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(54) Title: HEAT DISTRIBUTION OF COMPUTING DEVICES

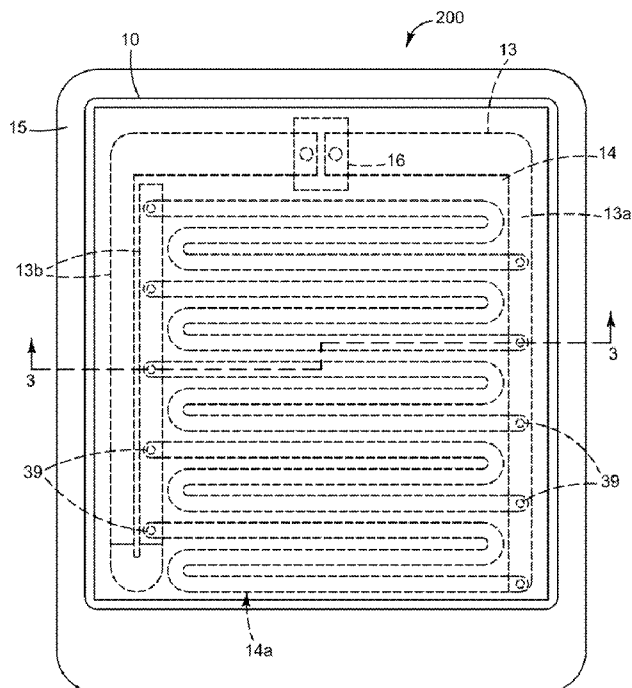


FIG. 2

(57) Abstract: A computing device, a tablet computing system and a method are disclosed. The computing device, tablet computing system, and a method include a display, electronic components, a plurality of layers, and a pump. The pump provides fluid through channels of the layers to redistribute heat from the electronic components.



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— *as to the identity of the inventor (Rule 4.17(i))*

HEAT DISTRIBUTION OF COMPUTING DEVICES

BACKGROUND

[0001] Computing devices such as tablets, laptop computers, notebook computers, and the like, may allow users to perform computing functions, social media functions, gaming functions, and communicate via email, and the like, in a mobile environment. The users may hold or contact the computing devices. In operation, the computing devices may generate heat.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Non-limiting examples are described in the following description, read with reference to the figures attached hereto and do not limit the scope of the claims. Dimensions of components and features illustrated in the figures are chosen primarily for convenience and clarity of presentation and are not necessarily to scale. Referring to the attached figures:

[0003] FIG. 1 is a block diagram illustrating a computing device according to an example.

[0004] FIG. 2 is a schematic view illustrating a computing device according to an example.

[0005] FIG. 3 is a cross-sectional view along line 3-3 illustrating the computing device of FIG. 2 according to an example.

[0006] FIG. 4 is a schematic view illustrating a fin layer in communication with a manifold layer of the computing device of FIG. 2 according to an example.

[0007] FIG. 5 is a schematic view illustrating respective channels of the computing device of FIG. 2 according to an example.

[0008] FIG. 6 is a schematic view illustrating several fin channels of the computing device of FIG. 2 according to an example.

[0009] FIG. 7 is a schematic view illustrating fluid flow paths through respective channels of the computing device of FIG. 2 according to an example.

[0010] FIG. 8 is a block diagram illustrating a tablet computing system according to an example.

[0011] FIG. 9 is a flowchart illustrating a method to redistribute heat of a computing device according to an example.

DETAILED DESCRIPTION

[0012] Computing devices such as tablets, laptop computers, notebook computers, and the like, may allow users to perform computing functions, social media functions, gaming functions, and communicate via email, and the like, in a mobile environment. For example, the users may hold or contact the computing devices during its operation. Further, in operation, the computing devices may generate heat. That is, electronic components of the computing devices such as processors, and the like, may generate heat in processing information.

[0013] In some computing devices, an increase in functionality, processing tasks, and processing speeds may increase an amount of heat generated by the electronic components and/or the amount and/or severity of hot spots on the product enclosure. For example, an increase in processing speed of the computing device may correlate to an increase in generated heat which results in an increase in a computing device surface temperature. Increasing a surface temperature may reduce user comfort. Continued increases in surface temperatures may result in product safety concerns and a potential failure to meet government regulatory requirements. Designers often compromise to limit heat generation by limiting computing performance. One such approach is to use lower performance processors limiting the capability of

the device. Heat generation may reduce user comfort and/or limit computing performance. Thus, user comfort and user experience may be reduced due to the increased temperature and/or the amount and/or severity of hot spots on the respective product enclosures.

[0014] Alternatively, the performance of the computing device may be dynamically limited (e.g., throttling) in order to increase user comfort. Throttling may also be applied to ensure chip temperature limits are not exceeded, or to reduce operating power when computing tasks do not require such operating power. Throttling may be accomplished dynamically by the systems BIOS firmware or other mechanism. That is, throttling reduces performance and, thus, may be undesirable. For example, if throttling is necessitated to control surface temperature and reduce user discomfort, it may negatively impact performance. Although, mechanical solutions may be used to reduce surface temperatures such as a remote heat exchanger approach used in traditional notebooks. In some designs, such a remote heat exchanger approach is impractical due to the thickness of the design.

[0015] In examples, a computing device includes an input/output member, electronic components, a housing enclosure, and a pump. The electronic components provide functionality of the computing device. The housing enclosure includes at least one manifold layer, at least one fin layer, and at least one outer housing layer. For example, the plurality of layers may be laminated as thin sheets into a product enclosure such as a computing device shell to function as a radiator. In some examples, the laminated, product enclosure may provide cooling of the computing device without requiring fans and/or heat pipes.

[0016] At least one manifold layer includes a manifold output channel and a manifold input channel. At least one fin layer includes a plurality of fin channels in fluid communication with the manifold output channel and the manifold input channel. The outer housing layer, for example, in a form of a product enclosure, provides support for a user to hold and/or contact the computing device. That is, a user of the computing device may hold the

exterior surface of the outer housing layer in order to interact and/or transport the computing device.

[0017] Also, the pump is in fluid communication with the manifold output channel and the manifold input channel. The pump provides fluid through the manifold output channel, the plurality of fin channels, and the manifold input channel to redistribute heat from the electronic components to the outer housing layer. For example, heat passes from the electronic components into the circulating fluid following the fluid flow passages and, is thus, distributed across the surface of the computing device. Consequently, the heat may leave the computing device evenly, and across a large surface area, resulting in reducing surface temperatures of the computing device.

[0018] Thus, the amount of hot spots on the product enclosures may be decreased and/or eliminated. Additionally, the temperature on the product enclosures may be reduced and/or maintained to provide comfort and a pleasant user experience to users holding and operating the computing devices. Also, the computing devices may have increased functionality and speed while not reducing the comfort and pleasant user experience of the users. That is, the removal of even more heat from the computing device resulting in reducing and/or eliminating hot spots may allow for an increase in processing speed.

[0019] FIG. 1 is a block diagram illustrating a computing device according to an example. Referring to FIG. 1, in some examples, a computing device 100 includes an input/output member 10, electronic components 11, a housing enclosure 12, and a pump 16. The input/output member 10 may convey information. For example, in some examples, the input/output member 10 may include a display to output information processed by the electronic components 11, for example, in a form of images such as text, graphics, and the like. In some examples, the display such as a touch screen may also input information to be processed by the electronic components 11. The electronic components 11 provide functionality of the computing device 100. The electronic components 11 may process and provide information to the display

10, and/or other components of the computing device 100. In some examples, the electronic components 11 may include processors, and the like.

[0020] Referring to FIG. 1, in some examples, the housing enclosure 12 includes at least one manifold layer 13, at least one fin layer 14, and at least one outer housing layer 15. The at least one manifold layer 13 includes a manifold output channel 13a and a manifold input channel 13b. The at least one fin layer 14 includes a plurality of fin channels 14a in fluid communication with the manifold output channel 13a and the manifold input channel 13b. The at least one outer housing layer 15 provides support for a user to hold the computing device 100. For example, the outer housing layer 15 may be in the form of a product enclosure.

[0021] Referring to FIG. 1, in some examples, the pump 16 is in fluid communication with the manifold output channel 13a and the manifold input channel 13b. In some examples, heat sinks may also communicate, for example, with the manifold output channel 13a to dissipate heat from the fluid. For example, the pump 16 may transport the fluid therein to the manifold output channel 13a, and receive the fluid from the manifold input channel 13b. That is, the pump 16 provides fluid through the manifold output channel 13a, the plurality of fin channels 14a, and the manifold input channel 13b to redistribute heat from the electronic components 11 to the outer housing layer 15. The outer housing layer 15. For example, the outer housing layer 15 may transfer the heat from the fluid in the fin channels 14a to air or surfaces proximate to an external surface of the outer housing layer 15. The outer housing layer 15 may provide support for a user to hold the computing system 100. For example, the outer housing layer 15 may be in the form of a product enclosure. In some examples, the computing device 100 may include a tablet, mobile workstation such as a laptop computer, a notebook computer, and the like.

[0022] FIG. 2 is a schematic view illustrating a computing device according to an example. FIG. 3 is a cross-sectional view along line 3-3 illustrating the computing device of FIG. 2 according to an example. FIG. 4 is a schematic view illustrating a fin layer in communication with a manifold layer of

the computing device of FIG. 2 according to an example. The computing device 200 may include the input/output member 10, the electronic components 11, the housing enclosure 12, and the pump 16 previously discussed with respect to the computing device 100 of FIG. 1. Referring to FIGS. 2-4, in some examples, the housing enclosure 12 may include an outer housing layer 15, a manifold layer 13, a fin layer 14, and an inner housing layer 35. In some examples, space 38 may exist between the input/output member 10 such as a display and an inner housing layer 35, for example, to enable electrical components, batteries, and the like to be disposed therein.

[0023] Referring to FIGS. 2-4, in some examples, each one of the outer housing layer 15, the manifold layer 13, the fin layer 14, and the inner housing layer 35 may be formed of rigid sheets. Additionally, the outer housing layer 15, the manifold layer 13, the fin layer 14, and the inner housing layer 35 may be laminated to each other. In some examples, the outer housing layer 15 may be formed of metal such as aluminum, and the like. In some examples, the respective layers 35, 13, 14, and 15 may adhere to each other through adhesive. For example, adhesive may be inserted between each one of the respective adjacent layers to form a laminated, housing enclosure. Thus, the laminated, housing enclosure may be in a form of a laminated, product enclosure such as a laminated, computing device shell.

[0024] Referring to FIGS. 2-4, in some examples, the at least one manifold layer 13 includes a manifold output channel 13a and a manifold input channel 13b. The at least one fin layer 14 includes a plurality of fin channels 14a in fluid communication with the manifold input channel 13b and the manifold output channel 13a. In some examples, the respective channels 13a, 13b, and 14a may be formed by etching, molding, drilling, and the like. The respective channels 13a, 13b, and 14a may communicate with each other, for example, by openings such as through-holes 39. The outer housing layer 15 provides support for a user to hold the computing device 200. For example, the computing device 200 may include a tablet computing device in which a user can hold an external surface of the outer housing layer 15. In some

examples, the user may grab the ends and/or edges of the outer housing layer 15.

[0025] Referring to FIGS. 2-4, in some examples, the fin channels 14a are arranged in a zigzag pattern proximate to an internal surface of the outer housing layer 15 to redistribute heat from the electronic components 11 thereto. In some examples, the fin channels 14a may be adjacent to an internal surface of the outer housing layer 15. The zigzag pattern may correspond to fin channels 14a having sharp turns in alternating directions. Thus, the flow of the fluid through various portions and/or segments of the respective fin channels 14a in a zigzag pattern may change its direction of travel from left to right, for example, to right to left, and the like. In some examples, a fluid flow rate may be varied to maintain a temperature of an external surface of the outer housing layer 15 within a predetermined range. In some examples, the turns may be rounded and/or curved to promote efficient fluid flow. The zigzag pattern of the fin channels 14a may be disposed in a broad area proximate to and expand across the inner surface of the outer housing layer 15.

[0026] FIG. 5 is a schematic view illustrating respective channels of the computing device of FIG. 2 according to an example. FIG. 6 is a schematic view illustrating several fin channels of the computing device of FIG. 2 according to an example. FIG. 7 is a schematic view illustrating fluid flow paths through respective channels of the computing device of FIG. 2 according to an example. Referring to FIGS. 5-7, in some examples, each one of the fin channels 14a include channel segments 14b such that the fluid flows through adjacent channel segments of a respective fin channel 14a in opposite directions d_1 and d_2 to each other. That is, the fluid may flow in a first direction d_1 from a first side of the area of the zigzag pattern towards a second side of the area of the zigzag pattern in one of the adjacent channel segments of the respective fin channels 14a as illustrated in FIG. 5. Additionally, the fluid may flow in a second direction d_2 from the second side of the area of the zigzag pattern towards the first side of the area of the zigzag pattern in another one of

the adjacent channel segments of the respective fin channels 14a as illustrated in FIG. 5.

[0027] Referring to FIGS. 5-7, in some examples, each one of the respective fin channels 14a may include an initial channel segment 14_{bi}, an intermediate channel segment 14_{bm}, and a final channel segment 14_{bf}. In some examples, a respective initial channel segment 14_{bi} of one fin channel 14_{a1} is positioned adjacent to a respective final channel segment 14_{bf} of another fin channel 14_{a2}. The initial channel segment 14_{bi} may receive the fluid from the manifold output channel 13a. The intermediate channel segment 14_{bm} may receive the fluid from the initial channel segment 14_{bi} and provide it to the final channel segment 14_{bf}. The final channel segment 14_{bf} may receive the fluid from the intermediate channel segment 14_{bm} and provide it to the manifold input channel 13b. Typically, the fluid in the initial channel segment 14_{bi} of a respective fin channel has a higher temperature than the fluid leaving the final channel segment 14_{bf} of the respective fin channel. That is, the temperature of the fluid is lowered as the fluid proceeds and the heat dissipates along the respective fin channel.

[0028] Thus, positioning a respective initial channel segment 14_{bi} of one fin channel 14_{a1} having fluid therein of a higher temperature adjacent to a respective final channel segment 14_{bf} of another fin channel 14_{a2} having a fluid therein of a lower temperature assists in maintaining a uniform temperature across the outer housing layer 15 and/or reducing an amount of hot spots thereof. The outer housing layer 15 is configured to transfer the heat from the fluid in the fin channels 14a to air or surfaces proximate to an external surface of the outer housing layer 15. In some examples, the temperature across the external surface of the outer housing layer 15 is uniform. Alternatively, in some examples, a temperature of the external surface of the outer housing layer 15 is maintained within a predetermined range during operation thereof.

[0029] Referring to FIGS. 5-7, in some examples, the computing device 200 may also include a plurality of through-holes 39, a first flow path 78a, and a second flow path 78b. In some examples, the pump 16 is in fluid

communication with the manifold output channel 13a and the manifold input channel 13b. The pump 16 provides fluid through the manifold output channel 13a, the plurality of fin channels 14a, and the manifold input channel 13b to redistribute heat from the electronic components 11 to the outer housing layer 15. In some examples, heat sinks may also be used to efficiently convey heat from the electronic components 11 to the circulating fluid. In some examples, the pump 16 includes a piezoelectric pump disposed on the outer housing layer 15.

[0030] Referring to FIGS. 5-7, in some examples, the plurality of through-holes 39 may provide fluid communication between the respective fin channels 14a, and each one of the manifold output channel 13a and the manifold input channel 13b. The first flow path 78a of fluid extends from the pump 16, through the manifold output channel 13a, through one of the fin channels, and through the manifold input channel 13b to the pump 16 corresponding to a first length. The second flow path 78b of fluid extends from the pump 16, through the manifold output channel 13a, through another one of the fin channels, and through the manifold input channel 13b to the pump 16 corresponding to a second length which is about equal to the first length. For example, equal length flow paths 78a and 78b may assist in providing equally balanced flow rates. In some examples, the fluid is water and/or a water-based coolant.

[0031] FIG. 8 is a block diagram illustrating a tablet computing system according to an example. Referring to FIG. 8, in some examples, a tablet computing system 800 includes a display 80, electronic components 11, a housing enclosure 12, and a pump 16. The display 80 may output information from the electronic components 11, for example, in a form of images such as text, graphics, and the like. In some examples, the display 80 may also input information to be processed by the electronic components 11. For example, the display 80 may include a touch screen.

[0032] Referring to FIG. 8, in some examples, the electronic components 11 provide functionality of the tablet computing system 800. The

electronic components 11 may process and provide information to the display 80, and/or other components of the tablet computing system 800. The housing enclosure 12 includes an inner housing layer 35, a manifold layer 13, a fin layer 14, and an outer housing layer 15. The fin layer 14 and the manifold layer 13 are disposed between the inner housing layer 35 and the outer housing layer 15. In some examples, the inner housing layer 35, the manifold layer 13, the fin layer 14, and the outer housing layer 15 are laminated to each other to form a laminated, housing enclosure. In some examples, the housing enclosure 12 may include additional layers. For example, the laminated, housing enclosure may be in a form of a product enclosure such as an integrated, tablet shell.

[0033] Referring to FIG. 8, in some examples, the manifold layer 13 includes a manifold output channel 13a and a manifold input channel 13b. The fin layer 14 includes a plurality of fin channels 14a in fluid communication with the manifold output channel 13a and the manifold input channel 13b. The fin channels 14a are arranged in a zigzag pattern proximate to an internal surface of the outer housing layer 15. The outer housing layer 15 provides support for a user to hold the tablet computing system 800.

[0034] Referring to FIG. 8, in some examples, the pump 16 is in fluid communication with the manifold output channel 13a and the manifold input channel 13b. The pump 16 provides fluid through the manifold output channel 13a, the plurality of fin channels 14a, and the manifold input channel 13b to redistribute heat from the electronic components 11 to the outer housing layer 15. The outer housing layer 15 is configured to transfer the heat from the fluid in the fin channels 14a to air or surface proximate to an external surface of the outer housing layer 15. In some examples, the tablet computing system 800 may also include a plurality of through-holes 39 to provide fluid communication between the respective fin channels 14a, and each one of the manifold output channel 13a and the manifold input channel 13b. In some examples, heat sinks may also communicate, for example, with the manifold output channel 13a to dissipate heat into the fluid.

[0035] FIG. 9 is a flowchart illustrating a method to redistribute heat of a computing device according to an example. In some examples, the modules, assemblies, and the like, previously discussed with respect to FIGS. 1-8 may be used to implement the method of FIG. 9. Referring to FIG. 9, in block S910, fluid is pumped through respective flow paths of a plurality of channels extending through a plurality of layers of a housing enclosure of a computing device by a pump.

[0036] In some examples, the plurality of layers may include a fin layer, a manifold layer, and through-holes therein. The fin layer may include a plurality of fin channels in a zigzag pattern in an area proximate to the outer housing layer. The zigzag pattern may correspond to fin channels having sharp turns in alternating directions. In some examples, the turns may be rounded and/or curved to promote efficient fluid flow. In some examples, each one of the fin channels include channel segments such that the fluid flows through adjacent channel segments of a respective fin channel in opposite directions to each other.

[0037] In some examples, each one of the respective fin channels may include an initial channel segment, an intermediate channel segment, and a final channel segment such that a respective initial channel segment of one fin channel is positioned adjacent to a respective final channel segment of another fin channel. The manifold layer may be laminated to the fin layer. The manifold layer may include a manifold output channel and a manifold input channel. The through-holes may provide fluid communication between the fin channels, and each one of the manifold output channel and the manifold input channel.

[0038] In block S912, heat is redistributed from electronic components disposed within the housing enclosure to an outer housing layer of the housing enclosure by the fluid passing through the channels. In block S914, support is provided for a user to hold the computing device by the outer housing layer. For example, the outer housing layer may be in a form of a

product enclosure. In some examples, the method may also include providing lengths corresponding to the respective flow paths about equal to each other.

[0039] It is to be understood that the flowchart of FIG. 9 illustrates architecture, functionality, and/or operation of examples of the present disclosure. Although the flowchart of FIG. 9 illustrates a specific order of execution, the order of execution may differ from that which is depicted. For example, the order of execution of two or more blocks may be rearranged relative to the order illustrated. Also, two or more blocks illustrated in succession in FIG. 9 may be executed concurrently or with partial concurrence. All such variations are within the scope of the present disclosure.

[0040] The present disclosure has been described using non-limiting detailed descriptions of examples thereof that are not intended to limit the scope of the general inventive concept. It should be understood that features and/or operations described with respect to one example may be used with other examples and that not all examples have all of the features and/or operations illustrated in a particular figure or described with respect to one of the examples. Variations of examples described will occur to persons of the art. Furthermore, the terms "comprise," "include," "have" and their conjugates, shall mean, when used in the disclosure and/or claims, "including but not necessarily limited to."

[0041] It is noted that some of the above described examples may include structure, acts or details of structures and acts that may not be essential to the general inventive concept and which are described for illustrative purposes. Structure and acts described herein are replaceable by equivalents, which perform the same function, even if the structure or acts are different, as known in the art. Therefore, the scope of the general inventive concept is limited only by the elements and limitations as used in the claims.

CLAIMS

WHAT IS CLAIMED IS:

1. A computing device, comprising:
 - an input/output member to convey information;
 - electronic components to provide functionality;
 - a housing enclosure including at least one manifold layer, at least one fin layer, and at least one outer housing layer;
 - the at least one manifold layer including a manifold output channel and a manifold input channel;
 - the at least one fin layer including a plurality of fin channels in fluid communication with the manifold input channel and the manifold output channel; and
 - the outer housing layer to provide support for a user to hold the computing device; and
 - a pump in fluid communication with the manifold input channel and the manifold output channel, the pump to provide fluid through the manifold output channel, the plurality of fin channels, and the manifold input channel to redistribute heat from the electronic components to the outer housing layer.
2. The computing device of claim 1, further comprising:
 - a plurality of through-holes to provide fluid communication between the respective fin channels, and each one of the manifold input channel and the manifold output channel.
3. The computing device of claim 1, wherein:
 - a first flow path of fluid extends from the pump, through the manifold output channel, through one of the fin channels, and through the manifold input channel to the pump corresponding to a first length; and

a second flow path of fluid extends from the pump, through the manifold output channel, through another one of the fin channels, and through the manifold input channel to the pump corresponding to a second length which is about equal to the first length.

4. The computing device of claim 1, wherein the fin channels are arranged in a zigzag pattern proximate to an internal surface of the outer housing layer to redistribute heat from the electronic components thereto.

5. The computing device of claim 1, wherein the heat is transferred from the fluid in the fin channels to air or a surface proximate to an external surface of the outer housing layer.

6. The computing device of claim 1, wherein a fluid flow rate is varied to maintain a temperature of an external surface of the outer housing layer within a predetermined range.

7. The computing device of claim 1, wherein a temperature across an external surface of the outer housing layer is substantially uniform.

8. The computing device of claim 1, wherein the pump comprises:
a piezoelectric pump disposed on the outer housing layer.

9. The computing device of claim 1, wherein the housing enclosure further comprises:
an inner housing layer.

10. The computing device of claim 1, wherein the computing device is a tablet computing device.

11. A tablet computing system, comprising:

a display to display information;

electronic components to provide functionality;

a housing enclosure including an inner housing layer, an outer housing layer, a manifold layer, and a fin layer;

the manifold layer disposed between the inner housing layer and the outer housing layer, the manifold layer including a manifold output channel and a manifold input channel;

the fin layer disposed between the inner housing layer and the outer housing layer, the fin layer including a plurality of fin channels in fluid communication with the manifold input channel and the manifold output channel such that the fin channels are arranged in a zigzag pattern proximate to an internal surface of the outer housing layer; and

the outer housing layer to provide support for a user to hold the tablet computing device; and

a pump in fluid communication with the manifold input channel and the manifold output channel, the pump to provide fluid through the manifold output channel, the plurality of fin channels, and the manifold input channel to redistribute heat from the electronic components to the outer housing layer.

12. The tablet computing system of claim 11, wherein the inner housing layer, the manifold layer, the fin layer, and the outer housing layer are laminated to each other to form a laminated, housing enclosure.

13. A method to redistribute heat of a computing device, the method comprising:

pumping fluid through respective flow paths of a plurality of channels extending through a plurality of layers of a housing enclosure of a computing device by a pump;

redistributing heat from electronic components disposed within the housing enclosure to an outer housing layer of the housing enclosure by the fluid passing through the channels; and

providing support for a user to hold the computing device by the outer housing layer.

14. The method of claim 13, further comprising:
providing lengths corresponding to the respective flow paths about equal to each other.

15. The method of claim 13, wherein the plurality of layers further comprise:

a fin layer including a plurality of fin channels in a zigzag pattern in an area proximate to the outer housing layer, each one of the fin channels including a plurality of channel segments such that the fluid flows through adjacent channel segments of a respective fin channel flow in opposite directions to each other;

a manifold layer laminated to the fin layer, the manifold layer including a manifold output channel and a manifold input channel; and

a plurality of through-holes to provide fluid communication between the fin channels, and each one of the manifold output channel and the manifold input channel.

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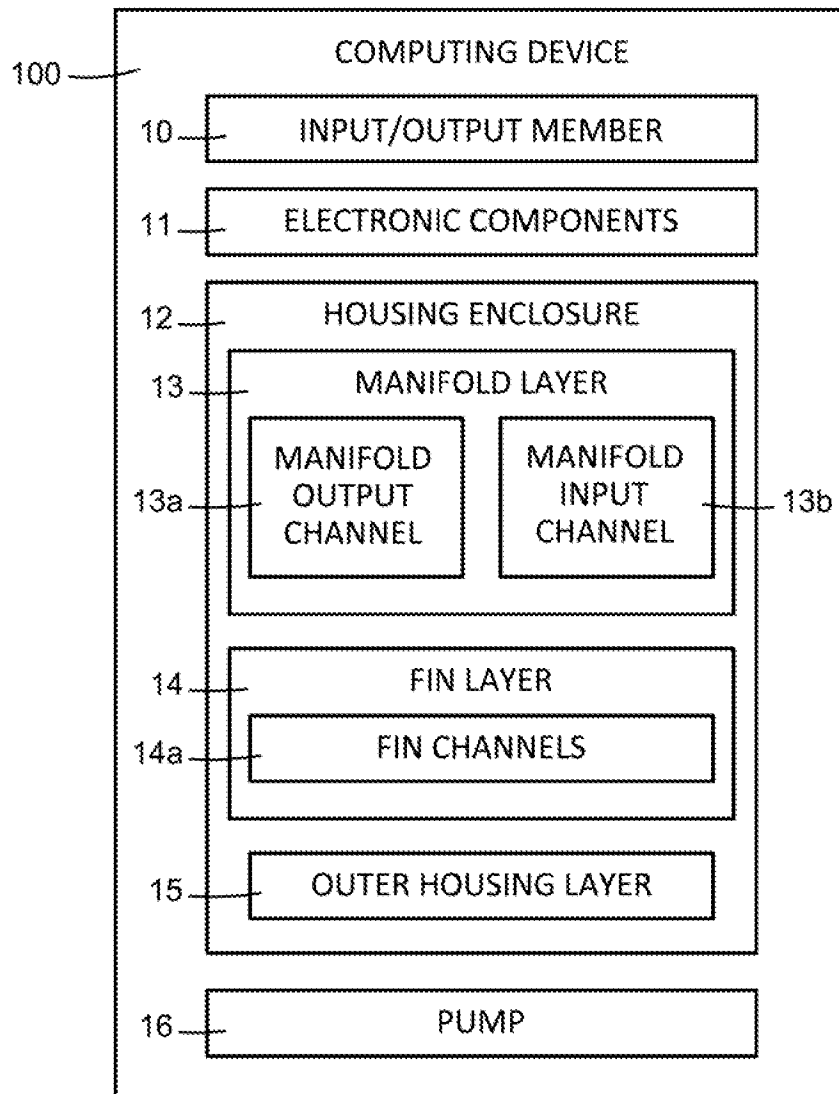


FIG. 1

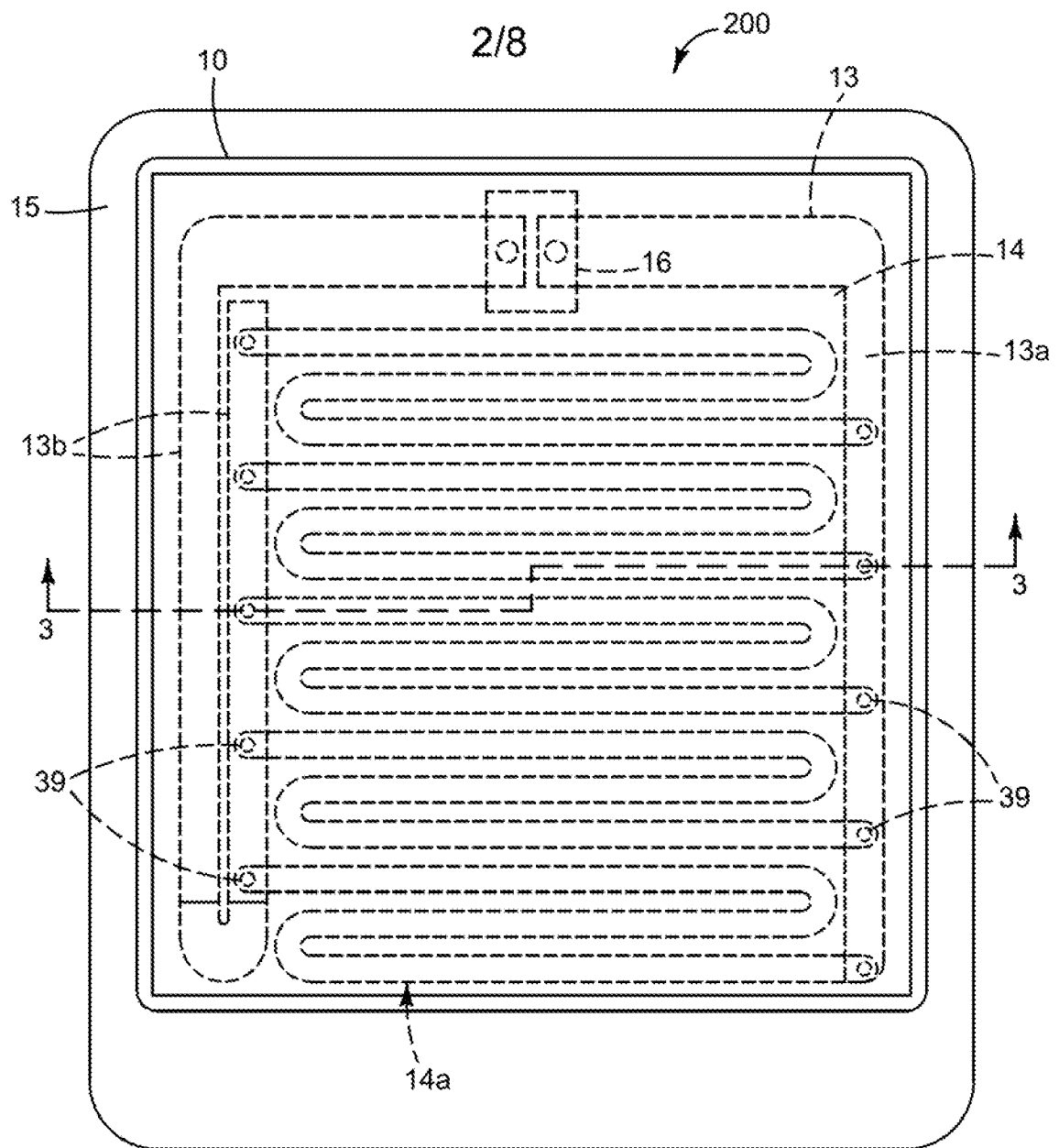


FIG. 2

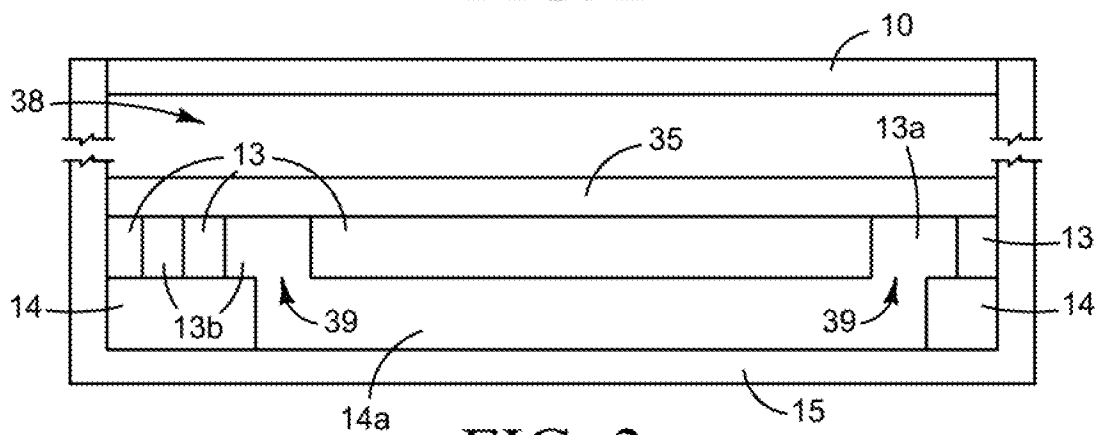


FIG. 3

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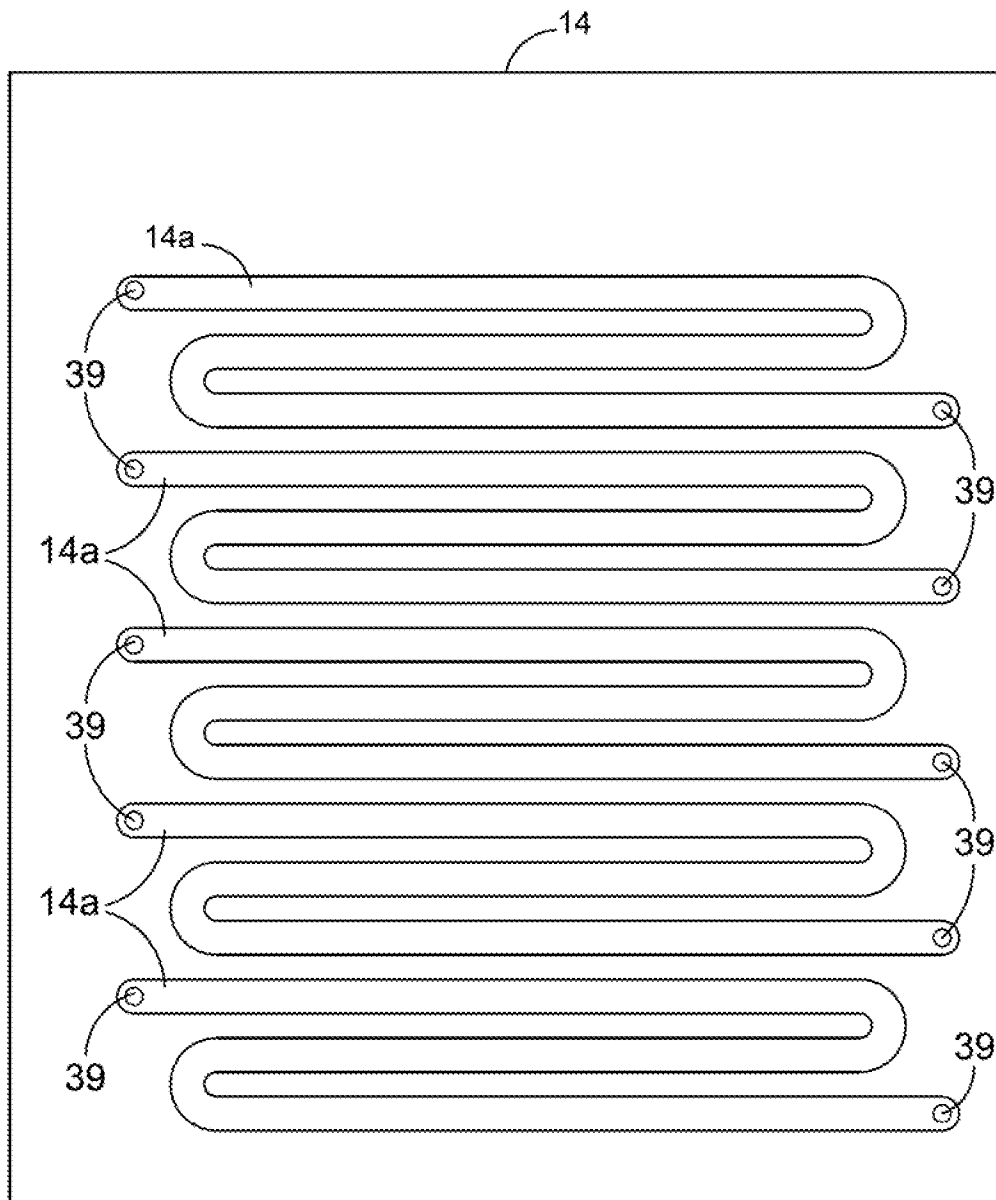


FIG. 4

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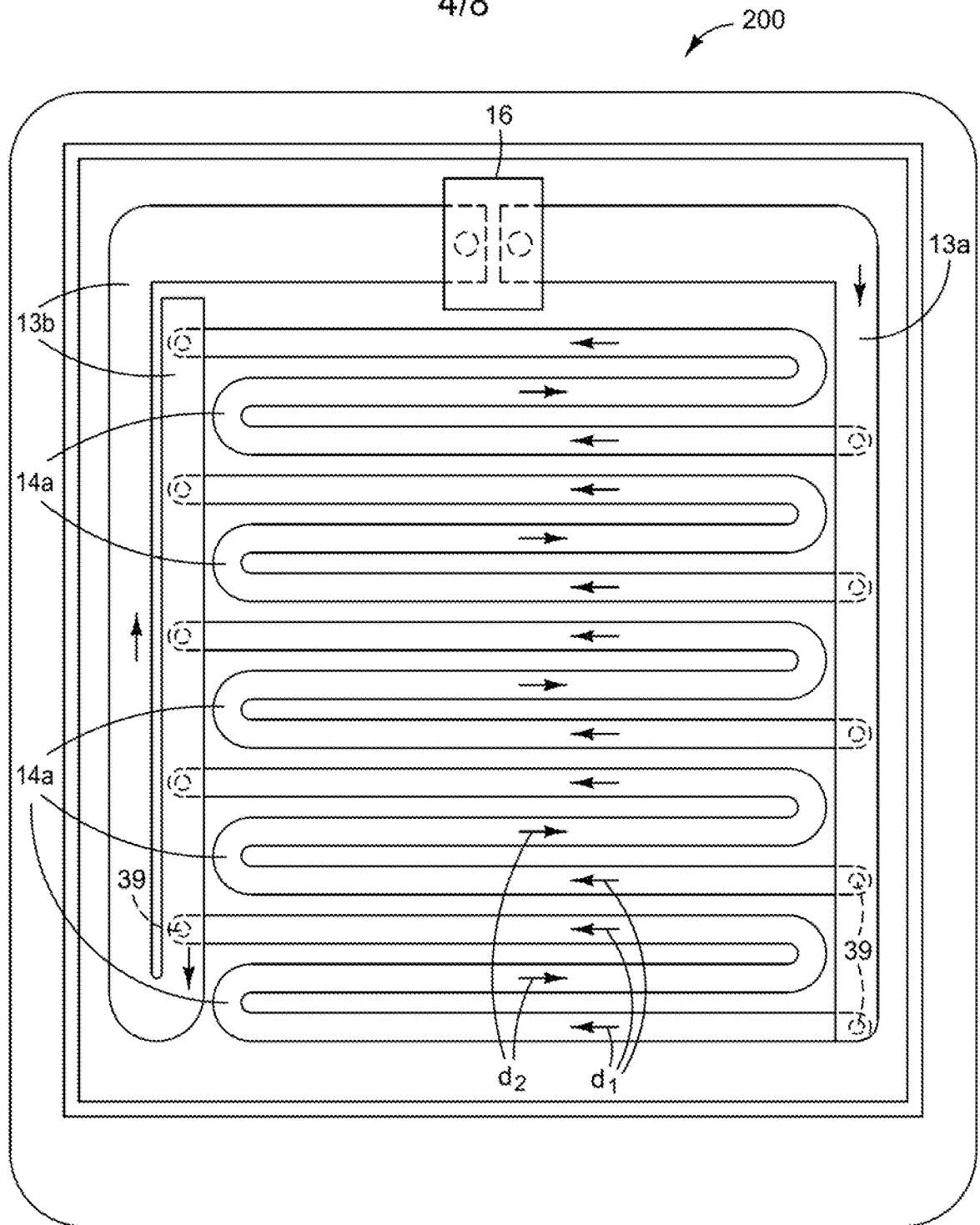


FIG. 5

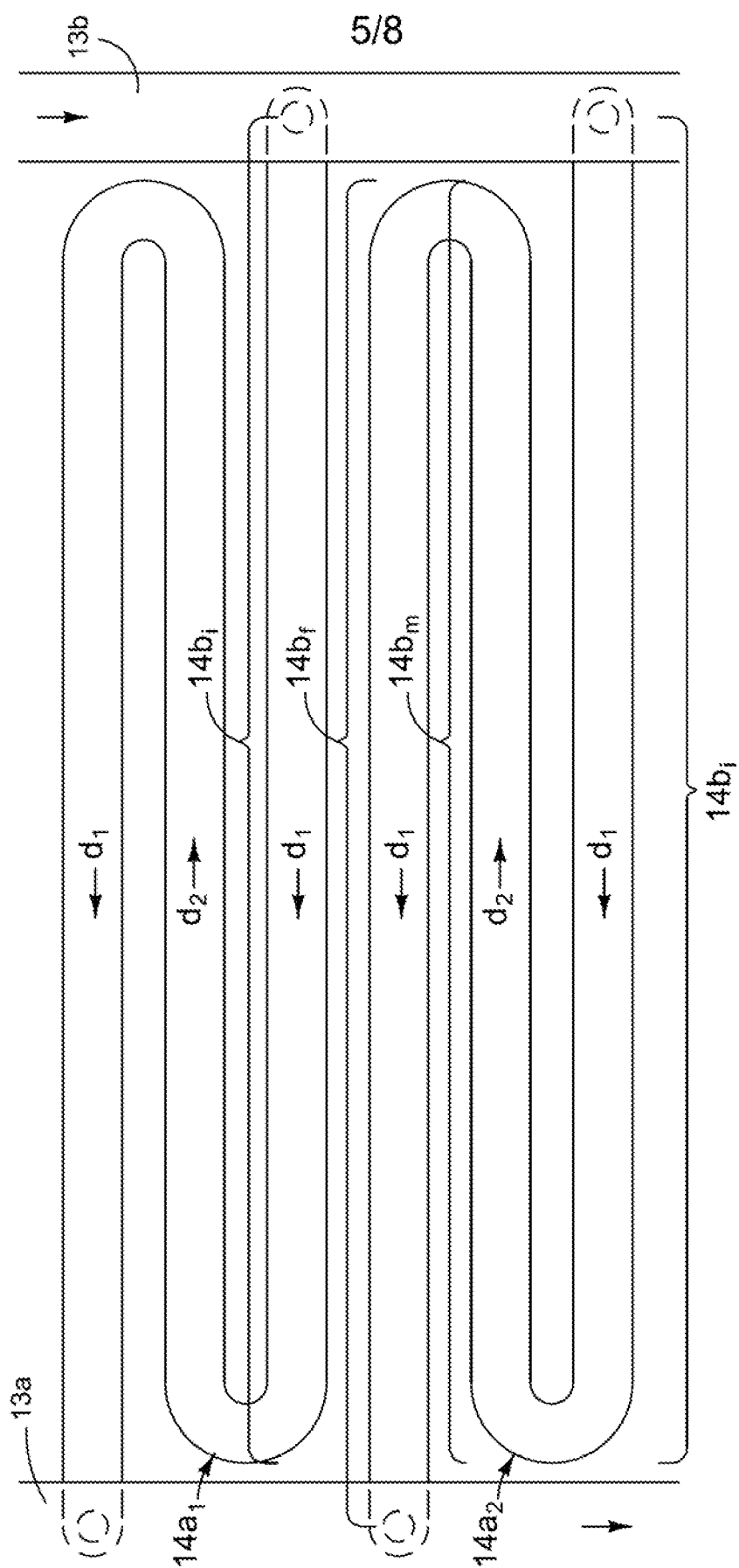


FIG. 6

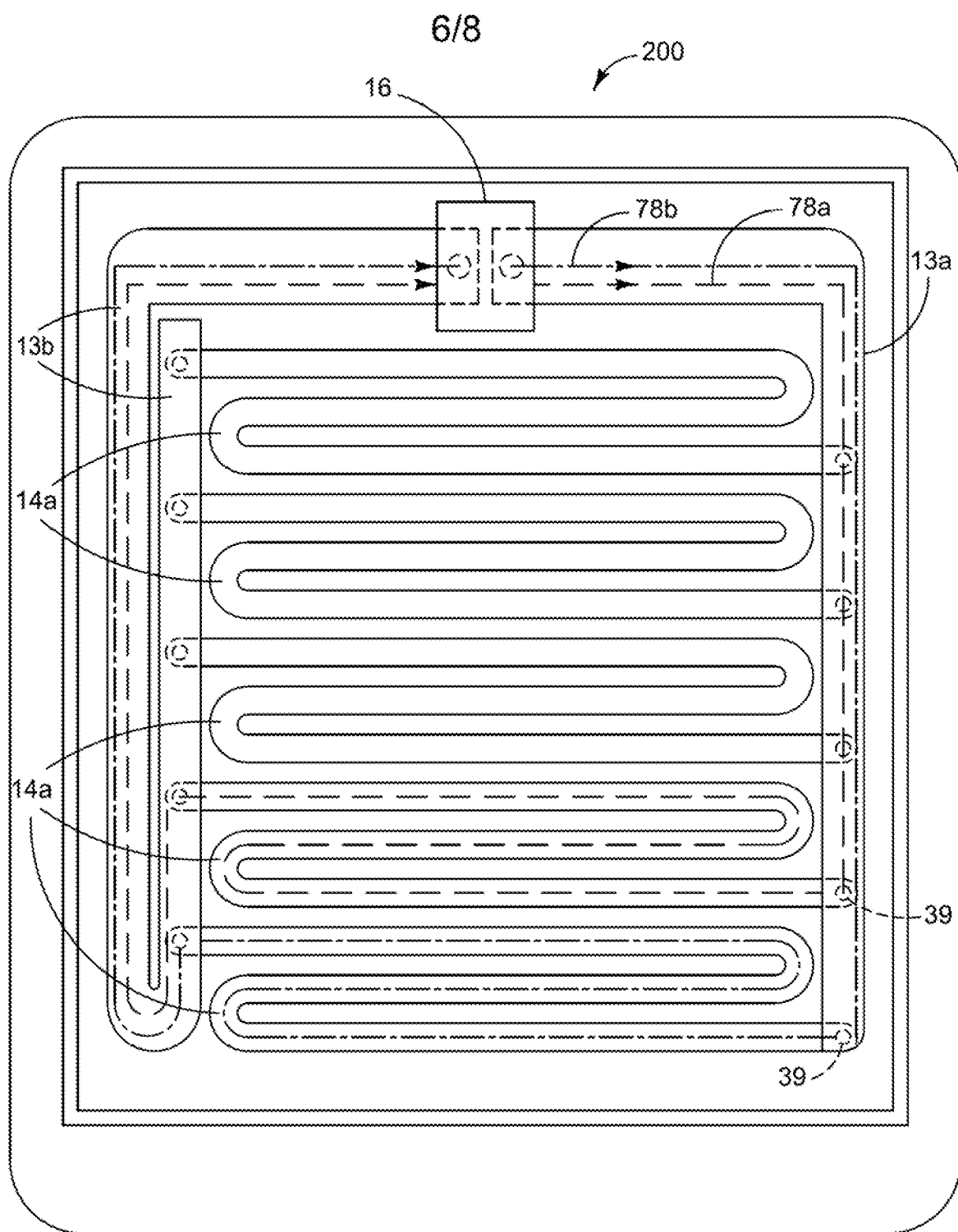


FIG. 7

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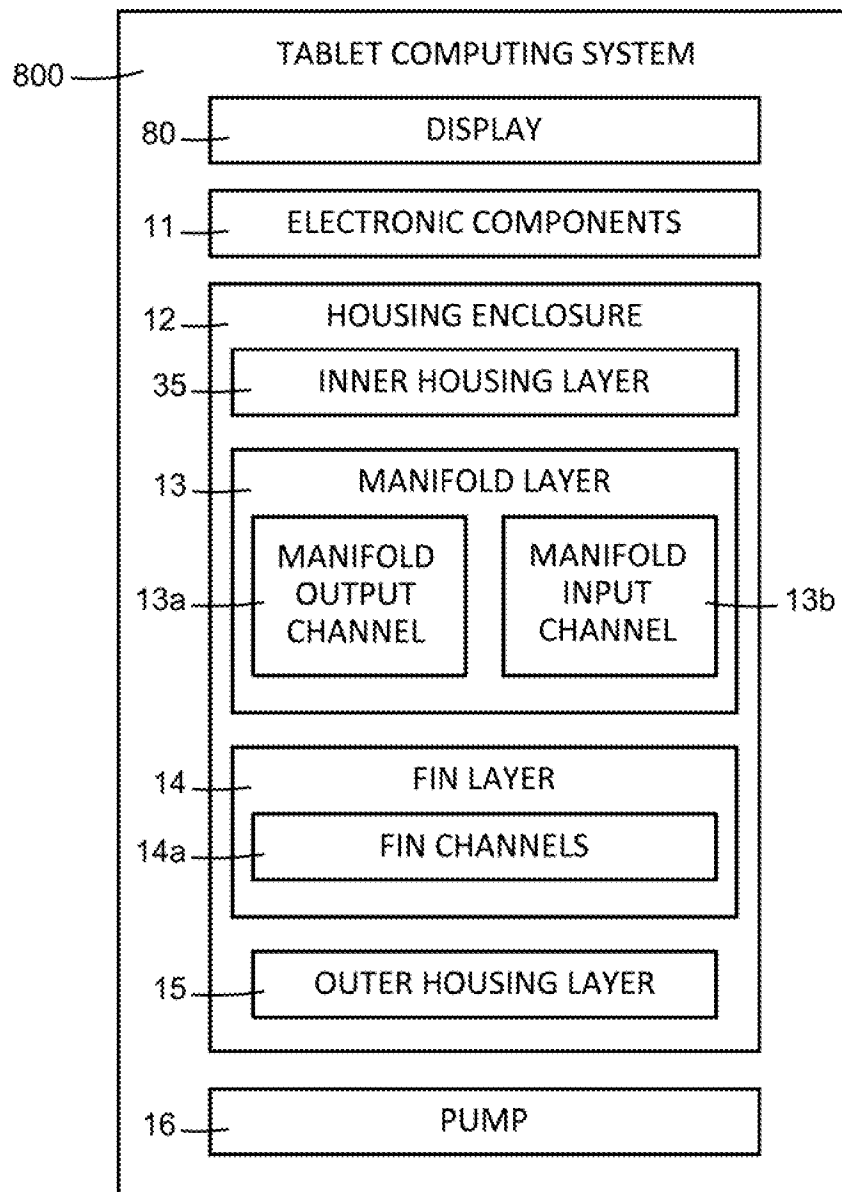


FIG. 8

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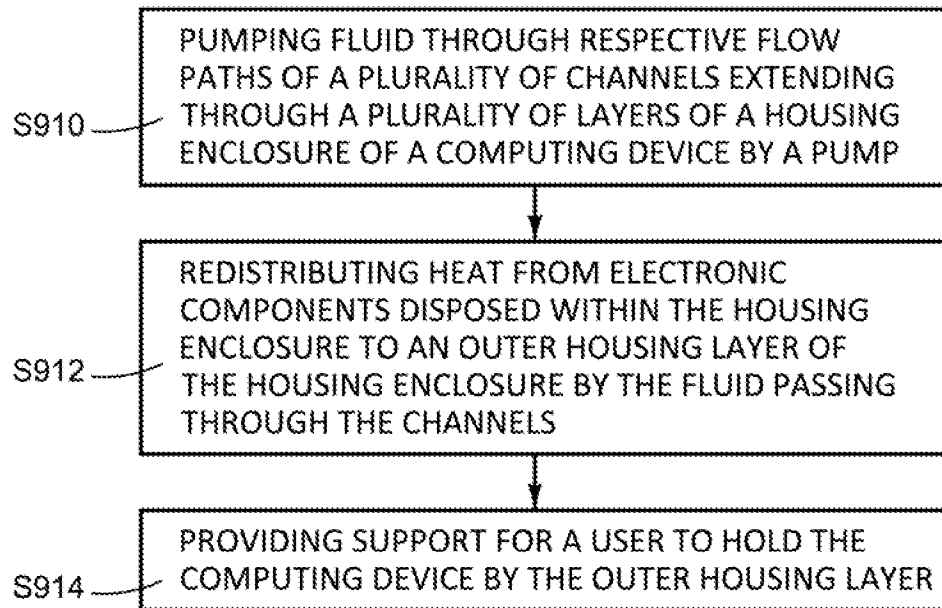


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/044615**A. CLASSIFICATION OF SUBJECT MATTER****G06F 1/20(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)

G06F 1/20; H05K 7/20; F28D 15/00; H01L 23/473

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

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: housing, heat, pump, manifold, fin, layer, channel, fluid

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2004-0001310 A1 (RICHARD C. CHU et al.) 01 January 2004 See paragraphs [0007], [0009], [0028]; and figures 1, 3B-4A.	1-15
A	US 2013-0301213 A1 (BORYS S. SENYK et al.) 14 November 2013 See paragraph [0018]; and figure 2.	1-15
A	US 2013-0271913 A1 (MARK MACDONALD) 17 October 2013 See paragraph [0050]; and figure 2B.	1-15
A	EP 1564626 A1 (HITACHI, LTD.) 17 August 2005 See paragraph [0010]; and figure 1.	1-15
A	US 2006-0039112 A1 (RINTARO MINAMITANI et al.) 23 February 2006 See paragraph [0048]; and figure 1.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

23 February 2015 (23.02.2015)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/044615

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