing element to
2 fluidically seal the end portion of the rigid fluid pipe upon disconnection of the second
3 connection element from the first connection element.
- 1 4. The system of claim 1, wherein the heat-generating assembly comprises an electronic
2 device and a heat sink attached to the flexible fluid pipe.
- 1 5. The system of claim 4, wherein the heat-generating assembly with the flexible fluid
2 pipe is mountable in the housing as a unit, and wherein the flexible fluid pipe is arranged to
3 enable manipulation for connecting the first and second connection elements.
- 1 6. The system of claim 4, wherein the electronic device is thermally contacted to the
2 heat sink, and wherein the heat sink has an internal fluid passage to receive cooling fluid
3 from the flexible fluid pipe.
- 1 7. The system of claim 6, wherein the heat-generating assembly further has a second
2 flexible fluid pipe, and the system further comprises:

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3 a second rigid fluid pipe fixedly mounted inside the housing; and
4 a connection mechanism for removably connecting the second flexible fluid pipe to
5 the second rigid fluid pipe, wherein the second flexible fluid pipe is to carry heated cooling
6 fluid away from the heat sink.

1 8. The system of claim 1, wherein the heat-generating assembly is removably mounted
2 in the system.

1 9. The system of claim 1, wherein the heat-generating assembly comprises a heat
2 exchanger.

1 10. The system of claim 9, wherein the heat exchanger includes heat fins and at least one
2 fan to generate a flow of air across the fins.

1 11. A method of providing cooling to a system having a housing, comprising:
2 fixedly mounting a rigid fluid pipe inside the housing to carry a cooling fluid;
3 mounting a heat-generating assembly inside the housing, wherein the heat-generating
4 assembly has a flexible fluid pipe; and
5 removably connecting the rigid fluid pipe to the flexible fluid pipe using a
6 quick-connect mechanism, wherein the quick-connect mechanism has an automatic sealing
7 mechanism to reduce likelihood of leakage of the cooling fluid upon disconnection of the
8 quick-connect mechanism.

1 12. The method of claim 11, wherein removably mounting the heat-generating assembly
2 inside the housing comprises removably mounting an assembly including a heat sink in an
3 electronic device thermally contacted to the heat sink.

1 13. The method of claim 11, wherein removably mounting the heat-generating assembly
2 comprises removably mounting a heat exchanger that includes heat fins and one or more fans.

1 14. The method of claim 11, further comprising:
2 fixedly mounting additional rigid fluid pipes inside the housing; and

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3 organizing locations of the rigid fluid pipes to enable convenient insertion and
4 removal of the heat-generating assembly.

1 15. The method of claim 14, further comprising:
2 providing additional flexible fluid pipes attached to the heat-generating assembly; and
3 removably connecting the additional flexible fluid pipes to corresponding additional
4 rigid fluid pipes using respective quick-connect mechanisms.

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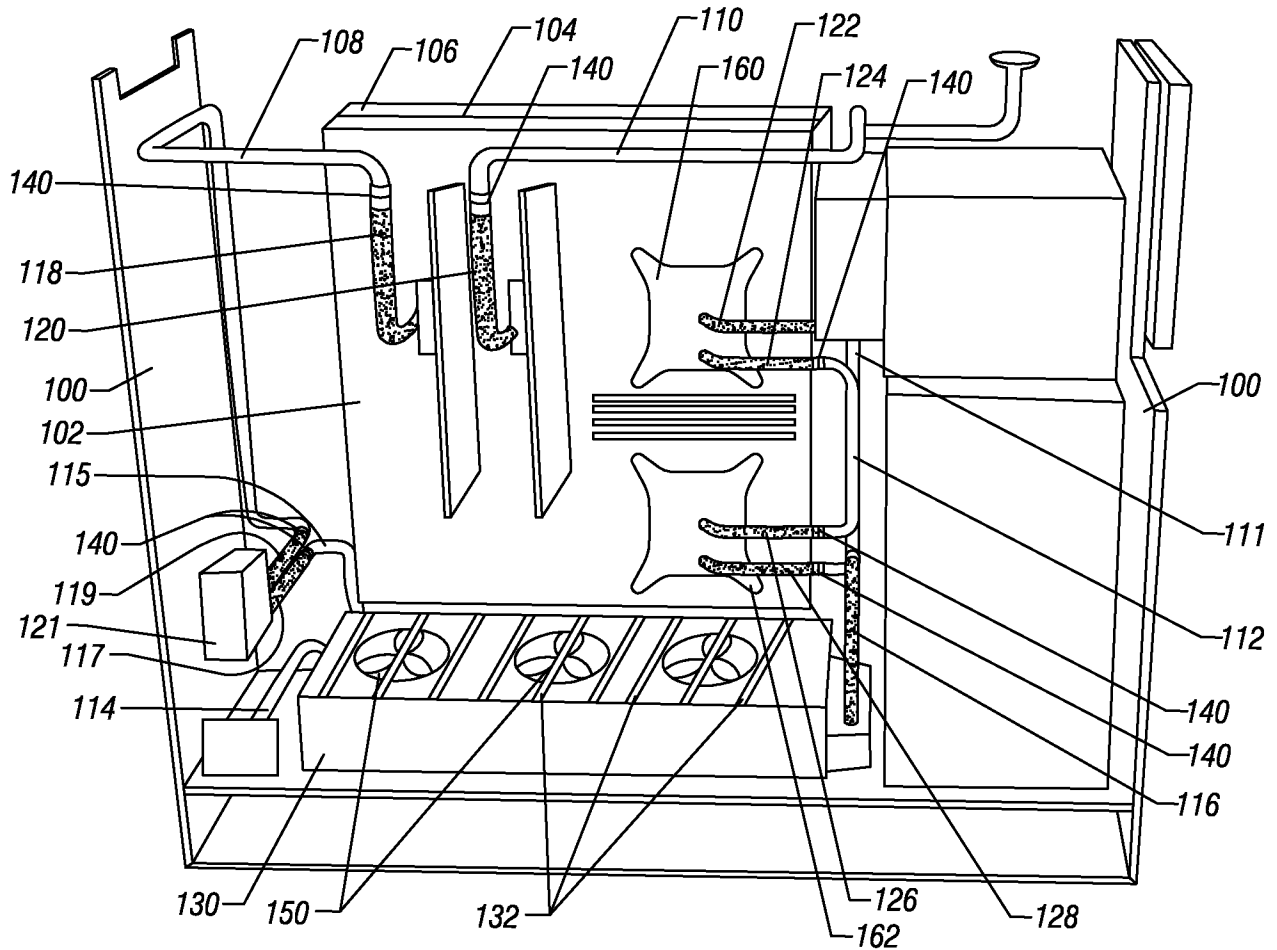


FIG. 1

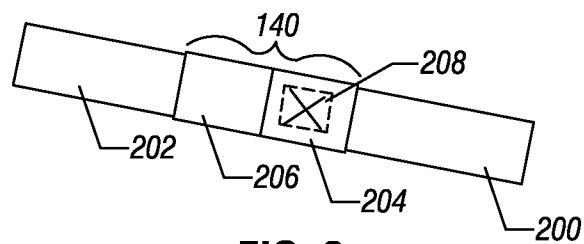


FIG. 2

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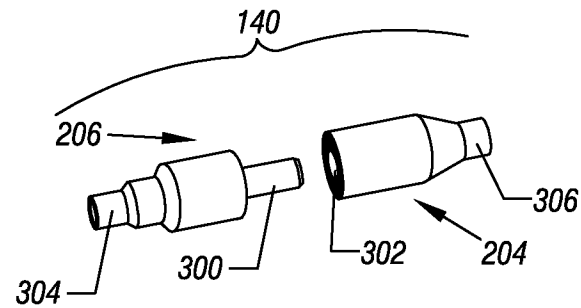


FIG. 3

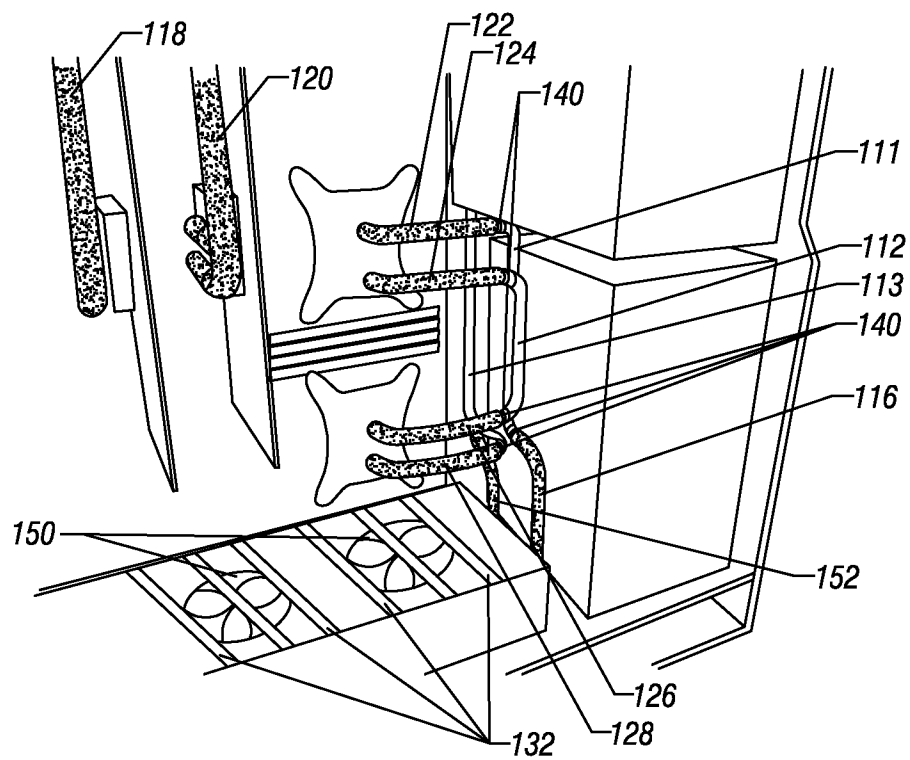


FIG. 4

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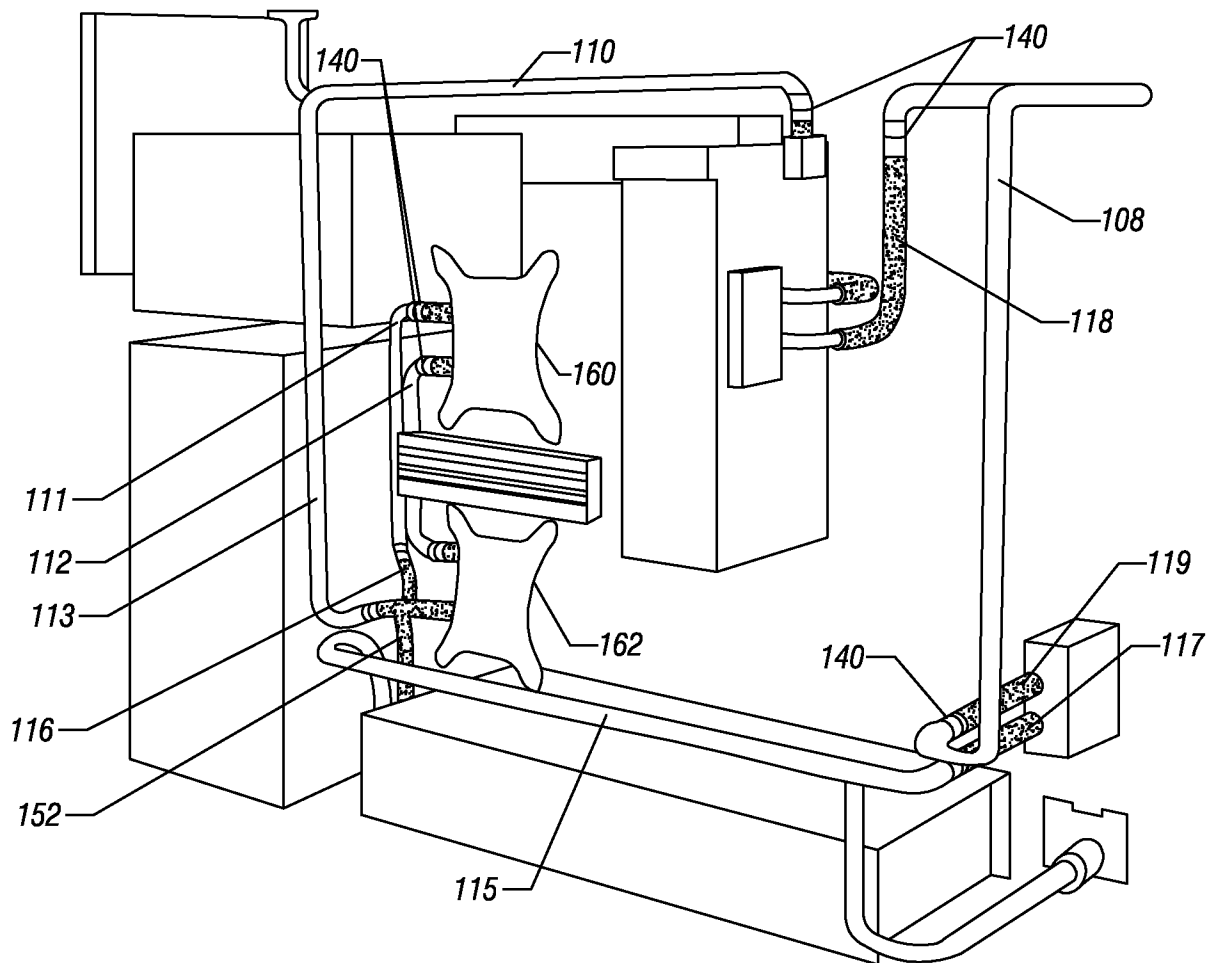


FIG. 5

A. CLASSIFICATION OF SUBJECT MATTER**G06F 1/20(2006.01)i, H05K 7/20(2006.01)i, G06G 7/57(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC G06F, H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS(KIPO internal) "Keywords: cooling system including fluid pipes and similar terms"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-175075 A (HITACHI CABLE LTD.) 30 June 2005 See the abstract, paragraphs [0013-0021], and figure 2.	1-15
Y	US 2005-241802 A1 (CHRISTOPHER G. MALONE et al.) 03 November 2005 See the abstract, paragraphs [0011, 0016, 0038], and figures 1A, 4.	1-15
Y	US 5144531 A (ZAMA HIROSHI GO et al.) 01 September 1992 See the abstract, column 1, line 66 - column 3, line 4, column 3, line 55 - column 4, line 6, column 4, line 35 - line 37, and figures 1-3.	1-15
A	US 2005-0243517 A1 (CHRISTOPHER G. MALONE) 03 November 2005 See the abstract, paragraphs [0003, 0011-0014, 0018], and figures 1A-1B.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2005-175075 A	30.06.2005	None	
US 2005-241802 A1	03.11.2005	GB 0506329 D0 GB 2413704 A GB 2413704 B JP 2005-317969 A	04.05.2005 02.11.2005 21.05.2008 10.11.2005
US 5144531 A	01.09.1992	JP 03-208365 A	11.09.1991
US 2005-0243517 A1	03.11.2005	GB 0506335 D0 GB 2413707 A GB 2413707 B JP 2005-317013 A US 6989990 B2	04.05.2005 02.11.2005 21.11.2007 10.11.2005 24.01.2006