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(54) VERTICAL COUNTERFLOW EVAPORATIVE COOLER

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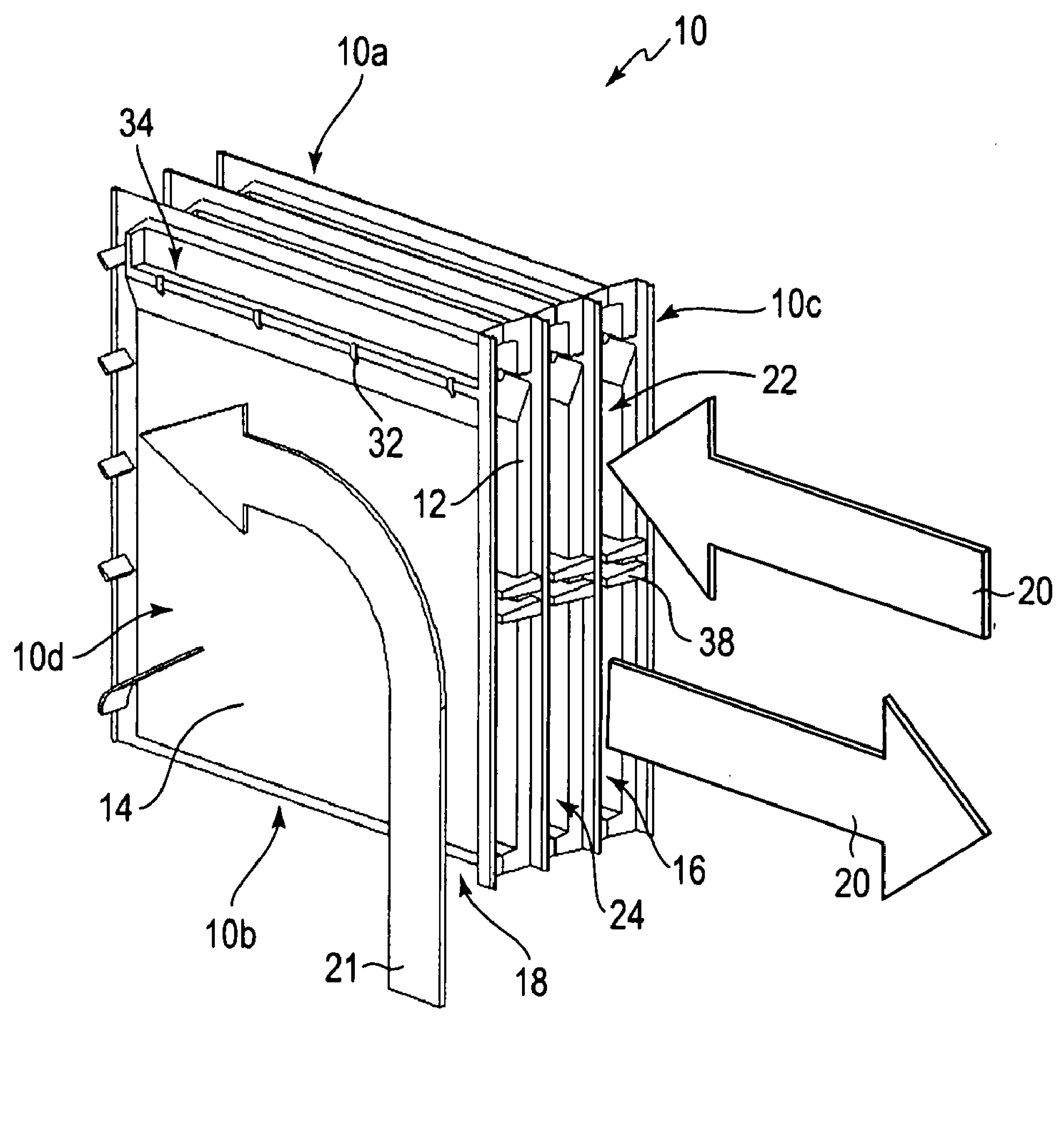
(57) **ABSTRACT**

An evaporative plate-type heat exchanger is provided having a plurality of alternating first plates and second plates positioned in side-by side relationship to form a top surface, a bottom surface, a front surface and a rear surface. The first and second plates form a plurality of dry air flow passages, between first faces of the first plates and first faces of adjacent second plates, that are in communication with dry air flow inlet openings and dry air flow outlet openings formed in the front surface. The first and second plates form a plurality of dry air flow passages, between second faces of the first plates and second faces of adjacent second plates, that are in communication with wet air flow inlet openings formed in the bottom surface and with wet air flow outlet openings formed in the rear surface. A method of forming the plate-type heat exchanger includes forming alternating first plates and second plates in a continuous sheet, and folding the continuous sheet in a fan fold arrangement.



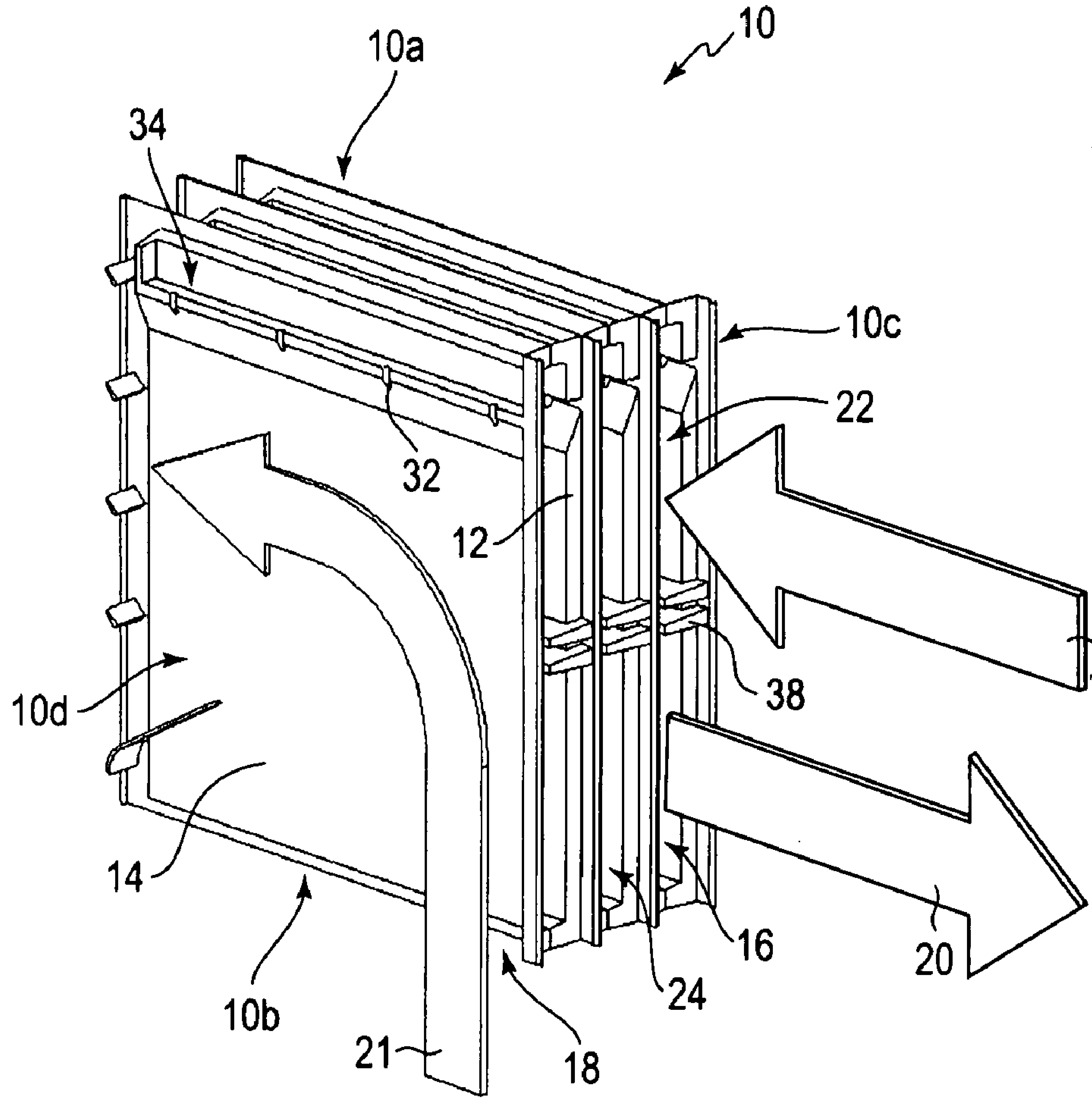


FIG. 1

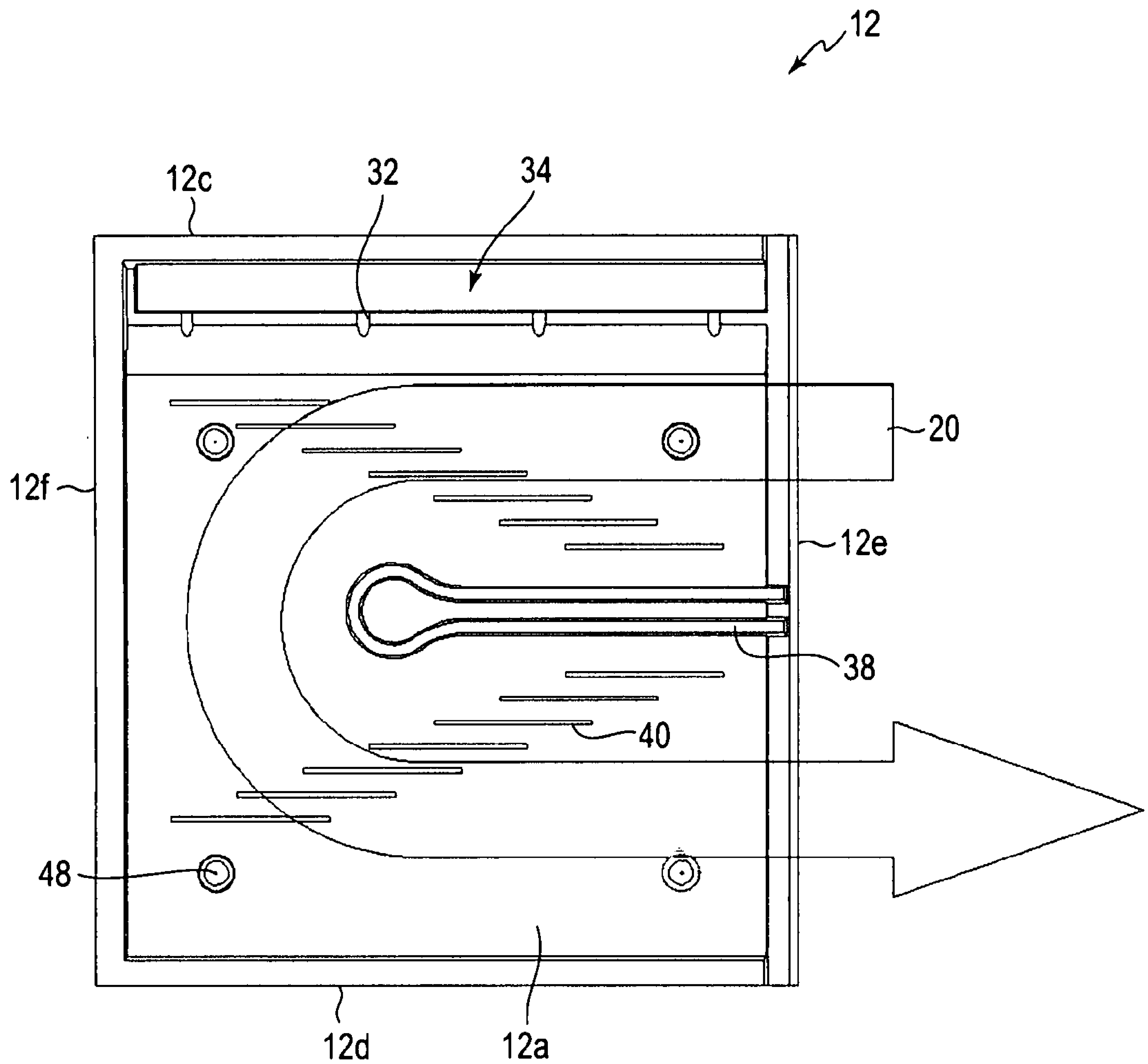


FIG. 2

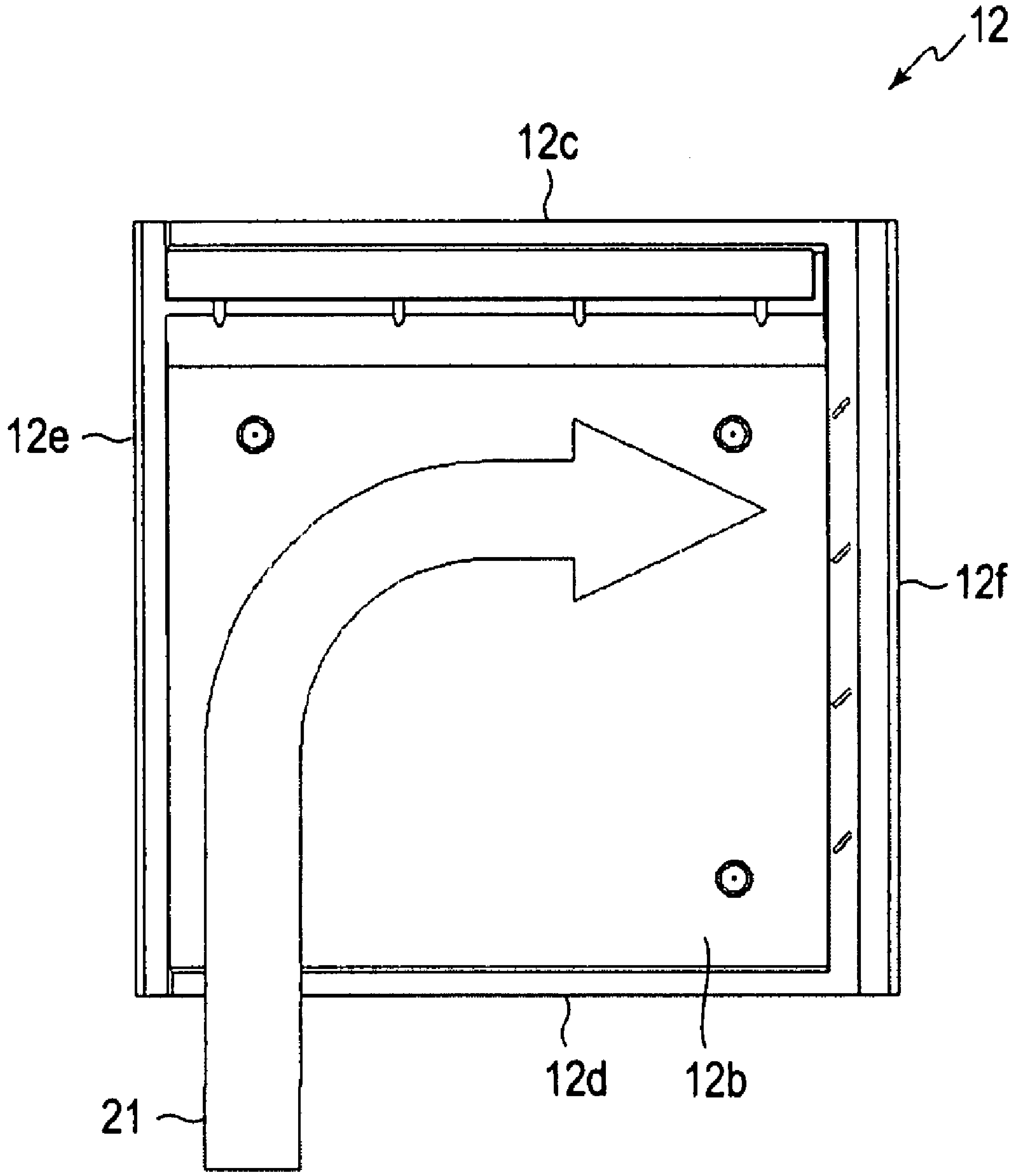


FIG. 3

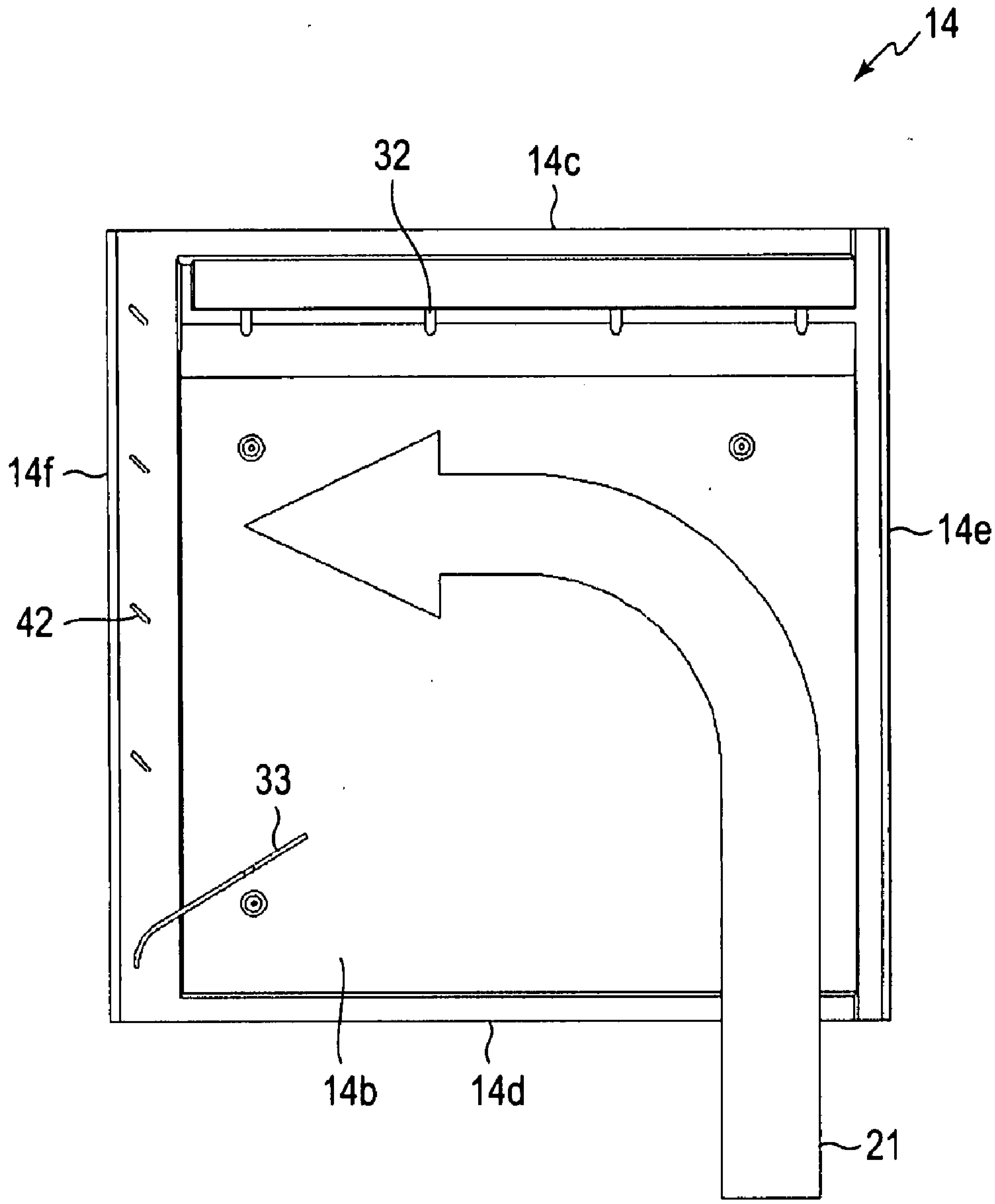


FIG. 4

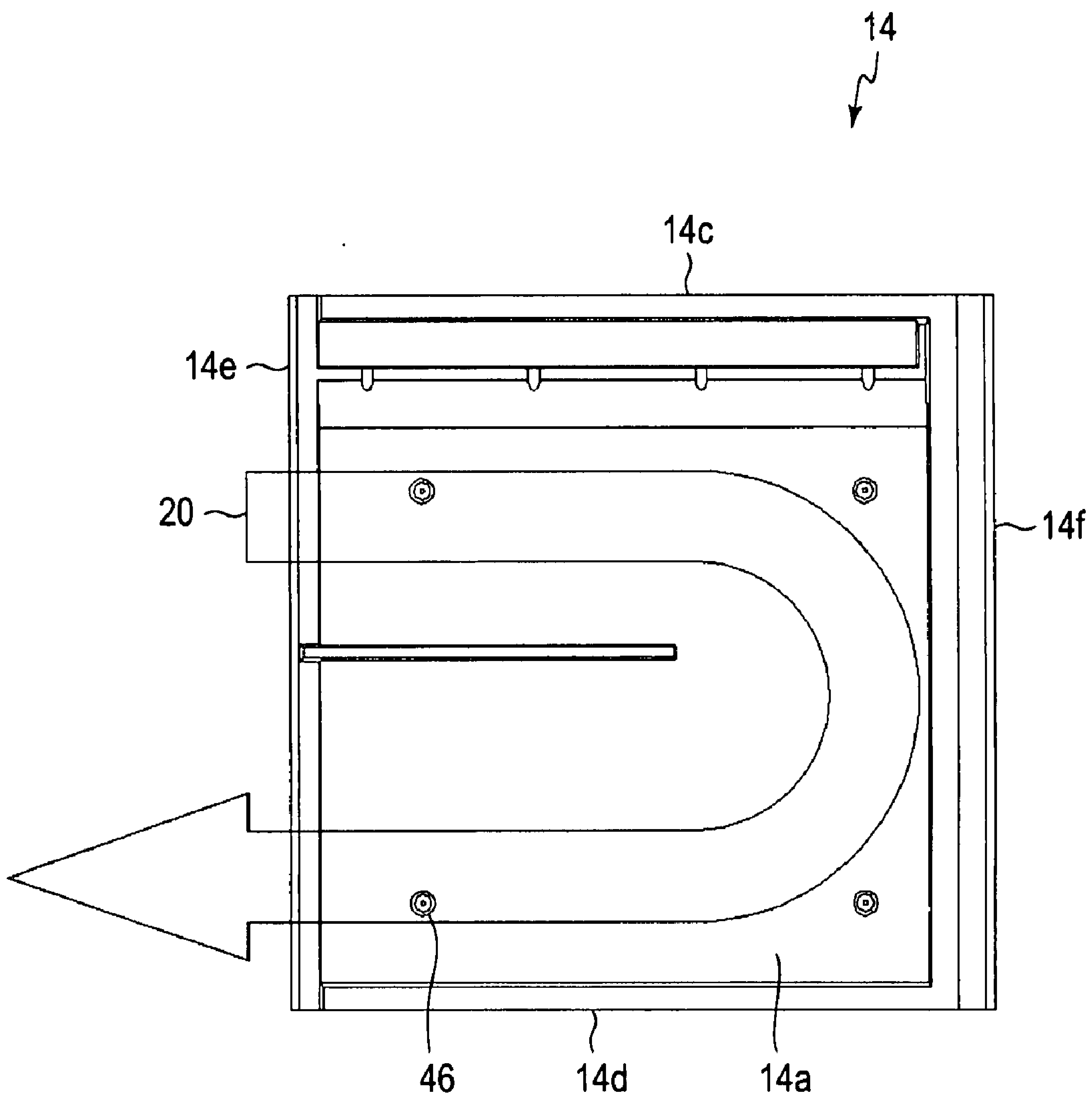


FIG. 5

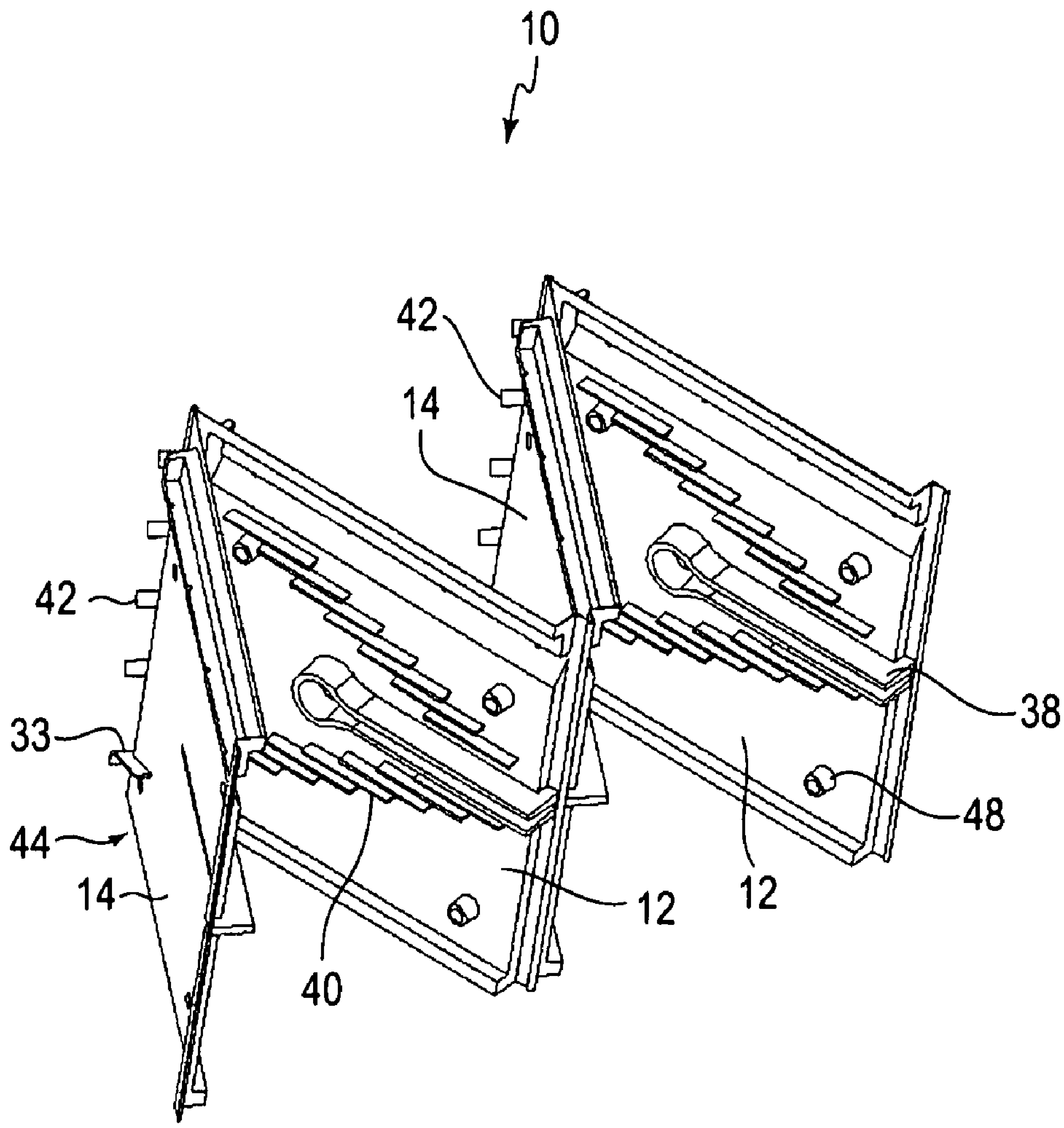


FIG. 6

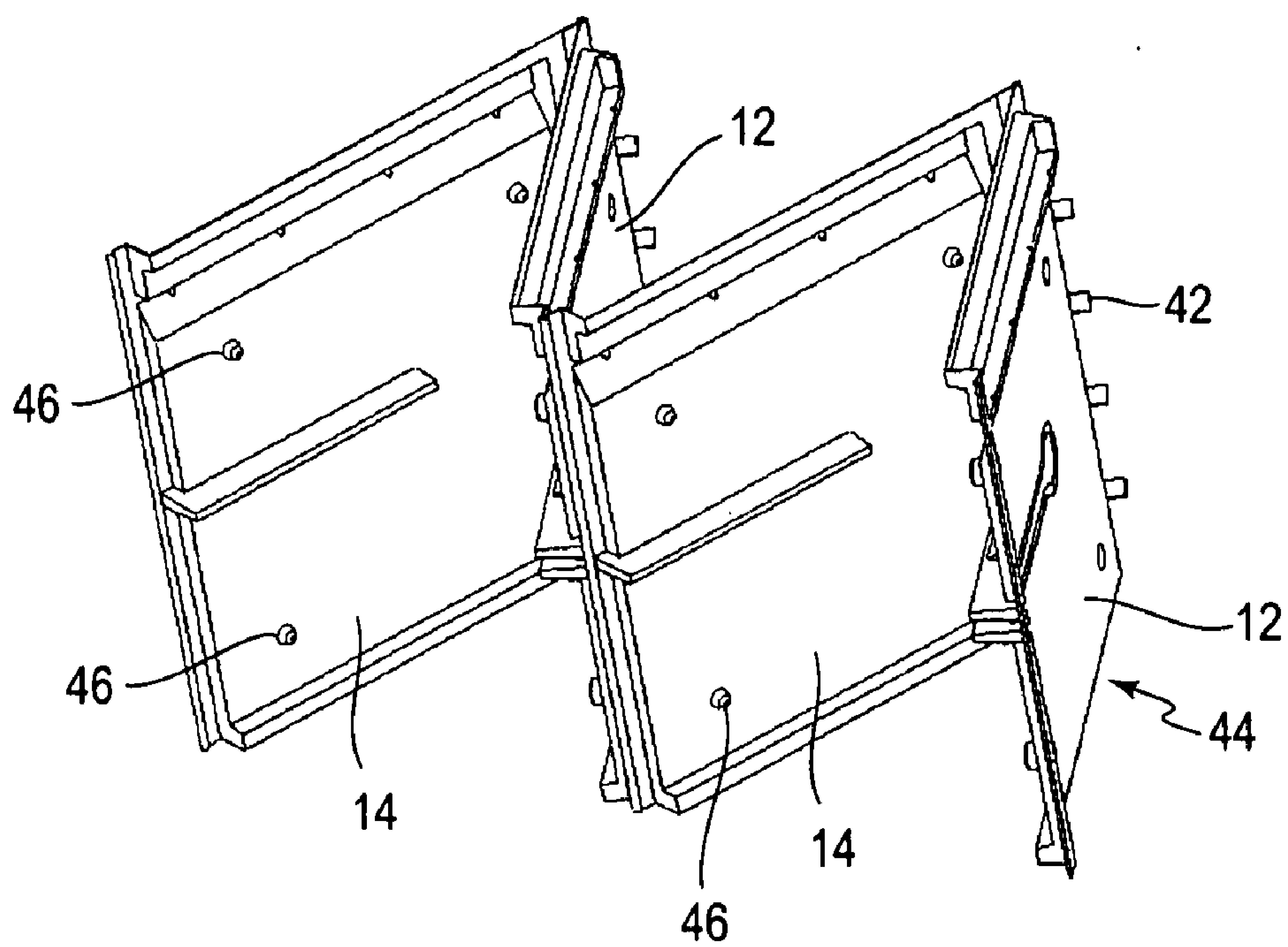


FIG. 7

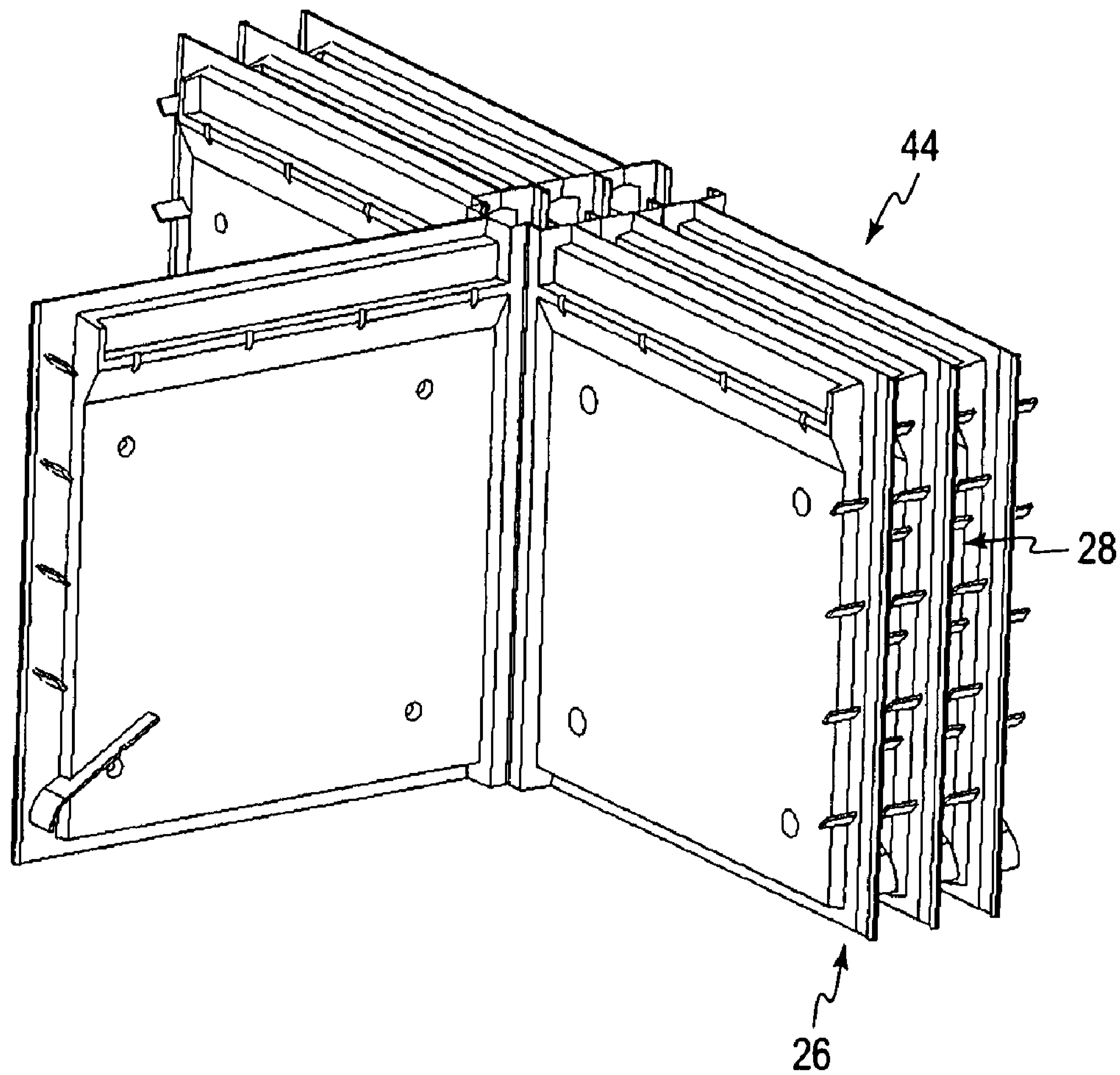


FIG. 8

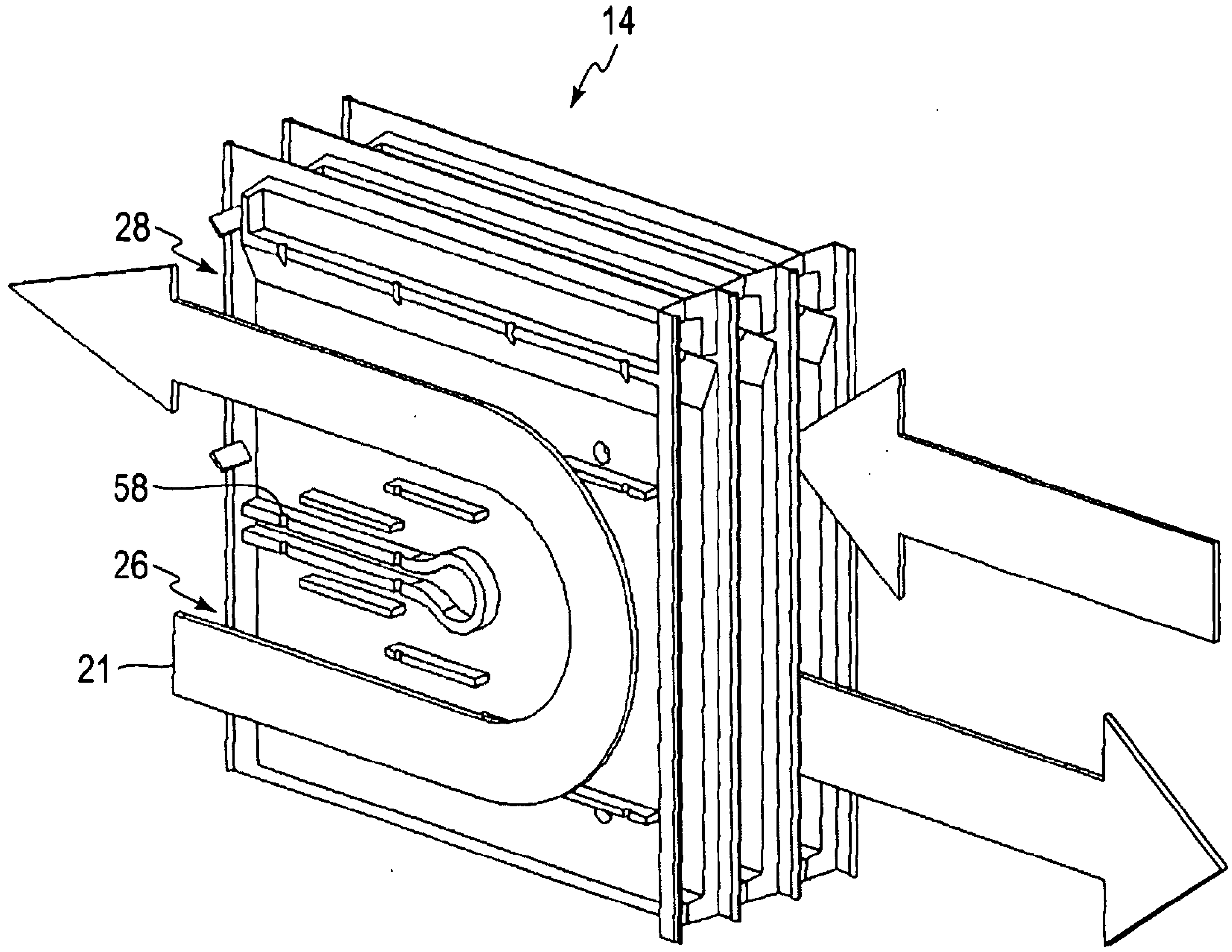


FIG. 9

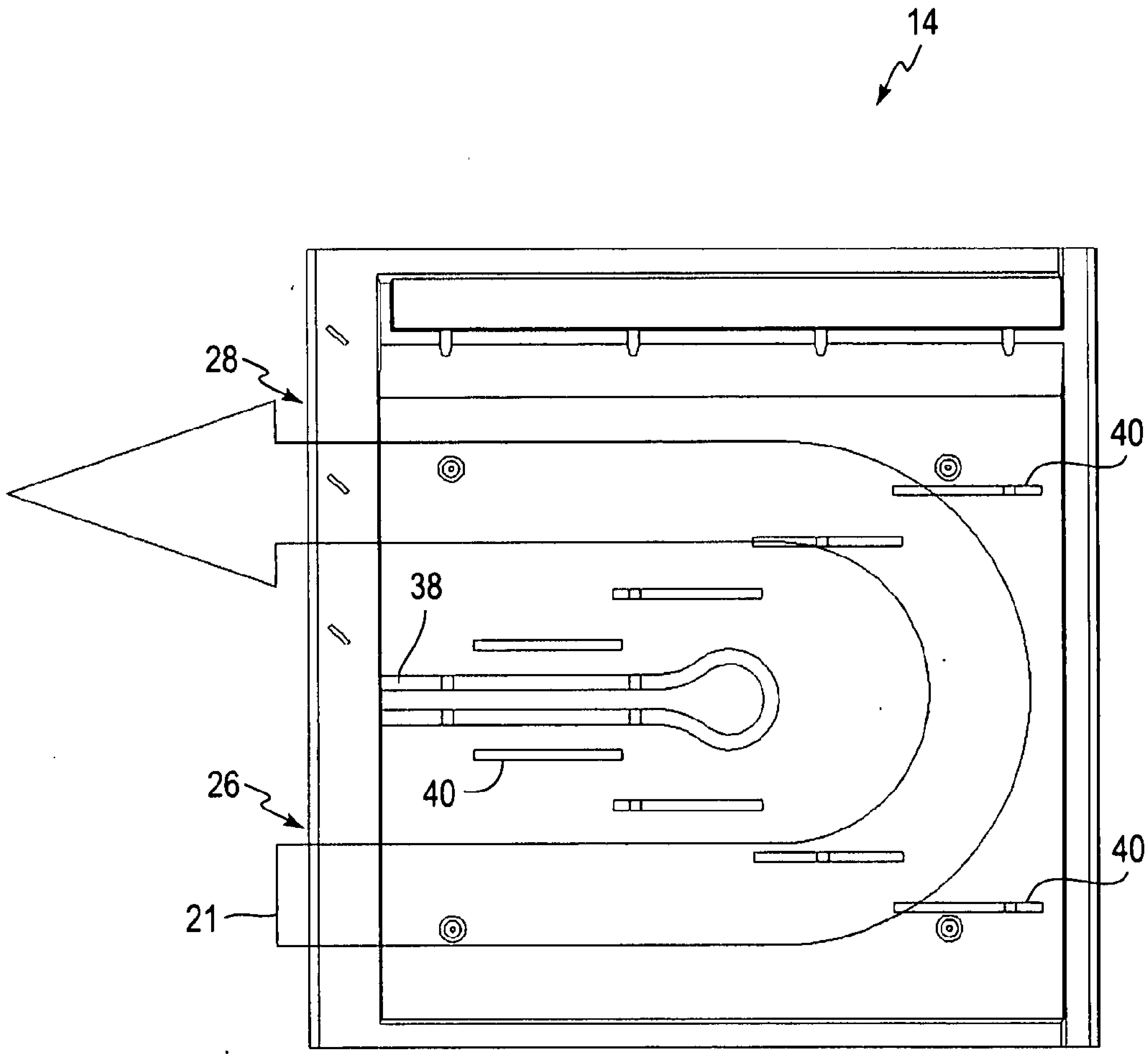


FIG. 10

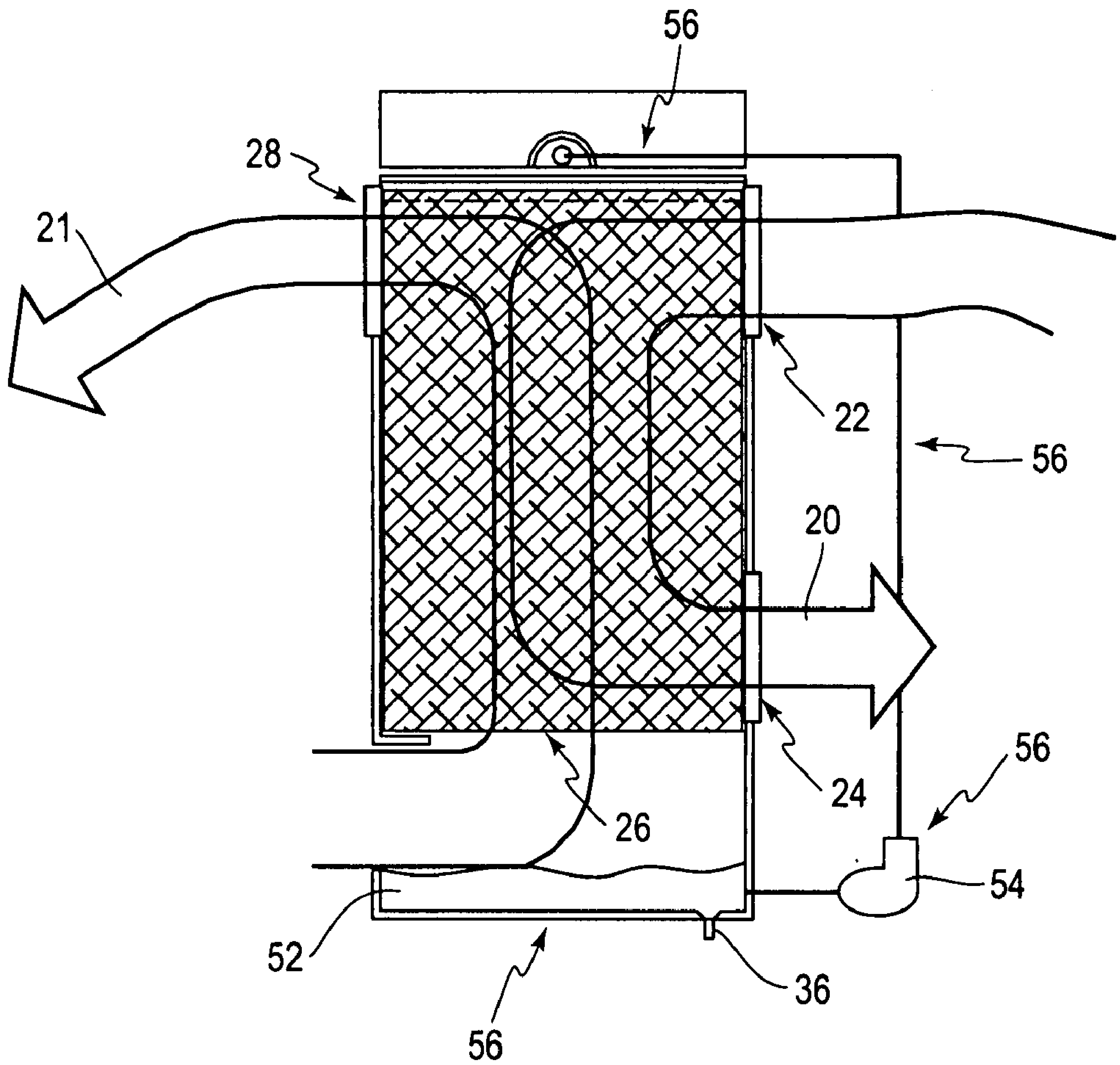


FIG. 11

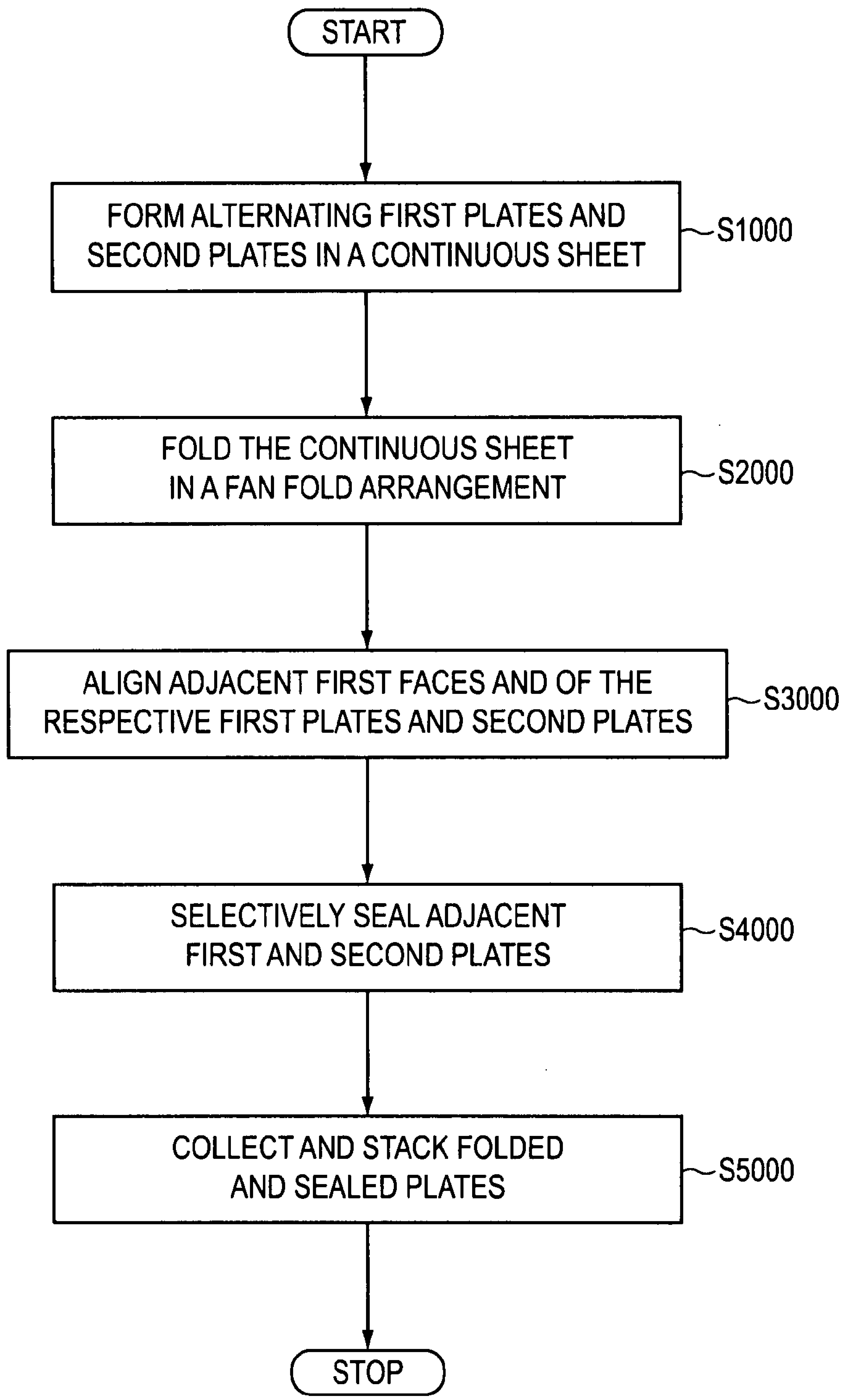

START
FORM ALTERNATING FIRST PLATES AND SECOND PLATES IN A CONTINUOUS SHEET
S1000
FOLD THE CONTINUOUS SHEET IN A FAN FOLD ARRANGEMENT
S2000
ALIGN ADJACENT FIRST FACES AND OF THE RESPECTIVE FIRST PLATES AND SECOND PLATES
S3000
SELECTIVELY SEAL ADJACENT FIRST AND SECOND PLATES
S4000
COLLECT AND STACK FOLDED AND SEALED PLATES
S5000
STOP

FIG.12

VERTICAL COUNTERFLOW EVAPORATIVE COOLER

[0001] This invention was made with Government support under Contract #DE-FC26-05NT42325 awarded by the United States Department of Energy. The Government has certain rights in the invention.

BACKGROUND

[0002] This invention relates to evaporative cooling units designed to evaporatively cool air indirectly, with or without integral direct evaporative cooling of water.

[0003] Simple evaporative coolers benefit from the psychrometric process in which dry air and water can be cooled by adding moisture. This evaporation also humidifies the air being cooled. The humidification can be beneficial in very arid climates but has drawbacks in non-desert climates. In many climates, indirect evaporative cooling where two airstreams are used; a 'wet' airstream that evaporates water to directly cool both the water and air and a 'dry' airstream that is cooled through a heat exchanger (usually a thin walled plate) without moisture addition to the dry airstream. Such indirect evaporative coolers have tended to be expensive to build.

[0004] Previous attempts to provide combined water and air cooling evaporative plates have met limited success. One such system is described in U.S. Pat. No. 6,845,629 B1 issued to Bourne et al., which uses a set of plates to cool air, water, or both for building or process cooling needs. However, manufacturing the plates proved to be time consuming and problematic.

[0005] Other indirect evaporative plate-type coolers rely on labor intensive and therefore costly means to manufacture the plates. Additionally, many existing systems, such as that described in U.S. Pat. No. 6,581,402 issued to Maisotsenko et al., have high pressure drops that require significant fan energy, thus lowering the Energy Efficiency Ratio (EER) to the point that they are not significantly more efficient than traditional vapor compression systems. The heat exchanger disclosed in Maisotsenko et al. requires the heat exchanger to use at least a fraction of outdoor air, limiting layout options and actual cooling capacity during warm weather periods.

[0006] Most new low-rise non-residential buildings in the U.S. are cooled by packaged rooftop units (RTU's) that include one or more compressors, a condenser section that includes one or more air-cooled condensing coils and condenser fans, an evaporator coil, a supply blower, an intake location for outdoor ventilation air (with or without an economizer to fully cool from outdoor air when possible), optional exhaust air components, and controls. These components are packaged by manufacturers in similar configurations that, because they are air-cooled, fail to take advantage of the opportunity to improve efficiency and reduce electrical demand through evaporative cooling of both condenser coils and ventilation air streams.

SUMMARY

[0007] A cooling unit that incorporates plate-type evaporative heat exchangers is provided to efficiently cool either water or air, or both. The cooling unit utilizes indirect evaporative pre-cooling of ventilation air, which can be used to assist in cooling various building types, for example, commercial building systems. At least 10% of supply air in many such buildings is typically outdoor air needed for building ventilation; in some cases, such as for laboratory facilities, cooling systems must deliver 100% outdoor air. In warm weather, cooling of ventilation air represents a significant fraction of the total cooling load. In very dry climates, ventilation air can be pre-cooled by a direct evaporative process, but in most applications an indirect process that adds no moisture to the ventilation air is preferred.

[0008] The plate-type evaporative heat exchanger cooling unit can also be used with "dedicated outdoor air" units that isolate the ventilation air load from other HVAC components. Such units may be incorporated into "variable-air-volume" (VAV) systems that provide required fresh air volumes at low speeds. The plate-type heat exchanger delivering 100% outdoor air, with building exhaust air used in alternating wet passages, provides an indirect evaporative ventilation air cooling unit during the cooling season, as well as a heat recovery unit in heating season by operating without water flow to wet air passages. Thus, the plate-type heat exchanger can pre-heat ventilation air from warm building exhaust air.

[0009] The plate-type evaporative heat exchanger cooling unit for evaporative pre-cooling of ventilation air can also be used with energy-efficient systems that provide cooled water for circulation through tubing to cool building structures. The plate-type heat exchanger can alternatively be used to deliver water utilized with radiant floor cooling systems.

[0010] Embodiments of a vertical counter-flow evaporative cooler (VCEC) plate-type evaporative heat exchanger are provided that can effectively cool either air or a combination of air and water. An exemplary embodiment uses a C-shaped flow path in the dry passages and an L-shaped flow path in the wet passages, instead of the conventional semi-counter flow (Z-Z or L-L) paths. The C-shaped dry passage air flow configuration provides a passage that is sealed on three sides, providing individual pockets that, when lined up in the heat exchanger stack, create alternating dry passage and wet passage assemblies that can be securely sealed together. This structure provides a robust connection to each dry passage and includes seals around the perimeter of each individual dry passage, so that the dry ventilation air stream is completely isolated from the wet zone surrounding it. This structure can be manufactured in an efficient, cost-effective manner.

[0011] An embodiment provides an evaporative section that includes a plate-type evaporative cooler that cools both water and air; a water sump, pump, and water distribution system that captures and re-circulates water within the evaporative section; automatic systems that refill and drain the water sump; a fan that draws air through the dry passages, another fan that draws air through the wet passages; electrical controls; and a cabinet that houses the unit.

[0012] In alternate preferred embodiments, the pump and sump are eliminated and replaced with a drain pan to simplify the design and to utilize a 'once through' water flow approach that relies on municipal water pressure to distribute water to the plates and then discards excess water through a drain.

[0013] The preferred embodiment of the VCEC uses a C-shaped flow path in the dry passages and an L-shaped flow path in the wet passages. Most plate-type heat exchangers use either straight-through cross-flow, or use semi-counter flow paths such as Z-Z or L-L flow paths to maximize counter-flow behavior. The use of C-shaped flow paths present a challenge in circulating air into the corners and avoiding short-circuiting. The C-shaped dry passages have seals on three sides, providing individual pockets that when lined up in the heat exchanger stack create alternating dry passage and wet passage assemblies that can be securely sealed together. This structure provides a robust connection to each dry passage and seals around the perimeter of each individual dry passage, so that the dry ventilation air stream is completely isolated from the wet zone surrounding it. An alternative embodiment uses a C-shaped flow path in the wet passage, which minimizes the height required for the unit by allowing the sump and drain to be located directly below the VCEC.

[0014] Many evaporative heat exchangers exhaust wet passage air out through the top of the heat exchanger, making water distribution a challenge. Spray nozzles leave space for wet air to escape, but require high pump head and a drift eliminator assembly. Gravity weir systems can restrict airflow and are susceptible to starvation from out-of-level conditions.

[0015] An embodiment of the VCEC wet passage flow path exhausts wet passage air out an upper rear surface. Without the need to accommodate exhaust airflow, this allows the top surface to be dedicated to water distribution. An embodiment of the heat exchanger provides each wet passage to have a weir thermoformed into its upper surface. The weirs are formed when the alternating first and second plates are formed together. The weirs, which can hold water such as, for example, up to ¾" deep, eliminate out-of-level concerns. Water may be fed to the weirs by a water distribution system having, for example, a perforated sheet positioned above the VCEC, with a perforated distribution tube above the sheet.

[0016] Another embodiment provides use of the VCEC for heat recovery ventilation in heating season. In this application, no water is used but fresh air is introduced through the dry passages and building exhaust air is introduced through the "now-dry" exhaust passages. The large area and thin plates allow a significant fraction of exhaust air sensible heat to be transferred to the inlet air, reducing the amount of heat needed to bring the ventilation air up to the required temperature.

[0017] Another embodiment of the VCEC provides a total energy recovery heat exchanger. This application is similar to the sensible heat recovery application described above in that no water is applied to the wet passages. Instead, this embodiment uses a porous material that allows moisture to migrate through the plates. In this configuration, the low humidity of the building exhaust air dehumidifies the higher humidity outdoor air. Latent heat transfer can be enhanced with the use of desiccant-infused porous material. Latent heat recovery also can combine with conventional sensible heat recovery. This embodiment is particularly effective in humid climates where ventilation air latent cooling demand is greater than sensible cooling demand.

[0018] In embodiments, the VCEC plates are formed in pairs from a continuous sheet of polymer or other suitable thin material such as, but not limited, to a thin metal. Folds are created as the plates are formed to allow the entire exchanger or some subset of the exchanger to be formed by a single piece. With a polymeric material, this fan fold arrangement makes it possible to use automated sealing equipment on the top and bottom edges to completely seal the dry passages from the adjacent wet passages. The heat exchanger may be formed, folded, sealed, and stacked in one continuous operation.

[0019] These and other objects and advantages will be apparent to those skilled in the art in light of the following disclosure, claims and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The exemplary embodiments will be described in detail in reference to the following drawings in which like reference numerals refer to like elements and where:

[0021] FIG. **1** is a perspective view of an exemplary embodiment of a plate-type heat exchanger;

[0022] FIG. **2** is a left side view of an embodiment of a first face of a first plate of a plate-type heat exchanger showing an airflow path in a dry passage;

[0023] FIG. **3** is a right side view of an embodiment of a second face of a first plate of a plate-type heat exchanger showing an airflow path in a wet passage;

[0024] FIG. **4** is a left side view of an embodiment of a second face of a second plate of a plate-type heat exchanger showing an airflow path in a wet passage;

[0025] FIG. **5** is a right side view of an embodiment of a first face of a second plate of a plate-type heat exchanger showing an airflow path in a dry passage;

[0026] FIGS. **6-8** are perspective views of an exemplary embodiment of a plate-type heat exchanger having first and second plates in a fan fold arrangement;

[0027] FIG. **9** is a perspective view of an alternate embodiment of a plate-type heat exchanger having a C-shaped wet airflow path;

[0028] FIG. **10** is a left side view of an alternate embodiment of a second face of a second plate of a plate-type heat exchanger showing a C-shaped airflow path in a wet passage;

[0029] FIG. **11** is a is a cross-sectional view showing an exemplary embodiment of a vertical counterflow evaporative cooler system; and

[0030] FIG. **12** is a flowchart illustrating an exemplary method of forming a heat exchanger.

DETAILED DESCRIPTION OF EMBODIMENTS

[0031] In the following description, reference is made to the drawings. In the drawings, like reference numerals have been used throughout to designate identical elements. FIGS. **1-10** show exemplary embodiments of an evaporative heat exchanger **10** having a plurality of alternating first plates **12** and second plates **14** positioned in side-by-side relationship to form a top surface **10***a*, a bottom surface **10***b*, a front surface **10***c* and a rear surface **10***d*. The alternating plates **12** and **14** form a plurality of dry air flow passages **16** between a first face **12***e* of one of the first plates and a first face **14***e* of an adjacent second plate. The dry air passages **16** are in communication with at least one dry air flow inlet opening **22** and at least one dry air flow outlet opening **24** formed in the front surface **10***a*. The alternating plates **12** and **14** also form a plurality of wet air flow passages **18** between a second face **14***f* of one of the first plates and a second face **16** of an adjacent second plate. The wet air passages **18** are in communication with at least one wet air flow inlet opening **26** formed in the bottom surface **10***b* and with at least one wet air flow outlet opening **28** formed in the rear surface **10***d*.

[0032] In an embodiment of the heat exchanger shown in FIGS. **1-5**, each wet air flow passage **18** is in communication with one or more water flow inlet openings **32** formed in the top surface **10***a*. The top surface **10***a* may form at least one weir **34** having the water flow inlet openings **32** formed in its bottom surface **34***a*. Water exits the wet air flow passage **18** through the at least one wet air flow inlet opening **26** formed in the bottom surface **10***b*.

[0033] In the exemplary embodiment shown in FIGS. **1**-**5**, the dry air flow path **20** enters and exits the heat exchanger through the front surface **10***c*. The dry air flow inlet and outlet openings **22** and **24** are separated by a divider **38** around which the dry air flows. The divider **38** is positioned in each dry air flow passage **16** between the dry air flow inlet and outlet openings **22** and **24**. To assist in defining the dry air flow path **20**, one or more vanes **40** are provided in each dry air flow passage **16**.

[0034] An alternative embodiment of a heat exchanger **10** provides a different configuration of the wet air flow passage **18**, namely, the wet air passage **18** is in communication with at least one wet air flow inlet opening **26** and at least one wet air flow outlet opening **28** both of which are formed in the rear surface **10***d*, as shown in FIGS. **9** and **10**. This provides a wet air flow path **21** similar to the dry air flow path **20**. In embodiments, the divider **38** and vanes **40** may form a plurality of water passage openings **58**, such as shown, for example, in FIG. **9**, to allow water to pass downward through the divider **38** and vanes **40**.

[0035] In an embodiment of the heat exchanger **10**, each first plate **12** has a front edge **12***e* and a rear edge **12***f*, each second plate has a front edge **14***e* and a rear edge **14***f*, and the front edge **12***e* of each first plate is hingedly connected to the front edge **14***e* of an adjacent second plate, and the rear edge **12***f* of each first plate is hingedly connected to the rear edge **12***f* of an adjacent second plate. This configuration provides first and second plates **12** and **14** that can be folded and unfolded in a fan fold arrangement.

[0036] An exemplary method of forming a heat exchanger of the fan fold configuration, shown in FIG. **12**, includes step S**1000**, forming alternating first plates **12** and second plates **14** in a continuous sheet **44**, continuing to step S**2000**, folding the continuous sheet **44** in a fan fold arrangement. The continuous sheet **44** may be included of, for example, a polymer.

[0037] The method of forming may further include step S**4000**, selectively sealing adjacent first and second plates along one or more of the top surface **10***a*, bottom surface **10***b*, front surface **10***c* and rear surface **10***d*, for example, by heating, ultrasonic welding, radio frequency (RF) welding, and/or induction heat welding. In the case of metal or porous plates where the base materials cannot be cost effectively joined, a clamp strip may be used. The method of forming may also include step S**3000**, aligning adjacent first faces **12***a* and **14***a* of the respective first plates and second plates. The aligning step may include the step of inserting at least one projection **46** extending from the surface of the first face **12***a* of the first plates into a receiver **48** extending from the first face **14***a* of an adjacent second plate that slidingly receives the projection **46**. Other alignment means known in the art may be utilized to align the first face **12***a* of the first plates with the first face **14***a* of an adjacent second plate. In embodiments, the method may include step S**5000**, collecting and stacking folded and sealed plates.

[0038] FIG. **1** is an isometric view showing airflow patterns in the parallel heat exchange plates **12** and **14** with a 'C-shaped' dry air flow path **20** and an 'L-shaped' wet air flow path **21** designed to cool both air and water. In this embodiment, dry air enters the dry inlet air openings **22** into the dry passages **16** and makes a 180-degree turn via the use of a divider **38** and fins **40** built into the plates, as shown in FIG. **2**. The air entering the dry passages **16** can be outdoor air, return air from the building HVAC system, outdoor air, or a combination thereof. Another air stream enters the inlet wet air flow openings **26** and is cooled by water that flows down the wet passages **18**. This cooling, in turn, indirectly cools the air in the dry passages **16** by conduction through the thin walls **12** and **14** of the heat exchanger **10**. The air entering the wet passages **18** can be return air from the building HVAC system, outdoor air, or a combination thereof.

[0039] FIG. **2** shows a first face **12***a* of a first plate and the dry airflow path **20** therein. A divider **38** ensures that the air follows a longer path to provide substantial cooling of the dry air. Vanes **40** further control and direct the airflow to follow the optimal path to minimize pressure drop and maximize heat transfer. An alignment-receiving cavity **48** for slidingly receiving the projection **46** is provided to align the adjacent first faces **12***a* and **14***a* of the first and second plates. FIG. **5** shows a first face **14***a* of a second plate and the dry airflow path **20** therein. An alignment projection **46** is provided to align the adjacent first faces **12***a* and **14***a* of the first and second plates.

[0040] FIG. **3** shows a second face **12***b* of a first plate and the wet airflow path **21** therein. Drift eliminators **42**, which catch water droplets that are picked up by wet air stream, are provided to minimize the possibility of water being carried out the side of the VCEC. Baffle **33** serves the dual purpose of directing water that collects and drips off the drift eliminators **42** and also minimizes the chance of air stream short circuiting and exiting low on the side where it would have less cooling effect. FIG. **4** shows a second face **14***b* of a second plate and the wet airflow path **21** therein.

[0041] FIGS. **6**-**8** show pairs of adjacent first and second plates **12** and **14** in an 'open' fan fold arrangement. This fan fold arrangement allows adjacent plate assemblies to be formed from a continuous sheet **44** of material. This continuity allows the entire heat exchanger **10** to be formed from one continuous sheet **44**, and facilitates a high degree of automation to reduce costs. The alignment projections **46** are shown with corresponding alignment receivers **48** on corresponding opposing plates. This configuration ensures that the completed heat exchanger **10** is aligned for proper dry and wet air flows **20** and **21**, and that the completed array has a generally rectangular shape. In the preferred embodiments, the plates **12** and **14** are formed from polymers using a thermoforming process. Porous fibrous materials can also be used, including porous material infused with a desiccant, when both latent and sensible heat transfer are desired for a total energy recovery unit.

[0042] FIG. **8** shows a plurality of plate pairs **12** and **14** with the top surface **10***a* and bottom surface **10***b* of the heat exchanger sealed to isolate the dry passages **16** from the wet passages **18** to prevent water intrusion into the dry passages **16**. This sealing may be accomplished using heat, radio frequency electromagnetic field, induction welding, or ultrasonic vibration to weld the edges of adjacent sheets. The fan fold design of the heat exchanger **10** enables this process to be automated to reduce costs and improve both appearance and repeatability. Adhesives or mechanical fastening may also alternatively be used for sealing polymer, metal or fibrous sheets.

[0043] Referring to FIGS. **1** and **6**-**8**, the heat exchanger assembly **10** includes multiple plate pairs **12** and **14** aligned in a parallel vertical configuration. All plates **12** and **14** may be formed from a single continuous sheet **44** folded at front **12***e* and **14**e and rear **12**f and **14**f edges of the plates. The top edges **12**c and bottom edges **12**d of the plates may be sealed to the corresponding adjacent plate to form a sealed dry passages **16** in combination with the fold on edge. A first air stream enters the top portion of the open side of the dry passage **16**. This air stream is turned within the dry passage (see FIG. **2**) and exits as cooled dry air stream.

[0044] Water is distributed above the VCEC into weirs **34**, from which the water flows downward through water flow inlet openings **32** into the wet passages **18** of the VCEC. The design allows excess water to collect in the deep weirs **34**, permitting the VCEC assembly to be slightly "off-level" and still maintain uniform water distribution. The water flows down the faces **12**b and **14**b of the wet passages **18** and is cooled by evaporation into the wet air stream. The dry passages **16** are in turn also cooled by conduction through the walls of the heat exchanger. Fins **42** serve as drift eliminators to minimize the possibility of water being carried out the side of the VCEC. Baffle **33** serves the dual purpose of directing water that collects and drips off the fins **42** and also prevents the wet air stream from short circuiting and exiting low on side where it would have less cooling effect. A cooling coil to cool refrigerant (serving as a condensing coil for a vapor compression cooling system,) or fluid for additional building or process cooling can be located below the VCEC to take advantage of the water that is evaporatively cooled by the VCEC.

[0045] FIGS. **9** and **10** illustrate an alternate embodiment with a C-shaped wet airflow path. This alternative embodiment of a heat exchanger **10** provides a different configuration of the wet air flow passage **18**, namely, the wet air passage **18** is in communication with at least one wet air flow inlet opening **26** and at least one wet air flow outlet opening **28** both of which are formed in the rear surface **10**d, as shown in FIGS. **9** and **10**. This provides a C-shaped wet air flow path **21** similar to the dry air flow path **20**. In embodiments, the divider **38** and vanes **40** may form a plurality of water passage openings **58**, such as shown, for example, in FIG. **9**, in the wet passage to allow water to flow downward and pass through the divider **38**. The alternate configuration allows for lowering the height of the heat exchanger **10** because the sump and/or drain can be placed immediately below the heat exchanger **10**. This configuration also provides for fuller counterflow between a C-shaped wet air flow path **21** and a C-shaped dry air flow path **20**.

[0046] FIG. **11** illustrates an embodiment of a vertical counterflow evaporative cooler system that includes an evaporative heat exchanger **10** designed to be able to cool both air and water. The system includes a reservoir **52** from which water is pumped via a water pump **54** to a water distribution system **56** located above the heat exchanger plates. Heat can be transferred from the water stream, after it exits the reservoir and before the water distribution system, to a chiller/condenser, a process cooling load, or a fan coil, radiant surface natural convection heat exchanger for cooling a building.

[0047] Although the subject matter of this application has been described with reference to various exemplary embodiments, it is to be understood that the subject matter is not limited to the exemplary embodiments or constructions. To the contrary, the subject matter of this application is intended to cover various modifications and equivalent arrangements. In addition, while the various elements of the exemplary embodiments are shown in various combinations and configurations, others combinations and configurations, including more, less, or only a single element, are also within the spirit and scope of the invention.

What is claimed is:

1. An evaporative heat exchanger, comprising:

a plurality of alternating first plates and second plates positioned in side-by side relationship to form a top surface, a bottom surface, a front surface and a rear surface;

a plurality of dry air flow passages, each dry air passage being formed between a first face of one of the first plates and a first face of an adjacent second plate, and being in communication with at least one dry air flow inlet opening and at least one dry air flow outlet opening formed in the front surface; and

a plurality of wet air flow passages, each wet air passage being formed between a second face of one of the first plates and a second face of an adjacent second plate, and being in communication with at least one wet air flow inlet opening formed in the bottom surface and with at least one wet air flow outlet opening formed in the rear surface.

2. An evaporative heat exchanger as described in claim **1**, wherein

each first plate has a front edge and a rear edge;

each second plate has a front edge and a rear edge;

the front edge of each first plate is hingedly connected to the front edge of an adjacent second plate; and

the rear edge of each first plate is hingedly connected to the rear edge of an adjacent second plate.

3. An evaporative heat exchanger as described in claim **1**, wherein each wet air flow passage is in communication with at least one water flow inlet opening formed in the top surface.

4. An evaporative heat exchanger as described in claim **3**, wherein the top surface forms at least one weir having at least one water flow inlet opening.

5. An evaporative heat exchanger as described in claim **1**, wherein at least one of the first plates and second plates is comprised of a porous material that allows moisture to migrate from the wet air passages to the dry air passages through the porous material.

6. An evaporative heat exchanger as described in claim **5**, wherein the porous material is infused with a desiccant.

7. An evaporative heat exchanger as described in claim **1**, further comprising a divider positioned in each dry air flow passage that separates the at least one dry air flow inlet opening and the at least one dry air flow outlet opening.

8. An evaporative heat exchanger as described in claim **1**, further comprising one or more vanes positioned in each dry air flow passage.

9. An evaporative heat exchanger as described in claim **1**, further comprising one or more drift eliminators positioned in each wet air flow passage.

10. An evaporative heat exchanger as described in claim **9**, further comprising a baffle positioned in each wet air flow passage.

11. An evaporative heat exchanger as described in claim **1**, further comprising alignment means for aligning the first face of the first plates with the first face of an adjacent second plate.

12. An evaporative heat exchanger as described in claim **11**, wherein the alignment means comprises at least one projection extending from the surface of the first face of the first plates and a receiver extending from the first face of an adjacent second plate that slidingly receives the projection.

13. An evaporative heat exchanger comprising

a plurality of alternating first plates and second plates positioned in side-by side relationship to form a top surface, a bottom surface, a front surface and a rear surface,

a plurality of dry air flow passages, each dry air passage being formed between a first face of one of the first plates and a first face of an adjacent second plate, and being in communication with at least one dry air flow inlet opening and at least one dry air flow outlet opening formed in the front surface; and

a plurality of wet air flow passages, each wet air passage being formed between a second face of one of the first plates and a second face of an adjacent second plate, and being in communication with at least one wet air flow inlet opening and at least one wet air flow outlet opening formed in the rear surface.

14. An evaporative heat exchanger as described in claim **13**, further comprising a divider positioned in each wet air flow passage that separates the at least one wet air flow inlet opening and the at least one wet air flow outlet opening.

15. An evaporative heat exchanger as described in claim **13**, further comprising one or more drift eliminators positioned in each wet air flow passage.

16. An evaporative heat exchanger as described in claim **13**, further comprising a baffle positioned in each wet air flow passage.

17. An evaporative heat exchanger as described in claim **13**, wherein the divider forms a plurality of water passage openings.

18. A method of forming a heat exchanger as recited in claim **1**, comprising:

forming alternating first plates and second plates in a continuous sheet, and

folding the continuous sheet in a fan fold arrangement.

19. A method of forming a heat exchanger as recited in claim **18**, wherein the continuous sheet is a polymer.

20. A method of forming a heat exchanger as recited in claim **18**, further comprising selectively sealing adjacent first and second plates along one or more of the top surface, bottom surface, front surface and rear surface.

21. A method of forming a heat exchanger as recited in claim **18**, further comprising collecting an stacking folded and sealed plates.

22. A method of forming a heat exchanger as recited in claim **18**, further comprising aligning adjacent first faces of the respective first plates and second plates.

23. A method of forming a heat exchanger as recited in claim **22**, wherein the aligning step comprises inserting at least one projection extending from the surface of the first face of the first plates into a receiver extending from the first face of an adjacent second plate that slidingly receives the projection.

24. A method of forming a heat exchanger as recited in claim **18**, further comprising selectively sealing adjacent first and second plates along a top surface and a bottom surface using heat fusion.

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