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(54) **FLUID CONDITIONING ARRANGEMENTS**

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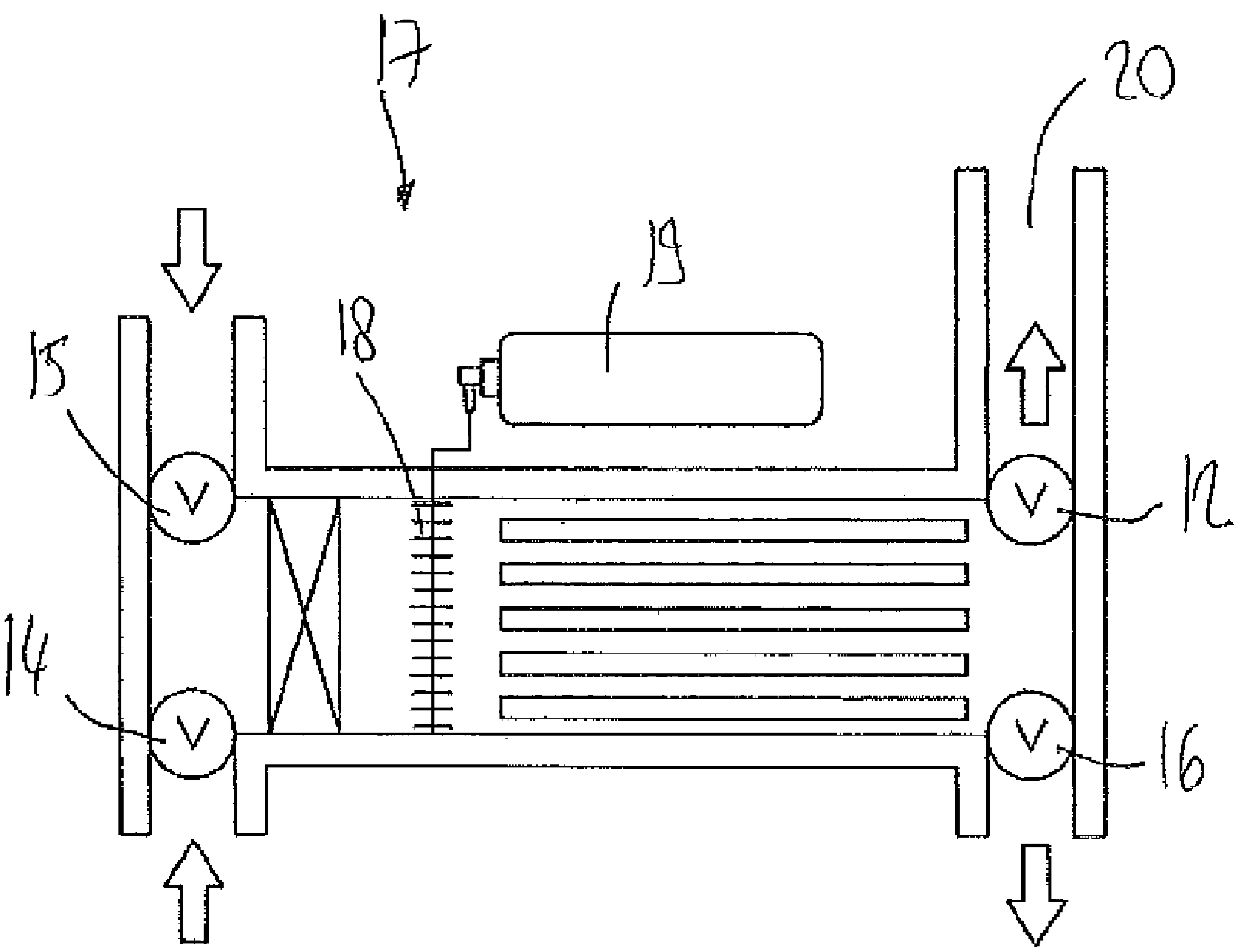
(57) **ABSTRACT**

A fluid conditioning arrangement comprises a primary heat exchanger configured to cool and/or heat the fluid; a secondary heat exchanger configured to cool and/or heat the fluid; and a controller for operating said secondary heat exchanger when said primary heat exchanger fails to cool and/or heat the fluid at a predetermined acceptablelevel; wherein said primary heat exchanger is a phase change material (PCM) based heat exchanger.



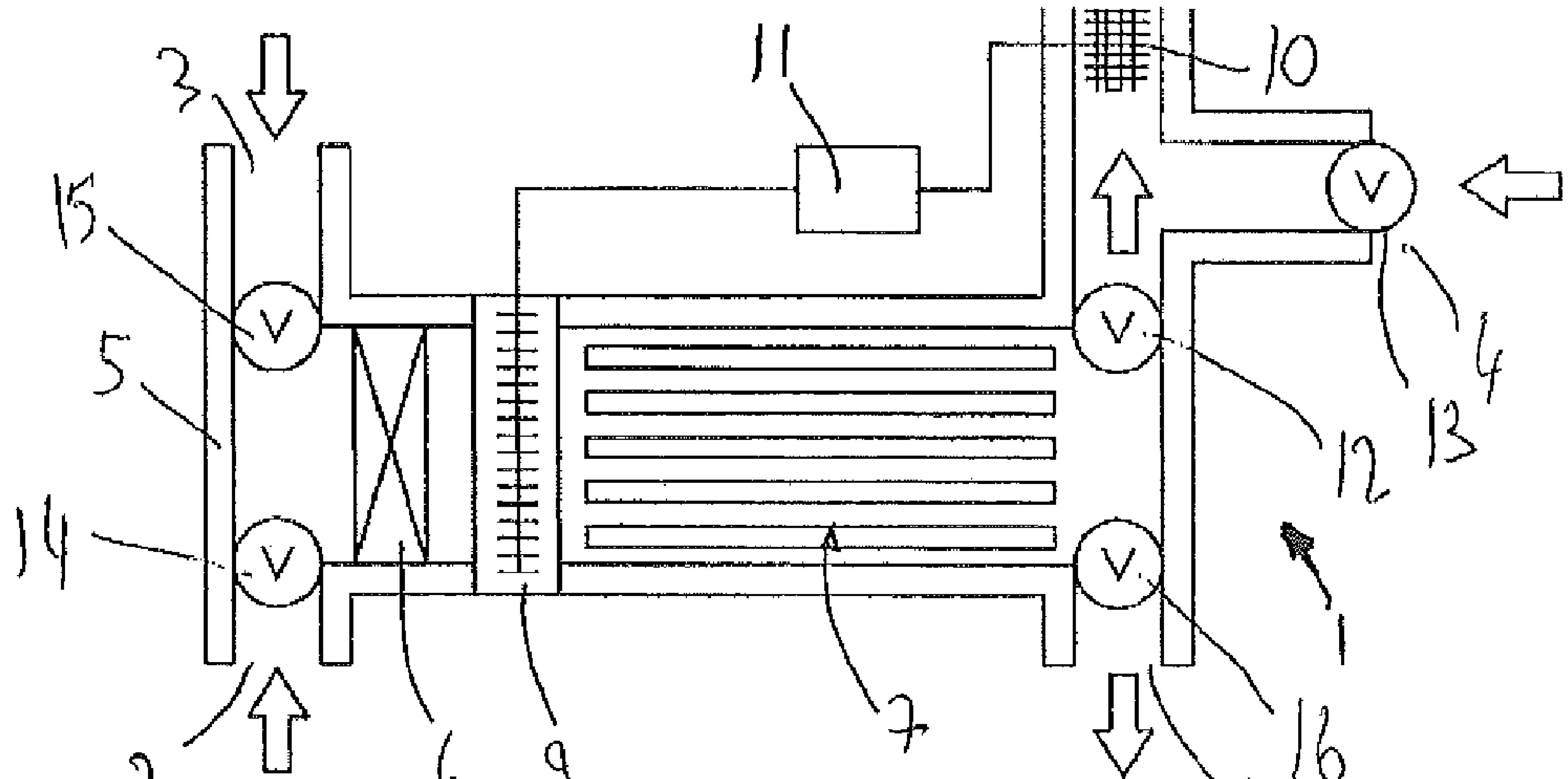


FIG. 1

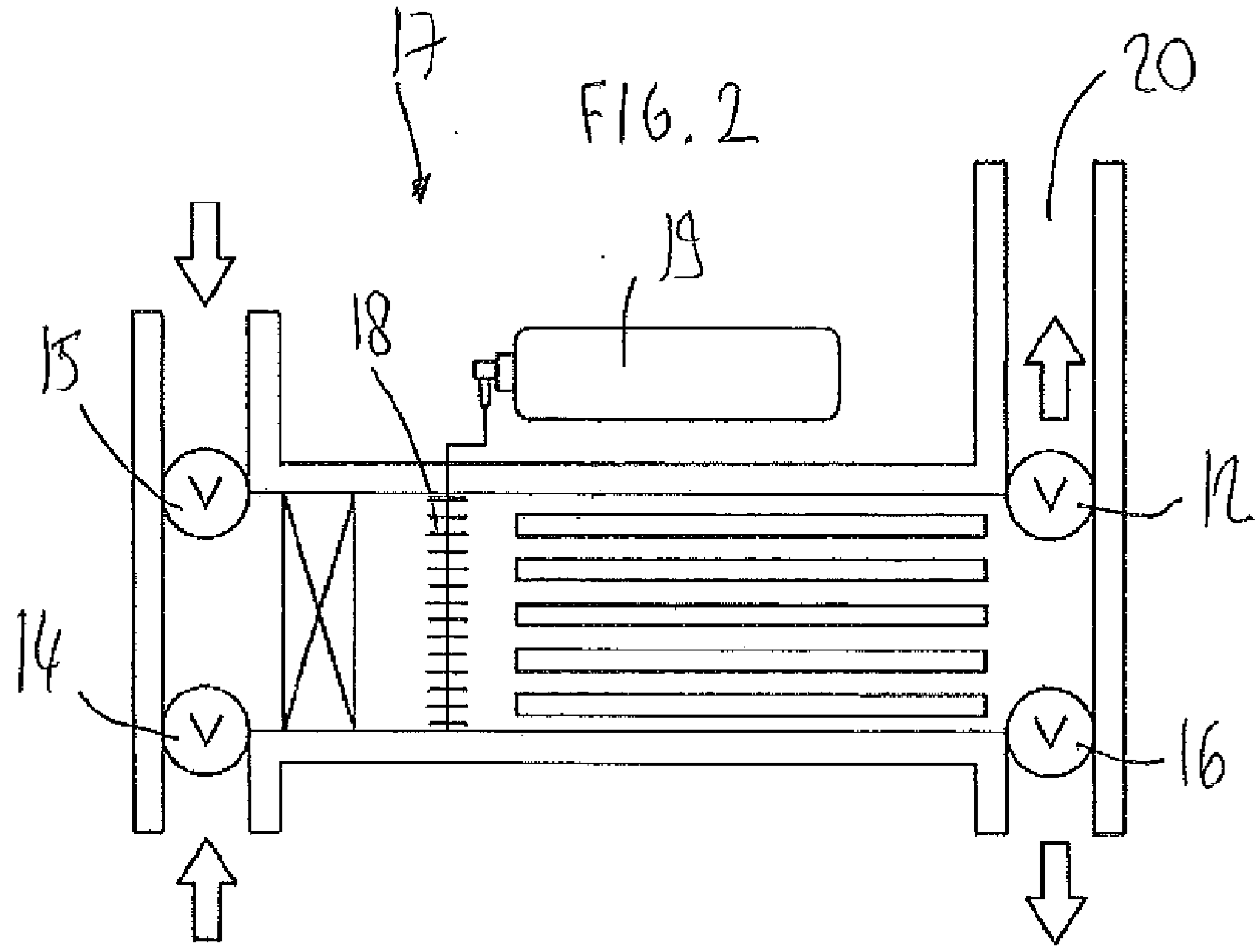


FIG. 2

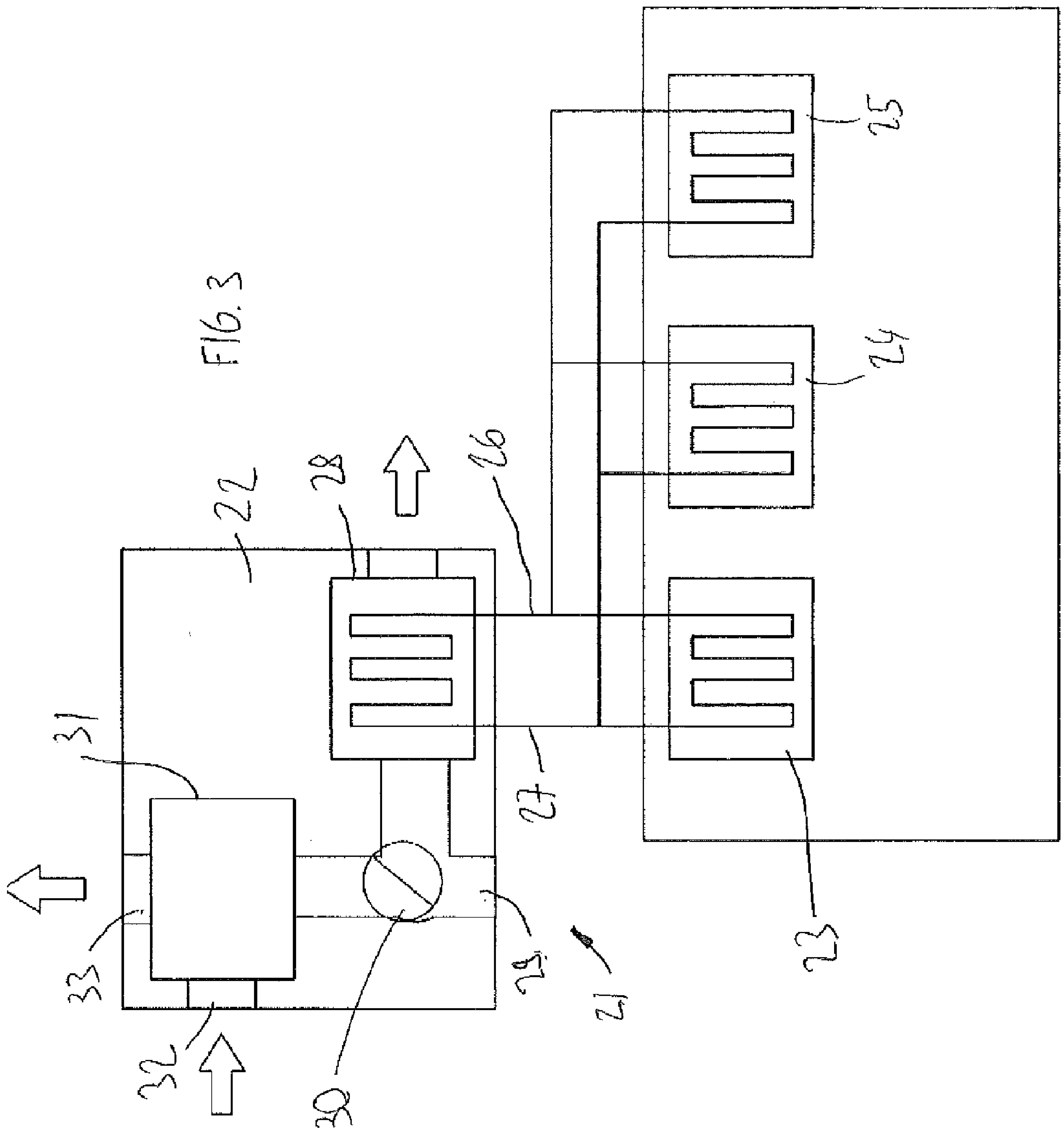


FIG. 3

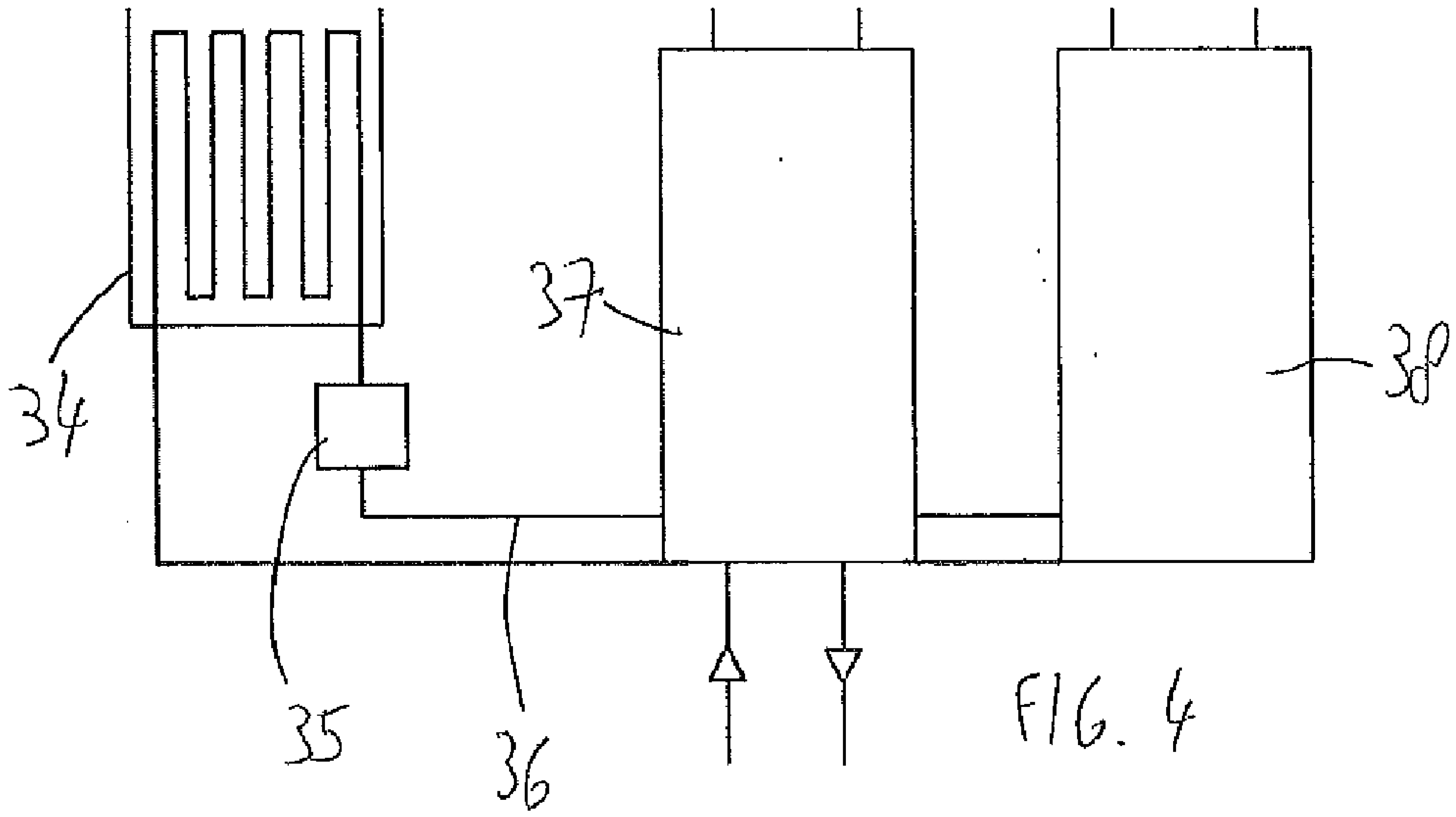


FIG. 4

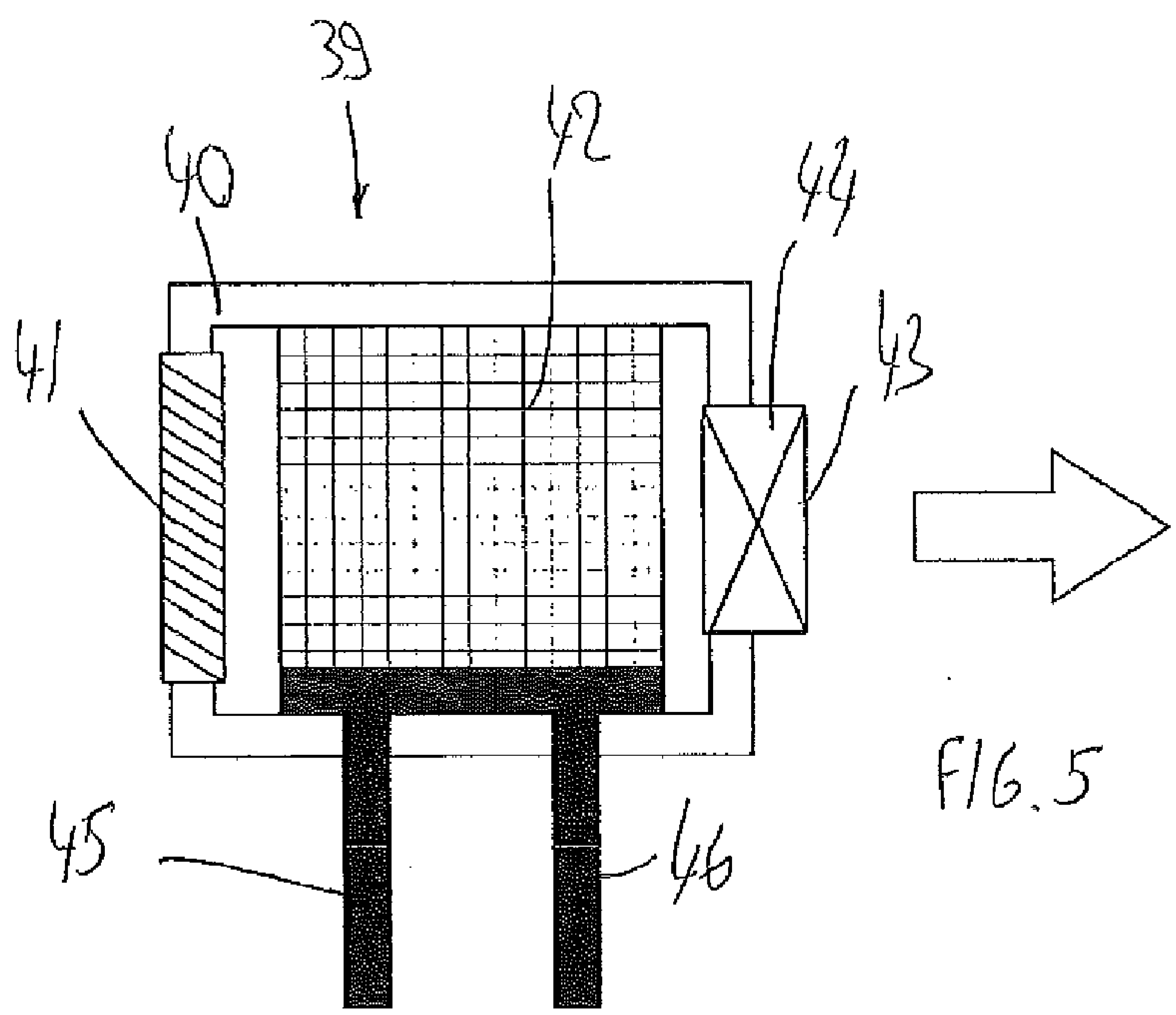


FIG. 5

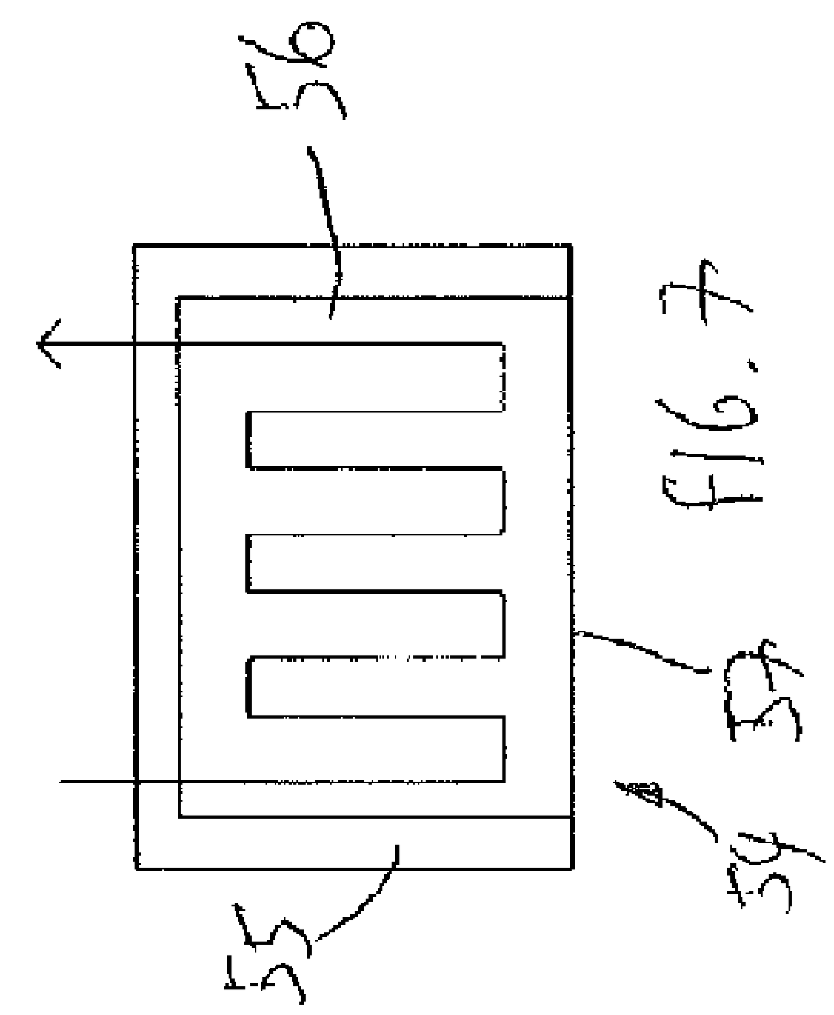
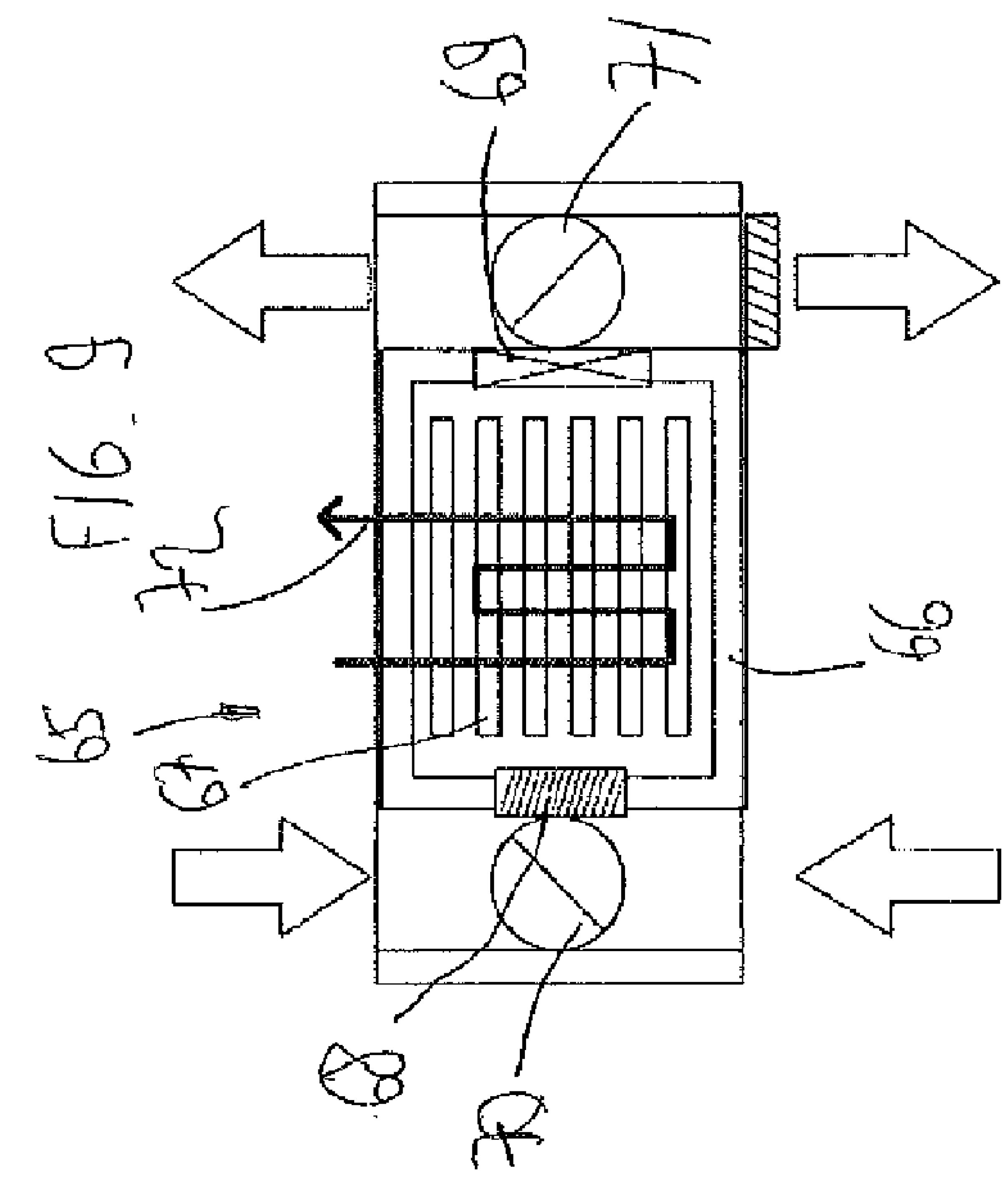


FIG. 7



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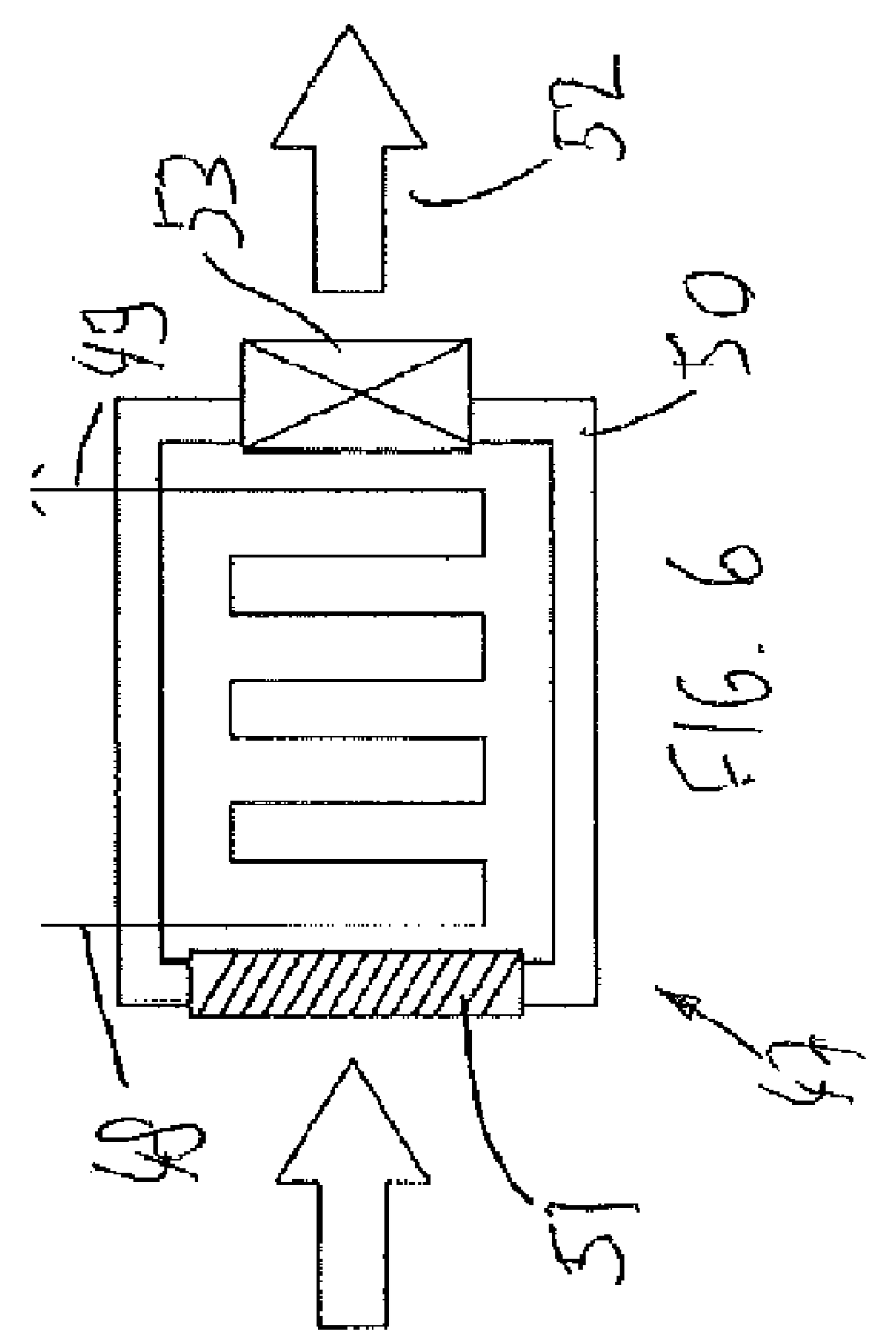

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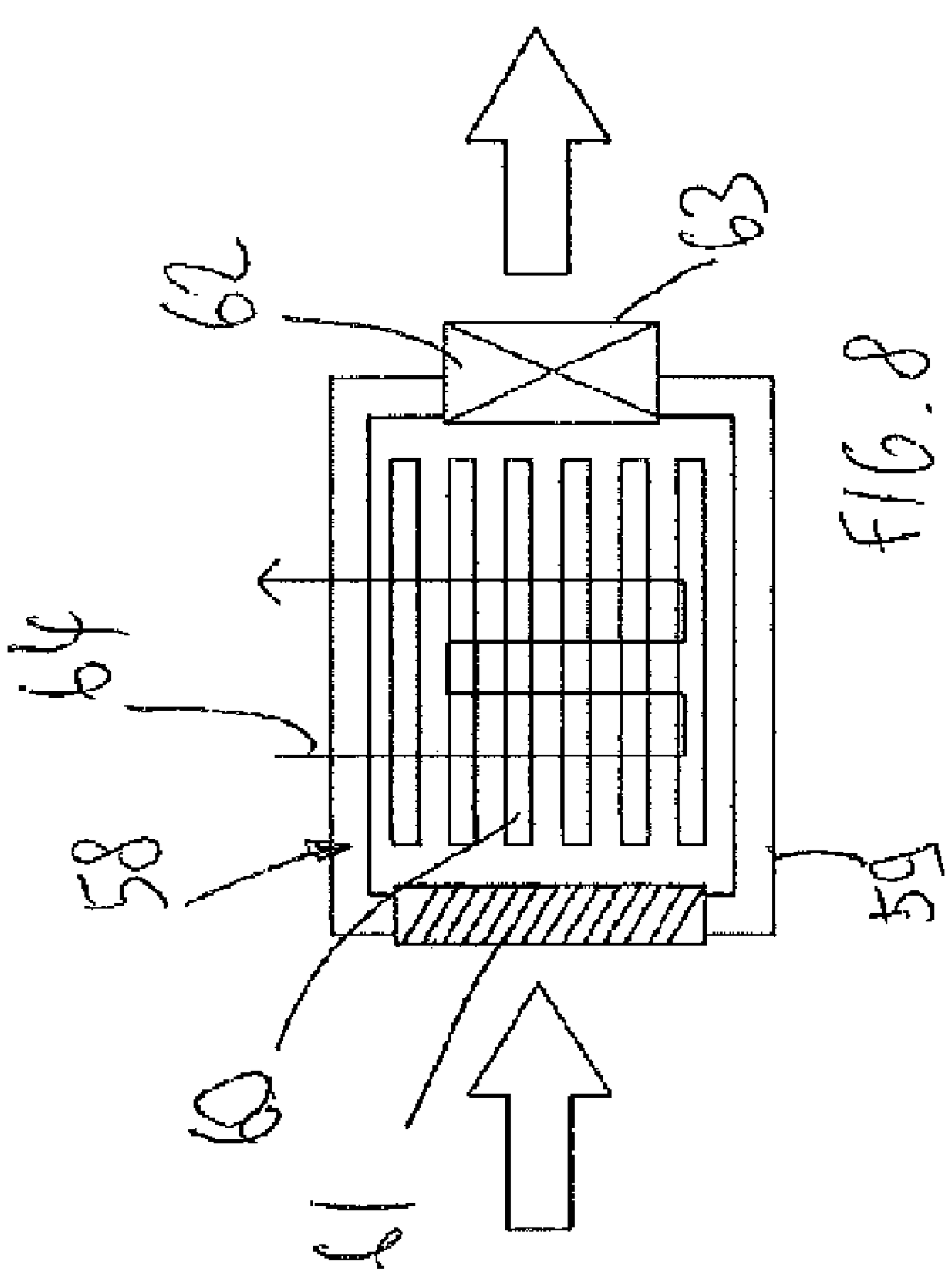

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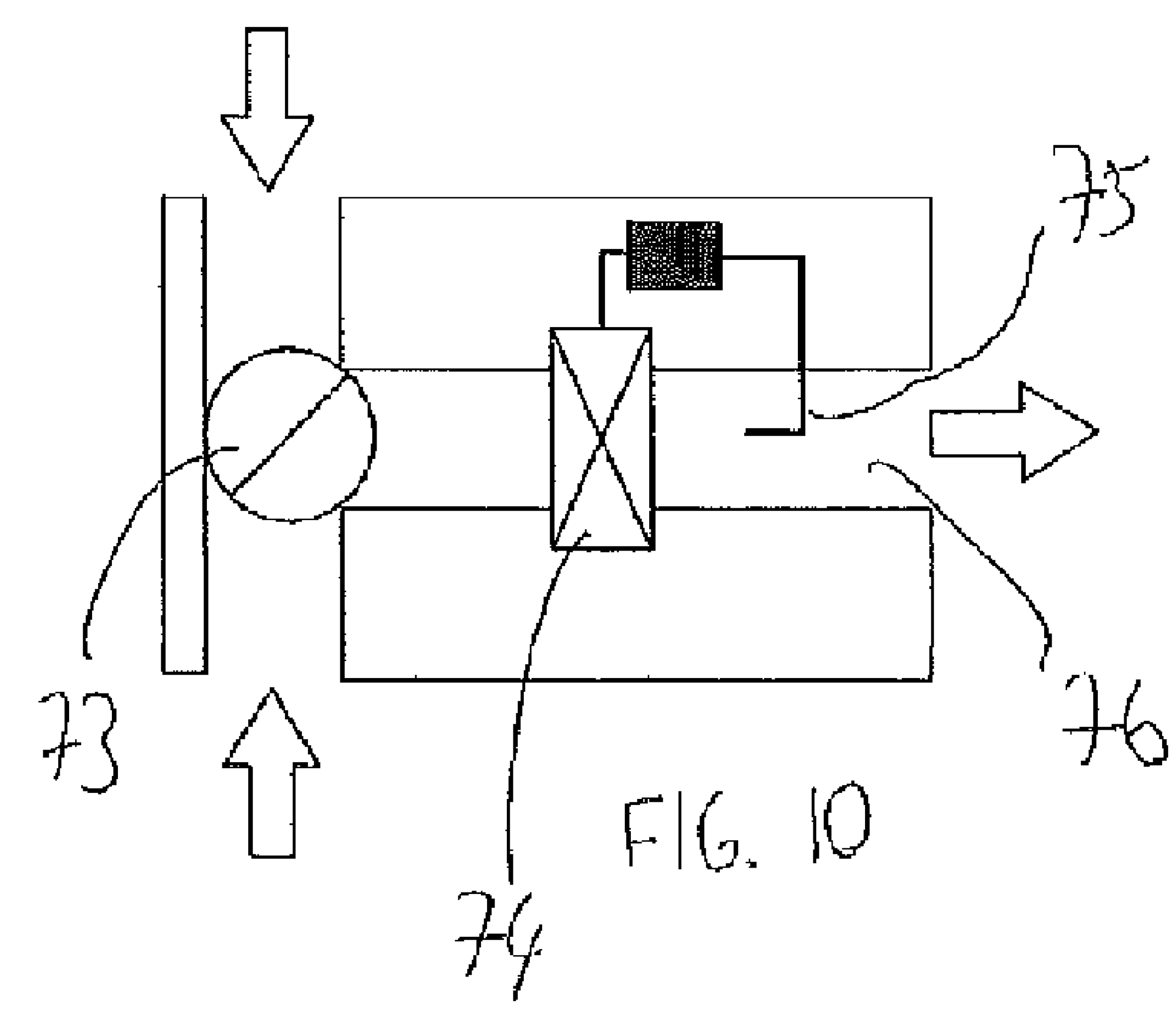
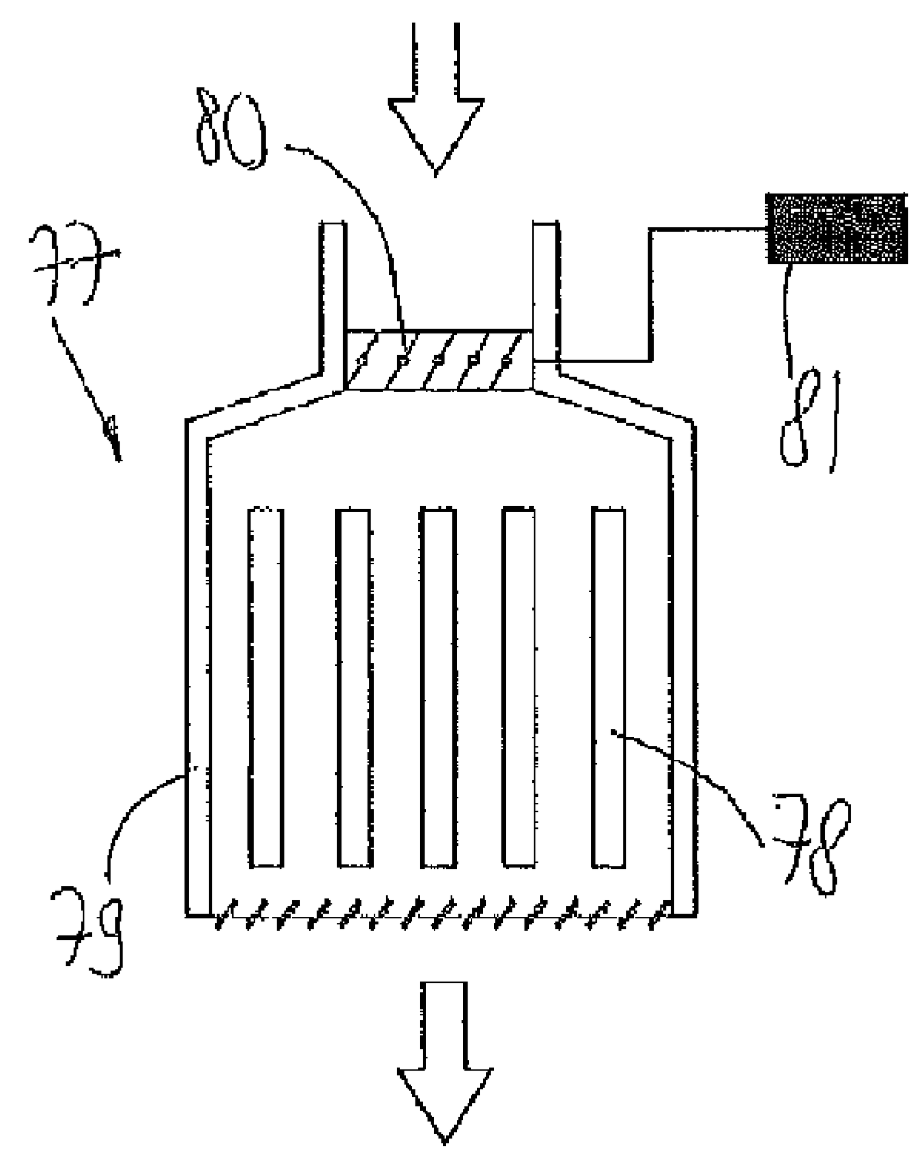


FIG. 10



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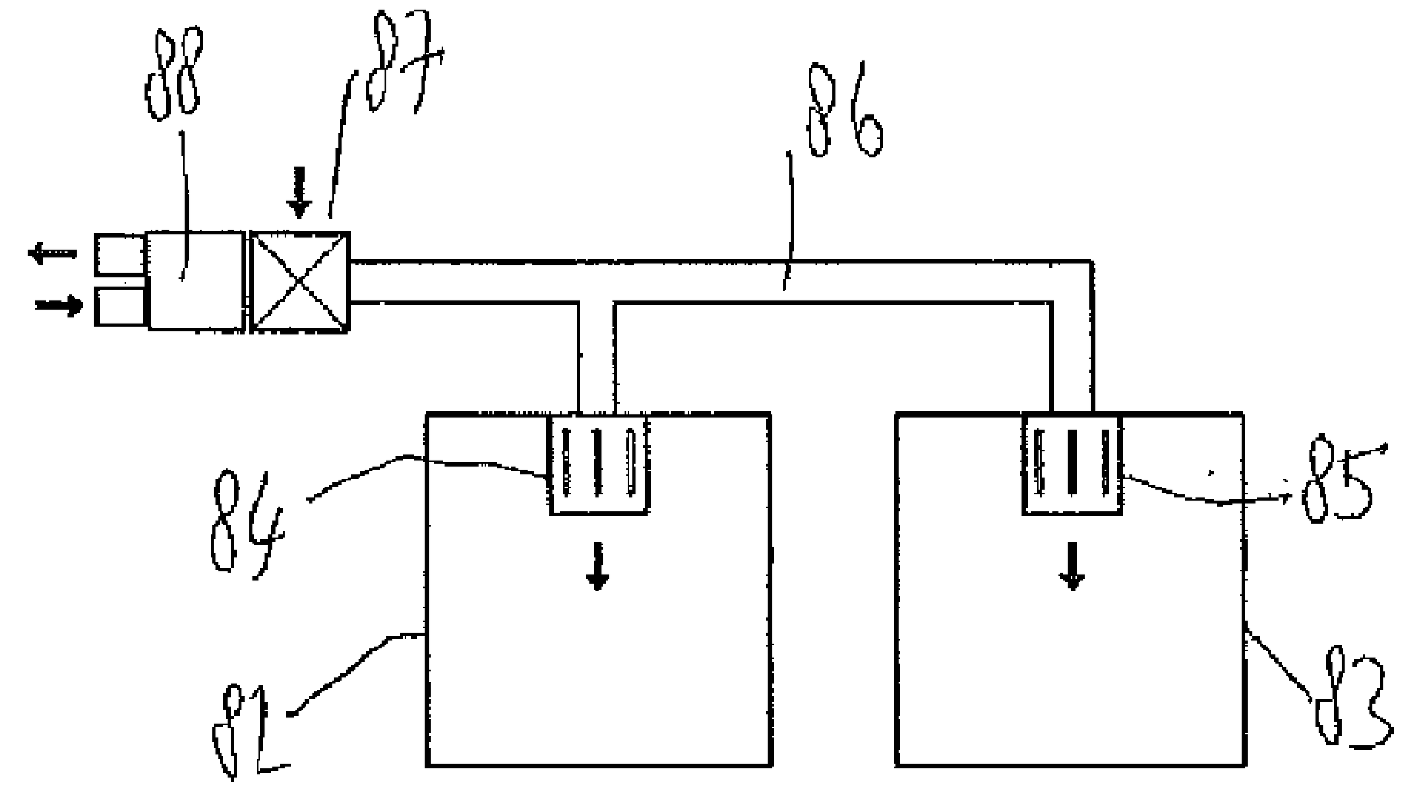

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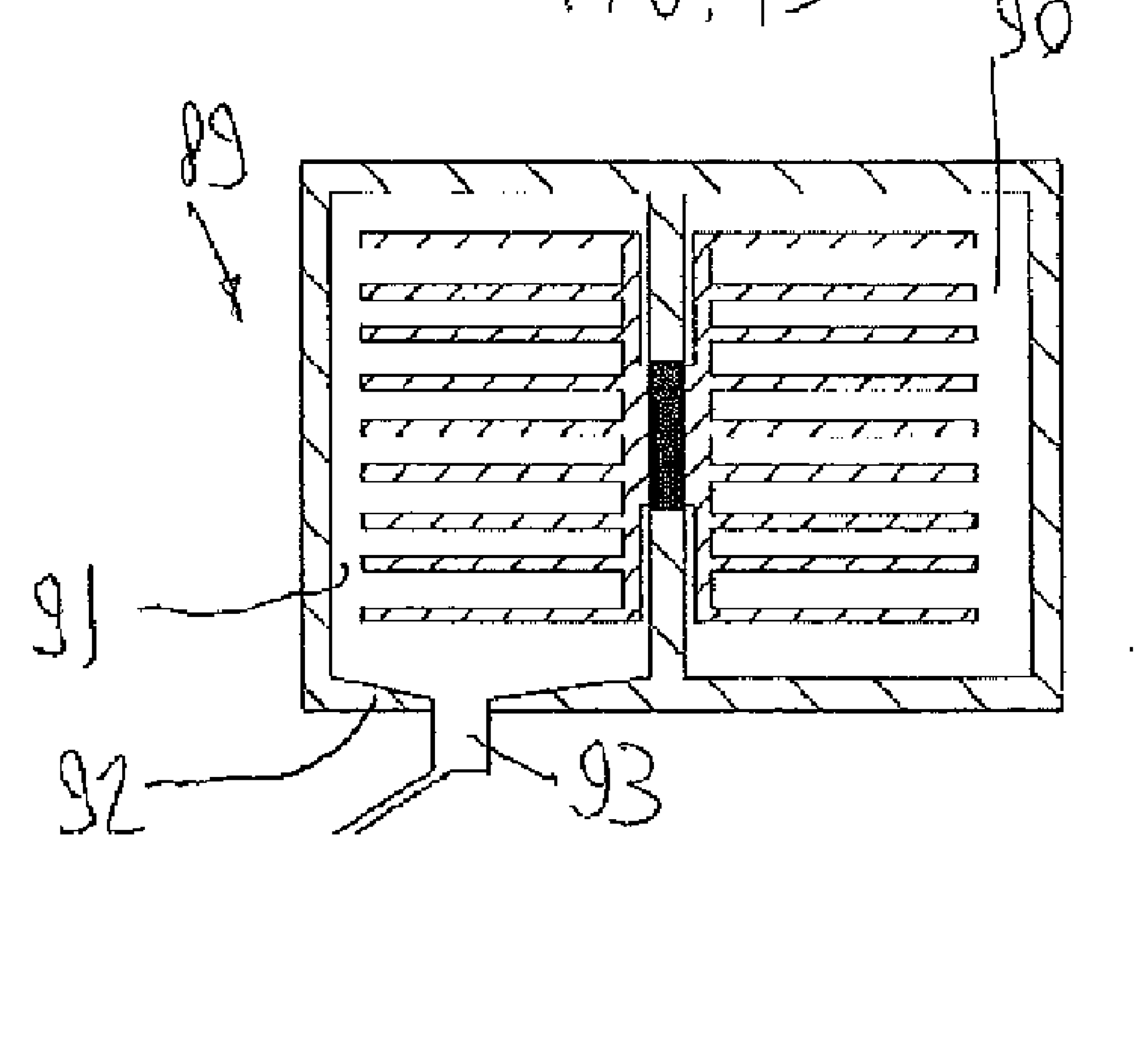
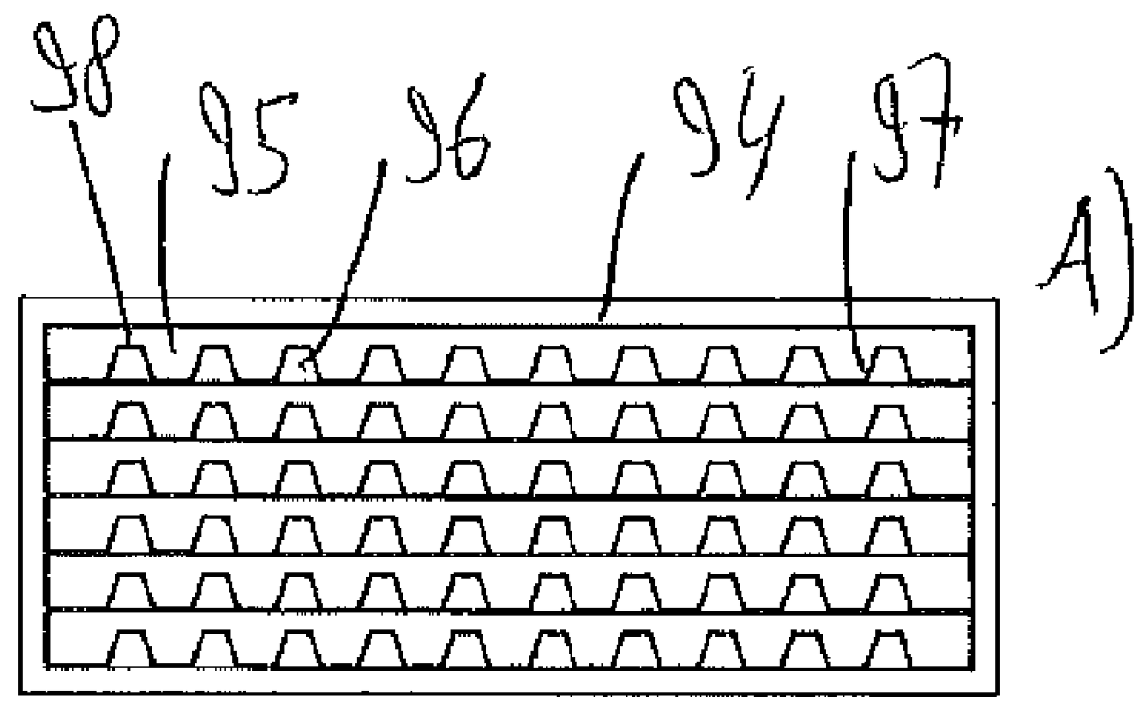
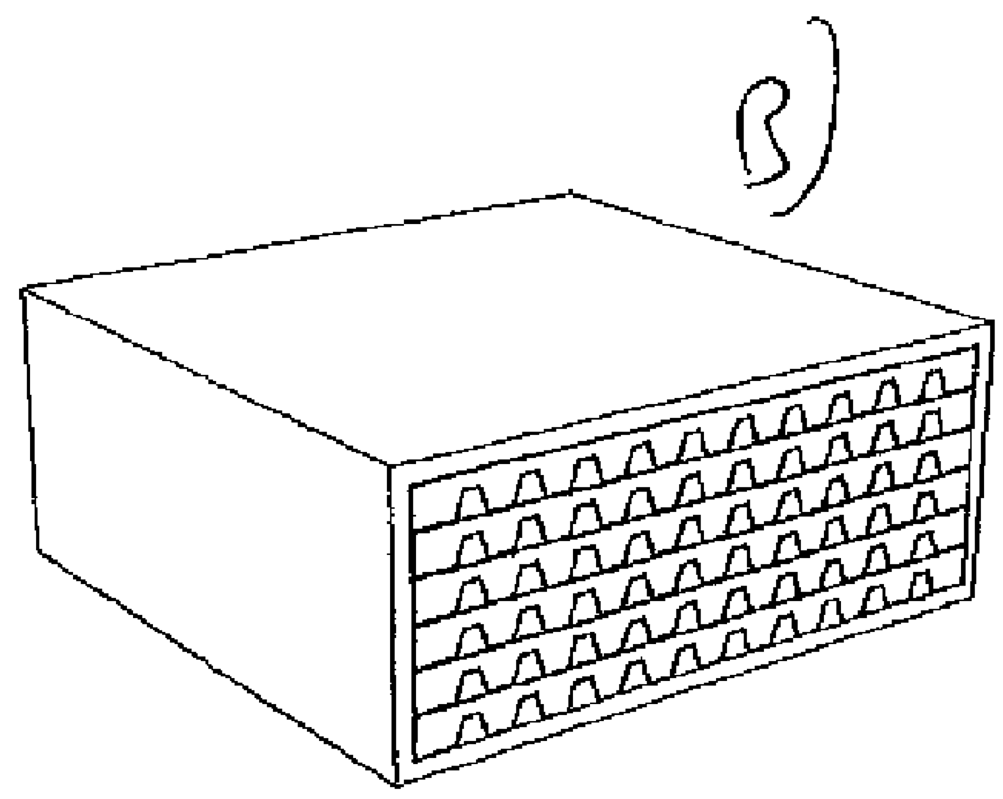
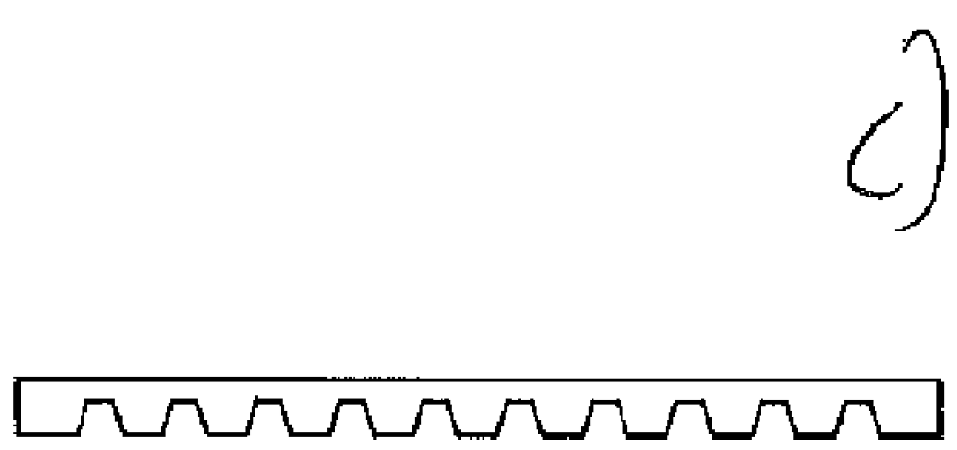
FIG. 13

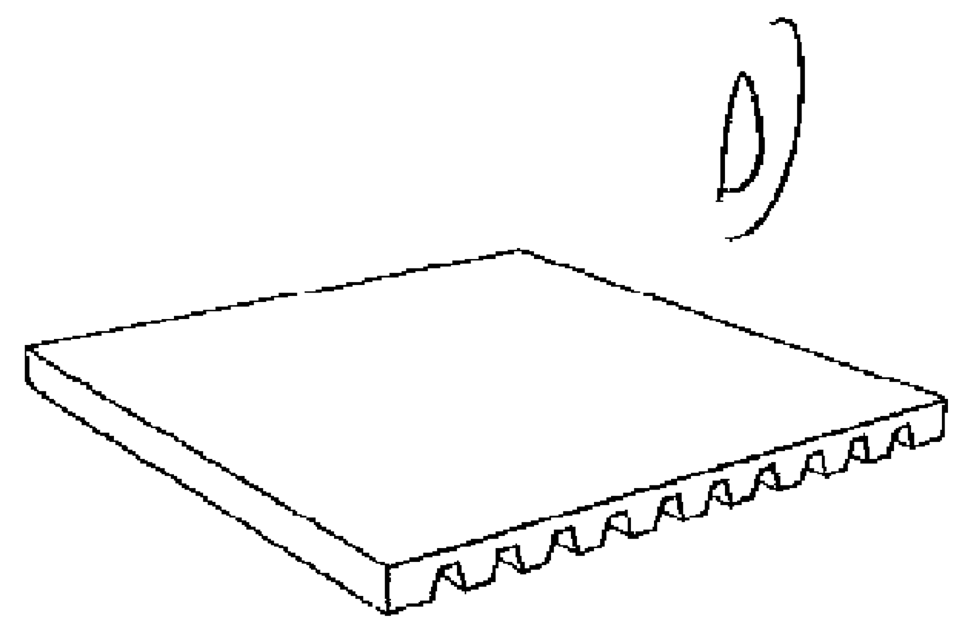


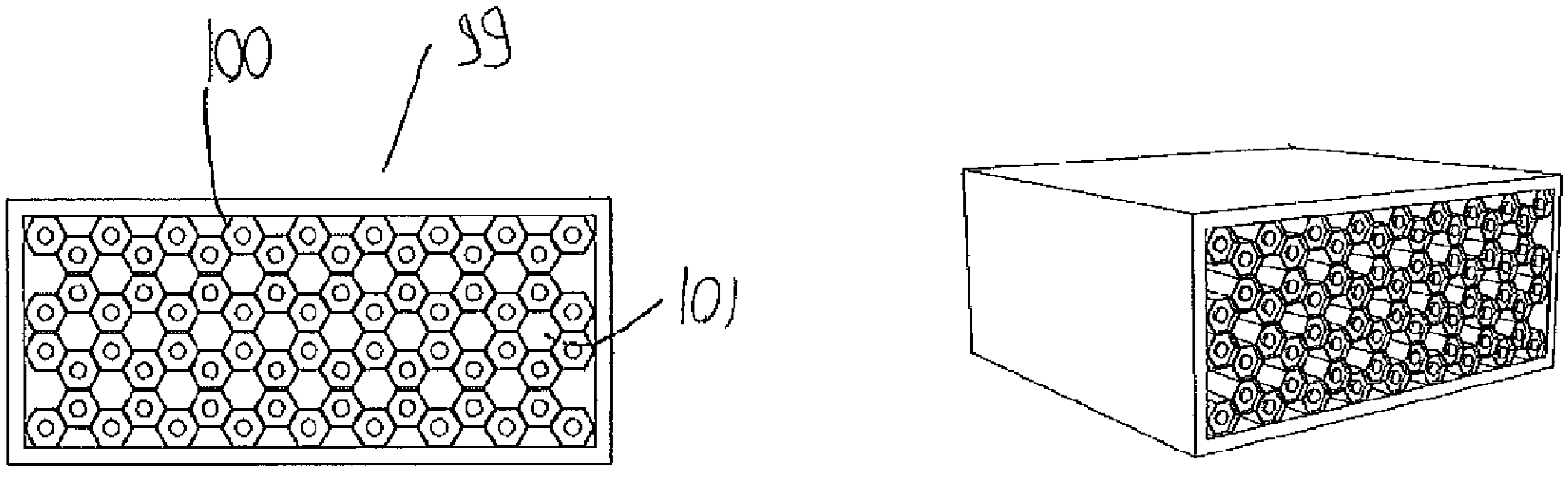


FIGS 14

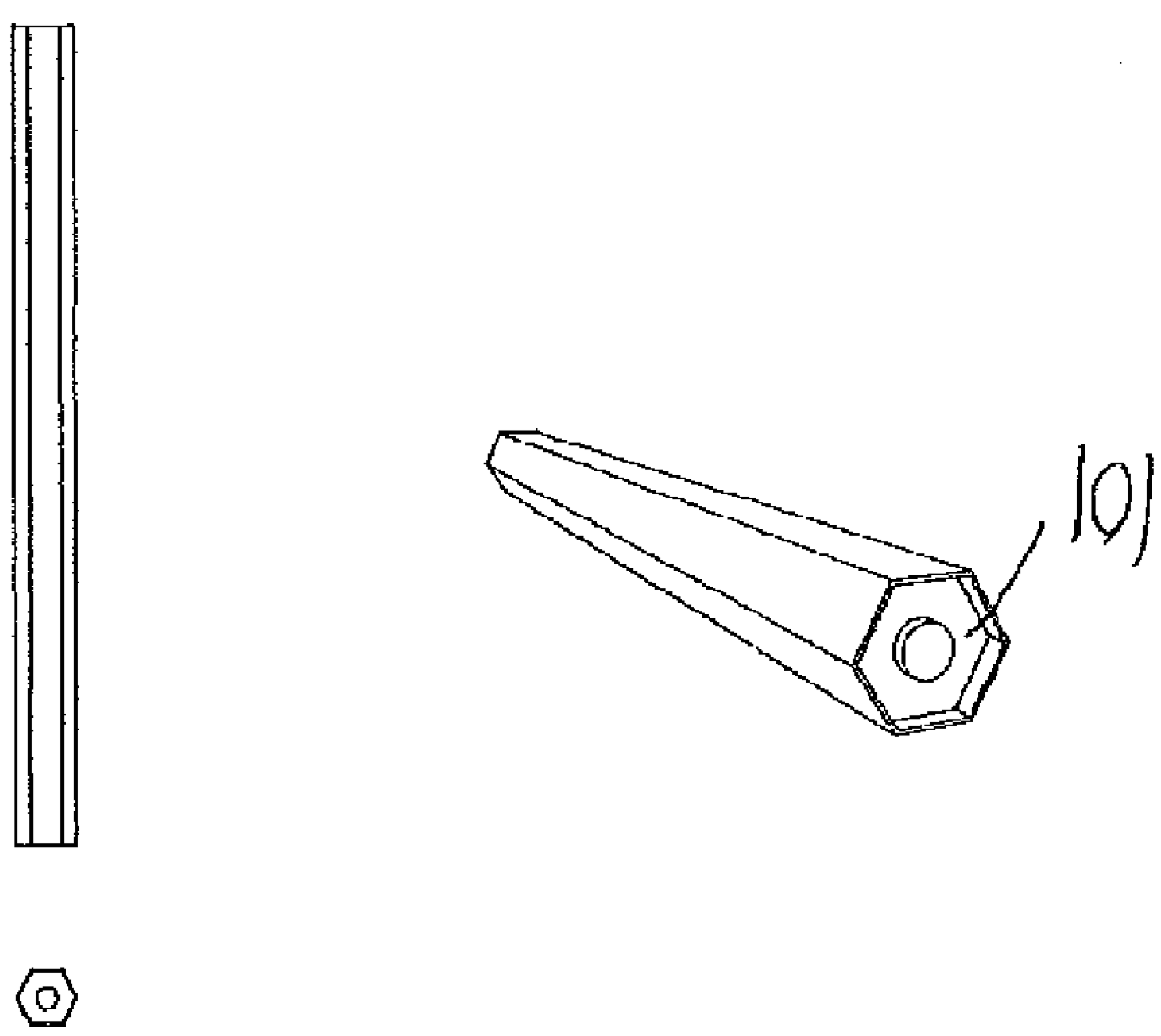


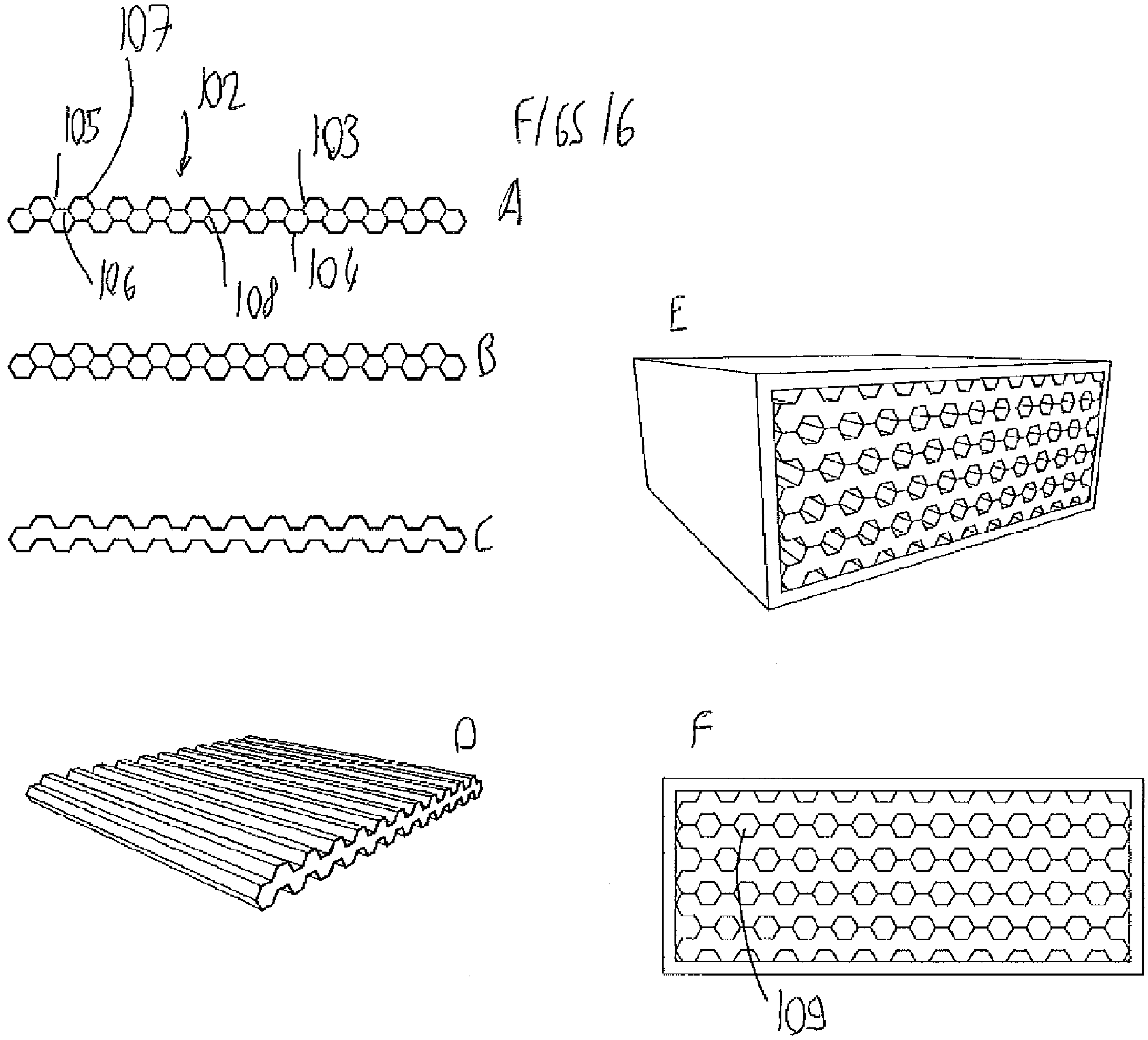






FIGS 15

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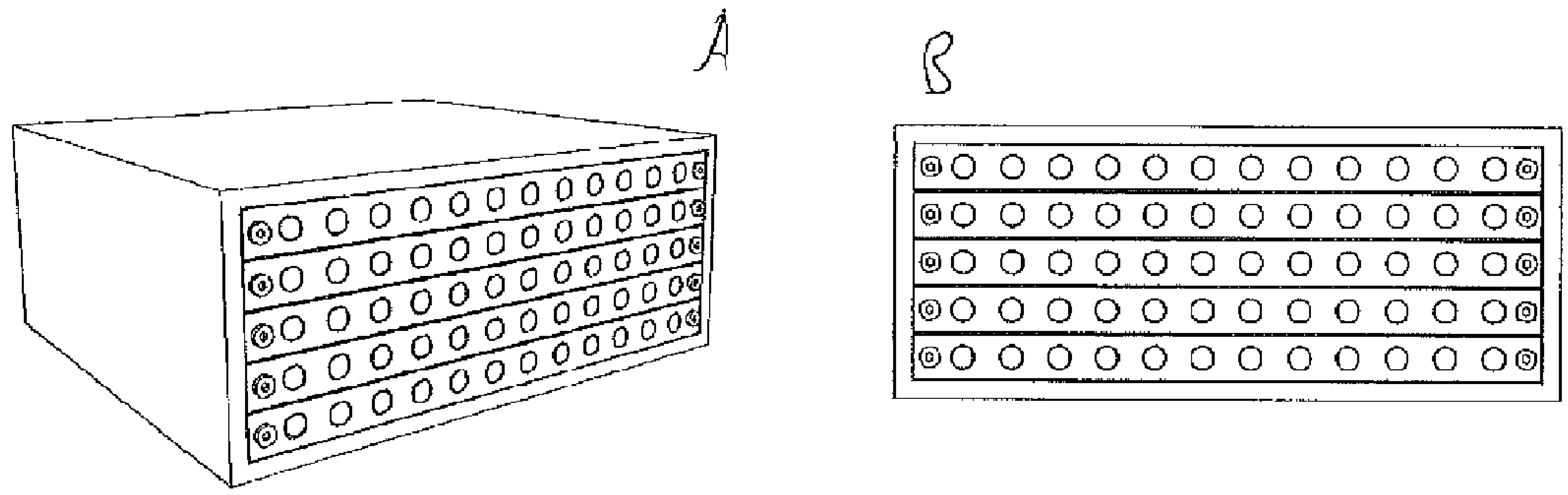

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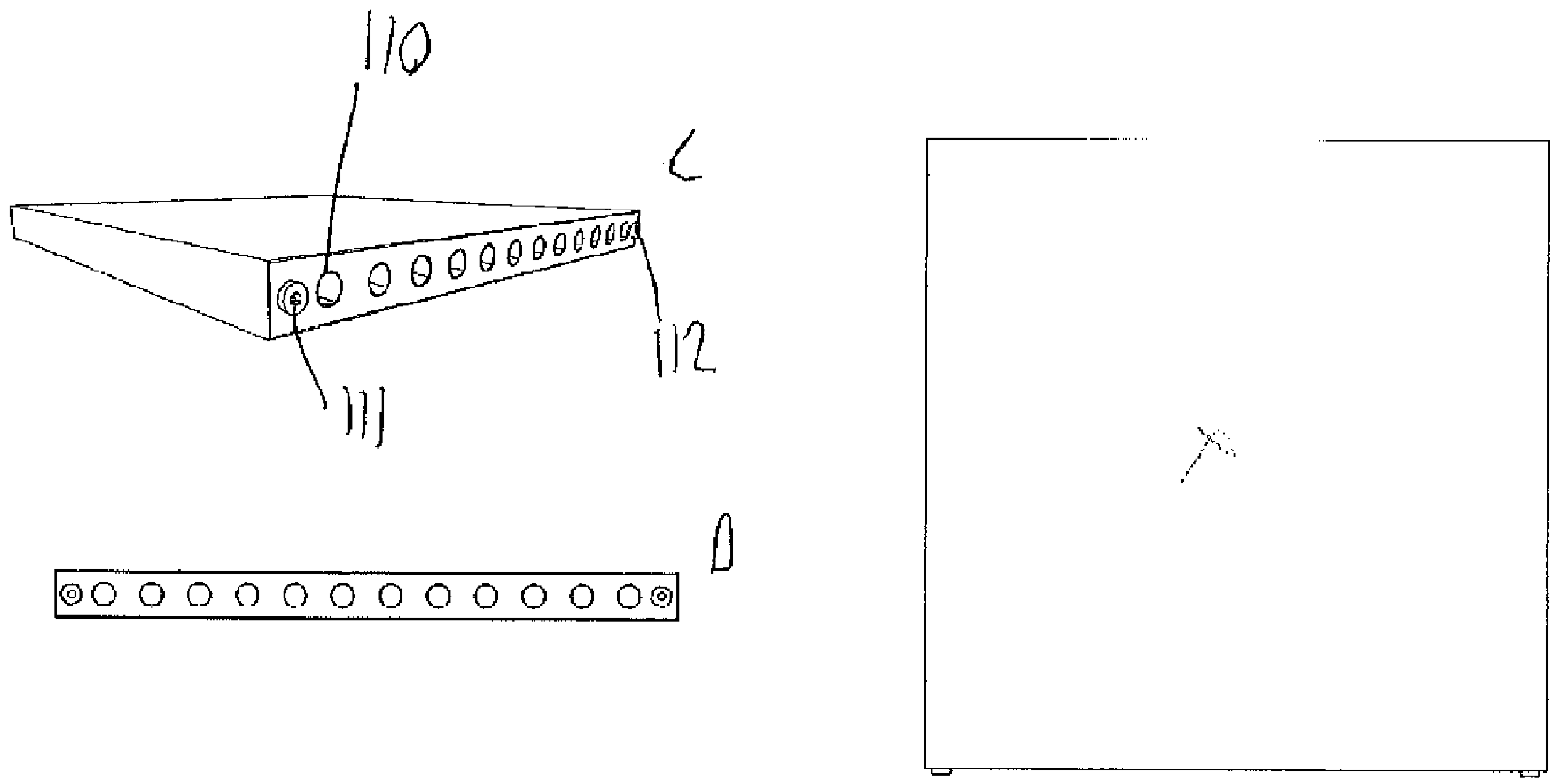

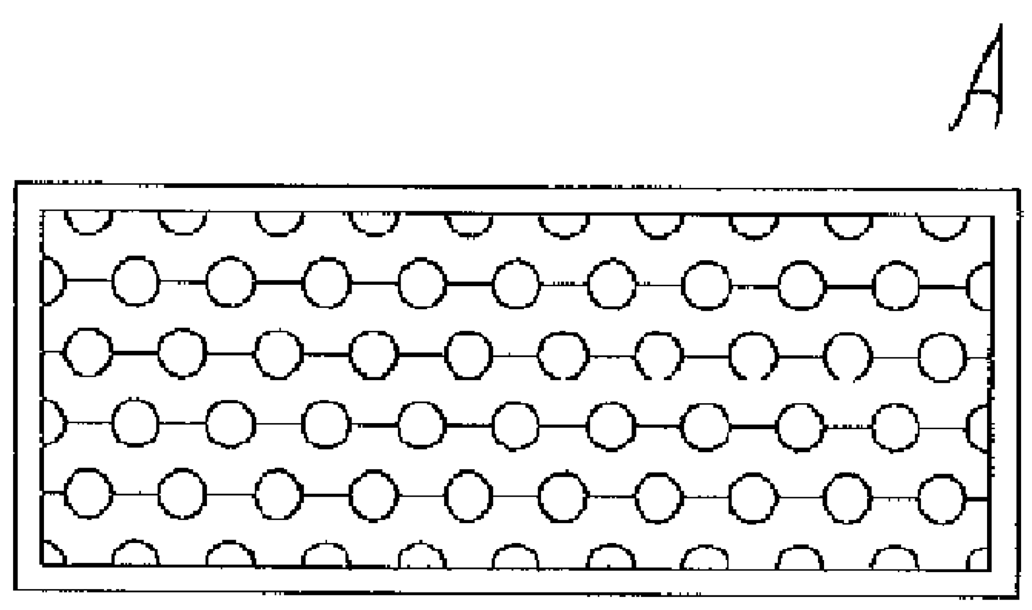

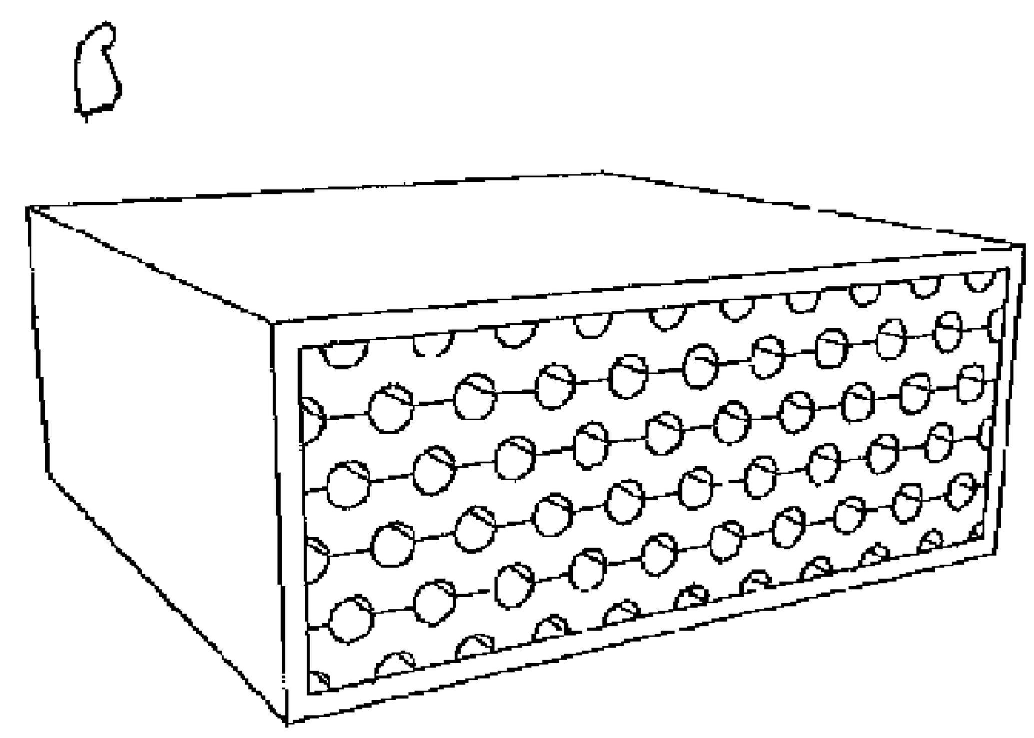

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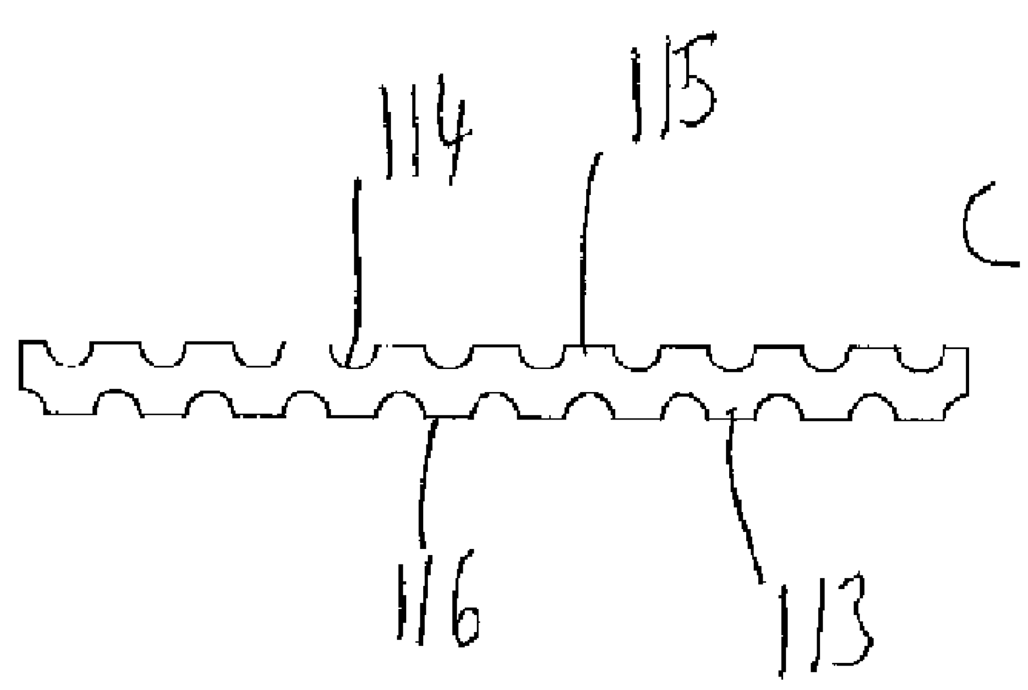

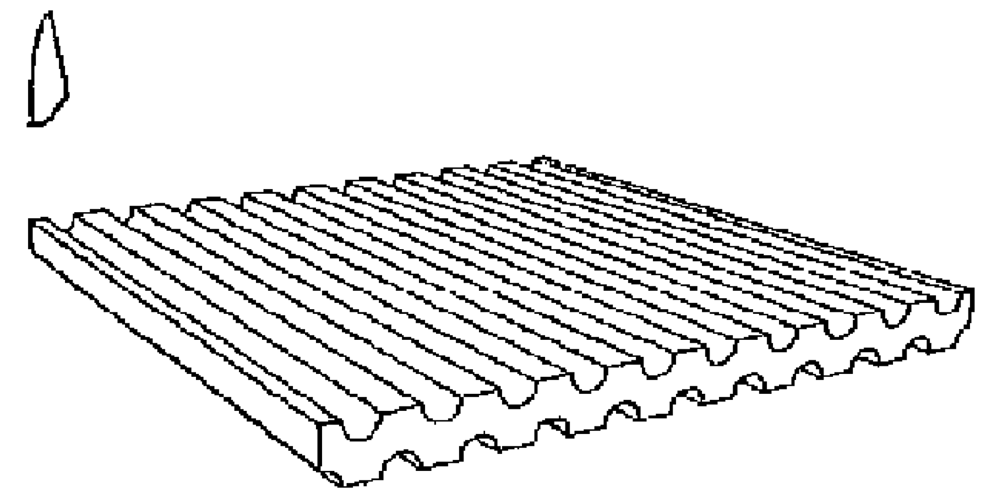

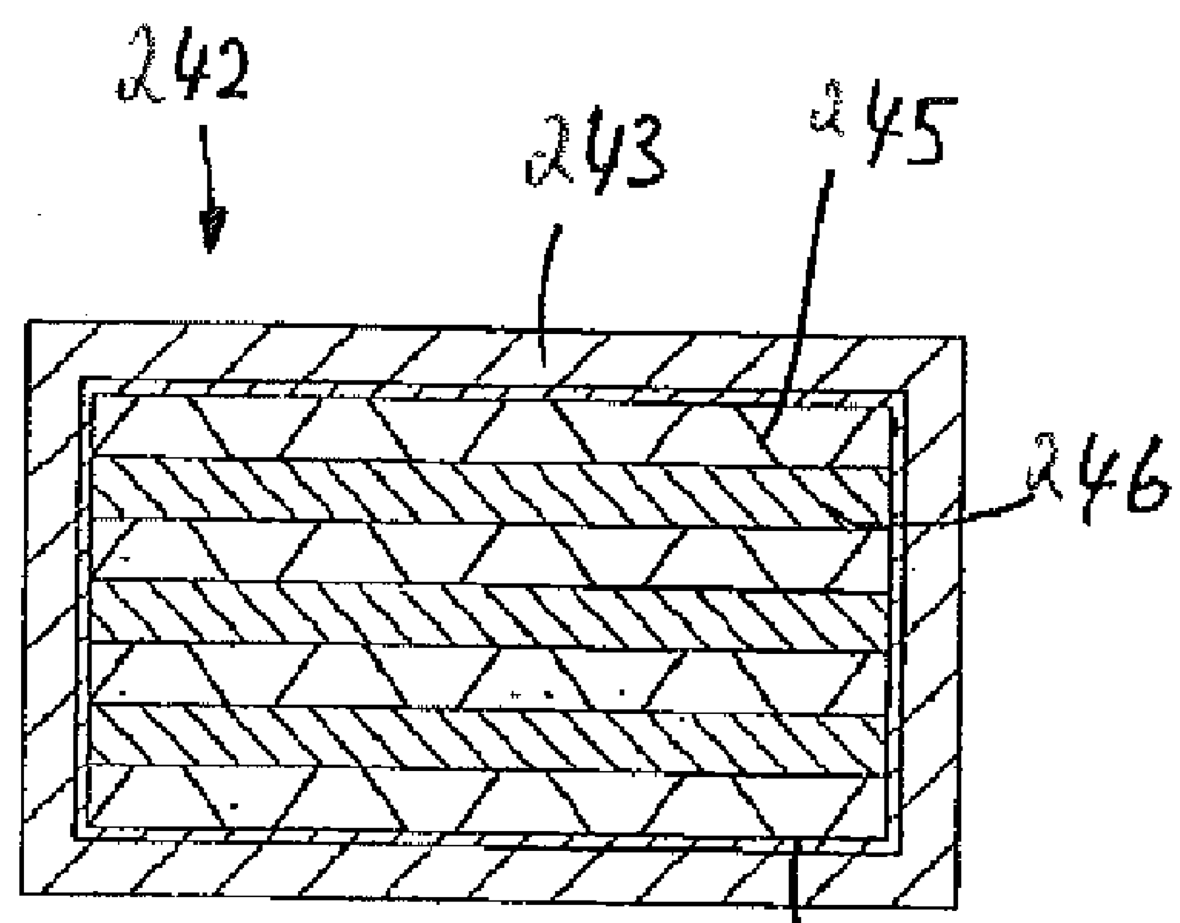

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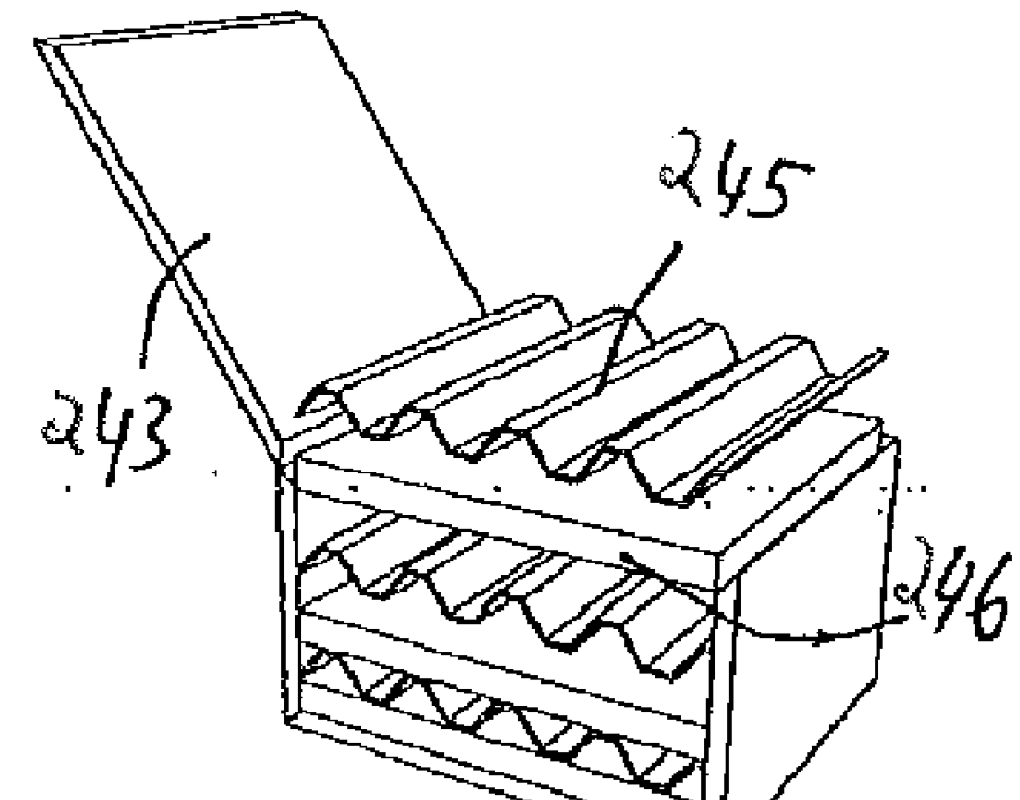

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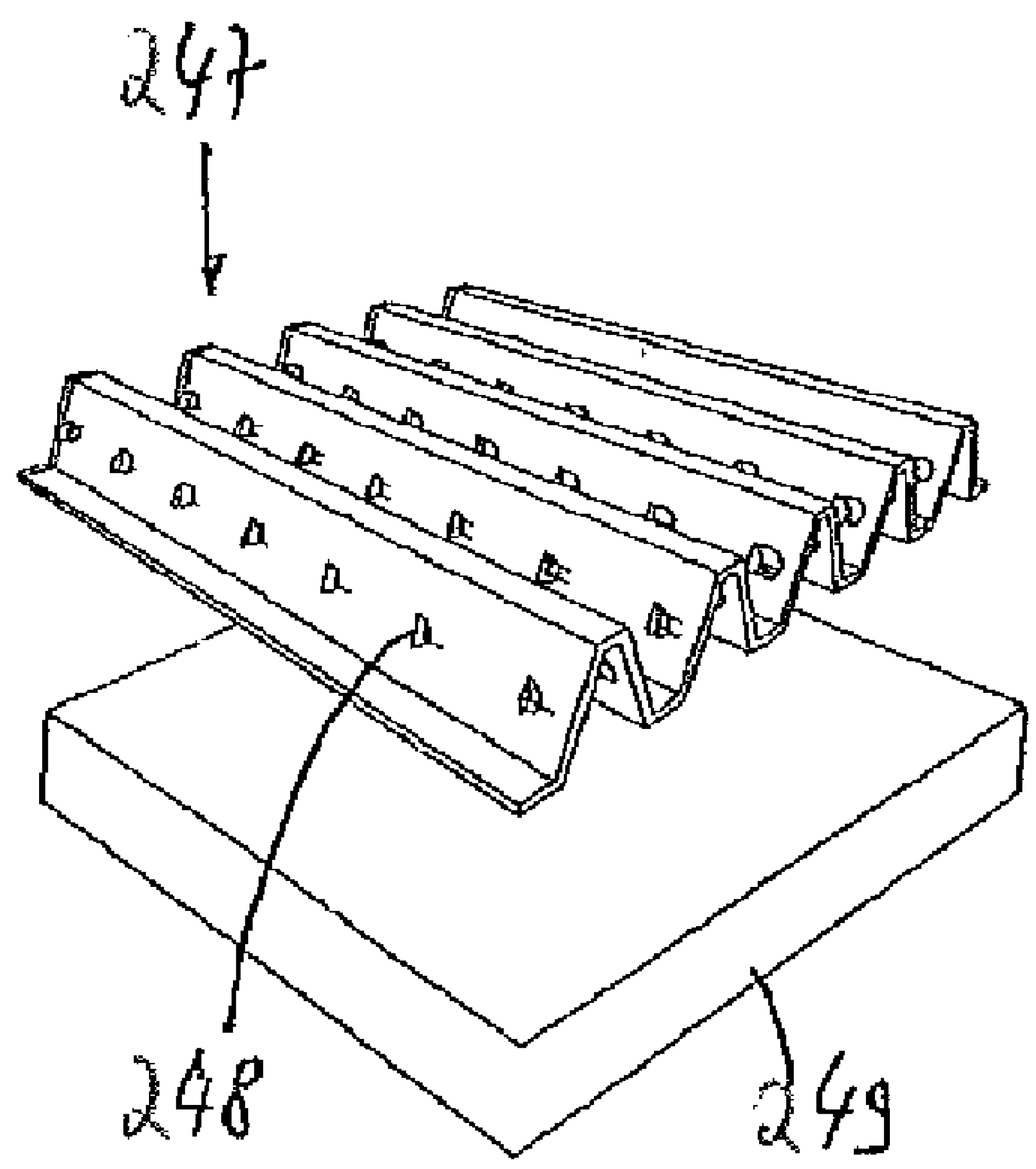

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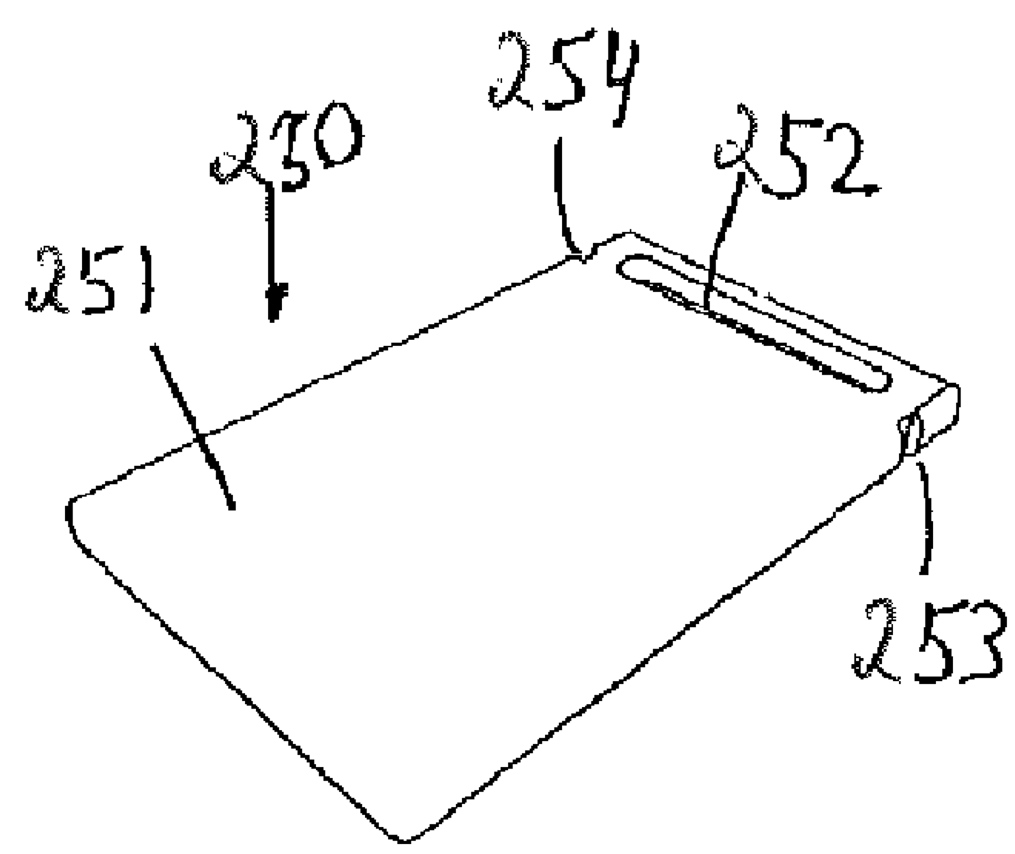

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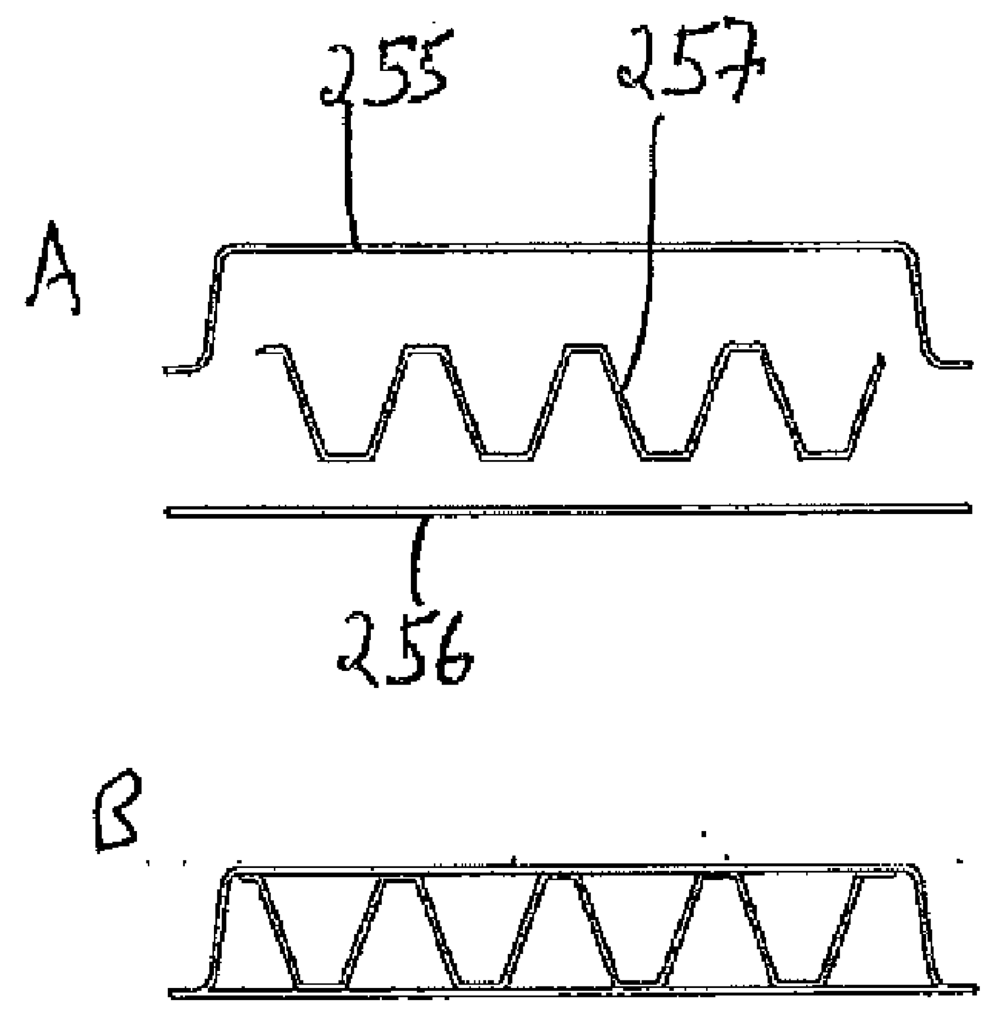

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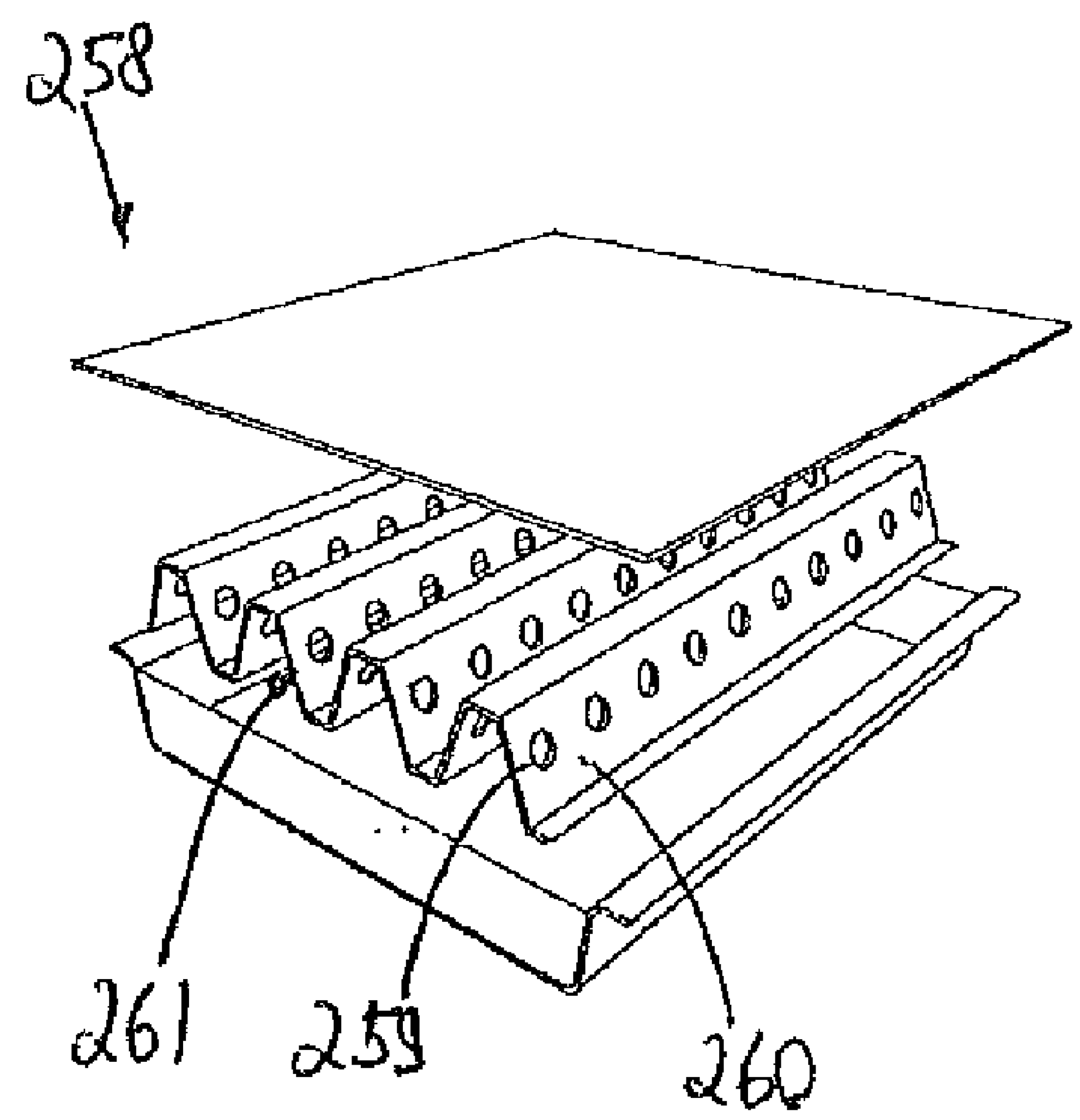

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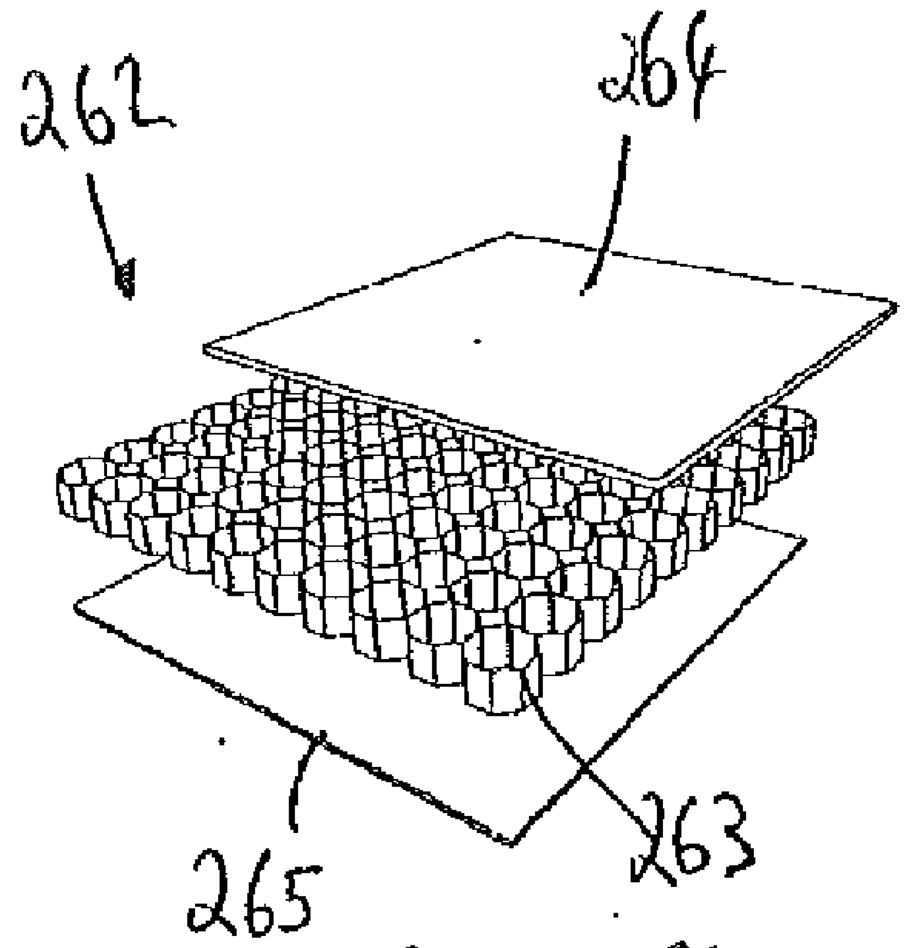

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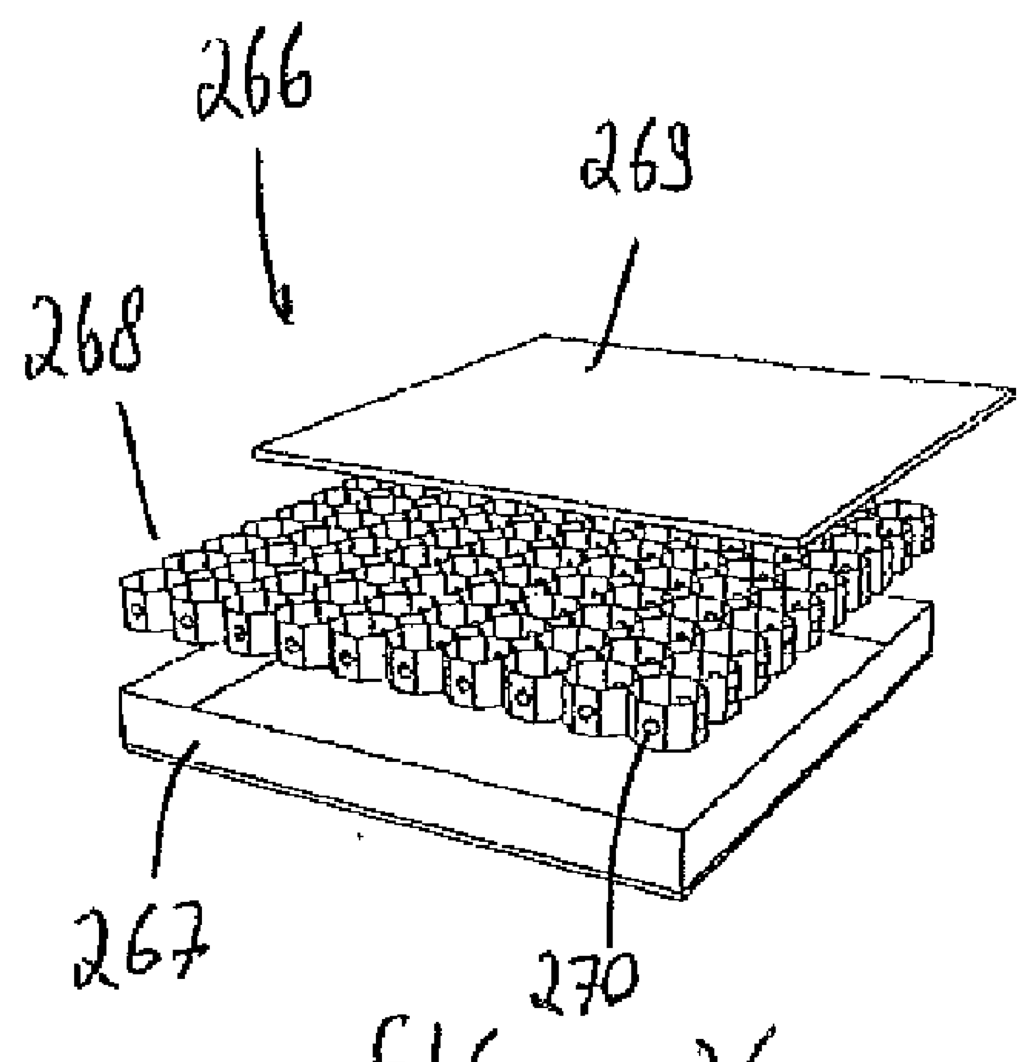

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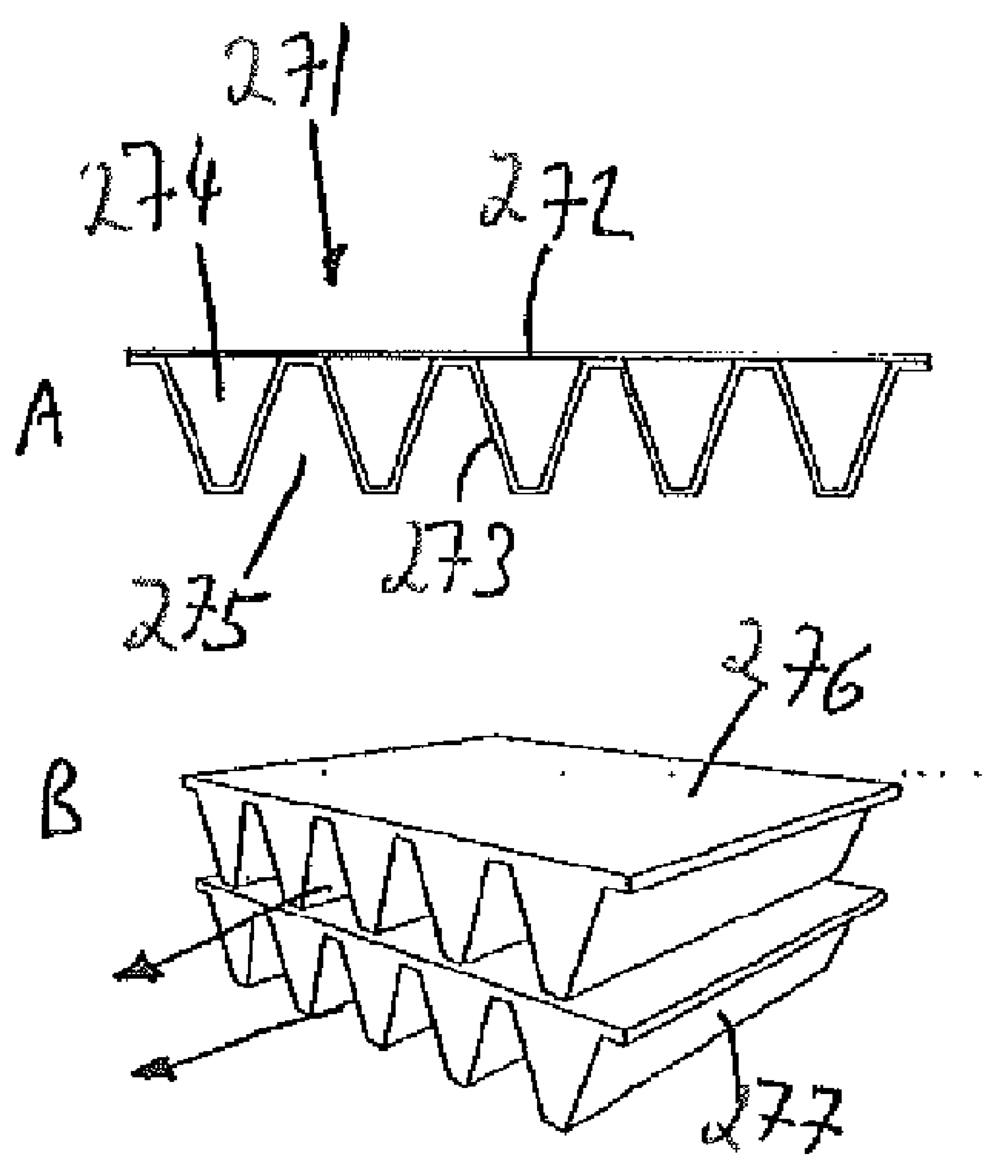
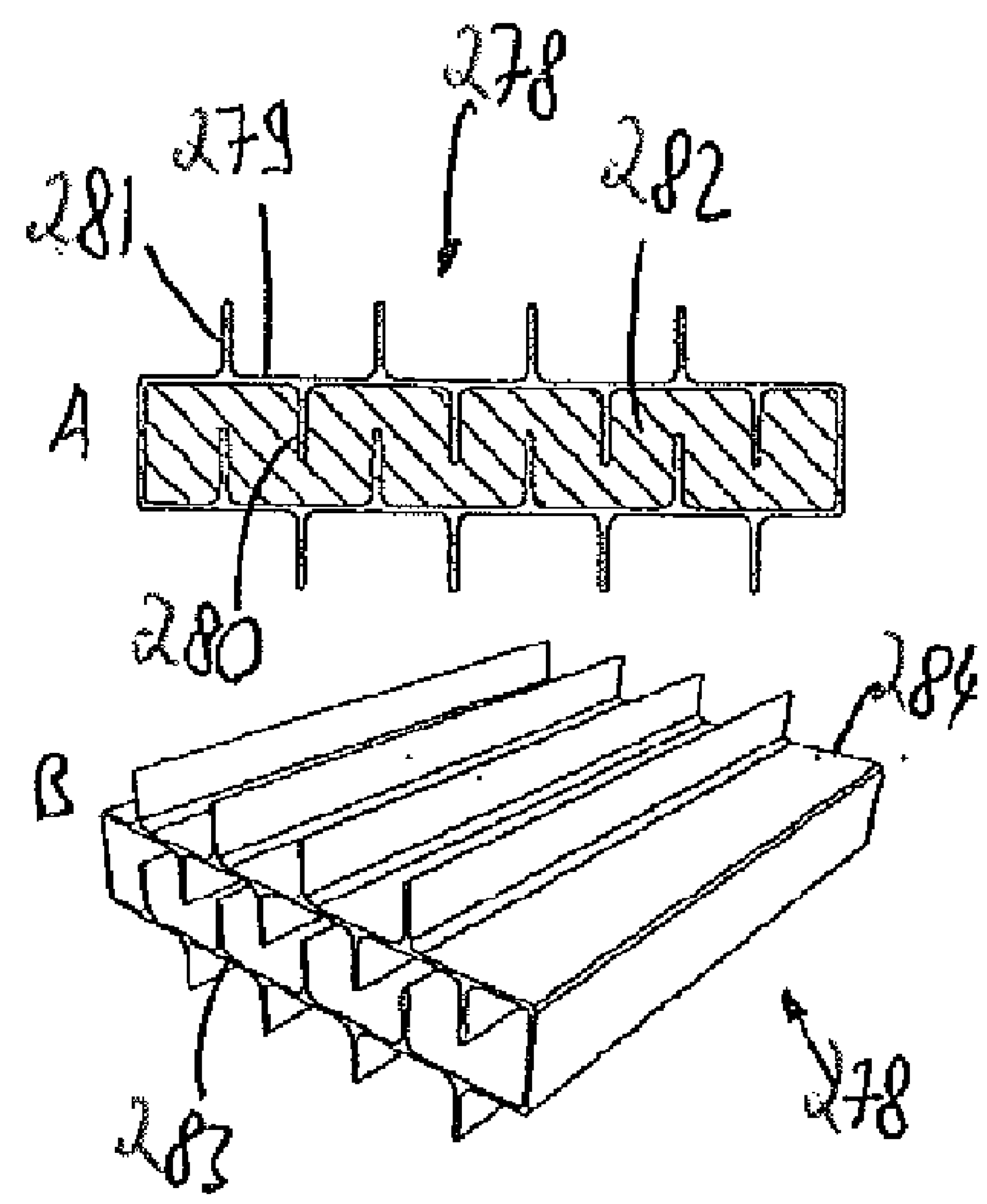


FIGS 27



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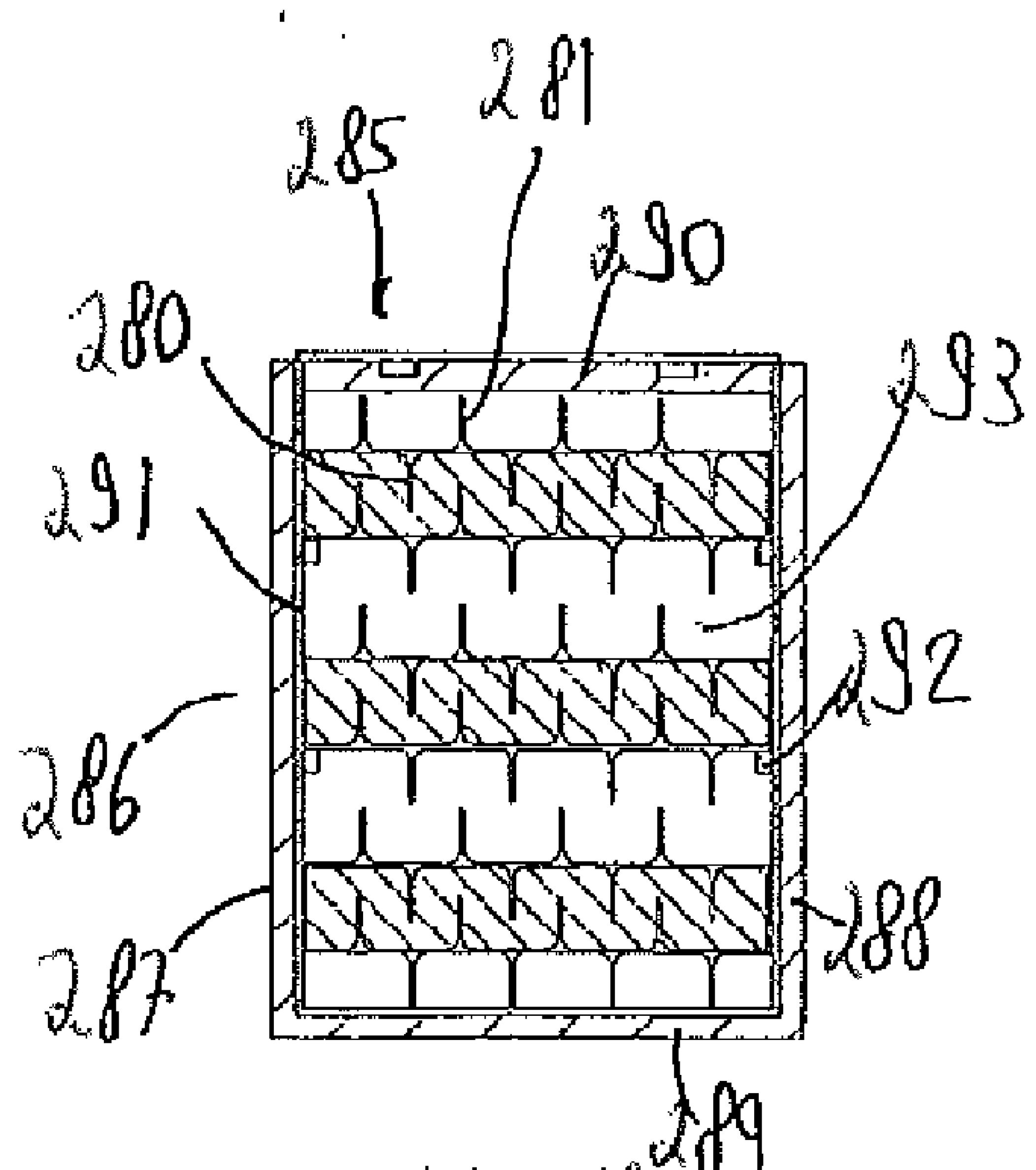

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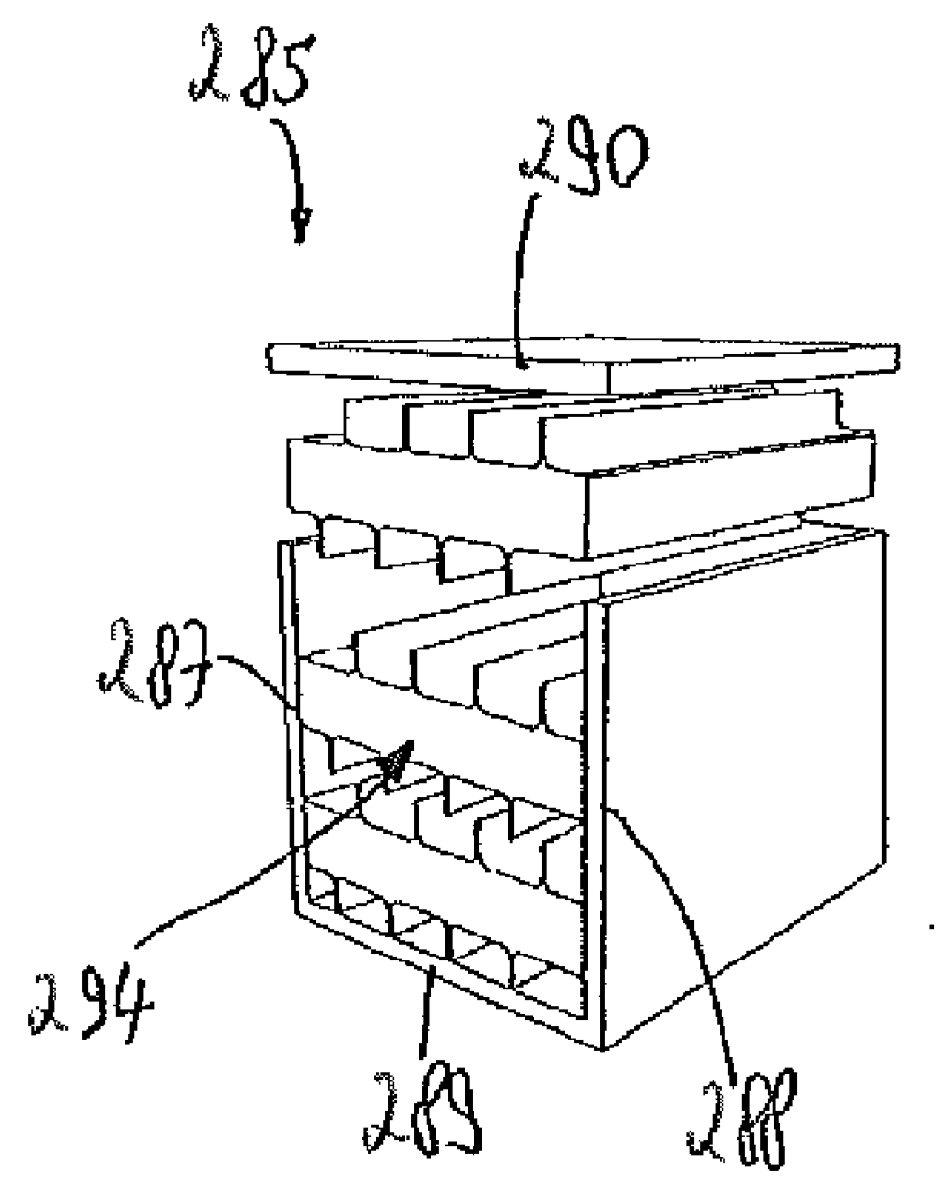

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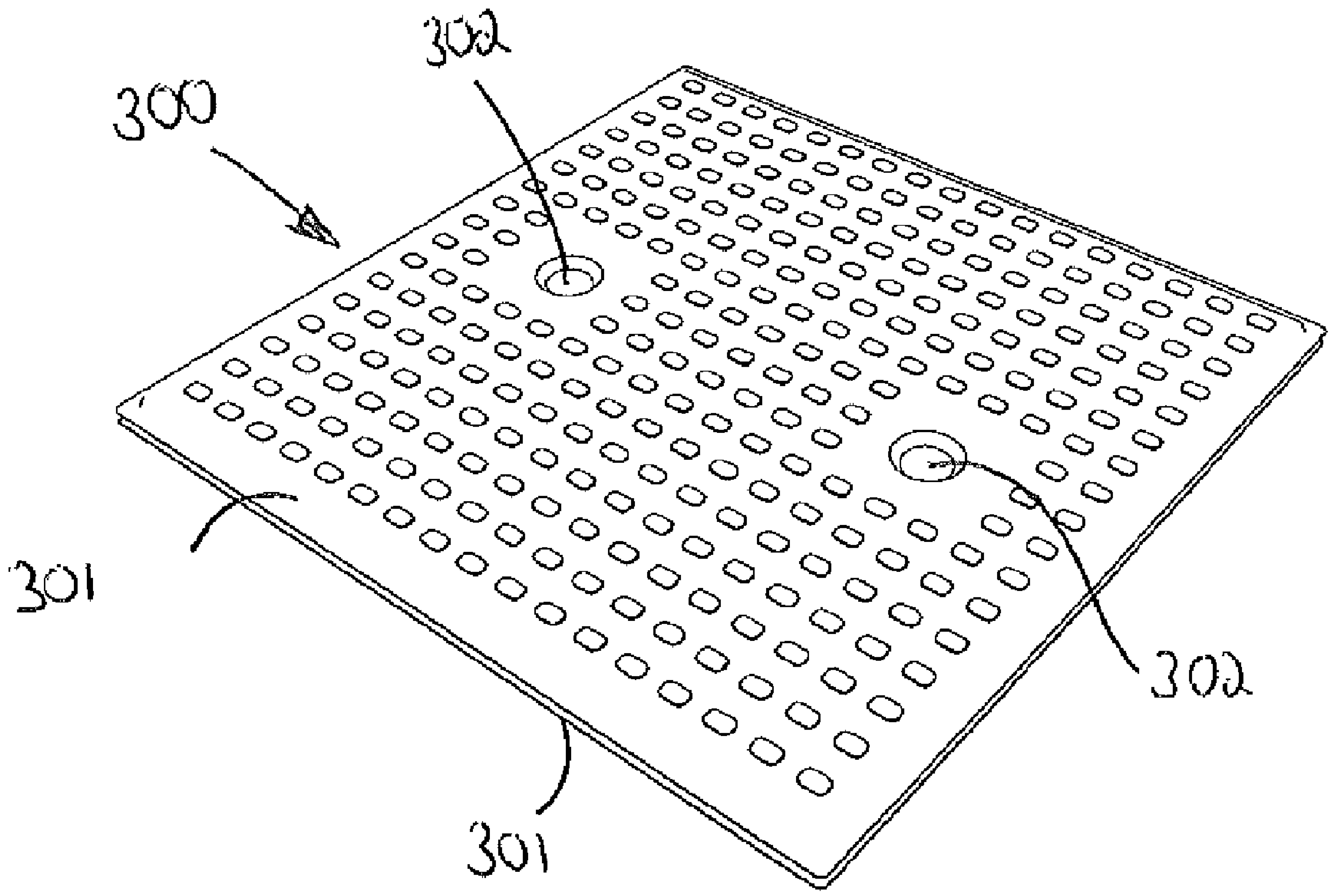

Fig. 31

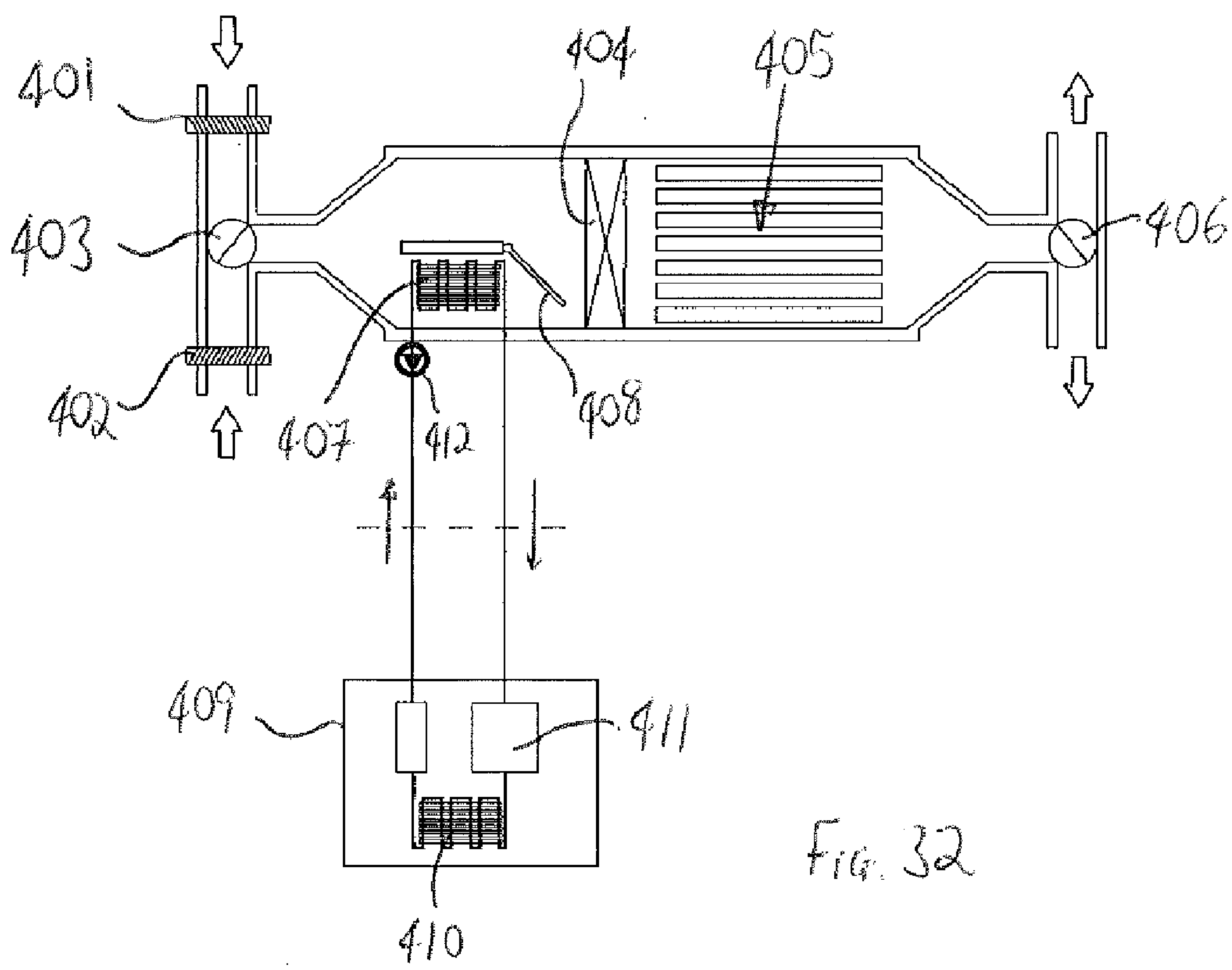
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Fig. 32

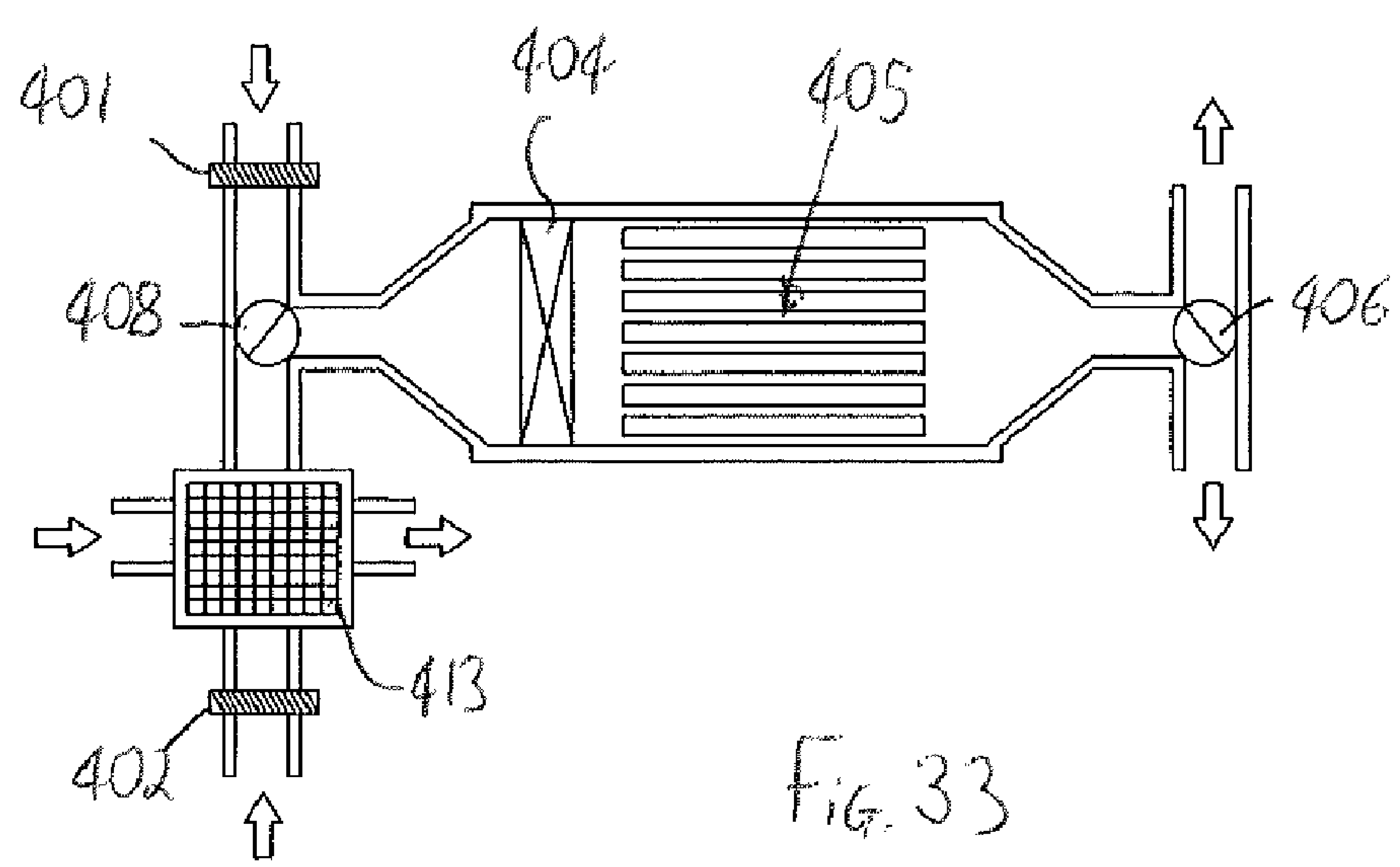
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Fig. 33

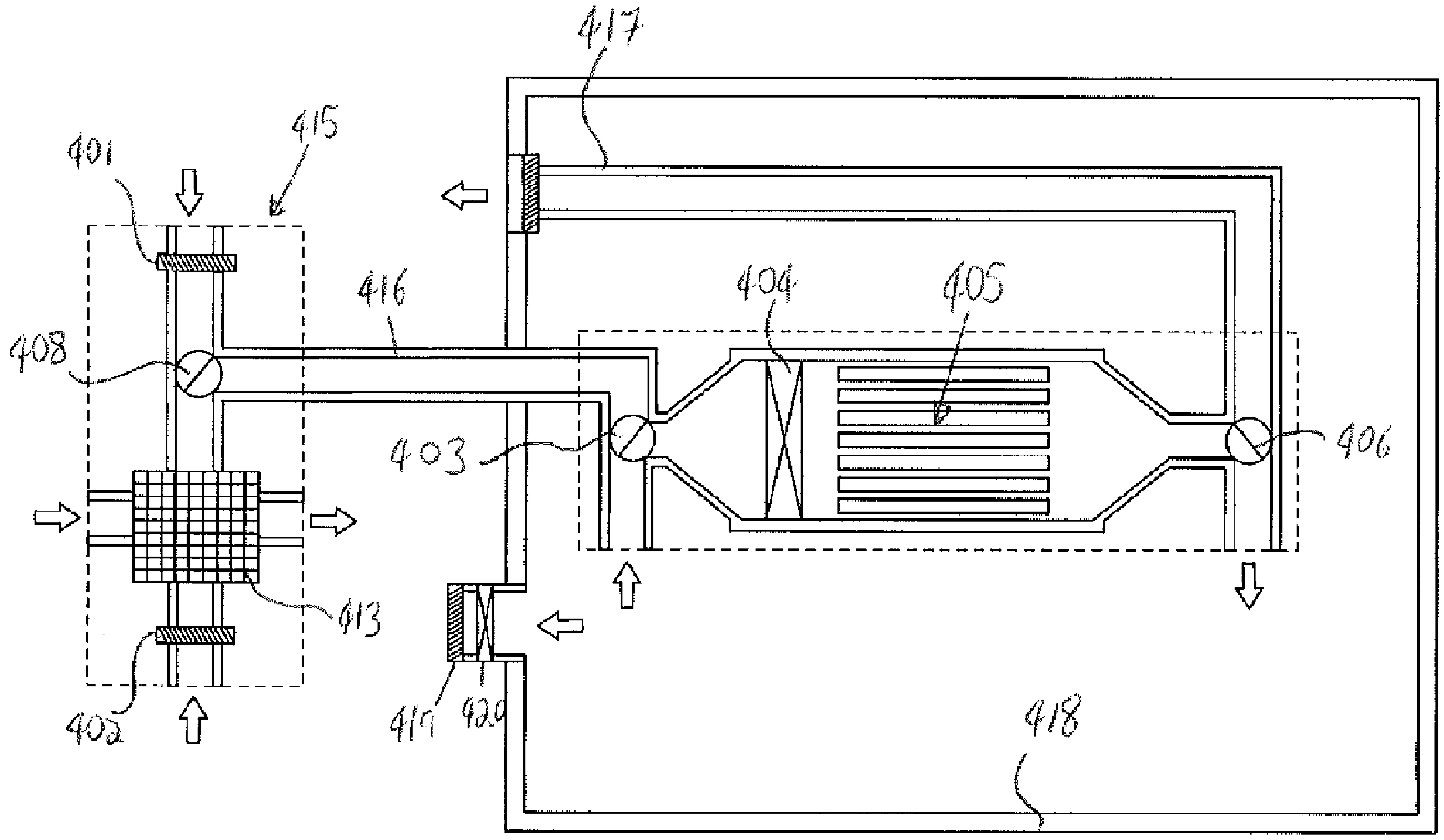
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Fig. 34

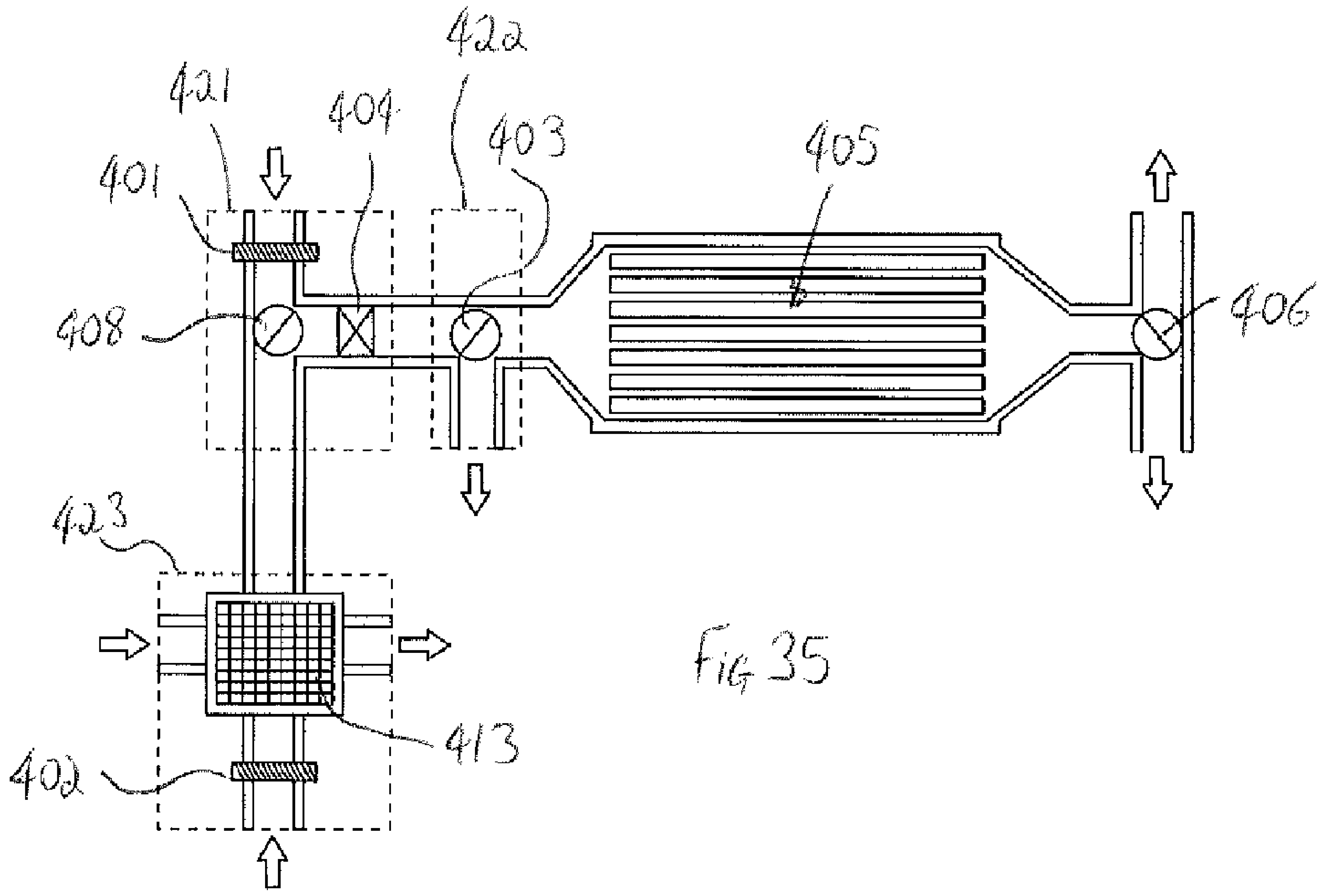
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Fig 35

FLUID CONDITIONING ARRANGEMENTS

FIELD OF THE INVENTION

[0001] The invention relates to fluid conditioning arrangements, phase change material (PCM) modules and/or components operated in conjunction with these. The invention is of particular applicability to the use of PCM for the ambient temperature control, for example within domestic and commercial buildings.

BACKGROUND

[0002] Phase change materials use the latent heat property of material to store thermal energy and can be used in methods of controlling temperature. Phase change materials are either organic such as paraffin or non-paraffin compounds, inorganic (salt hydrates and metallics) or eutectic (organic-organic, organic-inorganic, inorganic-inorganic). Typically, PCMs have a latent heat capacity at least ten times larger than their specific heat capacity.

[0003] The following prior art documents are acknowledged: DE102007013779, U.S. Pat. No. 5,647,225, U.S. Pat. No. 7,124,594, U.S. Pat. No. 7,162,878, U.S. Pat. No. 5,255,526, U.S. Pat. No. 7,363,772, U.S. Pat. No. 5,211,029, U.S. Pat. No. 4,916,916, U.S. Pat. No 5,647,225, U.S. Pat. No. 5,860,287, and U.S. Pat. No. 6,393,861.

[0004] One of the objects of the invention is to try to improve primarily PCM based fluid conditioning arrangements in terms of performance and reliability.

BRIEF SUMMARY OF THE DISCLOSURE

[0005] In a first broad independent aspect, the invention provides a fluid conditioning arrangement comprising a primary heat exchanger configured to cool and/or heat fluid; a secondary heat exchanger configured to cool and/or heat fluid; and a controller for operating said secondary heat exchanger when said primary heat exchanger fails to cool and/or heat the fluid at a predetermined acceptable level, (or the fluid fails to cool or heat the primary heat exchanger to an acceptable level), wherein said primary heat exchanger is a phase change material (PCM) based heat exchanger.

[0006] This configuration improves the overall performance of the system as it allows the PCM heat exchanger to do most of the work of cooling and/or heating for minimal energy usage, but provides a backup system to improve performance and reliability when needed. For example, a PCM may be selected which freezes/melts around room temperature (20-26 C). In many climates such as Northern Europe the night time temperatures fall below 20 C, even in summer. Therefore the PCM can be used to store cool energy from the night to provide space cooling during the day. Because these cycles rely on natural fluctuations and the weather, on occasion the night time temperatures may not be low enough to freeze or recharge the PCM. In this situation, a back up or booster system can be used to provide additional cooling during the night, because the temperature is already lower at night the back up or booster system has to do less work than if it was run during the day and has the advantage of using cheaper night time electricity. In this situation the backup booster may only need to cool the night time air by the difference between the target temperature and the actual night time temperature, for example if the temperature needed to freeze the PCM is 18 C, and the night time temperature is 20 C the booster only needs to provide an additional 2 degrees of cooling.

[0007] In a second scenario the PCM based heat exchanger may be required to provide cooling or heating. Because the latent heat store is finite there may be occasions where the system is required to provide more energy than stored. If the primary heat exchanger cannot adequately heat or cool the fluid then the secondary system can provide an additional heating or cooling of the fluid. This allows a primarily PCM cooling and/or heating system to minimise energy usage and operate under normal conditions, but have the performance and reliability of a conventional system by incorporating a booster or backup system. It allows the arrangement to operate over a wide variety of outside temperature conditions. It also further improves the energy efficiency when compared to conventional systems.

[0008] In a subsidiary aspect, said secondary heat exchanger is selected from: a vapour compression cycle based air conditioning system, a heat pump, an absorption chiller, a desiccant, an adsorption cooler or a heater element, for example an electrical heater element, an electrical panel heater, or infrared heater.

[0009] In a subsidiary aspect, the secondary heat exchanger incorporates a liquid store suitable for cryogenic cooling. This combination further reduces the energy requirements for the secondary heat exchanger. It is particularly advantageous when the use of the secondary heat exchanger is relatively infrequent.

[0010] In a further subsidiary aspect, said secondary heat exchanger incorporates a single or multiple stage evaporative cooler. This combination synergistically reduces the energy requirement for an achievable level of cooling, because an evaporative cooler can be more effective at night.

[0011] In a further subsidiary aspect, the evaporative cooler incorporates a housing with an air intake; a corresponding air outlet; a liquid inlet; a corresponding liquid outlet; and a wicking surface. It can also improve the heat exchange between an evaporative cooler and a PCM heat exchanger due to the benefits of a fluid based heat exchanger when compared to an air based heat exchanger.

[0012] In a further subsidiary aspect, said secondary heat exchanger incorporates a Peltier cooler. This configuration is also particularly advantageous in that the secondary heat exchanger is only required infrequently. It also lends itself to a particularly compact solution. In a further subsidiary aspect, said secondary heat exchanger exchanges heat with a liquid which then exchanges heat with the PCM of said primary heat exchanger. This configuration has the advantage of using a heat transfer fluid with a higher capacity than air. This kind of system may however still be used to provide fresh cooled air.

[0013] In a further subsidiary aspect, said primary heat exchanger incorporates one or more units housing PCM; wherein said housing incorporates a PCM tank. This configuration simplifies the construction when compared to multiple packs in a housing.

[0014] In a further subsidiary aspect, said tank incorporates insulated sides and at least one side without insulation in order to enhance convection through said side. This configuration is particularly advantageous in order to release cooling/heating into a room. In a generalization of this aspect, the tank may comprise at least one side that, in use, faces the space with which heat is to be exchanged, e.g. the room to be heated or cooled, and this side may be uninsulated. The sides which do not face the space with which heat is to be exchanged may be insulated.

[0015] In a further broad independent aspect, the invention provides a phase change material (PCM) module comprising one or more PCM packs; a housing for thermally insulating said number of PCM packs from a module's surrounding medium; said packs being in the form of a panel with an upper surface, a lower surface and relatively narrow lateral sides; wherein a plurality of troughs in at least either the upper or lower surfaces of the panel are provided to allow fluid to flow through the module for heat exchange with PCM. This configuration reduces the number of components required in order to provide the spaces in a stack of PCM packs, and maximises surface area and the energy storage density of the heat exchanger.

[0016] In a further broad independent aspect, the invention provides a phase change material (PCM) module comprising a number of PCM monoliths or tubes; a housing for thermally insulating said number of PCM monoliths from a module's surrounding medium; and gaps being formed between a stack of said monoliths or tubes in said module to allow fluid to flow through the module for heat exchange with the PCM. This configuration allows a stack of such monoliths or tubes to achieve improved heat exchange with a heat transfer fluid. It also provides a particularly robust stack which is also particularly straightforward to assemble whilst employing relatively lightweight individual components.

[0017] In a further subsidiary aspect, said monoliths are hexagonal in cross-section. This allows the individual monoliths to be stacked in a uniform manner.

[0018] In a further broad independent aspect, the invention provides a phase change material (PCM) module comprising a number of PCM packs; a housing for thermally insulating said number of PCM packs from a module's surrounding medium; and conduits passing through said PCM packs to allow fluid to flow through the module for heat exchange with the PCM. This configuration further improves the efficiency of the heat exchange for certain applications.

[0019] In a further broad independent aspect, the invention provides a fluid conditioning arrangement comprising a first heat exchanger configured to heat and/or cool fluid; and a second heat exchanger configured to cool and/or heat fluid; wherein said one of said heat exchangers is a phase change material (PCM) based heat exchanger and the other is an evaporative cooler. This configuration is also particularly advantageous in terms of energy efficiency when compared to conventional heat pumps and conventional combinations of heat pumps and evaporative coolers.

[0020] In a further broad independent aspect, the invention provides a fluid conditioning arrangement comprising a first heat exchanger configured to cool and/or heat fluid; and a second heat exchanger configured to cool and/or heat fluid; wherein said one of said heat exchangers is a phase change material (PCM) based heat exchanger; and the other is a Peltier cooler. This configuration is also particularly advantageous in terms of efficiency when compared to conventional combinations of heat pumps and PCM material. It lends itself to the Peltier acting as a booster system which is particularly advantageous when the demand for the use of the Peltier cooler is relatively infrequent.

[0021] In a further broad independent aspect, the invention provides a fluid conditioning arrangement comprising a first heat exchanger configured to cool and/or heat fluid; and a second heat exchanger configured to cool and/or heat fluid; wherein said one of said heat exchangers is a phase change material (PCM) based heat exchanger; and the other is a solar based heat exchanger or solar collector.

[0022] In a further broad independent aspect, the invention provides a transportable PCM (phase change material) module comprising a number of PCM packs; a housing for thermally insulting said number of PCM packs from a module's surrounding medium; spaces separating said packs and forming one or more channels for the flow of a fluid; said housing incorporating a fluid inlet and a fluid outlet; whereby, in use, fluid flows through said channels from said inlet to said outlet.

[0023] This configuration is particularly advantageous because it allows systems to be built up from a number of modules for variable energy requirement. It may also reverse conventional thinking when it is configured without any driven or powered component in the module. It may thus allow for retrofitting to existing air flow systems. It also improves energy usage effectiveness.

[0024] In a subsidiary aspect, said inlet and/or said outlet incorporates one or more flow regulating valves. If the module consists of these components only it further reduces the number of components necessary and allows for particularly compact modules compared to module incorporating power components per module.

[0025] In a further subsidiary aspect, said PCM packs are arranged substantially side by side. In this configuration, the cooling is advantageous.

[0026] In a further subsidiary aspect, said PCM packs are separated by one or more thermal conductors extending transversely and forming said channels. This allows the PCM portion to be of greater effective volume and therefore improves its effectiveness.

[0027] Further aspects improve one or more of the following: the effectiveness of the PCM, the turbulence of the flow, the compactness of the system relative to its effectiveness, its overall packaging weight and its manufacturing requirements.

[0028] In a further subsidiary aspect, said thermal conductors take the form of a corrugated sheet.

[0029] In a further subsidiary aspect, at least one of said PCM pack incorporates a corrugated wall forming a channel for the flow of fluid.

[0030] In a further subsidiary aspect, a number of projections are provided in at least one of said channels.

[0031] In a further subsidiary aspect, at least one of said PCM pack incorporates a wall from which projections project into said channel.

[0032] In a further subsidiary aspect, the or each PCM pack comprises a laminate of a first conducting panel and a second conducting panel enclosing a portion formed primarily of PCM; wherein said portion of PCM incorporates thermal conductors. In a further subsidiary aspect, said thermal conductors extend in a transverse direction from one or both of said conducting panels.

[0033] In a further subsidiary aspect, said thermal conductors form hexagonal cells when viewed in plan.

[0034] In a further subsidiary aspect, said laminate further incorporates a corrugated thermally conductive panel.

[0035] In a further subsidiary aspect, said laminate incorporates a third conductive panel and a fourth conductive panel enclosing a second portion formed primarily of PCM; and a corrugated thermally conductive panel located between said second and third conductive panels.

[0036] In a further subsidiary aspect, said laminate incorporates a plurality of projections on said panels.

[0037] In a further subsidiary aspect, said thermally conductive panels are selected from the group comprising aluminium based material, steel based material, and plastics material.

[0038] In a further subsidiary aspect, said PCM is selected from the group comprising a salt, a salt based hydrate, a mixture of salt, and/or salt based hydrate, and/or an organic material.

[0039] In a further subsidiary aspect, said salt based hydrate are selected from the group comprising hydrated calcium chloride or hydrated sodium sulphate.

[0040] In a further subsidiary aspect, said salt based hydrate incorporates a thickening agent selected from the group comprising Xanthan and/or Laponite.

[0041] In a further subsidiary aspect, said organic material is paraffin based.

[0042] In a further subsidiary aspect, said thermal conductors incorporate a conductive compound mixed into said PCM. In a further subsidiary aspect, said thermal conductor is a carbon based compound mixed into said PCM.

[0043] In a further subsidiary aspect, said carbon based compound is carbon black.

[0044] In a further subsidiary aspect, said thermal conductors incorporate wire wool or chemical carbon nanotubes.

[0045] In a further subsidiary aspect, said module further incorporates a pettier cooler.

[0046] In a further subsidiary aspect, said module further incorporates an evaporative cooler.

[0047] In a second broad independent aspect, the invention provides an air conditioning arrangement, comprising:

- **[0048]** one or more transportable PCM modules according to any of the preceding claims; and
- **[0049]** at least one transportable control module incorporating a housing with an inlet and an outlet; and a pump for causing, in use, the flow of fluid from said inlet to said outlet;
- **[0050]** wherein said arrangement incorporates a conduit for linking said transportable control module to said transportable PCM modules.

[0051] In a subsidiary aspect, said control module incorporates a first and a second inlet located on separate sides of said housing and a valve configured to regulate the intake between said inlets.

[0052] In a further subsidiary aspect, said control module incorporates an internal conduit between said inlet and said outlet; said internal conduit comprising two adjacent paths, one of which incorporates a pump and a second of which incorporates a non-return valve.

[0053] In a further subsidiary aspect, said arrangement further comprises a transportable backup module incorporating one of a heat pump, an inverter, a peltier cooler, or an evaporative cooler; and further incorporating means for linking said backup module to said PCM module.

[0054] In a third broad independent aspect, a PCM (phase change material) pack comprises a laminate of a first conducting panel and a second conducting panel enclosing a portion formed primarily of PCM; wherein said portion of PCM incorporates thermal conductors.

[0055] In a subsidiary aspect, said thermal conductors extend in a transverse direction from one or both of said conducting panels.

[0056] In a further subsidiary aspect, said thermal conductors form hexagonal cells when viewed in plan.

[0057] In a further subsidiary aspect, said laminate further incorporates a corrugated thermally conductive panel.

[0058] In a further subsidiary aspect, said laminate incorporates a third conductive panel and a fourth conductive panel enclosing a second portion formed primarily of PCM; and a corrugated thermally conductive panel located between said second and third conductive panels.

[0059] In a further subsidiary aspect, said laminate incorporates a plurality of projections on said panels.

[0060] In a further subsidiary aspect, said thermally conductive panels are selected from the group comprising aluminium based material, steel based material, and plastics material.

[0061] In a further subsidiary aspect, said PCM is selected from the group comprising a salt, a salt based hydrate, a mixture of salt, and/or salt based hydrate, and/or an organic material.

[0062] In a further subsidiary aspect, said salt based hydrate are selected from the group comprising hydrated calcium chloride or hydrated sodium sulphate. In a further subsidiary aspect, said salt based hydrate incorporates a thickening agent selected from the group comprising Xanthan and/or Laponite.

[0063] In a further subsidiary aspect, said organic material is paraffin based.

[0064] In a further subsidiary aspect, said thermal conductors incorporate a conductive compound mixed into said PCM.

[0065] In a further subsidiary aspect, said thermal conductor is a carbon based compound mixed into said PCM.

[0066] In a further subsidiary aspect, said carbon based compound is carbon black.

[0067] In a further subsidiary aspect, said thermal conductors incorporate wire wool or chemical carbon nanotubes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0068] Embodiments of the invention are further described hereinafter with reference to the accompanying drawings, in which:

[0069] FIG. **1** shows a fluid conditioning arrangement in schematic cross-sectional view of an embodiment incorporating primarily a PCM module and secondarily a heat exchanger unit.

[0070] FIG. **2** shows a schematic cross-sectional view of a PCM based fluid conditioning arrangement with a cryogenic booster.

[0071] FIG. **3** shows a schematic of a fluid conditioning arrangement where the heat transfer between a first fluid conditioning arrangement and a second fluid conditioning arrangement is achieved by using fluid instead of air.

[0072] FIG. **4** shows a schematic of the central unit in a fluid conditioning arrangement in accordance with a further embodiment.

[0073] FIG. **5** shows a fluid conditioning arrangement incorporating an evaporative unit.

[0074] FIG. **6** shows a module which has no PCM material.

[0075] FIG. **7** shows a PCM tank.

[0076] FIG. **8** shows a PCM module with a fluid based heat exchange.

[0077] FIG. **9** shows a further embodiment with a PCM module of the kind shown in FIG. **8**.

[0078] FIG. **10** shows a control unit.

[0079] FIG. 11 shows a PCM module.

[0080] FIG. 12 shows a system with a couple of modules.

[0081] FIG. 13 shows a Peltiere booster.

[0082] FIGS. 14 show PCM packs in a plurality of views.

[0083] FIGS. 15 show PCM monoliths in a plurality of views.

[0084] FIGS. 16 show a plurality of PCM packs with hexagonal components throughout.

[0085] FIGS. 17 shows PCM packs in a plurality of views.

[0086] FIGS. 18 show PCM packs with semi-circular troughs in a plurality of views.

[0087] FIG. 19 shows a heat exchanger in cross section with a plurality of PCM packs separated by corrugated plates.

[0088] FIG. 20 shows an exploded view in a perspective of the embodiment of FIG. 19.

[0089] FIG. 21 shows in perspective view the combination of a PCM pack with a corrugated plate.

[0090] FIG. 22 shows in perspective view a portable PCM pack.

[0091] FIGS. 23A and B show a PCM pack incorporating a thermally conductive corrugated plate.

[0092] FIG. 24 shows in perspective view the assembly of a PCM pack with a corrugated plate with a plurality of holes.

[0093] FIG. 25 shows a perspective view of the assembly of a hexagonal array.

[0094] FIG. 26 shows a perspective view of the assembly of a PCM pack with a hexagonal array with perforations.

[0095] FIGS. 27A and B show in cross section and in perspective view PCM packs incorporating a corrugated wall.

[0096] FIGS. 28A and B show respectively in cross section and in perspective a PCM pack whose envelope may be formed by extrusion.

[0097] FIG. 29 shows a perspective view of a heat exchanger incorporating a number of PCM packs of the kind shown in FIG. 28.

[0098] FIG. 30 shows a perspective view of a heat exchanger incorporating a number of PCM packs of the embodiment of FIGS. 28.

[0099] FIG. 31 illustrates a phase change material pack in accordance with the invention.

[0100] FIGS. 32 to 35 show schematically various embodiments of the fluid conditioning system.

DETAILED DESCRIPTION

[0101] FIG. 1 shows a fluid conditioning arrangement generally referenced 1. The air conditioning arrangement 1 incorporates three air inlets respectively referenced 2, 3 and 4. Through inlet 3 fresh air from outside is drawn into the housing 5 by a fan or pump 6. It is important to note that whilst the embodiments of the invention are primarily illustrated for cooling air, other fluids may also be cooled and/or heated using these systems. In a conventional mode of operation the air is fed through a PCM heat exchanger 7 so that any heat in the air may be absorbed by the PCM before exiting the housing through outlet 8. The arrangement may preferably be equipped with a controller which may be configured to measure the temperature of the PCM in order to determine the extent of cooling that may be achieved by the heat exchanger. If due to the conditions surrounding the heat exchanger, a booster is required, as for example, the PCM heat exchanger fails to be effective or the incoming fluid temperatures are not hot/cold enough, the controller switches on the booster. In this configuration, the booster incorporates a heat pump with a cold heat exchanger and condensation tray 9 located in the path of the air to be cooled and a hot heat exchanger 10. The heat pump would incorporate the necessary compressor and expansion valve or an absorption chiller, desiccant or adsorption cooler. Block 11 illustrates its location between hot heat exchanger 10 and cold heat exchanger 9 when cooling. If the booster is provide to heat the air then heat exchanger 10 is the cool heat exchanger and the hot heat exchanger is heat exchanger 9. If the booster is needed during the day, the controller would cause the provision of air flow over the hot heat exchanger and would cause valve 12 to be closed whilst valve 13 would be opened. An additional fan would pump air through inlet 4 when the arrangement would be operating in the booster mode of operation. Valve 14 is provided to allow re-circulated air through the arrangement. Valve 15 is provided to allow and/or block dependent upon the operator's selection of the intake of fresh air to the arrangement. Valves 14 and 15 can be combined. The invention also envisages systems without the valves or with fewer valves dependent upon the level of control required. Valve 16 is provided in the outlet to the room. The diagram does not show other standard air conditioning components such as air diffusers.

[0102] FIG. 2 shows a fluid conditioning arrangement generally referenced 17 with a booster arrangement employing a liquid carbon dioxide or nitrogen store to provide cooling as it expands in the cold heat exchanger 18. Other than for this booster arrangement, the fluid conditioning arrangement is similar to the arrangement shown and described in detail in FIG. 1. Instead of incorporating an air supply to the hot heat exchanger of the booster, the arrangement incorporates an outlet 20 to allow air back outside. At night, valve 15 opens and valve 14 closes to let in night air. The controller of the arrangement causes the booster arrangement to operate if the night air is not cold enough to freeze the PCM. Valve 16 closes and valve 12 opens if the room temperature gets too cold. During the day valve C closes and valve D opens to let air into the room. If it is cold outside then valve 15 opens and valve 14 closes so less air is re-circulated and vice versa. An escape valve is also provided to allow the expanded gas to escape once the cooling has been transferred to the heat exchanger.

[0103] FIG. 3 shows a further fluid conditioning arrangement generally referenced 21, with a central unit 22 incorporating a booster unit 31, and a plurality of PCM units 23, 24 and 25 distributed around the space to be heated or cooled. Heat transfer fluid lines are provided such as heat transfer fluid line 26. A return line 27 is provided. When the control unit identifies that the PCM stores which are positioned around the building have failed to deliver the desired cooling effect, the booster system 31 is switched on. The booster incorporates a heat exchanger, and could be an evaporative, heat pump, vapour compression system, etc. An air intake 29 draws air from outside across the heat exchanger 28 for cooling or heating when the booster is not needed. A valve 30 is provided between air inlet 29 and optional booster system 31. A further air intake 32 allows air into the optional booster system when in use. An air outlet 33 exhausts hot air from the booster if applicable; for example if a heat pump is used to provide cooling. The system can work in a number of ways, For example at night cool air via inlet 29, can be passed over heat exchanger 28, and this transferred to the PCM modules 23,24 and 25 via the separate fluid lines 26 and 27 to freeze the PCM. If the night time temperature is not cool enough to freeze the PCM then the booster 31 is turned on and air is passed through booster 31 from outside and further cooled by the booster before passing over heat exchanger 28. During the day the PCM modules **23**,**24**,**25** can independently provide cooling to the space as is needed, via radiation or by passing air over a separate heat exchanger. If additional cooling or heating is needed then the booster system can operate independently.

[0104] FIG. **4** shows a central unit for heating or cooling. This system incorporates an external solar collector **34** which is in fluid communication with a drain-off tank **35** which is configured to prevent water freezing in the solar collector at night. A further fluid line **36** is provided between tank **35** and a hot water tank **37**. A boiler **38** is located in series with the hot water tank. The solar collector provides hot water or cooling by working as a radiator at night. During the day, the solar collector provides hot water which can be boosted by the boiler if needed and stored in the hot water tank. Because much of the heat is provided during the day and heating is required at night in residential buildings, the heat may be stored in the latent heat stores around the building. In the summer, the system can still store hot water in the tank for showers but at night cooling from outside can be fed to the PCM tanks in the room by bypassing the hot water tank.

[0105] Instead of employing the central unit of the kind described in FIG. **4**, an evaporative central unit generally referenced **39** may be employed as shown in FIG. **5**. This unit incorporates housing **40**, an air inlet **41** equipped with a filter, a single or a multiple stage evaporative cooler with a wicking mesh **42**, an exhaust air outlet **43** and a fan **44** to cause the flow of air through the unit. A first heat transfer line **45** is employed to return warm water to the unit whilst a heat transfer line **46** is employed to allow cold water to circulate to units in the room. This configuration is particularly advantageous because it allows the working fluid, i.e. the water from the evaporator to cool the PCM rather than the wet air to be used by an evaporative cooler which increases the humidity of a room.

[0106] Instead of, or in addition to, the PCM units of FIG. **3**, a unit **47** as shown in FIG. **6** may be employed. This unit may receive and return fluid from a central system by heat transfer line inlet **48** and outlet **49**. Housing **50** incorporates an air inlet **51** equipped with a filter. An air outlet **52** is provided at an opposite side of the housing **50**. A fan **53** draws the air through the unit.

[0107] FIG. **7** shows an alternative unit which may be placed in a building and which may receive and return fluid from a central system. Unit **54** incorporates a housing **55** containing PCM **56**. One or more of the sides of the unit such as side **57** incorporates no insulation so that cooling and/or heating may be released from these sides by radiation and natural convection into the room.

[0108] FIG. **8** shows a unit **58** with a housing **59** for containing spaced apart PCM components such as component **60**. The unit incorporates an air inlet **61** equipped with a filter and an air outlet **62** with a fan **63**. The PCM components may be plate-like, spherical, shell-like and tubular heat exchangers etc. A heat transfer line **64** forms a winding pattern in close proximity to the PCM, or inside the PCM Pack itself in order to optimise heat transfer. The invention also envisages employing two different kinds of PCM with different melting temperatures for heating and cooling. The heating range may be 40 to 60° Degrees Celsius whilst the cooling range may be 15 to 32° Celsius.

[0109] FIG. **9** shows a further unit generally referenced **65** with a housing **66** containing a plurality of PCM components such as component **67**. The housing **66** incorporates an air intake **68** and an air outlet **69**. A valve **70** is provided in a duct to regulate whether air is received from outside or re-circulated from the room. A further valve **71** is provided to regulate whether the air goes back outside or whether it goes into the room. When this system is combined with ventilation, it has the advantage of using a heat transfer fluid line **72** with a higher heat capacity than air. It is particularly advantageous when used to freeze PCM whilst still providing fresh air.

[0110] FIG. **10** shows a control unit which may be used to assess the requirements of a system. A valve **73** is provided to determine whether the air is re-circulated from the building, taken from outside, or taken from a booster. A fan **74** is provided to draw air through the system. A pressure sensor **75** determines the pressure in order to adjust the fan speed. If the pressure in the duct **76** increases, then the fan is caused to slow down. The pressure sensor may incorporate a pilot tube or any other component suitable for determining a value which may then be equated to the pressure in the duct.

[0111] FIG. **11** shows a further unit generally referenced **77** with a stack of PCM packs such as pack **78**. Unit **77** incorporates a housing **79** for insulating the contents of the unit from the outside heat. Dampers or valves **80** are provided in the inlet duct. A control unit **81** is provided to determine how much air flows through the unit dependent upon how much cooling is needed. An operator interface may be provided to adjust the level of cooling needed.

[0112] FIG. **12** shows two rooms **82** and **83**, each incorporating a PCM module respectively referenced **84** and **85**. A duct **86** communicates air to the PCM modules. A control unit which may be of the kind shown in FIG. **10** is generally referenced **87**. Upstream from the control unit, a booster unit **88** is provided. The booster unit may be of the kind shown in the previous embodiments. These control and PCM modules can be those of FIGS. **10** and **11**.

[0113] The booster may take the form of a Peltier booster which may be of the form shown in FIG. **13** where a unit **89** has a hot side **90** and a cold side **91**. The cold side **91** incorporates a condensation tray **92** or a condensation catcher **93** in order to allow condensation to run off.

[0114] FIG. **14** shows a PCM unit **94** incorporating PCM packs **95**. Each pack incorporates a plurality of recess portions **96** running the length of the packs. The PCM packs incorporate PCM material and an appropriate non-permeable envelope **97**. The recesses are formed in the envelope. The recesses extend only partially across the depth of the packs. The recesses reduce in width progressively as the depth of the recess increases. A flat base face **98** is provided at the bottom of each recess. The recess portions allow the circulation of fluid for optimum heat exchanging. FIG. **14**B shows the arrangement of Figure A in perspective view. FIG. **14** C shows a cross-sectional view of a PCM pack, whilst FIG. **14**D shows a perspective view of a PCM pack.

[0115] FIGS. **15** show a PCM unit **99** with a plurality of hexagonal tubes **100**. Each tube contains PCM material and is capped at both ends by a lid **101**. By stacking a plurality of hexagonal tubes **100**, a number of hexagonal ducts **101** are formed which may be used to allow heating fluid to circulate through the unit.

[0116] FIGS. **16** show views of PCM packs. PCM pack **102** with upper and lower surfaces **103** and **104** which are formed by a succession of recess portions such as recessed portion **105** which increases in width from a flat base portion **106**. The recess portions are effectively half of a hexagon. There are provided protrusions **107** which are also effectively half of a hexagon. The PCM pack is formed as if it were formed by a plurality of side-by-side hexagonal tubes with the common faces such as face **108** removed so that the PCM material is distributed throughout the PCM pack. Thermal conductors may be provided between the upper surface **103** and the lower surface **104** in an alternative embodiment. By stacking a plurality of PCM packs of this form as shown in FIG. **6**F channels for circulating fluid such as channel **109** are formed.

[0117] FIGS. **17** show PCM packs incorporating tubes at regular intervals extending through the PCM layer. Tubes **110** may be used to circulate cooling fluid as appropriate. A cap **111** allows access to the inside of the pack for filling the pack with PCM. A second cap **112** is also provided for facilitating the filing and emptying of the PCM pack.

[0118] FIGS. **18** show PCM packs in accordance with a further embodiment where the pack **113** incorporates a plurality of semi-circular, in cross section, troughs **114**. The recesses or troughs are provided in both the upper surface **115** and the lower surface **116**. The troughs in the upper surface are offset relative to the troughs of the lower surface. A trough in the upper surface is located opposite a flat outermost portion of the lower surface.

[0119] FIG. **19** shows a PCM module in cross-section which takes the form of a heat exchanger **242** with an insulative housing **243**. The housing wall may be selected to hold 80 to 90% of the "coolth" over 8 hours. It may be of approximately 25 mm in thickness with a conductivity of 0.01 to 0.02 W/MK. On the inside of housing **243**, a conductive metal frame **244** forms a lining. A succession of layers of corrugated plates such as plate **45** alternate with PCM pack layers such as layer **246**. FIG. **20** shows the components of FIG. **19** in an exploded view. The corrugated plate may instead be replaced by a number of transverse fins or links which in a similar fashion as the corrugated plate would increase the surface area in contact with air flowing through the channels left between the PCM packs. Since the surface area in contact with air is increased, the PCM packs may be thicker thus allowing greater cooling to be achieved. In a preferred embodiment, the gap between the PCM packs is slightly smaller than the height of the corrugated fins to ensure optimum thermal contact. In order to support the weight of the PCM packs, there is provided rails on the inside of the frame (not shown in the figures). FIG. **21** shows a corrugated plate **247** with a number of projections such as projection **248**. Alternatively, these projections may be holes or a combination of holes and projections in order to break up laminar flow by creating turbulence in order to increase heat transfer. The corrugated plate **247** may be disposed as shown in FIG. **19** adjacent to a sealed PCM pack **249**. The corrugated plate **247** may preferably be made of sheet metal preferably less than 1 mm thick. For optimum structural strength and thermal conductivity, a range of 0.1 to 0.2 mm is envisaged. A number of known techniques are envisaged to form the plate such as pressing or folding. Instead of employing sheet metal, a thermally conductive plastics material may also be selected.

[0120] FIG. **22** shows a PCM pack **250** with an impermeable outer layer **251** for containing the PCM. A handle **252** is provided which may take the form of an oblong opening. A number of recesses **253** and **254** are provided on opposite lateral sides of the pack. These may be employed in order to lock the pack into releasable attachment means provided in a heat exchanger for example. This embodiment illustrates how the PCM pack may be rendered readily portable.

[0121] FIG. **23**A shows a PCM pack formed with an upper wall **255** and a lower wall **256** for trapping PCM. Between walls **255** and **256**, there is provided a plate **257** formed as a succession of V-shaped portions when viewed in cross-section. The components of FIG. **23**A are shown in FIG. **23**B as glued or sealed together in order to prevent any escape of PCM during use.

[0122] The PCM is one of an organic, a salt based hydrate, or a combination of both. A paraffin based PCM is envisaged with a melt temperature preferably within the range of 21 to 24 degrees Celsius. In order to achieve an optimal melt temperature, the different types of available paraffins are mixed in the appropriate proportions.

[0123] Salt hydrates which are suitable for use may for example be hydrated forms of calcium chloride or sodium sulphate. The invention also envisages employing a thickening agent as an addition to the salt hydrates to maintain the salt in its hydrated form. Suitable thickening agents may be selected from the group comprising: Xanthan or Laponite. In addition to the transverse conductive fins of the corrugated plate **257** or instead of such transverse fins, a conductive element may be suspended in the mixture of PCM. An appropriate compound for suspension may be carbon black.

[0124] FIG. **24** shows an alternative construction of a PCM pack generally referenced **258**. The configuration of the PCM pack differs from the preceding embodiment in that a number of holes **259** are provided in the fins **260** of the corrugated plate generally referenced **261**. Such holes allow molten PCM to distribute evenly and to keep air out. The corrugated panel may be glued to improve strength.

[0125] The corrugated panels may be pressed and mainly made of very thin wall thicknesses such as less than 1 mm in order to keep weight to a minimum whilst the profile/ridges/pattern adds a strength. The transverse fins allow the thickness of the PCM pack to be increased by improving conductivity. It allows the PCM to be at an optimal maximum distance of between 4 to 16 mm (or 10 to 20 mm) from the links throughout the pack. Alternative thermal conductors are envisaged to be located in the PCM such as wire wool, chemical carbon nano-tubes, suspended carbon black which may be randomly distributed throughout the material.

[0126] The transverse links may be made of thin metal/plastic which would preferably be less than 1 mm in thickness. The shape and configuration of the plate may be obtained by pressing, stamping and/or folding processes.

[0127] FIG. **25** shows a PCM pack **262** in an exploded view with an array of closely contiguous cylinders **263** for receiving PCM. The cylindrical tubes may take the form of a hexagonal mesh. The array may be formed from a single sheet which is laser cut and pulled apart to result in an array with walls of a thickness of approximately 0.1 mms. Secured to the top and bottom of the array, there is provided top and bottom plates respectively referenced **264** and **265**. The process of assembling may incorporate the following steps: a) attaching the array of hexagonal receptacles to one of the top or bottom plates, b) filling the tubes with PCM in its molten phase allowing sufficient clearance for its expansion as it freezes before c) gluing to attach the remaining panel.

[0128] An alternative PCM pack **266** is shown when compared to the embodiment of FIG. **25**. PCM pack **266** incorporates a shallow walled plateau **267** into which an array of hexagonal receptacles **268** is located. The array of receptacles is sealed between lid **269** and plateau **267**. Holes such as hole **270** are provided through each of the hexagonal receptacles in order to allow PCM to distribute. The panel **269** may be attached to the plateau **267** by ultrasonic welding or by gluing.

[0129] If the PCM is selected to be salt based the material for the pack is preferably selected to be a coated aluminium or a conductive plastics material (for example K greater than 5 W/MK) or stainless steel in order to prevent corrosion.

[0130] One of the key advantages of transverse links is that it allows PCM packs to be made of a greater thickness than would otherwise be possible. For example packs with material thicknesses of 20 to 50 mm may be achieved with effective conductivity.

[0131] FIGS. **27**A and **27**B a PCM pack (FIG. **27**A) and a stack of PCM packs (FIG. **27**B). In this embodiment, the PCM pack is generally referenced **271** and is formed only of two plates **272** and **273** allowing for the filling of PCM in an array of cavities such as cavity **274**. The cavities are formed in cross-section in a V-shape. The portions such as portion **275** would be exposed to air flow. In addition, it is envisaged for the external surface exposed to the flow to incorporate knurling and/or bumps. This kind of relief may be used in any of the preceding embodiments in order to increase the flow turbulence and therefore the heat transfer properties of the pack. The undulated or corrugated plate **273** is formed for example by pressing or folding. As indicated in the stack of packs **276** and **277** air may flow in the cavities provided as indicated by the arrows. This embodiment allows an increase in surface area in contact with the air and a reduction of the maximum distance between the PCM and the conductive material. In other words, it combines the function f the PCM packaging with the transverse links inside as well as the corrugated heat exchanger in touch with the air.

[0132] FIGS. **28**A and **28**B show a PCM pack **278** in two separate views. The PCM packs **278** incorporate a single peripheral wall **279** with a number of inwardly projecting webs such as web **280** and outwardly projecting webs such as web **281**. In other embodiments only externally projecting webs may be provided and/or only internally projecting webs. Within the envelope formed by peripheral wall **279**, PCM **282** is placed to fill the space. In order to enclose the PCM pack, end pieces (not shown in the figures) may be provided and secured onto lateral edges **283** and **284**. The materials used for these PCM packs may be a relatively low permeable plastics material. Alternatively, coated aluminium is also advantageous. Preferably, a conductive of plastics material would be selected with a thermal conductivity factor greater than 1 W/MK. An option of achieving this kind of conductive of plastics material for the PCM pack material would be to add carbon nano-tubes or particles to the plastics material. The process envisaged in order to produce wall **279** would be to form the wall by extrusion.

[0133] FIG. **29** shows a PCM pack module generally referenced **285**. Module **285** incorporates an insulative outer layer **286** formed by side walls **287**, **288**, a base wall **289** and a lid **290**. Within the insulation, there is provided a frame **291** with a number of ledges such as ledge **292** for supporting a stack of PCM packs in a spaced apart relationship. Gaps such as gap **93** are provided to allow the circulation of fluid. The links **280** and **281** extend in this embodiment only partially towards a neighbouring PCM pack plate.

[0134] As shown in FIG. **30**, during assembly, a side **294** may be fully open in order to allow the insertion of the successive packs in similar fashion to a drawer sliding into its case.

[0135] FIG. **31** shows a phase change material pack **300** according to an embodiment of the invention. The pack is made from two pressed panels **301** which are joined at their edges and at two locations **302** in the middle of the pack surface for strength. The surface of the pack is textured to induce turbulent flow in the fluid (air) passing over it.

[0136] A conductive PCM material allows the PCM packs to be thicker, reducing manufacturing costs. Currently the PCM packs/panels are 10-15 mm thick. Where salt based hydrates are used then the pack material must be non-corrosive, non-permeable and robust. Preferably, depending on the thickness, the material should be thermally conductive.

[0137] Preferably metals are used to form the panels **301** as they are non-permeable and highly conductive. Those with the best corrosive properties are aluminium and stainless steel. Further coatings may be needed to reduce the effects of corrosion depending on the salt. Suitable techniques are anodizing, E-Coat or Electro Coat, silane coating, PTFE. Depending on the method of manufacture there are many processes which allow the protective layer to form naturally during the manufacturing process. Aluminium alloys 5052 & 5251 have good formability and very good corrosion resistance, reducing the need for the level of coatings.

[0138] Many plastics have poor permeability and their mechanical properties degrade over time due to the effects of the salt hydrate weakening the plastic, this means that plastics generally need higher wall thickness, ie 1-5 mm rather than 0-1 mm with metals. HDPE is one of the best off the shelf plastics. Additives/processes used to make plastics more conductive also have a positive effect on plastics permeability.

[0139] A composite material may be used. As used commonly in the food industry this may consist of a film of a number of different materials, e.g. aluminium foil for permeability reasons, plastic for corrosive reasons.

[0140] The typical method of manufacture is using superforming/hydroforming or stamping two sides of the pack, and then epoxy gluing or welding the edges shut. A preferably resealable opening is left to fill/refill the pack.

[0141] The methods to control the selective operation of the secondary heat exchanger will now be described. Temperature sensors are placed outside, or within a duct in which outside air enters the building, and inside the area to be serviced by the system. Depending on the required temperature inside the system can provide ventilation, free cooling or cooling/heating via the latent heat store. For example if it is colder outside than inside and cooling is needed, the system can provide direct ventilation bypassing the latent heat store to cool the room. This saves the latent heat store until it is needed. If it is warmer outside than inside then the proportion of outside air to re-circulated air is determined by the minimal ventilation requirements, and the latent heat store is used to cool the air.

[0142] The latent heat store is recharged by passing cool night time air through the system, and either dumping the air in the room (with the benefit of cooling the room) or outside (if the room is occupied and in danger of being over cooled).

[0143] In winter the system traps excess heat at the end of the day, or during peak heating periods (e.g. when the sun hits a glass fronted building—even in winter overheating can occur in these situations) and this is used to temper the ventilated air.

[0144] An optional humidity sensor(s) may monitor the outside humidity and humidity inside, in order to ensure the internal environment does not fall outside the optimum range of 30-70%. For example when raining or it is very humid outside, less ventilation may be provided in order to prevent the humidity rises above these parameters.

[0145] An optional CO2 or other pollutant sensor may be provided to monitor indoor air quality and used to control the amount of fresh air/ventilation provided to the space. Alternatively infra red, motion or proximity sensors may be used to detect occupants or the number of occupants. This is advantageous when the area to be serviced has a variable number of occupants, or usage and therefore the ventilation rate can be varied to better serve the occupants and/or save energy.

[0146] Contacts can be placed inside the pack, and the electrical resistance across the phase change material can be measured. The resistance changes as the PCM melts or solidifies. Care needs to be taken that the pack does not 'short' the measurement circuit.

[0147] A temperature sensor can be used inside the pack to measure the temperature of the PCM itself or placed on the surface of the pack to measure the outside temperature of the pack. One potential problem with both this method and the previous one is that they only measure in a single location, and may result in localised effects, or they require multiple sensors. The sensors also have to be able to be disconnected as the packs are removable.

[0148] With either of these methods the system can monitor the state of the PCM. If the PCM does not reach the desired temperature after a certain time, e.g. when cooling at night, then the control system will turn the booster on.

[0149] Typically a temperature sensor and preferably a humidity sensor are placed at the start and end of the PCM heat exchanger. An algorithm can then be used to calculate the state of the PCM and whether the booster is needed.

[0150] The power output of the heat exchanger is governed by the following equation:

$$P=\rho.v.c.h(\Delta T)$$

[0151] P—power (KW or KJ/s)

[0152] ρ—density of air or HT fluid (~1.2 Kg/m^3)

[0153] v—volume flow rate (m^3/s)

[0154] h—heat exchanger efficiency (%)

[0155] ΔT—difference in temperature between start and end of heat exchanger

[0156] The flow rate can be determined by the control system from the fan speed and whether the air is recirculated/mixed or pulled in from outside (as the resistance will change). Apart from the temperatures the other variables are constant.

[0157] If the temperature of the air out of the heat exchanger is greater than a certain value, e.g. 18 C then the PCM needs further cooling. The system knows the total energy stored in the PCM (from the latent heat KJ/KG and the mass of PCM), and the rate that the system is recharging the PCM based on the equation above. If the temperature difference between the air in and air out of the heat exchanger is small, or if the system calculates that the recharge rate will not freeze all the PCM in the given time period (e.g. 6 hours overnight), then the system can increase the air flow via the fan speed to get the required recharge rate, or turn on the booster system to lower the temperature of the air entering the heat exchanger. When the temperature difference between the air entering the heat exchanger and leaving it is small, then the system knows that no further recharging is possible unless the outside temperature drops further (in which case the fan speed can be turned down/off to save energy) or the booster is turned on to drop the temperature further. The system may also take into account approximate

[0158] In a similar way the system can calculate whether the current rate of cooling will mean the system will run out of cooling before the end of the day, and therefore turn the booster on, increase or decrease the air flow rate.

[0159] FIG. **32** show an embodiment of the fluid conditioning apparatus in which the secondary heat exchanger can be bypassed when not in use, so that energy is not wasted when the secondary heat exchanger is not in use. In this embodiment, air from outside the building enters the system through a first filter **401**. Air from the room to be heated/cooled enters through a second filter **402**. A valve **403** selects the proportion of air from outside and from within the room that is supplied to the fan **404** and through the PCM heat exchanger **405**. A second valve **406** selects the proportion of air that is returned to the outside or back to the room after passing through the PCM heat exchanger.

[0160] An evaporator and secondary heat exchanger **407** is provided in the path of the air from the first valve **403**. A bypass valve **408** selects whether the incoming air passes through the secondary heat exchanger or not. A condenser air conditioning unit **409**, usually located outside the building comprises a condenser **410** and a compressor **411**. Any chiller unit could be used. An expansion valve **412** is provided in the upstream path from the air conditioning unit **409**.

[0161] FIG. **33** shows a further version of the fluid conditioning apparatus in which the same reference numerals are used for the same components shown in FIG. **32**. In FIG. **33**, an indirect evaporator **413** is provided to separate the wet side of the system from the air entering the controlled environment so that there is no increase in humidity in the controlled environment. The evaporator **413** may be located remotely. In this embodiment the first valve **403** acts as a bypass valve **408**.

[0162] FIG. **34** shows a further version of the fluid conditioning apparatus in which the same reference numerals are used for the same components shown in FIGS. **32** and **33**. In this embodiment, a remote booster unit **415**, which may use any suitable heat exchanger is connected to the PCM heat exchanger **405** via an input duct **416**. An exhaust duct **417** is provided to the outside environment. In FIG. **34**, the outside perimeter of the room to be serviced is indicated by reference number **418**. A weather louvre **419** is provided with an additional fan **420** for pulling air out of the room **418** so that the load on the main fan **404** is reduced.

[0163] FIG. **35** shows a further version of the fluid conditioning apparatus in which the same reference numerals are used for the same components as the preceding figures. In FIG. **35**, the dashed lines show how the system can be divided up into a control unit module **421**, a bypass module **422** and a booster module **423** connected by appropriate ducting. The booster module **423** can also be placed between the control module **421** and the PCM heat exchanger **405**.

[0164] Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of them mean "including but not limited to", and they are not intended to (and do not) exclude other moieties, additives, components, integers or steps. Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

[0165] Features, integers or characteristics described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith. All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. The invention is not restricted to the details of any foregoing embodiments. The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

1. A fluid conditioning arrangement comprising a primary heat exchanger configured to cool and/or heat the fluid; a secondary heat exchanger configured to cool and/or heat the fluid; and a controller for operating said secondary heat exchanger when said primary heat exchanger fails to cool and/or heat the fluid at a predetermined acceptable level; wherein said primary heat exchanger is a phase change material (PCM) based heat exchanger.

2. An arrangement according to claim **1**, wherein said secondary heat exchanger is selected from: a vapour compression cycle based air conditioning system, a heat pump, an absorption chiller, a desiccant, an adsorption cooler or a heater element.

3. An arrangement according to claim **1**, wherein said secondary heat exchanger incorporates a liquid store suitable for cryogenic cooling.

4. An arrangement according to claim **1**, wherein said secondary heat exchanger incorporates an evaporative cooler.

5. An arrangement according to claim **4**, wherein said evaporative cooler incorporates a housing with an air intake; a corresponding air outlet; a liquid inlet;

a corresponding liquid outlet; and a wicking surface.

6. An arrangement according to claim **1**, wherein said secondary heat exchanger incorporates a Peltier cooler.

7. An arrangement according to claim **1**, wherein said secondary heat exchanger exchanges heat with a liquid which then exchanges heat with the PCM of said primary heat exchanger.

8. An arrangement according to claim **1**, wherein said primary heat exchanger incorporates one or more units housing PCM; wherein said housing incorporates a PCM tank.

9. An arrangement according to claim **8**, wherein said tank incorporates insulated sides and at least one side without insulation in order to enhance convection through said side.

10. A phase change material (PCM) module comprising a number of PCM packs; a housing for thermally insulating said number of PCM packs from a module's surrounding medium; said packs being in the form of a panel with an upper surface, a lower surface, and relatively narrow lateral sides; wherein a plurality of troughs in at least either the upper or lower surfaces of the panel are provided to allow fluid to flow through the module for heat exchange with the PCM.

11. A phase change material (PCM) module comprising a number of PCM monoliths; a housing for thermally insulating said number of PCM monoliths from a module's surrounding medium; and gaps being formed between a stack of said monoliths in said module to allow fluid to flow through the module for heat exchange with the PCM.

12. A module according to claim **11**, wherein said monoliths are hexagonal in cross-section.

13. A phase change material (PCM) module comprising a number of PCM packs; a housing for thermally insulating said number of PCM packs from a module's surrounding medium; and conduits passing through said PCM packs to allow fluid to flow through the module for heat exchange with the PCM.

14. A fluid conditioning arrangement comprising a first heat exchanger configured to cool and/or heat fluid; and a second heat exchanger configured to cool and/or heat fluid; wherein said one of said heat exchangers is a phase change material (PCM) based heat exchanger; and the other is an evaporative cooler.

15. A fluid conditioning arrangement comprising a first heat exchanger configured to cool and/or heat fluid; and a second heat exchanger configured to cool and/or heat fluid; wherein said one of said heat exchangers is a phase change material (PCM) based heat exchanger; and the other is a Peltier cooler.

16. A fluid conditioning arrangement comprising a first heat exchanger configured to cool and/or heat fluid; and a second heat exchanger configured to cool and/or heat fluid; wherein said one of said heat exchangers is a phase change material (PCM) based heat exchanger; and the other is a solar based heat exchanger.

17. (canceled)

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