



(11)

EP 4 502 523 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.02.2025 Bulletin 2025/06

(51) International Patent Classification (IPC):
F28D 15/02^(2006.01) F28D 15/04^(2006.01)

(21) Application number: **24199313.8**

(52) Cooperative Patent Classification (CPC):
F28D 15/0275; F28D 15/04

(22) Date of filing: **09.09.2024**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(71) Applicant: **Purple Cloud Development Pte. Ltd.
Singapore 128424 (SG)**

(72) Inventor: **WANG, Xue Mei
Hui Zhou City, Guang Dong Province (CN)**

(74) Representative: **Grünecker Patent- und
Rechtsanwälte
PartG mbB
Leopoldstraße 4
80802 München (DE)**

(30) Priority: **08.09.2023 CN 202322450877 U
03.07.2024 CN 202410882906
08.09.2023 CN 202311161671
02.08.2023 CN 202323347257 U**

(54) **THREE-DIMENSIONAL HEAT PIPE ASSEMBLY**

(57) A heat pipe assembly includes a first heat pipe having an inner surface, an outer surface, and at least one opening, the inner surface forms a first chamber, the at least one opening is disposed on a longitudinal side of the first heat pipe, and at least one second heat pipe having a second chamber and a connecting opening at one end, wherein the at least one second heat pipe is disposed on the first heat pipe at the at least one opening, and the second chamber connects with the first chamber through the at least one opening of the first heat pipe and the connecting opening of the at least one second heat pipe.

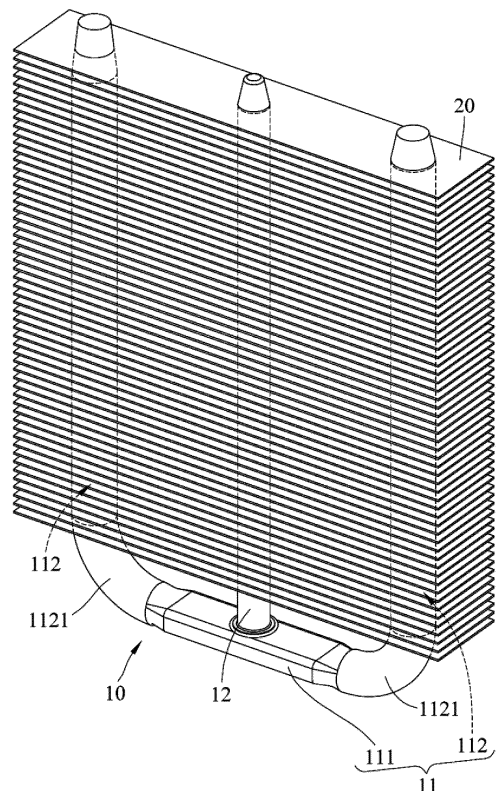


FIG. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure is related to the field of heat pipe assembly, in particular a composite heat pipe assembly.

BACKGROUND

[0002] Electronic devices can generate high heat during operation, so manufacturers usually install heat pipes to dissipate heat. Heat pipes can use the evaporation and condensation of the internal coolant to achieve the effect of rapid temperature uniformity. In detail, the liquid coolant in the heat pipe absorbs heat at the evaporation end, and the liquid coolant vaporizes and moves to the condensing end by vapor pressure. After the gaseous coolant at the condensing end is exothermic and condensed into liquid coolant, the liquid coolant flows back to the evaporation end through the internal capillary structure to absorb heat and evaporates again, therefore carry out the cooling cycle.

[0003] Heat pipes are available in a variety of forms to be used in a variety of heat dissipation modules. Tower cooling modules usually use U-shaped heat pipes that need to be bent to form. However, the U-shaped heat pipe will be limited by the bending angle, resulting in the limited heat exchange area of the U-shaped heat pipe, which in turn makes the heat dissipation efficiency of the U-shaped heat pipe insufficient. Therefore, how to improve the heat dissipation efficiency of U-shaped heat pipes is one of the problems that R&D personnel should solve.

SUMMARY

[0004] Aspects of the disclosure provide a heat pipe assembly. The heat pipe assembly can include a first heat pipe having an inner surface, an outer surface, and at least one opening, the inner surface forms a first chamber, the at least one opening is disposed on a longitudinal side of the first heat pipe, and at least one second heat pipe having a second chamber and a connecting opening at one end, wherein the at least one second heat pipe is disposed on the first heat pipe at the at least one opening, and the second chamber connects with the first chamber through the at least one opening of the first heat pipe and the connecting opening of the at least one second heat pipe.

[0005] In some embodiments, the first heat pipe can include a first thermal conductive section and at least one second thermal conductive section, the at least one second thermal conductive section is connected to one end of the first thermal conductive section, the at least one second thermal conductive sections protrude perpendicular to the first thermal conductive section, and the at least one opening is disposed at the first thermal conductive section.

[0006] In some embodiments, the at least one second thermal conductive section can include a bending section that connects the at least one second thermal conductive section to the first thermal conductive section. In some embodiments, a portion of the first thermal conductive section is a flat tube.

[0007] In some embodiments, the at least one of the second heat pipe can include a folded edge at the connecting opening, the folded edge is disposed on the outer surface of the first heat pipe at the at least one opening.

[0008] In some embodiments, the first thermal conductive section can include a recessed region on the outer surface of the first heat pipe that surrounds the at least one opening, and the at least one of the second heat pipe has a folded edge at the connecting opening, the folded edge is disposed in the recessed region. In some embodiments, wherein the first thermal conductive section comprises a recessed region on the outer surface of the first heat pipe that surrounds the at least one opening, and the at least one second heat pipe is disposed in the recessed region.

[0009] In some embodiments, a portion of the at least one second heat pipe is inserted into the at least one opening. In some embodiments, the at least one second heat pipe can include a tapered structure adjacent to the connecting opening and is inserted into the first chamber of the first heat pipe.

[0010] In some embodiments, the first heat pipe can include a folded edge perpendicular to the first thermal conductive section at the at least one opening, the at least one second heat pipe has a portion that is inserted through the at least one opening and sleeved by the folded edge. In some embodiments, the first heat pipe can include a folded edge perpendicular to the first thermal conductive section at the at least one opening, the at least one second heat pipe has a portion that is inserted through the at least one opening and sleeves the folded edge. In some embodiments, the at least one second heat pipe can include a folded edge at the connecting opening and is disposed on the inner surface of the first thermal conductive section of the first heat pipe.

[0011] In some embodiments, the heat pipe assembly can further include at least one ring connector having a narrow portion and a wide portion that is disposed between the first heat pipe and the at least one second heat pipe and connects the first heat pipe and the at least one second heat pipe, wherein the first heat pipe connects at the narrow portion and the at least one second heat pipe connects at the wide portion.

[0012] In some embodiments, the heat pipe assembly can further include a first capillary structure and at least one second capillary structure, the first capillary structure is disposed in the first chamber of the first heat pipe, the at least one second capillary structure is disposed in the second chamber of the at least one second heat pipe and connects with the first capillary structure. In some embodiments, the second capillary structure can include two crescent parts that are symmetrically disposed adjacent

to the connecting opening. In some embodiments, the second capillary structure can have a semicircular shape. In some embodiments, the heat pipe assembly can further include a third capillary structure disposed in the first chamber of the first heat pipe and disposed on the first capillary structure, the second capillary structure connects the first capillary structure via the third capillary structure.

[0013] In some embodiments, the at least one second heat pipe can be welded to the first heat pipe.

[0014] In some embodiments, the heat pipe assembly can further include a plurality of third heat pipes, the plurality of third heat pipes are arranged perpendicular on the first heat pipes and the at least one second heat pipes.

[0015] In some embodiments, the first heat pipe can include a first thermal conductive section and two second thermal conductive sections, the two second thermal conductive sections are respectively connected to opposite ends of the first thermal conductive section, the two second thermal conductive sections protrude perpendicular to the first thermal conductive section, the at least one opening is disposed at the first thermal conductive section, and each of the second thermal conductive sections includes a bending section that connects each of the second thermal conductive section to the first thermal conductive section at the respective opposite ends.

BRIEF DESCRIPTION OF DRAWINGS

[0016] Aspects of the present disclosure can be understood from the following detailed description when read with the accompanying Figures. 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 the combination of a heat pipe assembly 10 and fins 20 according to a first embodiment of the present invention.

Fig. 2 illustrates a detailed exploded view of the heat pipe assembly 10 in Fig. 1.

Fig. 3 illustrates a top view of a second heat pipe 12 of the heat pipe assembly 10 in Fig. 1.

Fig. 4 illustrates a cross-sectional view of the heat pipe assembly 10 in Fig. 1.

Fig. 5 illustrates a detailed exploded view of the heat pipe assembly 10A according to a second embodiment of the present disclosure.

Fig. 6 illustrates a cross-sectional view of the heat pipe assembly 10A in Fig. 5.

Fig. 7 illustrates a detailed exploded view of the heat pipe assembly 10B according to a third embodiment of the present disclosure.

Fig. 8 illustrates a cross-sectional view of the heat pipe assembly 10B in Fig. 7.

Fig. 9 illustrates a detailed exploded view of the heat pipe assembly 10C according to a fourth embodiment of the present disclosure.

Fig. 10 illustrates a cross-sectional view of the heat pipe assembly 10C in Fig. 9.

Fig. 11 illustrates a detailed exploded view of the heat pipe assembly 10D according to a fifth embodiment of the present disclosure.

Fig. 12 illustrates a cross-sectional view of the heat pipe assembly 10D in Fig. 11.

Fig. 13 illustrates a detailed exploded view of the heat pipe assembly 10E according to a sixth embodiment of the present disclosure.

Fig. 14 illustrates a cross-sectional view of the heat pipe assembly 10E in Fig. 13.

Fig. 15 illustrates a detailed exploded view of the heat pipe assembly 10F according to a seventh embodiment of the present disclosure.

Fig. 16 illustrates a cross-sectional view of the heat pipe assembly 10F in Fig. 15.

Fig. 17 illustrates a detailed exploded view of the heat pipe assembly 10G according to an eighth embodiment of the present disclosure.

Fig. 18 illustrates a cross-sectional view of the heat pipe assembly 10G in Fig. 17.

Fig. 19 illustrates a detailed exploded view of the heat pipe assembly 10H according to a ninth embodiment of the present disclosure.

Fig. 20 illustrates a cross-sectional view of the heat pipe assembly 10H in Fig. 19.

Fig. 21 illustrates a top view of a second capillary structure 141 of the heat pipe assembly 101 according to a tenth embodiment of the present disclosure.

Fig. 22 illustrates a perspective view of the heat pipe assembly 10J according to an eleventh embodiment of the present disclosure.

Fig. 23 illustrates a perspective view of the heat pipe assembly 10K according to a twelfth embodiment of the present disclosure.

Fig. 24 illustrates a perspective view of the heat pipe assembly 10L according to a thirteenth embodiment of the present disclosure.

Fig. 25 illustrates a cross-sectional view of the heat pipe assembly 10L in Fig. 24.

Fig. 26 illustrates a perspective view of the heat pipe assembly 10M according to the fourteenth embodiment of the present disclosure.

Fig. 27 illustrates a detailed exploded view of the heat pipe assembly 10N according to a fifteenth embodiment of the present disclosure.

Fig. 28 illustrates a cross-sectional view of the heat pipe assembly 10N in Fig. 27.

Fig. 29 illustrates a cross-sectional view of the heat pipe assembly 10P according to the seventeenth embodiment of the present disclosure.

Figs. 30A-30F illustrate different shapes of the second heat pipe and the second capillary structure according to embodiments of the present disclosure.

DETAILED DESCRIPTION

[0017] 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.

[0018] Refer to Figs. 1-3. Fig. 1 illustrates a perspective view of the combination of a heat pipe assembly 10 and fins 20 according to a first embodiment of the present invention. Fig. 2 illustrates a detailed exploded view of the heat pipe assembly 10 in Fig. 1. Fig. 3 illustrates a top view of a second heat pipe 12 of the heat pipe assembly 10 in Fig. 1.

[0019] The combination of the heat pipe assembly 10 and the fins 20 of this embodiment can be used for a tower heat dissipation module and can be thermally coupled to a heat source (not shown). The thermal coupling can be referred to thermal contact or connection by means of other thermally conductive media. The heat pipe assembly 10 can include a first heat pipe 11, a second heat pipe 12, a first capillary structure 13 and a second capillary structure 14. The first heat pipe 11 can include a first conductive heat section 111 and two second conductive sections 112. The first thermal conductive section 111 can be a flat tube. In other embodiments, the first thermal conductive section can be any other shape that is suitable for the particular heat dissipating needs. The two second thermal conductive sections 112 can be a circular pipe. Each second thermal conductive section 112 can be connected to one end of the first thermal conductive section 111 via a bending section 1121. The two second thermal conductive sections 112 are configured to protrude in the same direction. Therefore, the first heat pipe 11 can be configured to be in U-shape.

[0020] Also refer to Fig. 4. Fig. 4 illustrates a cross-sectional view of the heat pipe assembly 10 in Fig. 1. The first heat pipe 11 can include a first inner surface 113, a first outer surface 114 and an opening 115. The first inner surface 113 is located on the inner side of the first heat pipe 11 and extends from the first thermal conductive section 111 to the second thermal conductive section 112. The first inner surface 113 surrounds a first chamber S1. The first chamber S1 can be used to contain the cooling fluid (not shown). The first outer surface 114 is located on the outside of the first heat pipe 11 and extends from the first thermal conductive section 111 to the second thermal conductive section 112. The first outer surface 114 is facing away from the first inner surface 113. The opening 115 is located in the first thermal conductive section 111 of the first heat pipe 11 and penetrates through each of the first inner surface 113 and the first outer surface 114 once and connects the first chamber S1.

[0021] The second heat pipe 12 can be a round pipe. The second heat pipe 12 can be disposed on the first

thermal conductive section 111 and between the two second thermal conductive sections 112 of the first heat pipe 11. The second heat pipe 12 can be disposed at the center of the first thermal conductive section 111 and the distances between the second heat pipe 12 and each of the second thermal conductive section 112 can be the same. The second heat pipe 12 has a connecting opening 124 that is configured to connect with the opening 115 of the first heat pipe 11. The second heat pipe 12 can include a folded edge 121 at the connecting opening 124. The folded edge 121 circulates around the connecting opening 124. The folded edge 121 is disposed on the outer surface 114 of the first thermal conductive section 111 of the first heat pipe 11. The folded edge 121 can be soldered onto the first heat pipe 11 at the first thermal conductive section 111 by solder material 30.

[0022] The second heat pipe 12 can include a second inner surface 122 and a second outer surface 123. The second inner surface 122 is located on the inner side of the second heat pipe 12 and surrounds a second chamber S2. The second chamber S2 can be used to contain the cooling fluid (not shown). The second outer surface 123 is located on the outer side of the second heat pipe 12. The second outer surface 123 is facing away from the second inner surface 122. The second chamber S2 is connected with the first chamber S1 of the first heat pipe 11 through the connecting port 124 and the opening 115.

[0023] The first heat pipe 11 can include a first capillary structure 13 disposed in the first chamber S1. The second heat pipe 12 can include a second capillary structure 14 disposed in the second chamber S2. The first capillary structure 13 connects with the second capillary structure 14. The first capillary structure 13 and the second capillary structure 14 are both powder sintered structure. The second capillary structure 13 can further include a set of crescent parts 141 at the connecting opening 124. The crescent parts 141 are symmetrically disposed and extend out of the connecting opening 124. When the cooling fluid absorbs the heat of the heat source and evaporates, it can flow back to the heat source through the first capillary structure 13 and the second capillary structure 14 to achieve the effect of cooling cycle.

[0024] Compared with the heat pipe generally used for a tower heat dissipation module, its width can be limited by the bending angle of the two bending sections of the first heat pipe. This can result in the heat exchange area of the heat pipe being limited and the heat dissipation efficiency of the heat pipe being insufficient. The heat pipe assembly 10 of the present embodiment has the second heat pipe 12 configured to be disposed between the two second thermal conductive sections 112. In this way, the heat exchange area of the heat pipe assembly 10 can be increased when the width of the heat pipe assembly 10 is limited, and the heat dissipation efficiency of the heat pipe assembly 10 can be improved.

[0025] In the first embodiment, the two second conductive sections 112 of the first heat pipe 11 are round pipes, but are not limited to this. In other embodiments,

the two second conductive sections of the first heat pipe may also be flat tubes.

[0026] In the first embodiment, the two second thermal conductive segments 112 are each connected with the opposite ends of a bending segment 1121 and the first thermal conductive segment 111, but are not limited to this. In other embodiments, the two second thermal conductive sections can be connected with the opposite ends of the first thermal conductive section at straight angles.

[0027] In the first embodiment, the first heat pipe 11 is U-shaped, but not limited to this. In other embodiments, the first heat pipe may also be of other shapes, for example, L-shaped.

[0028] In the first embodiment, the distances between the second heat pipe 12 and the two second conductive sections 112 of the first heat pipe 11 are the same, so that the second heat pipe 12 is arranged in the middle between the two second conductive sections 112, but is not limited to this. In other embodiments, the distances between the second heat pipes and the two second thermal conductive sections of the first heat pipes can be different, so that the second heat pipes can be offset from the center point of the first thermal conductive section of the first heat pipe.

[0029] In the first embodiment, the folded edge 121 of the second heat pipe 12 is directly welded to the first outer surface 114 of the first heat conductive section 111 of the first heat pipe 11 via the solder material 30, but is not limited to this. In other embodiments, the folded edge of the second heat pipe can be fixed by laser welding first, then welded to the first outer surface of the first thermal conductive section of the first heat pipe via solder.

[0030] In the first embodiment, the first capillary structure 13 is connected with the second capillary structure 14, but is not limited thereto. In other embodiments, the first capillary structure and the second capillary structure may not be connected.

[0031] Refer to Figs. 5 and Fig. 6. Fig. 5 illustrates a detailed exploded view of the heat pipe assembly 10A according to a second embodiment of the present disclosure. Fig. 6 illustrates a cross-sectional view of the heat pipe assembly 10A in Fig. 5.

[0032] In the second embodiment, the first heat conductive section 111A of the first heat pipe 11A has a recessed portion 111A1. The recessed portion 111A1 is located on the outer surface 114A and surrounds the opening 115. The folded edge 121 of the second heat pipe 12 can be disposed in the recessed portion 111A1 and be welded to the recessed portion 111A1.

[0033] Refer to Figs. 7 and 8. Fig. 7 illustrates a detailed exploded view of the heat pipe assembly 10B according to a third embodiment of the present disclosure. Fig. 8 illustrates a cross-sectional view of the heat pipe assembly 10B in Fig. 7.

[0034] In the third embodiment, the second heat pipe 12B does not include a folded edge as compared to the second heat pipe 12 illustrated in Fig. 2. The second heat

pipe 12B is partially inserted in the opening 115 and welded to the first heat pipe 11. As illustrated, the second heat pipe 12B can have partially extension portions at the connecting opening 124B to overlap with the set of crescent parts 141B of the second capillary structure 14B.

[0035] Refer to Figs. 9 and 10. Fig. 9 illustrates a detailed exploded view of the heat pipe assembly 10C according to a fourth embodiment of the present disclosure. Fig. 10 illustrates a cross-sectional view of the heat pipe assembly 10C in Fig. 9.

[0036] In the fourth embodiment, the second heat pipe 12C does not include a folded edge as compared to the second heat pipe 12 illustrated in Fig. 2. Instead, the second heat pipe 12C can include a tapered structure 125C at the connecting opening 124C. The second heat pipe 12C is partially inserted in the opening 115 so that the tapered structure 125C can be disposed in the first chamber S1. The second heat pipe 12C can be welded to the first heat pipe 11 at the opening 115. As illustrated, the tapered structure 125C of the second heat pipe 12C only covers with the set of crescent parts 141C of the second capillary structure 14C. The crescent parts 141C are also tapered. In some other embodiments, the tapered structure 125C can over cover the set of the crescent parts 141C. In some other embodiments, the tapered structure 125C can undercover the set of the crescent parts 141C.

[0037] Refer to Figs. 11 and 12. Fig. 11 illustrates a detailed exploded view of the heat pipe assembly 10D according to a fifth embodiment of the present disclosure. Fig. 12 illustrates a cross-sectional view of the heat pipe assembly 10D in Fig. 11.

[0038] In the fifth embodiment, the second heat pipe 12D is similar to the second heat pipe 12B as illustrated in Fig. 7, except that the second heat pipe 12D does not have partially extension portions to cover the set of crescent parts 141D. The first heat conductive section 111D of the first heat pipe 11D has a recessed portion 111D1. The recessed portion 111D1 is located on the outer surface 114D and surrounds the opening 115. The second heat pipe 12D can be disposed in the recessed portion 111D1 and be welded to the recessed portion 111D1.

[0039] Refer to Figs. 13 and 14. Fig. 14 illustrates a detailed exploded view of the heat pipe assembly 10E according to a sixth embodiment of the present disclosure. Fig. 14 illustrates a cross-sectional view of the heat pipe assembly 10E in Fig. 13.

[0040] In the sixth embodiment, the first heat pipe 11E includes a folded edge 116E at the opening 115E. Further, the second heat pipe 12E does not include a folded edge and is similar to the second heat pipe 12D as illustrated in Fig. 11. The second heat pipe 12E is partially inserted into the opening 115E of the first heat pipe 10E via the folded edge 116E. In other words, the folded edge 116E surrounds a portion of the second heat pipe 12E. The second heat pipe 12E can then be welded to the folded edge 116E of the first heat pipe 11E.

[0041] Refer to Fig. 15 and 16. Fig. 15 illustrates a

detailed exploded view of the heat pipe assembly 10F according to a seventh embodiment of the present disclosure. Fig. 16 illustrates a cross-sectional view of the heat pipe assembly 10F in Fig. 15.

[0042] In the seventh embodiment, the first heat pipe 11F can include a folded edge 116F. At least two inserting openings 117F can be configured between the folded edge 116F and the first thermal conductive section 111F to allow the set of crescent parts 141F through. The second heat pipe 12F can be configured to sleeve the folded edge 116F and be welded to the end of the folded edge 116F.

[0043] Refer to Figs. 17 and 18. Fig. 17 illustrates a detailed exploded view of the heat pipe assembly 10G according to an eighth embodiment of the present disclosure. Fig. 18 illustrates a cross-sectional view of the heat pipe assembly 10G in Fig. 17.

[0044] In the eighth embodiment, the heat pipe assembly 10G can include a ring connector 15G. The ring connector 15G can have a narrow portion 15G1 and a wide portion 15G2. The ring connector 15G can be used to connect the first heat pipe 11 and the second heat pipe 12G at the opening 115 and the connecting opening 124G. The narrow portion 15G1 can be disposed in the opening 115 of the first heat pipe 11 and the second heat pipe 12G can be disposed in the wide portion 15G2.

[0045] In this embodiment, the number of first heat pipe 11 and the number of connecting rings 15G are each being one, but are not limited to this. In some embodiments, the number of first heat pipes and the number of connecting rings can be more than one. In some embodiments, when the heat pipe assembly includes multiple second heat pipes, the number of ring connectors can match the number of the second heat pipes to connect to the first heat pipe.

[0046] Refer to Figs. 19 and 20. Fig. 19 illustrates a detailed exploded view of the heat pipe assembly 10H according to a ninth embodiment of the present disclosure. Fig. 20 illustrates a cross-sectional view of the heat pipe assembly 10H in Fig. 19.

[0047] In the ninth embodiment, the first thermal conductive section 111H of the first heat pipe 11H can be divided into a bottom shell 111H1 and a top shell 111H2. The bottom shell can be welded to the two second thermally conductive sections 112 and the top shell 111H2 can be welded to the bottom shell 111H1. The opening 115 is located at the top shell 111H2, and the first inner surface 113 extends from the bottom shell 111H1 to the top shell 111H2. A recessed portion 111A3 is located on the inner surface 113 and surrounds the opening 115. Similar to the second heat pipe 12, the second heat pipe 12H includes a folded edge 121H. The folded edge 121H of the second heat pipe 12H can be disposed at the recessed portion 111A3 on the first inner surface 113. The second heat pipe 12H can be welded to the first heat pipe 11H on the first outer surface 114H of the first heat pipe 11H.

[0048] Since recessed portion 111A3 is located on the

first inner surface 113, the top shell 111H2 needs to be separated from the bottom shell 111H1. After the second heat pipe 13H passes through the opening 115 and the folded edge 121H is disposed in the recessed portion 111A3, the second heat pipe 13H can be welded to the top shell 111H2. The top shell 111H2 can then be welded to the bottom shell 111H1 and the two second thermal conductive sections 112 and form the first chamber S1.

[0049] In the above embodiments, the second capillary structure 14 includes a set of crescent parts 141 as illustrated in Fig. 3, but is not limited to this. In some embodiments, the second capillary structure can include a single structure that extends out at the connecting opening. Fig. 21 illustrates a top view of a second capillary structure 141 of the heat pipe assembly 101 according to a tenth embodiment of the present disclosure. The second capillary structure 141 can include a semicircular single structure that extends out of the connecting opening. In some embodiments, the second capillary structure can include a plurality of different structures or shapes.

[0050] Fig. 22 illustrates a perspective view of the heat pipe assembly 10J according to an eleventh embodiment of the present disclosure. The heat pipe assembly 10J includes two second heat pipes 12J. The two second heat pipes 12J is arranged between the two second conductive sections 112 of the first heat pipe 11. The two second heat pipes 12J can be connected to the first thermal conductive section 111 in similar manners as described in the above embodiments. For example, the two second heat pipes 12J can be soldered or welded to the first thermal conductive section 111. For example, two ring connectors can be used to connect the two second heat pipe 12J with the first thermal conductive section 111. For example, one of the two second heat pipes 12J can have a ring connector to connect with the first thermal conductive section 111, and the other one of the two second heat pipes 12J can be welded to the first thermal conductive section 111.

[0051] Fig. 23 illustrates a perspective view of the heat pipe assembly 10K according to a twelfth embodiment of the present disclosure. The heat pipe assembly 10K can include a plurality of third heat pipes 16K. The third heat pipes 16K can be arranged to connect to the first heat pipe 11 and the two second heat pipe 12K respectively in a non-interfering manner with each other. The third heat pipes 16K can be perpendicular to the first heat pipe 11 and the second heat pipes 12K. In some embodiments, the heat pipe assembly can further include a plurality of fourth heat pipes being arranged on the third heat pipes. The fourth heat pipes can be perpendicular to the third heat pipes. In this way, the heat exchange area within the first, second, third, and fourth heat pipes are increased, which also increases the heat dissipating efficient of the heat pipe assembly.

[0052] Refer to Figs. 24 and 25. Fig. 24 illustrates a perspective view of the heat pipe assembly 10L according to a thirteenth embodiment of the present disclosure. Fig. 25 illustrates a cross-sectional view of the heat pipe

assembly 10L in Fig. 24.

[0053] In the thirteenth embodiment, the first thermal conductive section 111L of the first heat pipe 11L is a semi-flat tube. That is, the first thermal conductive section 111L has a rounded bottom and a flat top. The opening 115L is located at the flat top of the first thermal conductive section 111L.

[0054] In this embodiment, the first heat conductive section 111L of the first heat pipe 11L is a semi-flat tube, but is not limited to this. In other embodiments, the first thermal conductive section of the first heat pipe can be any shape that is suitable for the specific application of the heat pipe assembly. For example, the first thermal conductive section can be a flat tube, a round tube, a rectangular tube, or an oval tube.

[0055] Fig. 26 illustrates a perspective view of the heat pipe assembly 10M according to the fourteenth embodiment of the present disclosure. In this embodiment, the second heat pipe 12M of the heat pipe assembly 10M is a flat tube. In other embodiments, the second heat pipe 12M can be any shape that is suitable for the specific application of the heat pipe assembly. For example, the first thermal conductive section can be a flat tube, a round tube, a rectangular tube, or an oval tube.

[0056] Refer to Figs. 27 and 28. Fig. 27 illustrates a detailed exploded view of the heat pipe assembly 10N according to a fifteenth embodiment of the present disclosure. Fig. 28 illustrates a cross-sectional view of the heat pipe assembly 10N in Fig. 27.

[0057] Compared to the second heat pipe 12 illustrated in Fig. 2, the second heat pipe 12N of the fifteenth embodiment only includes half of the folded edge 121N. In other embodiments, the folded edge of the second heat pipe can be divided into any suitable pieces. For example, the folded edge can have one third of the full folded edge. For example, the folded edge can have four pieces that are not connected with each other.

[0058] In addition, the first capillary structure 13N and the second capillary structure 14N does not connect to each other. In some embodiments, the first capillary structure and the second capillary structure can be connected with each other by powder sintering or directly by welding.

[0059] Fig. 29 illustrates a cross-sectional view of the heat pipe assembly 10P according to the seventeenth embodiment of the present disclosure. The first heat pipe 11P can further include a third capillary structure 17 disposed on the first capillary structure 13P. The third capillary structure 17 can be disposed on the bottom of the first thermal conductive section 111P. The crescent parts 141 of the capillary structure 14P can connect to the first capillary structure 13P via the third capillary structure 17. When the cooling fluid absorbs the heat of the heat source and evaporates, it can be refluxed to the heat source through the capillary structure 13P, 17 and 14P to achieve the effect of cooling cycle.

[0060] As illustrated, the third capillary structure 17 is a raised block structure. The capillary shape of the third

capillary structure 17 can be any shape that is suitable for the specific application of the heat pipe assembly. For example, the third capillary structure 17 can be round, square, oval, triangular, or other irregular shapes. The third capillary structure 17 can be a powder sintered structure or a woven mesh or any other suitable structures. The third capillary structure 17 and the first capillary structure 13P are integrated structures as shown in the Fig. 29. In other embodiments, the third capillary structure 17 and the first capillary structure 13P can be two individual structures.

[0061] Figs. 30A-30F illustrate different shapes of the second heat pipe and the second capillary structure according to embodiments of the present disclosure. The second heat pipe can have different structures that can be suitable for the specific application of the heat pipe assembly. In some embodiments, the second heat pipe can have straight pipe structure as shown in Fig. 30A. In some embodiments, the second heat pipe can have a folded edge as shown in Figs. 30B, 30D, and 30F. In some embodiments, the second heat pipe can have a narrowed end as shown in Figs. 30C and 30D. In some embodiments, the second heat pipe can have a widened end as shown in Figs. 30E and 30F. In some embodiments, the second heat pipe having narrowed end or widened end can also have a folded edge as shown in Fig. 30D and 30F.

[0062] The second capillary structure can have different lengths that can be suitable for the specific application of the heat pipe assembly. In some embodiments, the second capillary structure can have an extended section that extends out of the connecting opening as shown in the lift figures of Figs. 30A-30F. In some embodiments, the second capillary structure can have the same length as the second heat pipe wall as shown in the right figures, of Figs. 30A-30F.

[0063] The heat pipe assembly as disclosed in the above embodiments can increase the heat exchange area of the heat pipe assembly when the width of the heat pipe assembly is limited, therefore, improve the heat dissipation efficiency of the heat pipe assembly.

[0064] 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. Of course, the disclosed embodiments are merely exemplary embodiments and that various modifications can be made without departing from the spirit and scope of the dis-

closure. Further, it should be understood that various aspects of the embodiment are not mutually exclusive of each other and can be combined as desired by a person of ordinary skill in the art as a matter of design choices.

[0065] 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 heat pipe assembly, comprising:

a first heat pipe having an inner surface, an outer surface, and at least one opening, the inner surface forms a first chamber, the at least one opening is disposed on a longitudinal side of the first heat pipe; and

at least one second heat pipe having a second chamber and a connecting opening at one end, wherein the at least one second heat pipe is disposed on the first heat pipe at the at least one opening, and the second chamber connects with the first chamber through the at least one opening of the first heat pipe and the connecting opening of the at least one second heat pipe.

2. The heat pipe assembly of claim 1, wherein the first heat pipe comprises a first thermal conductive section and at least one second thermal conductive section, the at least one second thermal conductive section is connected to one end of the first thermal conductive section, the at least one second thermal conductive sections protrude perpendicular to the first thermal conductive section, and the at least one opening is disposed at the first thermal conductive section.

3. The heat pipe assembly of claim 2, wherein the at least one second thermal conductive section comprises a bending section that connects the at least one second thermal conductive section to the first thermal conductive section.

4. The heat pipe assembly of claim 2 or 3, wherein a portion of the first thermal conductive section is a flat tube.

5. The heat pipe assembly of one of claims 1 to 4, wherein the at least one of the second heat pipe comprises a folded edge at the connecting opening, the folded edge is disposed on the outer surface of the first heat pipe at the at least one opening.

6. The heat pipe assembly of one of claims 2 to 5, wherein the first thermal conductive section comprises a recessed region on the outer surface of the first heat pipe that surrounds the at least one opening, and the at least one of the second heat pipe has a folded edge at the connecting opening, the folded edge is disposed in the recessed region.

7. The heat pipe assembly of one of claims 2 to 5, wherein the first thermal conductive section comprises a recessed region on the outer surface of the first heat pipe that surrounds the at least one opening, and the at least one second heat pipe is disposed in the recessed region.

8. The heat pipe assembly of one of claims 1 to 7, wherein a portion of the at least one second heat pipe is inserted into the at least one opening.

9. The heat pipe assembly of one of claims 1 to 8, wherein the at least one second heat pipe comprises a tapered structure adjacent to the connecting opening and is inserted into the first chamber of the first heat pipe.

10. The heat pipe assembly of one of claims 2 to 9, wherein the first heat pipe comprises a folded edge perpendicular to the first thermal conductive section at the at least one opening, the at least one second heat pipe has a portion that is inserted through the at least one opening and sleeved by the folded edge.

11. The heat pipe assembly of one of claims 2 to 9, wherein the first heat pipe comprises a folded edge perpendicular to the first thermal conductive section at the at least one opening, the at least one second heat pipe has a portion that is inserted through the at least one opening and sleeves the folded edge.

12. The heat pipe assembly of one of claims 2 to 4, wherein the at least one second heat pipe comprises a folded edge at the connecting opening and is

disposed on the inner surface of the first thermal conductive section of the first heat pipe.

13. The heat pipe assembly of one of claims 2 to 4, further comprises at least one ring connector having a narrow portion and a wide portion that is disposed between the first heat pipe and the at least one second heat pipe and connects the first heat pipe and the at least one second heat pipe, wherein the first heat pipe connects at the narrow portion and the at least one second heat pipe connects at the wide portion. 5 10
14. The heat pipe assembly of one of claims 1 to 13, further comprises a first capillary structure and at least one second capillary structure, the first capillary structure is disposed in the first chamber of the first heat pipe, the at least one second capillary structure is disposed in the second chamber of the at least one second heat pipe and connects with the first capillary structure. 15 20
15. The heat pipe assembly of claim 14, wherein the second capillary structure comprises two crescent parts that are symmetrically disposed adjacent to the connecting opening. 25
16. The heat pipe assembly of claim 14 or 15, wherein the second capillary structure has a semicircular structure. 30
17. The heat pipe assembly of one of claims 14 to 16, further comprises a third capillary structure disposed in the first chamber of the first heat pipe and disposed on the first capillary structure, the second capillary structure connects the first capillary structure via the third capillary structure. 35
18. The heat pipe assembly of one of claims 1 to 17, wherein the at least one second heat pipe is welded to the first heat pipe. 40
19. The heat pipe assembly of one of claims 1 to 18, further comprises a plurality of third heat pipes, the plurality of third heat pipes are arranged perpendicular on the first heat pipes and the at least one second heat pipes. 45
20. The heat pipe assembly of one of claims 1 to 19, wherein the first heat pipe comprises a first thermal conductive section and two second thermal conductive sections, the two second thermal conductive sections are respectively connected to opposite ends of the first thermal conductive section, the two second thermal conductive sections protrude perpendicular to the first thermal conductive section, the at least one opening is disposed at the first thermal conductive section, and 50 55

each of the second thermal conductive sections includes a bending section that connects each of the second thermal conductive section to the first thermal conductive section at the respective opposite ends.

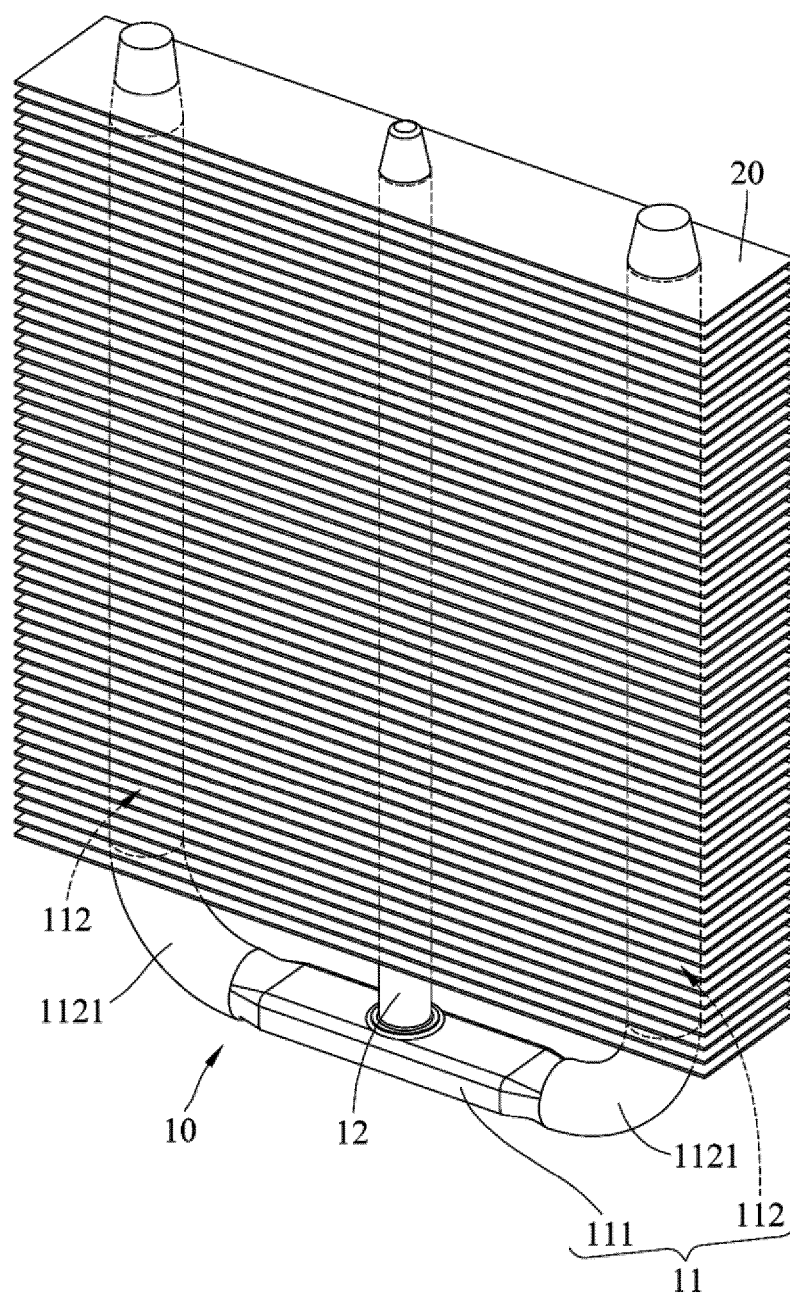


FIG. 1

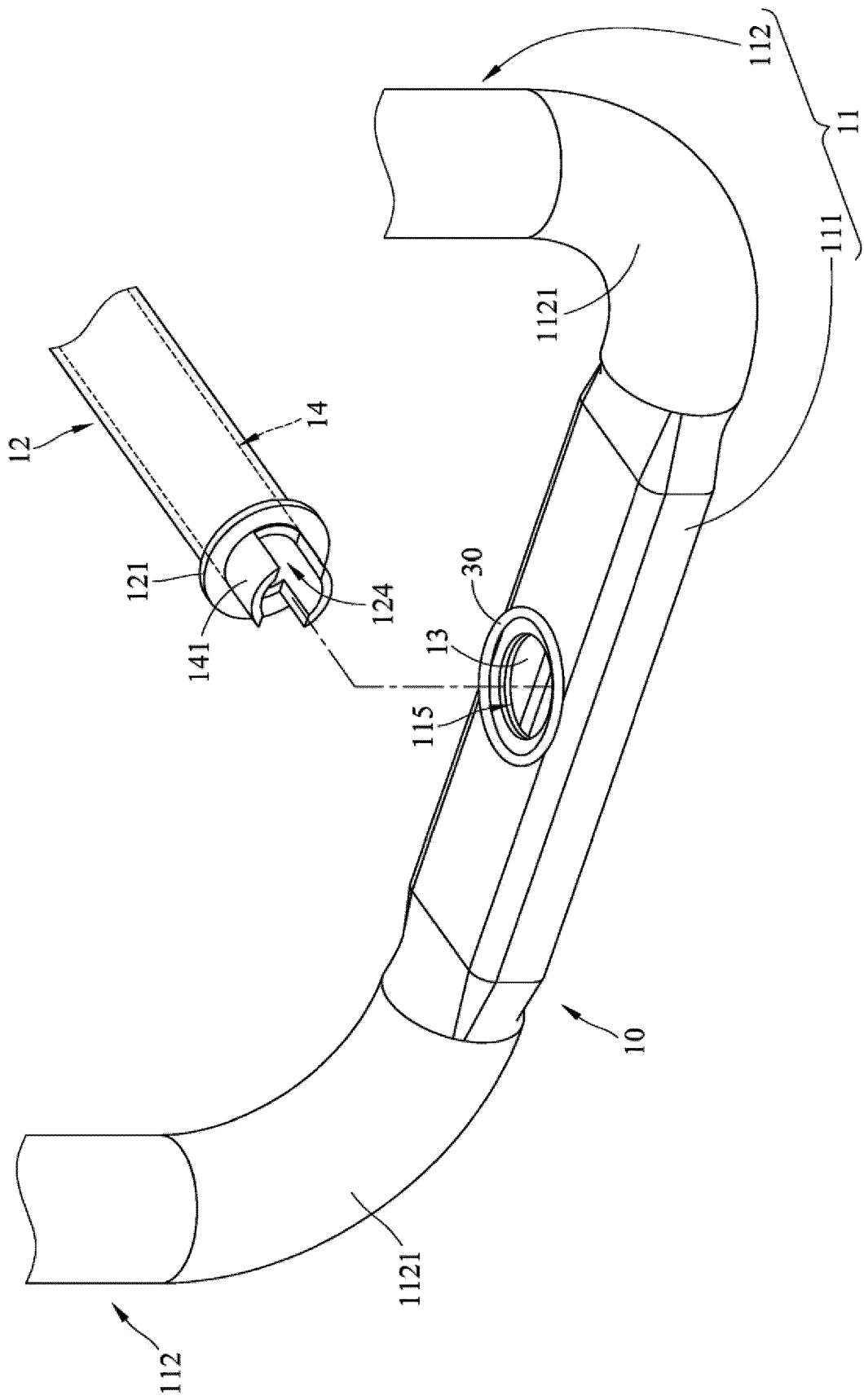


FIG. 2

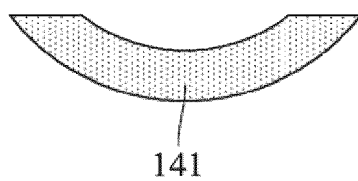
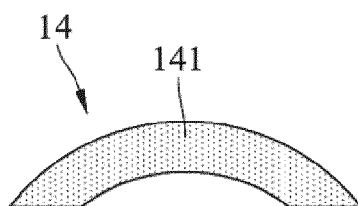


FIG. 3

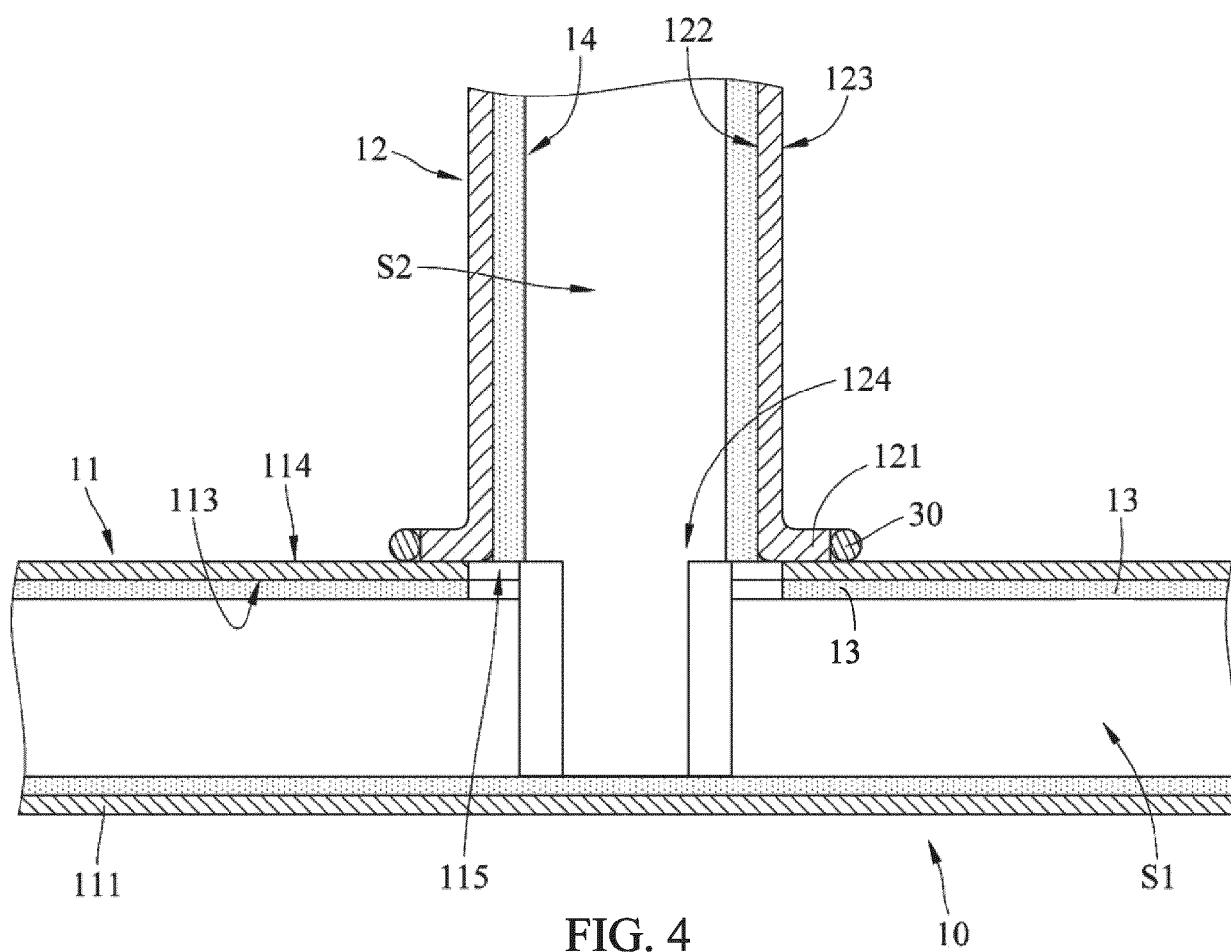


FIG. 4

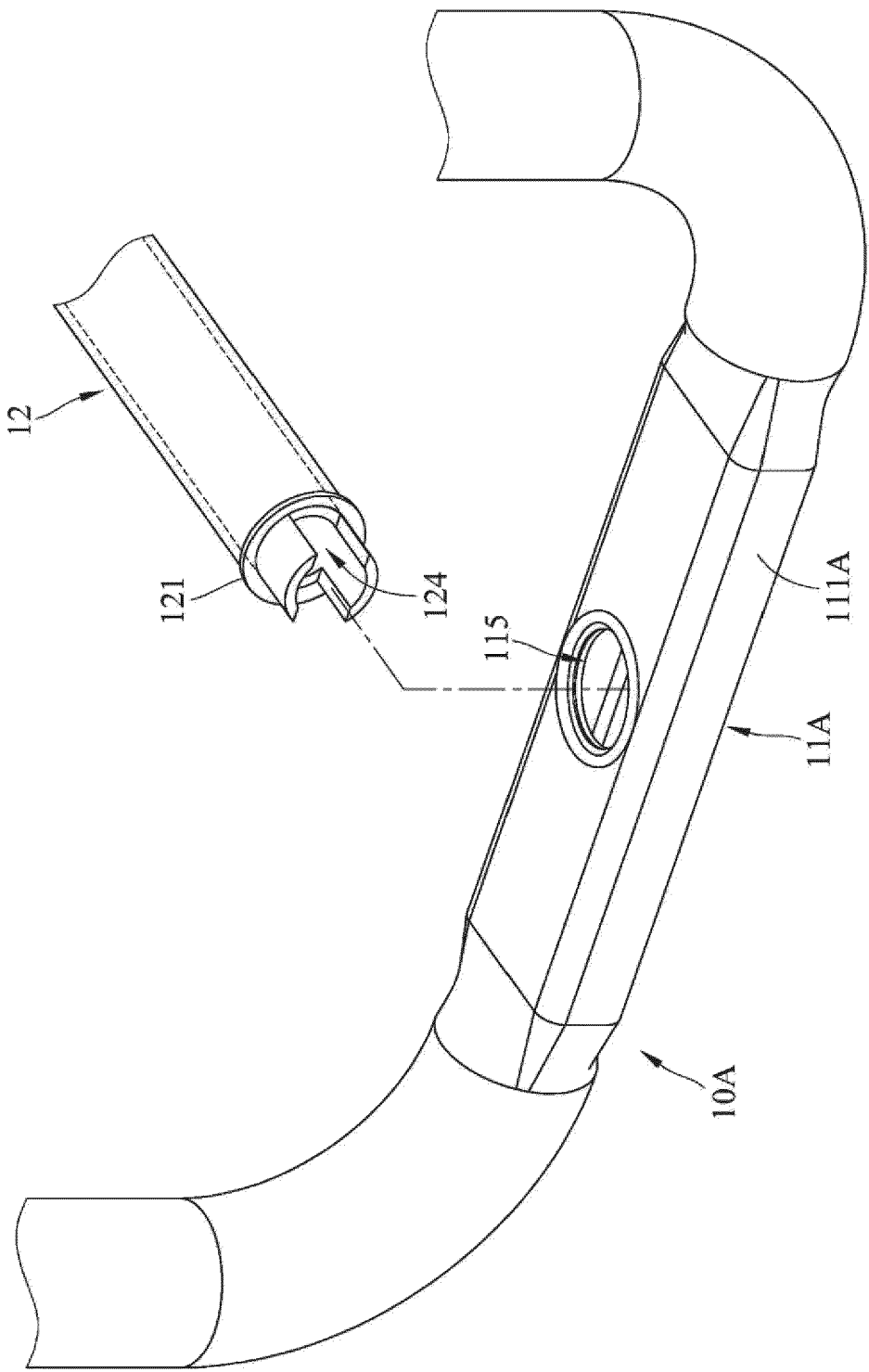


FIG. 5

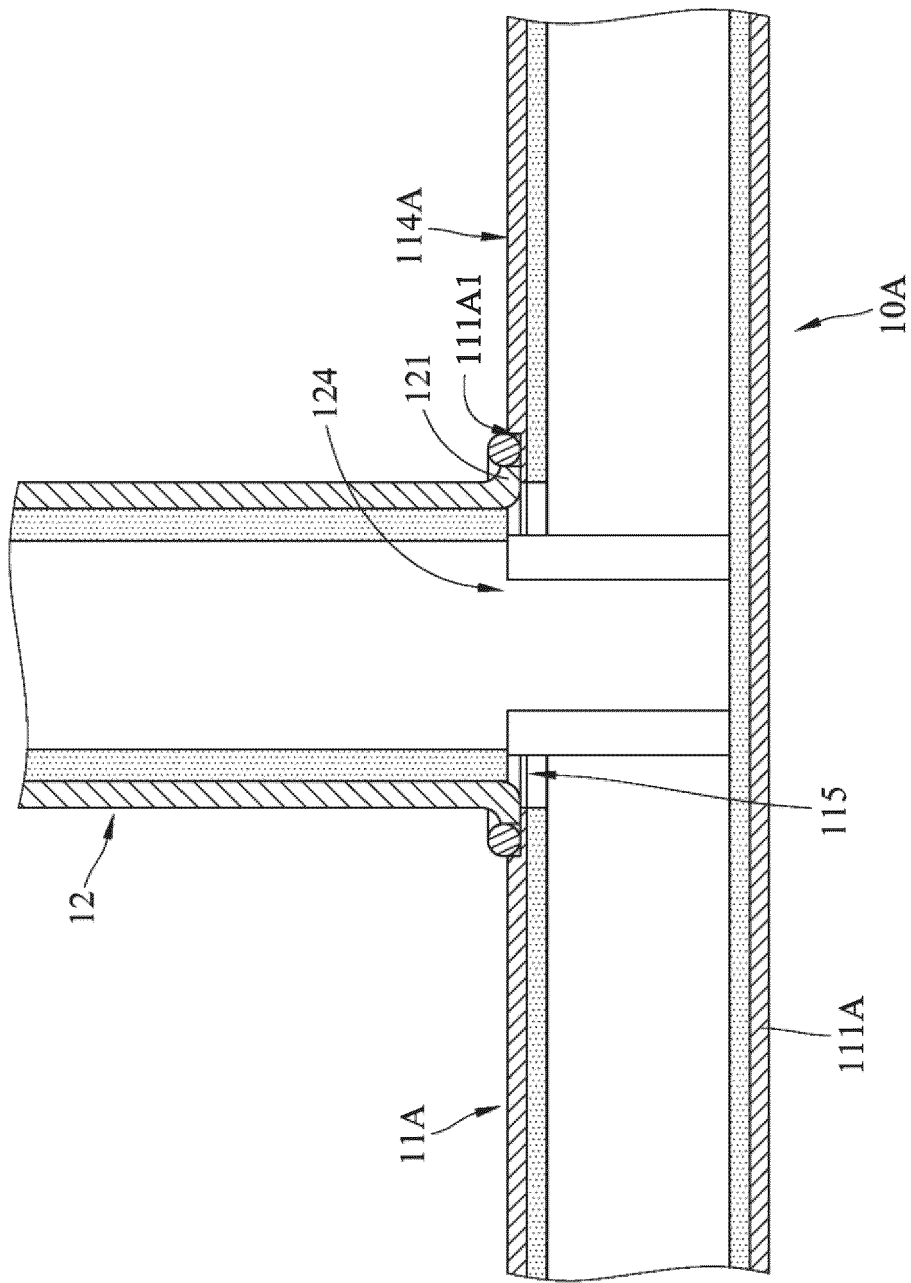


FIG. 6

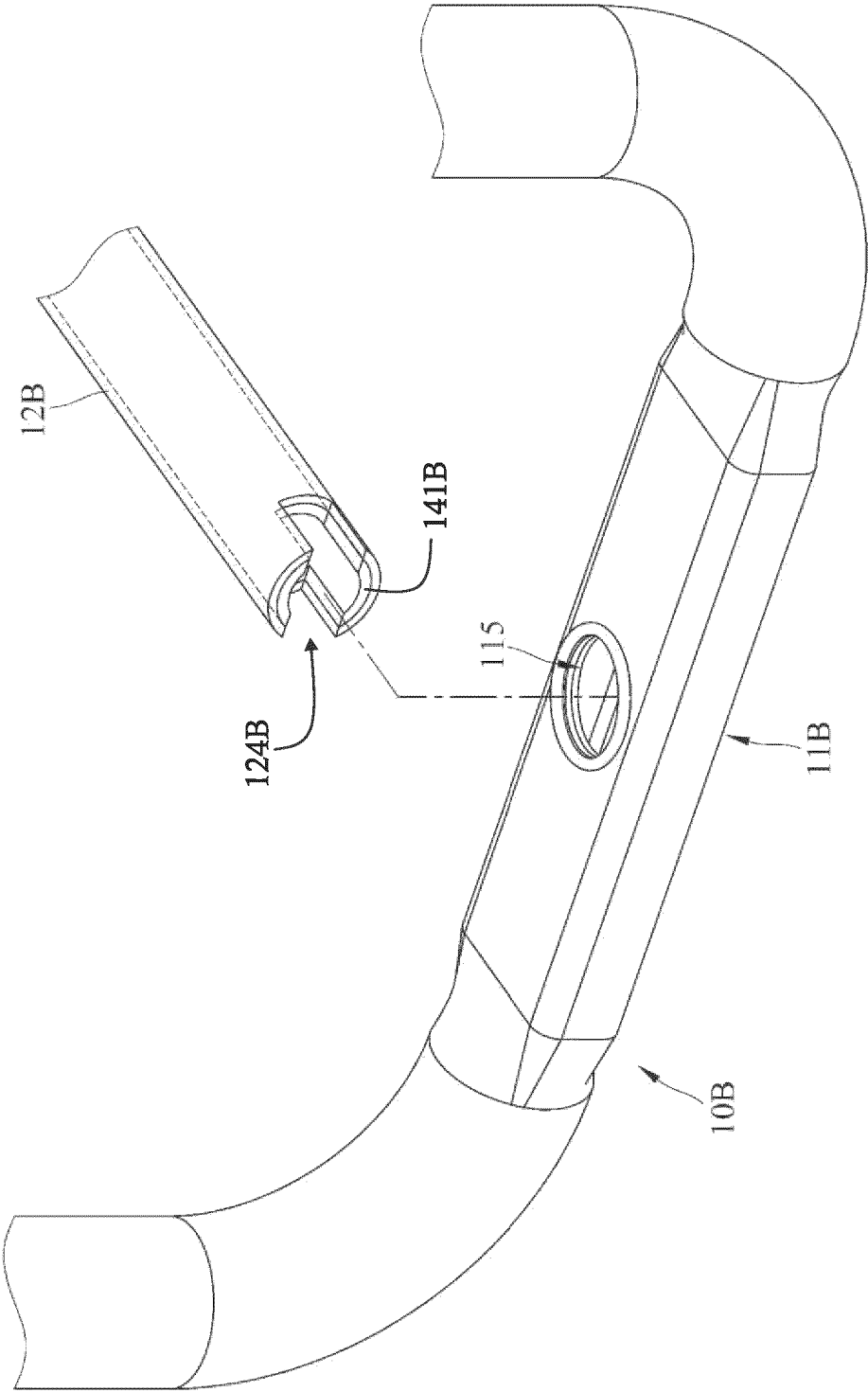


FIG. 7

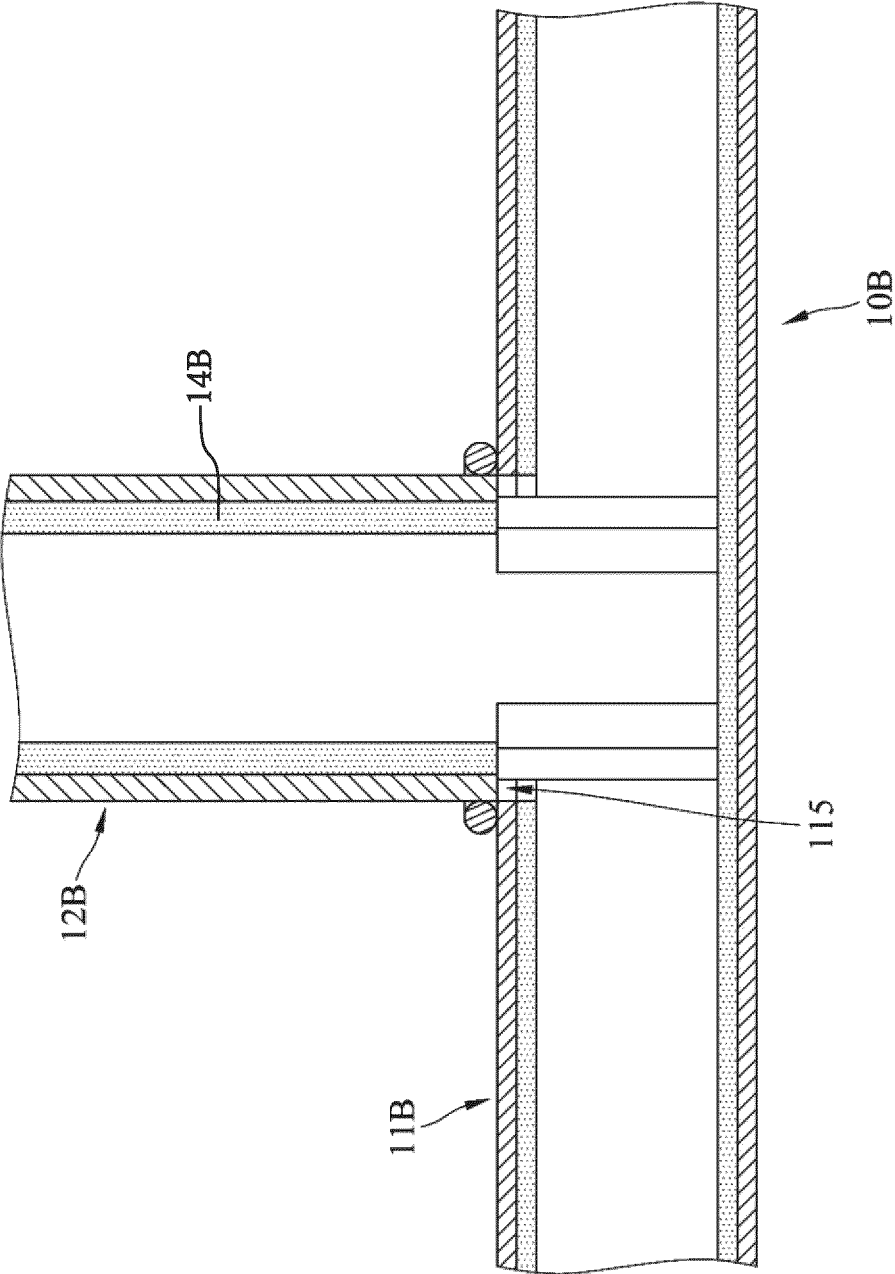


FIG. 8

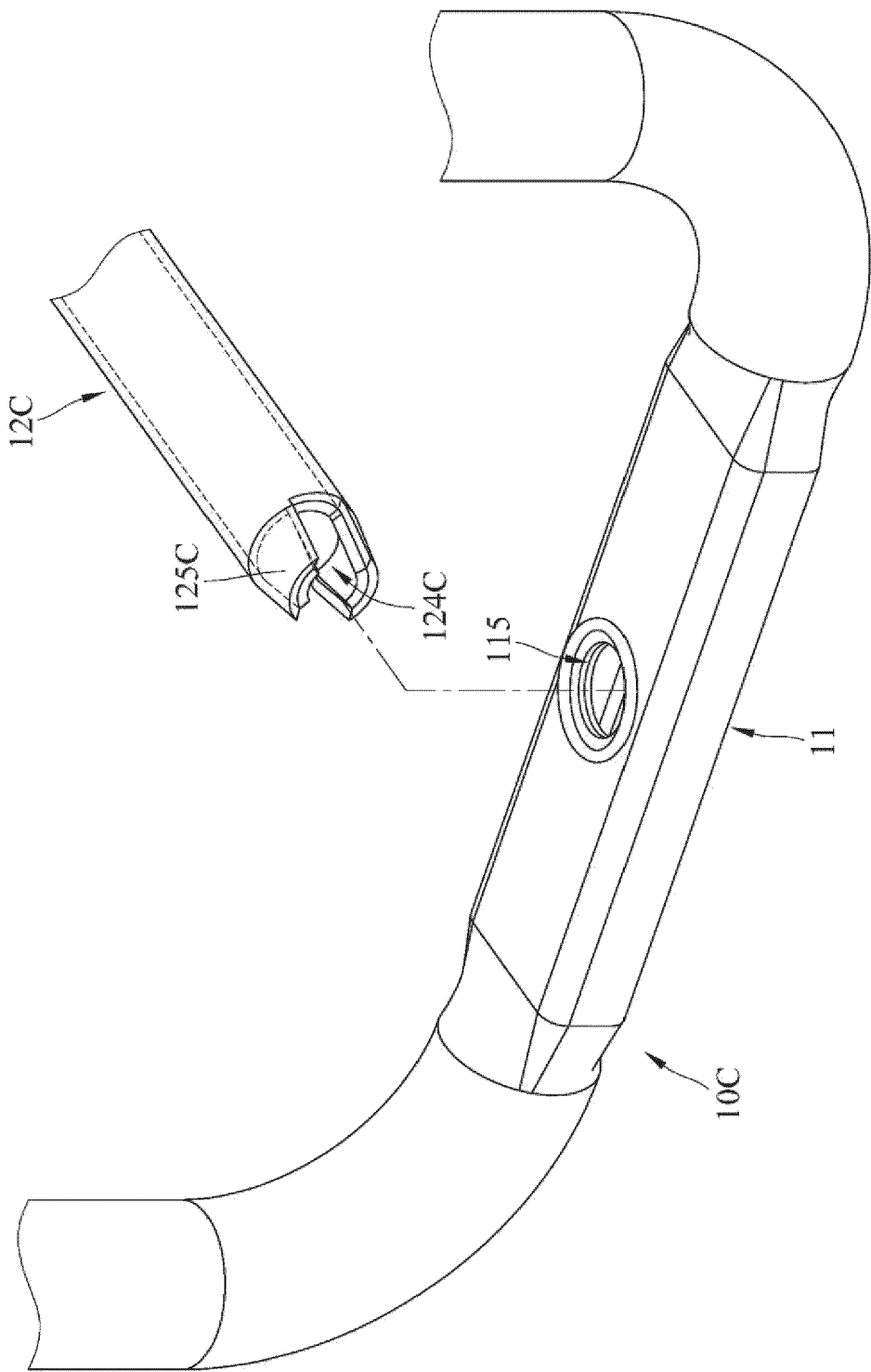


FIG. 9

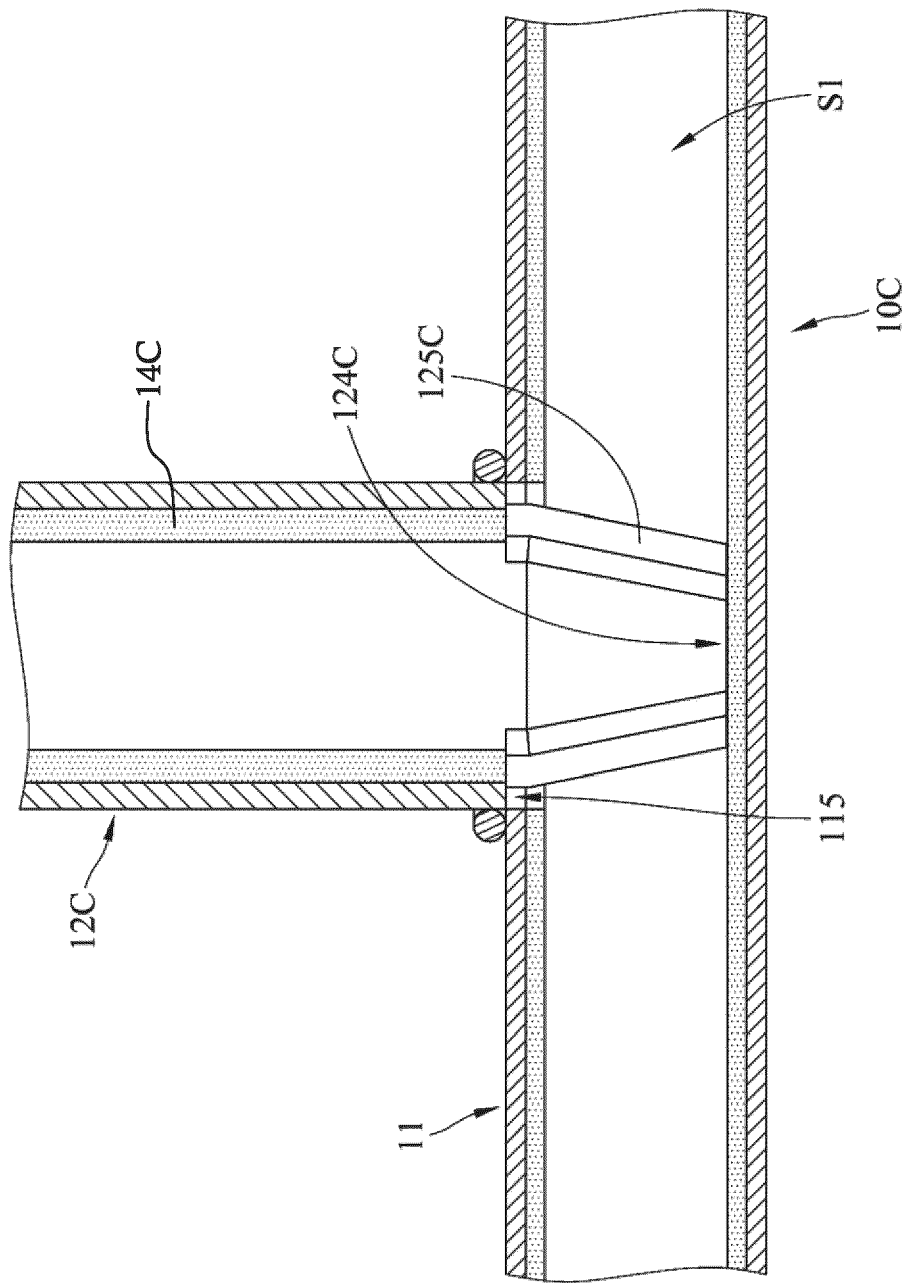


FIG. 10

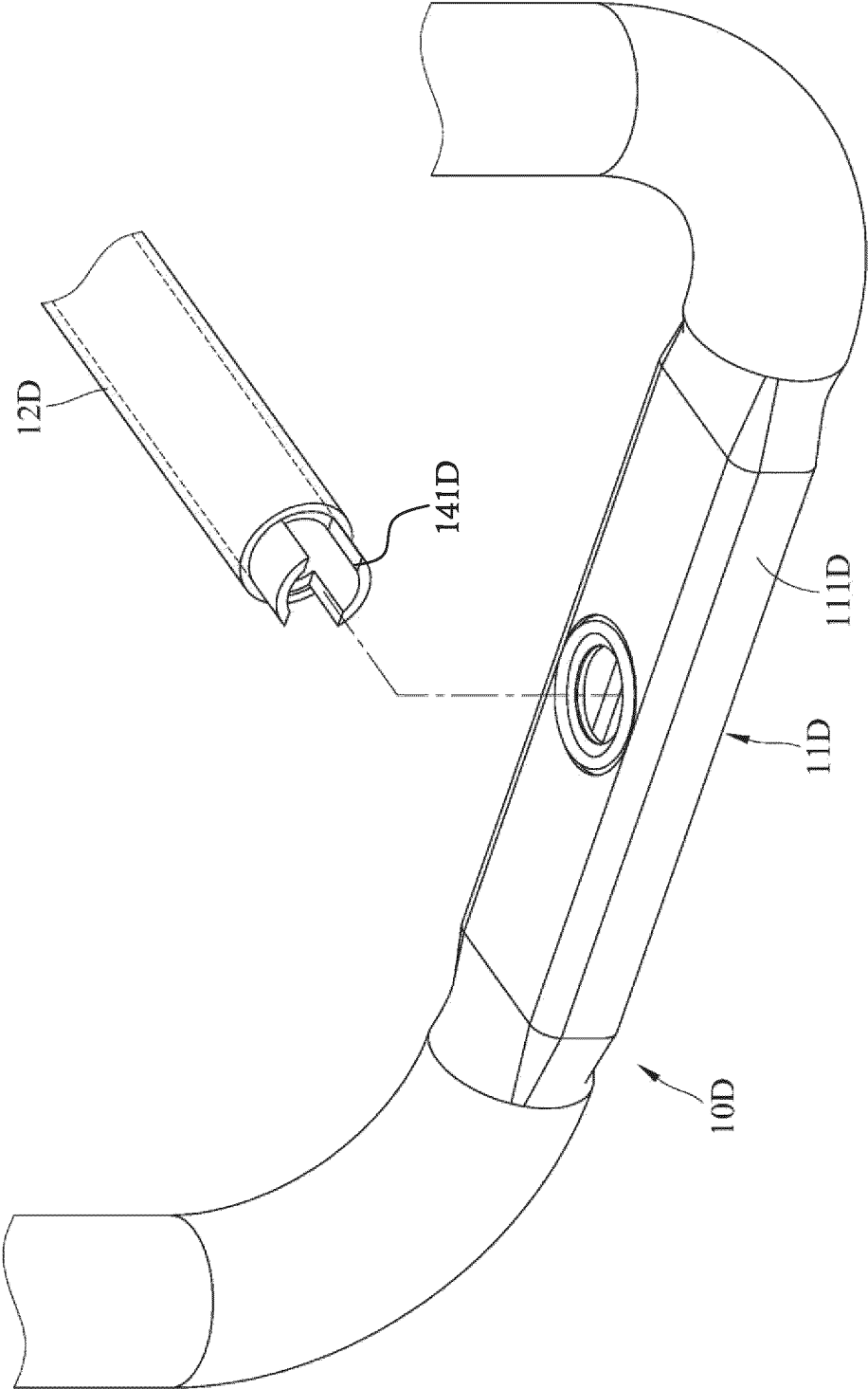


FIG. 11

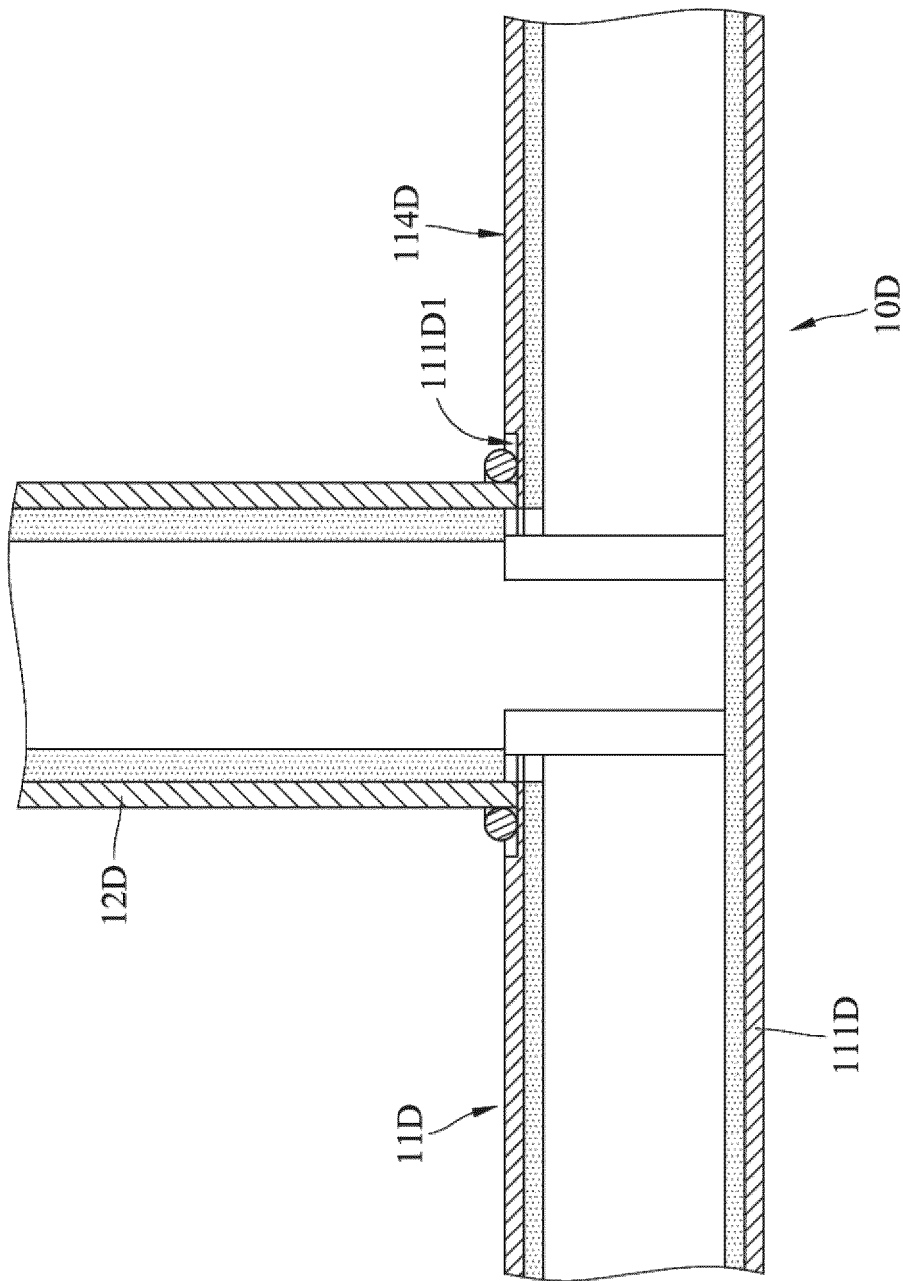


FIG. 12

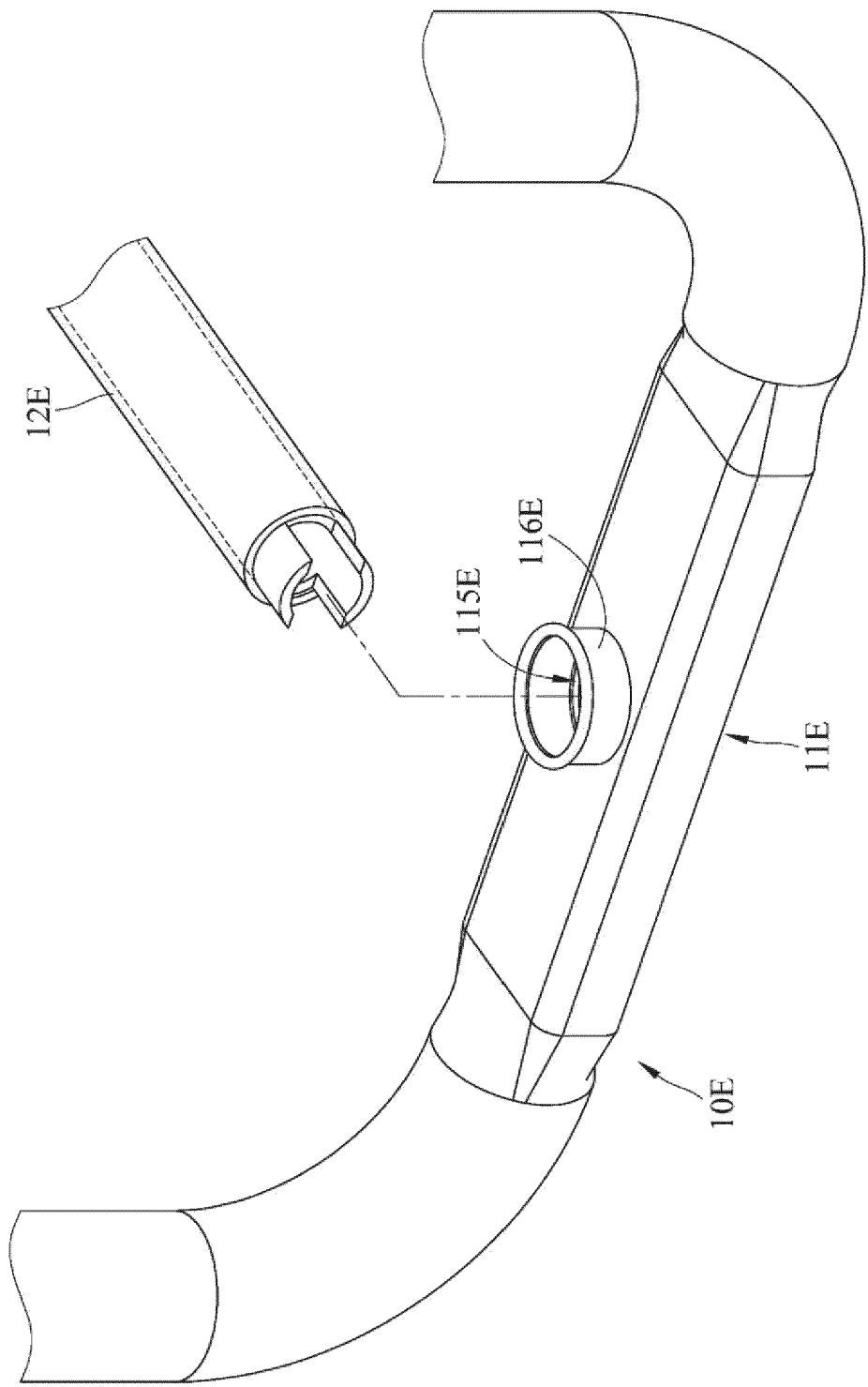


FIG. 13

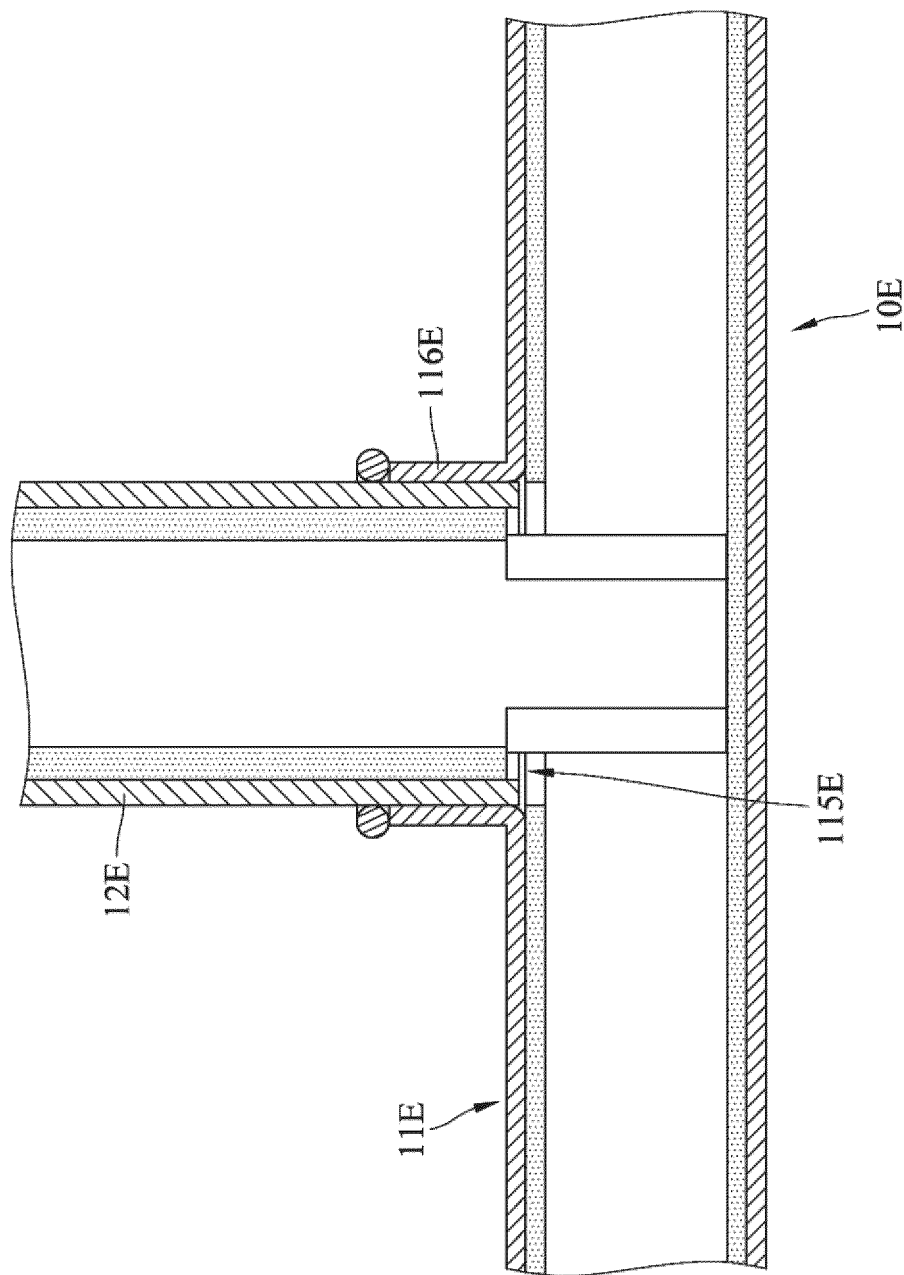


FIG. 14

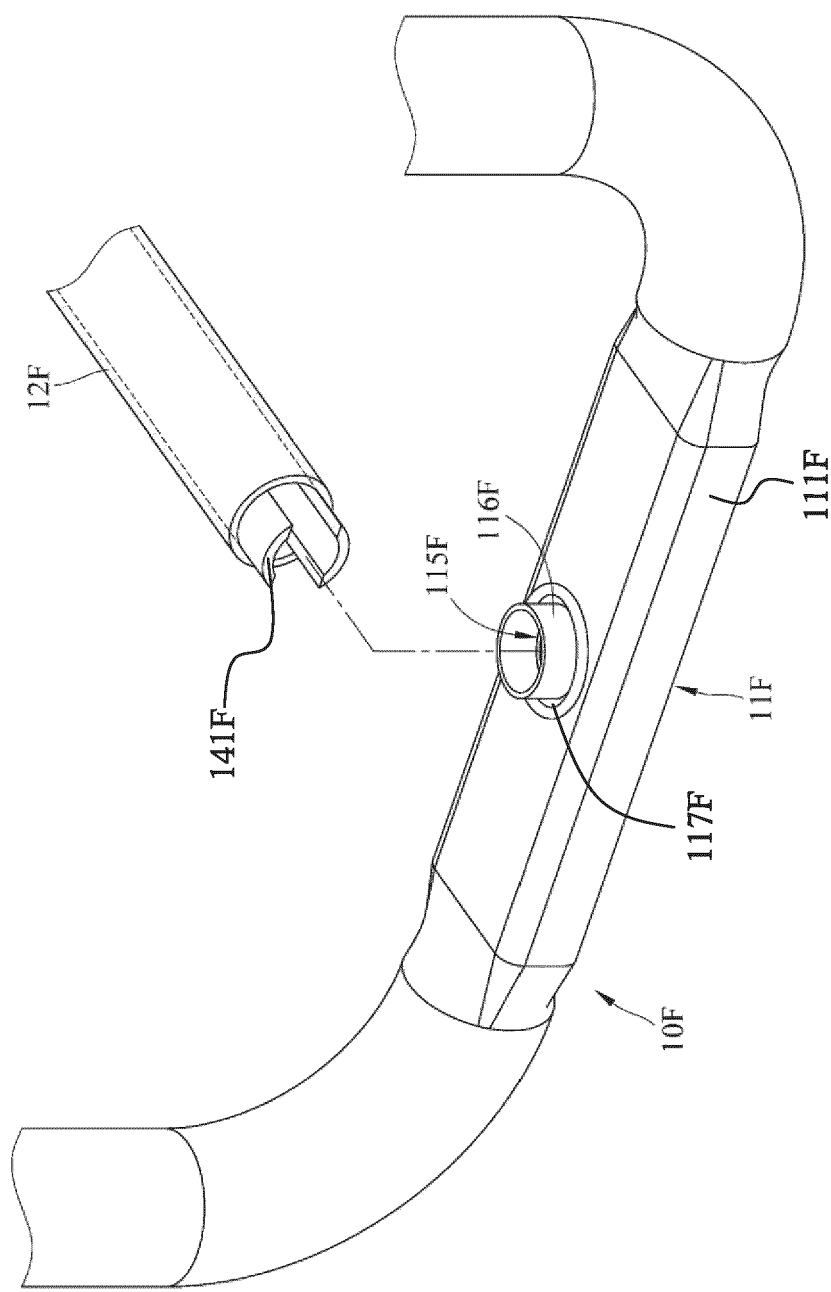


FIG. 15

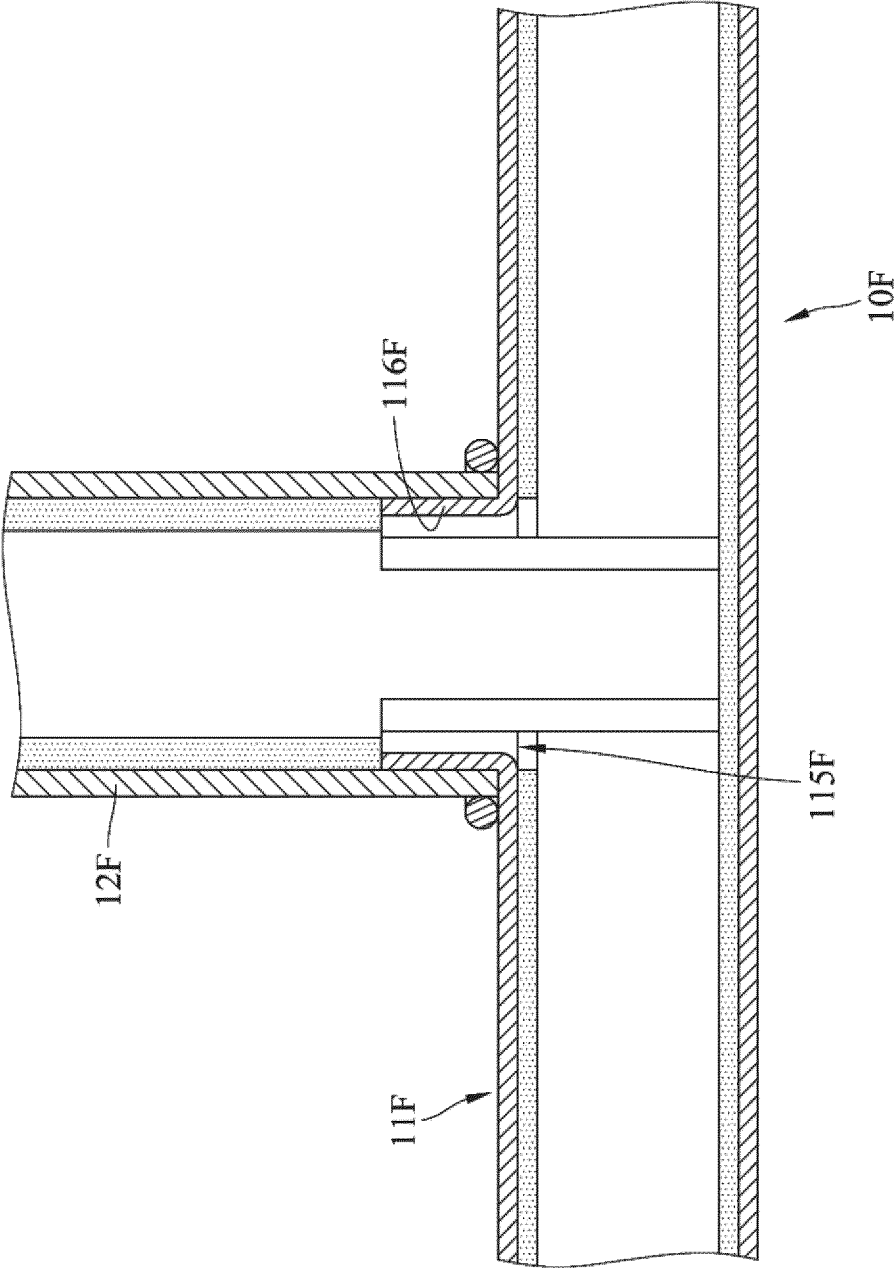


FIG. 16

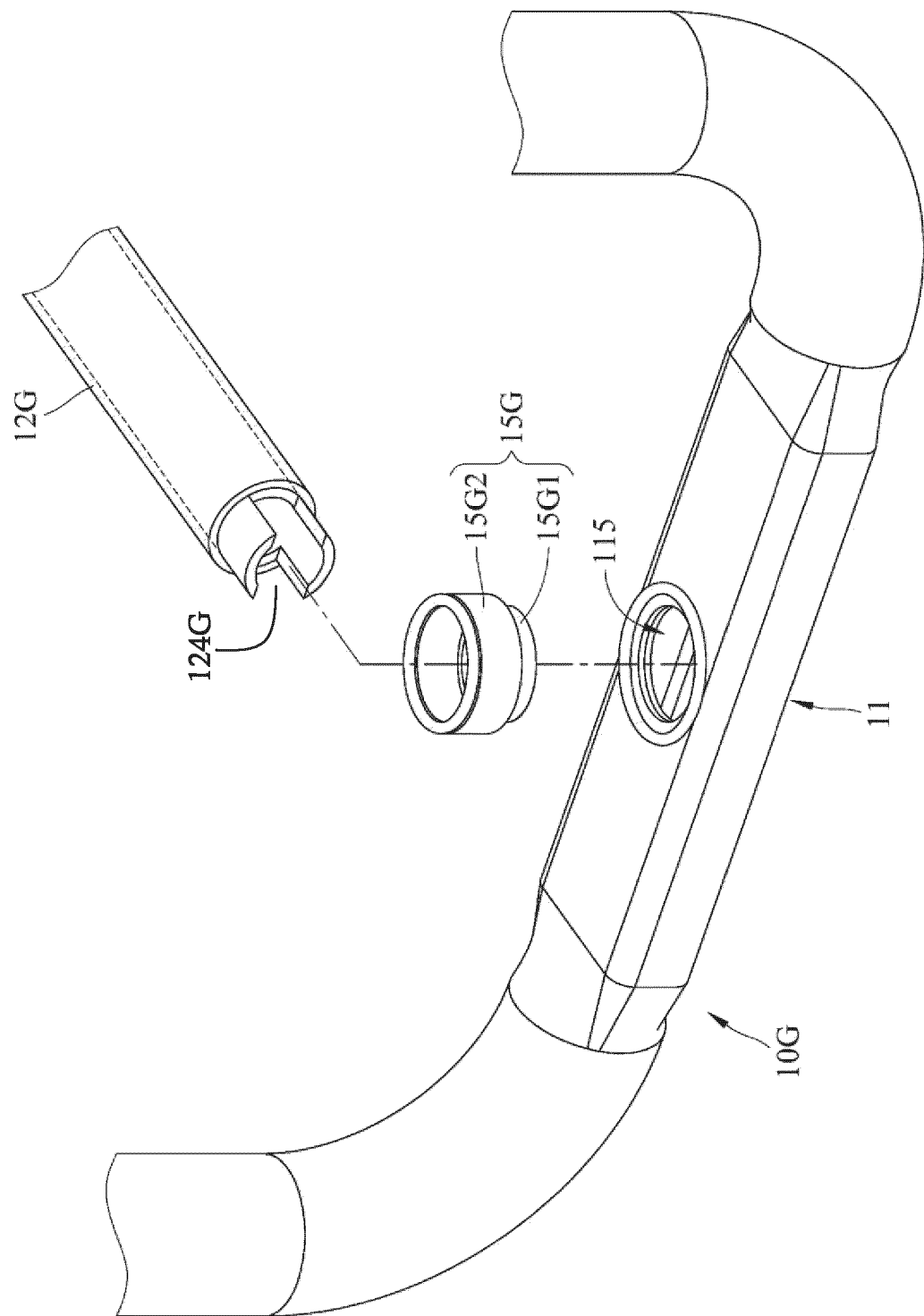


FIG. 17

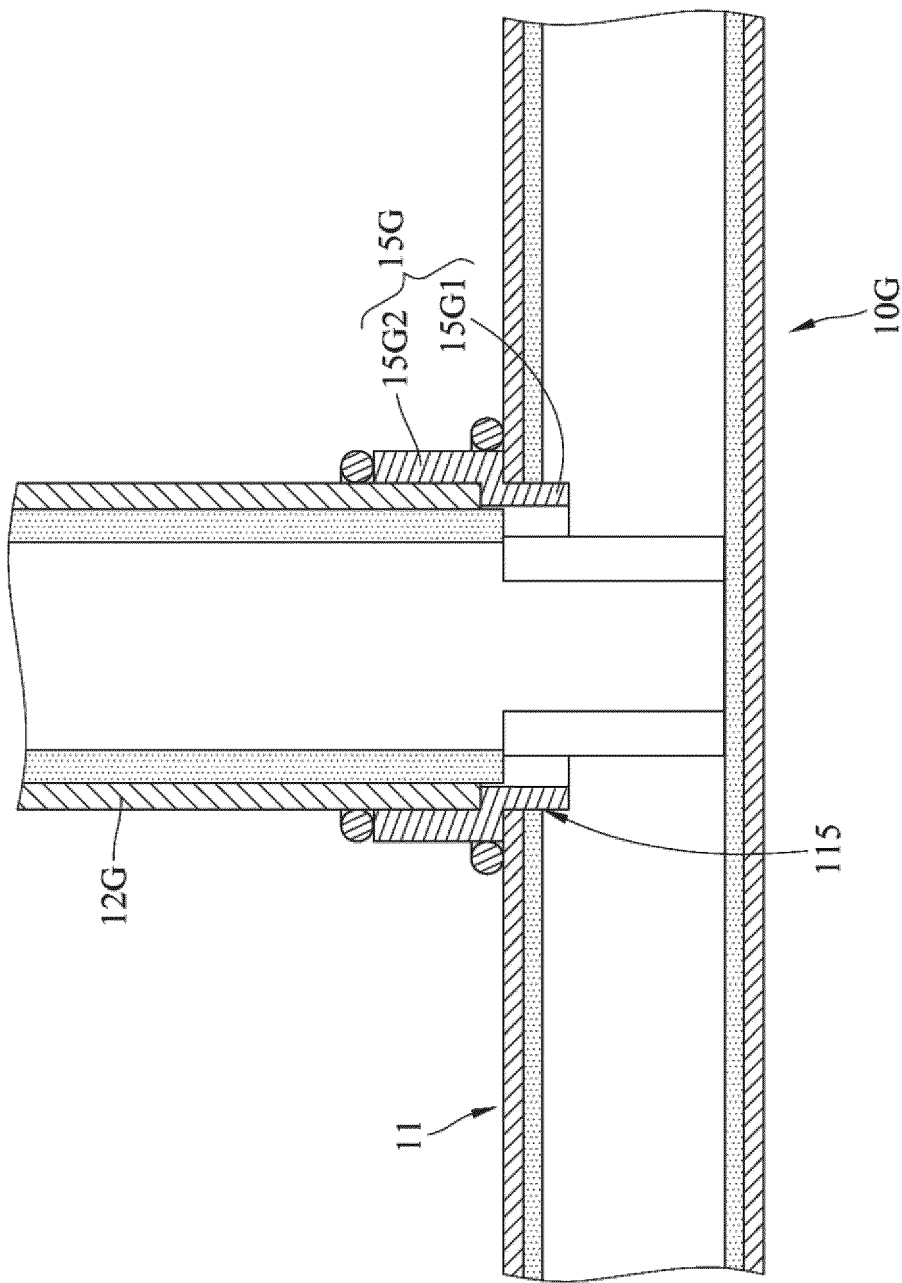


FIG. 18

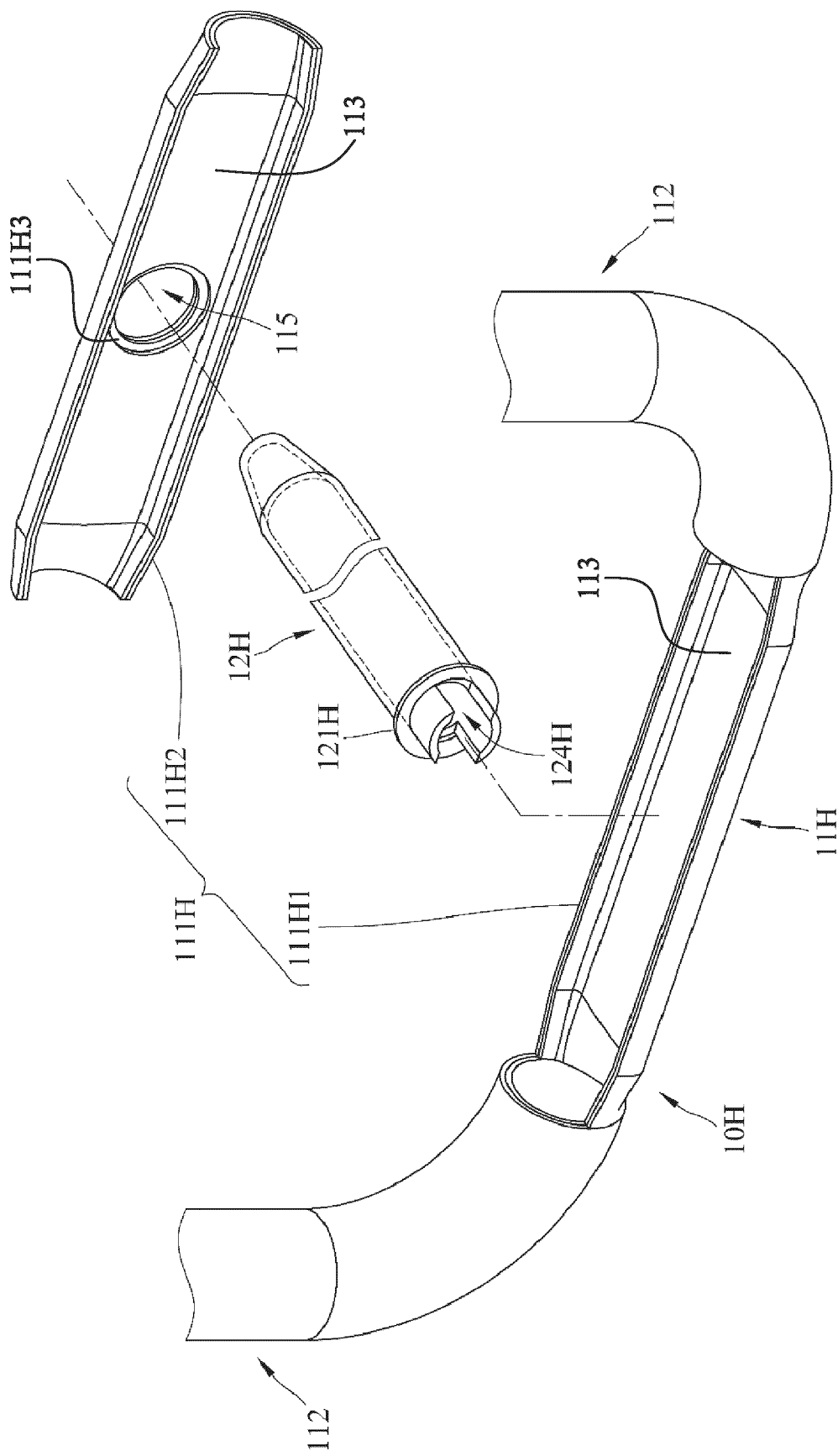
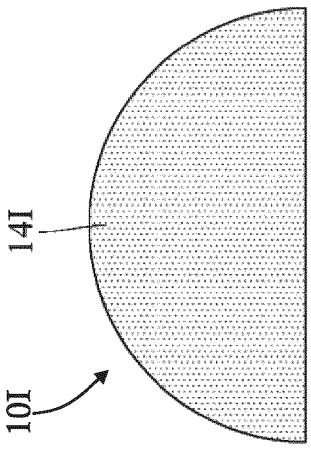
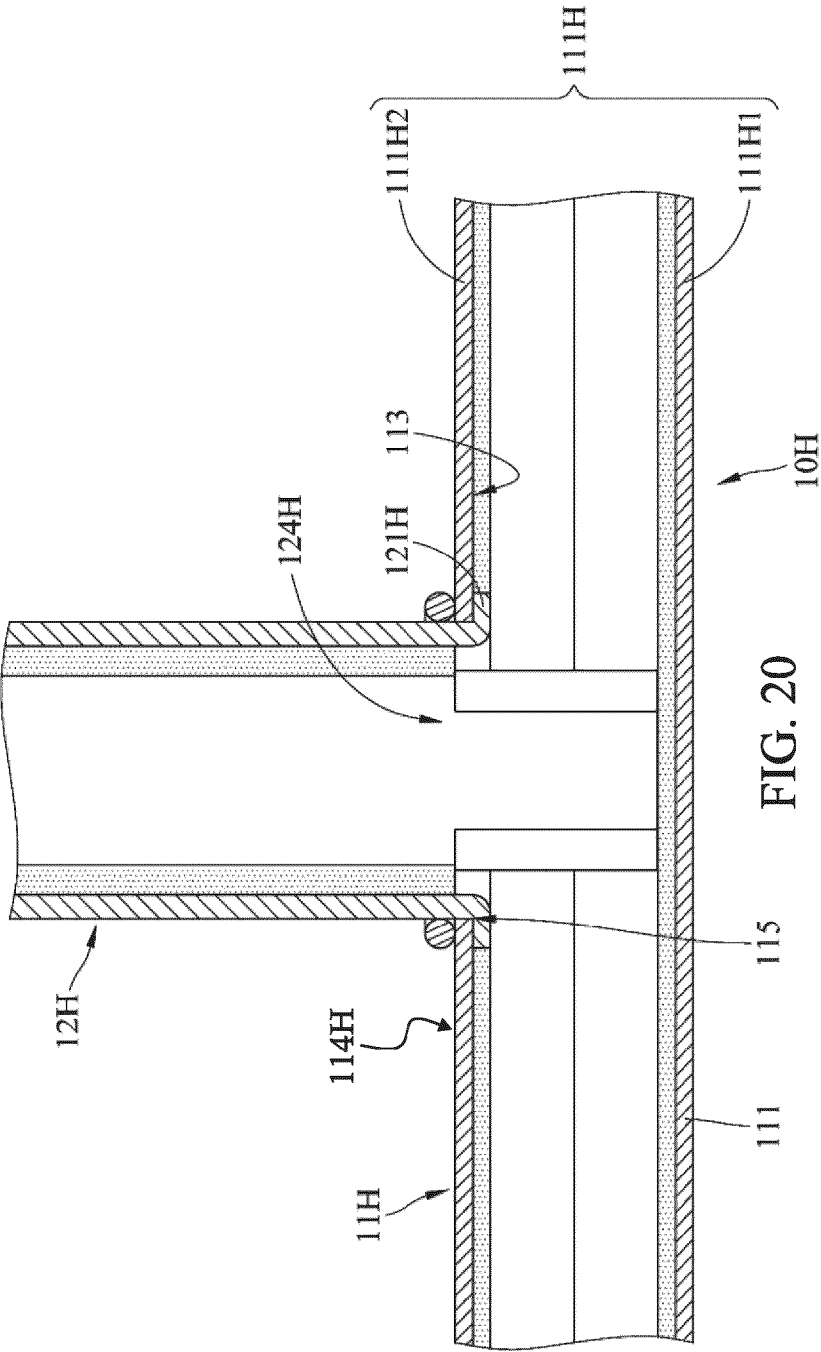


FIG. 19



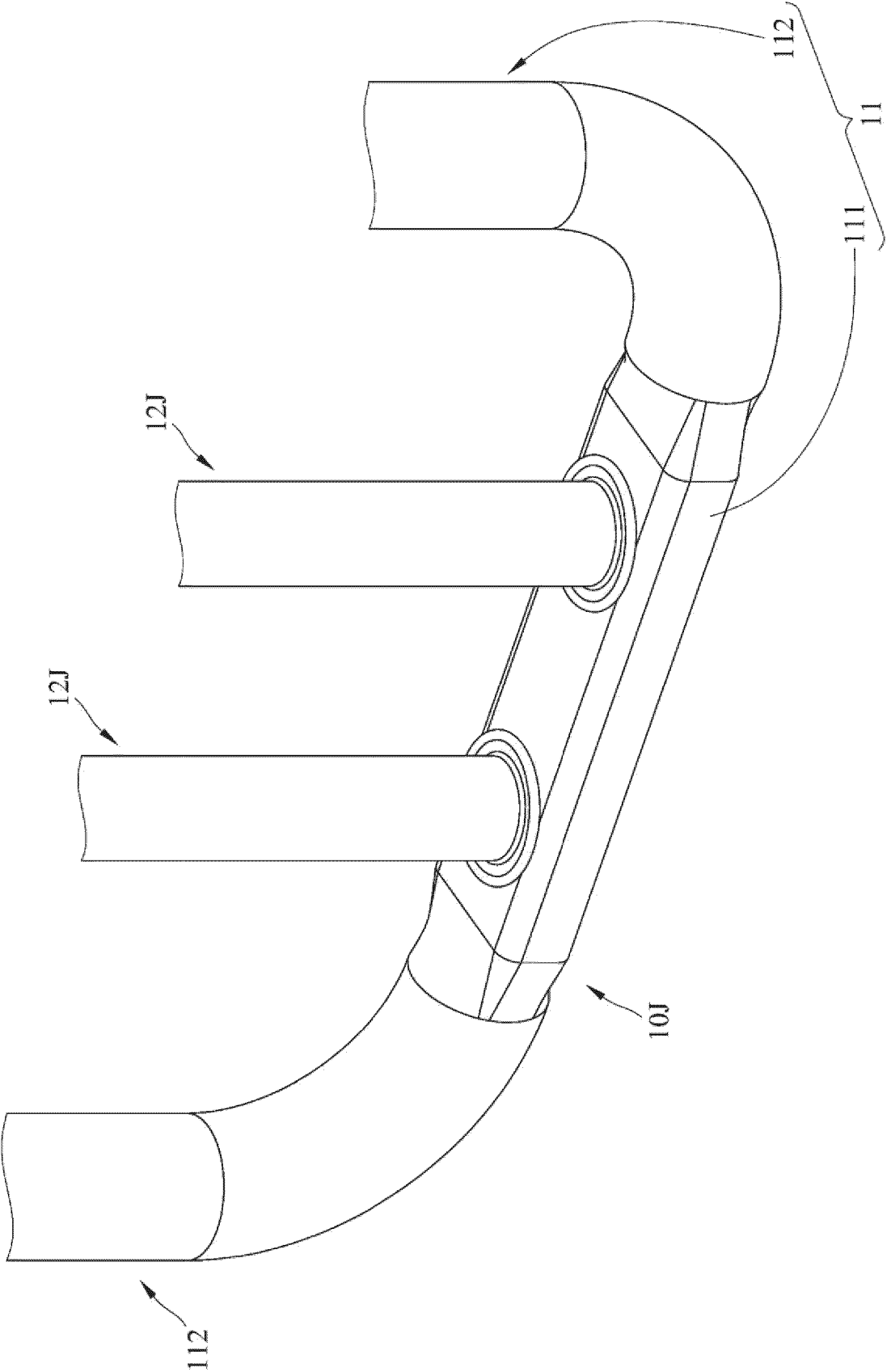


FIG. 22

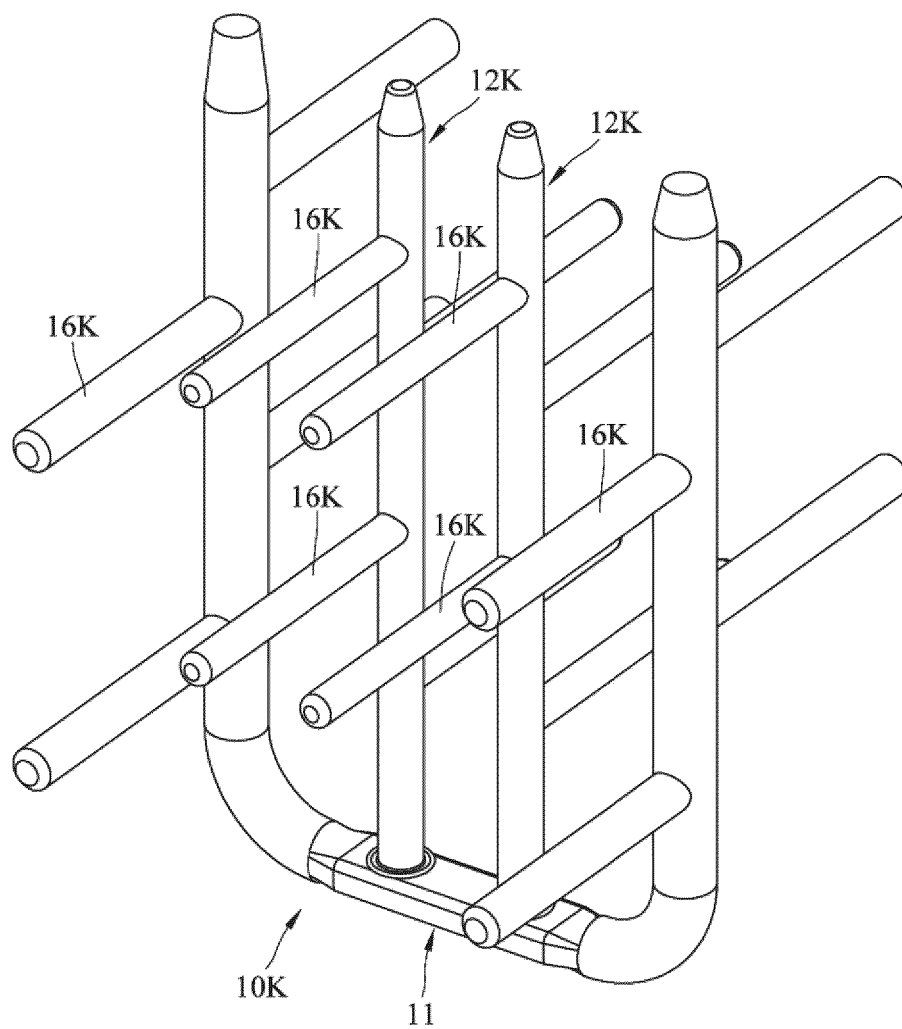


FIG. 23

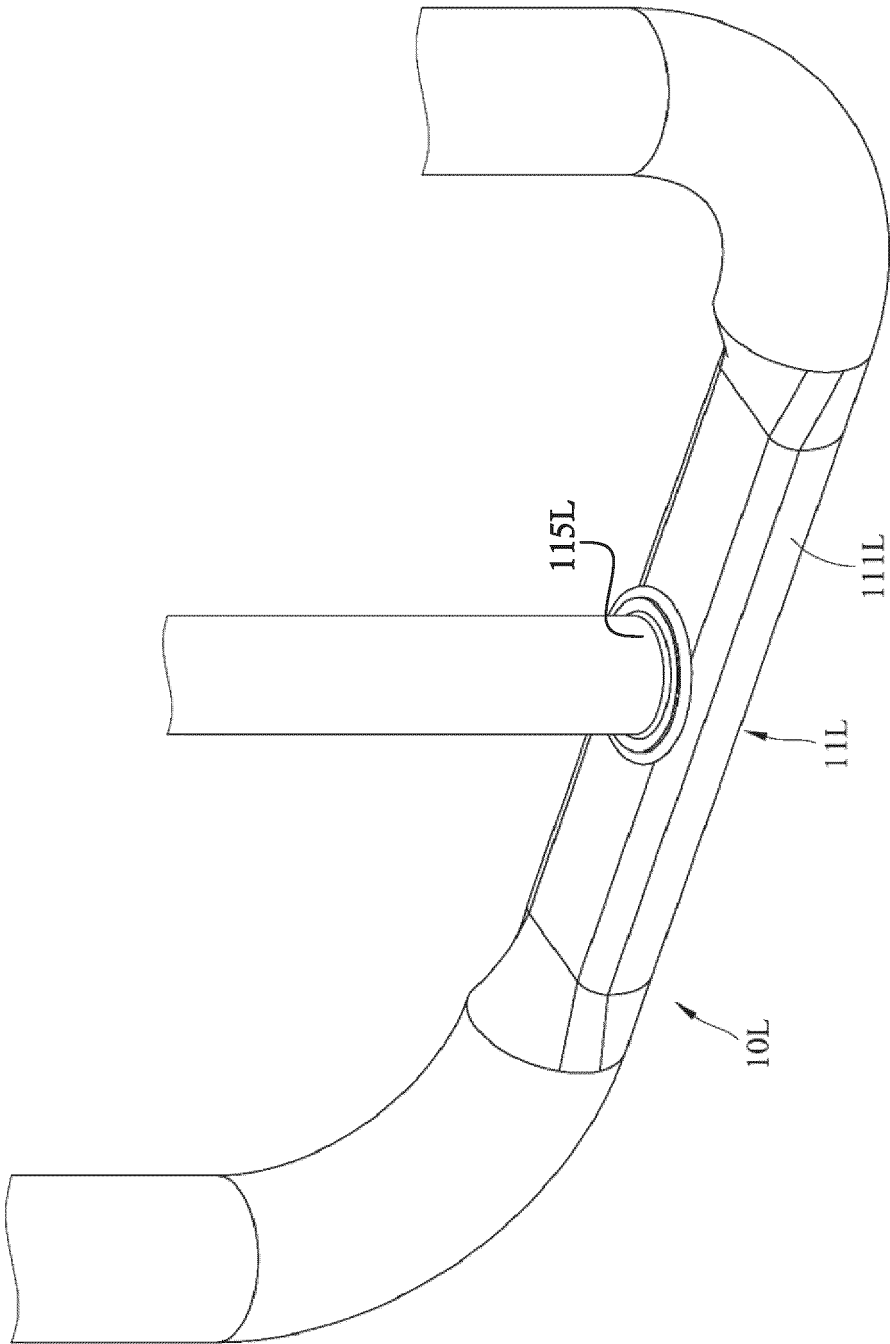


FIG. 24

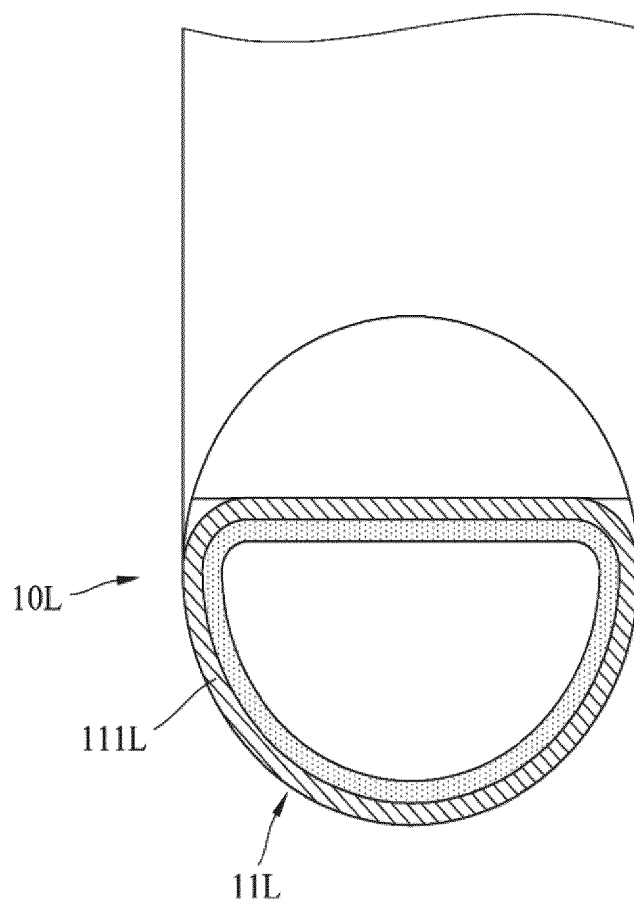


FIG. 25

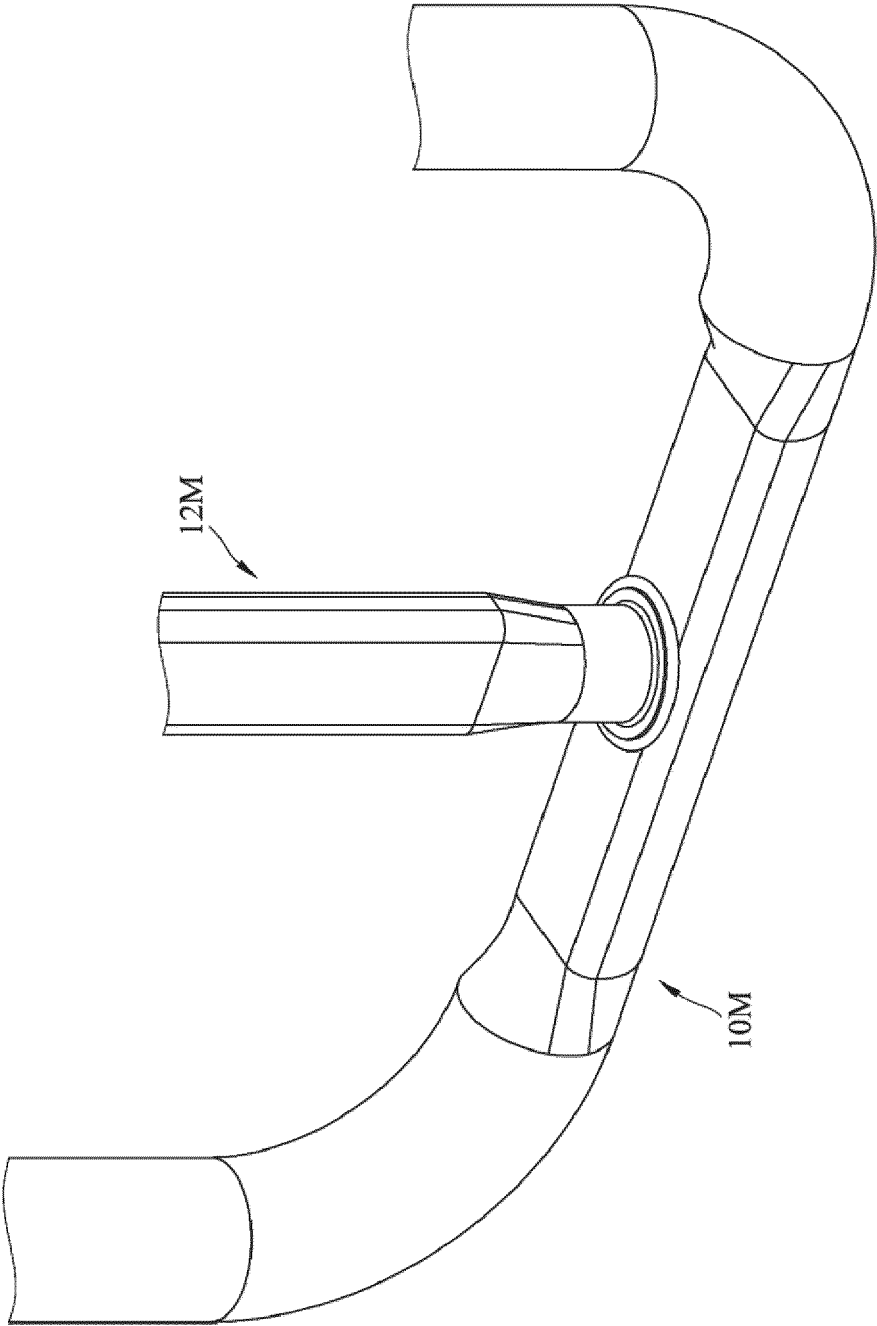


FIG. 26

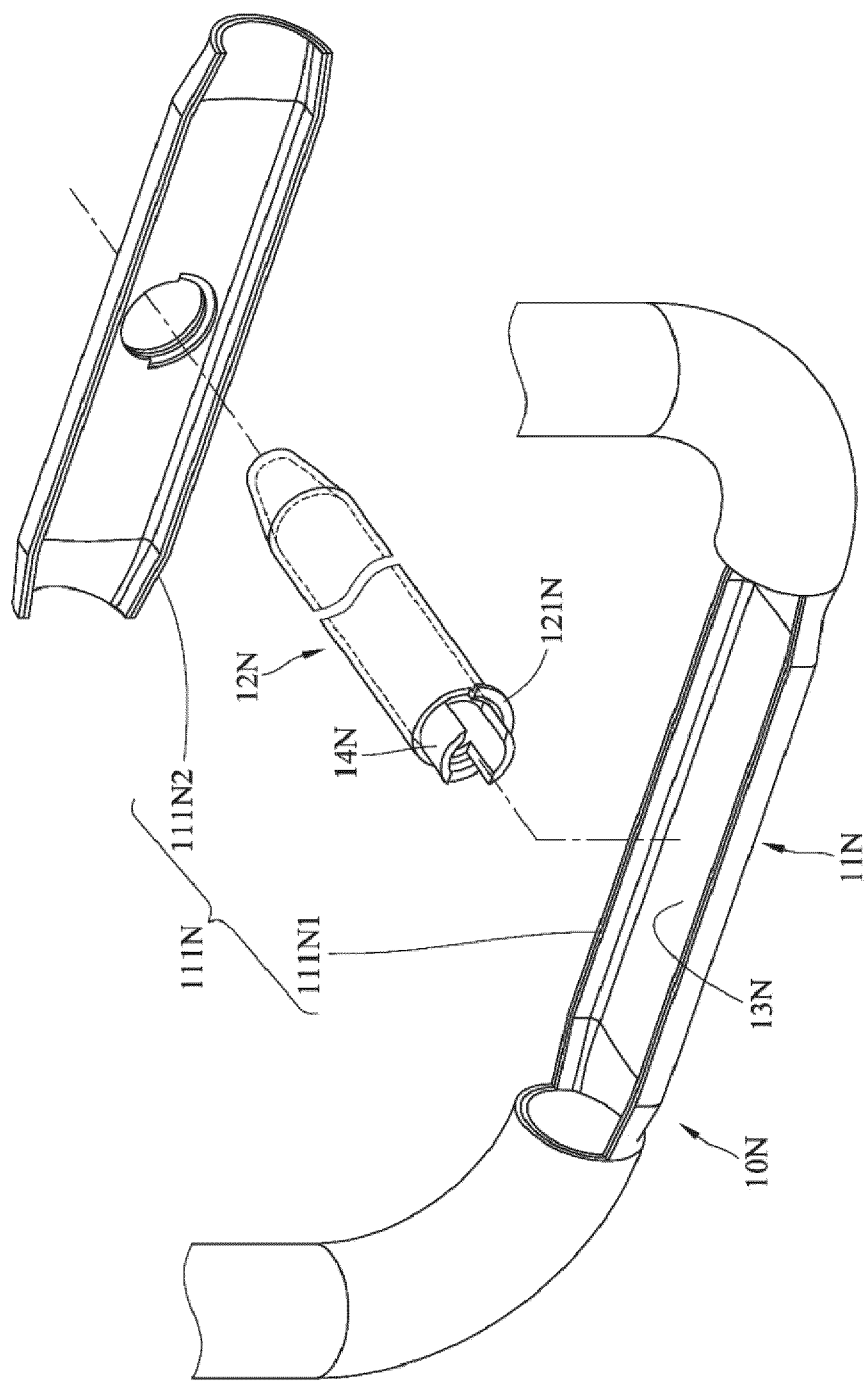


FIG. 27

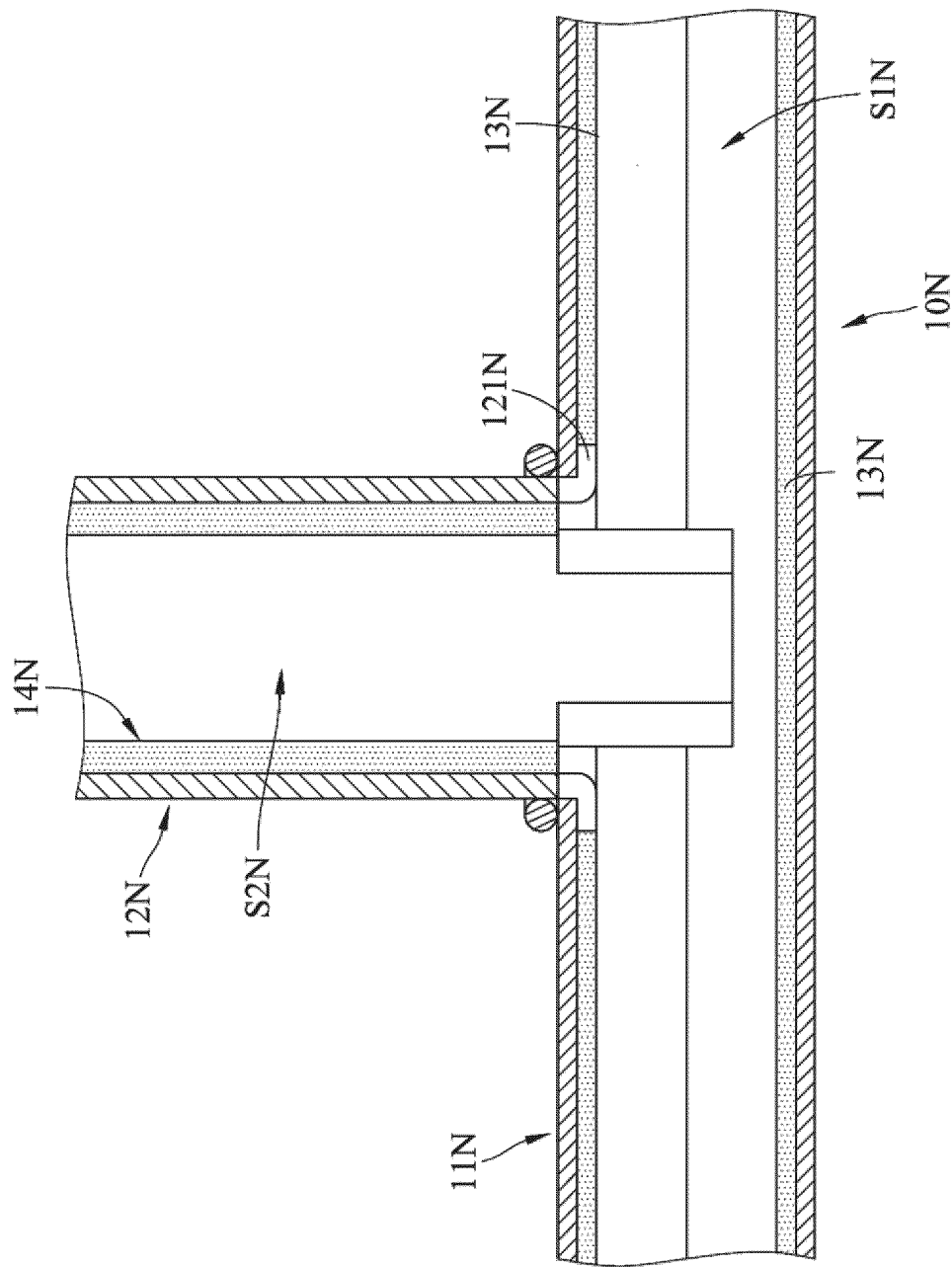


FIG. 28

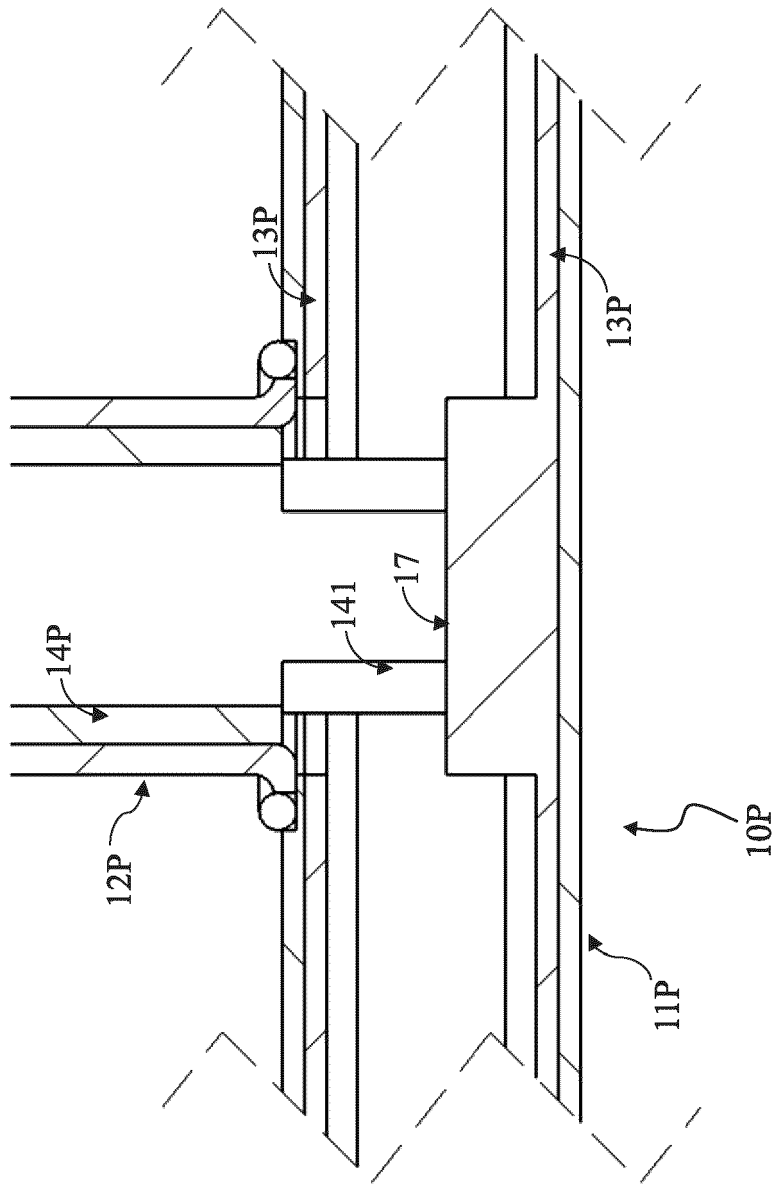


FIG. 29

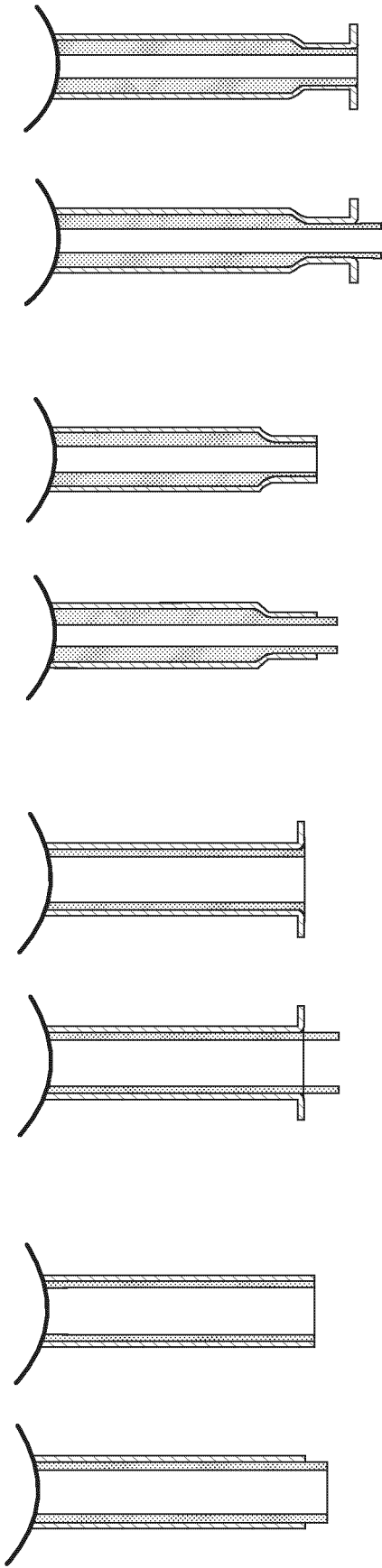


FIG. 30D

FIG. 30C

FIG. 30B

FIG. 30A

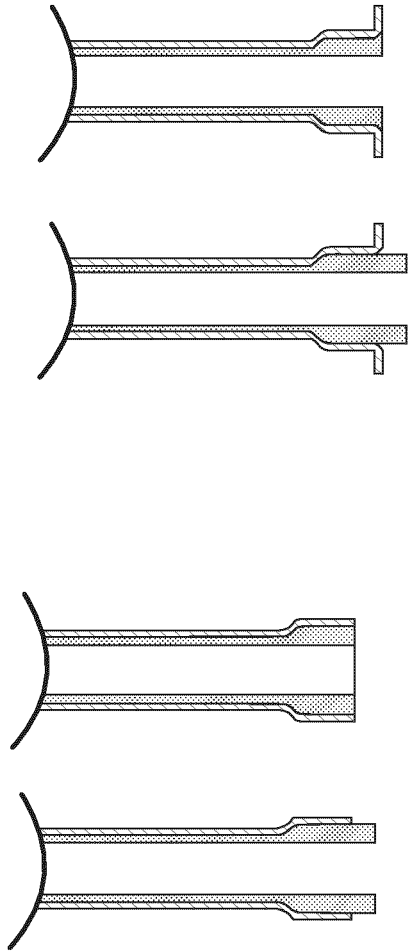


FIG. 30F

FIG. 30E



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Application Number

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Y	* paragraph [0037] - paragraph [0046]; figures 1,2,4 *	3	
Y	US 2022/082333 A1 (LIU LEI LEI [CN] ET AL) 17 March 2022 (2022-03-17) * figure 7 *	3	
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X	US 10 612 862 B2 (HEATSCAPE COM INC [US]) 7 April 2020 (2020-04-07) * figures 3b, 4a *	1,2,4,5,11-13,20	
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 3 December 2024	Examiner Jessen, Flemming
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