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(54) FLAT-PLATE HEAT-PIPE WITH LANCED-OFFSET FIN WICK

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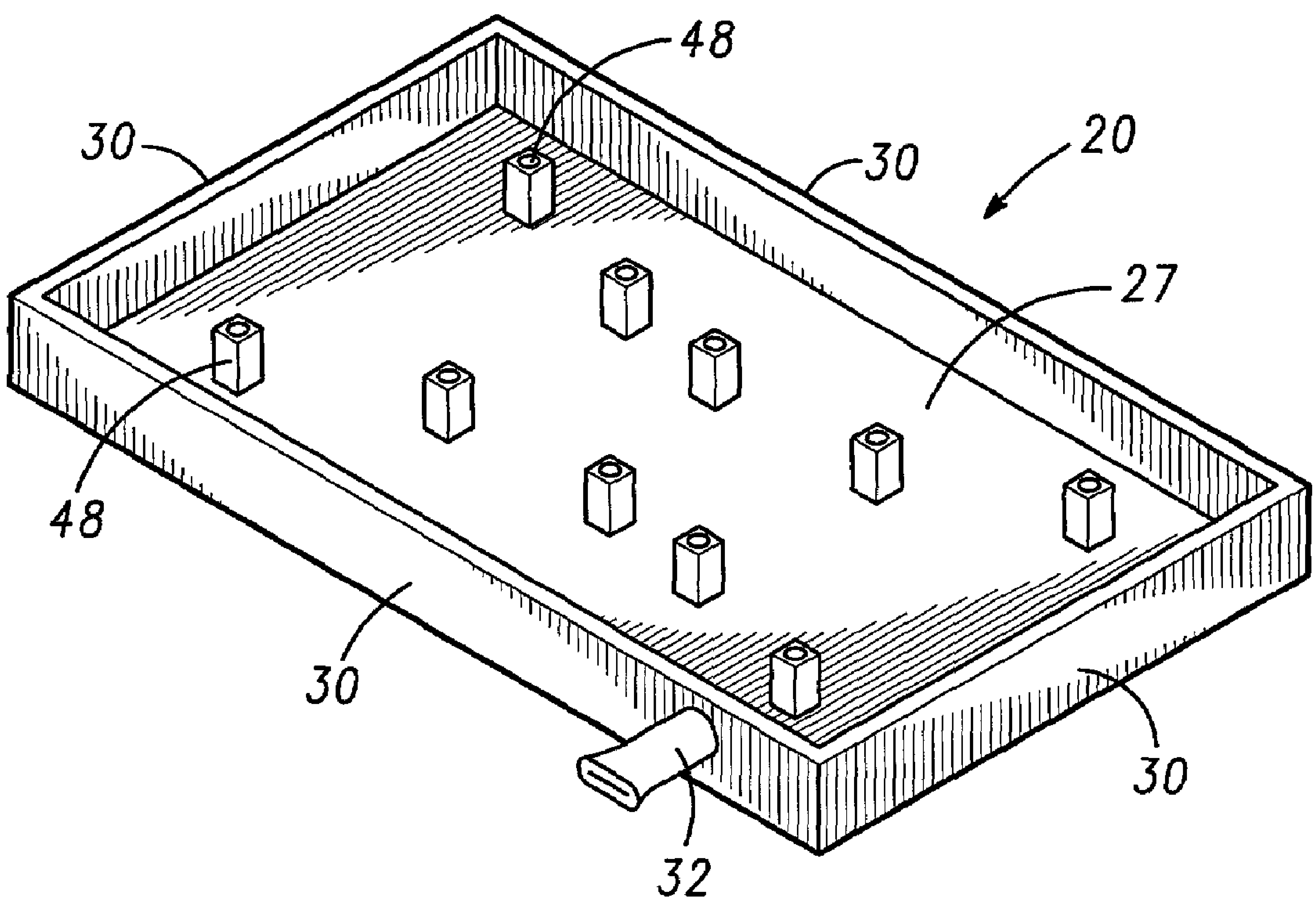
(57) ABSTRACT

A passive cooling unit for integrated electronics in form of flat-plate heat-pipe device having a shallow cavity base member, a cover plate, and a lanced-offset fin member and associated porous metal wick material sandwiched therebetween, the fin member being braced to the base member and cover plate to provide structural support and also being coated with the wick material. The resultant flat-plate heat-pipe device, when formed of a lightweight metal such as aluminum or titanium, results in a passive cooling device that is lightweight, structurally strong, and of low cost manufacture.



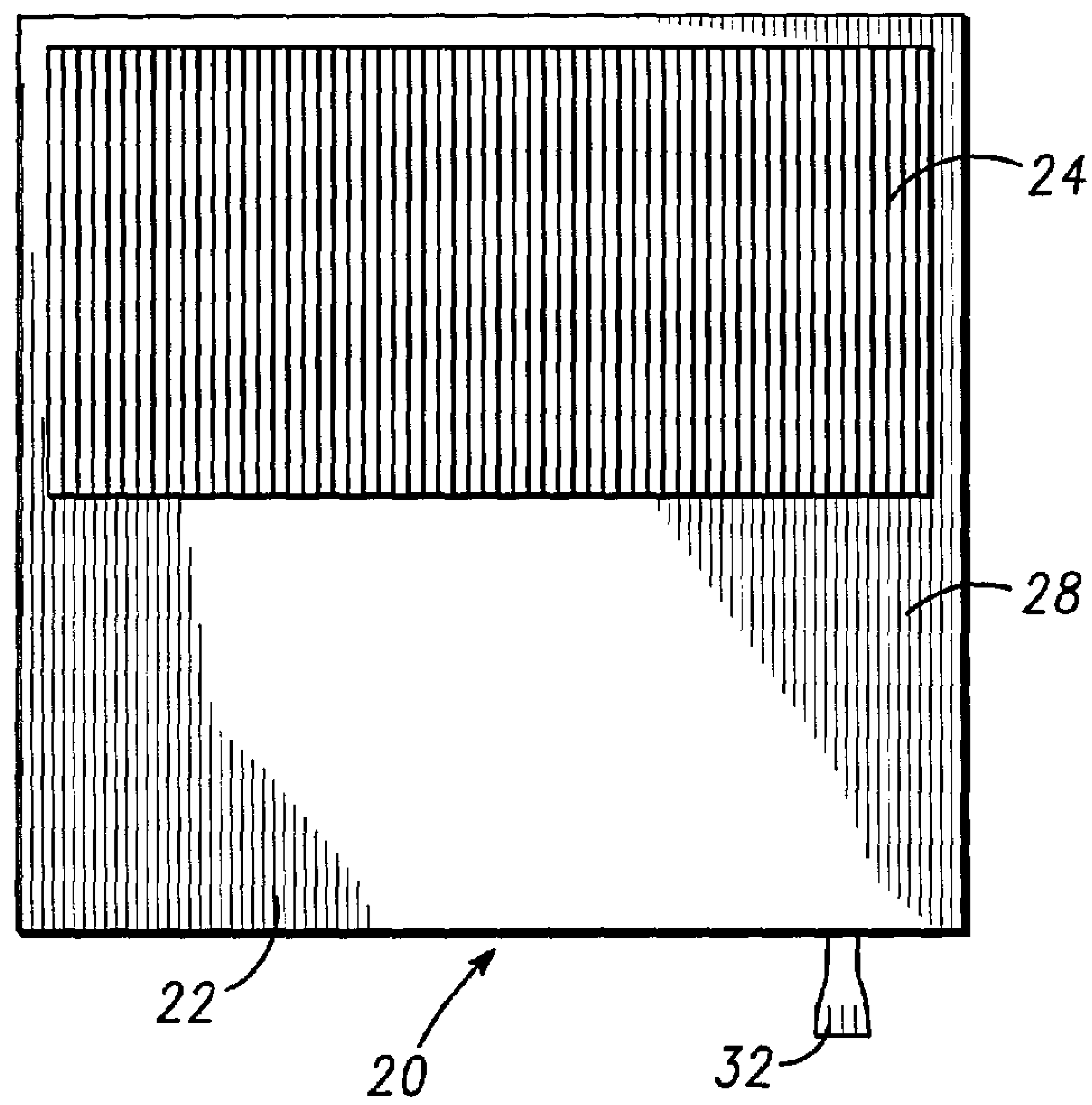


FIG. 1

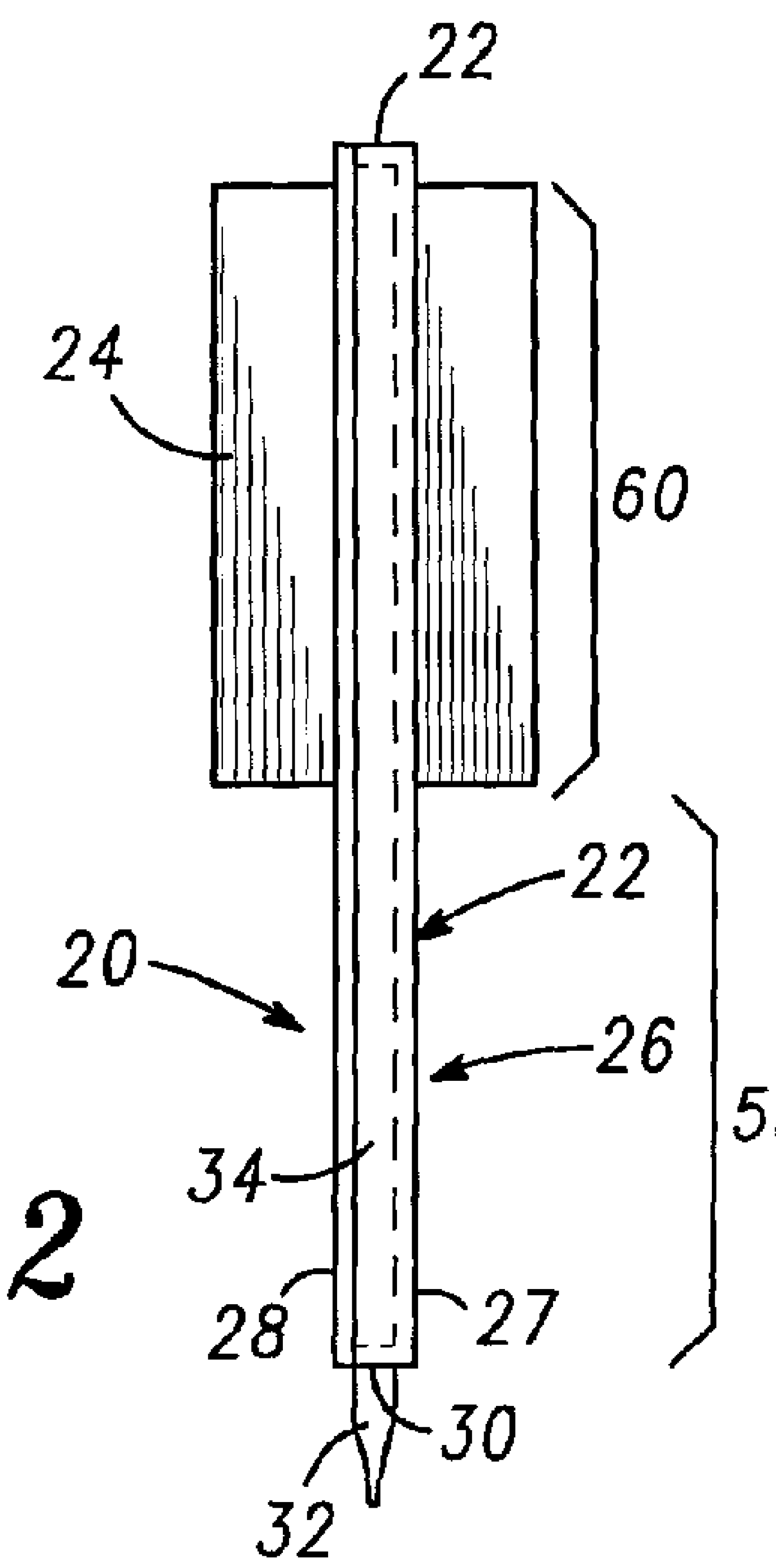


FIG. 2

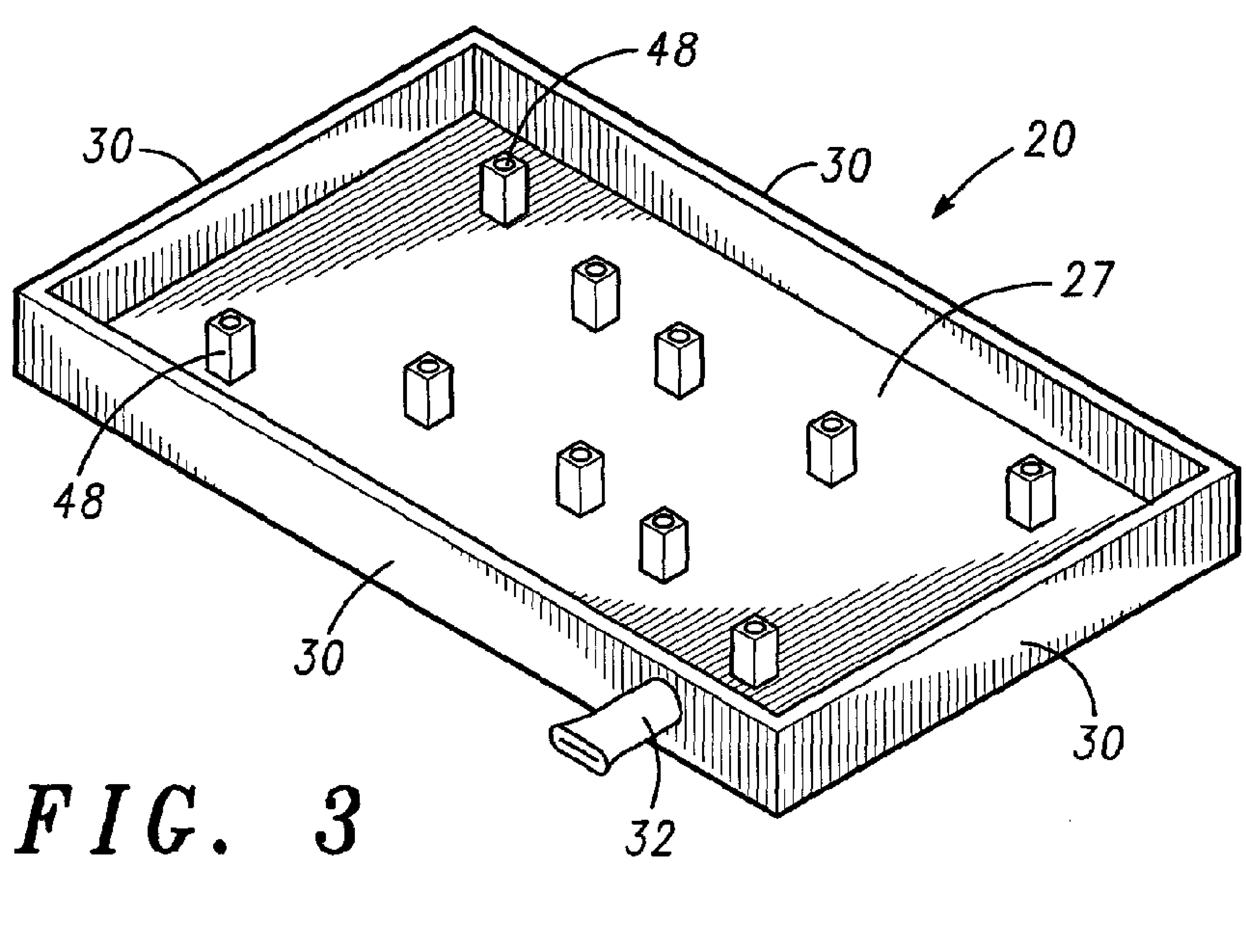


FIG. 3

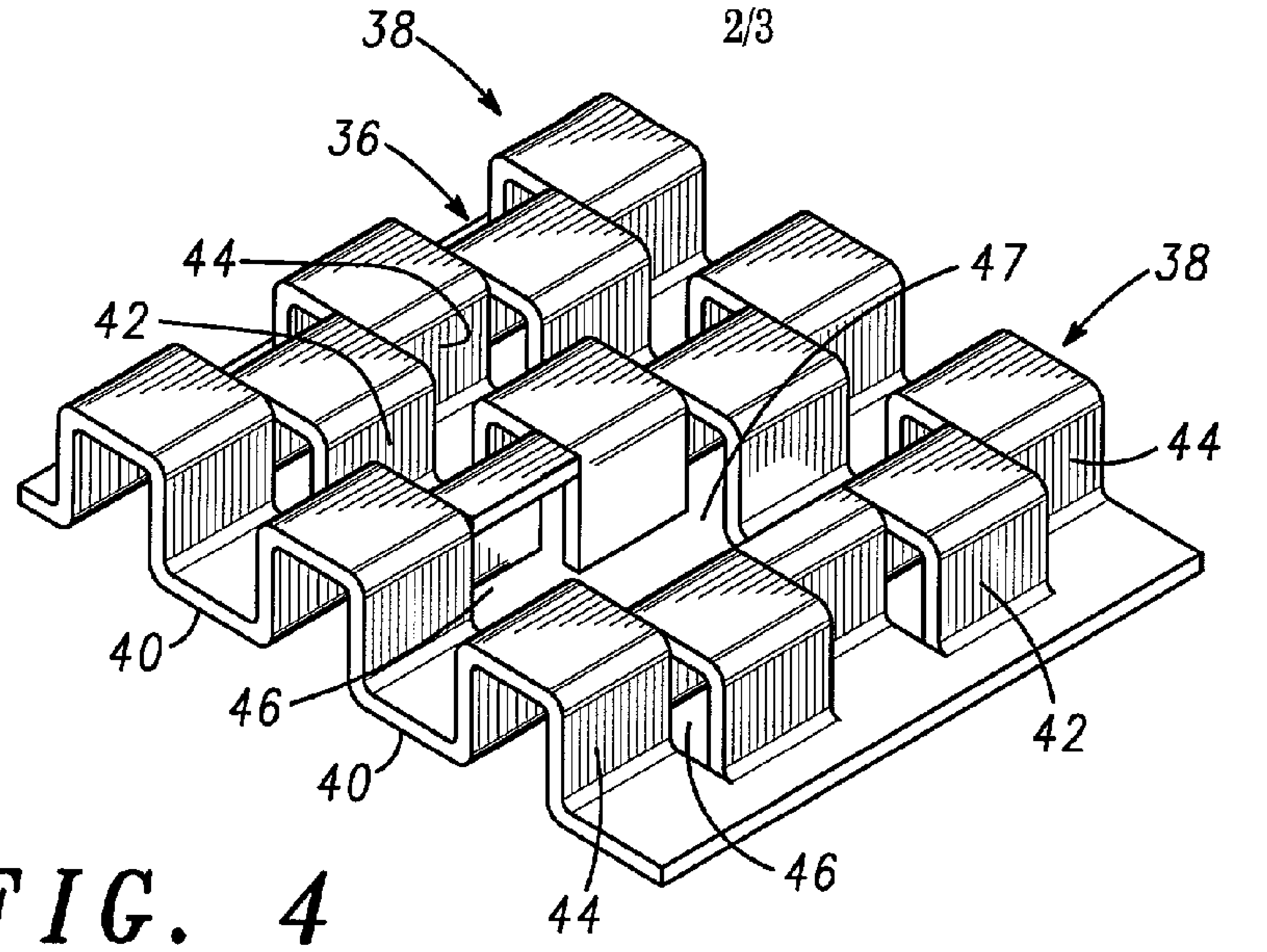


FIG. 4

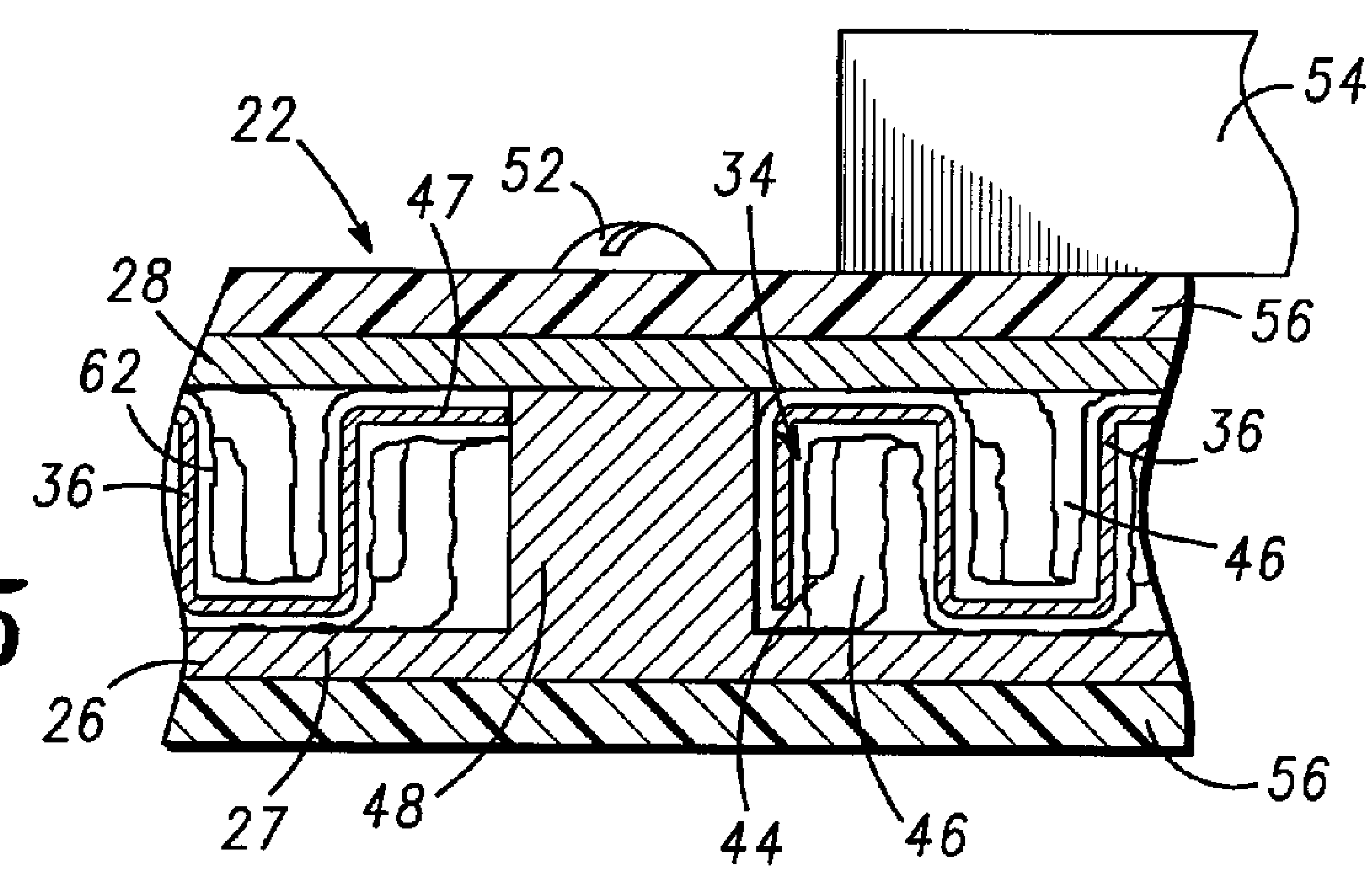


FIG. 5

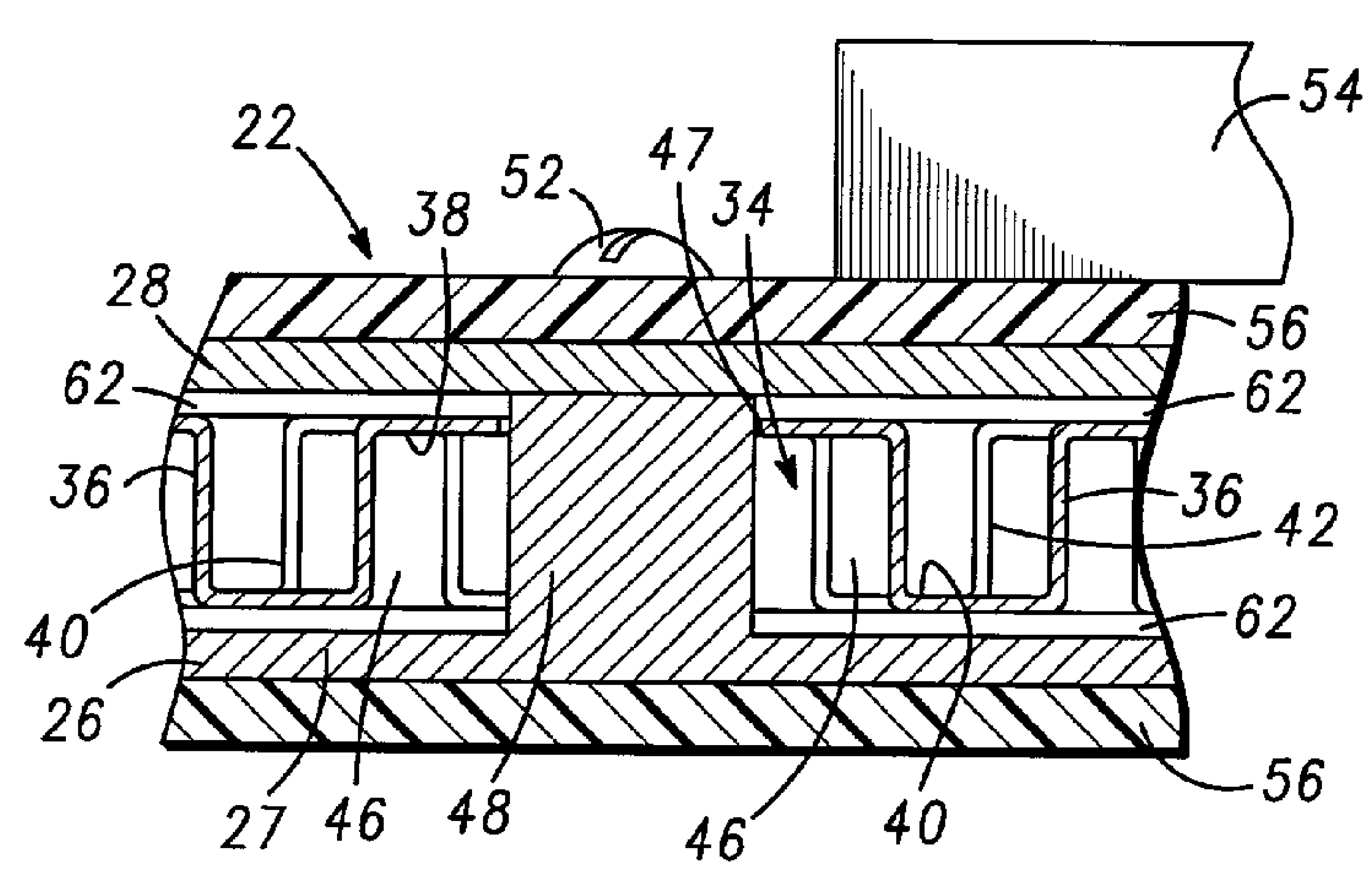


FIG. 6

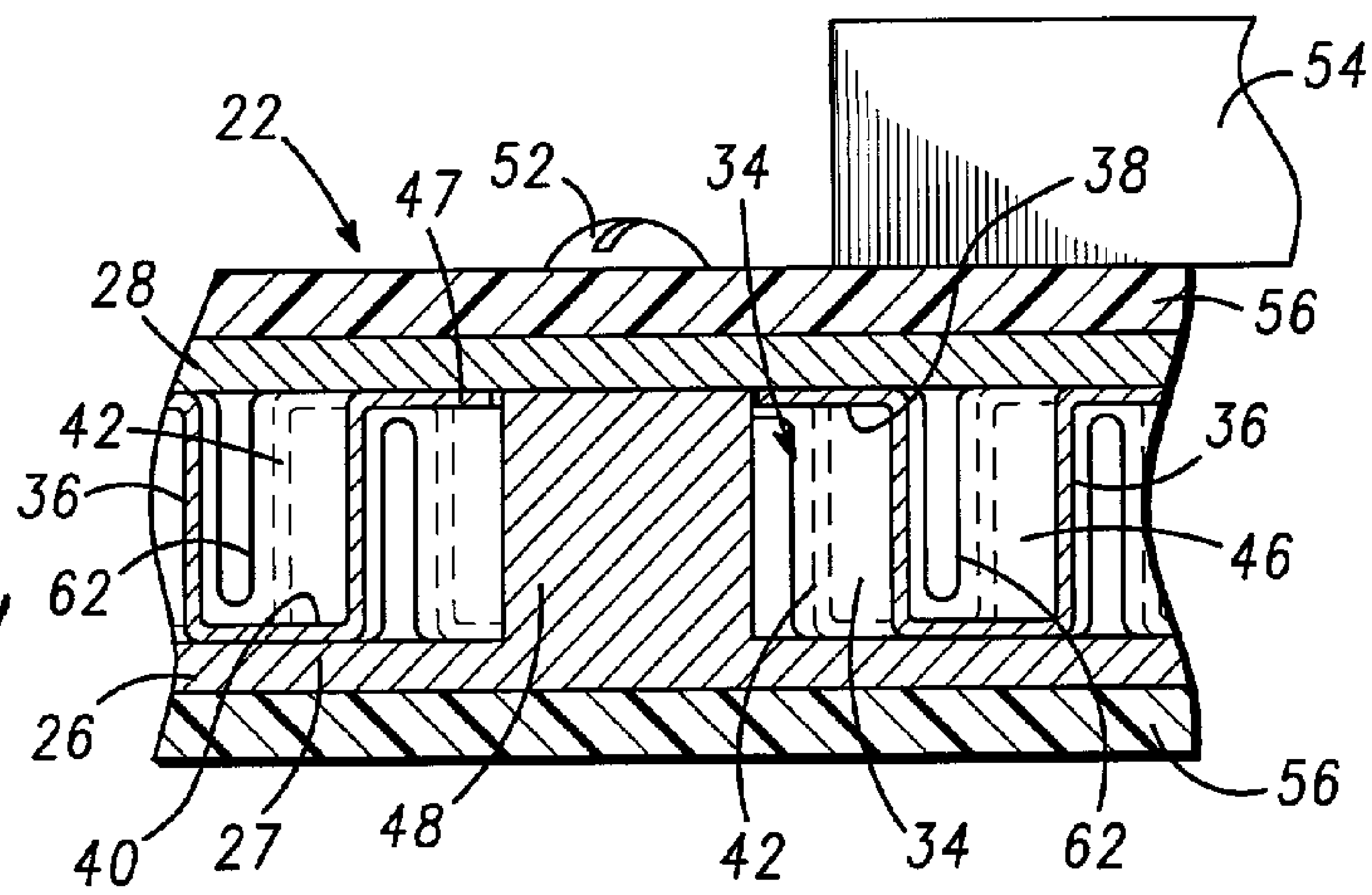


FIG. 7

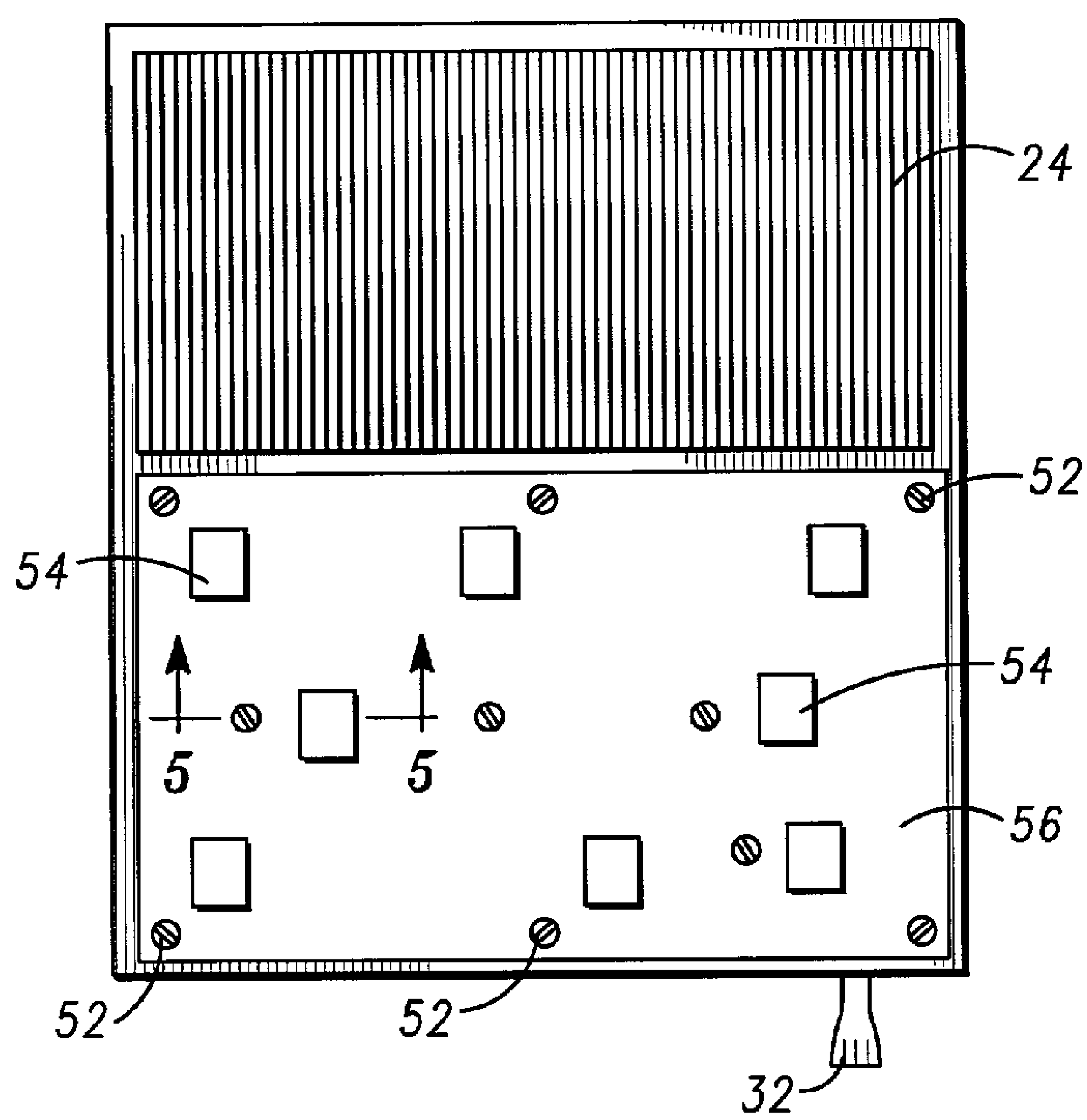


FIG. 8

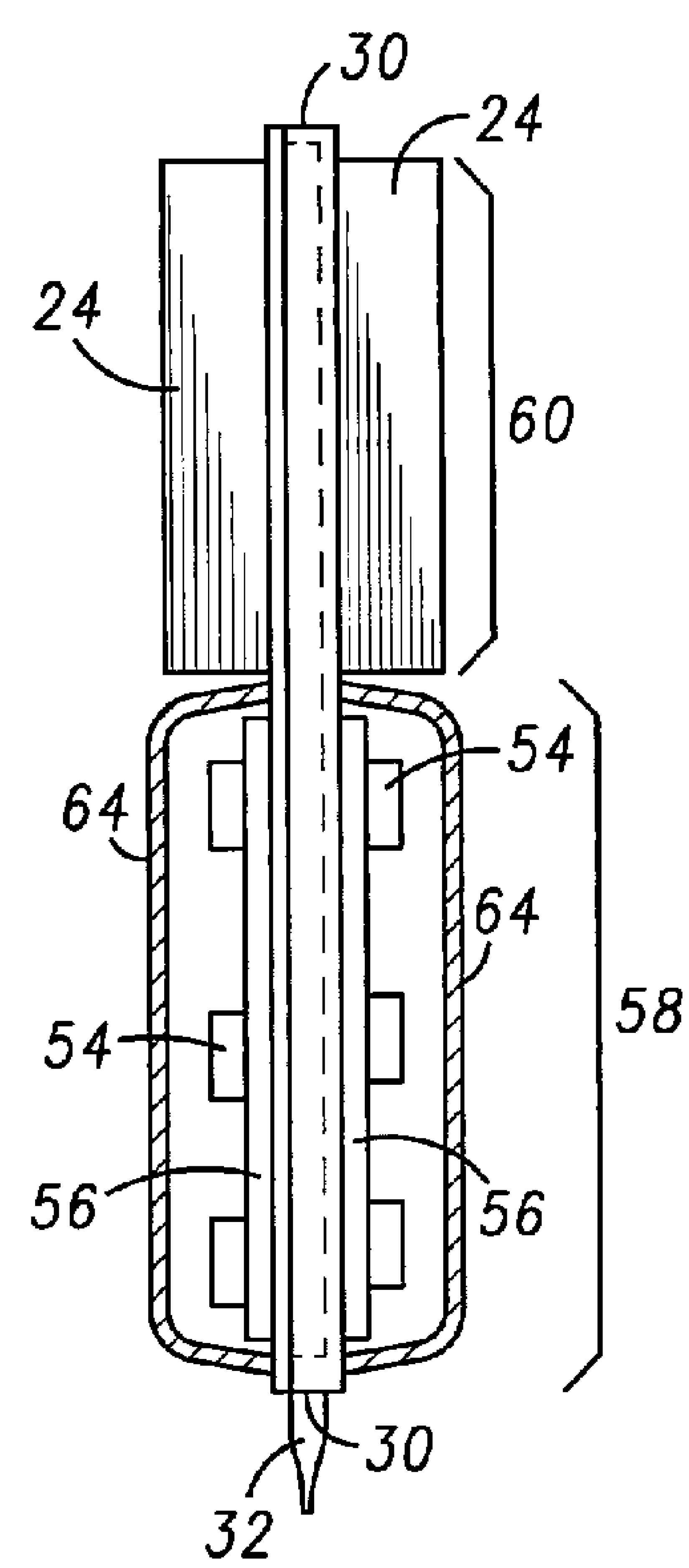


FIG. 9

FLAT-PLATE HEAT-PIPE WITH LANCED-OFFSET FIN WICK

FIELD OF THE INVENTION

[0001] This invention relates generally to passive cooling for electronic devices, and more particularly to a flat-plate heat-pipe having an internal lanced-offset fin wick structure with associated porous wick material, and a method for forming the same.

BACKGROUND OF THE INVENTION

[0002] Electronic devices such as power amplifiers, power supplies, integrated circuit chips, multi-chip modules, heat spreaders, electronic hybrid assemblies such as power amplifiers, microprocessors and passive components such as filters, contain heat sources which require cooling during normal operation. Various techniques may be used for cooling electronic devices. Traditionally, electronic devices have been cooled by natural or forced convection which involves moving air past conduction heat sinks attached directly or indirectly to the devices.

[0003] Efforts to reduce the size of electronic devices have focused upon increased integration of electronic components. Sophisticated thermal management techniques using liquids, which allow further reduction of device sizes, have often been employed to dissipate the heat generated by integrated electronics.

[0004] Two-phase thermosyphons have often been used to provide cooling for electronic devices. Two-phased thermosyphons typically include a two-phase material within a housing. The two-phase material, typically a liquid, vaporizes when sufficient heat density is applied to the liquid in the evaporator section. The vapor generated in the evaporator section moves away from the liquid towards the condenser. In the condenser section, the vapor transforms back to liquid by rejecting heat to the ambient. The heat can also be dissipated to the ambient atmosphere by a variety of means, such as natural convection, forced convection, liquid and other suitable means. Typifying such two-phase thermosyphons is U.S. Pat. No. 6,234,242, assigned to the assignee of the present invention.

[0005] However, there are significant orientation limitations inherent in the use of such two-phase thermosyphons since they only work in a vertical orientation. This is because thermosyphons need the assistance from gravity to get the condensed working liquid from the condenser section to the evaporator section, i.e., the condenser must always be higher than the evaporator section. Additionally, such two-phased thermosyphon devices are not well suited for very low heat-flux applications.

[0006] Another cooling device often used is the so-called flat-plate heat-pipe device ("FPHP"). Such FPHP devices are suitable for low heat-flux and medium heat-flux applications, and thus, are suitable for many electronics applications such as cellular telephonic infrastructure products. FPHP devices operate on the principal of a closed loop of evaporation/boiling and condensation of a fluid. The working liquid evaporates and boils off in the areas where heat is dissipated by electronic components, which components are mounted externally to the FPHP device's walls, and then travels to the condensation section as a vapor. Contrary to the boiling occurring in two-phase thermosyphons, the evaporation in a FPHP device can advantageously occur with a very small temperature rise between the working liquid and the FPHP surface. The vapor spreads evenly in the condensation space and condenses back into liquid form by rejecting heat to the ambient, as often assisted by externally-mounted fin structure to create a heat sink. The condensed liquid travels back to the heated section by a wicking action through porous wick structure formed on the interior surfaces of the FPHP device's cover plates.

[0007] Importantly, such FPHP devices have the ability to operate in any orientation. However, commercially available FPHP devices are typically made of thick-walled copper making such FPHP units extremely heavy, and therefore impractical for most electronic cooling situations related to cellular infrastructure products. They typically use a sintered copper wick on the interior faces of the cover plate, such that no other wick substructure is present. Also, due to their method of manufacture, commercially available FPHP devices are very costly and relatively weak. In fact, because they are so structurally weak, they are unable to withstand high internal positive pressures or perform effectively throughout the broad temperature range found in many cellular and other electronic infrastructure products. They are generally limited to operating when internal pressure is lower than 1 atm. Another type of FPHP that has been typically used employs multiple cylindrical heat pipes embedded in a solid plate of aluminum. Typifying such prior FPHP devices are U.S. Pat. No. 4,880,052, which discloses flat plates with individual heat-pipes embedded within.

[0008] Yet a further cooling device used with integrated electronics takes the form of an integral heat pipe, heat exchanger and clamping plate, forming a grid-like pattern of wick-lined channels, such as typified by U.S. Pat. No. 5,253,702. There, a base plate functions as an evaporator having a multiplicity of intersecting parallel and perpendicular internal channels extending across the baseplate. A sintered copper thermo wick material is applied to the surfaces of all channels, and there is a series of vertically aligned condenser tubes forming a condenser region terminating at their upper ends in cooling fins. This is a complicated structure formed at great cost, and also has orientation limitations to its use.

[0009] There is a need for a lightweight and compact flat-plat heat-pipe cooling device that is structurally robust, thermally efficient, and has a low cost of manufacture.

SUMMARY OF THE INVENTION

[0010] A lightweight flat-plate heat-pipe device is constructed as a sealed cavity fabricated by brazing a thin, flat shallow cavity base member with a cover plate to create a thin-shelled hollow-enclosure to contain an evaporative working fluid. The base member includes a number of upstanding bosses which incorporate holes for locating the fasteners used for installing external electronic circuit boards, and other modules, on the outer surfaces of the FPHP device. A lanced-offset fin structure is affixed internally within the cavity to provide structural support to the thin base member and cover plate. The lanced-offset fins have an associated porous wick structure. This overall sandwiched assembly is brazed together to provide a structurally robust sealed unit having very thin external walls, and a small opening for the introduction of a charge of the working fluid. The porous wick structure associated with the lanced offset fins acts as a capillary-type wick for transporting the condensed liquid from the condenser section back to the heated evaporator section. One end of the respective external faces of the FPHP unit, i.e., at the condenser section end, can be configured with appropriate cooling fins to convert the FPHP device into a light-weight heat-sink.

[0011] In one embodiment of the present flat-plate heat-pipe invention, the porous wick structure is flame-sprayed directly onto the lanced offset fins. In another embodiment, the porous material is flame-spayed or otherwise applied to the internal facing surfaces of the respective base member and cover plate. In a final embodiment, used for heavy-duty applications, all of the generally transverse surfaces of the lanced-offset fins, i.e. those surfaces extending between the respective base member and cover plate, are encased and all open spaces packed with a sintered metal wick material to create a structurally supportive porous wick which permits capillary movement of the working fluid in all directions and vapor movement in the direction of the fins.

[0012] Preferably, the base member, cover plate and lanced-offset wick structure are formed of a lightweight aluminum material or aluminum alloy. Further, the porous wicking material is preferably formed of aluminum powder that has been flame-sprayed or sintered in place.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The means by which the foregoing and other aspects of the present invention are accomplished and the manner of their accomplishments will be readily understood from the following specification upon reference to the accompanying drawings, in which:

[0014] **FIG. 1** depicts a front elevation view of the flat-plate heat-pipe device with lance-offset fin wick structure of the present invention;

[0015] **FIG. 2** is an end elevation view of the flat-plate heat-pipe device of **FIG. 1**;

[0016] **FIG. 3** is a perspective view of the base member of the device of **FIG. 1**;

[0017] **FIG. 4** is a perspective view of the lanced-offset fin structure of the present invention;

[0018] **FIG. 5** is an enlarged cross-sectional view, taken at circled location **5-5** in **FIG. 8**, of the present flat-plate heat-pipe device showing the lanced-offset fin structure with associated porous wick material, and showing circuit board structure, and with certain components deleted for better viewing;

[0019] **FIG. 6** is another cross-sectional view, similar to **FIG. 5**, but of an alternative form of the flat-plate heat-pipe device of the present invention;

[0020] **FIG. 7** is yet a further enlarged cross-sectional view, similar to **FIGS. 5 and 6**, but of yet a further alternative embodiment for the flat-plate heat-pipe device of the present invention;

[0021] **FIG. 8** is a side elevation view, similar to **FIG. 1**, of the present flat-plate heat-pipe device showing a circuit board including heat-dissipating electronic devices, and a clam shell housing; and

[0022] **FIG. 9** is a side elevation view of the flat-plate heat-pipe device of **FIG. 8**.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Having reference to the drawings, wherein like reference numerals indicate corresponding elements, there is shown in **FIG. 1** an illustration of a flat-plate heat-pipe passive cooling device, generally denoted by reference numeral **20**. The cooling device **20** includes a flat-plate heat-pipe member **22** and external cooling fins **24**, to create a passive cooling heat sink assembly. The FPHP member **22** comprises a base member **26** and a cover plate **28**. The base member comprises a base plate **27**, a series of upstanding support bosses or shoulders **48** (described later herein), and a peripheral end wall or frame **30**. Collectively, the components base member **26** create a shallow cavity generally denoted by reference numeral **34**, which when covered off by the cover plate **28** becomes a sealed enclosed cavity. The base member **26** and cover plate **28** are preferably formed of a suitable aluminum material, such as an aluminum-6061 alloy. The base member **26** can be machined from aluminum plate stock to yield cavity **34** and raised bosses **48**. So as to create a thin-shelled cooling unit **20**, the wall thickness for the aluminum plates **26**, **28** is preferably less than 1 mm in thickness, but not less than 0.5 mm thick, and preferably approximately 0.7 mm. Alternatively, instead of using an aluminum alloy for the base member **26**, cover plate **28**, and the lanced-offset fin member **36**, a suitable titanium material could be used. This likewise would provide suitable structural support and rigidity to FPHP member **22**, yet allow it to remain sufficiently lightweight.

[0024] An opening tube **32** (see **FIGS. 1 and 7**), preferably some 4.8 mm in diameter and welded along the end wall **30** (but which may also be welded along the baseplate **27** or cover plate **28**, but not shown in either location) can be used to seal off the inner cavity **34**. After the charging process, the filler tube **32** is preferably sealed off by means of an ultrasonic welder, which pinches and applies ultrasonic energy to the pinched section of tube **32** to form the needed closure seal.

[0025] A lanced-offset fin member, generally denoted by reference numeral **36**, is shown in FIGS. **4-7**. The lanced-offset fin member **36** is preferably made of an aluminum material, such as an aluminum-3033 alloy, and is commercially available from vendors such as Robinson Fin Machines of Kenton, Ohio. This lanced-offset fin member **36** has a series of generally upstanding channel sections **38** and an intervening valley sections **40**, with a width therebetween in the range from approximately 0.5 mm to 2.5 mm, with the preferred width range of approximately 1.0 to 2.0 mm. The transverse wall sections **42** integrally connecting the channel sections **38** and valley sections **40** comprise a staggered or offset series of walls **44** as separated by punched openings **46**. Selectively cut clearance holes **47** in fin member **36** permit fin member **36** to fit over and nestle around respective raised bosses **48** within cavity **34**.

[0026] As will be seen in **FIGS. 3 and 5**, the lanced-offset fin member **36**, while formed as a lightweight component, still creates a rigid structural member to support the thin-walled base plate **27** and cover plate **28** particularly against the both significant internal and external pressures that are created within enclosed cavity **34**. The material wall thickness for the overall lanced-offset fin member **36** is preferably less than approximately 0.5 mm thick. Importantly, besides providing structural support, the particular punched-wall configuration of the lanced-offset fin **36** presents numerous surfaces (channel sections **38**, valley sections **40**, and intervening wall sections **42**) to support the associated porous wick material as described below. Other configurations for the lanced-offset fin member **36** can include a wave-type folded fin (shaped like the corrugated layer in cardboard), lanced-offset fins like member **36** but with inclined walls (where the vertical walls are at approximately 120° to the horizontal walls), lanced-offset fins with a fine curved pitch (where the upper and lower horizontal faces are generally curved surfaces instead of flat), and louvered fins (where the vertical faces of a wave-type folded fin have vertically aligned louver openings). However, lanced-offset fin member **36** of **FIG. 4** is considered the preferred design because that design permits the best liquid-vapor movement perpendicular to general flow direction, to provide the best thermal performance, such vertical faces provide the best structural strength, and such horizontal faces provide the best high strength brazing bond between the fin **36** and base plate **27**, cover plate **28**.

[**0027**] **FIG. 5** depicts how the lanced-offset fin member **36** is fitted into the base member **26** and is sandwiched between the base plate **27** and cover plate **28**. During manufacture, the lanced-offset fin **36** can be further shaped by laser cut or EDM to fit into the cavity **34** of base member **26** with needed clearance holes **47** to fit around the raised bosses **48**. As is known in brazing operations, a shim of suitable brazing material (not shown), such as aluminum alloy 4004 or 4104, is placed over the interior surface of base plate **27**, and the configured lanced-offset fin **36** (with associated porous wick material as described below), is dropped into place on top of the brazing material. The cover plate **28** clad with a suitable brazing material (not shown) is then placed on top of the base member **26** and fin **36**, to create a sandwiched assembly. That assembly is then fixtured to provide uniform pressure over its entire span and then placed in a vacuum brazing furnace to seal the cover plate to the base member **26**, and to secure affix the fin structure **36** to the interior surfaces of both base plate **27** and cover plate **28**. In this manner, the lanced-offset fin member **36** operates to structurally separate and structurally support the respective base member **26** and cover plate **28** to create a thin-shelled flat, rigidly supported FPHP device **22**.

[**0028**] Importantly, the use of the lanced-offset fin **36** acts to eliminate the need for having one of the base plate **27** or cover plate **28** punched or dimpled for separating the base and cover plates, such as was required with many prior passive cooling devices. For example, see the Thermacore (Trademark) product sold under the product name Thermabase (Trademark).

[**0029**] The raised bosses **48** (see **FIG. 3**) each have an opening **50** to receive a threaded fastener **52**, which can be used to secure heat dissipating members **54** on associated circuit boards **56** to the FPHP member **22**. As seen in **FIG. 7, a** pair of such circuit boards **56** have been mounted to the respective front and rear external sides of FPHP member **22** via fasteners **52** engaging openings **50** in bosses **48**. As seen in **FIGS. 7 and 8**, a large number of heat-dissipating members **54** are mounted to the respective circuit boards **56**. Devices **54** can comprise power amplifiers, power supplies, integrated circuit chips, multi-chip modules, heat spreaders, and electronic hybrid assemblies such as power supplies, microprocessors and passive components such as filters. All of these electronic devices contain heat sources which require cooling during normal operation.

[**0030**] As seen in **FIG. 2**, the FPHP member **22** can have cooling fins **28** mounted to both external surfaces at the upper end thereof to form a complete heat sink assembly. This acts to divide the FPHP unit **22** into generally an evaporator section **58** and a cooling or condensing section **60**. Alternatively, simply the FPHP member **22** can be used alone, i.e., without external cooling fins **24**, by having the member's condensing section **60** of member **22** in contact with a chassis (not shown) which conducts rejected heat away, such as with a thermal backplane device.

[**0031**] Turning to **FIG. 4**, the various external surfaces of the lanced-offset fin member **36** (comprising channel sections **38**, valley sections **40**, and transverse punched wall sections **42**) have an appropriate porous metal wicking material, generally denoted by reference numeral **62**, applied thereon. The porous metal wicking material **62** forms a porous wick structure to transport fluid medium therealong, and is supported by fin member **36**. Material **62** preferably comprises a porous aluminum foam coating, such as powdered aluminum which has been preferably flame-sprayed onto the fin member **36**. Advantageously, use of a flame-spraying application method results in a uniform layered coating of wick material **62**. The porous wicking material layer **62** is preferably between approximately 1.0 and 2.0 mm thick. Such a porous aluminum wicking material **62** acts as an excellent capillary-type wick to convey the condensed working liquid (such as an evaporative liquid medium; not shown) from the condenser section **60** along the lanced-offset fin member **36** to the evaporator section **58**. As an alternate material to use for the porous wicking material **62**, it could instead be formed as a sintered copper or sintered bronze material. Either such alternate material can be suitably flame-sprayed or otherwise applied to the lanced-offset fin member **36** to again create a suitable wicking structure for FPHP member **22**.

[**0032**] Due to the presence of the porous wicking material **62** as flame-sprayed onto the lanced-offset fin member **36**, the present FPHP cooling unit **20** can be utilized in any orientation. That is, the present invention's FPHP device **20** is not gravity-dependent, such as were the prior art FPHP and two-phase thermosyphon devices which were always required to be oriented vertically. Thus, such an "operable-in-all-orientations" feature is a significant improvement over the previously available passive cooling products. In sum, besides acting as a structural support for the base plate **27** and cover plate **28**, the lanced-offset fin member **36** further acts as a structural support for the wick surface formed of porous wicking material **62** inside the inner cavity **34** of the FPHP member **22**.

[**0033**] Referring to **FIGS. 1 and 3**, using suitable evacuation equipment, the inner shallow cavity **34** can be evacuated via the opening tube **32**. Then the desired amount of a suitable working fluid medium, such as acetone, can be introduced through opening tube **32**. Once the evaporative liquid medium has been introduced into inner cavity **34**, the opening tube **32** can be closed, such as by pinching off opening tube **32**, ultrasonic welding, or some other suitable method to seal off filler tube **32** and the inner cavity **34** thereby retaining the working medium within the FPHP member **22**. Alternatively, instead of using an aluminum alloy for the base member **26**, cover plate **28**, and the lanced-offset fin member **36**, a suitable titanium material could be used. This likewise would provide suitable structural support and rigidity to FPHP member **22**, yet remain sufficiently lightweight.

[**0034**] An alternate embodiment of the present invention is depicted in **FIG. 6**, where like reference numerals are used for like structural elements relative to the preferred embodiment of **FIG. 5**. That is, in **FIG. 6**, the porous wicking material **62** is shown, instead of being applied directly on the lanced-offset fin member **36**, as being flame-sprayed onto the interior facing surfaces of the respective base plate **27** and cover plate **28**. Thus, in this embodiment there is no porous wicking material **62** present on the lanced-offset fin member **36** at all. Otherwise, this alternate embodiment FPHP member **22'** of **FIG. 6** is identical to the FPHP member **22** of the preferred embodiment depicted in **FIG. 5**.

[**0035**] Depicted in **FIG. 7** is yet a further alternative embodiment of the present invention, generally denoted by a reference numeral **22"**. Here, the associated porous wicking material **62** is so formed and configured that the material **62** encases, and packs all open spaces, around the walls **44** of punched wall sections **42**, upstanding channel sections **38**, and intervening valley sections **40** of lanced-offset fin member **36**. Thus, while no porous wicking material **62** is present or formed directly on the inner surfaces of base plate **27** and cover plate **28** so that appropriate brazing occurs, nevertheless there is a substantially larger amount of the porous wicking material **62** present and structurally supported by the lanced-offset fin member **36** in this **FIG. 7** embodiment than with the prior two embodiments (of **FIGS. 5 and 6**).

[**0036**] The specific configuration for the porous wicking material **62** found in the embodiment of **FIG. 6** is formed by utilizing a pair of stainless steel plates with inwardly-protruding, mating linear fins (none shown) to sandwich the lanced-offset fin member **36** therebetween. The remaining open spaces are packed with a suitable powdered metal material, and then sintered in a furnace. A porous aluminum powdered metal can be used. Then, once suitably adhered to the lanced-offset fin structure **36**, the porous wick structure is created with the sintered powdered metal being heat fused together but still essentially retaining to same pore geometry as previously present between the powdered metal particles. The stainless steel plates (not shown) are then removed to result in an integral assembly of lanced-offset fin **36** with sintered wick structure (formed of porous wick material **62**) as shown in **FIG. 6**. Importantly, the surfaces of the lanced-offset fin **36** that face and mate with the base plate **27** and cover plate **28** are free of porous wick material **62**, thus allowing a very high strength braze joint between the same. The resulting sintered metal wick structure allows X-Y-Z movement of condensed fluid throughout the structure, while vapor moves in the open areas where the stainless steel fins were during sintering. Due to this particular metal wick structure, a very strong FPHP device **22** is created that is capable of withstanding significant internal and external pressure, e.g., greater than 500 psig.

[**0037**] It will be understood that the specially-configured sintered metal wick and lanced-offset fin assembly described above for this alternate embodiment of **FIG. 7** can also be beneficially used in the heavy-walled copper type FPHP's of the prior art, so as to reduce their overall resultant weight and cost.

[**0038**] In **FIG. 8** is shown a suitable clam shell-type cover housing **64**, which is used to cover off and protect the respective circuit boards **56** and heat dissipating members **54** carried thereon from external environment and potential damage. As needed, the cover housing **64** can be readily removed for suitable installation or repair purposes. Housing **64** can be formed as a cast aluminum or cast magnesium component.

[**0039**] The present FPHP cooling devices are thin-shelled units with lanced-offset fin structure brazed to both cover plates, resulting in a structurally strong sealed unit. They can, for example, be some 406 mm (16 inches) by 254 mm (10 inches) in size. It provides significant weight, size and cost savings over the prior two phase thermosyphons, and prior heavy, thick-walled copper-clad FPHP devices. The present passive cooling FPHP devices are particularly useful in cellular base station equipment, personal computers, supercomputers, power supplies, automotive electronic, and communication infrastructure equipment, e.g., microsite and picosite cellular equipment. The present invention allows use of a low cost passive cooling system in such electronics applications, reduces overall permissible product size and weight, and thus allows a higher overall electronics package density for the end user.

[**0040**] From the foregoing, it is believed that those skilled in the art will readily appreciate the unique features and advantages of the present invention over previous types of passive cooling units for integrated electronic devices. Further, it is to be understood that while the present invention has been described in relation to a particular preferred and alternate embodiments as set forth in the accompanying drawings and as above described, the same nevertheless is susceptible to change, variation and substitution of equivalents without departure from the spirit and scope of this invention. It is therefore intended that the present invention be unrestricted by the foregoing description and drawings, except as may appear in the following appended claims.

We claim:

1. A flat-plate evaporative-fluid type passive cooling device for use in dissipating heat in electronic applications, comprising in combination:

a base member having a shallow cavity formed internally therein, said cavity including a plurality of upstanding support boss members;

a cover plate adapted to sealably close off said base member to enclose said shallow cavity to enable containing an evaporative fluid medium therewithin;

lanced-offset fin means fitted into said shallow cavity and adapted to support said cover plate and said base member against external and internal pressure; and

porous metal wick means associated with said lanced-offset fin means and adapted to permit the evaporative fluid medium to travel therealong by capillary action once condensed from an evaporative state.

2. The device of claim 1, wherein said base member comprises a base plate portion, said plurality of upstanding bosses are formed on said base plate portion, and a peripheral wall portion extends from said base plate portion to form said shallow cavity within said base member.

3. The device of claim 1, and wherein said lanced-offset fin means, said base member, and said cover plate are formed of metallic material and said lanced-offset fin means are affixed to said base member and said cover plate by brazing.

4. The device of claim 3, wherein said porous metal wick means comprise a powdered metal coating applied directly onto said lanced-offset fin means.

5. The device of claim 4, wherein said applied coating of said powdered material is a flame-sprayed coating.

6. The device of claim 4, wherein said applied coating covers all non-brazed surfaces of said lanced-offset fin means.

7. The device of claim 2, wherein said porous metal wick means is applied onto the interior surfaces of said base plate and said cover plate.

8. The device of claim 3, wherein said porous metal wick means is formed as a sintered metal enclosure covering all non-brazed surfaces of said lanced-offset fin means, whereby said sintered metal enclosure permits the evaporative fluid medium to travel by capillary action in all directions once condensed from an evaporative state.

9. The device of claim 1, and filler opening means adapted to permit evacuation, filling, and sealing of said enclosed shallow cavity.

10. The device of claim 3, wherein said metallic material is formed from one of aluminum and an aluminum alloy.

11. The device of claim 1, and wherein said porous metal wick means is formed of aluminum powder.

12. The device of claim 1, wherein said porous metal wick means comprises flame-sprayed aluminum powder.

13. The device of claim 1, wherein said porous metal wick means is from approximately 1.0 mm to 2.0 mm thick.

14. The device of claim 2, wherein said base plate portion and said cover plate are each from approximately 0.5 mm to 1.0 mm thick.

15. The device of claim 1, and extended cooling fin means affixed to the outer surfaces of at least one end of said respective base member and said cover plate to permit external heat sink dissipation of heat collected and released during condensation of said evaporative fluid medium.

16. The invention of claim 3, wherein said metallic material is formed from one of titanium and a titanium alloy.

17. A method for providing passive cooling for integrated electronic devices, comprising the steps of:

a) forming a shallow-cavity metal base member having a base plate member, a peripheral wall member, and a plurality of upstanding support boss members;

b) fitting a lanced-offset metallic fin member into the shallow cavity base member;

c) installing porous metal wicking material into said shallow cavity base member;

d) enclosing the shallow cavity by affixing a cover plate to the base member;

e) brazing the lanced-offset metallic fin member to both the base member and the cover plate;

f) forming a fitting opening for the enclosed shallow cavity;

g) evacuating the interior of the enclosed shallow cavity through the fitting opening;

h) introducing a quantity of evaporative liquid medium into the enclosed shallow cavity through the fitting opening; and

i) sealing off the fitting opening.

18. The method of claim 17, and the step of forming the shallow cavity base member, cover plate, and lanced-offset metallic fin member of aluminum.

19. The method of claim 1, and the step of forming the porous metal wicking material of aluminum powder.

20. The method of claim 19, and the step of flame-spraying the aluminum powder.

21. The method of claim 17, and the step of applying said porous metal wicking material onto the surfaces of the lanced-offset metallic fin member.

22. The method of claim 17, and the step of applying said porous metal wicking material onto the interior surfaces of the base plate member and cover plate.

23. The method of claim 17, and the step of encasing the portions of the lanced-offset fin member which as extend between the base plate member and cover plate with the porous metal wicking material.

24. The method of claim 23, and the step of forming the encasement of porous metal wicking material about the lanced-offset fin member by fixturing the fin member between metal plates formed with depending linear fins, filling the voids between the metal plates and within and surrounding the exposed surfaces of the lanced-offset fin member with a metal powder, sintering the metal powder to the lanced-offset fin member by heating, and removing the metal plate members.

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