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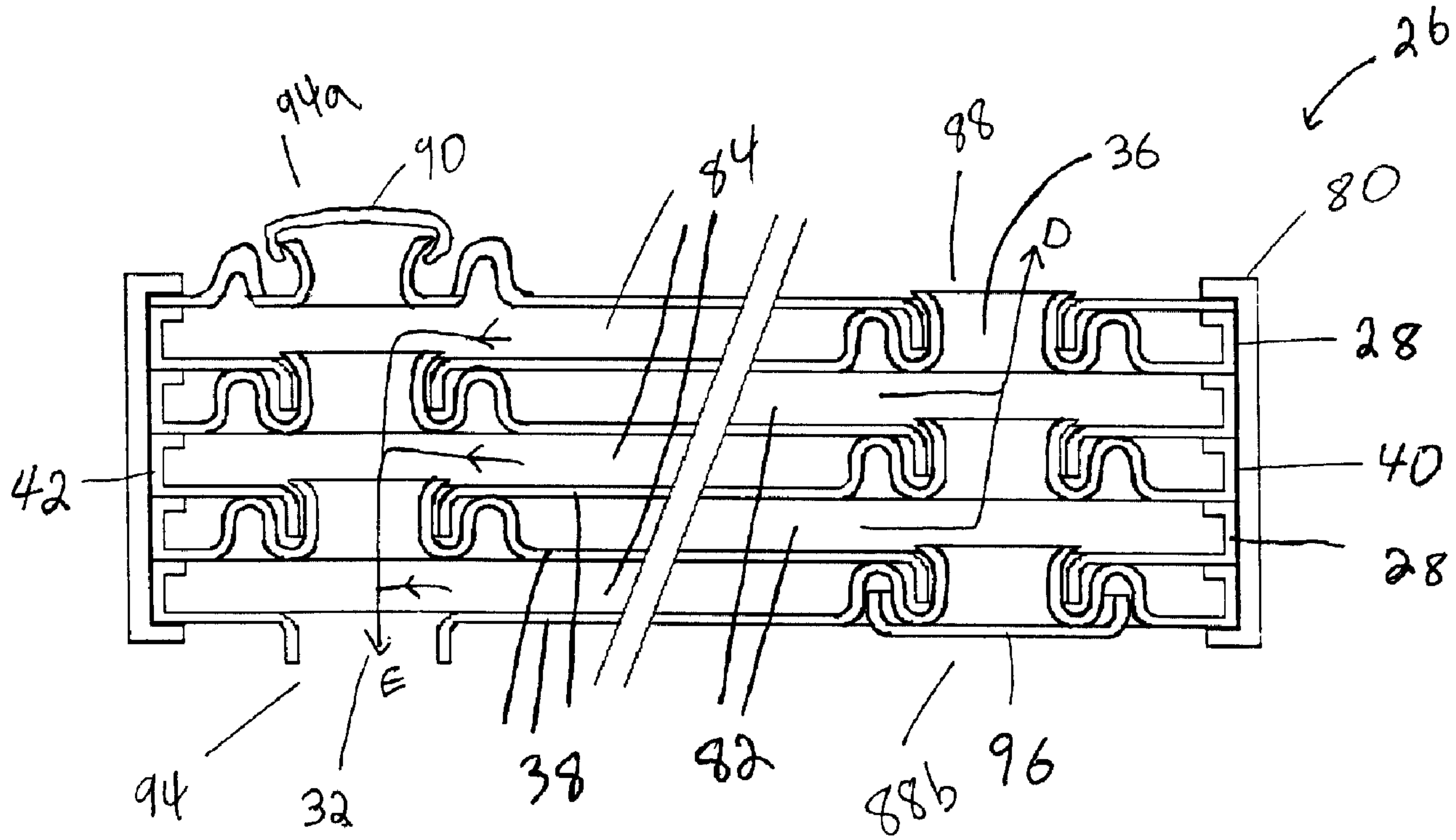
(54) Titre : ECHANGEUR DE CHALEUR
(54) Title: HEAT EXCHANGER



(57) Abrégé/Abstract:
A heat exchanger for exchanging heat between a cooler first air flow and a warmer second air flow is disclosed. The heat exchanger comprises a heat exchanger unit having a housing containing a plurality of heat exchanger plates stacked together to form a stack. Each heat exchanger plate has four corners and an aperture located adjacent each corner, the heat exchanger plates being dimensioned and configured such that the apertures of the heat exchanger plates overlap to form a first, second, third and fourth air passageways in the stack. The heat exchanger plates are further configured to form an alternating series of first and second flat parallel air chambers in the stack, the first set of air chambers being continuous with the first and second air passages

(57) Abrégé(suite)/Abstract(continued):
such that air can pass between the first and second air passages through the first set of air chambers, the second set of air chambers being continuous with the third and fourth air passageways such that air can pass between the third and fourth air passageways through the second set of air chambers. The stack of heat exchanger plates are further configured such that the first and second set or air chambers are substantially air tight such that air does not leak between the first and second set of air chambers. The heat exchanger unit has a first and second side, the first, second, third and fourth air passageways each having a first end open to the first side of the heat exchanger unit at a first port and an opposite second end opened to the second side of the heat exchanger unit at a second port. The stack is further adapted such that each port may be selectively plugged by a plug member, the heat exchanger unit having four plug members, each plug member plugging one end of each air passageway. Finally, the first, second, third and fourth air conduits, are each operatively coupled to one of the air passageways, the air conduits carrying the first and second air flows.

ABSTRACT

A heat exchanger for exchanging heat between a cooler first air flow and a warmer second air flow is disclosed. The heat exchanger comprises a heat exchanger unit having a housing containing a plurality of heat exchanger plates stacked together to form a stack. Each heat exchanger plate has four corners and an aperture located adjacent each corner, the heat exchanger plates being dimensioned and configured such that the apertures of the heat exchanger plates overlap to form a first, second, third and fourth air passageways in the stack. The heat exchanger plates are further configured to form an alternating series of first and second flat parallel air chambers in the stack, the first set of air chambers being continuous with the first and second air passages such that air can pass between the first and second air passages through the first set of air chambers, the second set of air chambers being continuous with the third and fourth air passageways such that air can pass between the third and fourth air passageways through the second set of air chambers. The stack of heat exchanger plates are further configured such that the first and second set or air chambers are substantially air tight such that air does not leak between the first and second set of air chambers. The heat exchanger unit has a first and second side, the first, second, third and fourth air passageways each having a first end open to the first side of the heat exchanger unit at a first port and an opposite second end opened to the second side of the heat exchanger unit at a second port. The stack is further adapted such that each port may be selectively plugged by a plug member, the heat exchanger unit having four plug members, each plug member plugging one end of each air passageway. Finally, the first, second, third and fourth air conduits, are each operatively coupled to one of the air passageways, the air conduits carrying the first and second air flows.

TITLE OF THE INVENTION: HEAT EXCHANGER

FIELD OF THE INVENTION:

The invention relates generally to the field of heat exchangers for exchanging heat between cold air and heated air.

BACKGROUND OF THE INVENTION:

Countercurrent heat exchangers are well known. They generally consist of a housing having a plurality of heat exchanger plates which separate a first flow of fluid from a second flow of fluid. The heat exchanger plates generally consist of substantially flat plates which, while keeping the first and second flows separate, bring both flows in sufficiently close proximity to permit heat to be exchanged between the two flows.

Countercurrent heat exchangers are presently used in several applications, however, their use in residential and commercial building has been limited by their high cost. Heat exchanger plates are usually welded or bonded together using expensive and time consuming techniques. Furthermore, present day heat exchangers are difficult to integrate into modern forced air heating and air conditioning systems. Finally, due to their expense and complexity of design, existing heat exchangers are difficult to customize. In most cases, a heat exchanger requires the installer little flexibility in duct positioning; thereby decreasing its appeal to builders. A simplified, low cost and flexible heat exchanger system would be easier to sell to the residential and commercial construction industries.

SUMMARY OF THE INVENTION:

The present invention is a heat exchanger for exchanging heat between a cooler first air flow and a warmer second air flow. The heat exchanger comprises a heat exchanger unit having a housing containing a plurality of heat exchanger plates stacked together to form a stack. Each heat exchanger plate has four corners and an aperture located adjacent each corner, the heat exchanger plates being dimensioned and configured such that the apertures of the heat exchanger plates overlap to form a first, second, third and fourth air passageways in the stack. The heat exchanger plates are further configured to form an alternating series of first and second flat parallel air chambers in the stack, the first set of air chambers being continuous with the first and second air passages such that air can pass between the first and second air passages through the first set of air chambers, the second set of air chambers being continuous with the third and fourth air passageways such that air can pass between the third and fourth air passageways through the second set of air chambers. The stack of heat exchanger plates are further configured such that the first and second set or air chambers are substantially air tight such that air does not leak between the first and second set of air chambers. The heat exchanger unit has a first and second side, the first, second, third and fourth air passageways each having a first end open to the first side of the heat exchanger unit at a first port and an opposite second end opened to the second side of the heat exchanger unit at a second port. The stack is further adapted such that each port may be selectively plugged by a plug member, the heat exchanger unit having four plug members, each plug member plugging one end of each air passageway. Finally, the first, second, third and fourth air conduits, are each operatively coupled to one of the air passageways, the air conduits carrying the first and second air flows.

BRIEF DESCRIPTION OF THE DRAWINGS:

FIGURE 1. Is a perspective view of a heat exchanger made in accordance with the present invention.

FIGURE 2. Is a top view of a heat exchanger panel made in accordance with the present invention.

FIGURE 3. Is a cross sectional view of the panel shown in figure 2 taken along line A-A.

FIGURE 4. Is a long sectional view of the heat exchanger unit shown in figure 1 taken along line B-B.

FIGURE 5. Is a long sectional view of the heat exchanger unit shown in figure 1 taken along line C-C.

FIGURE 6. Is a cross sectional view of a portion of an air passageway section of a heat exchanger made in accordance with the present invention wherein the air passageway has not yet been sealed.

FIGURE 7. Is a cross sectional view of the portion of the heat exchanger unit shown in figure 6 after the passageway has been sealed.

FIGURE 8. Is a top view of an alternate embodiment of the heat exchanger panel,

FIGURE 9. Is a cross sectional view of the heat exchanger panel shown in figure 8 taken along line F-F.

FIGURE 10. Is a cross sectional view of a portion of an air passageway section of a heat exchanger made in accordance with an alternate embodiment of the present invention wherein the air passageway has not yet been sealed.

FIGURE 11. Is a cross sectional view of the portion of the heat exchanger unit shown in figure 10 after the passageway has been sealed.

FIGURE 12. Is a front view of two heat exchangers made in accordance with the present invention being mounted on the roof of a building.

DETAILED DESCRIPTION OF THE INVENTION:

Referring firstly to figure 1, a heat exchanger system, shown generally as item 10, can be used to transfer the heat from the internal air of a building to the external air outside of the building as the internal air is exhausted out of the building and the cooler outside air is vented into the building. A heat exchanger system made in accordance with the present invention consists of a heat exchanger unit 12 mounted between exhaust conduits 14 and intake conduits 16. Exhaust conduit 14 consists of parallel conduits 18 and 20 while intake conduit 16 consists of parallel conduits 22 and 24. Heat exchanger 12 consists of a plurality of heat exchanger units 26, each of which is formed from a plurality of heat exchanger plates 28. Heat exchanger unit 26 has conduit 30 for receiving warm stale air from conduit 18. Heat exchanger plates 28 channels the warm stale air from conduit 30 into opposite conduit 32 located on the other side of the heat exchanger plates. Air from conduit 32 is exhausted into conduit 20 via a fan or other means known in the art.

Heat exchanger unit 26 is also provided with conduits 34 which receives air from conduit 24. Air from conduit 34 is channeled through heat exchanger plates 28 to conduit 36 at the opposite end of plates 28. Conduit 24 is open to the outside of the building, and is therefore filled with cooler fresh air. Cooler fresh air is forced into conduit 24 by a fan or other means and makes its way into conduit 34. Conduit 34 distributes the cooler fresh air through plates 28, which exhaust into conduit 36. Conduit 36 in turn exhausts into conduit 22 which supplies the inside of the building with fresh air. As warm stale air from inside the building is forced through conduit 18 via a fan or other means, it passes through conduit 30 and out conduit 32 where it is in turn passed to conduit 20 and is exhausted out of the building. As the air passes from conduit 30 to 32, it passes through plates 28. Likewise, as air passes through conduit 34 to conduit 36, it passes through plates 28. For the purposes of this patent application, the air flow from conduit 30 to 32 will be referred to as the outgoing air flow, and the air flow from conduit 34 to 36 will be referred to as the ingoing air flow. As will be explained in greater detail, plates 28 are adapted and configured to separate the ingoing and outgoing air flows into separate ingoing and outgoing air channels. These separate air channels are arranged such that the ingoing and outgoing air flows travel in parallel but opposite directions through plates 28. As will be explained in greater detail, plates 28 are further configured such that the ingoing and outgoing air channels are in thermal contact, such that a portion of the heat contained in the warmer air of the outgoing air channels is transferred to the cooler air of the ingoing air channel. In this way, warm stale air from the inside of a building may be used to heat cold fresh air which is pumped into the building.

The capacity of heat exchanger plate 10 can be increased simply by increasing the number of heat exchanger units 26. Hence, if the heat exchanger capacity of heat exchanger 10 is to be increased, additional heat exchanger units 26 are mounted between conduits 14 and 16.

Referring now to figure 2, each heat exchanger plate 28 consists of a substantially flat metal plate having a flat surface 38, opposite ends 40 and 42, and opposite sides 44 and 46. Surface 38 is provided with a pair of apertures 48 and 50 towards opposite ends 40 and 42. Aperture 50 is provided with corrugated rim 52 which assists in the formation of an air passageway. Preferably, apertures 48 and 50 located at end 40 are in opposite orientation to apertures 48 and 50 located towards end 42.

Referring now to figure 3, corrugated rim 52 surrounding aperture 50 consists of outside wall 58, top 68, middle wall 56, lower portion 62 and inner wall 60. Inner wall 60, bottom portion 62 and middle wall 56 are formed such that inner gap 64 is created separating walls 56 and 60. Likewise, outer walls 58 and middle wall 56 are separated by gap 70. Aperture 48 is defined by horizontal wall 72 having shoulder 71 and lip 54. Wall 72 is substantially perpendicular to surface 38. Side 44 forms an angular wall rising perpendicularly from surface 38. Likewise, side 46 forms an angular wall having top surface 76 rising perpendicularly from surface 38.

Turning now to figures 4 and 5, each heat exchanger unit 26 is formed from a plurality of heat exchanger plates 28 which are stacked one on top of the other within housing 80 such that apertures 48 of one heat exchanger plate is alined with aperture 50 of the heat exchanger plate immediately below. Apertures 48 and 50 of heat exchanger plates 28 form air conduits 34, 30, 32 and 36. Heat exchanger plates 28 also form air chambers 84 and 82 which are separated by heat exchanger surfaces 38. Due to the sealing arrangement between apertures 48 and 50, conduit 34 is continuous with chambers 82 while conduit 30 is continuous with chambers 84. Conduit 34 is sealed at one end by cap 96 and conduit 30 is sealed at one end by cap 90. As air travels through conduit 34 it travels through air chambers 82 and out of air conduit 36. Likewise, as air travels through conduit 30 it travels into chambers 84 and out of conduit 32. Surfaces 38 of heat exchanger plates 28 separate the air flow in chambers 82 and 84. It will be appreciated that the air in chamber 82 is flowing in a parallel but opposite direction to the air in chambers 84. Since heat exchanger plates 28 are made of aluminum or sheet metal or some other such material, heat is exchanged between chambers 82 and 84 in a counter flow arrangement.

One of the advantages of the present heat exchanger plate design is that by simply capping different apertures, a different pattern of air flow can be created in the heat exchanger unit. For example, considering the embodiment shown in figures 4 and 5, heat exchanger unit 12 has eight possible ports through which air may pass into or out of the heat exchanger unit. In particular, heat exchanger unit 12 has ports 86a, 86b, 92a, 92b, 94a, 94b, 88a and 88b. These ports can either be left opened or closed, depending on the particular air flow pattern desired. In the particular example shown in figures 4 and 5, ports 86a, 92b, 88a and 94b are left open, while ports 92a, 86b, 94a and 88b are closed off by caps 90 and 96. This particular arrangement of open and closed ports permits a first airflow D between ports 86a and 88a and a second air flow E between ports 94b and 92b. If first airflow D represents the ingoing air flow and second airflow E represents the outgoing air flow, then cold fresh air would flow into port 86a, pick up heat from airflow E and then exhaust as warmer fresh air out of port 88a. Likewise, warmer stale air would enter port 92b, exchange its heat with air flow D, and exhaust as cooler stale air out port 94b. By capping different ports, a different air flow pattern can be created. For example, by capping ports 88a and 94b and opening ports 88b and 94a, a different counter current air flow pattern is created.

It will be appreciated that depending on the needs of the customer, certain air flow patterns may be more desirable than others. The particular arrangement shown in figure 1 shows fresh air being carried by conduits 24 and 22 of intake conduits 16 while stale air is carried in conduits 18 and 20 of exhaust conduit 14. In some applications, this particular arrangement may not be optimal since there will be a temperature difference between conduits 24 / 22 and conduits 18 / 20. In some applications, this may result in condensation build up. If condensation buildup is a problem, it may be preferable to keep both of the "warm" air flows together in the same intake or exhaust conduit. The versatility of the present design permits each heat exchanger unit to be customized to meet particular applications. All that is required to alter the internal air flow pattern is a number of caps 90 and 96. In this way, each heat exchanger can be tailored to the specific needs of the customer.

Referring now to figure 6, the method of sealing heat exchanger plates 28 will now be disclosed. The inside diameter of aperture 48 is selected such that lip 72 of first heat exchanger plate 98 can fit between middle wall 56 and inner wall 60 of lower heat exchanger plate 100. Surfaces 38 of heat exchanger plates 98 and 100 define chamber 102. The height of walls 58 and 56 define the height of chamber 102. Outer wall 58 and middle wall 56 form a rigid annular structure which supports heat exchanger plate 98. Aperture 48 is dimensioned such that lip 72 fits within gap 64 defined by middle wall 56 and inner wall 60 of heat exchanger plate 100. Inner wall 60 is dimensioned such that lip 66 projects above surface 38 of heat exchanger plate 98.

As seen in figure 7, plate 98 and 100 are sealed together such that relatively little air leaks from chamber 102 into aperture 50. The sealing is accomplished by deforming inner wall 60 and adjacent lip 66 such that lip 66 makes contact with shoulder 71 of upper heat exchanger plate 98. To ensure that lip 66 makes contact with shoulder 71 all along the periphery of aperture 50, lip 72 is selected to be sufficiently long such that rim 54 of lip 72 makes contact with lower portion 62 of lower heat exchanger plate 100. This structure permits lip 72 to resist the force of the tool which is used to deform edge 66 against shoulder 71. It has been discovered that if edge 54 of lip 72 does not make contact with bottom portion 62, then a tight seal between shoulder 71 and edge 66 is less likely to occur.

An alternate embodiment of the heat exchanger plates of the present invention is shown in Figures 8, 9, 10 and 11. The alternate embodiment essentially consists of an alternate structure for the sealing of the heat exchanger plates. As seen in Figure 8, heat exchanger plate 150 consists of a substantially flat metal plate having flat surface 152 opposite ends 154 and 156 and opposite sides 158 and 160. Flat surface 152 is provided with a pair of apertures 162 and 164 toward end 154 and apertures 166 and 168 toward end 156. Apertures 164 and 166 are provided with rim 170 and 172, respectively.

Referring now to Figure 9, rim 172 consists of a cone like base 176 surrounding a cylindrical collar 174. Base 176 is at an angle (alpha) relative to flat surface 152. Collar 174 is at an angle beta to base 176. It will be appreciated that base 176 consists of a cone-like base extending outwardly from collar 174. Collar 174 has an upper rim 182 which defines the diameter of opening 166. Base 176 and collar 174 are dimensioned such that rim 182 projects above ledges 178 and 180. Aperture 162 is formed on flat surface 152 as a simple aperture having rim 176. The diameter of aperture 162 is slightly higher than the outside diameter of collar 174. Preferably, aperture 162 is approximately 20 thousandth in radius larger than the outside diameter of collar 174.

Referring now to Figures 10 and 11, heat exchanger plates 150 can be stacked one on top of the other as in the previous embodiment. When heat exchange plates 150 are stacked one on top of the other, a plurality of parallel air chambers 188 and 190 are formed. An air passage way connecting air chambers 190 is formed by openings 166, and base 176. Collar portion 174 of a lower heat exchanger plate is inserted into aperture 162 of a corresponding upper heat exchanger plate such that collar portion 174 pass through aperture 162, as shown in Figure 10. To seal the gap separating rim 196 from collar 174, collar 174 is bent around rim 196 as shown in Figure 11. Angle alpha is selected to ensure that collar 174 can be deformed to seal aperture

162 without causing flat surfaces 152 to deform. It has been discovered that if angle alpha equals 38 degrees or less, and if collar 174 is approximately 0.03 inches in height between rim 182 and point 184 where the collar meets base 176, then wall 174 may be bent around rim 196 of aperture 162 without causing any significant deformation of flat surface 152. Experiments using aluminum 50-52 sheeting having a thickness of .02 inches, showed that an angle alpha of 38 degrees permitted tight sealing of aperture 162 without significant buckling of surface 152. By contrast, when Alpha angles of 40 degrees or 42 degrees were attempted, significant buckling of flat surface 152 occurred. Furthermore, where alpha was greater than 38 degrees, very poor ceiling around rim 196 was obtained.

As mentioned previously, one of the advantages of the present invention is how the air flow patterns in the heat exchanger can be modified to suit the particular needs of the customer. This is particularly evident when two heat exchangers are to be coupled for high volume applications. Referring now to figure 12, if building 200 requires a higher capacity of fresh air ventilation, then two heat exchangers, 104 and 106 may be mounted to roof 202. In order to ensure that only one hole is made in the roof to accommodate the exhaust ducts, exhaust conduit 108 of heat exchanger 106 and exhaust conduit 110 of heat exchanger 104 can be arranged such that the two exhaust conduits are side by side. This side by side arrangement permits the exhaust conduits of both heat exchangers 104 and 106 to be coupled to the same exhaust fan (not shown), thereby simplifying the installation of the units.

Specific embodiments of the present invention have been disclosed; however, several variations of the disclosed embodiments could be envisioned as within the scope of this invention. It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims.

WHAT IS CLAIMED IS:

1. A heat exchanger for exchanging heat between a first cool air flow and a second warmer air flow, the heat exchanger comprising:

a heat exchanger unit having a housing containing a plurality of heat exchanger plates in mutually arranged relation to form a stack, each plate having four corners and an aperture located adjacent each corner, the heat exchanger plates being dimensioned and configured such that said apertures overlap to form first, second, third and fourth air passageways in the stack, said plates being further configured to form an alternating set of first and second flat parallel air chambers in mutual serial relation in the stack, the first said set of air chambers being continuous with said first and second air passageways such that air can pass between the first and the second air passageways through said first set of air chambers; said second set of air chambers being continuous with said third and said fourth air passageways, such that air can pass between the third and the fourth air passageways through the second set of air chambers;

said stack of heat exchanger plates being further configured such that the first and second set of air chambers are substantially air tight so that air does not leak between the first and the second set of air chambers; said heat exchanger unit having a first side and a second side, the four said air passageways each having a first end open to said unit first side at a first port and an opposite, second end opened to said unit second side at a second port; said first and said second port being configured to be selectively plugged by a plug member; said unit having four said plug members, each plugging one end of a respective said air passageway; and first, second, third and fourth air conduits, each operatively coupled to a respective one of said air passageways and carrying a respective one of said first and second air flows.

2. The heat exchanger unit as defined in Claim 1 wherein said first and said second air passageways are formed on first opposite diagonal corners of said heat exchanger plates,

and wherein said third and said fourth air passageways are formed on second opposite diagonal corners of said heat exchanger plates.

3. The heat exchanger as defined in claim 2, wherein said first and said second air conduits are mounted to said first side of said heat exchanger unit, and said third and said fourth air conduits are mounted on said second side of said heat exchanger unit, said first air conduit being operatively coupled to two of said ports on said first side of said heat exchanger unit, said second air conduit being operatively coupled to two other said ports on said first side of said heat exchanger unit; said third air conduit being operatively coupled to two of said ports on said second side of said heat exchanger unit, and said fourth air conduit being operatively coupled to two other said ports on said second side of said heat exchanger unit.

4. The heat exchanger as defined in Claim 3, wherein the heat exchanger comprises a plurality of substantially identical said heat exchanger units, each said unit having its first said side mounted to said first and second air conduits, and its said second side mounted to said third and fourth air conduits.

5. A heat exchanger plate for use in forming said heat exchanger as defined by Claim 1, said heat exchanger plate comprising:

(a) a sheet having a flat surface and a peripheral rim of predetermined height;

(b) a first pair of said apertures formed on said sheet of predetermined diameter and an projecting peripheral edge;

(c) a pair of projecting collar portions extending perpendicularly from the sheet having a rim portion with an outside diameter slightly smaller than the inner diameter of said first pair of apertures;

(d) said collar portions and said apertures being located and positioned such that with two said heat exchanger plates in mutually stacked relation said collar portion rims of one said plate extend through said first pair of apertures of the adjacent said plate, to form said first, second, third and fourth air passageways in said stack, said collar portions being further configured to be deformed around the peripheral edge surrounding said first pair of apertures to form a substantially air tight seal;

(e) each of said air passageways having a first port at a first end of the passageway and a second port at a second end of the passageway, each port being configured to be selectively plugged by a plug member, one of a first and second port being plugged for each of said first, second , third and fourth air passageways.

6. The heat exchanger plate as defined in Claim 5 wherein each said collar portion is formed on said sheet and has a cone shaped base extending at an acute angle from the surface of the sheet and tapering to form said collar portion rim, said collar portion rim being substantially cylindrical and extending from the base as a shoulder.

7. The heat exchanger plate as defined in Claim 6 wherein said peripheral edges surrounding said first pair of apertures contact said shoulders of said collar portions.

8. The heat exchanger plate as defined in Claim 7 wherein said acute angle is greater than approximately 38 degrees.

9. The heat exchanger as defined in Claim 1, wherein each of said apertures has a circular peripheral edge, each said heat exchanger plate further including a pair of collar portions projecting perpendicularly from the plate, each collar portion having a rim defining a circular opening having an external diameter slightly smaller than the inner diameter of said aperture, said collar portions and said apertures being in mutually

positioned relation when said heat exchanger plates are stacked that said collar portion rims of one plate are aligned with and extend within said apertures in an adjacent heat exchanger plate to form said air passageways; each said collar portion rim being configured to be deformed at the peripheral edge surrounding the airway, to form a substantially air tight seal.

10. the heat exchanger plate as defined in Claim 5, said sheet being substantially rectangular, with four corners, said first pair of apertures and said pair of collar portions being formed such that each aperture and each collar portion is positioned adjacent to a corner of the sheet.

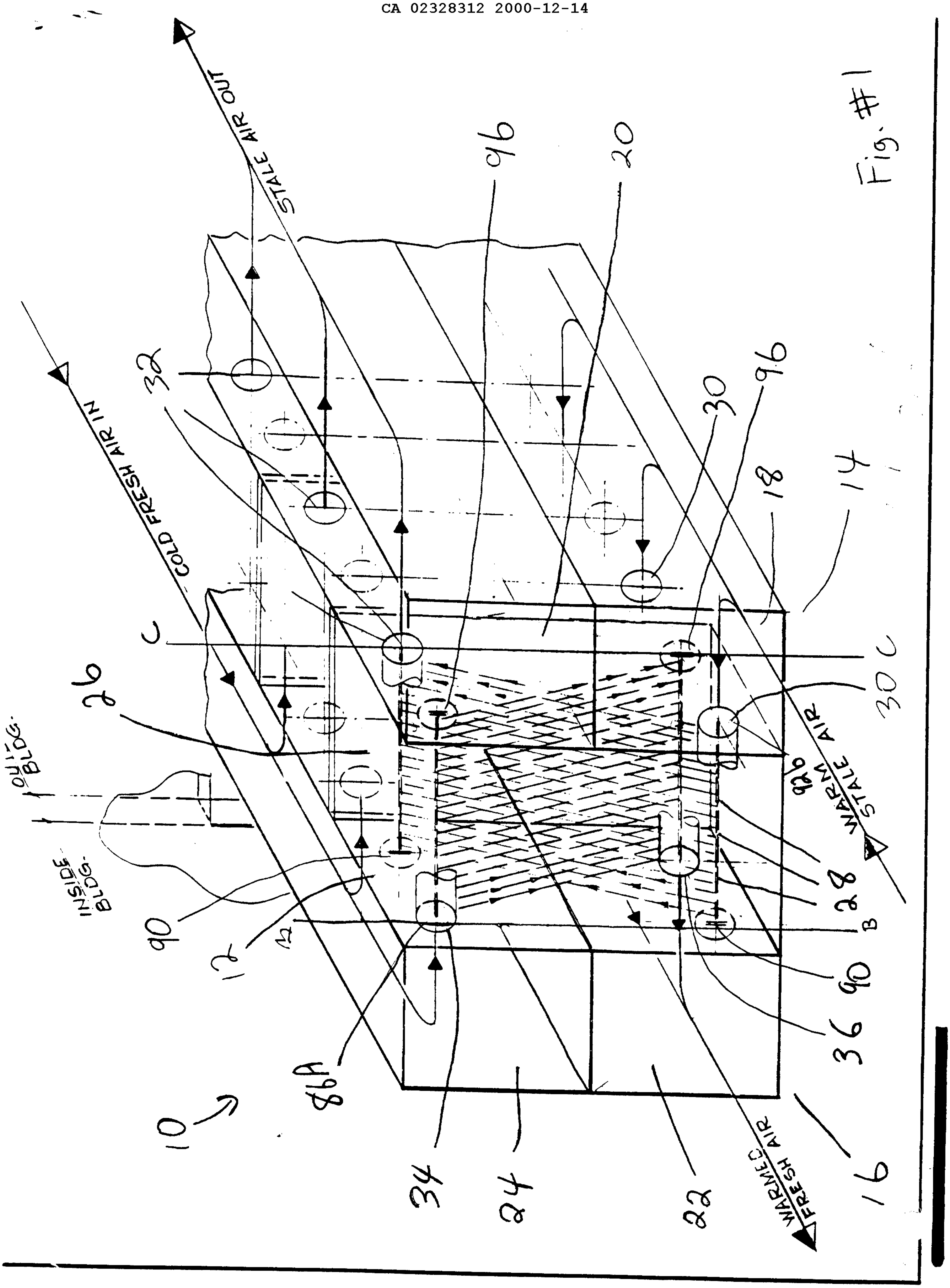

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Fig. #1

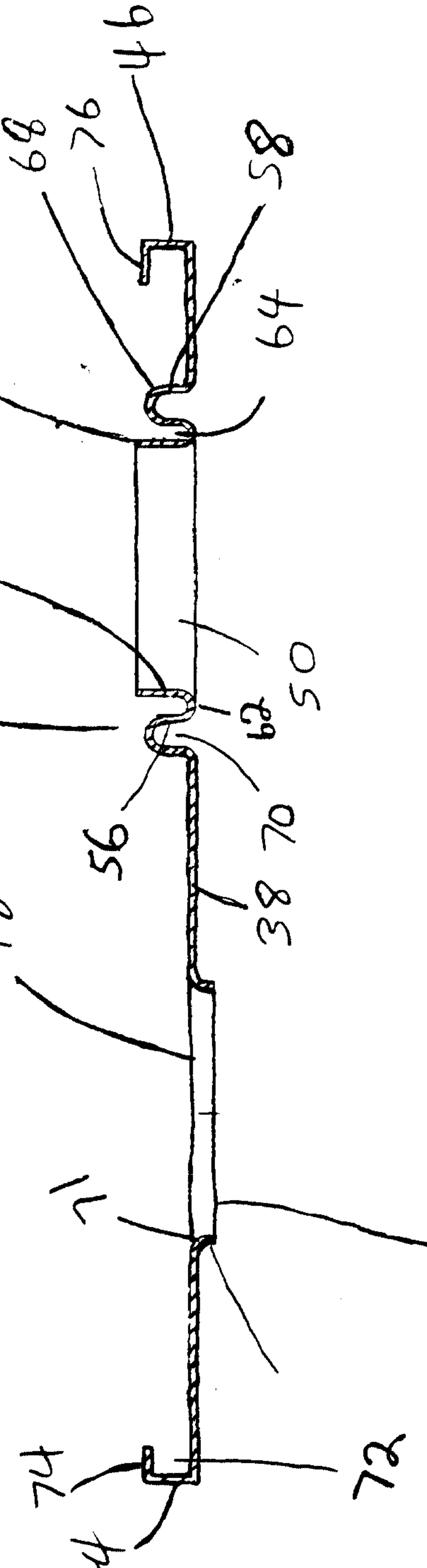
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Fig. 3.

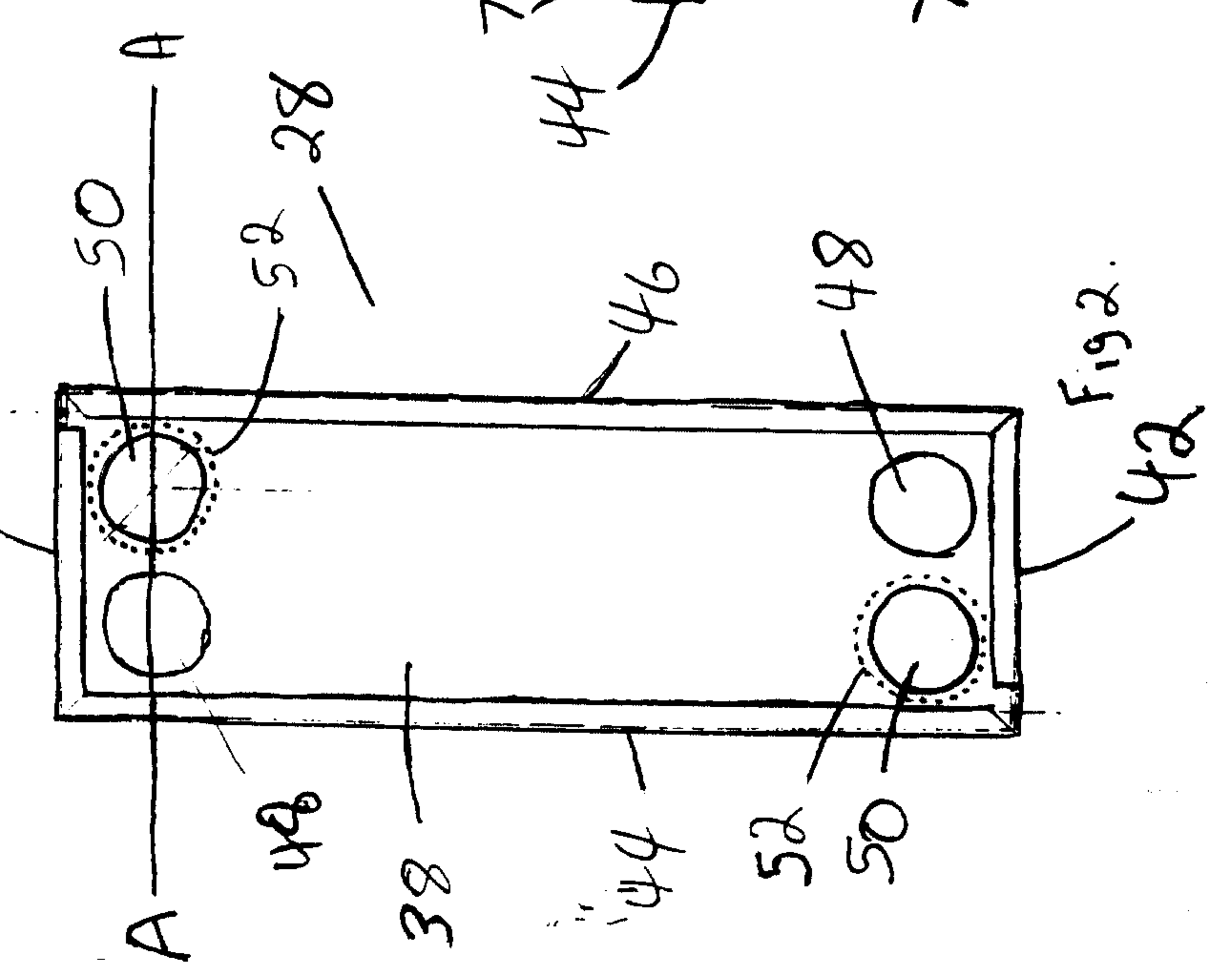
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Fig2.

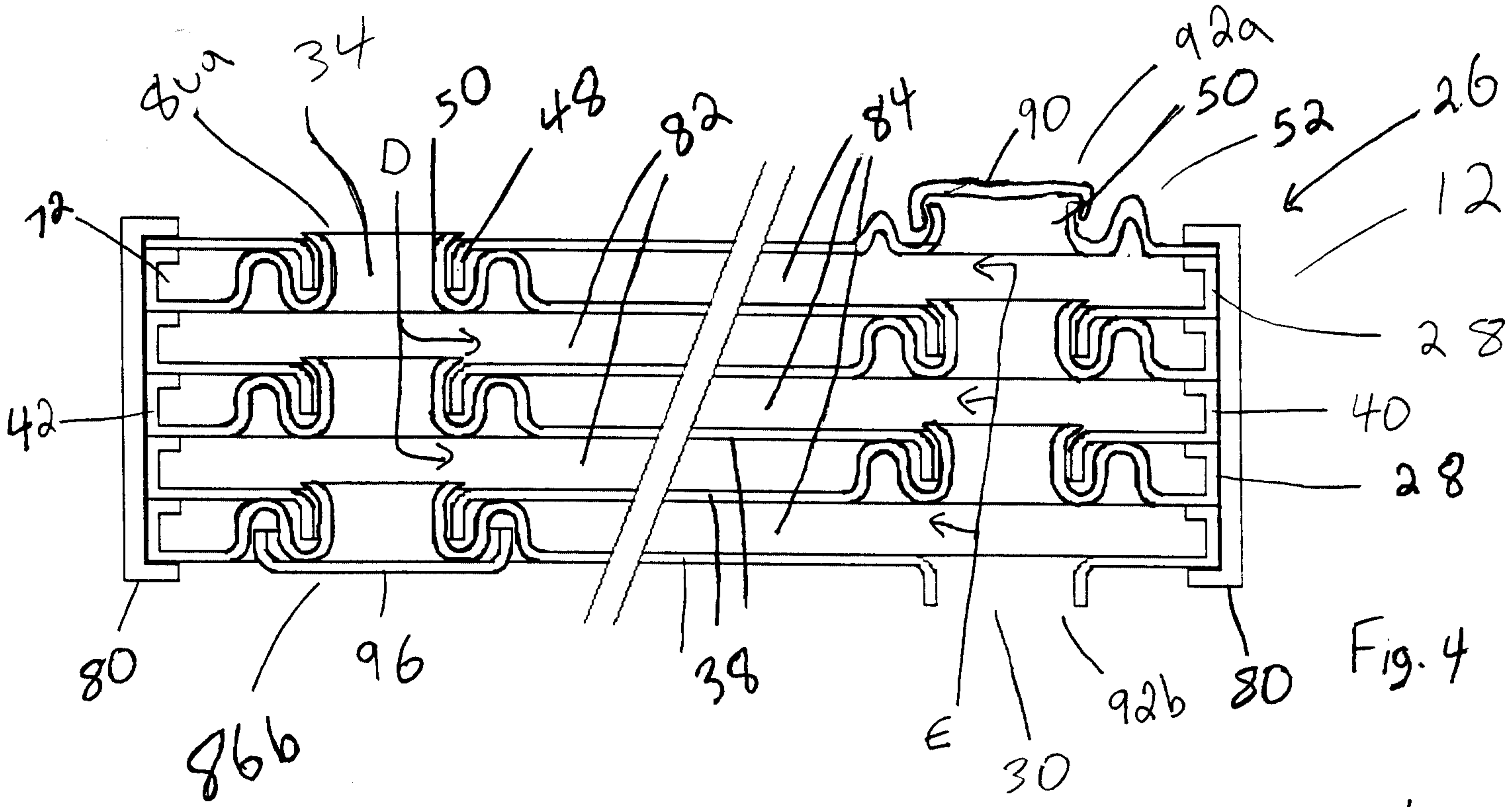

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Fig. 4

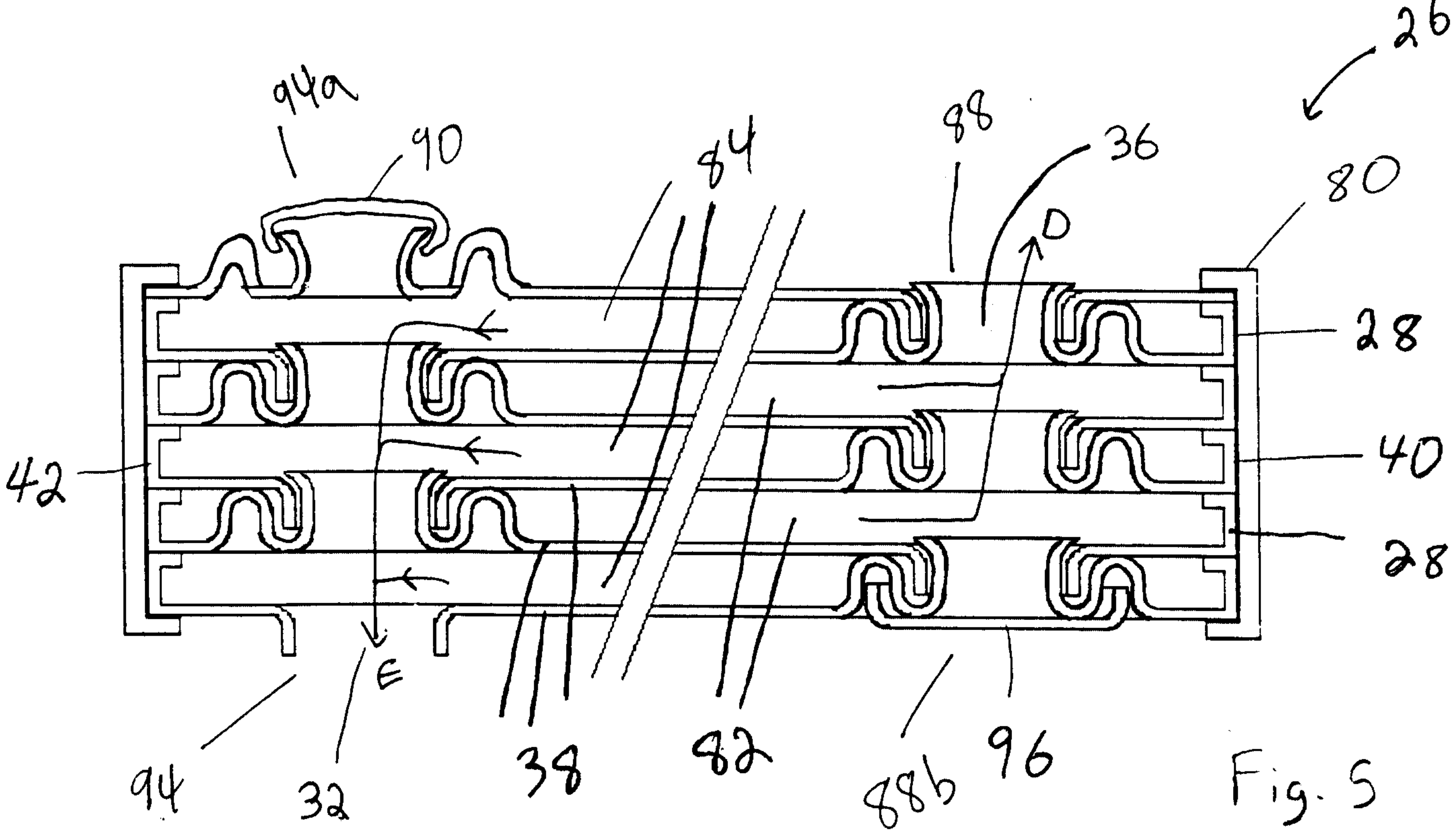

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Fig. 5

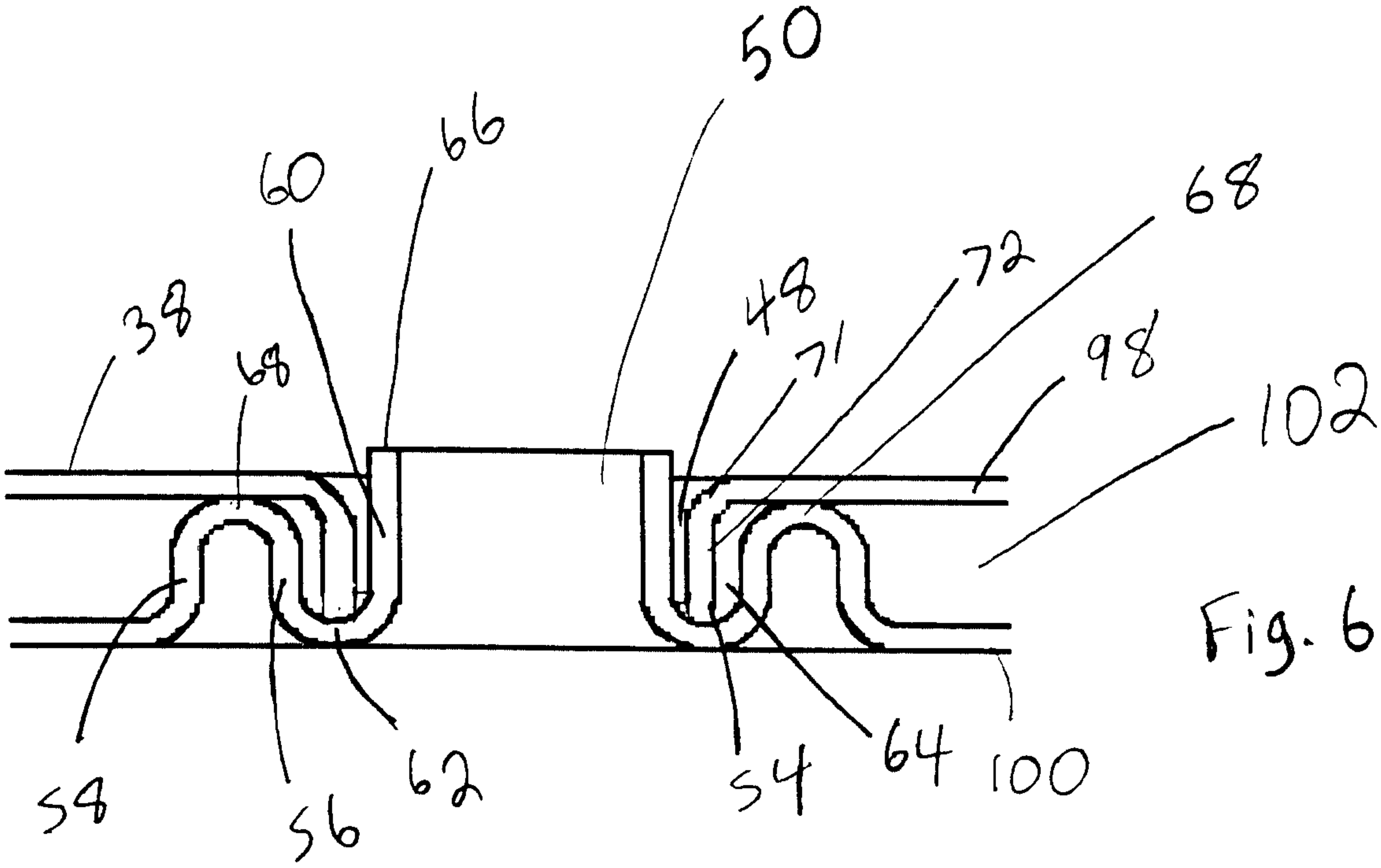
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Fig. 6

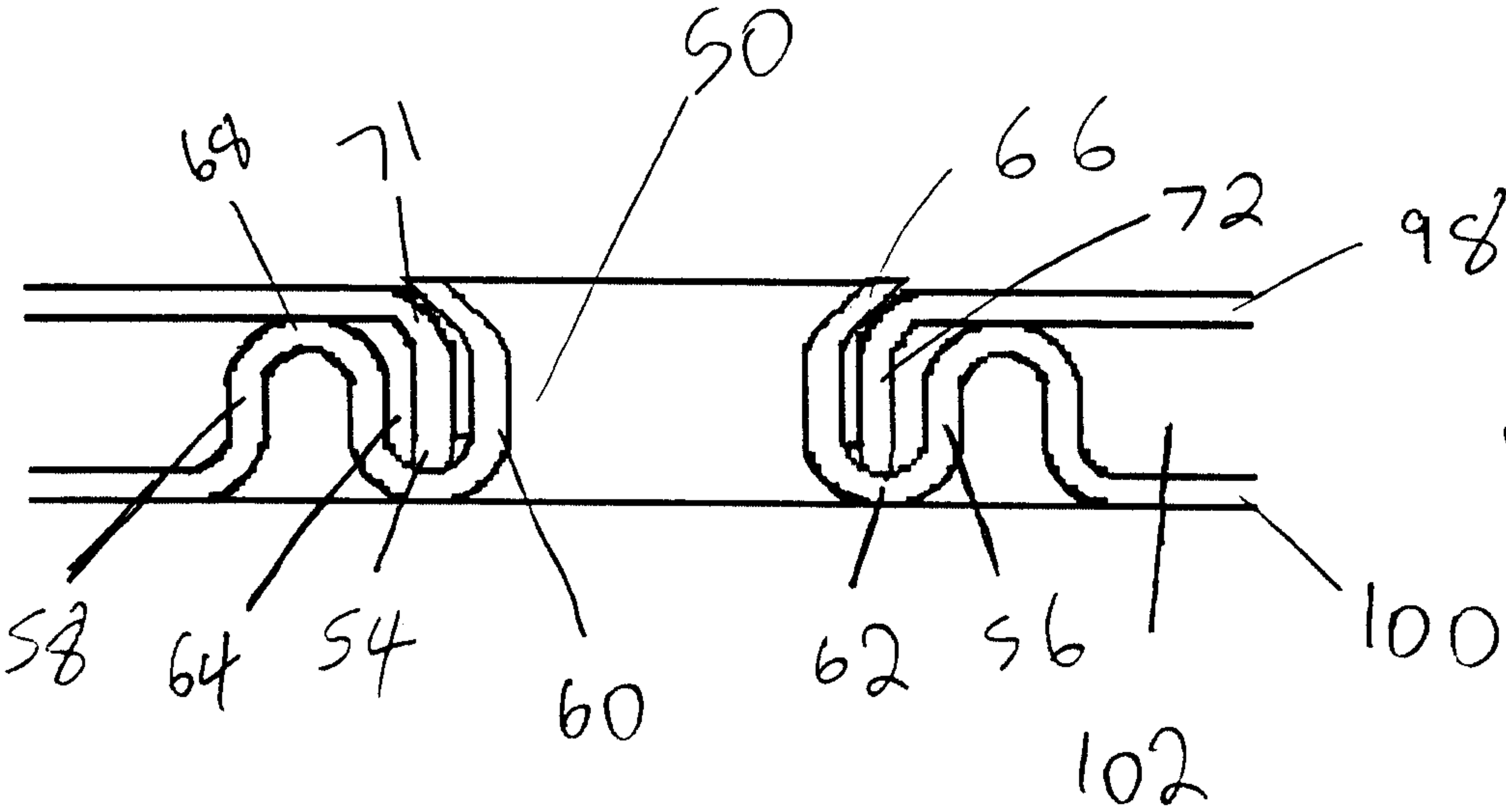
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Fig. 7

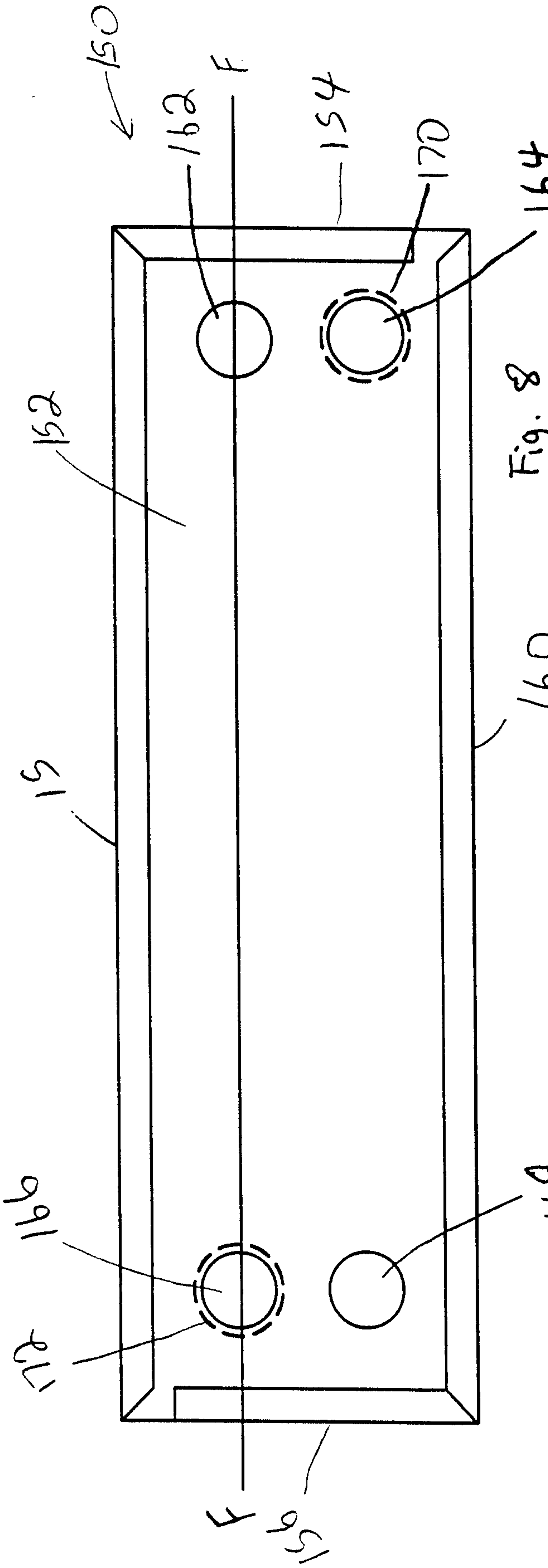
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Fig. 8

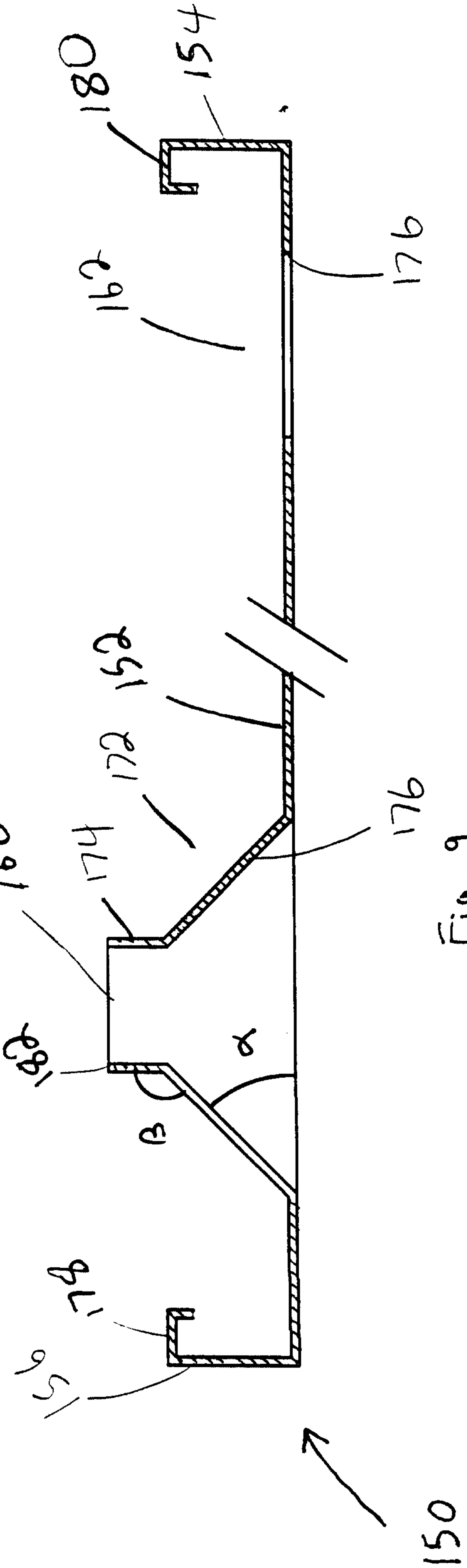
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Fig. 9

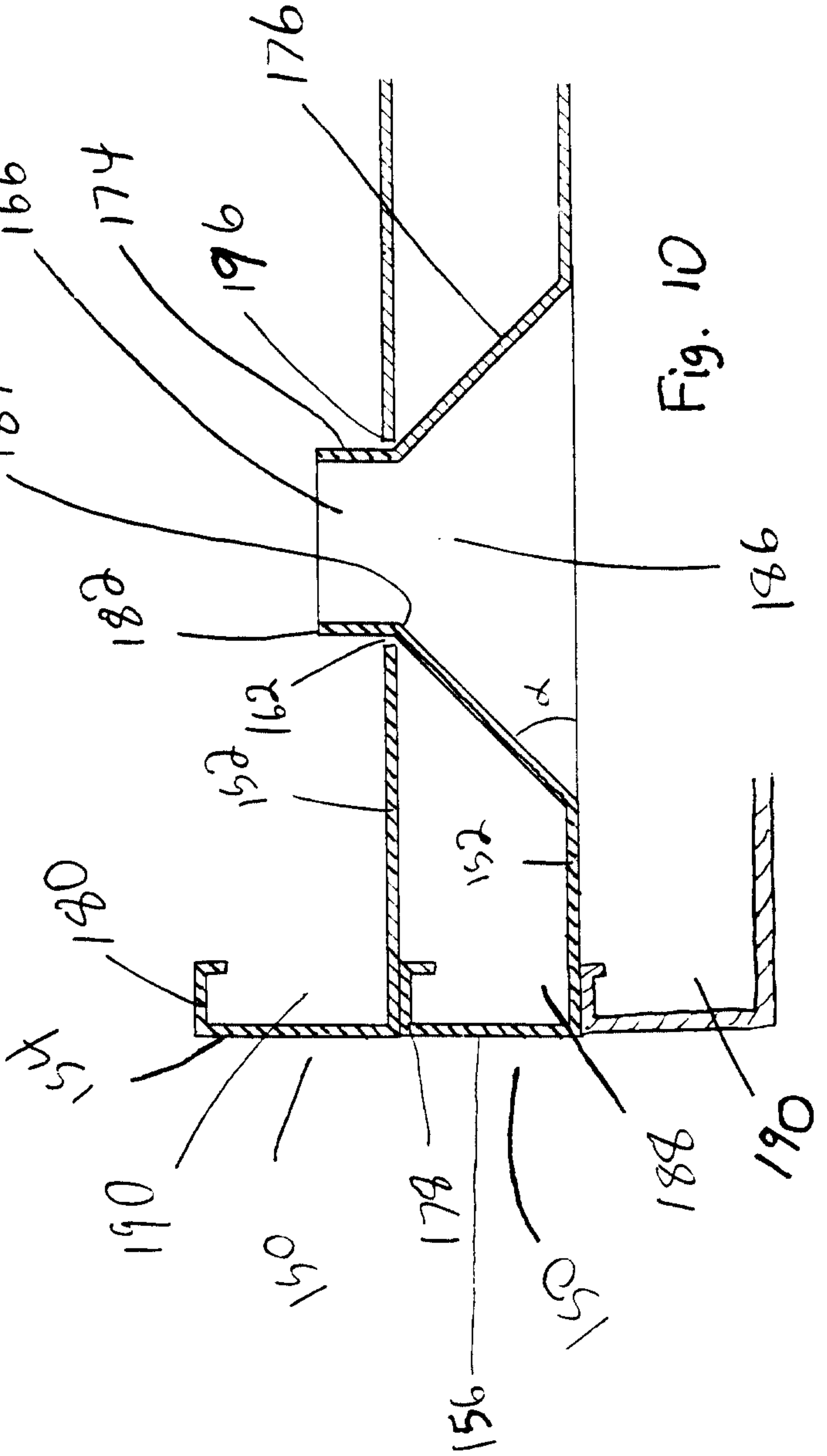
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Fig. 10

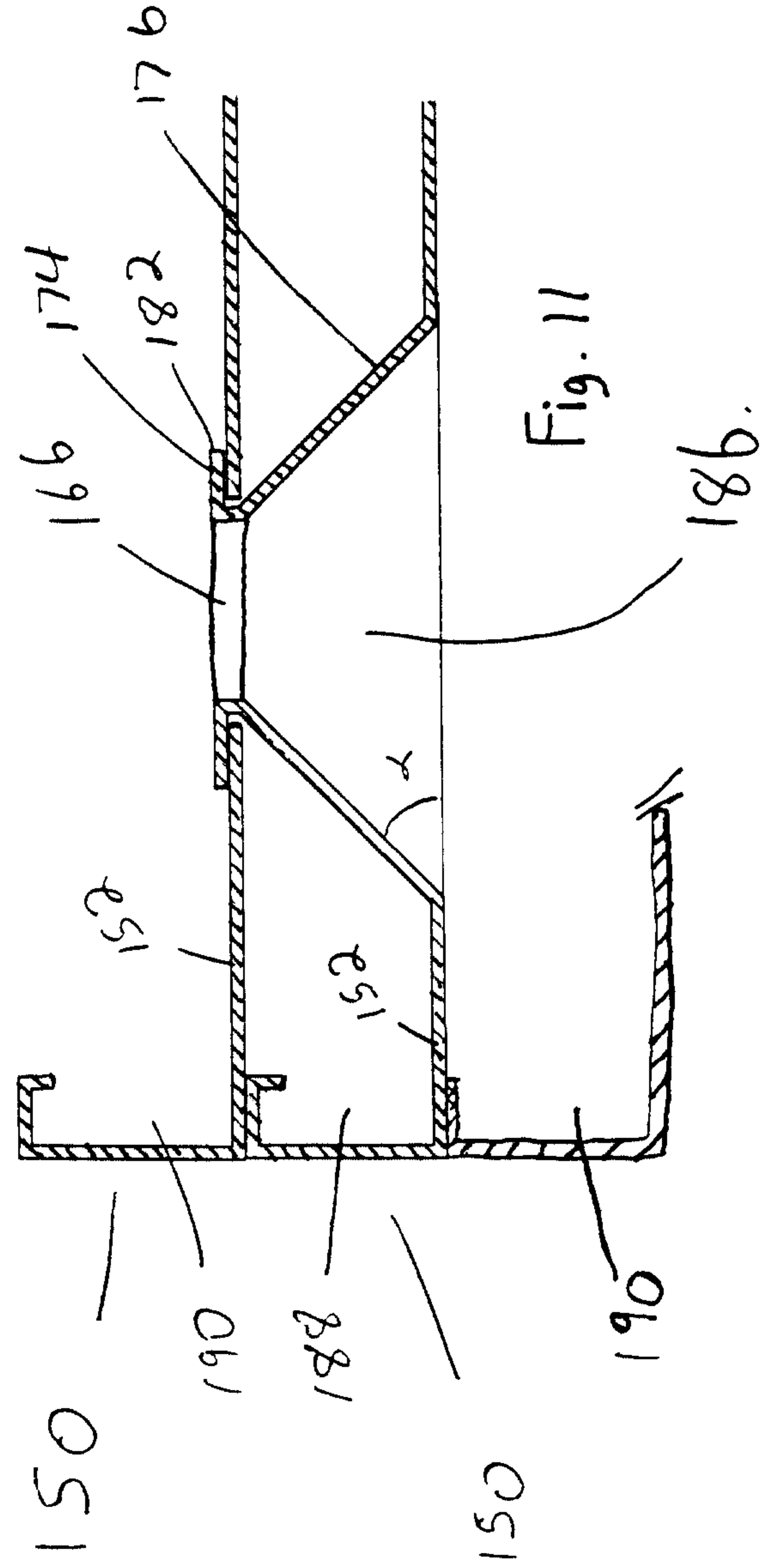
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Fig. 11

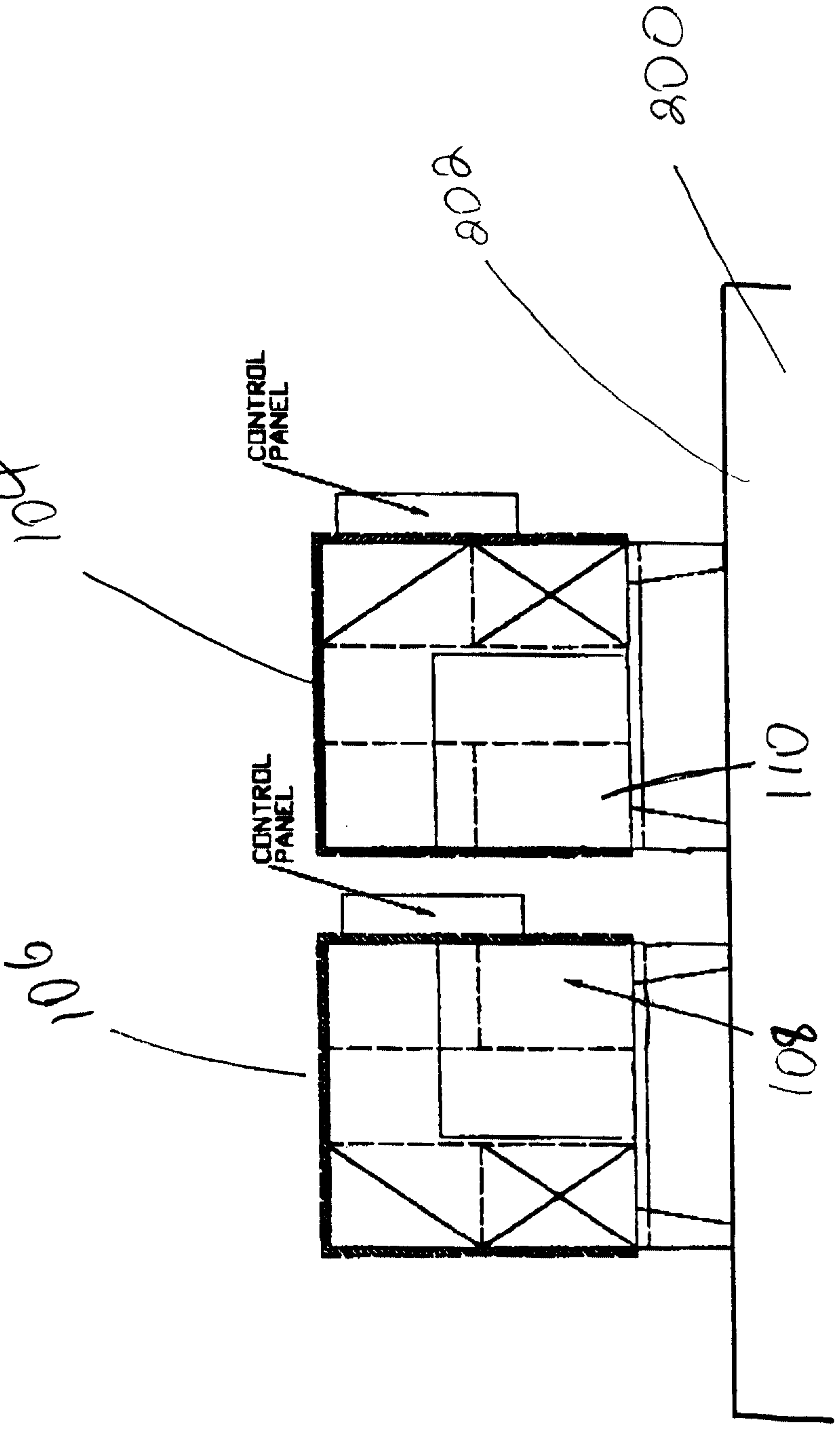
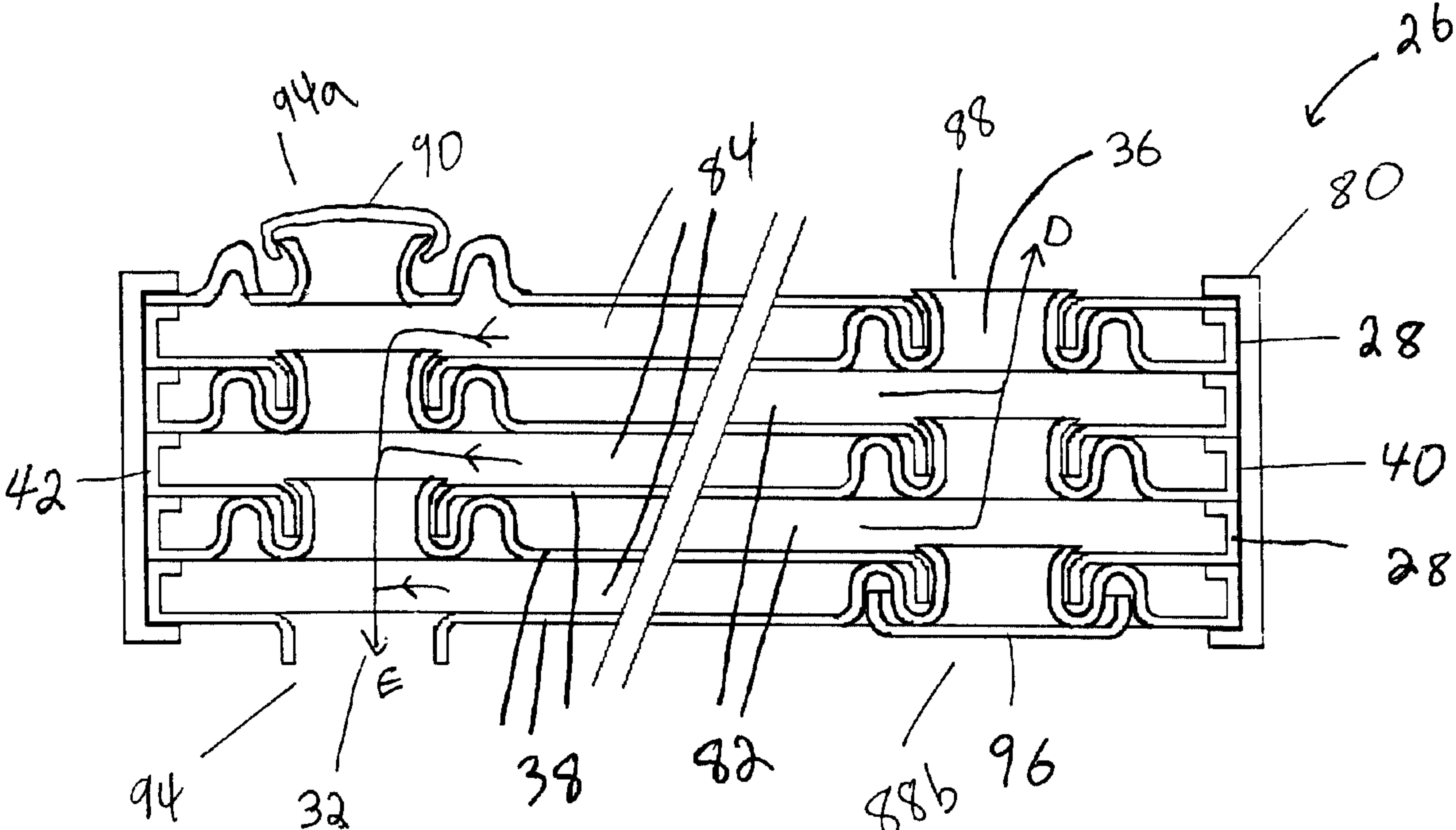


Fig. 12


26
94a
90
84
88
36
80
D
28
42
40
28
E
94
32
38
82
88b
96