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(54) **SOLAR THERMAL RECEIVER**

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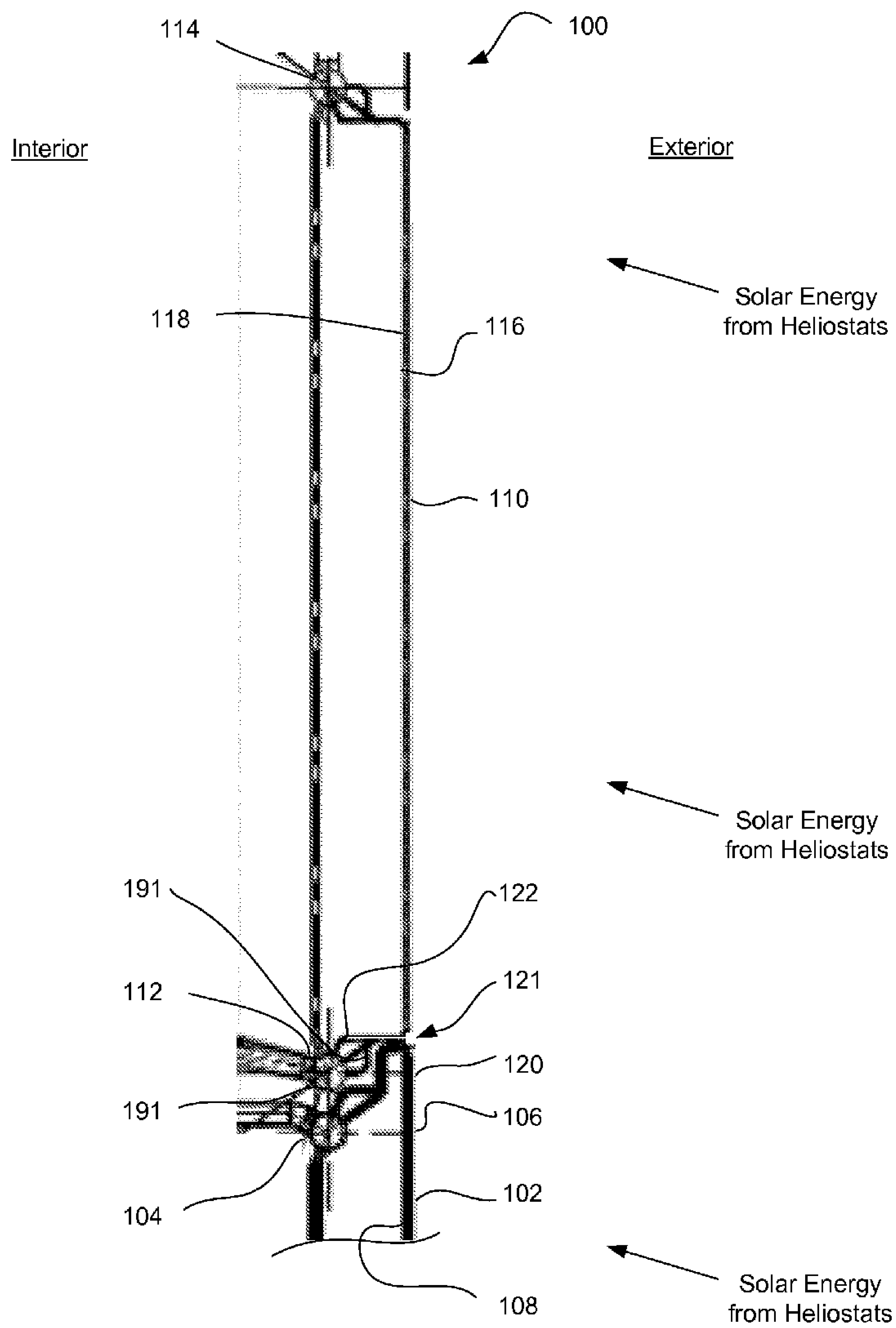
(52) **U.S. Cl.** **126/641**

(57) **ABSTRACT**

A boiler for a solar receiver includes a first boiler panel having a plurality of tubes fluidly connecting an inlet header of the first boiler panel to an outlet header of the first boiler panel. The first boiler panel tubes form a first solar receiver surface. A second boiler panel has a plurality of tubes fluidly connecting an inlet header of the second boiler panel to an outlet header of the second boiler panel. The second boiler panel tubes form a second solar receiver surface. The first and second boiler panels are adjacent one another, a portion of the first boiler panel and an end of the first solar receiver surface overlapping an end of the second boiler panel to reduce solar radiation passing between the first and second solar receiver surfaces. A plurality of boiler panels may be arranged in rectangular or cylindrical orientation about a boiler central axis.



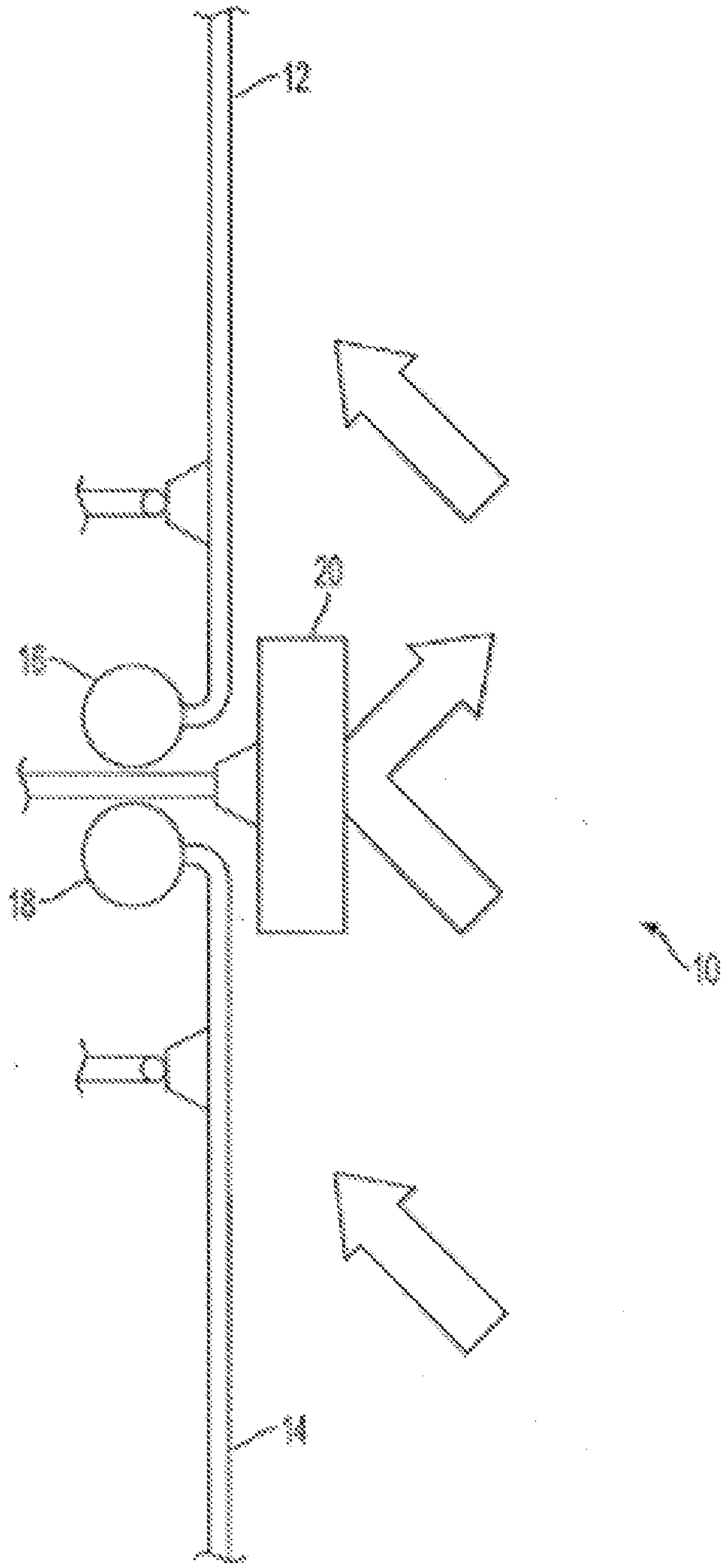


FIG. 1
PRIOR ART

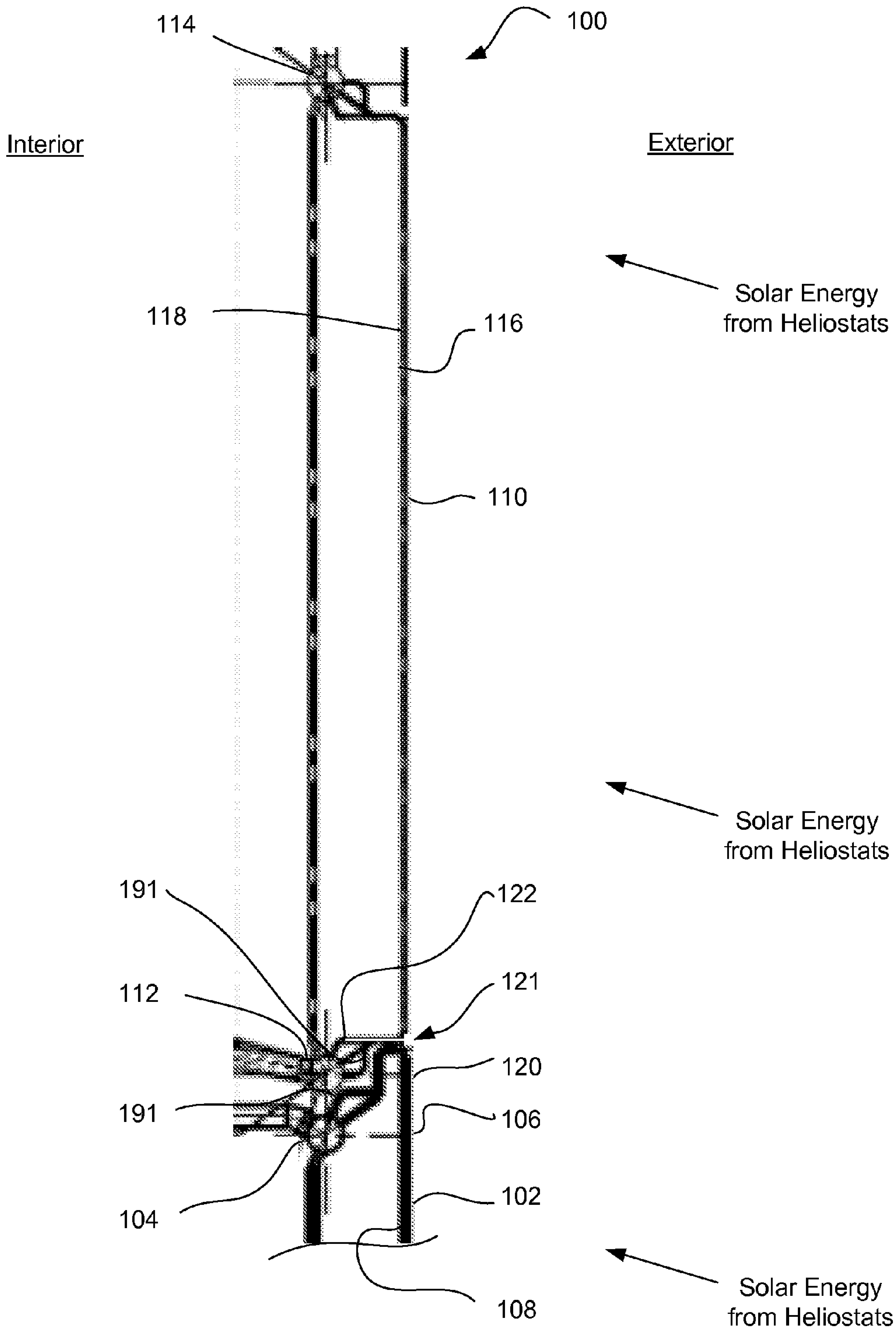

114
100
Interior
Exterior
Solar Energy
from Heliostats
118
116
110
Solar Energy
from Heliostats
191
122
121
112
120
191
106
104
102
108
Solar Energy
from Heliostats

FIG. 2

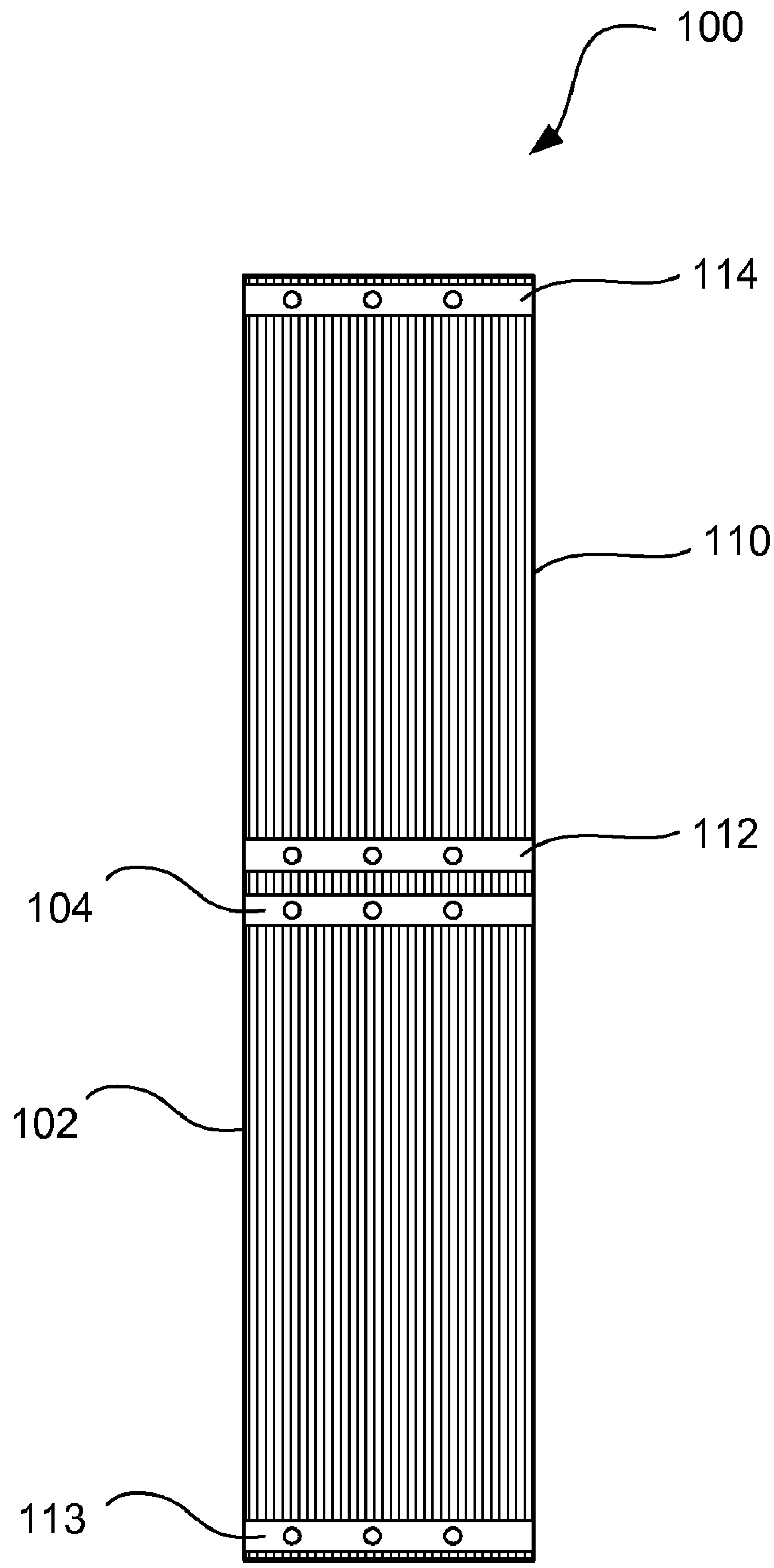


FIG. 3

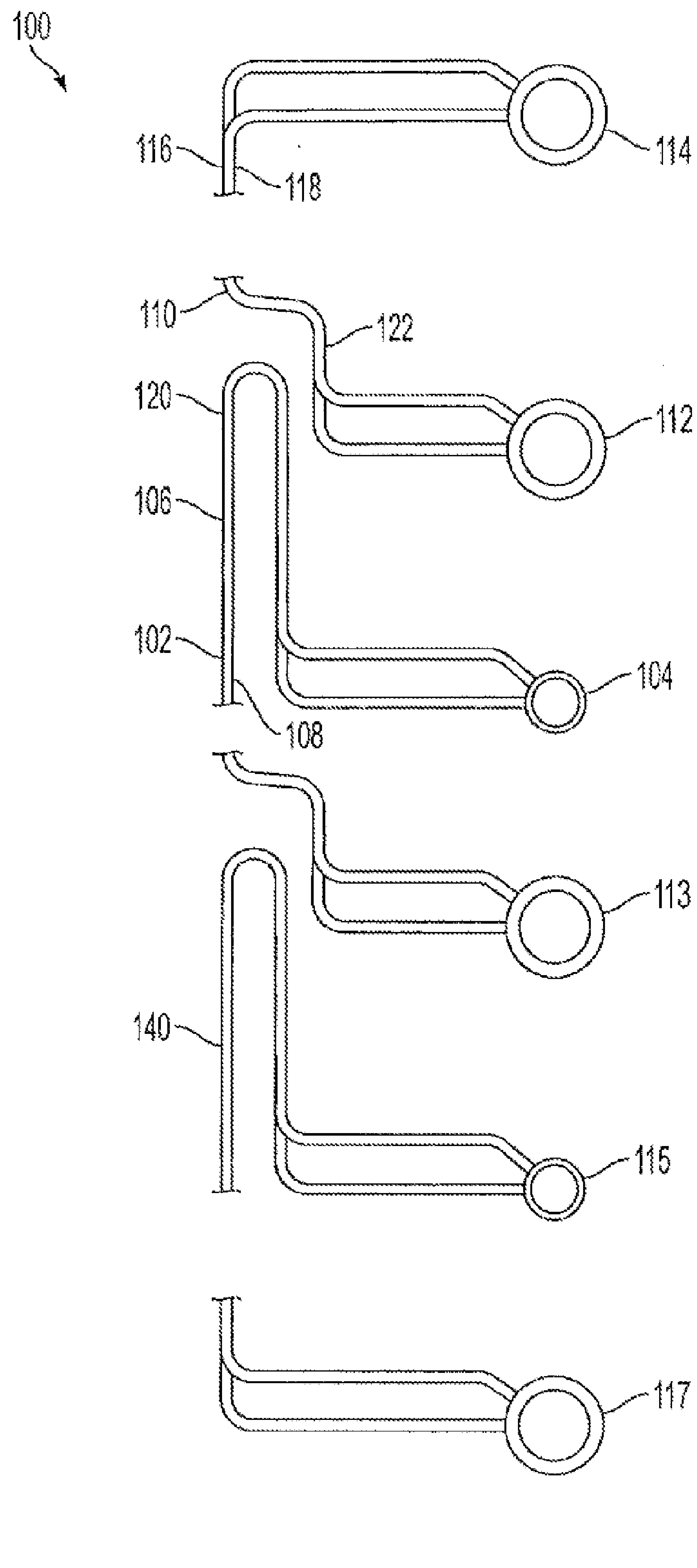


FIG. 4

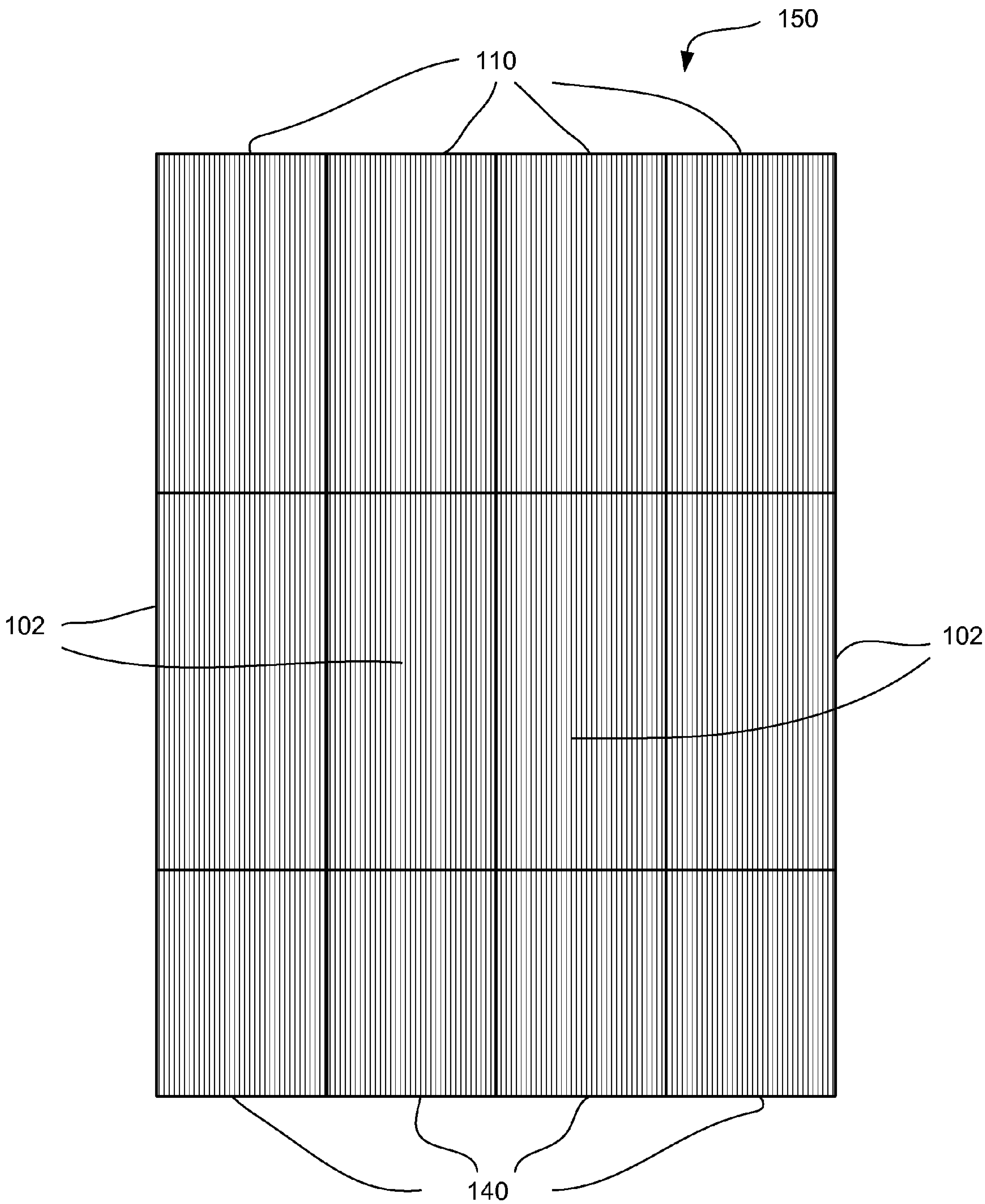


FIG. 5

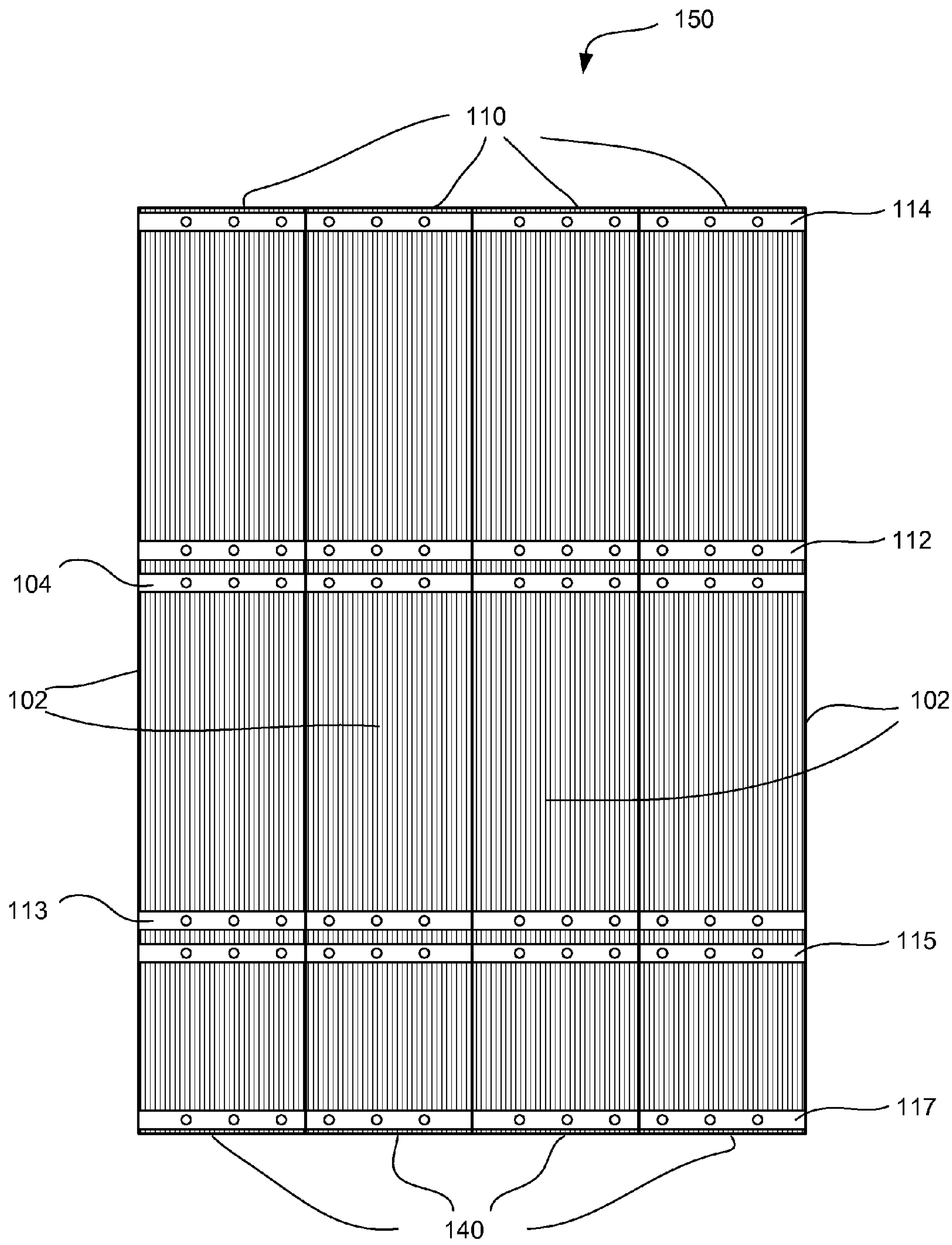


FIG. 6

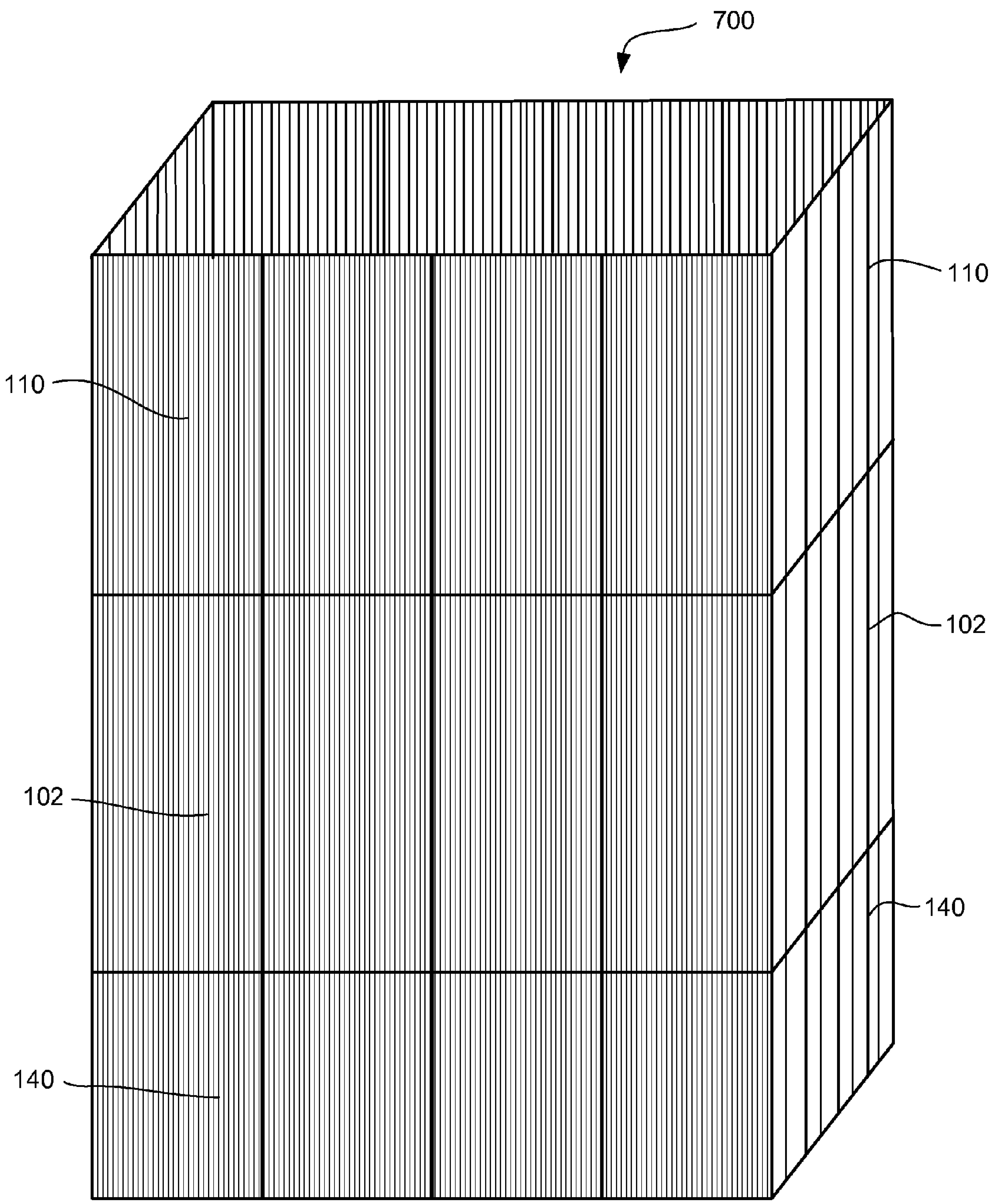


FIG. 7

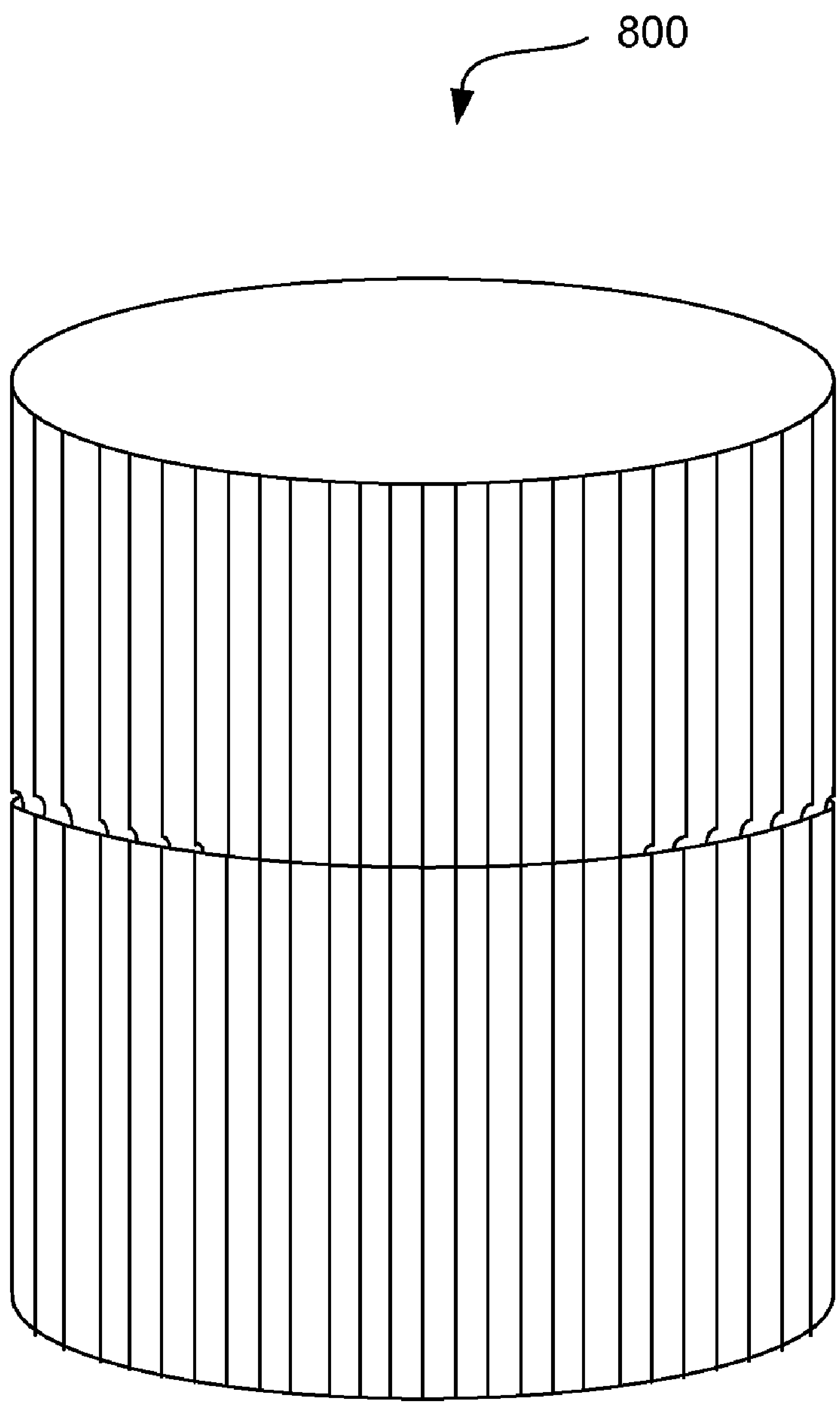


FIG. 8

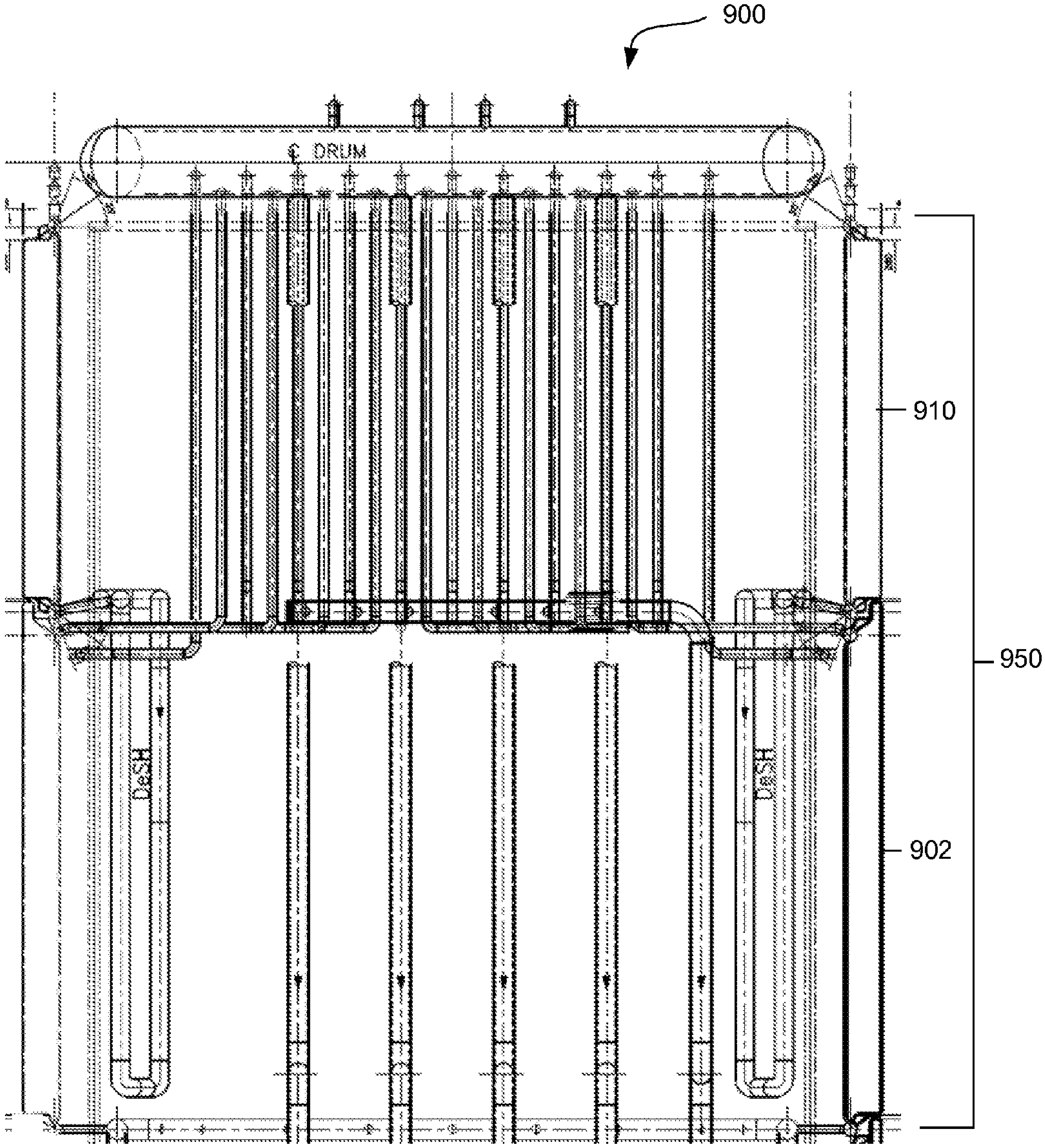


FIG. 9

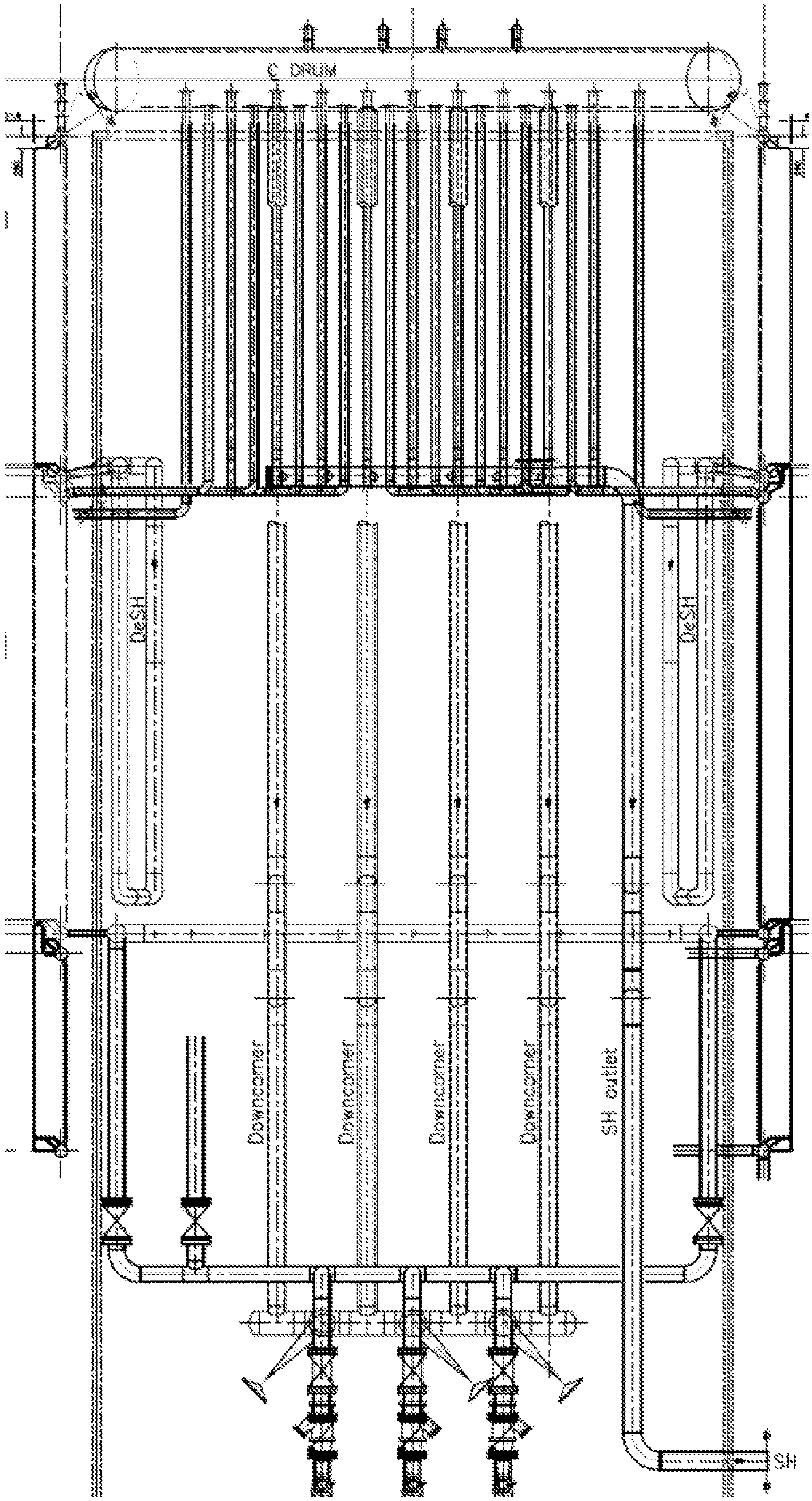

C DRUM
DeSH
DeSH
Downcomer
Downcomer
Downcomer
Downcomer
SH outlet
SH

FIG. 10

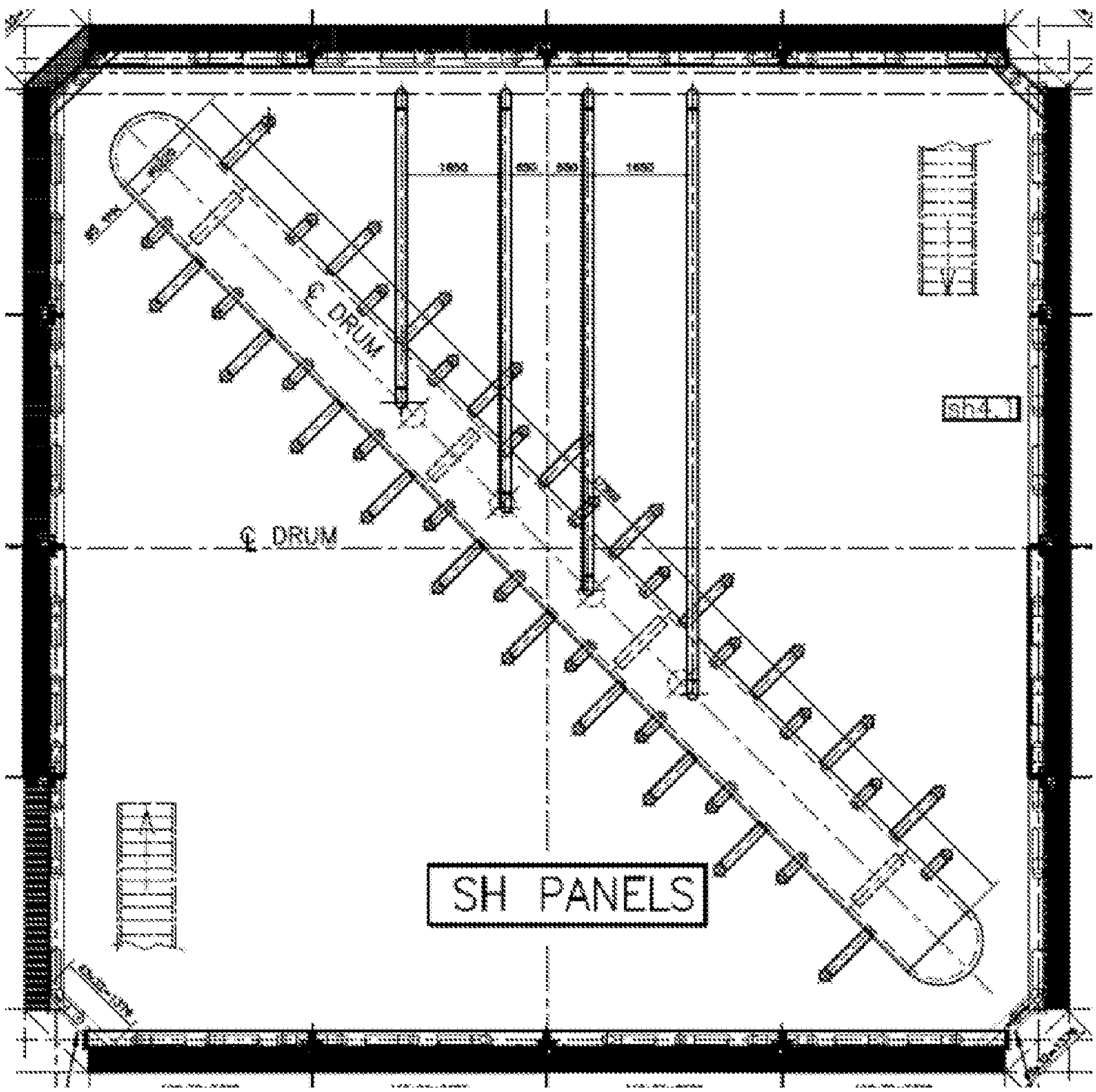


FIG. 11

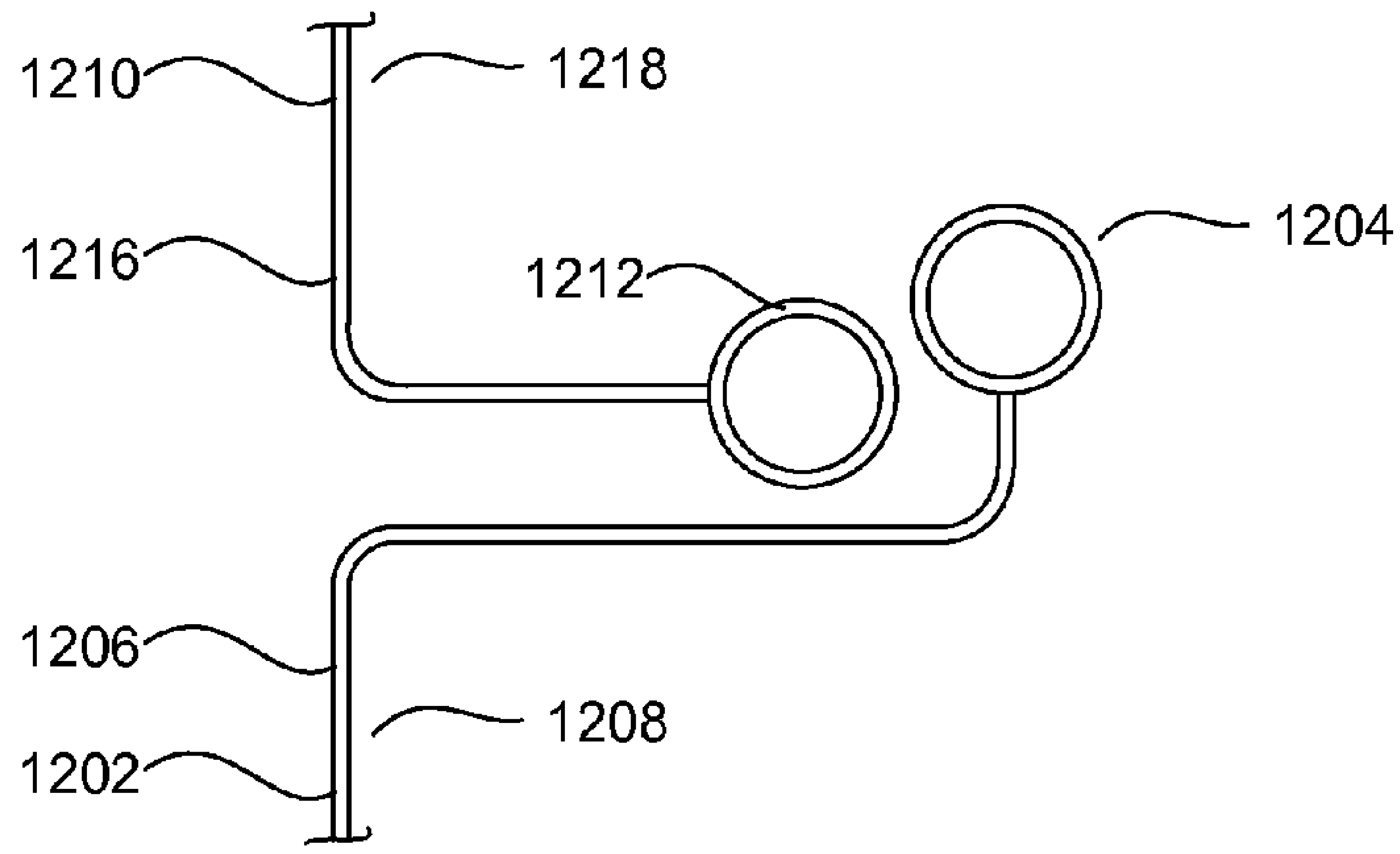


FIG. 12

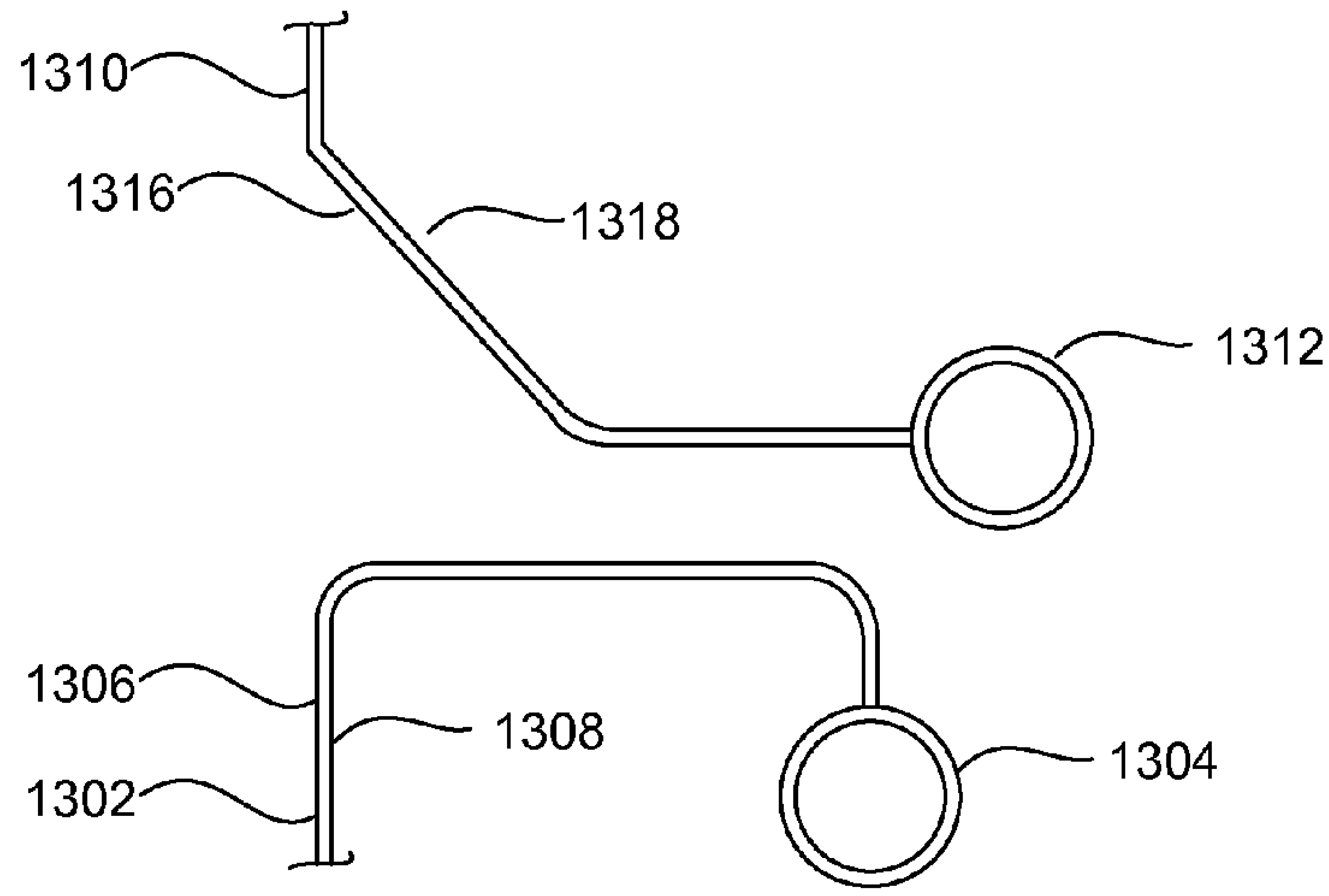


FIG. 13

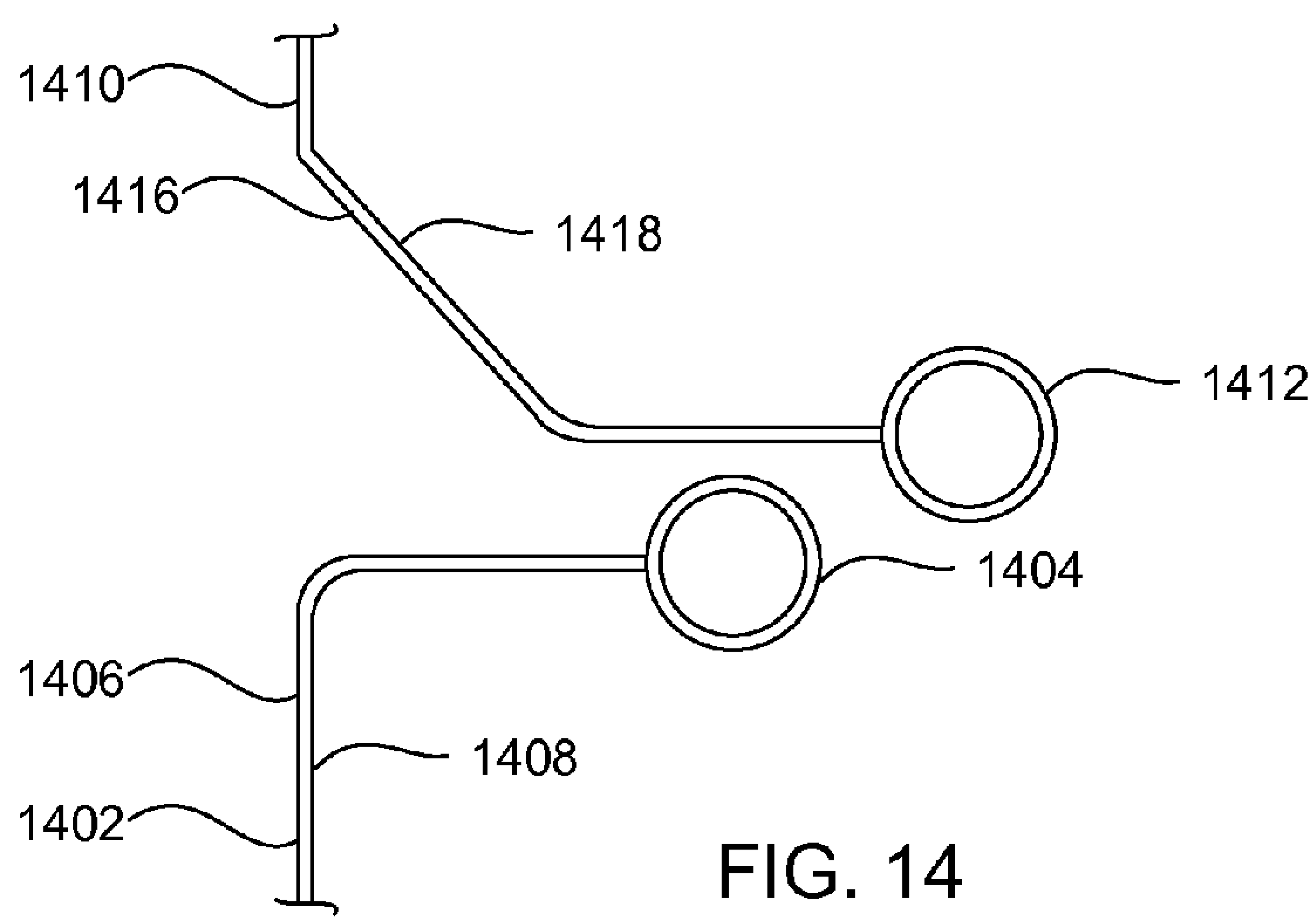


FIG. 14

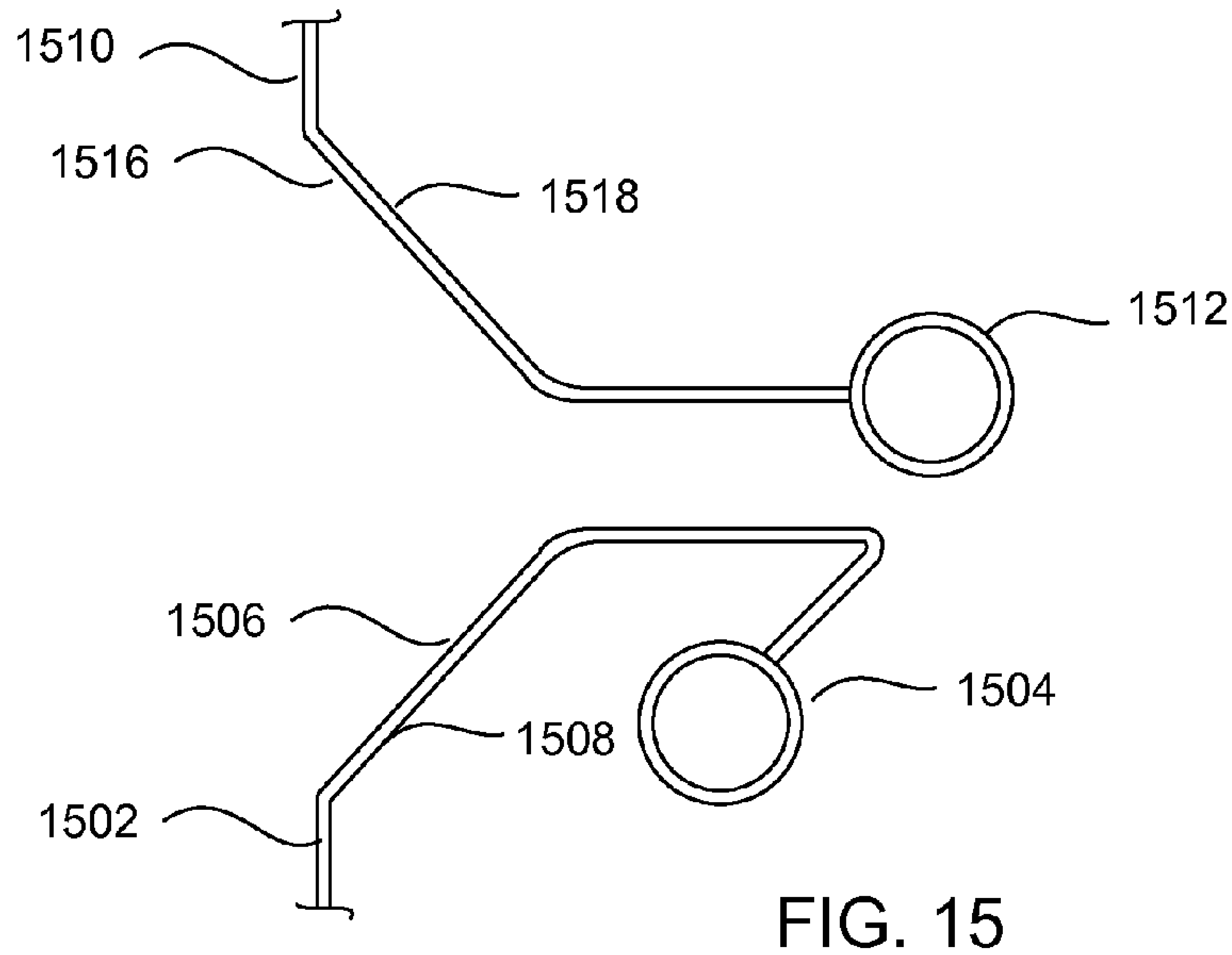


FIG. 15

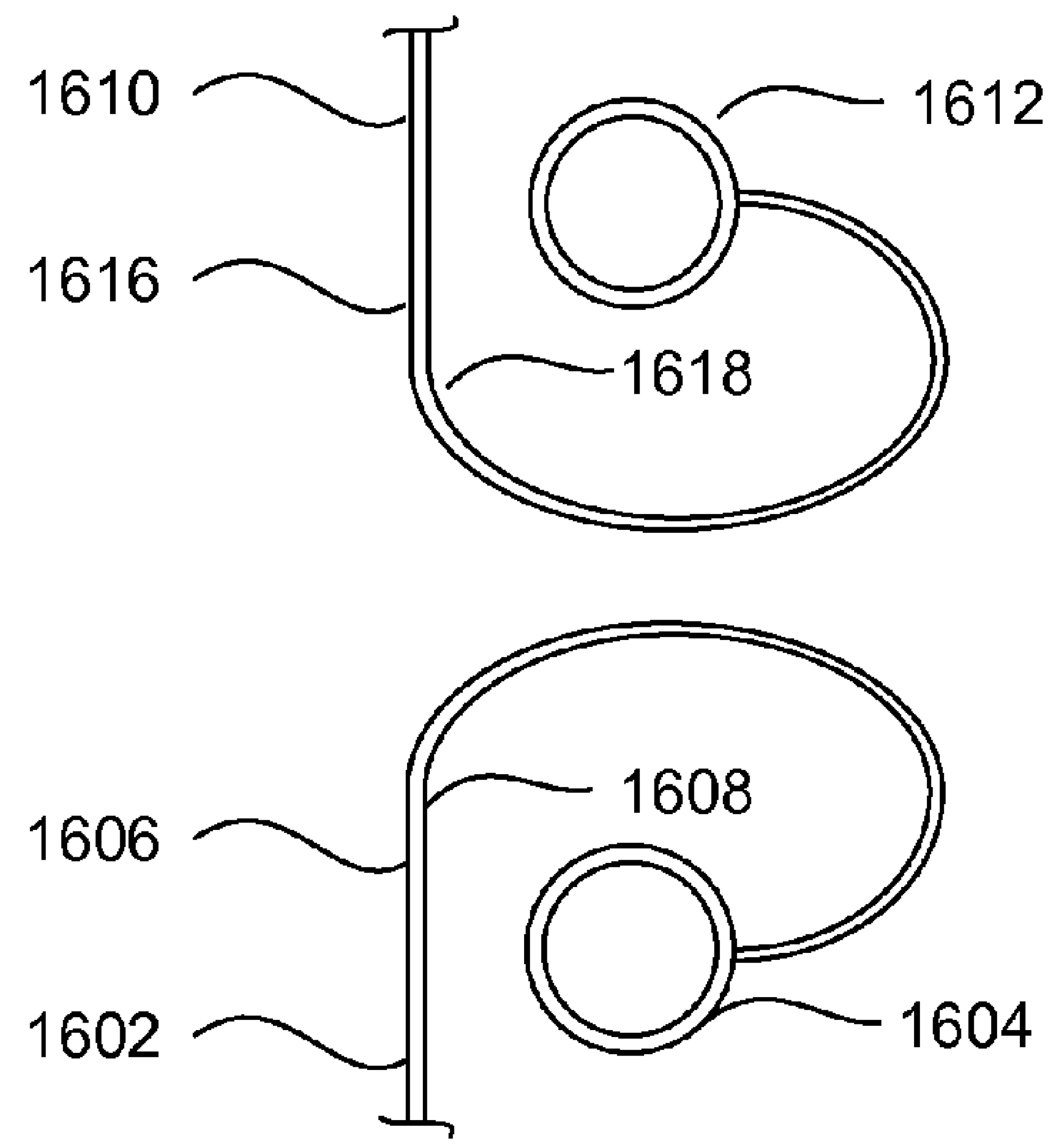


FIG. 16

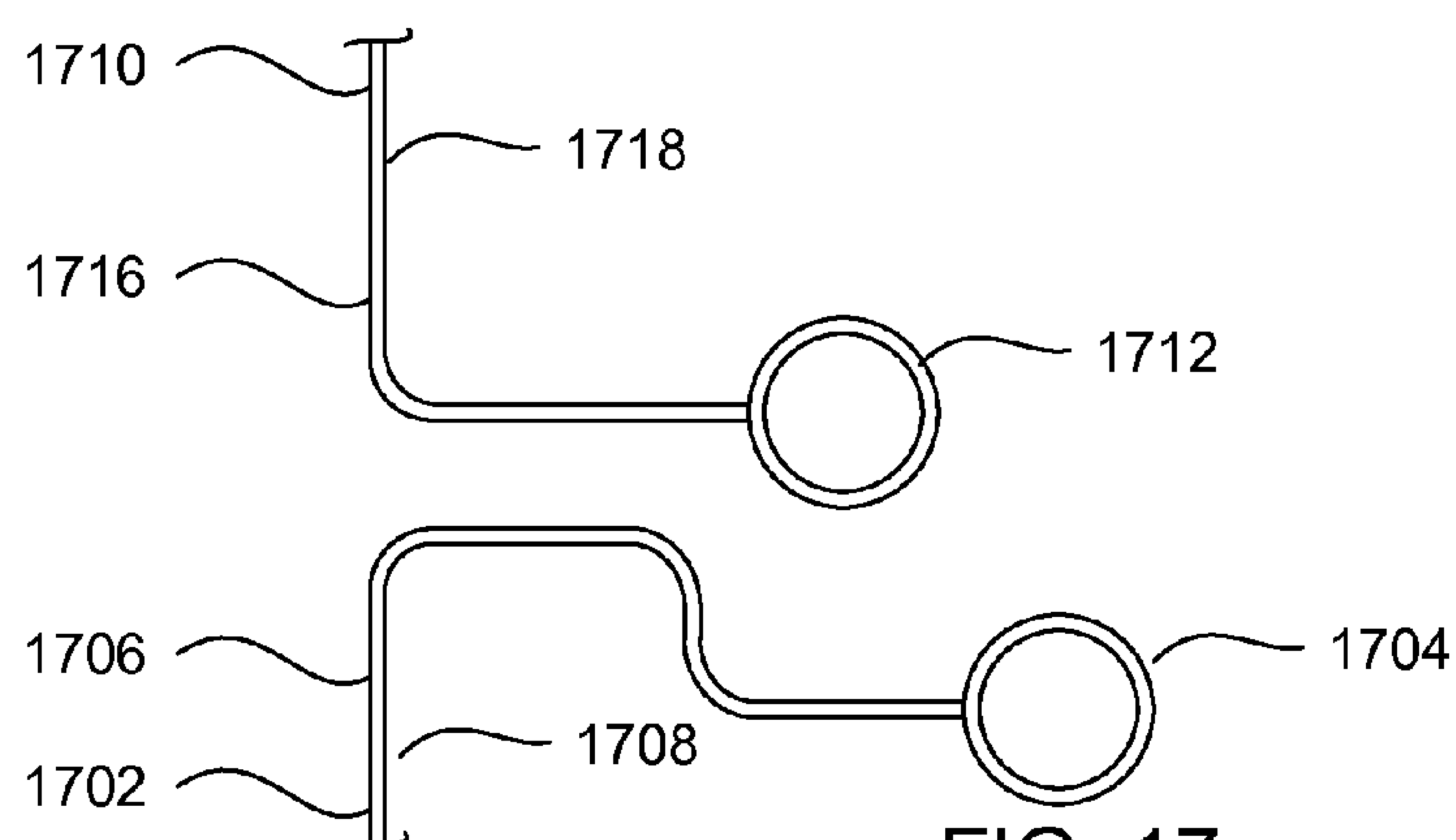


FIG. 17

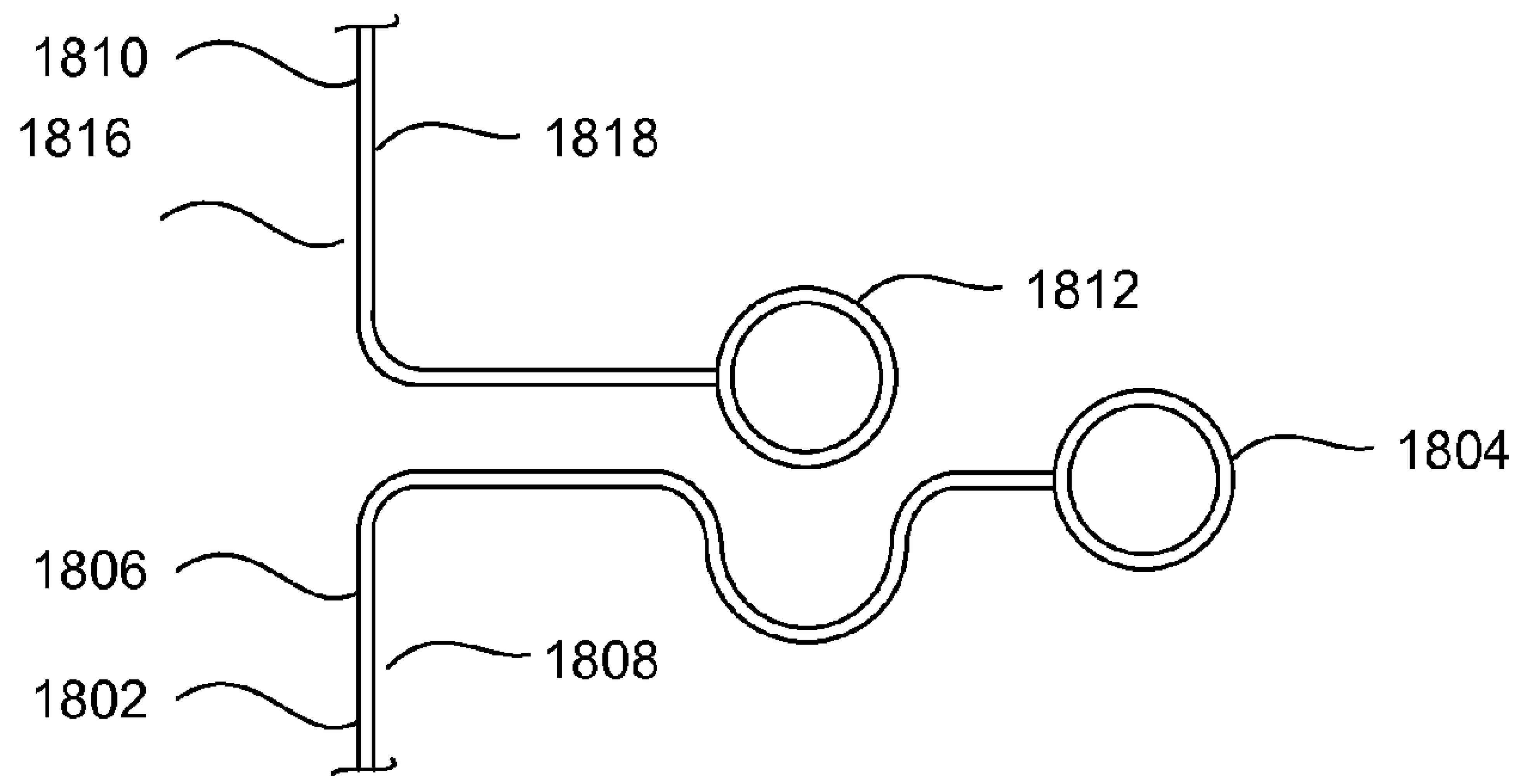


FIG. 18

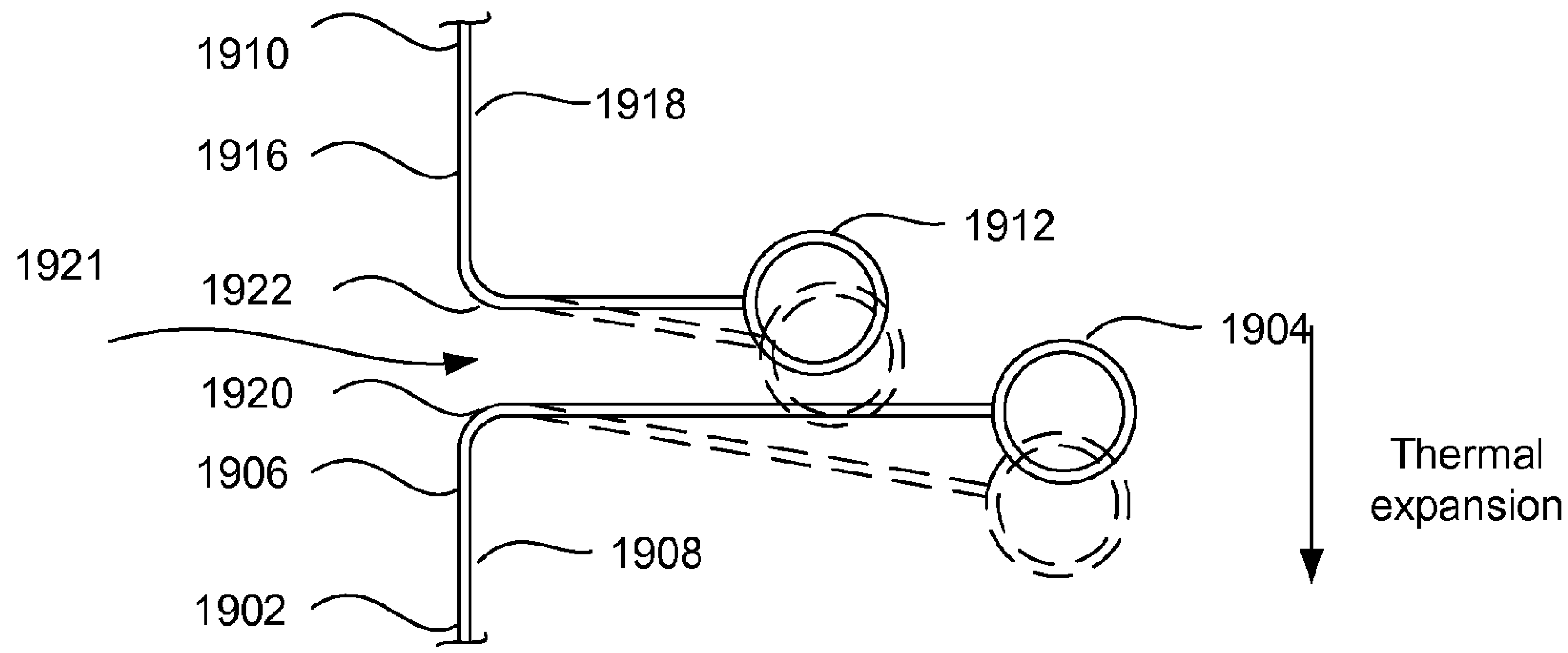


FIG. 19

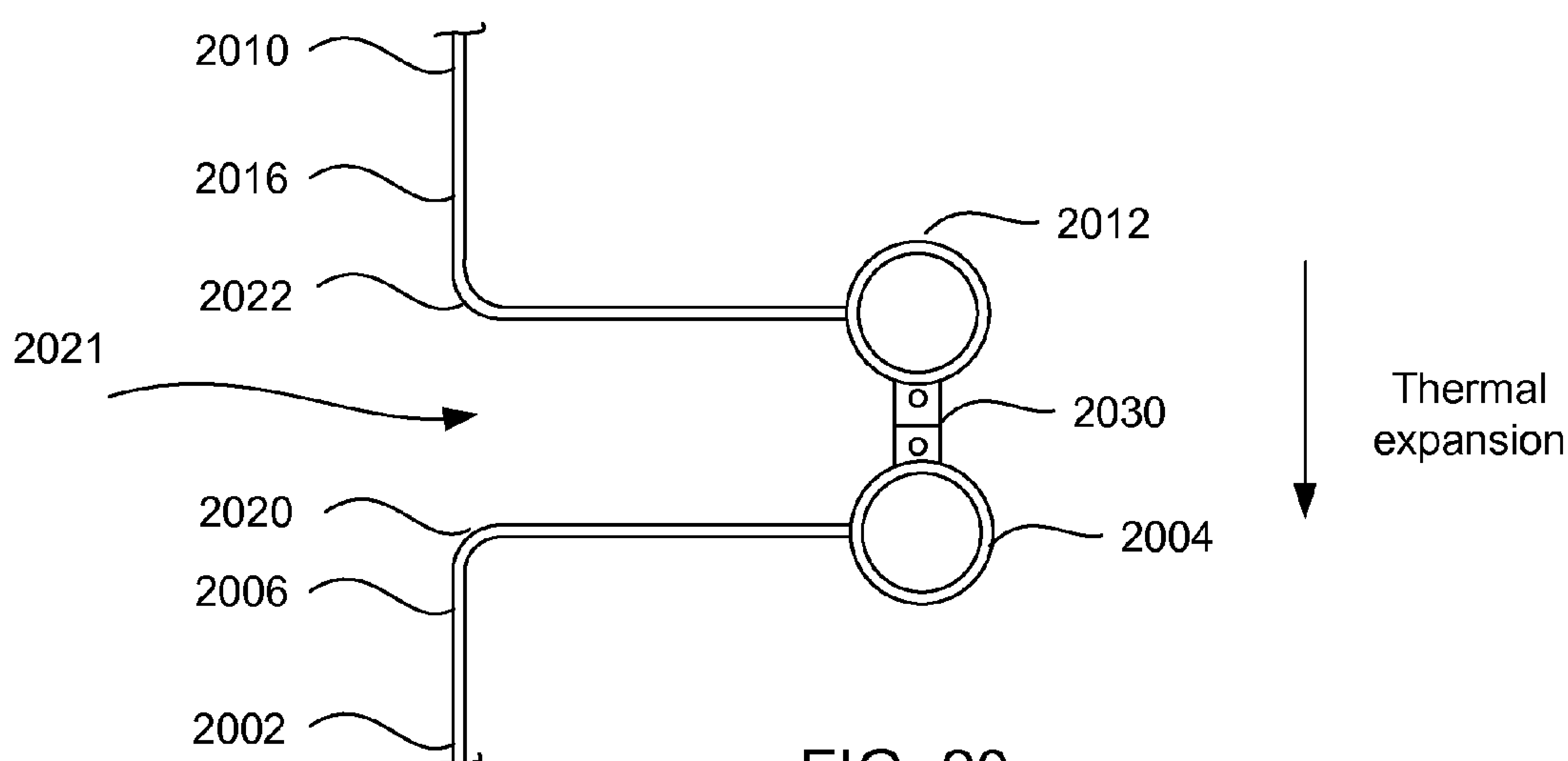


FIG. 20

SOLAR THERMAL RECEIVER

BACKGROUND

[0001] The present invention relates to solar power production, and more particularly, to solar receiver panels for use in solar boilers.

[0002] Solar power generation has been considered a viable source to help provide for energy needs in a time of increasing consciousness of the environmental aspects of power production. Solar energy production relies mainly on the ability to collect and convert energy freely available from the sun and can be produced with very little impact on the environment. Solar power can be utilized without creating radioactive waste as in nuclear power production, and without producing pollutant emissions including greenhouse gases as in fossil fuel power production. Solar power production is independent of fluctuating fuel costs and does not consume non-renewable resources.

[0003] Solar power generators generally employ fields of controlled mirrors, called heliostats, to gather and concentrate sunlight on a receiver to provide a heat source for power production. A solar receiver typically takes the form of a panel of tubes conveying a working fluid therethrough. Previous solar generators have used working fluids such as molten salt because it has the ability to store energy, allowing power generation when there is no solar radiation. The heated working fluids are typically conveyed to a heat exchanger where they release heat into a second working fluid such as air, water, or steam. Power is generated by driving heated air or steam through a turbine that drives an electrical generator.

[0004] More recently, it has been determined that solar production can be increased and simplified by using water/steam as the only working fluid in a receiver that is a boiler. This can eliminate the need for a potentially inefficient heat exchanger between two different working fluids. This development has lead to new challenges in handling the intense solar heat without damage to the system. Typical boilers include two or more sections at different temperatures and pressures, such as a section of steam generator panels, a section of superheater panels, and a section of reheater panels, for example. In a solar boiler, it is potentially advantageous to have boiler sections close together within the receiver where the focused solar radiation provides heat. One such configuration, for example, can include one boiler section on top of another boiler section. This exemplary configuration may include a gap between such adjacent sections, which accommodates headers and associated structures of the boiler sections and can provide room for thermal expansion and contraction of the boiler sections. The gap must be protected against the possibility of focused sunlight reaching components internal to the receiver panels (also known as leakage), where the intense radiation can be harmful.

[0005] One approach to this problem has been to cover the gaps between boiler sections with a thermal barrier or shield, which blocks the sunlight from entering the gap. Such a thermal barrier occupies surface area in the key receiving area of the boiler and thus reduces the amount of useable solar radiation from the heliostats that is actually received by the boiler.

[0006] There has remained a need in the art for solar receivers that can improve the useable receiving area while protecting internal spaces from leakage of solar radiation and allowing for thermal contraction and expansion. There also has remained a need in the art for such solar receivers that are easy to make and use.

SUMMARY

[0007] The present invention is directed to a new and useful boiler for a solar receiver. The boiler may include a first boiler panel having a plurality of tubes fluidly connecting an inlet header of the first boiler panel to an outlet header of the first boiler panel. The tubes of the first boiler panel form a first solar receiver surface and a first internal surface opposite the first solar receiver surface. The boiler may further include a second boiler panel having a plurality of tubes fluidly connecting an inlet header of the second boiler panel to an outlet header of the second boiler panel. The tubes of the second boiler panel form a second solar receiver surface and a second internal surface opposite the second solar receiver surface. The first and second boiler panels can be arranged adjacent to one another with a portion of the first boiler panel and an end of the first solar receiver surface overlapping an end of the second boiler panel to reduce solar radiation passing between the first and second solar receiver surfaces.

[0008] In certain exemplary embodiments, the first and second boiler panels may be adjacent to one another with an end of the first solar receiver surface overlapping an end of the second boiler panel so as to cover at least one of the headers behind the first solar receiver surface. It is also contemplated that an end of the first solar receiver surface can overlap an end of the second boiler panel so as to cover one of the headers of each boiler panel behind the first solar receiver surface.

[0009] The first and second internal surfaces can be covered with an insulation layer. A gap can be provided between the end of the second boiler panel and the portion of the first boiler panel overlapping the end of the second boiler panel to accommodate relative movement of the first and second boiler panels due to thermal growth, and the gap can be labyrinthine. The tubes of the first and second panels can be configured and adapted to be fully drainable by way of at least one header in each panel. It is also contemplated that the portion of the first solar receiver panel overlapping the end of the second boiler panel can include a 180° bend in the uppermost or lowermost end of the plurality of tubes of the first solar receiving panel. Additionally, the end of the first solar receiver surface overlapping an end of the second boiler panel may cover a header of the second solar receiver panel.

[0010] The invention may also include a boiler for a solar receiver including steam generator, superheater, and reheater panels, each having a plurality of tubes fluidly connecting a respective inlet header and a respective outlet header. The tubes of each panel can form a respective solar receiver surface and opposing internal surface. The steam generator and superheater panels may be located adjacent one another with a portion of the steam generator panel and an end of the solar receiver surface thereof overlapping an end of the superheater panel to reduce solar radiation passing between the solar receiver surfaces of the steam generator and superheater panels. The steam generator and reheater panels may be located adjacent one another with a portion of the reheater panel including an end of the solar receiver surface thereof overlapping an end of the steam generator panel to reduce solar radiation passing between the solar receiver surfaces of the steam generator and reheater panels. Alternatively, the steam generator and superheater panels may be located adjacent one another with a portion of the superheater panel including an end of the solar receiver surface thereof overlapping an end of the steam generator panel to reduce solar radiation passing between the solar receiver surfaces of the steam generator and superheater panels.

[0011] The boiler may include a plurality of the first and second boiler panels arranged in cylindrical or rectangular orientation about a central axis of the boiler. More specifically, the boiler may include a plurality of steam generator panels, superheater panels, and reheater panels arranged in cylindrical or rectangular orientation about a central axis of the boiler.

[0012] The invention may include a solar radiation interference device for reducing an amount of solar radiation passing between two adjacent solar receiver surfaces, that includes: a first boiler panel having a plurality of tubes fluidly connecting an inlet header of the first boiler panel to an outlet header of the first boiler panel, the tubes of the first boiler panel forming a first solar receiver surface and a first internal surface opposite the first solar receiver surface; a second boiler panel having a plurality of tubes fluidly connecting an inlet header of the second boiler panel to an outlet header of the second boiler panel, the tubes of the second boiler panel forming a second solar receiver surface and a second internal surface opposite the second solar receiver surface, the first and second boiler panels being adjacent one another; and an interference portion including an overlap of the first boiler panel and an end of the first solar receiver surface with respect to an end of the second boiler panel to reduce solar radiation passing between the first and second solar receiver surfaces.

[0013] These and other features of the systems and methods of the present invention will become more readily apparent to those skilled in the art from the following detailed description of the preferred embodiments taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a side elevation view of a gap between boiler sections in a typical solar boiler.

[0015] FIG. **2** is a side elevation view of a portion of an exemplary embodiment of a boiler constructed in accordance with the present invention, showing the overlap region between two receiver surfaces.

[0016] FIG. **3** is an interior elevation view of a portion of the boiler of FIG. **2**, showing the headers and the interior surfaces of the tubes in the boiler panels.

[0017] FIG. **4** is a side elevation view of a portion of the boiler of FIG. **2**, showing the overlap regions between adjacent superheater, steam generator, and reheater panels.

[0018] FIG. **5** is an exterior elevation view of an exemplary boiler wall including repeated sections of adjacent superheater, steam generator, and reheater panels.

[0019] FIG. **6** is an interior elevation view of the boiler wall of FIG. **5**, showing the headers and the interior surfaces of the tubes in the boiler panels.

[0020] FIG. **7** is a perspective view of an exemplary embodiment of a boiler constructed in accordance with the present invention.

[0021] FIG. **8** is a perspective view of another exemplary embodiment of a boiler constructed in accordance with the present invention.

[0022] FIG. **9** is a side elevation view of an exemplary embodiment of a boiler constructed in accordance with the present invention, showing a solar radiation interference device.

[0023] FIG. **10** is a side elevation view of an exemplary embodiment of a boiler constructed in accordance with the present invention.

[0024] FIG. **11** is a section view of an exemplary embodiment of a boiler constructed in accordance with the present invention.

[0025] FIGS. **12-20** are side elevation views of portions of exemplary embodiments of a boiler constructed in accordance with the present invention.

DETAILED DESCRIPTION

[0026] Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject invention. The systems of the invention can be used to increase the effective receiving area while protecting internal spaces and components in boilers, for example in solar power generation.

[0027] Solar boilers are typically set up in such a way that there are at least two distinct tube sections: one is a steam generator section containing boiling water and one or more is a superheating section containing superheated steam. FIG. **1** shows an example of a solar boiler **10** having a steam generator section **14** and a superheater section **12**. These sections receive solar energy on their exterior surface during operation, as indicated by straight arrows in FIG. **1**. It is required that the tubing in these different sections of tubes be physically separated from one another, e.g., where the headers **16** and **18** of the respective sections **12** and **14** are located in FIG. **1**. Some designs have had the ends of adjacent areas, including adjacent headers, located close together. Such designs typically leave a significant gap between the solar receiver surfaces of sections **12** and **14** that would allow direct solar radiation to leak between the two tube sections. Therefore, this gap area must be protected with a thermal barrier, such as barrier **20**. As indicated in FIG. **1** by a bent arrow, barrier **20** protects the gap region by blocking the incident solar radiation. This protection comes at a cost, namely the waste of concentrated solar energy in the receiving area that is incident on barrier **20** instead of on respective receiver surfaces of sections **12** and **14**.

[0028] Turning to FIG. **2**, there are shown features of a solar boiler **100** constructed in accordance with the present invention. Boiler **100** for a solar receiver includes a first boiler panel **102** having a plurality of tubes fluidly connecting an inlet header **113** of the first boiler panel (not shown in FIG. **2**, but see, FIG. **3**) to an outlet header **104** of first boiler panel **102**. The tubes of first boiler panel **102** form a first solar receiver surface **106** and a first internal surface **108** opposite first solar receiver surface **106**. The exterior receiver surface **106** receives solar energy, for example from a field of heliostats or mirrors, as indicated by arrows in FIG. **2**.

[0029] A second boiler panel **110** similarly includes a plurality of tubes fluidly connecting an inlet header **112** of second boiler panel **110** to an outlet header **114** of second boiler panel **110**. The tubes of second boiler panel **110** form a second solar receiver surface **116** and a second internal surface **118** opposite second solar receiver surface **116** (i.e. exterior and interior surfaces, as indicated in FIG. **2**). Like receiver surface **106**, exterior receiver surface **116** receives solar energy, for example from a field of heliostats, as indicated by arrows in FIG. **2**.

[0030] First and second boiler panels **102** and **110** are adjacent one another with an end portion **120** of first boiler panel **102** and the corresponding end portion of first solar receiver surface **106** overlapping an end **122** of second boiler panel **110** to reduce or prevent solar radiation passing in between the first and second solar receiver surfaces **106** and **116** into the interior space of boiler **100**. Interior surfaces **108** and **118** have a layer of insulating material (not shown) to protect the interior space of boiler **100** and components therein from the high temperatures on the backside of the tubes.

[0031] FIG. **3** shows the same portion of boiler **100** as in FIG. **2** but from the interior, to show the tubes and headers of panels **102** and **110**. While the example described above includes shielding headers **112** and **104** shielded behind first receiver surface **106**, those skilled in the art will readily appreciate that each panel can cover its own header, or any other suitable overlap configuration can be used without departing from the spirit and scope of the invention.

[0032] In this exemplary configuration, the tubes, which comprise the receiving surfaces **106** and **116**, are overlapped in such a way that there is no need for a barrier to cover a gap between the receiving surfaces **106** and **116**. This is accomplished by overlapping portions of the tubes of different boiler sections as described above. An overlapping tube design, in accordance with the present invention, may prevent the need for wasteful insulation or shielding covering external portions of the receiver area of boiler **100**. This also allows for a higher amount of absorption of solar radiation, which can increase the overall efficiency of the system.

[0033] As can be seen in FIG. **2**, the overlap region between panels **102** and **110** may allow for thermal expansion and contraction of the panels. There is a gap **121** between end portion **120** of boiler panel **102** and end portion **122** of boiler panel **110**. As can be seen in FIG. **2**, gap **121** is labyrinthine and thus any leakage of solar radiation is absorbed by the boiler tubes, e.g., in end portion **122**, and is not allowed to penetrate into the interior space of boiler **100**. Since end **120** of first panel **102** and end **122** of second panel **110** are spaced apart from one another, panels **102** and **110** can move relative to one another during the thermal expansion and contraction that results from the daily cycle of solar radiation incident on the receiver area of boiler **100**. Thus, while gap **121** accommodates thermal expansion and contraction, in terms of leakage of solar radiation there is effectively no gap between panels **102** and **110**.

[0034] If boiler panels are exposed to ambient conditions, it may be necessary to drain the water from the tubing after sunset to prevent damage from freezing water in the tubes. In tubes **102** and **110** this draining can be accomplished through drains (not shown). The overlapping design of ends **120** and **122** may allow the tubes of panels **102** and **110** to be completely drainable, as there is a header at each low point for each panel **102** and **110**. The 180° bend in end **120** of first panel **102** does not trap water during draining, since water on both sides of the bend can flow downward to a drain or header. If, for example, if there were a 180° bend at the very bottom of a panel, it could trap water during draining and such a panel may not be fully drainable.

[0035] An exemplary embodiment may include two or three end tubes **191** on each end of headers **112** and **104**. End tubes **191** can be bent inward to shorten the overall length of the respective headers **112** and **104**. If it is desired to make end tubes **191** fully drainable, this can be accomplished using any suitable configuration for panel headers without departing from the spirit and scope of the invention.

[0036] With reference now to FIG. **4**, panel **102** is shown as, for example, a steam generator panel, and panel **110** is shown as, for example, a superheater panel. Exemplary boiler **100** is shown as also including reheater panel **140**. Each reheater panel **140** includes a plurality of tubes fluidly connecting an inlet header **117** to an outlet header **115**, much as described above with respect to panels **102** and **110**. Panel **140** overlaps panel **102** in the same manner as panel **102** overlaps panel **110** as described above. Boiler **100** can include multiple, parallel panels of each of the previously described types. An alternative exemplary boiler can be configured such that superheater and steam generator panels **110** and **102** are adjacent one another with an end portion of superheater panel **110** and a corresponding end portion of solar receiver surface **116** overlapping an end of steam generator panel **102** to reduce or prevent solar radiation passing in between solar receiver surfaces **116** and **106** into the interior space of boiler **100**.

[0037] As can be seen from FIG. **5**, multiple sets of overlapped panels **102**, **110**, and **140** can be arranged side-by-side in parallel orientation into a boiler wall **150**. FIG. **6** shows the same boiler wall **150** as in FIG. **5** but from the interior, to show the tubes and headers of panels **102**, **110** and **140**. Multiple boiler walls can be joined, for example to form a four-sided boiler **700** as shown in FIG. **7**, or other multi-sided boiler capable of receiving concentrated solar energy from heliostats surrounding the base of the boiler. Additionally, multiple boiler walls can be configured and joined to form a cylindrical boiler **800**, such as that shown in FIG. **8**. While several exemplary embodiments were described herein in the context of a three-stage boiler, those skilled in the art will readily appreciate that any suitable number of stages can be used, and can be arranged in any suitable manner without departing from the spirit and scope of the invention.

[0038] FIG. **9** shows a partial elevation view of a boiler **900** that may include a solar radiation interference device **950** for reducing the amount of solar radiation passing between two adjacent solar receiver surfaces. Solar radiation interference device **950** includes a first boiler panel **902** and second boiler panel **910**, that are similar in configuration to those described with respect to FIG. **2**, and further includes an interference portion including an overlap of first boiler panel **902** and an end of the first solar receiver surface with respect to an end of the second boiler panel **910** to reduce solar radiation passing between the first and second solar receiver surfaces.

[0039] FIG. **10** shows a partial elevation view of a boiler in accordance with an exemplary embodiment of the invention.

[0040] FIG. **11** shows a partial sectional view of a boiler in accordance with an exemplary embodiment of the invention.

[0041] FIGS. **12-20** show side elevation views of portions of exemplary embodiments of a boiler constructed in accordance with the present invention.

[0042] Turning to FIG. **12** for example, there is shown a portion of a boiler for a solar receiver that includes a first boiler panel **1202** having a plurality of tubes fluidly connecting an inlet header (not shown) of the first boiler panel to an outlet header **1204** of first boiler panel **1202**. The tubes of first boiler panel **1202** form a first solar receiver surface **1206** and a first internal surface **1208** opposite first solar receiver surface **1206**. The exterior receiver surface **1206** can receive solar energy, for example from a field of heliostats or mirrors.

[0043] A second boiler panel **1210** similarly includes a plurality of tubes fluidly connecting an inlet header **1212** of second boiler panel **110** to an outlet header (not shown) of second boiler panel **1210**. The tubes of second boiler panel **1210** form a second solar receiver surface **1216** and a second internal surface **1218** opposite second solar receiver surface

1216 (i.e. exterior and interior surfaces, respectively). Like receiver surface **1206**, exterior receiver surface **1216** can receive solar energy, for example from a field of heliostats or mirrors.

[0044] FIGS. **13-20** show alternative embodiments to that shown in FIG. **12**. Corresponding elements of different embodiments have been numbered accordingly. These embodiments may be used individually or in combination with other embodiments of the present invention described herein.

[0045] As can be seen for example in FIG. **19**, the overlap region between panels **1902** and **1910** may allow for thermal expansion and contraction of the panels. There is a gap **1921** between an end portion **1920** of boiler panel **1902** and an end portion **1922** of boiler panel **1910**. Leakage of solar radiation is absorbed by the boiler tubes, e.g., in respective end portions of boiler panels **1902** and **1910**, and is not allowed to penetrate into the interior space of boiler. Since end portion **1920** of first panel **1902** and end portion **1922** of second panel **1910** are spaced apart from one another, panels **1902** and **1910** can move relative to one another during the thermal expansion and contraction that results from the daily cycle of solar radiation incident on the receiver area of boiler. Thus, while gap **1921** accommodates thermal expansion and contraction, in terms of leakage of solar radiation there is effectively no gap between panels **1902** and **1910**.

[0046] FIG. **20** shows an exemplary embodiment of a boiler constructed in accordance with the present invention, that similar to that shown in FIG. **19**, but that additionally includes a spacer **2030** for maintaining a gap **2021** between an end portion **2020** of boiler panel **2002** and an end portion **2022** of boiler panel **2010**.

[0047] The methods and systems of the present invention, as described above and shown in the drawings provide for increased effective area for receiving solar radiation in a boiler, such as in a solar receiver. This configuration can provide improved efficiency while also providing protection of components and spaces internal to the receiver panels from leakage of solar radiation from the heliostats, while allowing for thermal expansion and contraction. This configuration may also provide for drainability of the boiler sections.

[0048] While the apparatus and methods of the present invention have been shown and described with reference to preferred embodiments, those skilled in the art will readily appreciate that changes and/or modifications may be made thereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A boiler for a solar receiver comprising:

a) a first boiler panel having a plurality of tubes fluidly connecting an inlet header of the first boiler panel to an outlet header of the first boiler panel, the tubes of the first boiler panel forming a first solar receiver surface and a first internal surface opposite the first solar receiver surface; and

b) a second boiler panel having a plurality of tubes fluidly connecting an inlet header of the second boiler panel to an outlet header of the second boiler panel, the tubes of the second boiler panel forming a second solar receiver surface and a second internal surface opposite the second solar receiver surface, wherein the first and second boiler panels are adjacent one another with a portion of the first boiler panel and an end of the first solar receiver surface overlapping an end of the second boiler panel to reduce solar radiation passing between the first and second solar receiver surfaces.

2. A boiler for a solar receiver as recited in claim **1**, wherein the first and second boiler panels are adjacent to one another with an end of the first solar receiver surface overlapping an end of the second boiler panel so as to cover at least one of the headers behind the first solar receiver surface.

3. A boiler for a solar receiver as recited in claim **1**, wherein the first and second boiler panels are adjacent to one another with an end of the first solar receiver surface overlapping an end of the second boiler panel so as to cover one of the headers of each boiler panel behind the first solar receiver surface.

4. A boiler for a solar receiver as recited in claim **1**, wherein the first and second internal surfaces are covered with an insulation layer.

5. A boiler for a solar receiver as recited in claim **1**, wherein a gap is provided between the end of the second boiler panel and the portion of the first boiler panel overlapping the end of the second boiler panel to accommodate relative movement of the first and second boiler panels due to thermal growth.

6. A boiler for a solar receiver as recited in claim **1**, wherein the tubes of the first and second panels are configured and adapted to be fully drainable by way of at least one header in each panel.

7. A boiler for a solar receiver as recited in claim **1**, wherein the portion of the first solar receiver panel overlapping the end of the second boiler panel includes a 180° bend in the uppermost end of the plurality of tubes of the first solar receiving panel.

8. A boiler for a solar receiver as recited in claim **7**, wherein the end of the first solar receiver surface overlapping an end of the second boiler panel covers a header of the second solar receiver panel.

9. A boiler for a solar receiver comprising:

a) a steam generator panel having a plurality of tubes fluidly connecting an inlet header and an outlet header of the steam generator panel, the tubes of the steam generator panel forming a solar receiver surface and opposed internal surface;

b) a superheater panel having a plurality of tubes fluidly connecting an inlet header and an outlet header of the superheater panel, the tubes of the superheater panel forming a solar receiver surface and opposed internal surface, wherein the steam generator and superheater panels are adjacent one another with a portion of the steam generator panel including an end of the solar receiver surface thereof overlapping an end of the superheater panel to reduce solar radiation passing between the solar receiver surfaces of the steam generator and superheater panels; and

c) a reheater panel having a plurality of tubes fluidly connecting an inlet header and an outlet header of the reheater panel, the tubes of the reheater panel forming a solar receiver surface and opposed internal surface, wherein the steam generator and reheater panels are adjacent one another with a portion of the reheater panel including an end of the solar receiver surface thereof overlapping an end of the steam generator panel to reduce solar radiation passing between the solar receiver surfaces of the steam generator and reheater panels.

10. A boiler for a solar receiver as recited in claim **9**, wherein the steam generator and superheater panels are adjacent one another with an end of the solar receiver surface of the steam generator panel overlapping an end of the superheater panel so as to cover one header of each of the steam generator and superheater panels behind the solar receiver surface of the steam generator panel, and wherein the steam generator and reheater panels are adjacent one another with an end of the solar receiver surface of the reheater panel overlapping an end of the steam generator panel so as to cover one header of each of the steam generator and reheater panels behind the solar receiver surface of the reheater panel.

11. A boiler for a solar receiver as recited in claim **9**, wherein the internal surfaces of the steam generator, superheater, and reheater panels are covered with an insulation layer.

12. A boiler for a solar receiver as recited in claim **9**, wherein a first labyrinthine gap is provided between the end of the superheater panel and the portion of the steam generator panel overlapping the end of the superheater panel to accommodate relative movement of the steam generator and superheater panels due to thermal growth, and wherein a second labyrinthine gap is provided between the end of the steam generator panel and the portion of the reheater panel overlapping the end of the steam generator panel to accommodate relative movement of the steam generator and reheater panels due to thermal growth.

13. A boiler for a solar receiver as recited in claim **9**, wherein the tubes of the steam generator, superheater, and reheater panels are configured and adapted to be fully drainable by way of at least one header in each panel.

14. A boiler for a solar receiver as recited in claim **9**, wherein the portion of the steam generator panel overlapping the end of the superheater panel includes a 180° bend in the uppermost end of the plurality of tubes of the steam generator panel, and wherein the portion of the reheater panel overlapping the end of the steam generator panel includes a 180° bend in the uppermost end of the plurality of tubes of the reheater panel.

15. A boiler for a solar receiver as recited in claim **14**, wherein the end of the solar receiver surface of the steam generator panel overlapping an end of the superheater panel covers a header of the superheater panel, and wherein the end of the solar receiver surface of the reheater panel overlapping an end of the steam generator panel covers a header of the steam generator panel.

16. A boiler for a solar receiver comprising:

a) a first boiler panel having a plurality of tubes fluidly connecting an inlet header of the first boiler panel to an outlet header of the first boiler panel, the tubes of the first boiler panel forming a first solar receiver surface and a first internal surface opposite the first solar receiver surface; and

b) a second boiler panel having a plurality of tubes fluidly connecting an inlet header of the second boiler panel to an outlet header of the second boiler panel, the tubes of the second boiler panel forming a second solar receiver surface and a second internal surface opposite the second solar receiver surface, wherein the first and second boiler panels are adjacent one another with a portion of the first boiler panel including an end of the first solar receiver surface overlapping an end of the second boiler panel and covering one header of each of the first and second boiler panels, and wherein a labyrinthine gap is provided between the end of the first solar receiver surface and the end of the second boiler panel to accommodate relative movement of the first and second boiler panels due to thermal growth.

17. A boiler for a solar receiver as recited in claim **16**, wherein the tubes of the first and second panels are configured and adapted to be fully drainable by way of at least one header in each panel.

18. A boiler for a solar receiver as recited in claim **16**, wherein the portion of the first solar receiver panel overlapping the end of the second boiler panel includes a 180° bend in the uppermost end of the plurality of tubes of the first solar receiving panel.

19. A boiler for a solar receiver as recited in claim **16**, wherein the first and second internal surfaces are covered with an insulation layer.

20. A boiler for a solar receiver as recited in claim **1**, including a plurality of the first and second boiler panels disposed in cylindrical orientation about a central axis of the boiler.

21. A boiler for a solar receiver as recited in claim **1**, including a plurality of the first and second boiler panels disposed in rectangular orientation about a central axis of the boiler.

22. A boiler for a solar receiver as recited in claim **9**, including a plurality of steam generator panels, superheater panels, and reheater panels disposed in cylindrical orientation about a central axis of the boiler.

23. A boiler for a solar receiver as recited in claim **9**, including a plurality of steam generator panels, superheater panels, and reheater panels disposed in rectangular orientation about a central axis of the boiler.

24. A boiler for a solar receiver comprising:

a) a steam generator panel having a plurality of tubes fluidly connecting an inlet header and an outlet header of the steam generator panel, the tubes of the steam generator panel forming a solar receiver surface and opposed internal surface;

b) a superheater panel having a plurality of tubes fluidly connecting an inlet header and an outlet header of the superheater panel, the tubes of the superheater panel forming a solar receiver surface and opposed internal surface, wherein the steam generator and superheater panels are adjacent one another with a portion of the superheater panel including an end of the solar receiver surface thereof overlapping an end of the steam generator panel to reduce solar radiation passing between the solar receiver surfaces of the steam generator and superheater panels; and

c) a reheater panel having a plurality of tubes fluidly connecting an inlet header and an outlet header of the reheater panel, the tubes of the reheater panel forming a solar receiver surface and opposed internal surface, wherein the steam generator and reheater panels are adjacent one another with a portion of the reheater panel including an end of the solar receiver surface thereof overlapping an end of the steam generator panel to reduce solar radiation passing between the solar receiver surfaces of the steam generator and reheater panels.

25. A boiler for a solar receiver as recited in claim **24**, wherein the steam generator and superheater panels are adjacent one another with an end of the solar receiver surface of the superheater panel overlapping an end of the steam generator panel so as to cover one header of each of the steam generator and superheater panels behind the solar receiver surface of the superheater panel, and wherein the steam generator and reheater panels are adjacent one another with an end of the solar receiver surface of the reheater panel overlapping an end of the steam generator panel so as to cover one header of each of the steam generator and reheater panels behind the solar receiver surface of the reheater panel.

26. A boiler for a solar receiver as recited in claim **24**, wherein the portion of the superheater panel overlapping the end of the steam generator panel includes a 180 degree bend in the uppermost end of the plurality of tubes of the superheater panel, and wherein the portion of the reheater panel overlapping the end of the steam generator panel includes a 180° bend in the uppermost end of the plurality of tubes of the reheater panel.

27. A boiler for a solar receiver as recited in claim **26**, wherein the end of the solar receiver surface of the superheater panel overlapping an end of the steam generator panel covers a header of the steam generator panel, and wherein the end of the solar receiver surface of the reheater panel overlapping an end of the steam generator panel covers a header of the steam generator panel.

28. A boiler for a solar receiver as recited in claim **24**, wherein a first labyrinthine gap is provided between the end of the steam generator panel and the portion of the superheater panel overlapping the end of the steam generator panel to accommodate relative movement of the steam generator and superheater panels due to thermal growth, and wherein a second labyrinthine gap is provided between the end of the steam generator panel and the portion of the reheater panel overlapping the end of the steam generator panel to accommodate relative movement of the steam generator and reheater panels due to thermal growth.

29. A boiler for a solar receiver as recited in claim **24**, wherein the portion of the superheater panel overlapping the end of the steam generator panel includes a 180° bend in the lowermost end of the plurality of tubes of the superheater panel.

30. A solar radiation interference device for reducing an amount of solar radiation passing between two adjacent solar receiver surfaces, comprising:

a first boiler panel having a plurality of tubes fluidly connecting an inlet header of the first boiler panel to an outlet header of the first boiler panel, the tubes of the first boiler panel forming a first solar receiver surface and a first internal surface opposite the first solar receiver surface;

a second boiler panel having a plurality of tubes fluidly connecting an inlet header of the second boiler panel to an outlet header of the second boiler panel, the tubes of the second boiler panel forming a second solar receiver surface and a second internal surface opposite the second solar receiver surface, the first and second boiler panels being adjacent one another; and

an interference portion including an overlap of the first boiler panel and an end of the first solar receiver surface with respect to an end of the second boiler panel to reduce solar radiation passing between the first and second solar receiver surfaces.

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