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(54) **THREE-DIMENSION HEAT TRANSMISSION DEVICE**

(57) A three-dimensional (3D) heat transfer device that includes a thermal conductive shell body having a liquid-tight chamber, at least one first pipe having a first end connected to the thermal conductive shell body and in communicate with the liquid-tight chamber, and at least one second pipe having at least two portions that are connected to the thermal conductive shell and in communicate with the liquid-tight chamber.

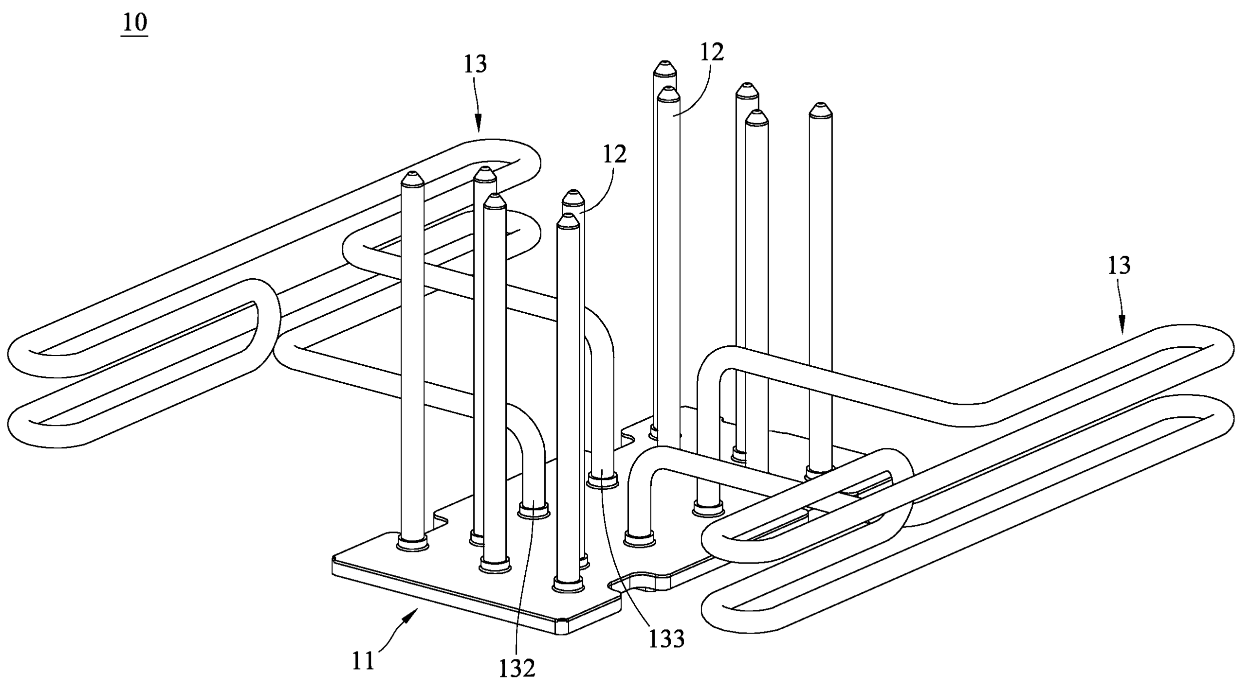

FIG. 1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat transfer device, in particular a three-dimensional heat transfer device.

BACKGROUND

[0002] Generally, a heat transfer device includes a heat transfer plate, a heat pipe, and a heat dissipater (e.g., fins and fan) to dissipate heat generated by a heat source. In detail, the heat transfer plate contacts the heat source to absorb heat, and the heat pipe is disposed between the heat transfer plate and the heat dissipater to transfer the heat to the heat dissipater to dissipate the heat via the heat dissipater.

[0003] In conventional heat transfer devices, capillary structures in both the heat transfer plate and the heat pipe are proximate with each other but not connected, which causes the heat transfer plate and the heat pipe to work independently because the capillary structures have a larger attraction force to the working fluid than gravity. Consequently, under such a circumstance, it reduces the flow of the working fluid, causing a decrease in the heat dissipation efficiency of the heat transfer device. Generally, manufacturers seek to improve the heat dissipation efficiency of three-dimensional heat transfer devices by either increasing the capillary force of the structures or enhancing the thermal conductivity of the evaporation zone. However, currently, existing devices still face challenges with the efficient return of vaporized working fluid, leading to overall heat dissipation performance that does not meet user expectations. Therefore, improving the return efficiency of the vaporized working fluid to improve the heat dissipation efficiency of three-dimensional heat transfer devices remains a critical challenge for researchers.

SUMMARY

[0004] The invention is as defined in the appended claims. Aspects of the disclosure provide a three-dimensional (3D) heat transfer device. The 3D heat transfer device includes a thermal conductive shell body having a liquid-tight chamber, at least one first pipe having a first end connected to the thermal conductive shell body and in communication with the liquid-tight chamber, and at least one second pipe having at least two portions that are connected to the thermal conductive shell and in communication with the liquid-tight chamber.

[0005] In an embodiment, opposite ends of the at least one second pipe body can be connected to the thermal conductive shell and in communication with the liquid-tight chamber.

[0006] In an embodiment, the at least one second pipe body can include at least one blocking-flow wick disposed in a hollow space of the second pipe and at one end of the second pipe body.

[0007] In an embodiment, a cross-section area of the blocking-flow wick can match a cross-section of the hollow space of the second pipe.

[0008] In an embodiment, the thermal conductive shell can include a first shell body and a second shell body, the second shell body is disposed on the first shell body to form the liquid-tight chamber, and the first pipe and the second pipe body are connected to the second shell body.

[0009] In an embodiment, the device can further include a first wick that is disposed on the first shell body, and the blocking-flow wick is connected to the first wick.

[0010] In one embodiment, the device can further include a first wick and a second wick, the first wick is disposed in the first shell body and the second wick is disposed in the second shell body, and the blocking-flow wick is connected to the second wick. For example, the blocking-flow wick can penetrate the second wick. For example, an end of the blocking-flow wick that is facing the second shell can be at a same level as an outer surface of the second wick that is facing away the liquid-tight chamber.

[0011] In an embodiment, a volume of the blocking-flow wick can be smaller than 50% of a volume of the hollow space of the second pipe.

[0012] In an embodiment, the device can further include a pipe wick disposed in the first pipe, a cross-section area of the pipe wick is smaller than a hollow space of first pipe.

BRIEF DESCRIPTION OF DRAWINGS

[0013] Aspects of the present disclosure can be understood from the following detailed description when read with the accompanying Figs. It is noted that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be increased or reduced for clarity of discussion.

Fig. 1 illustrates a perspective view of a three-dimensional (3D) heat transfer device 10 according to the first embodiment of the present disclosure.

Fig. 2 illustrates an exploded view of the 3D heat transfer device 10 in Fig. 1.

Fig. 3 illustrates a top view of the 3D heat transfer device in Fig. 1.

Fig. 4 illustrates a cross-sectional view of the second pipe body 13 of the 3D heat transfer device 10.

Fig. 5 illustrates a cross-sectional view of the 3D heat transfer device 10 along the A-A line.

Fig. 6 illustrates an enlarged view of the cross-section of region Z of Fig. 5.

Fig. 7 illustrates a perspective view with cross-section cut along AA line of the 3D heat transfer device 10.

Fig. 8 illustrates a cross-sectional view of the partial enlarged 3D heat transfer device 10A according to a second embodiment of the present disclosure.

Fig. 9 illustrates a cross-sectional view of the partial enlarged 3D heat transfer device 10B according to a third embodiment of the present disclosure.

Fig. 10 illustrates a perspective view of a 3D heat transfer device 10C according to a fourth embodiment of the present disclosure.

Fig. 11 illustrates a cross-sectional view of the partial enlarged 3D heat transfer device 10D according to a fifth embodiment of the present disclosure.

Fig. 12 illustrates a cross-sectional view of the partial enlarged 3D heat transfer device 10E according to a sixth embodiment of the present disclosure.

DETAILED DESCRIPTION

[0014] Detailed descriptions and technical contents of the present invention are illustrated below in conjunction with the accompanying drawings. However, it is to be understood that the descriptions and the accompanying drawings disclosed herein are merely illustrative and exemplary and not intended to limit the scope of the present invention.

[0015] Refer to Figs. 1 to 3. Fig. 1 illustrates a perspective view of a three-dimensional (3D) heat transfer device 10 according to one embodiment of the present disclosure. Fig. 2 illustrates an exploded view of the 3D heat transfer device 10 in Fig. 1. Fig. 3 illustrates a top view of the 3D heat transfer device in Fig. 1.

[0016] In one embodiment, the 3D heat transfer device 10 includes a thermal conductive shell body 11, a plurality of first pipes 12, at least two second pipes 13. The second pipe 13 can include a blocking-flow wick 14. The conductive shell 11 can include a first shell body 111 and a second shell body 112. The first shell body 111 can be thermally coupled to a heat source (not shown). Thermal coupling refers to thermal contact or connection through other thermally conductive media. The second shell body 112 is disposed on the first shell body 111 so that the first shell body 111 and the second shell body 112 together form a liquid-tight chamber S. The liquid-tight chamber S can be used to contain a cooling fluid (not shown).

[0017] One end of the first pipe bodies 12 and the opposite two ends of the second pipe bodies 13 are connected to the second shell body 112 and in communication with the liquid-tight chamber S. The second pipe 13 has a hollow space 131, a first end 132 and second end 133 that are opposite to each other. Vaporized cooling fluid can flow through the first end 132 from the liquid-tight chamber S to the hollow space 131. The vaporized cooling fluid can then be condensed into liquid form and flow back to liquid-tight chamber S through the second end 133. The second pipe 13 can be configured to have a body portion that is positioned away from the thermal conductive shell body 11. The body portion of the second pipe 13 can be configured with plurality of fins (not shown) for dissipating heat.

[0018] Also refer to Figs. 4 to 6. Fig. 4 illustrates a cross-sectional view of the second pipe 13 of the 3D heat transfer device 10. Fig. 5 illustrates a cross-sectional view of the 3D heat transfer device 10 along the A-A line. Fig. 6 illustrates an enlarged view of the cross-section of region Z of Fig. 5.

[0019] The blocking-flow wick 14 can have a pore size that is equal or less than 100 micrometers (μm). The blocking-flow wick 14 can be disposed at one end of the second pipe body 13 to restrict the flow rate of the cooling fluid. For example, the blocking-flow wick 14 can be disposed at the second end 133 of the second pipe 13. The volume of the blocking-flow wick 14is smaller than 50% of the volume of the hollow space 131. The cross-section area of the blocking-flow wick 14 would match the cross-section area of the hollow space 131. That is, the blocking-flow wick 14 is disposed in the hollow space 131 at the second end 133 to block the second end 133. The volume of the hollow space 131 is being blocked by the blocking-flow wick 14 is less than 50% of the total volume of the hollow space 131.

[0020] In one embodiment, the body portion of the second pipe 13 can be configured with fins to increase the heat dissipating area. Comparing to the conventional 3D heat transfer devices which may only include single heat dissipating area, the 3D heat transfer device 10 of this invention includes, in addition to the heat dissipating area of the first pipe 12, two more heat dissipating area of the two second pipes 13, that can provide lower thermal resistance and higher heat transfer capacity. Accordingly, the heat dissipation efficiency of the 3D heat transfer device 10 can be improved.

[0021] In one embodiment, the 3D heat transfer device 10 can also include a first wick 15 and a second wick 16. The pore size of the first wick 15 and the second wick 16 are larger than the pore size of the blocking-flow wick 14. In detail, the porosity of either the first wick 15 or the second wick 16 is greater than the porosity of the blocking-flow wick 14. Both the porosity of the first wick 15 and the porosity of the second wick 16 are greater than the porosity of the blocking-flow in greater or equal to 10%. For example, the porosity of the first wick 15 and the porosity of the second wick 16 is greater than or equal to 40% and less than or equal to 75%. The porosity of the blocking-flow wick 14 is less than or equal to 55%. In this way, the vaporized cooling fluid can pass through the first wick 15 and the second wick 16 but blocked by the blocking-flow wick 14.

[0022] The first wick 15 can be disposed in the first shell body 111. The second wick 16 can be disposed in the second shell body 112. The vaporized cooling fluid can reflux back to the liquid-tight chamber S via the first wick 15 and the second wick 16 after condensed in the second pipe body 13. The blocking-flow wick 14 can be connected with the second wick 16 and at the same level as the second wick 16. That is, the bottom edge of the blocking-flow wick 14 is at the same level as with the outer surface of the second wick 16.

[0023] In one embodiment, the first pipes 12 can further include a pipe wick 17. The pore size of the pipe wick 17 is larger than the pore size of the blocking-flow wick 14. The cross-sectional area of the pipe wick 17 is smaller than the cross-sectional area of the hollow space of the first pipe 12. The vaporized cooling fluid can flow upward in the first pipe 12 and flow back to the liquid-tight chamber S through the pipe wick 17 after condensed into liquid form.

[0024] In one embodiment, the blocking-flow wicks 14, the first wicks 15, the second wicks 16 and the pipe wicks 17 can be any suitable material depends on the specific application of 3D heat transfer device. For example, the wicks can be a metal mesh, a fiber, or a powder sintered body. In addition, because the pore size of the blocking-flow wick 14 is smaller than the pore size of either the first wick 15, the pore size of the second wick 16, or the pore size of the pipe wick 17, the cooling fluid is mainly driven by force of vapor to pass through the blocking-flow wick 14.

[0025] In one embodiment, the 3D heat transfer device includes plurality of the first pipe 12. In another embodiment, the number of first pipe bodies can be one only.

[0026] In this embodiment, the 3D heat transfer device includes two second pipes 13 and two blocking-flow wicks 14. In another embodiment, the number of second pipe body and the number of blocking-flow wick can be one only or more than two, respectively.

[0027] In one embodiment, the second pipe 13 has the first end 132 and the second end 133 connect to the second shell body 112 of the thermal conductive shell body 11. In another embodiment, the second pipe can have only either the first end 132 or the second end 133 connect to the second shell. In another embodiment, the second pipe can have more than two ends connect to the second shell.

[0028] Also refer to Fig. 7. Fig. 7 illustrates a perspective view with cross-section cut along A-A line of the 3D heat transfer device 10 shown in Fig. 3. The cooling cycle is described hereinafter. First, the cooling fluid within in the liquid-tight chamber S can absorb the heat from a heat source and then vaporizes into a gaseous cooling fluid. The vaporized cooling fluid can flow from the liquid-tight chamber S to the hollow space 131 of the second pipe body 13 through the first end 132 along a direction A. The vaporized cooling fluid can be condensed back into the liquid form in the second pipe 13. The liquified cooling fluid can be propelled by the vaporized cooling fluid from the first end 132 to the second end 133 of the second pipe 13. Because the capillary phenomenon of the blocking-flow wick 14, the liquified cooling fluid can pass through the blocking-flow wick 14 while the vaporized cooling fluid is blocked due to the low porosity of the blocking-flow wick 14. This can prevent the vaporized cooling fluid without fully cooled down return to the liquid-tight chamber S through the second end 133. The vaporized cooling fluid that flows into the second pipe 13 from the first end 132 can then push the liquified cooling fluid that has been condensed to pass through the blocking-flow wick 14 in a direction C. Finally, the liquified cooling fluid flows back to the liquid-tight chamber S, and the cooling cycle can be completed.

[0029] Fig. 8 illustrates a cross-sectional view of the partial enlarged 3D heat transfer device 10A according to one embodiment of the present invention. The 3D heat transfer device 10A of this embodiment is similar to the 3D heat transfer device 10 of the embodiments mentioned earlier, so the differences between this embodiment and the earlier-mentioned embodiments will be explained below, and the similarities will not be repeated. In this embodiment, the 3D heat transfer device 10A can include two blocking-flow wick 14A that is each disposed in the second end 133 of the two second pipes 13A. The 3D heat transfer device 10A can include a first wick 15 that is disposed in the first shell 111 and a second wick 16A that is disposed in the second shell 112. The blocking-flow wick 14A is connected to and penetrates through the second wick 16A. That is, the bottom edge of the blocking-flow wick 14A is at the same level as the inner surface of the second wick 16A.

[0030] Fig. 9 illustrates a cross-sectional view of the partial enlarged 3D heat transfer device 10B according to one embodiment of the present invention. The 3D heat transfer device 10B of the present embodiment is similar to the 3D heat transfer device 10 of the embodiments described above, so the differences between this embodiment and the earlier-mentioned embodiments will be explained below, and the similarities will not be repeated. In this embodiment, the 3D heat transfer device 10A can include two blocking-flow wick 14B that is each disposed in the second end 133 of the two second pipes bodies. The 3D heat transfer device 10B can include a first wick 15B that is disposed in the first shell 111 and a second wick 16B that is disposed in the second shell 112.

[0031] The second end 133 of the second pipe 13B can penetrate the second shell 112 and the second wick 16B and connect to the first shell 111 of the thermal conductive shell 11. The first end 132 can connect to the second shell 112 and in communicate with the liquid-tight chamber S as described in the earlier-mentioned embodiments. The blocking-flow wick 14B can connect with the first wick 15B and at the same level as the first wick 15B. That is, the bottom edge of the blocking-flow wick 14B is at the same level as the inner surface of the first wick 15B. In another embodiment, the second end 133 of the second pipe 13B can connect to the second shell 112 and in communicate with the liquid-tight chamber S as described in the earlier-mentioned embodiments, but only the blocking-flow wick 14B penetrates the second wick 16B and connect to the first wick 15B.

[0032] Fig. 10 illustrates a perspective view of a 3D heat transfer device 10C in accordance with one embodiment of the present invention. The 3D heat transfer device 10C of this embodiment is similar to the 3D heat transfer device 10 of the earlier-mentioned embodiments, so the differences between this embodiment and the earlier-mentioned embodiments will be explained below, and the similarities will not be repeated. In the present embodiment, the 3D heat transfer device 10C can include a plurality of fins 18. These fins 18 are respectively surround the first pipes 12 and the second pipes 13. In this way, the heat dissipation area of the 3D heat transfer device 10C can be increased.

[0033] Fig. 11 illustrates a cross-sectional view of the partial enlarged 3D heat transfer device 10D in accordance with one embodiment of the present invention. The 3D heat transfer device 10D of this embodiment is similar to the 3D heat transfer device 10 of the earlier-mentioned embodiments, so the differences between this embodiment and the earlier-mentioned embodiments will be explained below, and the similarities will not be repeated. In this embodiment, a second wick 16D disposed in the second shell body 112 can block the second end 133 of the second pipe 13 and restrict the flow of the cooling fluid. The 3D heat transfer device 10D can include two third wicks 19 that each is disposed in the hollow space 131 of the second pipe 13 close to the second end 133. The third wick 19 can be hollow and can be disposed on the inner surface of the second pipe 13. The third wick 19 use a coarser powder or capillary to provide a greater permeability. That is, the third wick 19 can provide higher capillary transfer velocity. In this way, the liquified cooling fluid can be quickly absorbed into the third wick 19 and returned to the second wick 16D. The permeability of the third wick 19 is greater than the permeability of the blocking-flow wick 14 of the earlier-mentioned embodiments. In addition, the third wick 19 is connected and at the same level as the second wick 16D. That is, the bottom edge of the third wick 19 is connected and at the same level as the outer surface of the second wick 16D.

[0034] Fig. 12 illustrates a cross-sectional view of the partial enlarged 3D heat transfer device 10E in accordance with one embodiment of the present invention. The 3D heat transfer device 10E of this embodiment is similar to the 3D heat transfer device 10 of the earlier-mentioned embodiments, so the differences between this embodiment and the earlier-mentioned embodiments will be explained below, and the similarities will not be repeated. In this embodiment, the 3D heat transfer device 10E can include a second wick 16E disposed in the second shell body 112 of the thermal conductive shell body 12 and completely cover the inner surface of the second shell body 112. The second wick 16E also covers the second ends 133 of the second pipes 13. In another embodiment, the second wick 16E can just cover the second ends 133 of the second pipes 13 to prevent the vaporized cooling fluid flow back to the liquid-tight chamber S.

[0035] The 3D heat transfer devices described in the above embodiments can provide an increase to the heat dissipating area of the device by providing the second pipe bodies having a middle section that is away from the thermal conductive shell. Compared to the conventional heat transfer device, the disclosed 3D heat transfer devices according to the above embodiment can have a lower thermal resistance and a higher heat transfer capacity. In this way, the heat dissipation efficiency of the 3D heat transfer device can be improved.

[0036] Therefore, embodiments disclosed herein are well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the embodiments disclosed may be modified and practiced in different but equivalent manners apparent to those of ordinary skill in the relevant art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered, combined, or modified and all such variations are considered within the scope and spirit of the present disclosure.

[0037] The embodiments illustratively disclosed herein suitably may be practiced in the absence of any element that is not specifically disclosed herein and/or any optional element disclosed herein. While compositions and methods are described in terms of "comprising," "containing," or "including" various components or steps, the compositions and methods can also "consist essentially of' or "consist of" the various components and steps. All numbers and ranges disclosed above may vary by some number. Whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range is specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the elements that it introduces.

Claims

1. A three-dimensional (3D) heat transfer device (10, 10A, 10B, 10C, 10D, 10E), comprising:

a thermal conductive shell body (11) having a liquid-tight chamber (S);
at least one first pipe (12) having a first end connected to the thermal conductive shell body (11) and in communication with the liquid-tight chamber (S); and
at least one second pipe (13) having at least two portions that are connected to the thermal conductive shell (11) and in communication with the

liquid-tight chamber (S).

2. The device (10, 10A, 10B, 10C, 10D, 10E) of claim 1, wherein opposite ends of the second pipe (13) are connected to the thermal conductive shell (11) and in communication with the liquid-tight chamber (S).

3. The device (10, 10A, 10B, 10C, 10D) of claim 1 or 2, wherein the second pipe (13) includes at least one blocking-flow wick (14, 14A, 14B, 19) disposed in a hollow space (131) of the second pipe (13) and at one end of the second pipe body (13).

4. The device (10, 10A, 10B) of claim 3, wherein a cross-section area of the blocking-flow wick (14, 14A, 14B,) matches a cross-section of the hollow space (131) of the second pipe (13).

5. The device (10, 10A, 10B, 10C, 10D) of one of claims 1 to 4, wherein the thermal conductive shell body (11) includes a first shell body (111) and a second shell body (112), the second shell body (112) is disposed on the first shell body (111) to form the liquid-tight chamber (S), and the first pipe (12) and the second pipe body (13) are connected to the second shell body (112).

6. The device (10B) of claim 5, further comprising a first wick (15B) that is disposed on the first shell body (111), and the blocking-flow wick (14B) is connected to the first wick (15B).

7. The device (10, 10A) of claim 5, further comprising a first wick (15) and a second wick (16, 16A), the first wick (15) is disposed in the first shell body (111) and the second wick (16, 16A) is disposed in the second shell body (112), and the blocking-flow wick (14, 14A) is connected to the second wick (16, 16A).

8. The device (10A) of claim 7, wherein the blocking-flow wick (14A) penetrates the second wick (16A).

9. The device (10) of claim 7, wherein an end of the blocking-flow wick (14) that is facing the second shell (112) is at a same level as an outer surface of the second wick (16) that is facing away from the liquid-tight chamber (S).

10. The device (10, 10A, 10B) of one of claims 4 to 9, wherein a volume of the blocking-flow wick (14, 14A, 14B) is smaller than 50% of a volume of the hollow space (131) of the second pipe (13).

11. The device (10) of one of claims 1 to 10, further comprising a pipe wick (17) disposed in the first pipe (12), a cross-section area of the pipe wick (17) is smaller than a hollow space of the first pipe (12).

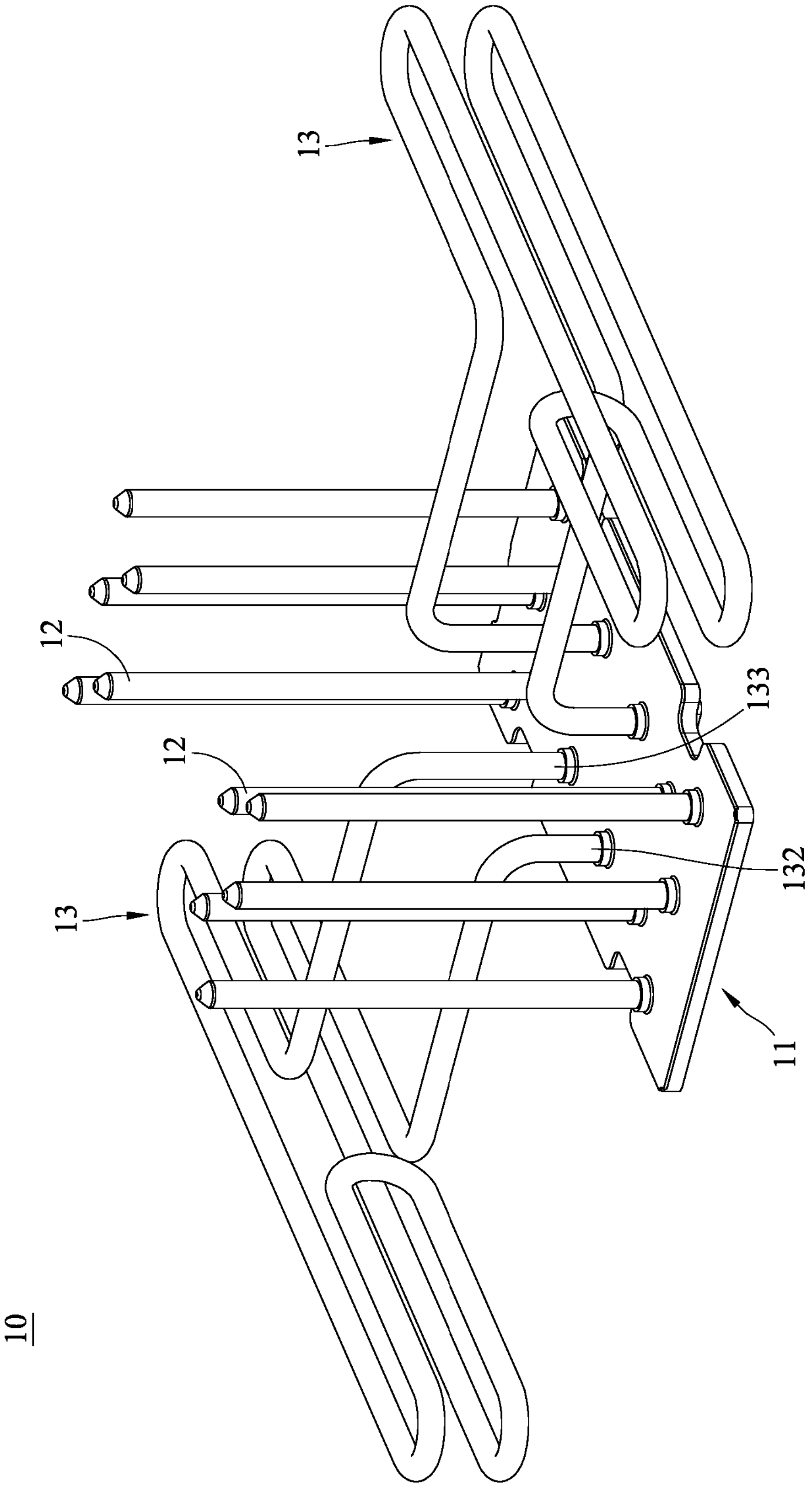

FIG. 1

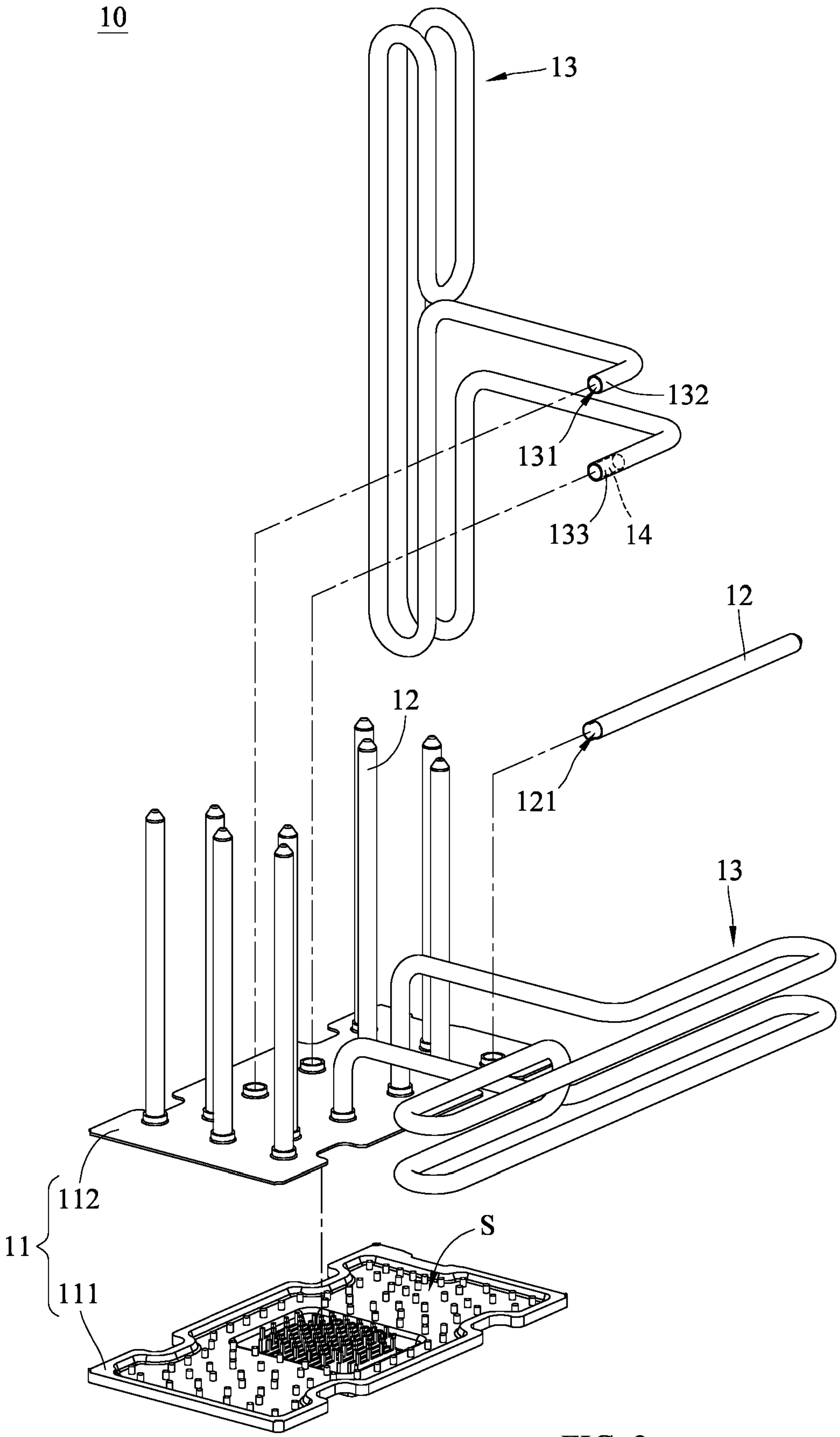

FIG. 2

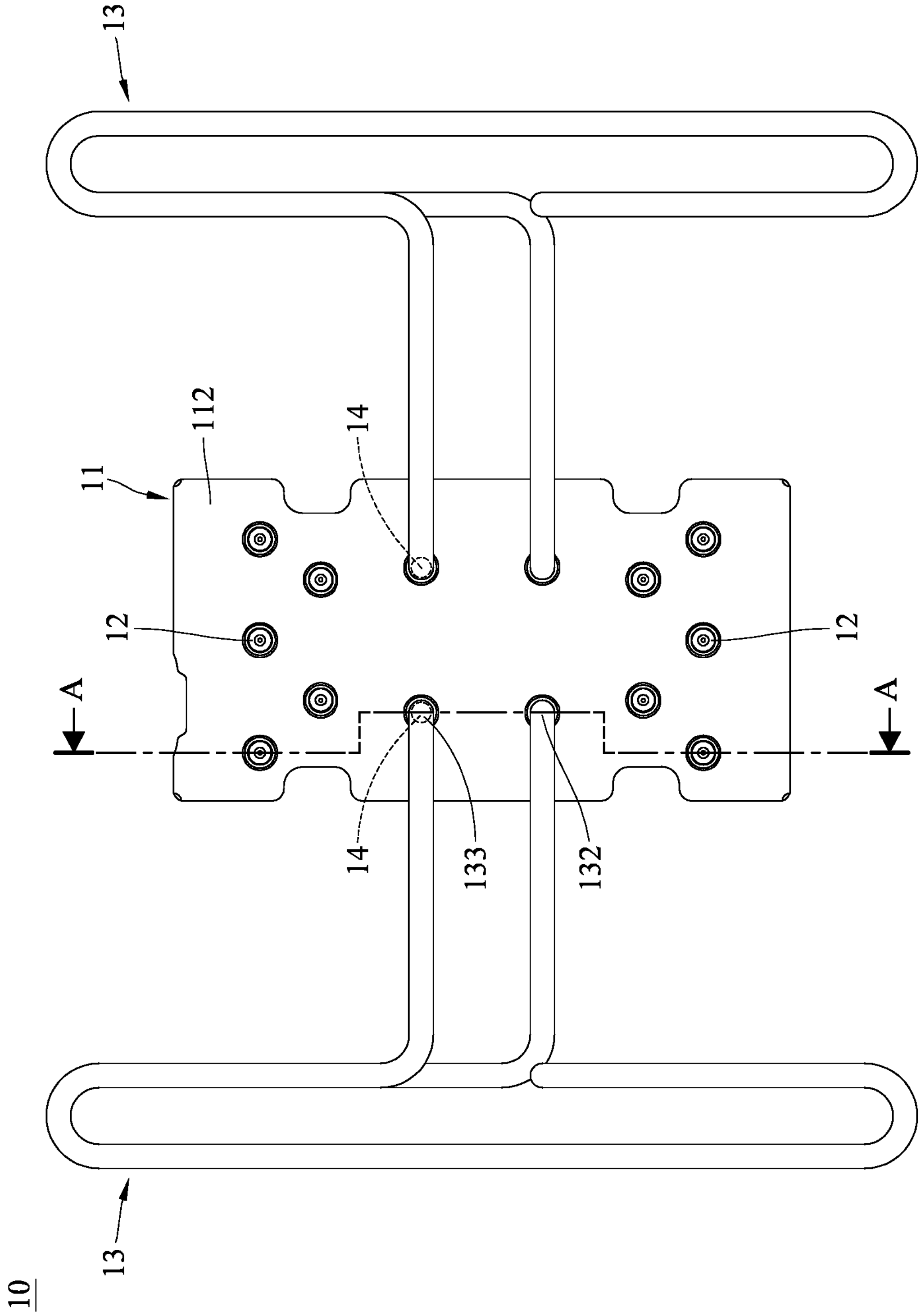

FIG. 3

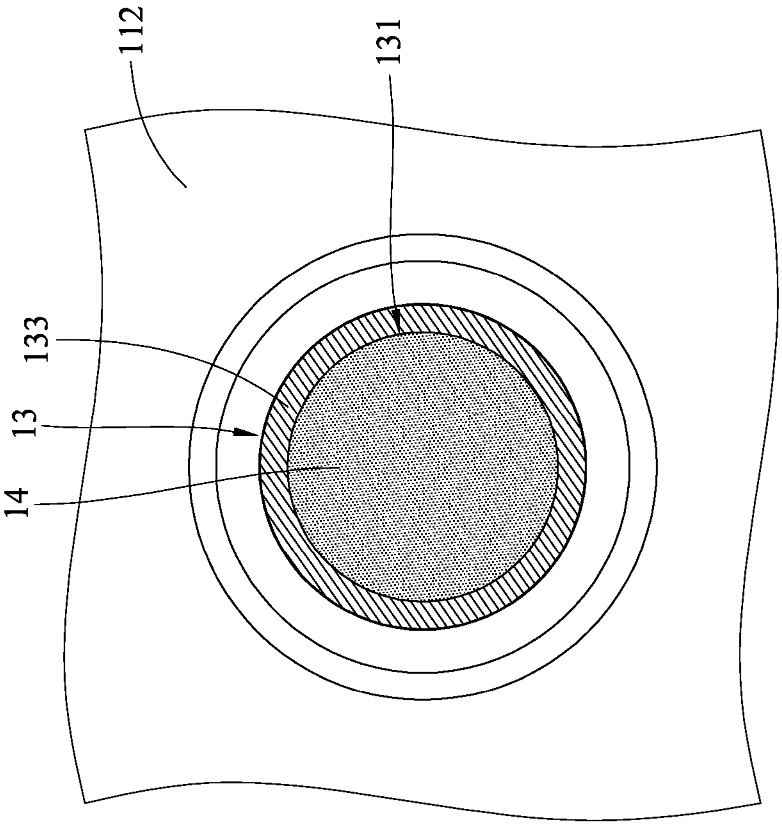

FIG. 4

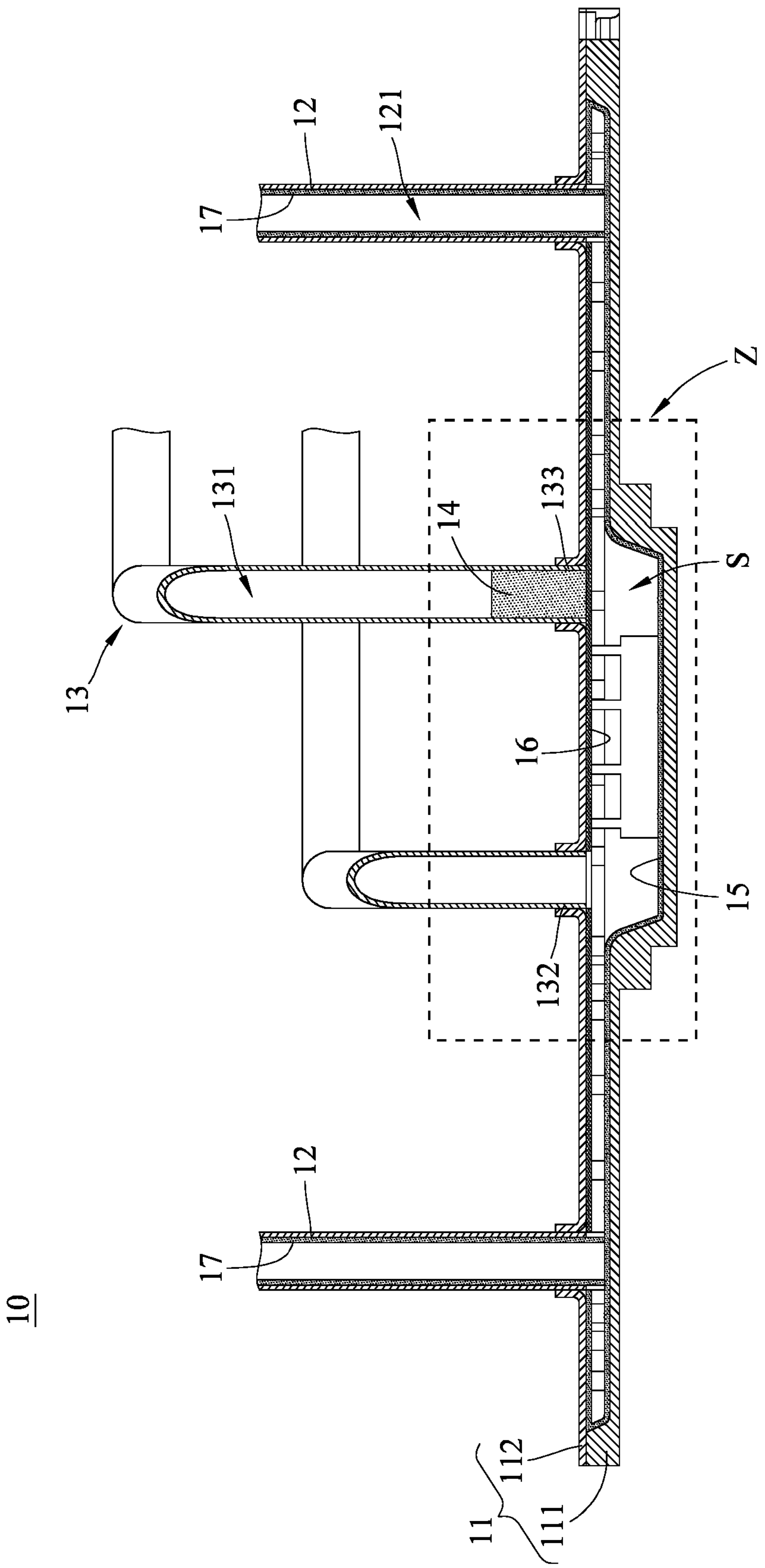

FIG. 5

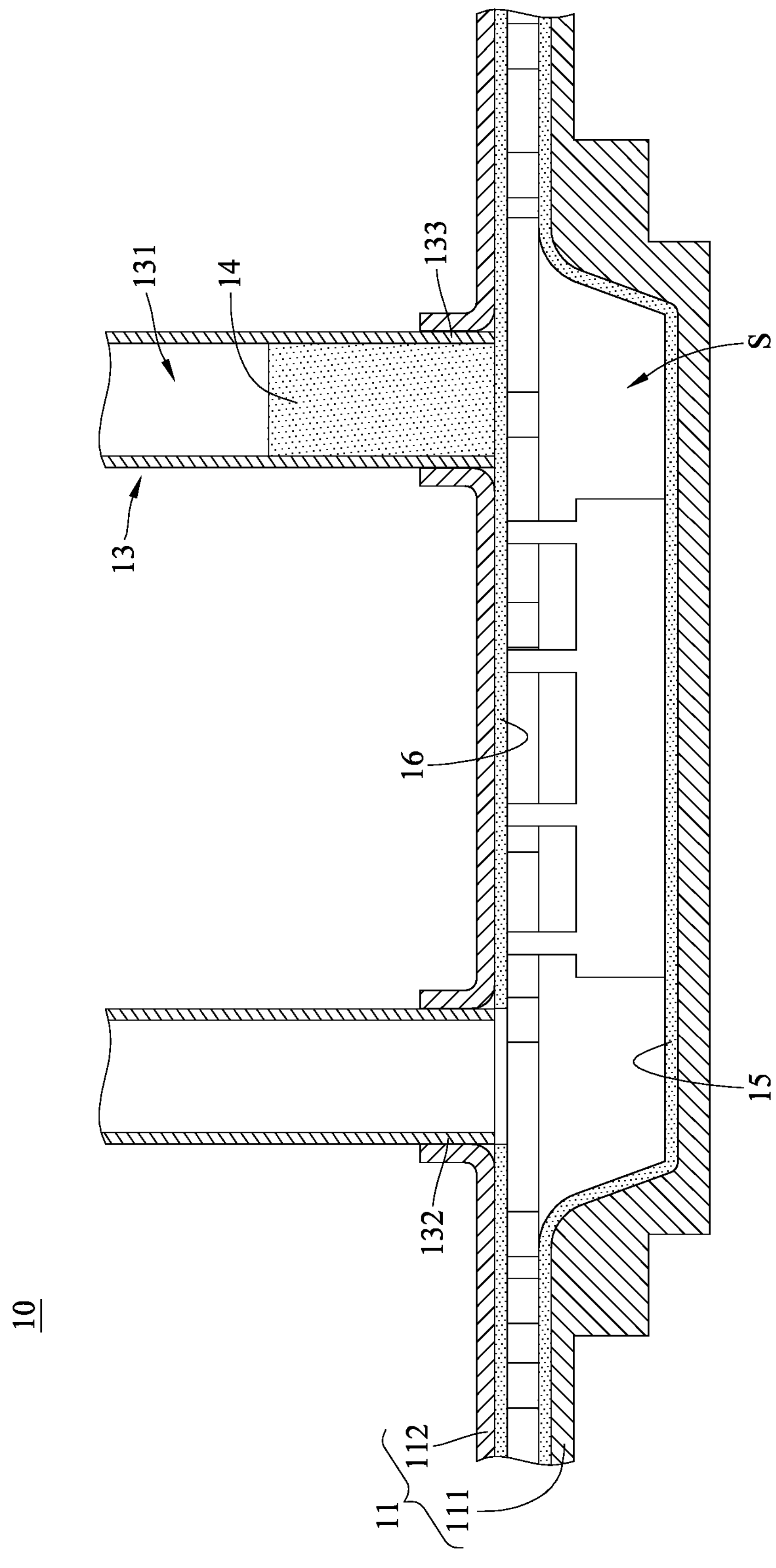

FIG. 6

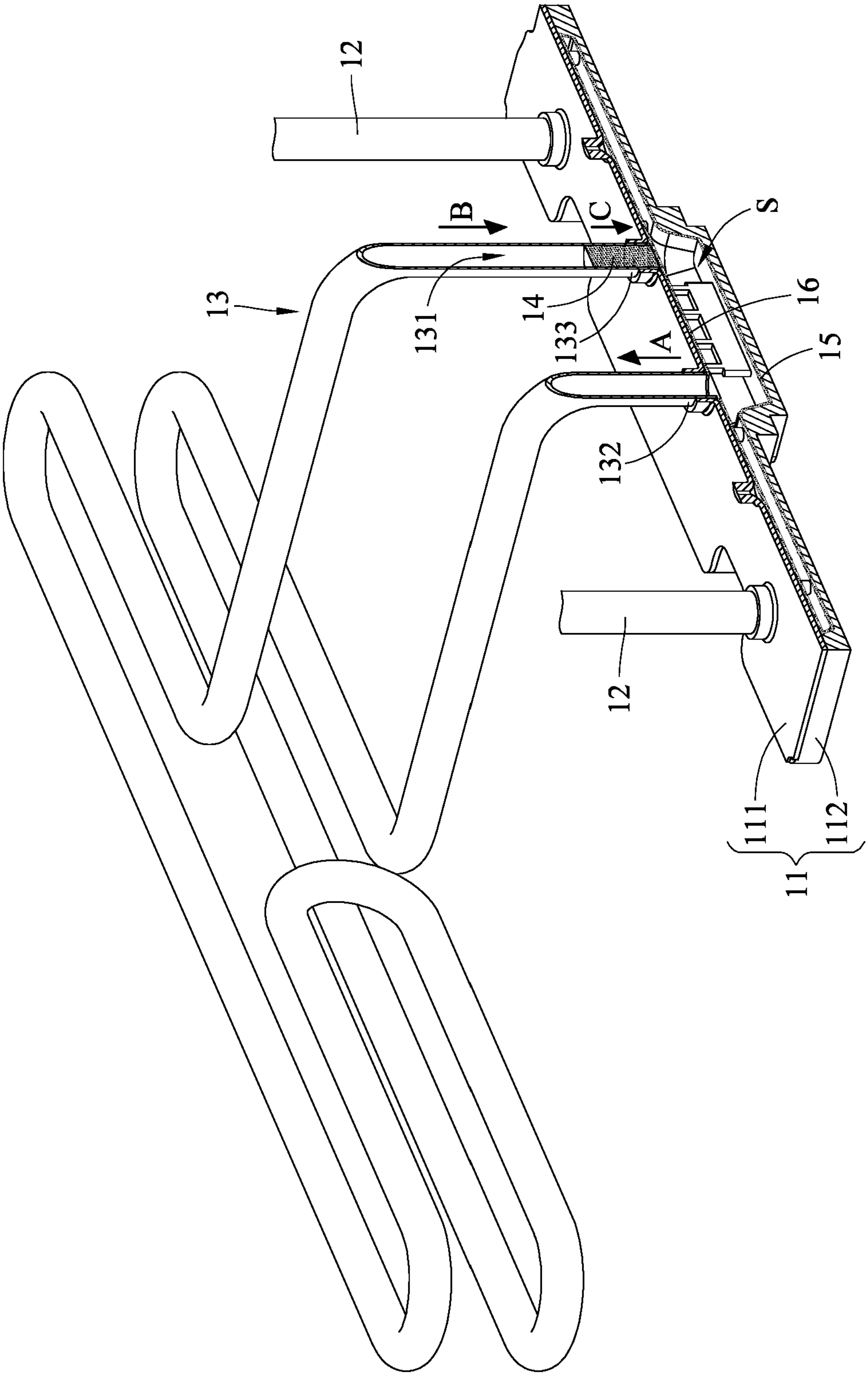

FIG. 7

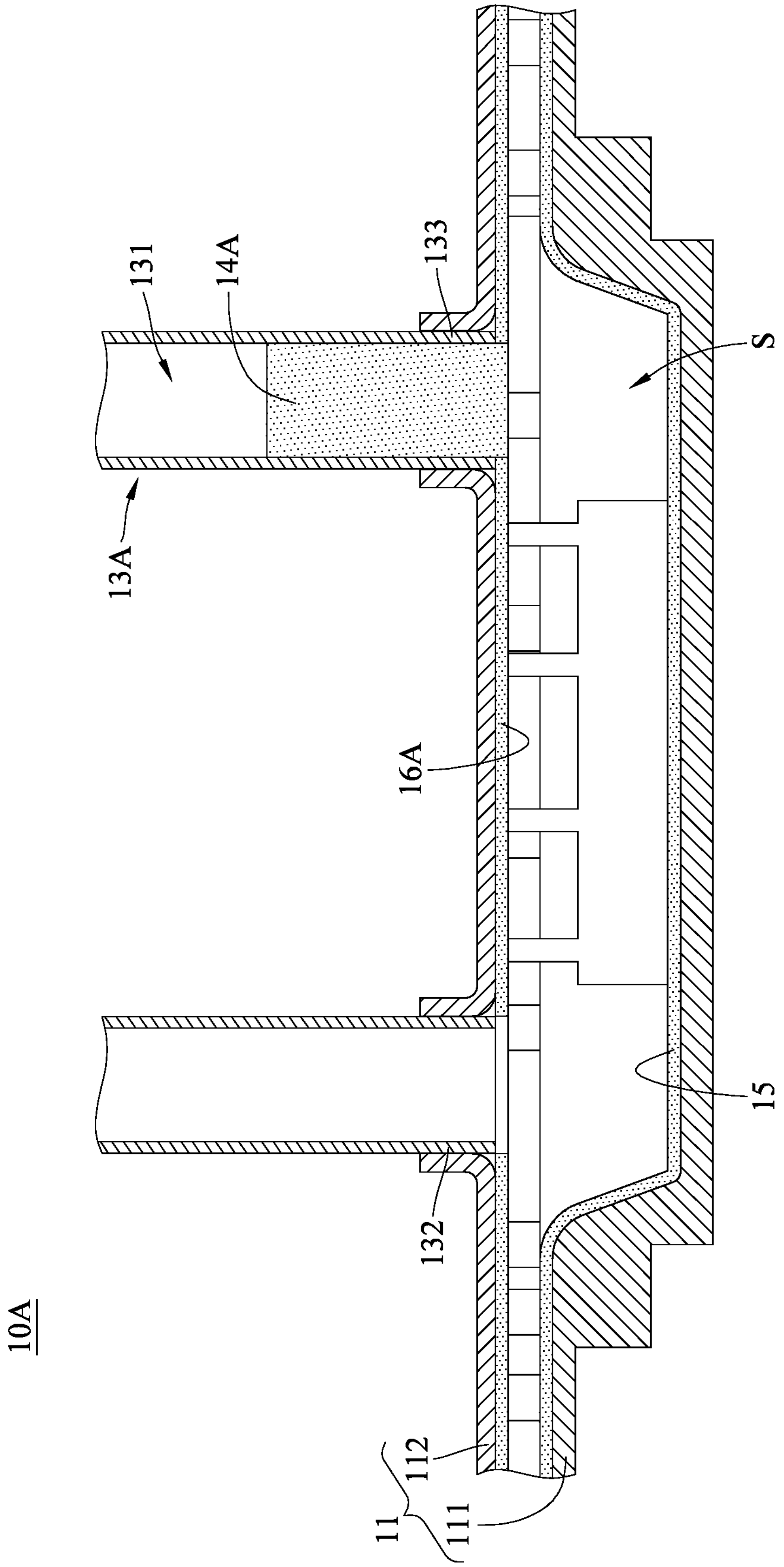

FIG. 8

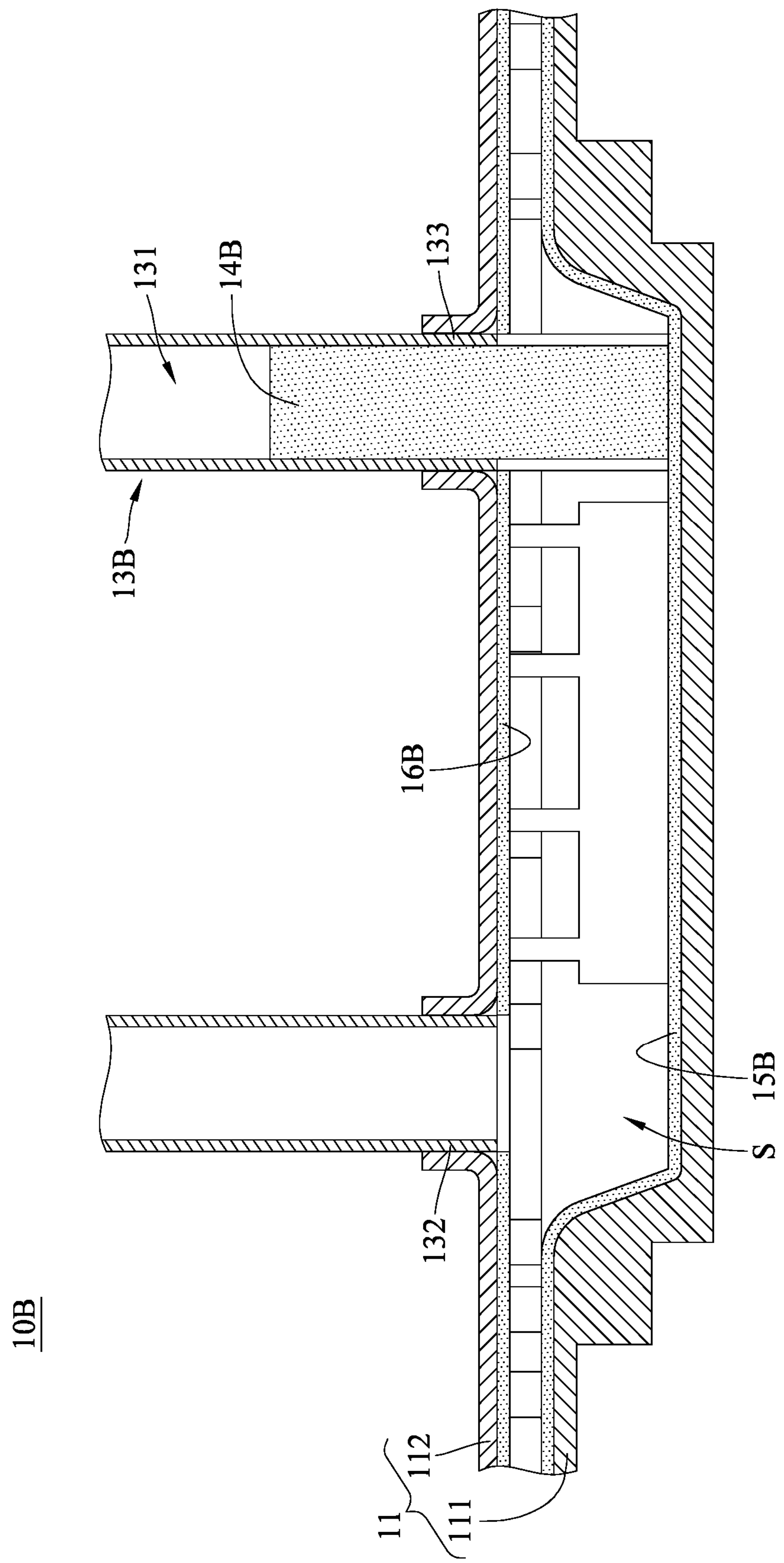

FIG. 9

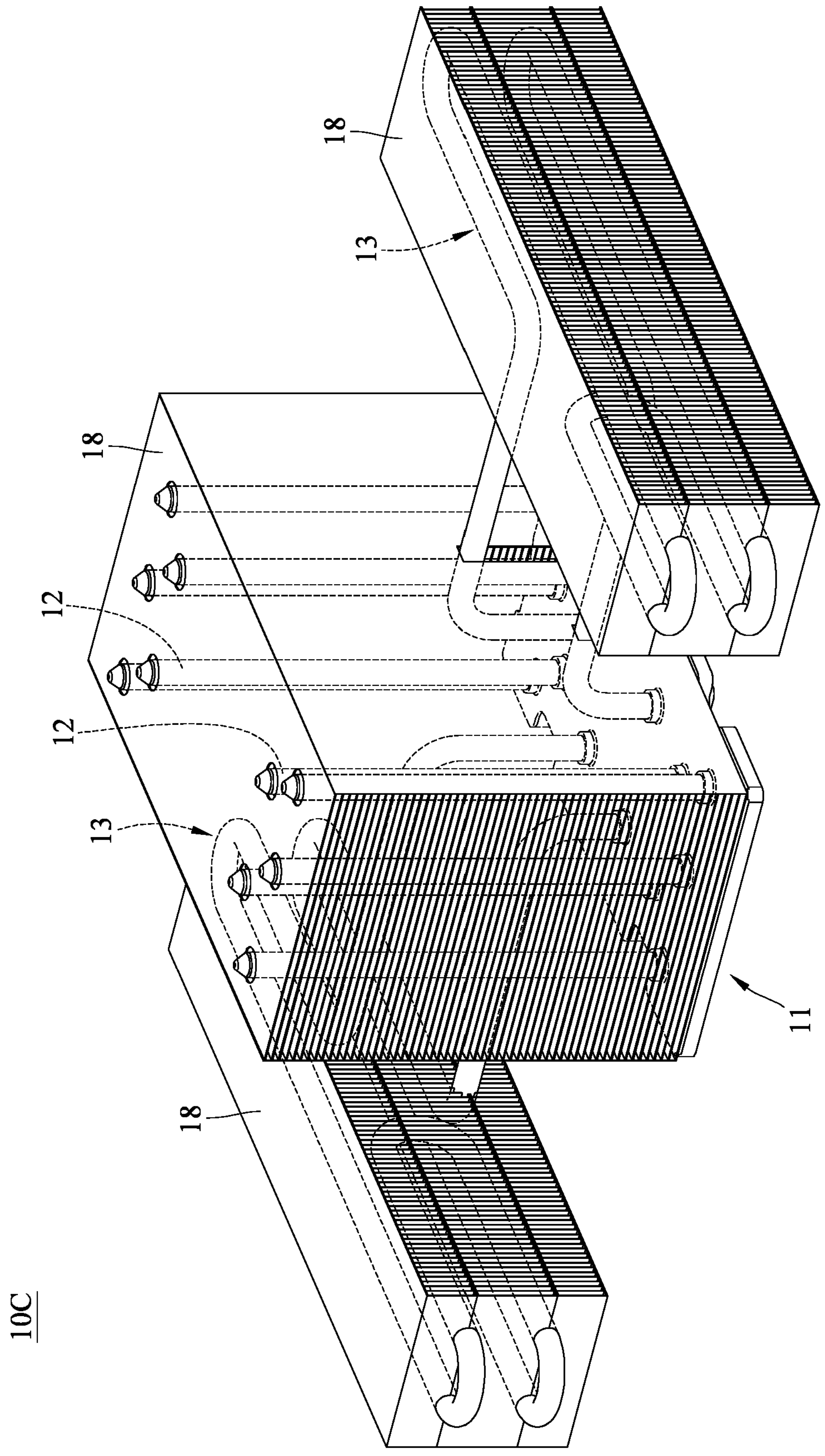

FIG. 10

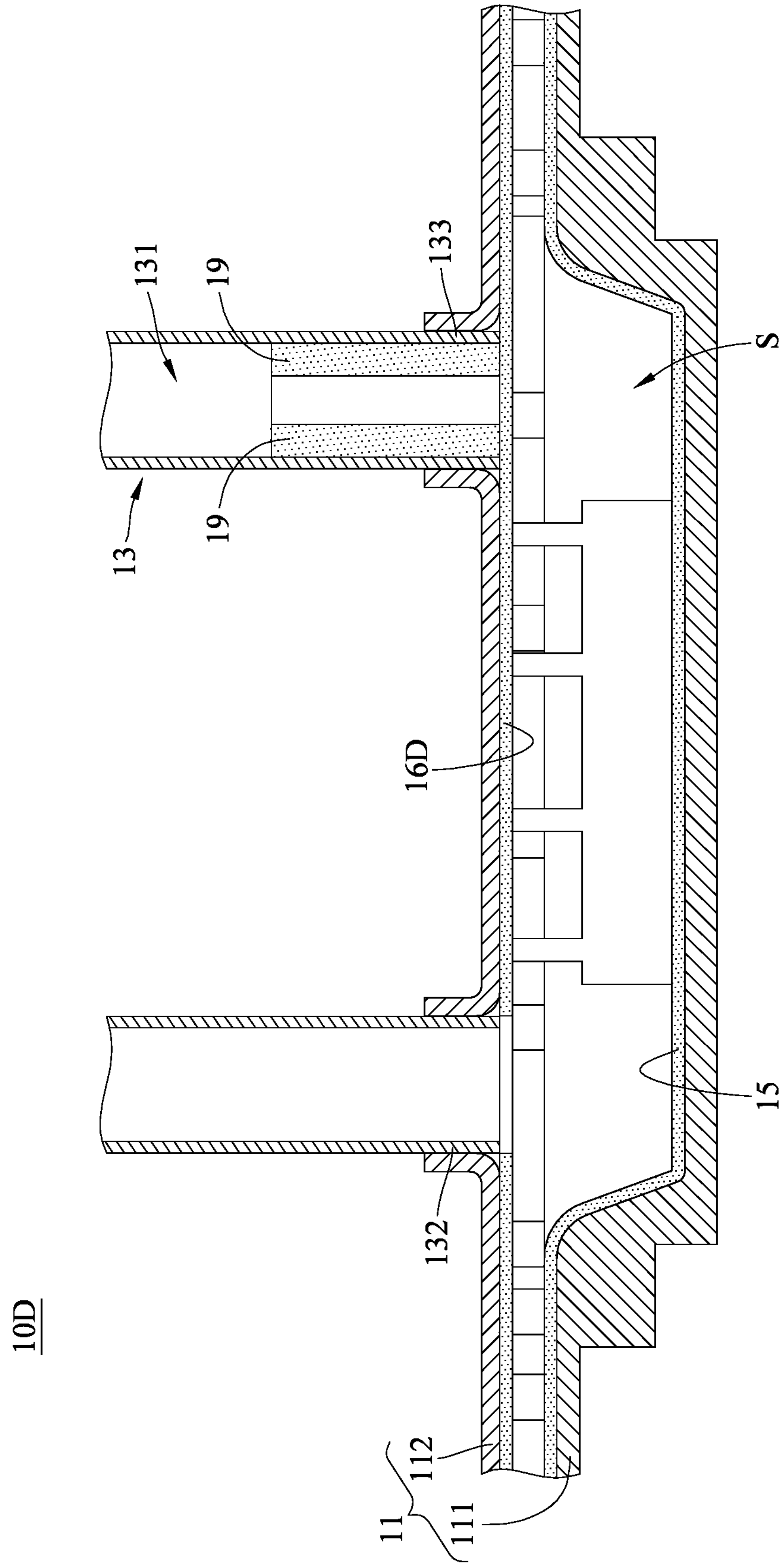

FIG. 11

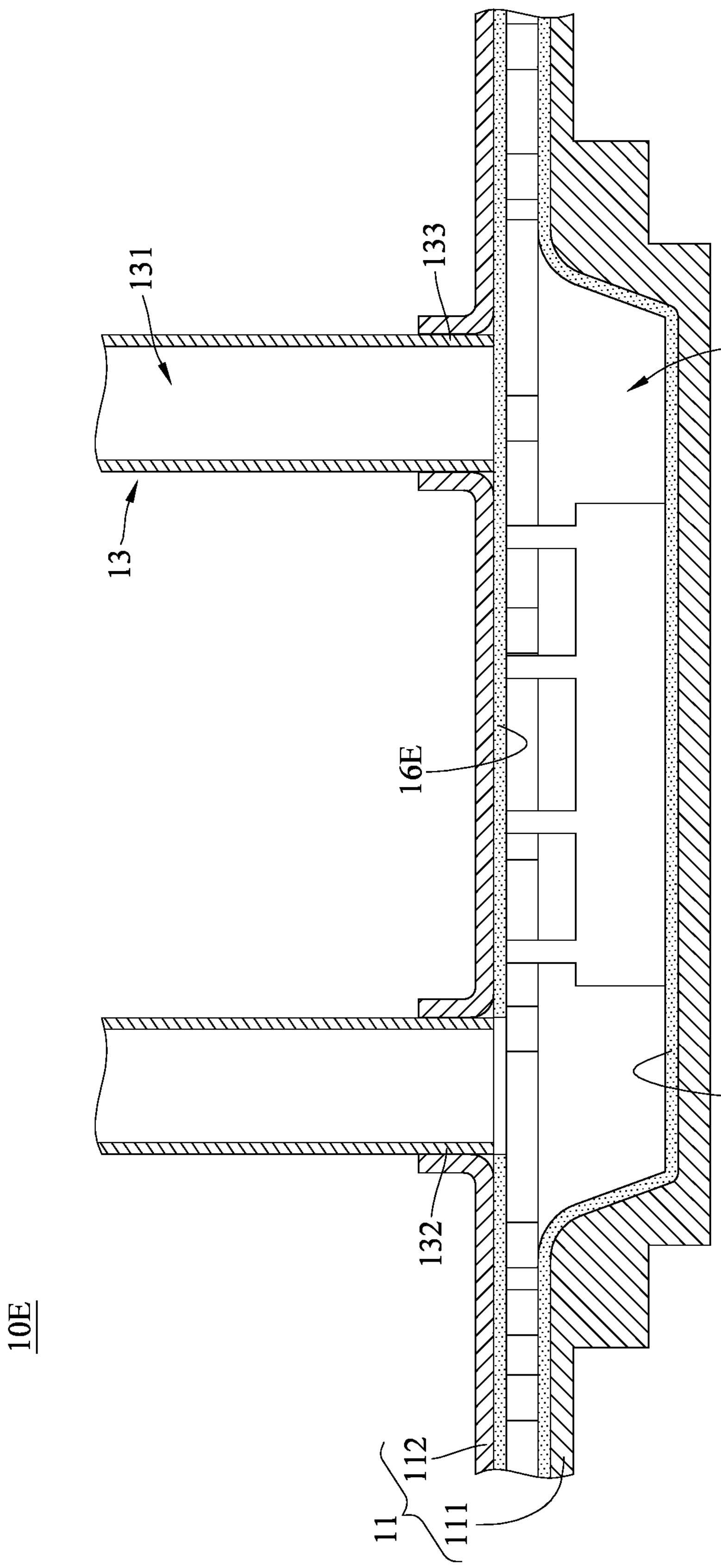

FIG. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 24 21 7366

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2022/018609 A1 (CHEN CHIH-WEI [TW] ET AL) 20 January 2022 (2022-01-20) * paragraphs [0037] - [0081]; figures 1-8B *	1-11	INV. F28D15/02 F28D15/04 F28F1/32
A	US 2023/358482 A1 (LIU LEI LEI [CN] ET AL) 9 November 2023 (2023-11-09) * the whole document *	1-11	
A	US 2023/213288 A1 (WANG XUE MEI [CN] ET AL) 6 July 2023 (2023-07-06) * the whole document *	1-11	
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A	US 2020/370837 A1 (LIU XUE-HUI [CN] ET AL) 26 November 2020 (2020-11-26) * the whole document *	1-11	
			TECHNICAL FIELDS SEARCHED (IPC)
			F28D

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	24 April 2025	Axters, Michael

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