US 20190137191A1

(19) **United States**

(12) **Patent Application Publication**

Lawrence

(10) **Pub. No.: US 2019/0137191 A1**

(43) **Pub. Date: May 9, 2019**

(54) **THERMAL CAPACITOR**

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(21) Appl. No.: **15/804,185**

(22) Filed: **Nov. 6, 2017**

Publication Classification

(51) **Int. Cl.**

F28D 20/02 (2006.01)
F28D 17/04 (2006.01)

(52) **U.S. Cl.**

CPC ***F28D 20/021*** (2013.01); ***F28D 17/04*** (2013.01)

(57) **ABSTRACT**

An insulated vessel containing phase change material (PCM), with an elongated conduit through the PCM, the conduit having an inlet and outlet extending outside of the insulated vessel. The PCM absorbs and stores thermal energy originating from a heat source external to the insulated vessel. Operation fluid flowing through the conduit absorbs stored thermal energy from the PCM and can be utilized on demand. A second conduit may be provided to introduce thermal energy to charge the PCM.

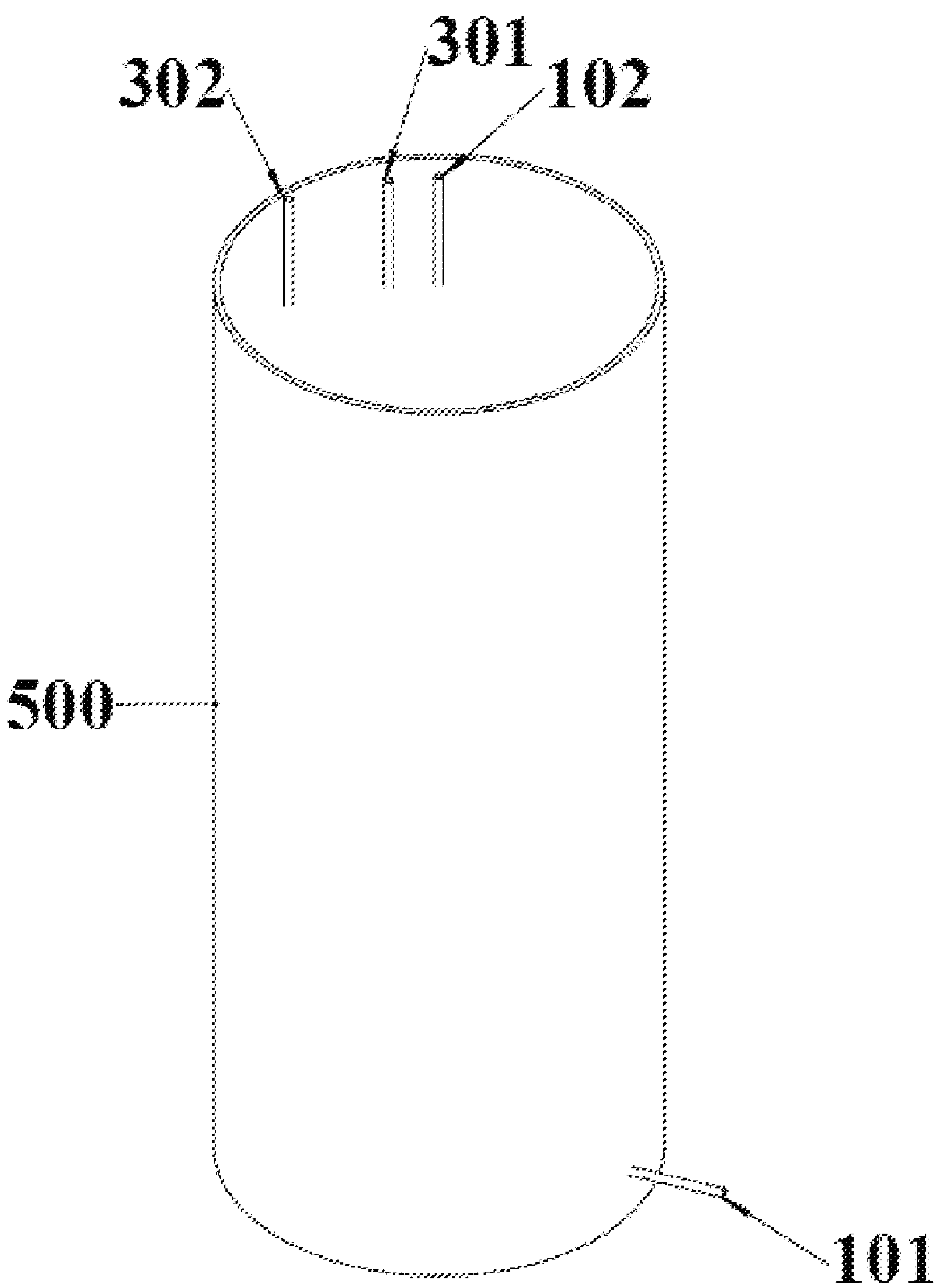


FIG 1

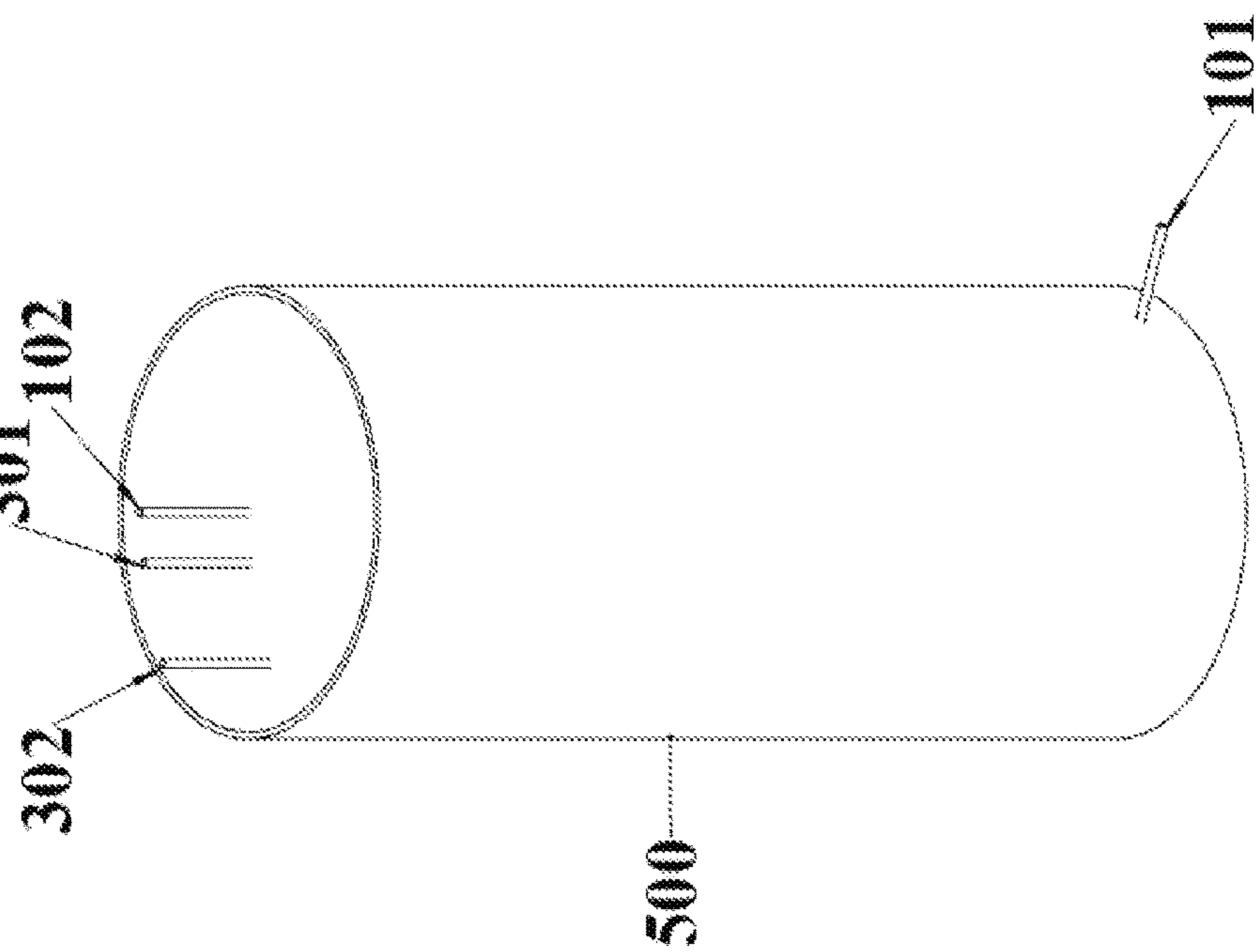


FIG 4

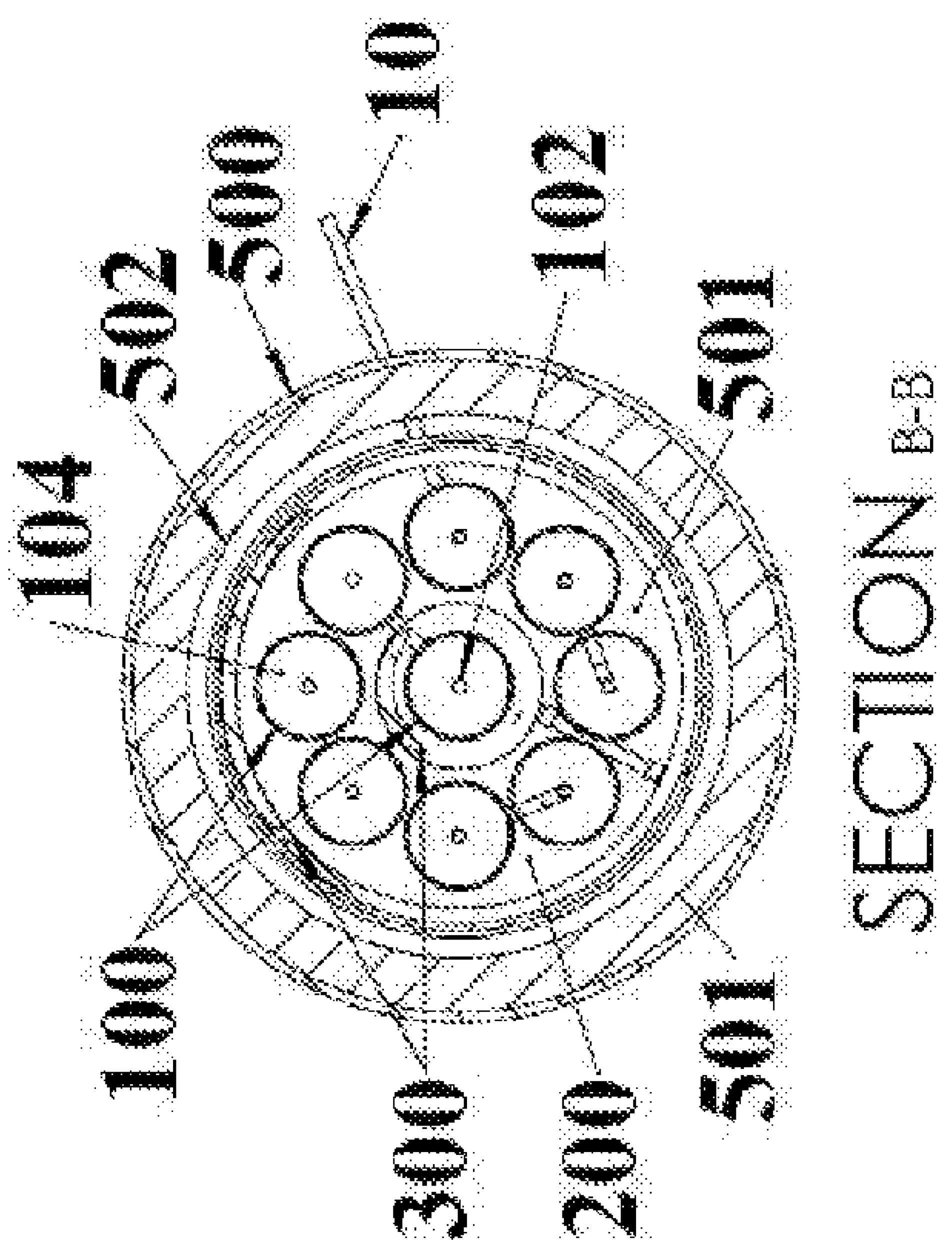


FIG 3

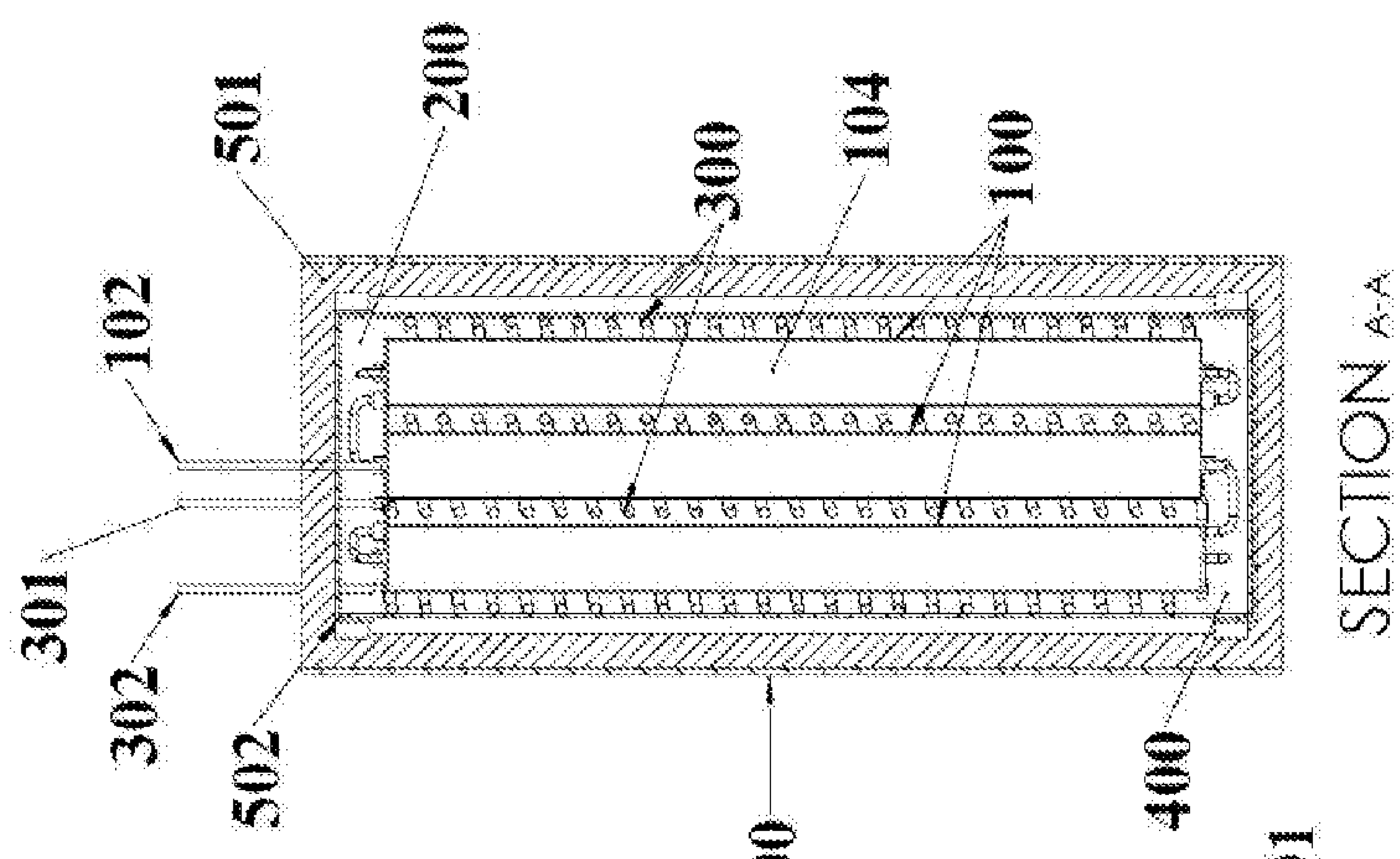


FIG 2

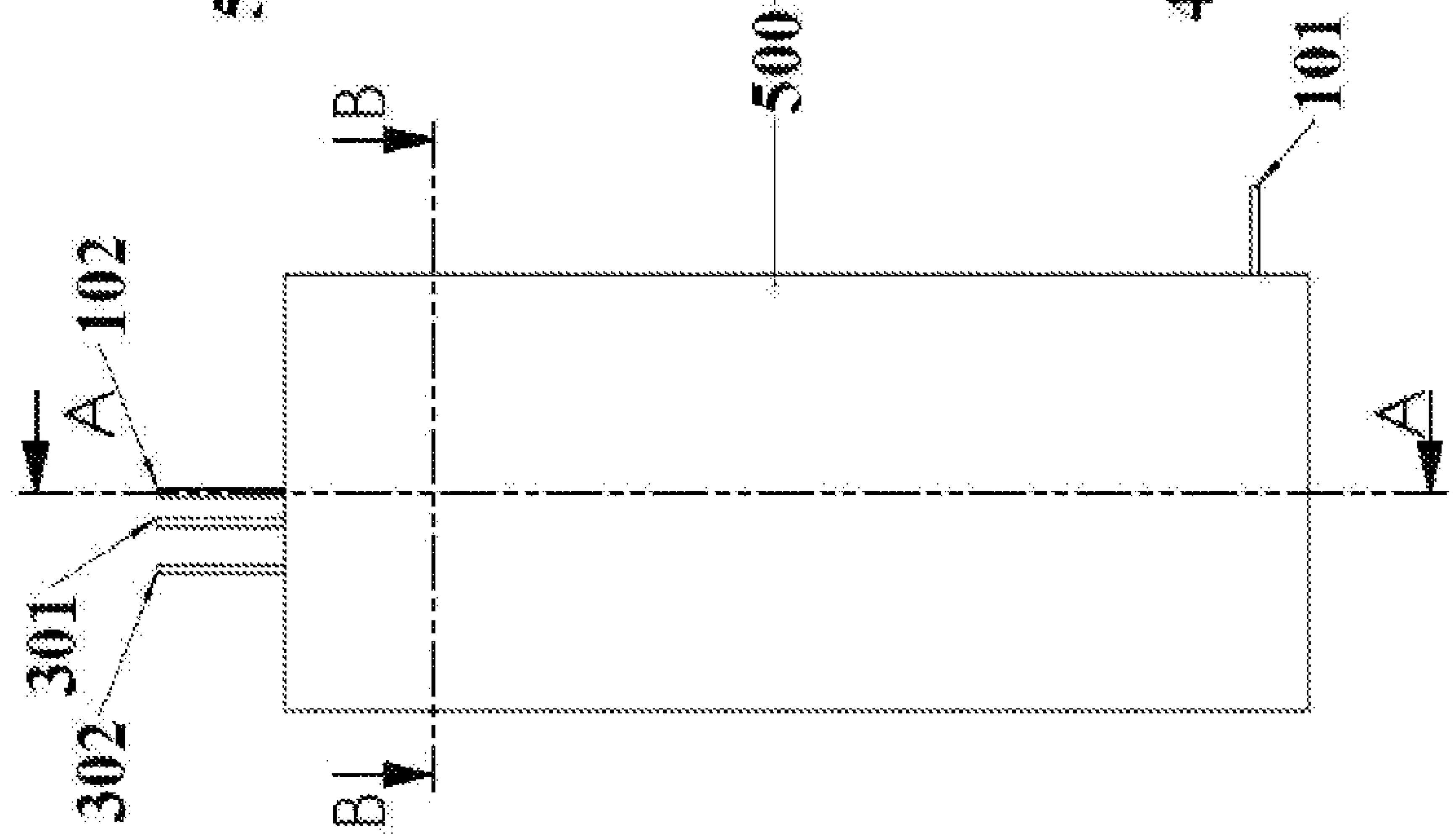


FIG 5

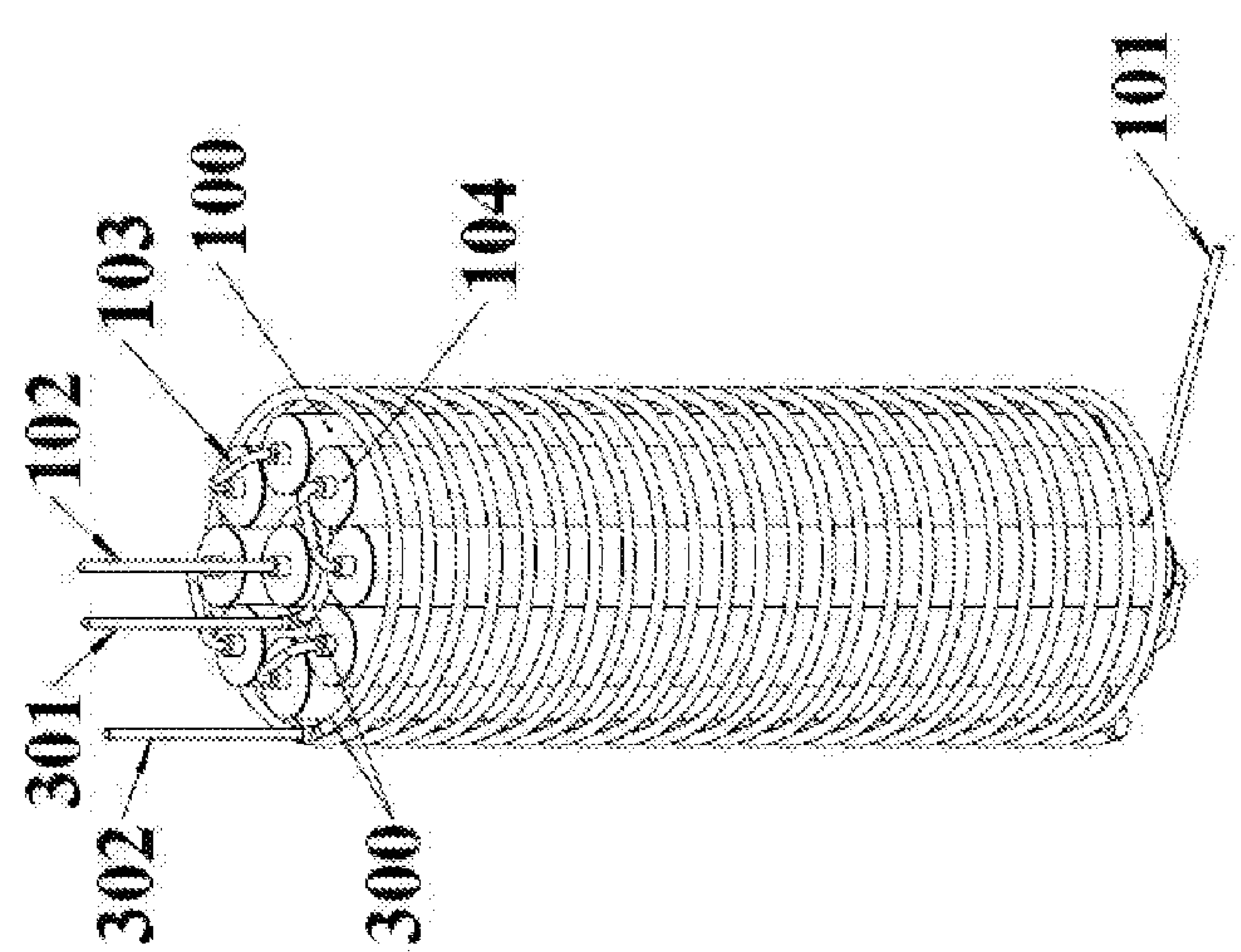


FIG 6

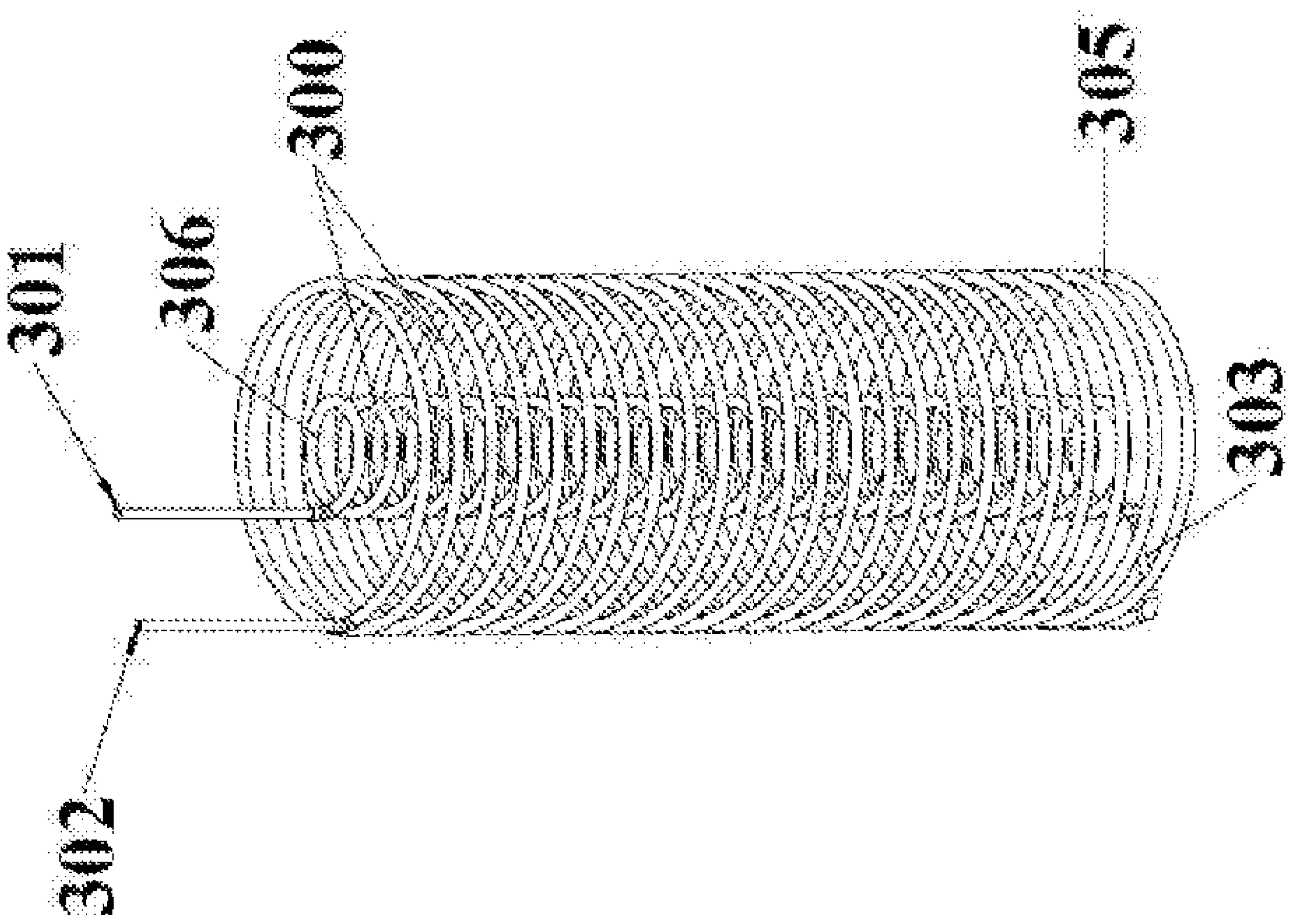


FIG 7

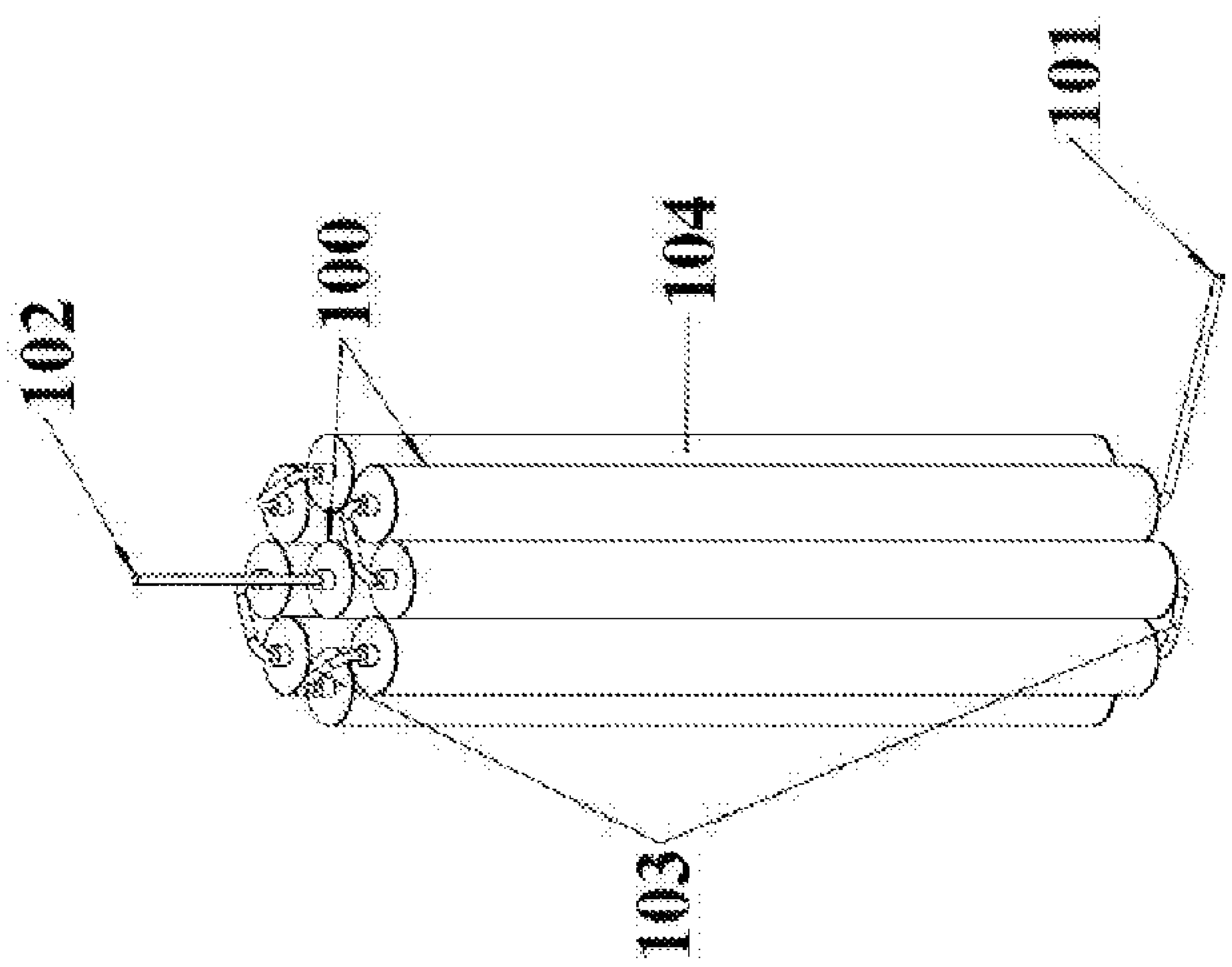


FIG 10

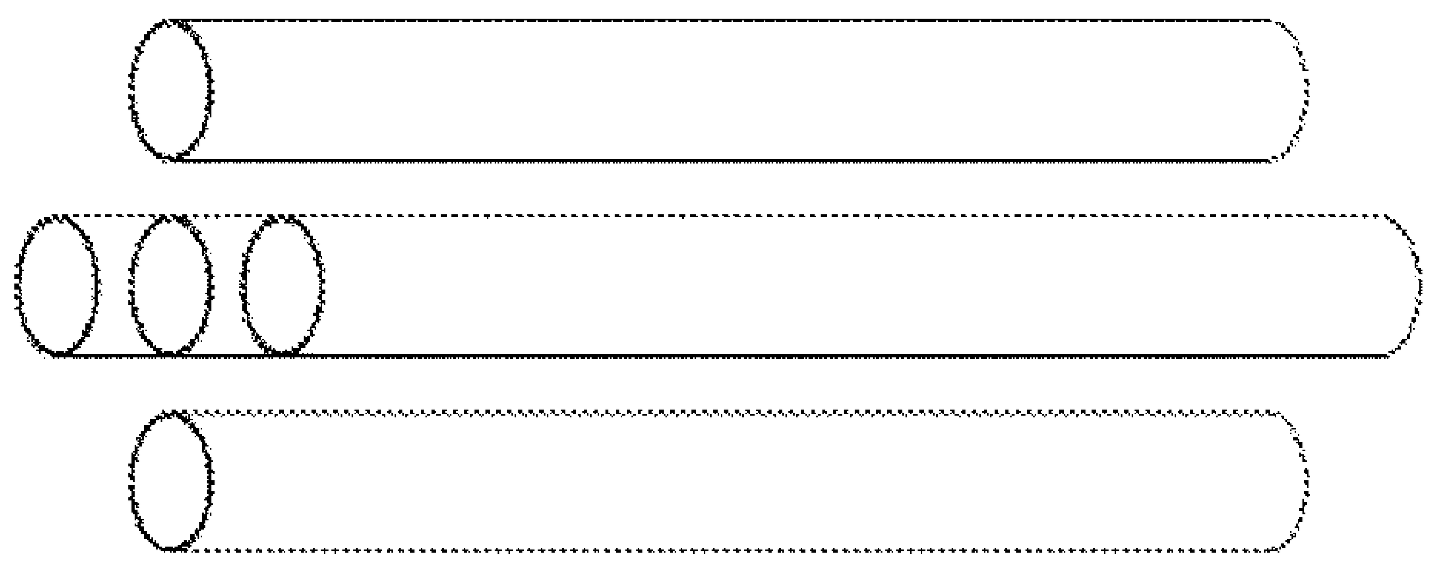


FIG 13

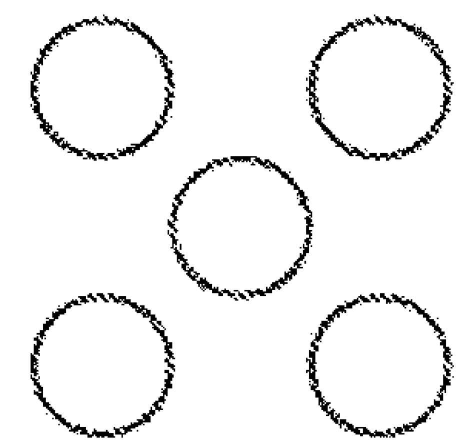


FIG 9

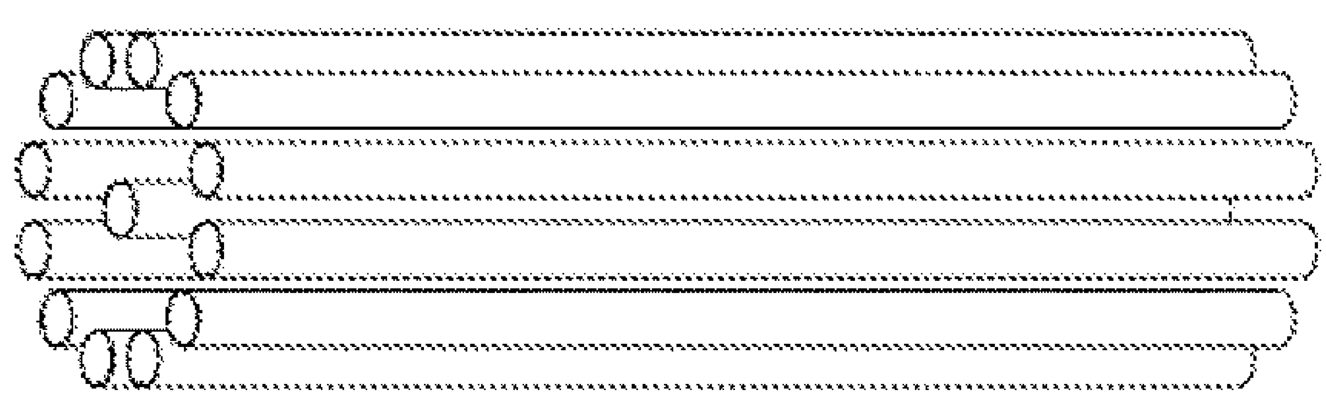


FIG 12

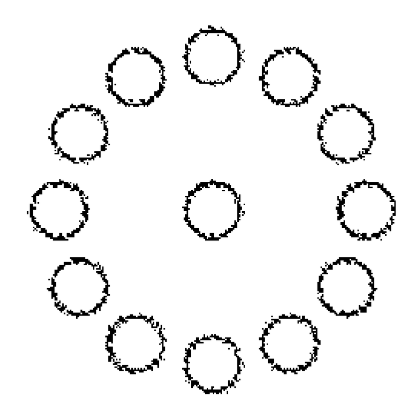


FIG 8

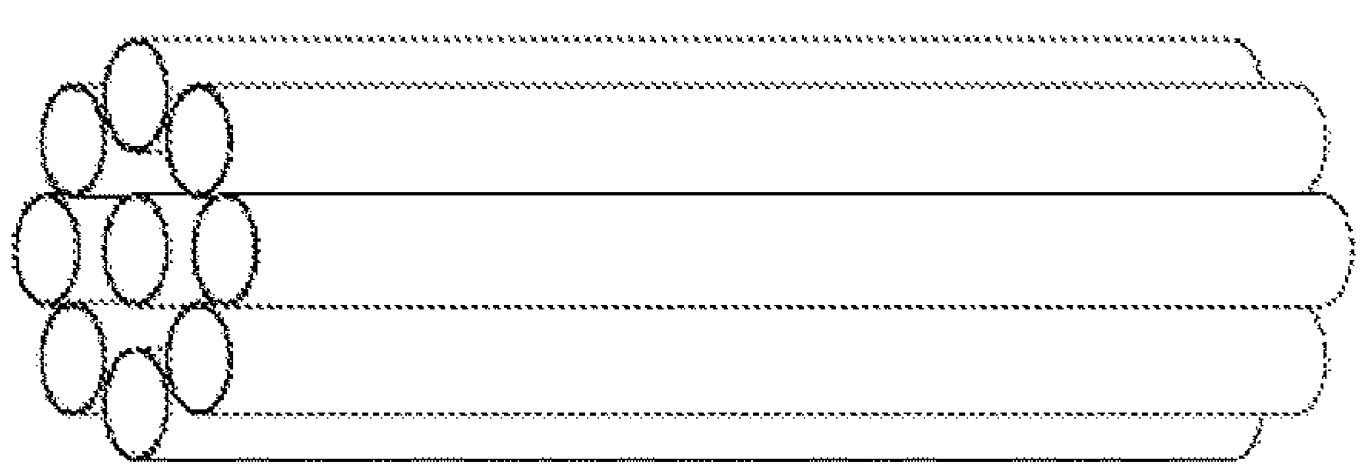


FIG 11

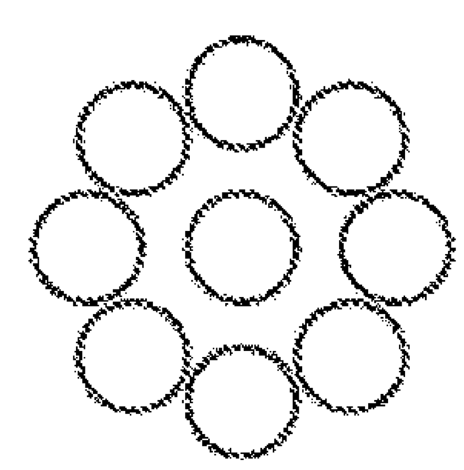


FIG 16

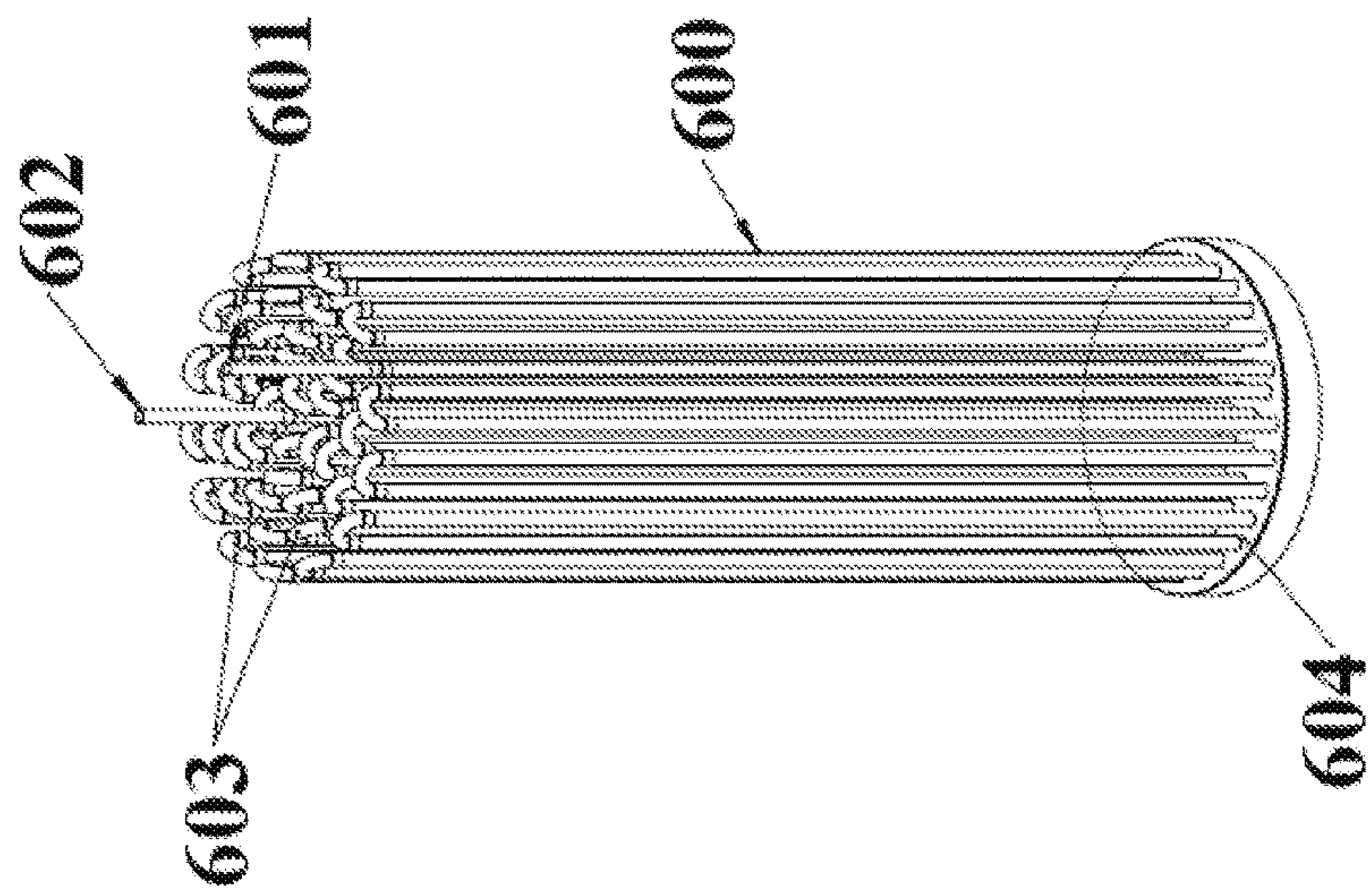


FIG 15

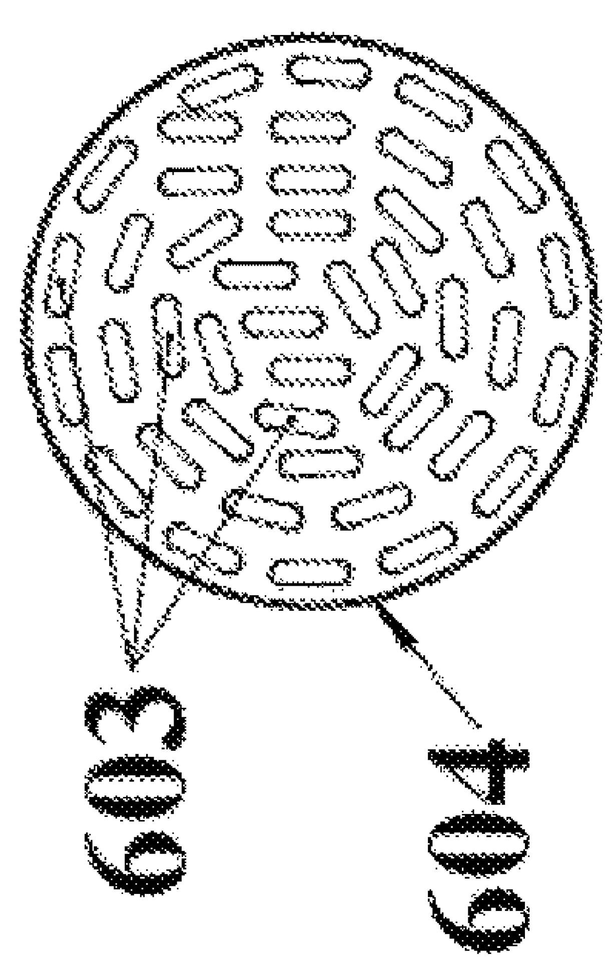


FIG 14

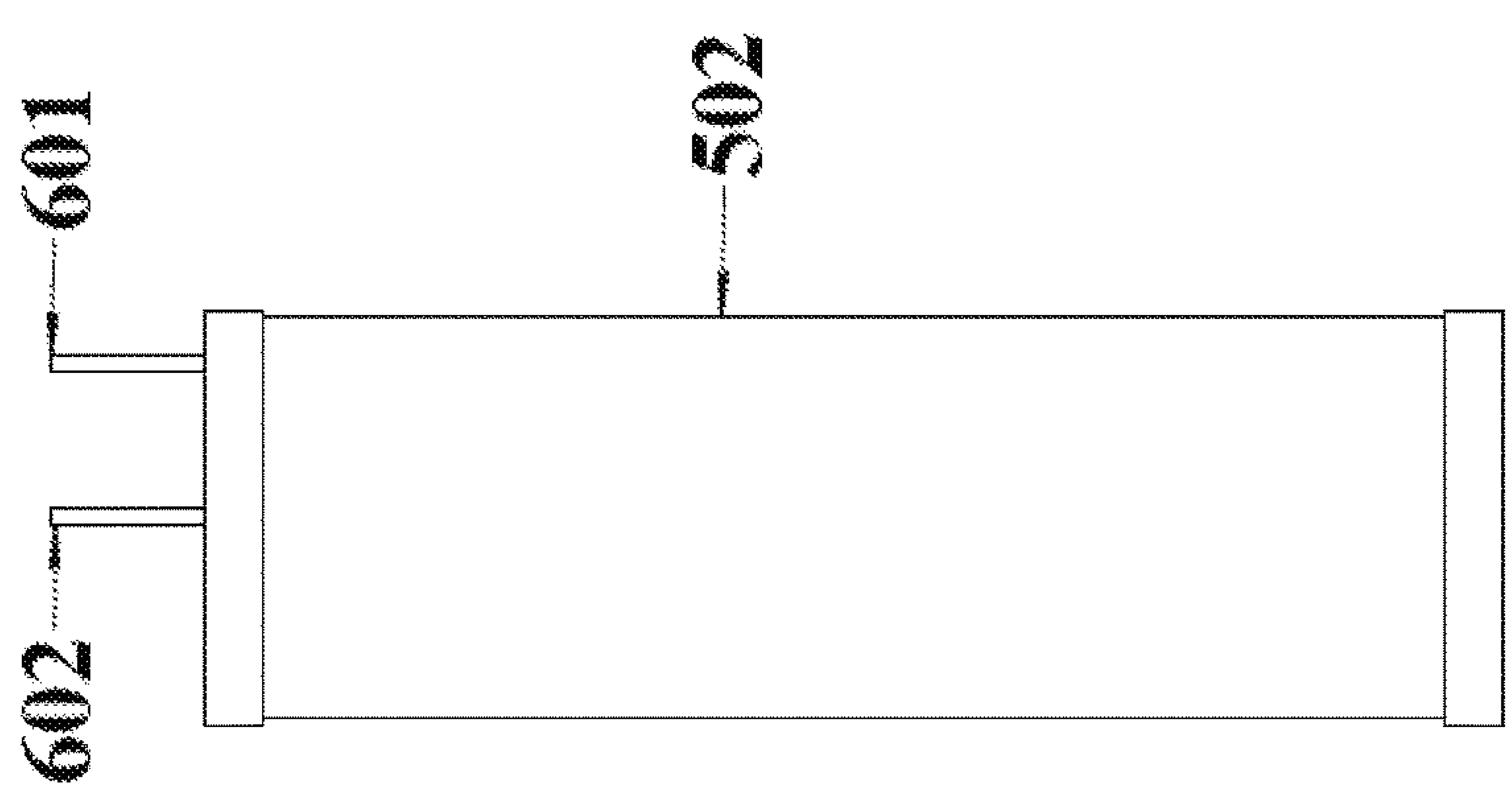


FIG 18

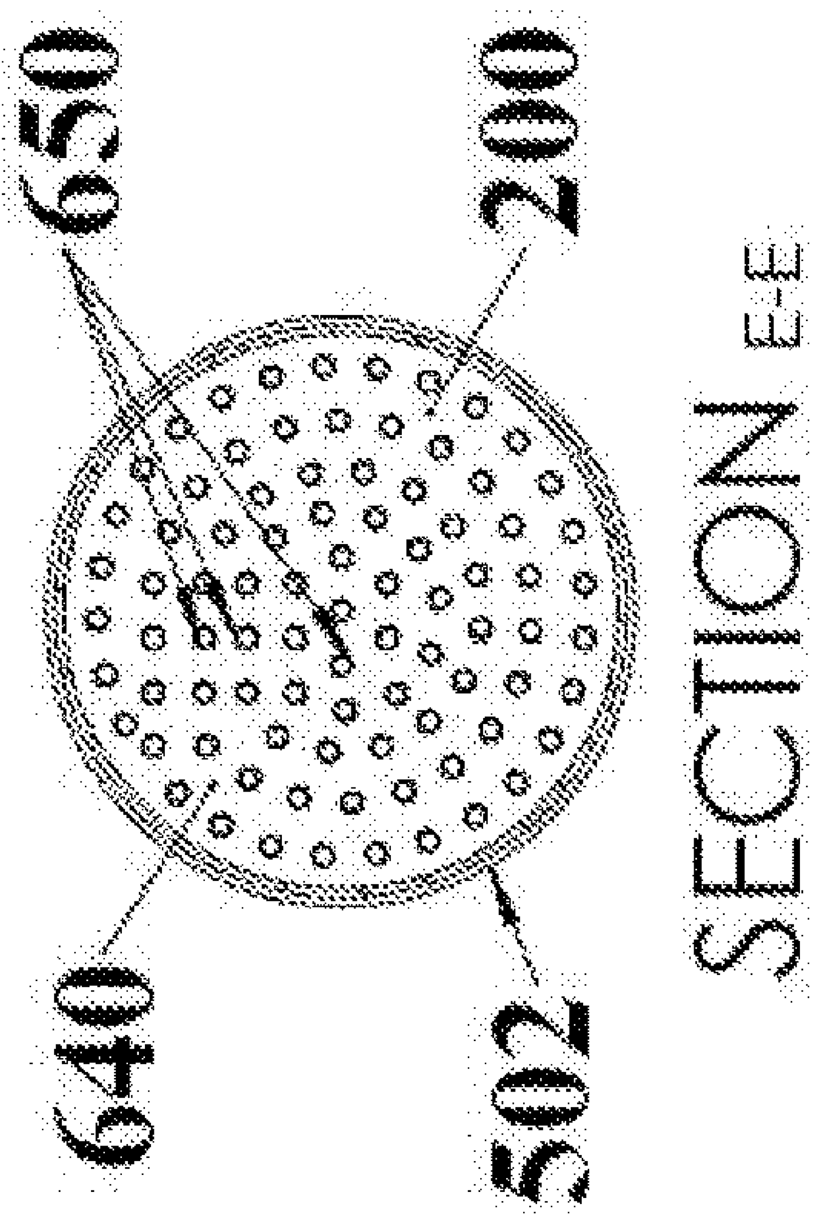


FIG 17

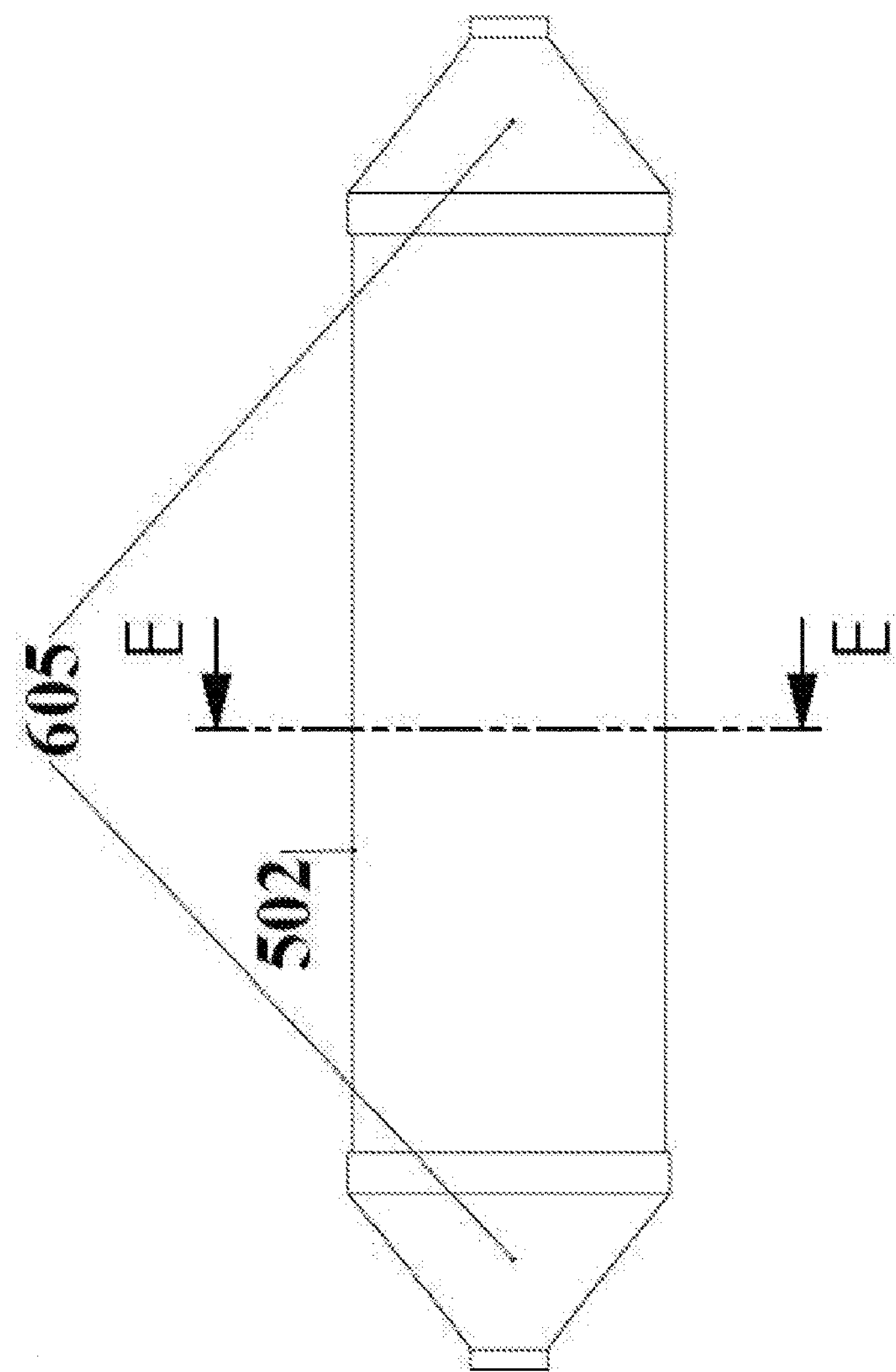


FIG 20

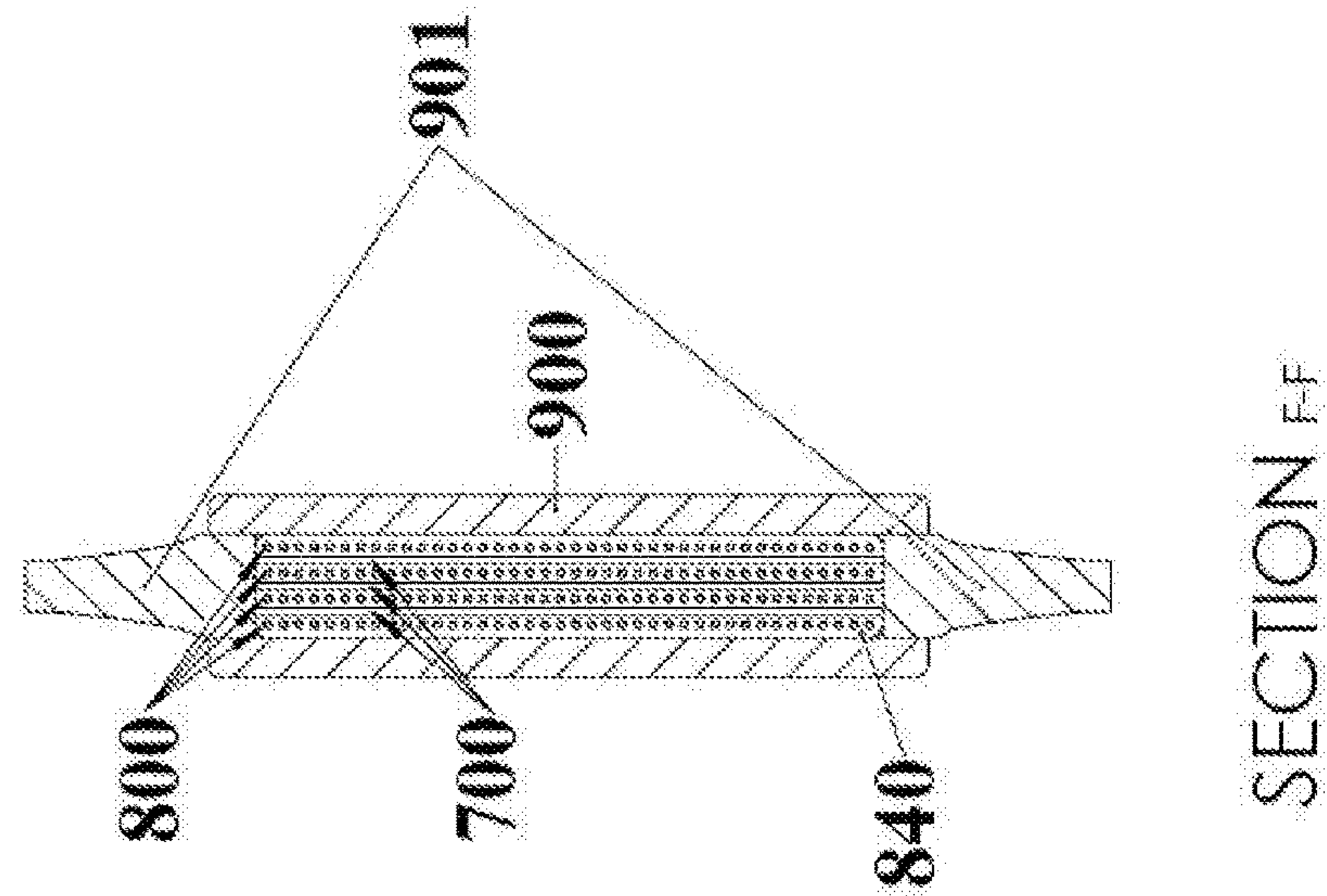


FIG 19

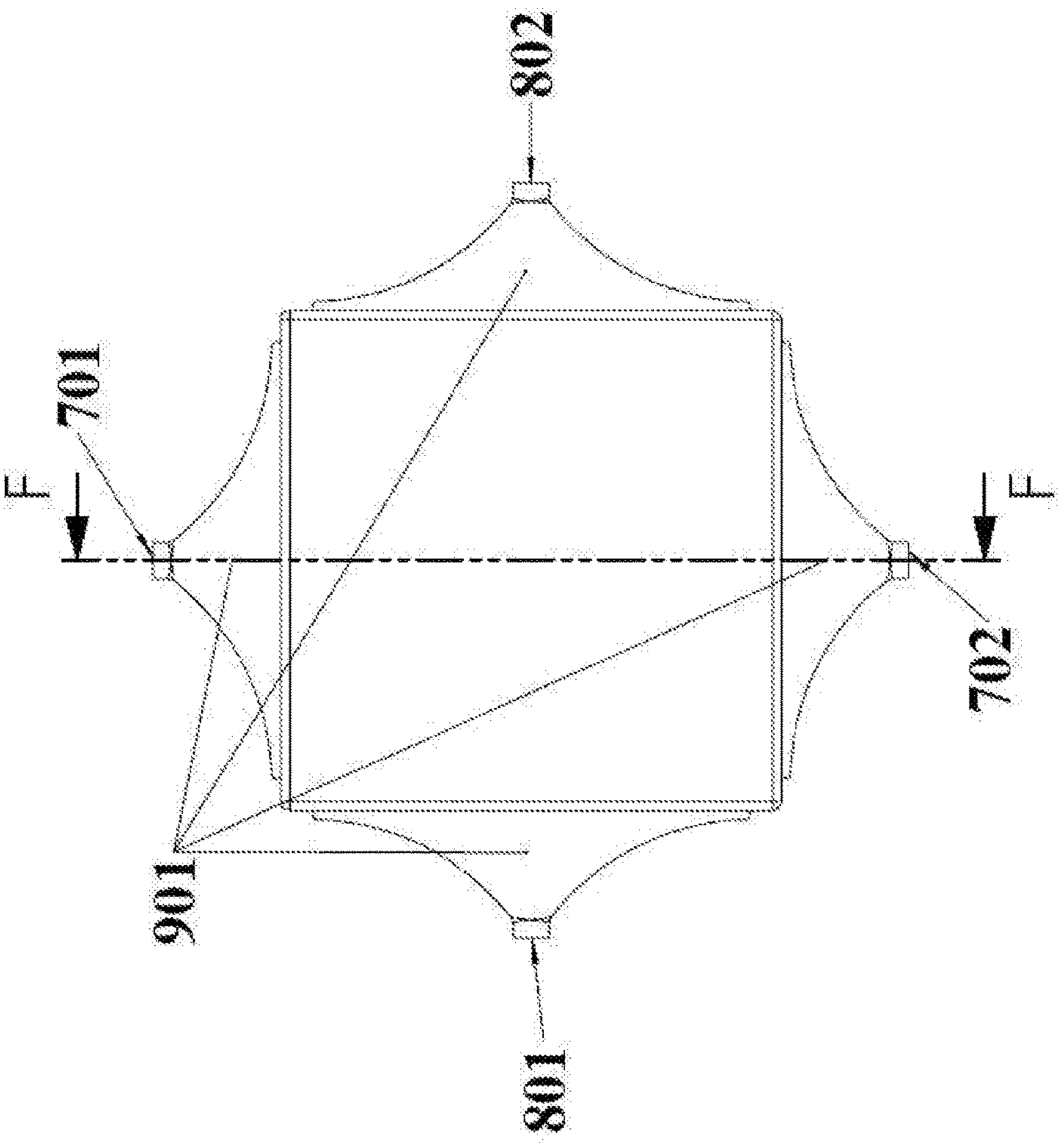


FIG 21

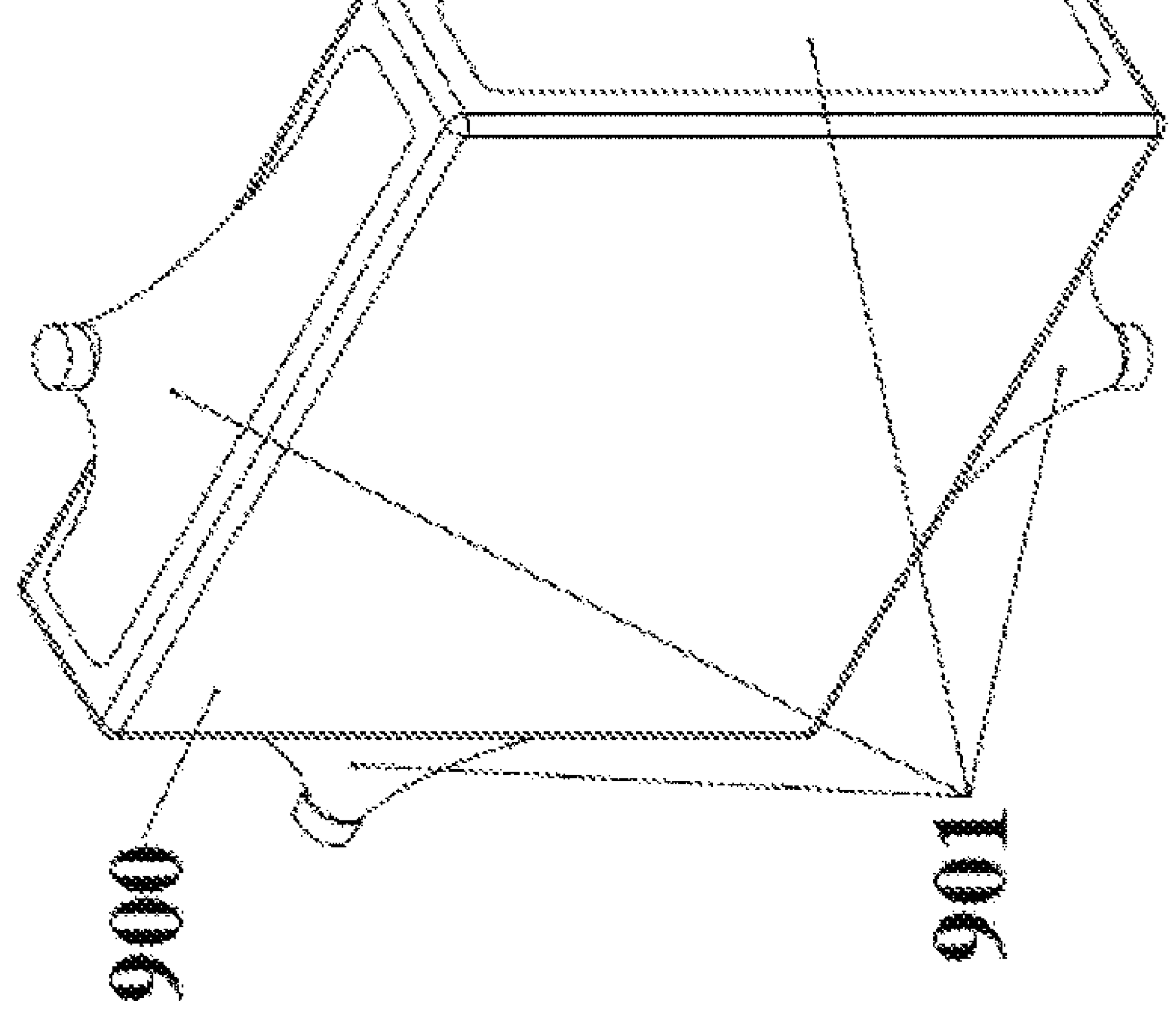


FIG 22

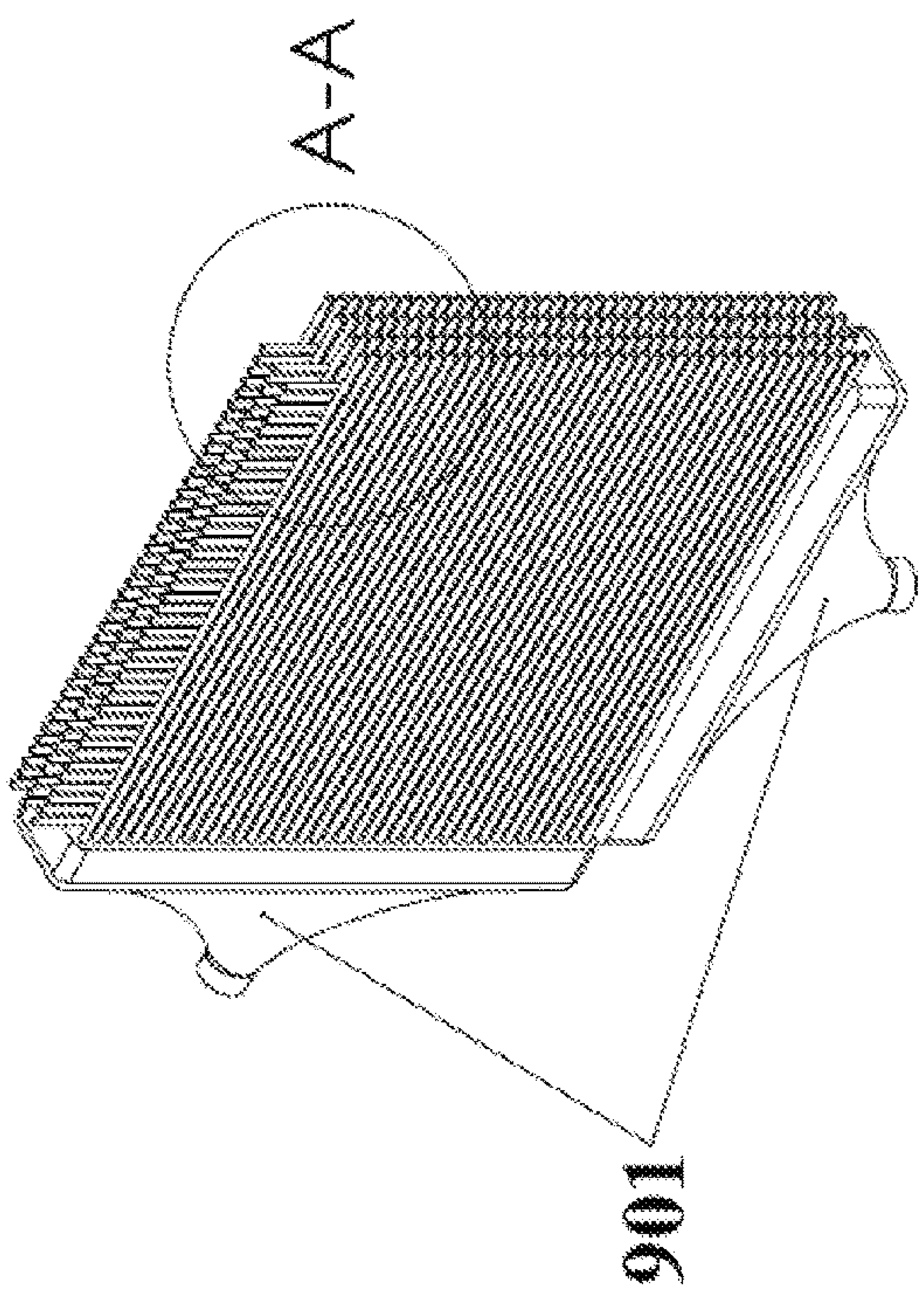
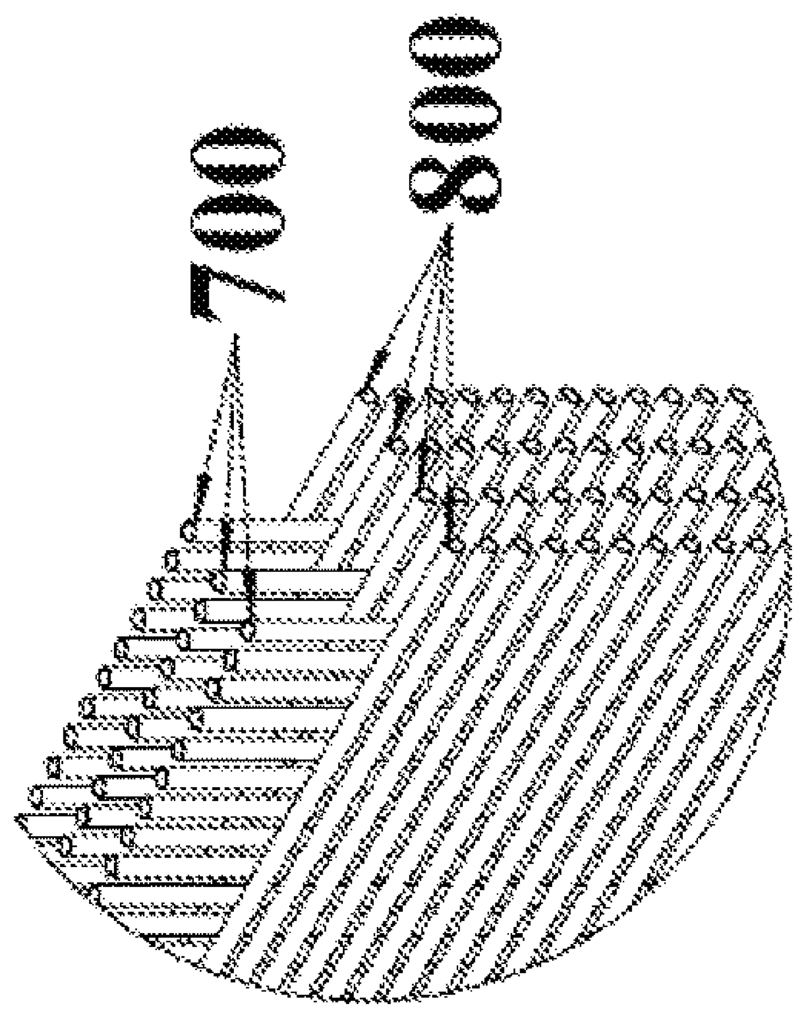


FIG 23



DETAIL A-A

FIG 24

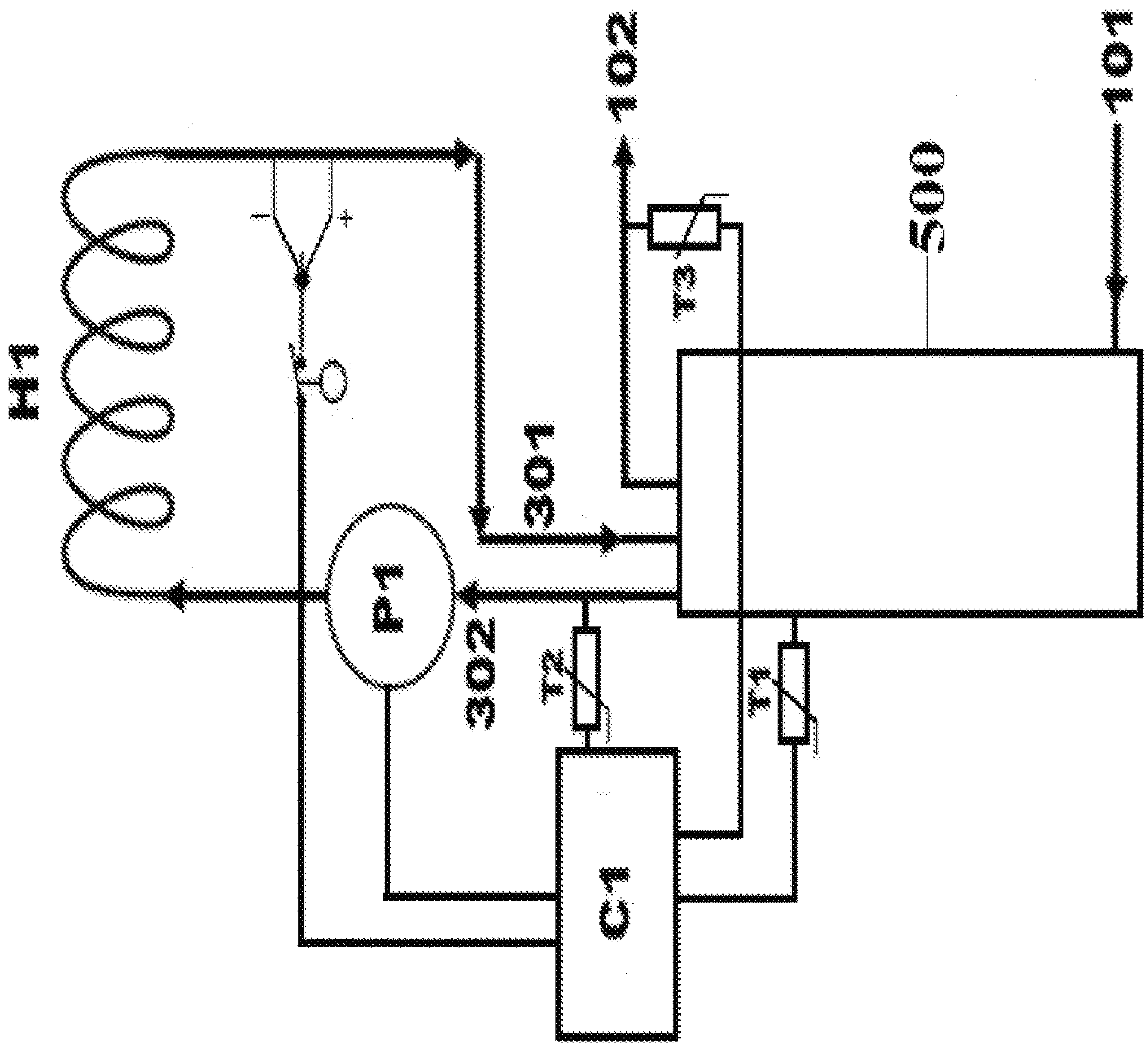
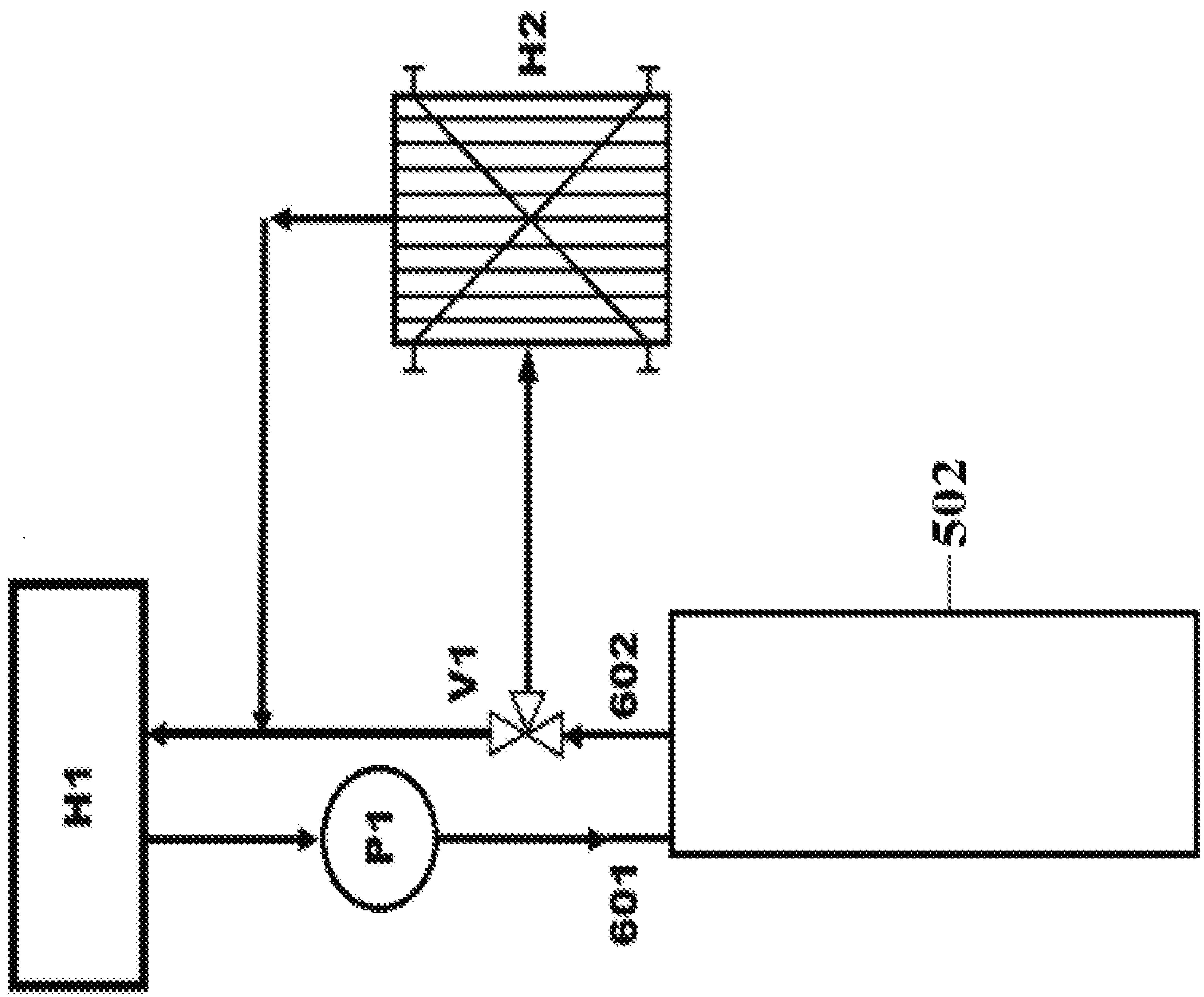


FIG 25



THERMAL CAPACITOR

FIELD OF INVENTION

[0001] This invention directly relates to the field of energy storage. The invention is a device used for increasing the efficiency and/or prolonging the operation of a fluid heating system. Such systems include but are not limited to water heating, space heating, boilers, and forced hot air systems.

BACKGROUND

[0002] Responsibly supplying energy needed for human society has arguably become the most complex, and controversial challenge facing us today. The sun setting at night remains the most prevalent challenge for solar energy as a primary power source. It is well known in the power industry that the highest demands for power usage are in the morning and evening, when people are leaving their homes for the day and returning home from work or school. Compounding the problem of high demand, these times are also when the sun's rays are at their weakest. This creates a need to supplement solar energy systems with some conventional carbon fuel based energy. Similarly, many long existing heating systems operate at low efficiencies. In between cycles, most conventional heating systems rapidly lose temperature to their surroundings, due to less than optimal insulation, and older, less efficient materials. This puts a heavy tax on the heat source, which must bring the entire system back up to operating temperature at the start of each cycle. These fundamental problems have led to widespread research into storage of thermal energy. Although there have been many reviews of storage media, there are not many which focus on the storage system itself. This disclosure goes in depth into the design and application of a practical and scalable thermal energy storage system.

[0003] The three most commonly used media for thermal energy storage today are water and stones, ceramic brick, and phase change material (PCM). This disclosure utilizes PCM as the storage media because it possesses the highest energy storage-to-volume ratio out of the three. This ratio means that PCM packs the most energy storage capability into the smallest footprint. PCMs are latent heat storage materials where thermal energy is absorbed by melting the PCM, and the majority of the thermal energy is absorbed at the PCM's melting temperature, during its transition from a solid to liquid.

[0004] There are two types of heat energy: latent and sensible. Latent heat is the amount of energy required to change matter from one state to another, such as from liquid-to-solid or liquid-to-gas. PCMs are typically substances which utilize a solid-to-liquid phase change. During a phase change of any substance, its temperature will remain the same as you add or subtract energy until its change is complete. This is something which can be observed by noting the amount of time liquid water will remain at 32° F. before freezing into a solid, or at 212° F. before turning into a vapor. Air conditioning is only possible because of this latent heat phenomenon. As warm liquid refrigerant is passed through a diffuser, the pressure drop causes the refrigerant to change phase into a gas, drawing an enormous amount of thermal energy out of its surroundings, thus cooling the air passing over it. Sensible heat is the very familiar rise of temperature which can be readily detected, and is the energy used to increase the temperature of an object without affecting a phase change. Sensible heat is far less efficient for thermal energy storage than latent heat, which may have 100 times the storage capacity of sensible heat. As an example, generic concrete has a specific heat (sensible) value of 1.0 kJ/kg K with no latent heat capacity. Whereas common paraffin wax as a PCM has a specific heat of 2.9 kJ/kg K with a latent heat capacity of 154 KJ/kg. The latent heat value is gained at the melting temperature of paraffin which is around 100° F. Examining a temperature rise from 0-100° F. (55.6 K) for **1**kg of paraffin wax, 55.6K*2.9 KJ/kg K*1 kg+154 KJ/kg*1 kg=315 KJ of energy stored. Concrete at the same temperature rise would only absorb 55.6*1 KJ/kg*1 kg=55.6 KJ. This means that you would need nearly six times the amount of concrete to achieve the same amount of energy storage as paraffin wax, showing the superiority of PCM to ceramic materials.

[0005] Phase change materials (PCM) are substances which absorb and release thermal energy depending on the thermodynamic process of its environment. During a process of melting or vaporizing, PCMs absorb large amounts of energy. Conversely, when such a material is in process of condensing or freezing it releases a large amount of energy in the form of latent heat at a relatively constant temperature. PCMs can store 5 to 14 times more heat per unit volume than naturally occurring materials such as water, masonry or rock. Among various heat storage options, PCMs are particularly attractive because they offer high-density energy storage and store heat within a narrow temperature range.

[0006] One key advantage to PCMs are their narrow temperature range of latent heat storage, based on its specific phase change temperature. This allows PCM systems to be optimized for specific applications. One example being household hot water, a PCM which melts at a desirable hot water temperature could be chosen and regulated at +/−5 degrees Fahrenheit of that temperature.

SUMMARY OF THE INVENTION

[0007] The invention provides a single self-contained system for storage and release of thermal energy. In a preferred embodiment, phase change material (PCM) is charged to store heat, and operation fluid flows through a heat exchanging system which is immersed in the PCM to absorb thermal energy from the PCM, increasing the temperature of the operation fluid for use outside of the invention. Preferably the PCM is charged by a heated charging fluid or other external heat source. The preferred embodiment of the invention uses separate modules of operation and/or charging fluid to interact with PCM by means of conduction, via a series of interconnected pipes. The interconnected pipes and PCM are contained within a well-insulated vessel to maximize the exchange of thermal energy between the PCM and operation/charging fluids. Where a charging fluid is used, a separate system of interconnected pipes carries thermal energy from an outside heat source, and transfers it to the surrounding PCM within the invention.

[0008] As used herein, the term "operation fluid" refers to fluid which is affected by the invention, for example heated water for use with residential or commercial plumbing and appliances. The term "charging fluid" refers to fluid used to affect the PCM of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a perspective view of a preferred embodiment of the invention

[0010] FIG. **2** is a side view of preferred embodiment showing cross sectional views along lines A-A and B-B of FIG. **3** and FIG. **4**

[0011] FIG. **3** is a cross sectional view along line A-A of FIG. **2**.

[0012] FIG. **4** is a cross sectional view along line B-B of FIG. **2**.

[0013] FIG. **5** is a perspective view of the heat exchanger assembly of the preferred embodiment of the invention.

[0014] FIG. **6** is a perspective view of the portion of the heat exchanger assembly in the preferred embodiment of the invention which contains charging fluid.

[0015] FIG. **7** is a perspective view of the portion of the heat exchanger assembly in the preferred embodiment of the invention which contains operation fluid.

[0016] FIGS. **8-10** are alternate configurations of the operation fluid containers for the heat exchanger assembly.

[0017] FIGS. **11-13** are top views of the alternate configurations of the operation fluid containers shown in FIGS. **8-10**.

[0018] FIG. **14** is a side view of an alternate embodiment of the present invention.

[0019] FIG. **15** is a bottom view of an alternate embodiment of the present invention.

[0020] FIG. **16** is a perspective view of the heat exchanger assembly of an alternate embodiment of the present invention.

[0021] FIG. **17** is a side view an alternate embodiment of the present invention showing cross sectional view along line E-E.

[0022] FIG. **18** is a cross sectional view along line E-E of FIG. **17**.

[0023] FIG. **19** is a front view of an alternate embodiment of the present invention showing cross sectional view along line F-F.

[0024] FIG. **20** is a cross sectional view along line F-F of FIG. **19**.

[0025] FIG. **21** is a perspective view of an alternate embodiment of the present invention.

[0026] FIG. **22** is a perspective view of the heat exchanger assembly of an alternative embodiment of the present invention.

[0027] FIG. **23** is a detailed view of detail A-A of FIG. **22**.

[0028] FIG. **24** is a flow diagram of the operation of the present invention.

[0029] FIG. **25** is a flow diagram of the operation of an alternate embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0030] FIG. **1** shows the preferred embodiment of the invention, with a dual fluid heat exchanger system contained within vessel **500**. Entry ports **101** and **301** and outlet ports **102** and **302** are shown extending out of vessel **500**. The location of the entry and outlet ports can be anywhere on vessel **500**.

[0031] As shown in FIGS. **2**, **3** and **4**, vessel **500** comprises a thermal insulating layer **501** surrounding an interior cavity wall **502**. Insulation layer **501** can be a variety of different standard types of thermal insulation such as spray foam, fiber glass, vacuum and other similar materials known in the art. Interior cavity wall **502** provides a sealed barrier for cavity **400** within vessel **500**. The cross sectional view in FIG. **3** shows a dual fluid heat exchanger assembly symmetrically centered within cavity **400**. The dual fluid heat exchanger assembly is comprised of charging circuit **300** which contains charging fluid and operation circuit **100** which contains operation fluid. Charging circuit **300** extends from entry port **301** to outlet port **302**. Operation circuit **100** extends from entry port **101** to outlet port **102**.

[0032] All free space within interior cavity wall **502** and surrounding the heat exchanger assembly is preferably filled with PCM **200**. PCM **200** may be any of the known types of phase charged materials, where the type of PCM will be determined by the preferred operating temperature. For household hot water use, the latent temperature of PCM **200** would preferably be in the range of 100 to 150 degrees Fahrenheit, similar to the range of a conventional hot water heater. For other uses, the latent temperature of PCM **200** may be in anywhere between 80 and 950 degrees Fahrenheit.

[0033] FIGS. **5-7** give more detailed views of the dual fluid heat exchanging assembly. FIG. **5** is a perspective view of the operation fluid circuit **100** intertwined with charging fluid circuit **300**. All dual fluid heat exchanger components are spaced such that the maximum amount of conduit surface area is in direct contact with PCM **200** inside of cavity **400**, optimizing thermal energy exchange within vessel **500**. All heat exchanging components are preferably comprised of materials with a high thermal conductivity to best facilitate the exchange of thermal energy from charging fluid contained within charging circuit **300** to PCM **200**, and from charged PCM **200** to operation circuit **100**, and operation fluid contained therein.

[0034] FIG. **6** gives a perspective view of the charging fluid circuit **300** alone. As shown in FIG. **6**, charging fluid circuit **300** is comprised of two concentric coils of heat exchange conduit, with an outer heat exchange coil **305** and an inner heat exchange coil **306**, connected together via conduit **303**. It is preferred that charging fluid enters heat exchange conduit **300** at entry port **301** and first flows through the inner heat exchange coil **306**. This allows for optimal heat retention in the system, as the PCM is preferably heated from the center of the system outward. Charging fluid flows from the inner coil **306** though connector conduit **303**, into the outer coil **305**. The charging fluid flows through outer heat exchange coil **305**, finally exiting the outlet port **302**. While the preferred embodiment of charging circuit **300** is the arrangement shown in the drawings, other layouts may be used, including vertical loops or zig zag configured conduits.

[0035] Entry port **301** is an inlet for heated charging fluid to enter vessel **500**, where the heated charging fluid provides thermal energy to the PCM within vessel **500**. Outlet port **302** is in fluid communication within vessel **500** to entry port **301**, and allows for cooled charging fluid to exit the vessel. Outlet port **302** is in fluid communication to an external heating source, such as a solar panel, furnace or hot water heater. In a preferred embodiment, the charging fluid path is cyclic, where the charging fluid starts at the external heating source, enters the charging fluid circuit **300** via entry port **301**, exchanges its thermal energy into the PCM, and then exits the vessel via outlet port **302** to return to the external heating source for reheating.

[0036] Charging fluid circuit **300** is preferably formed by an inner coil **306** and outer coil **305** which carry the charging fluid. These coils may be a standard copper tubing which is mechanically coiled into an optimally spaced helix, such that all of the coils' surface area is in contact with PCM. The inner coil **306** is positioned concentrically inside of the outer coil **305** and connected by connector conduit **303** which crosses over at the bottom or top of the dual fluid heat exchanger assembly. The coils are made such that the tubes are separated at an optimal distance for dissipating heat evenly all around into the PCM. The heated charging fluid first travels through the inner coil **306** then through the outer coil **305**, heating the PCM from the center of the vessel **500** outward, allowing for the highest temperatures to be in the center region of the vessel **500**.

[0037] FIG. **7** presents a side perspective view of the operation fluid circuit **100**. The operation fluid circuit **100** preferably comprises a plurality of piping **103**, connecting tubular operational fluid containers **104** with ports at either end, which ports can function as either an inlet or outlet for operation fluid to flow through. The operational fluid containers **104** are preferably constructed of material with high thermal conductivity to maximize the exchange of thermal energy between the PCM and the operation fluid. Aluminum is a preferred material for the operation fluid container **104** due to its thermal conductivity, low cost, and availability in many different diameters. As one anticipated use of the invention is the heating of water for household use as the operating fluid, the tubular containers **104** are preferably gas and liquid impermeable, to prevent contamination. Tubular containers **104** preferably have a wider internal diameter than other elements of operation fluid circuit **100**, to slow the flow of operation fluid through operation fluid circuit **100**, and allow for greater exposure to the PCM for temperature control. The internal diameter of tubular containers **104** is at least twice the internal diameter of the piping **103**.

[0038] Entry port **101** is an inlet for the introduction of operation fluid to be heated by the invention. Outlet port **102** in fluid connection with entry port **101**, said fluid connection within vessel **500**. Outlet port **102** allows for the heated operation fluid to exit the vessel. The heated fluid exiting from outlet port **102** is capable of any number of uses, such as appliances, showers, or other uses. The two fluids (charging fluid and operation fluid) flow through two separate paths within the heat exchanger assembly, and do not mix with each other. The locations of entry ports **101** and **301**, and outlet ports **102** and **302** may be in other locations relative to the vessel **500** than as shown in the figures, and one or both of the pairs of entry and outlet ports may be reversed.

[0039] As shown in FIGS. **3-7**, operation fluid containers **100** are arranged in a configuration to maximize the space of a cylindrical interior cavity **502**, but other configurations and sizes may also employed, including a single operation fluid container **104**, surrounded by a charging conduit **300**. FIGS. **8-13** show different configurations of the operation fluid containers **104**. In a preferred embodiment, the operation fluid containers **104** are connected in series, where operation fluid enters at one end of an operation fluid container **104**, filling the entire container, exiting the other end of the operation fluid container **104**, and travels through connector **103** to enter the next operation fluid container **104**. The operation fluid preferably repeats this process and travels through a number of operation fluid containers **104** before exiting the invention via outlet port **102** connected to a final operation fluid container **104** located in the center of the vessel, at a desired temperature. The outlet port **102** is connected to the last operation fluid container **104** preferably in the center of the vessel **500**, where as stated earlier temperatures will be the highest.

[0040] The inventive concept here is that a relatively cold operation fluid enters through entry port **101**, and travels through the operation fluid circuit **100**, consecutively flowing through each operation fluid container **104** before exiting though the last operation fluid container **104** via outlet port **102**. The operation fluid exiting outlet port **102** will preferably have been heated by the charged PCM **200** surrounding the operation fluid containers **104**, to reach a desired temperature, greater than the temperature of the operation fluid at entry port **101**. The PCM **200** surrounding the operation fluid containers **104** is charged by charging fluid traveling though the heat exchanging circuit **300**. Arriving at entry port **301** from an external heat source, heated charging fluid first travels down through the inner coil, and continues up through the outer coil via connection tube **303** at the bottom of the vessel. The heat exchanging circuit **300** carries thermal energy from an external heat source, and quickly disperse that energy to the PCM **200** by conduction.

[0041] The cylindrical shape of vessel **500** is preferred because it facilitates maximal contact surface area between the heat exchanging assembly and PCM material. The cylindrical shape also provides good manufacturing capability. Structures with angular cross-sections, such as rectangular or triangular cross-sections have corners which may create cold spots for the PCM **200** because of lack of contact area, or require additional thermal contact points.

[0042] FIGS. **14-23** show alternate embodiments of the invention. Specifically, FIGS. **14-16** show one style of a single fluid heat exchanger assembly **600** similarly immersed in PCM, contained within an impermeable barrier wall **502**. This embodiment operates as a thermal capacitor, which only allows one fluid to enter and exit. The single fluid heat exchanger **600** serves to charge the PCM **200** with thermal energy in a first cycle, and at a second cycle then extracts the thermal energy at a different time, usually upon demand. In the charging mode, the incoming fluid would be heated from an external heating source and flow into the vessel via entry port **601**. In this mode the thermal energy from the incoming fluid would be stored by the PCM **200**, as fluid travels through assembly **600**, eventually exiting outlet port **602**. Otherwise the vessel would be heating or maintaining temperature of the same fluid used within the larger system.

[0043] FIGS. **15** and **16** detail the single fluid heat exchanger concept with an arbitrary number of tubes. The ideal fluid flow direction for this type of exchanger is entering the vessel from the outer most tube via entry port **601**, filling each subsequent tube until exiting though the center tube via outlet port **602**. This way thermal energy is preserved the longest during a cycle which the system needs to draw energy from the vessel. The tubes may be held in place by an alignment plate **604** which has holes punched in it such that the tubes spiral inward to a centered exit tube. These are shown connected via fittings **603**, which may be conventional fittings as are known in the art for connecting tubes. Analogous to the dual fluid type heat exchanger system discussed earlier, the heat exchange conduit is spaced such that all of its surface area is in contact with PCM **200**.

[0044] FIGS. **17** and **18** detail an alternate embodiment of the single fluid heat exchanger concept. Instead of the fluid flowing though consecutive tubes in series, spiraling from the outer most tube to the inner most tube, in the alternate embodiment, fluid enters a collection manifold **605** and fills all of the tubes **650** simultaneously or in parallel. The tubes **650** are immersed in PCM **200** within cavity **640** and contained within a barrier wall **502**. The fluid flow may be bidirectional so outlet ports and inlet ports are interchangeable. This type of heat exchanger system would be better suited for high flow applications where fluid needs to pass through the system very quickly. Not shown in FIGS. **17** and **18**, is an insulation layer which would preferably surround barrier wall **502** and collection manifolds **605**.

[0045] FIGS. **19-23** show an alternate embodiment of a square shaped cross flow type heat exchanger system, with the heat exchanger assembly within cavity **840**, encased in an insulation layer **900**, and where cavity **840** is filled with PCM **200**. In this embodiment there are four collection manifolds **901**, each serving as either an entry or outlet port. Analogous to the preferred embodiment in FIG. **1**, cool operation fluid enters via entry port **701**, travels through operation fluid conduit **700** collecting thermal energy from surrounding charged PCM **200**, and heated operation fluid exits outlet port **702**. Heated charging fluid enters entry port **801**, travels through charging fluid conduit **800** heating the surrounding PCM, and cooled charging fluid exits outlet port **802**. All entry and outlet ports are bidirectional, and can be reversed.

[0046] FIGS. **22** and **23** show a perspective view of the operation fluid conduit **700** and charging fluid conduit **800** within the square embodiment. Here it can be seen that the operation fluid heat exchanging conduit **700** and charging fluid conduit **800** are evenly spaced and overlapping, with operation fluid conduit **700** preferably sandwiched in the center. In this collector manifold type design, fluid will fill all tubes simultaneously for both **700** and **800** with operation fluid and charging fluid respectively. It is important to note that for this type of heat exchanger, there are several different types of conduits which could be implemented aside from a tube shape. Any other types of conduit common in the radiator industry could be used such as bar-and-plate or wafer/fin. Equally important to note is that FIGS. **19-23** only display a dual fluid type exchanger, a more simplified version is easily imaginable with one entry port and one outlet port for operation with a single fluid.

[0047] FIG. **24** presents an example of a complete circuit using the invention, which may be directly applied to hot water heating. The system could be thermostatically controlled by any widely available HVAC controller C**1**. Charge mode would be initiated by the controller C**1** based on readings from the various temperature sensors T**1**, T**2**, and T**3** within the system. When in charge mode, the charging fluid is heated by any heat source H**1** and flows via pump P**1** to charge the PCM within vessel **500** to a desired latent heat temperature. Operation fluid, in this case household hot water, would enter through entry port **101** and travel through the operation fluid containers **100** within vessel **500** to be heated, then exit via outlet port **102** to be utilized. Some common plumbing safety devices not shown in this diagram would be required such as, an expansion tank and safety shutdown switch. The expansion take would allow for safe expansion and contraction of the charging fluid, while the shutdown switch would protect the PCM from being over heated by the heat source.

[0048] FIG. **25** presents an example of general system diagram of the single fluid vessel embodiment shown in FIGS. **14-16**. Taking an internal combustion engine as the cyclic heat source example H**1**, the melting temperature of the PCM chosen would match desired engine operating temperature. The secondary heat exchanging system H**2** would be the vehicle's heater core (for cab heating/hot air). The three way valve V**1** in this example would be optional, and the vessel could be plumbed directly to the heater core H**2**. When the engine is warm and operating normally, it would have the PCM in charge mode filling it with thermal energy. When the engine is turned off, there is no fluid flow and the energy is stored inside the insulated vessel **502**. Upon restarting the engine, hot fluid would travel from the vessel **502** though the heater core H**2** and into the engine. This means that the vessel would act as both an engine block heating device to combat cold starting emissions, and a luxury item providing cabin heat almost instantly at cold start-up.

[0049] In contrast to the three layer encapsulation method of having an outer most containment barrier concentric with an inner containment barrier with the empty space in-between the two filled with some insulation material, a single layer method of encapsulation is possible. Very similar to how beverage carriers are constructed, injection molded single layer encapsulation of the PCM and heat exchanger assembly is efficient. This type of encapsulation would make for a more efficient and cost effective volume production, greatly cutting down on material cost as well as labor time involved with assembly. Aside from injection molding techniques, this single layer design could also be formed stainless steel with a vacuum insulation layer. Although stainless steel is a more expensive material, it could provide a more efficient insulation layer, while also enabling the ability for the heat exchanging system and PCM to operate at much higher temperatures.

[0050] This disclosure takes into consideration common building materials which are commercially available. All internal heat exchanging components are preferably comprised of materials which have a high thermal conductivity. An example of such materials are aluminum and copper. The vessel which contains the PCM and heat exchanger assembly, should be made from nonporous materials with low thermal conductivity. Commonly available would be polymer plastics such as polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC). To maximize efficiency of the storage system, the containment vessel should also be insulated from its surroundings. To achieve this, the preferred embodiment utilizes an outer vessel to retain an insulation layer surrounding the PCM and heat exchanger assembly. This insulation layer can be made from a number of different media including vacuum, air, spray foam, hard foam, or fiberglass.

[0051] The capabilities of the storage system described in this disclosure are limited by the working temperature of the vessel which contains the PCM and heat exchanger assembly, and to a lesser extent the working temperature of the heat exchanger materials themselves. For instance, PVC and CPVC have a maximum operating temperature of 200° F. Common soldered joints of copper tubing will melt at 370° F., acting as another limit of the system. The designs presented in this disclosure could be made from any engineered materials. The highest latent heat temperatures of tested PCMs reach 900-1200° F. The heat exchanger and containment materials could be designed to withstand this temperature range.

[0052] While certain novel features of the present invention have been shown and described, it will be understood that various omissions, substitutions and changes in the forms and details of the device illustrated and in its operation can be made by those skilled in the art without departing from the spirit of the invention.

I claim:

1. A thermal storage device comprising:

a vessel surrounding an interior cavity;

phase change material within the interior cavity; and

a first elongated conduit with an entry end and an outlet end, the first elongated conduit extending through the phase change material, the first elongated conduit capable of allowing the passage of operation fluid therethrough, where the entry end and outlet end extend outside of the vessel.

2. The thermal storage device of claim **1**, further comprising:

a second elongated conduit with an input end and an output end, the second elongated conduit extending around the phase change material, the second elongated conduit capable of allowing the passage of charging fluid there through, where the input end and output end extend outside of the vessel, where the second elongated conduit is located adjacent to the first elongated conduit within the vessel.

3. The thermal storage device of claim **1**, where the first elongated conduit comprises an elongated tube with a first internal diameter.

4. The thermal storage device of claim **3**, where the first elongated conduit further comprises:

an elongated cylinder with a second internal diameter, where the second internal diameter is at least twice the first internal diameter of the elongated tube.

5. The thermal storage device of claim **4**, further comprising:

a second elongated conduit with an input end and an output end, the second elongated conduit extending around the phase change material, the second elongated conduit capable of allowing the passage of charging fluid there through, where the input end and output end extend outside of the vessel, where the second elongated conduit is arranged to be coiled around the elongated cylinder.

6. A thermal storage device comprising:

a vessel surrounding an interior cavity;

phase change material within the interior cavity; and

a first elongated conduit with an entry end and an outlet end, the first elongated conduit comprised of an elongated tube with a first internal diameter and an elongated cylinder with a second internal diameter, where the elongated tube and elongated cylinder are located within the interior cavity and surrounded by the phase change material, the first elongated conduit capable of allowing the passage of operation fluid therethrough, where the entry end and outlet end extend outside of the vessel; and

a second elongated conduit with an input end and an output end, the second elongated conduit extending around the phase change material, the second elongated conduit capable of allowing the passage of charging fluid there through, where the input end and output end extend outside of the vessel, where the second elongated conduit is located adjacent to the elongated cylinder within the vessel.

7. The thermal storage device of claim **6**, the first elongated conduit further comprising:

a plurality of elongated cylinders connected in series.

8. The thermal storage device of claim **6**, where a portion of the second elongated conduit is coiled around the elongated cylinder.

9. The thermal storage device of claim **1**, the first elongated conduit further comprising:

a first distribution manifold near the entry end of the first elongated conduit;

a second distribution manifold near the outlet end of the first elongated conduit; and

a plurality of elongated tubes extending from the first distribution manifold through the interior cavity to the second distribution manifold.

10. The thermal storage device of claim **1**, the second elongated conduit further comprising:

a third distribution manifold near the input end of the second elongated conduit;

a fourth distribution manifold near the output end of the second elongated conduit; and

a plurality of elongated tubes extending from the third distribution manifold through the interior cavity to the fourth distribution manifold.

11. The thermal storage device of claim **1**, where the phase change material converts from a liquid to a solid at a temperature between 100 and 150 degrees Fahrenheit.

12. The thermal storage device of claim **1**, where the phase change material converts from a liquid to a solid at a temperature between 100 and 1200 degrees Fahrenheit.

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