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(54) HEAT EXCHANGER FOR ELECTRONIC ASSEMBLIES

(75) Inventors: **John Santini**, Columbia, NJ (US); **Ronald Tallman**, Dingmans Ferry, PA (US); **Gary Mulcahy**, Flanders, NJ (US)

(73) Assignee: **TRANSISTOR DEVICES, INC. D/B/A TDI POWER**, Hackettstown, NJ (US)

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(57) **ABSTRACT**

A liquid-cooled heat exchanger for electronic assemblies and a method of making the heat exchanger. The exchanger has a solid metal body in the form of an elongated flat plate to which the electronic assembly can be mounted, or a number of such plates formed in an L- or U-shaped configuration to enclose two or more sides of the assembly. The elongated body is formed by extrusion, with parallel enclosed longitudinal passages formed along a length of the body during the extrusion process. Transverse passages are drilled to intersect the extruded longitudinal passages. The longitudinal passages and transverse passages are plugged on at least one of their outside ends, and optionally at points along their lengths, to create desired patterns of liquid flow through the heat exchanger.

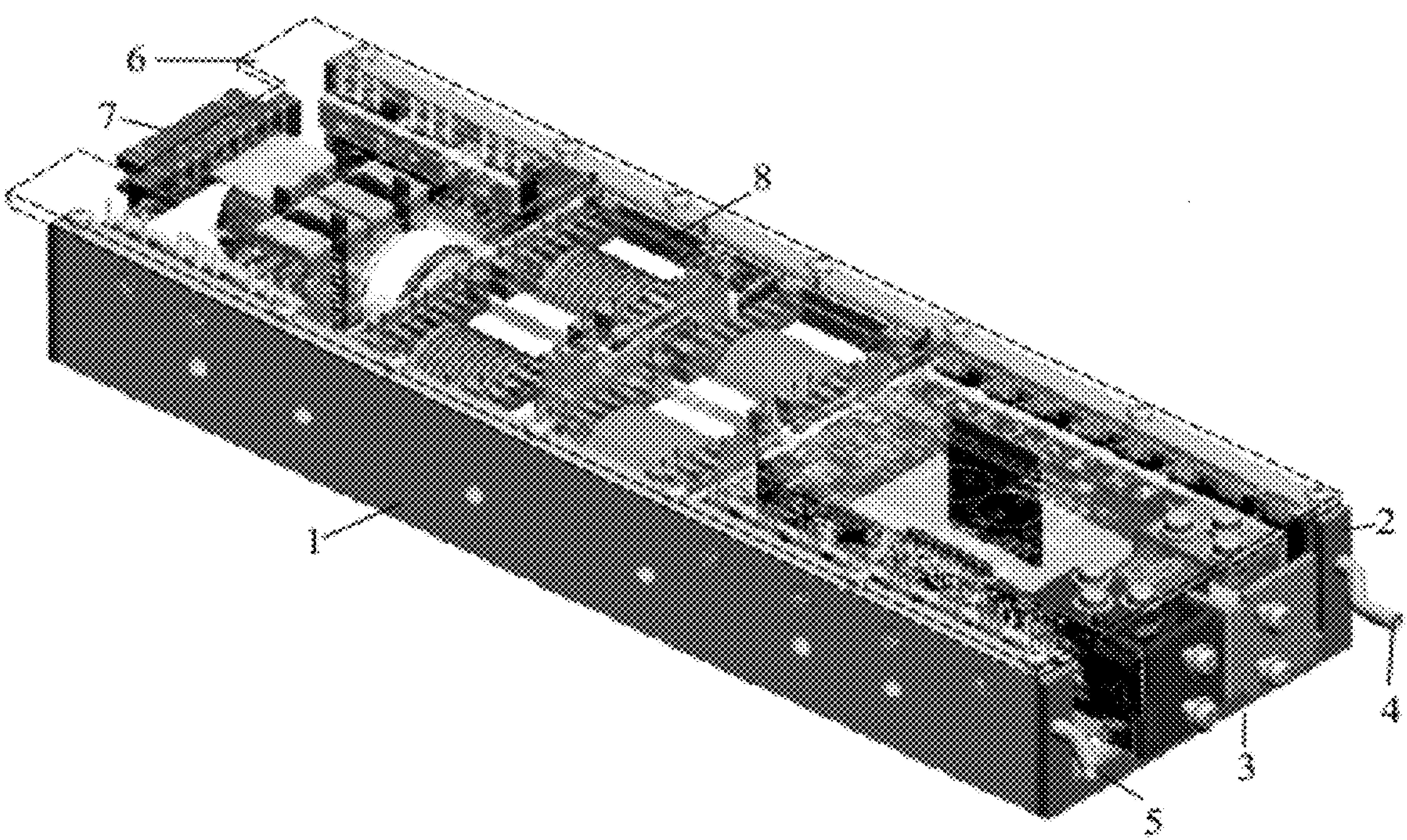

Fig. 1

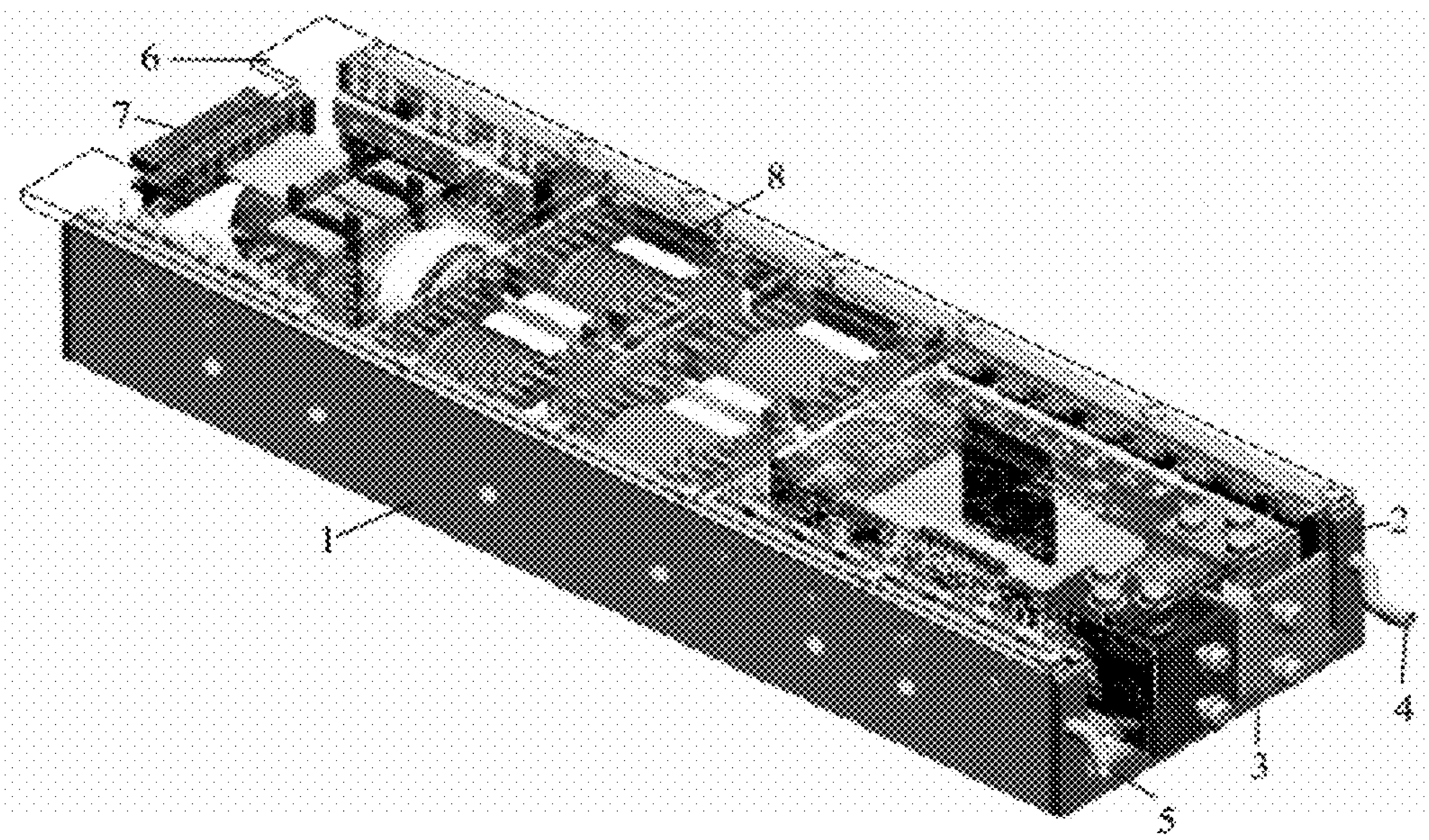
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Fig. 2

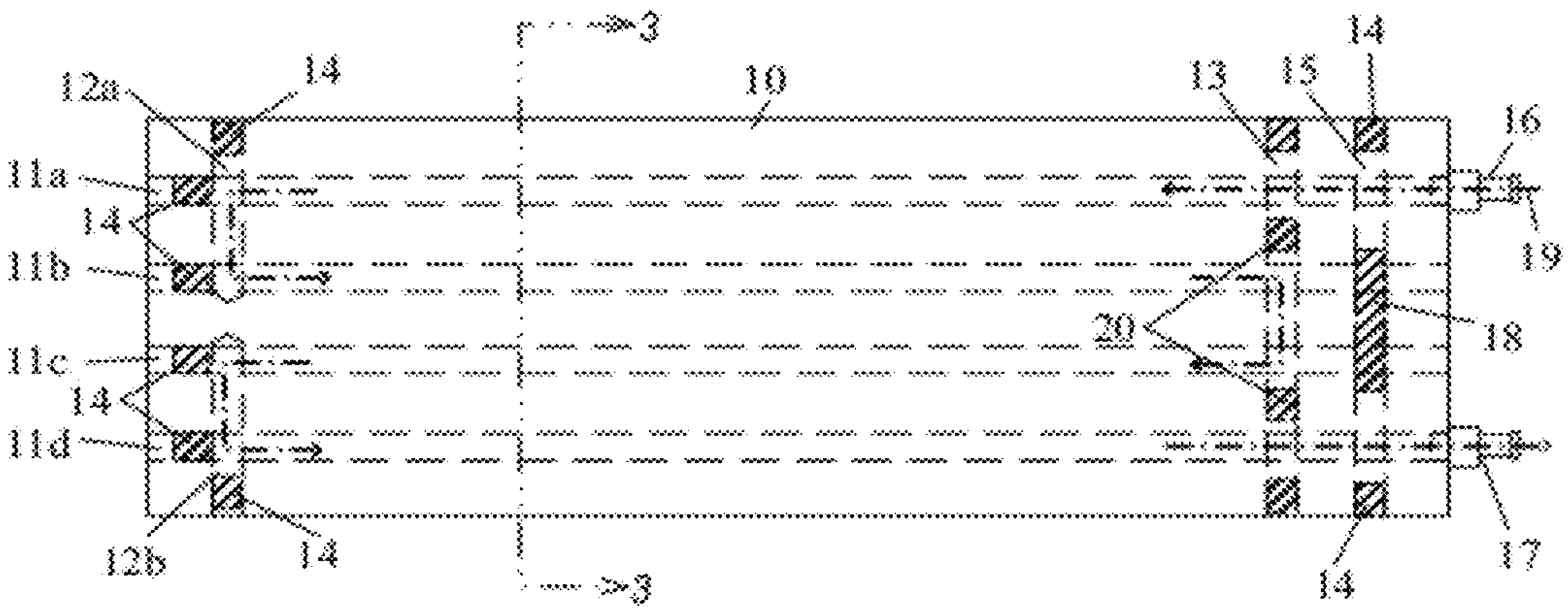
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Fig. 3

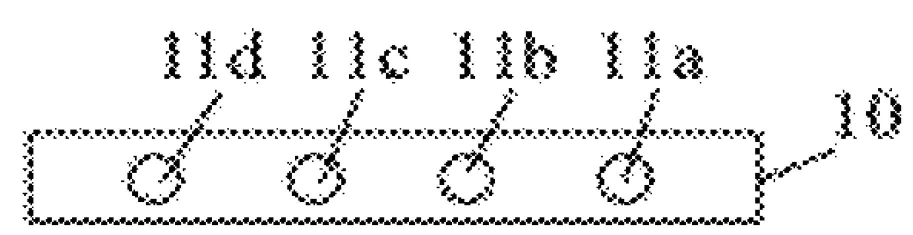


Fig. 4

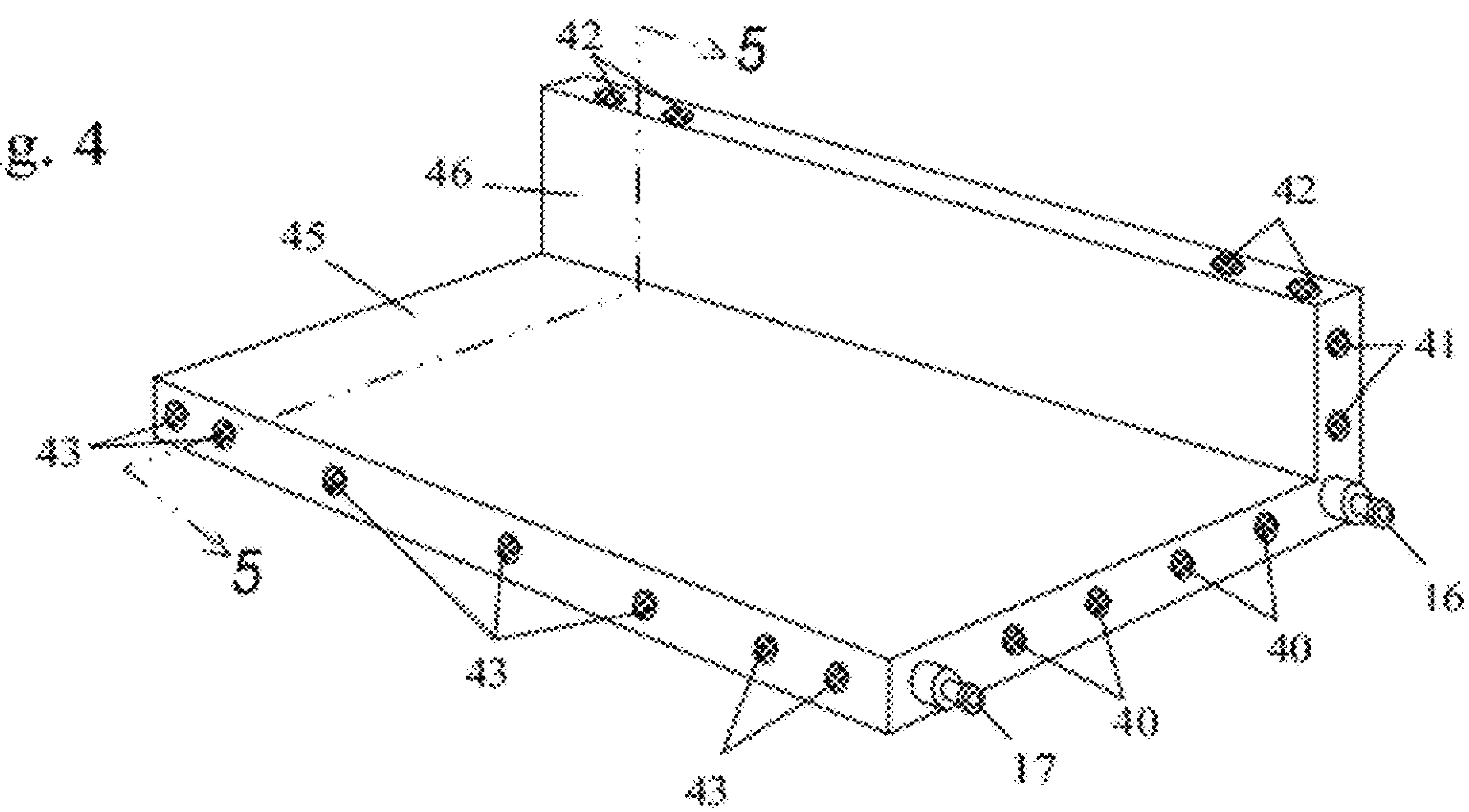


Fig. 5

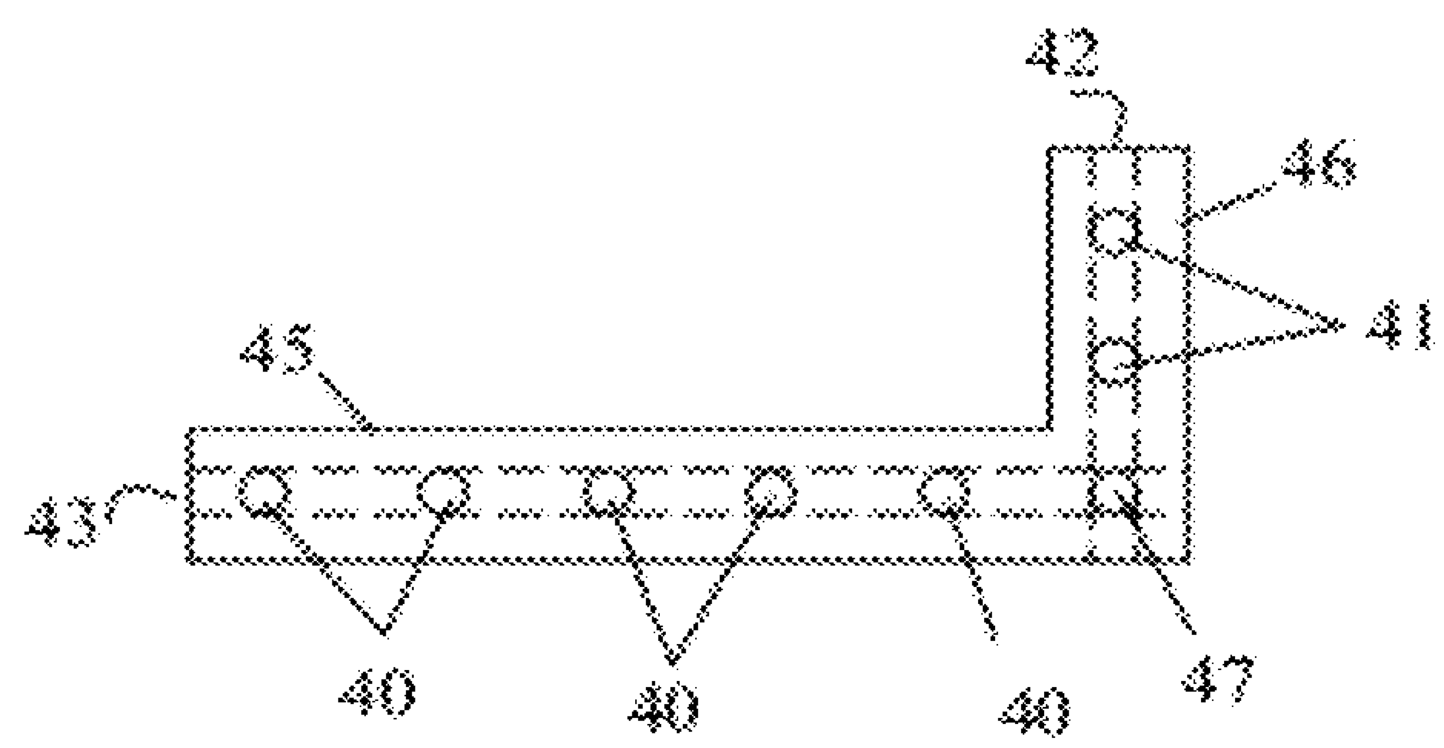


Fig. 6

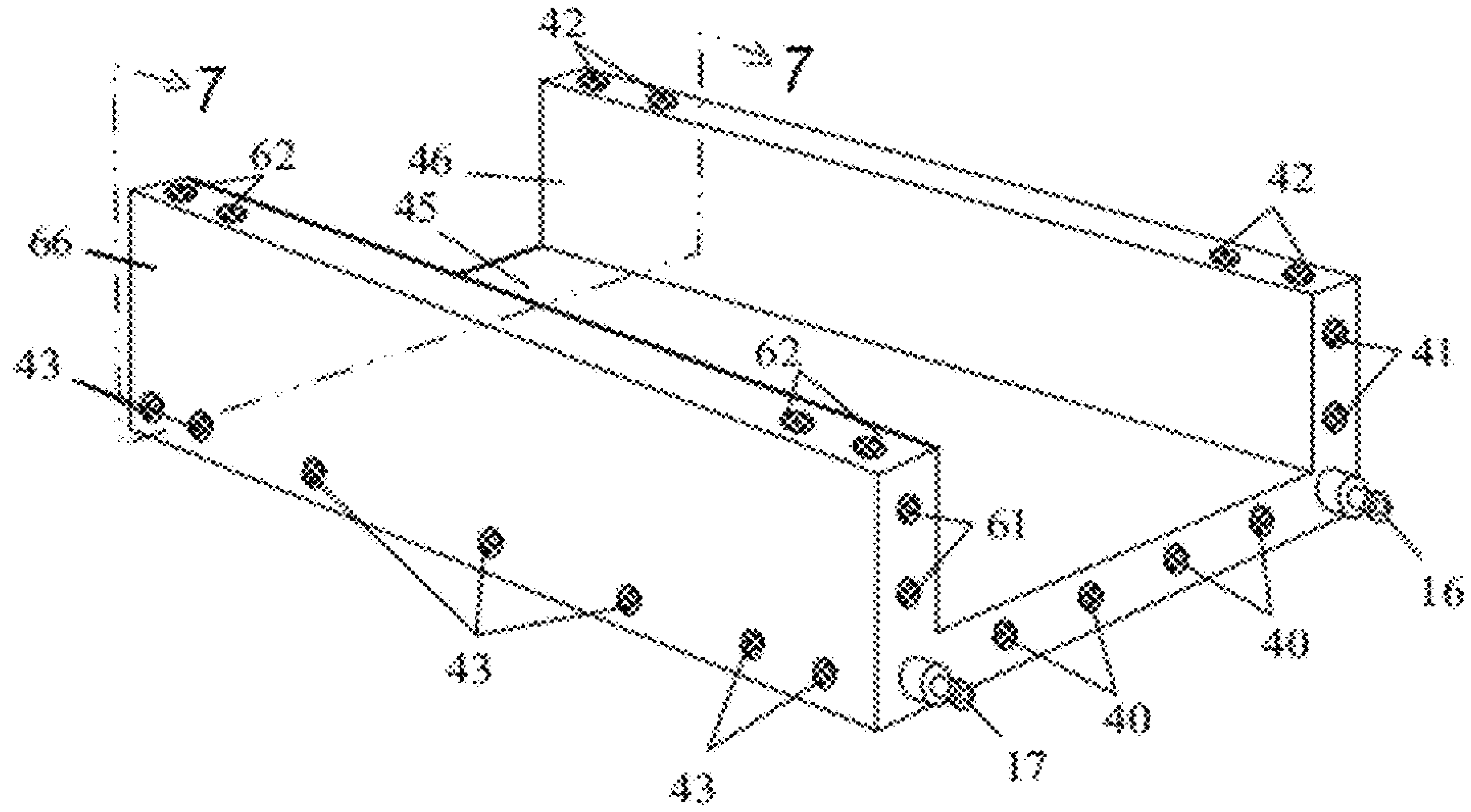


Fig. 7

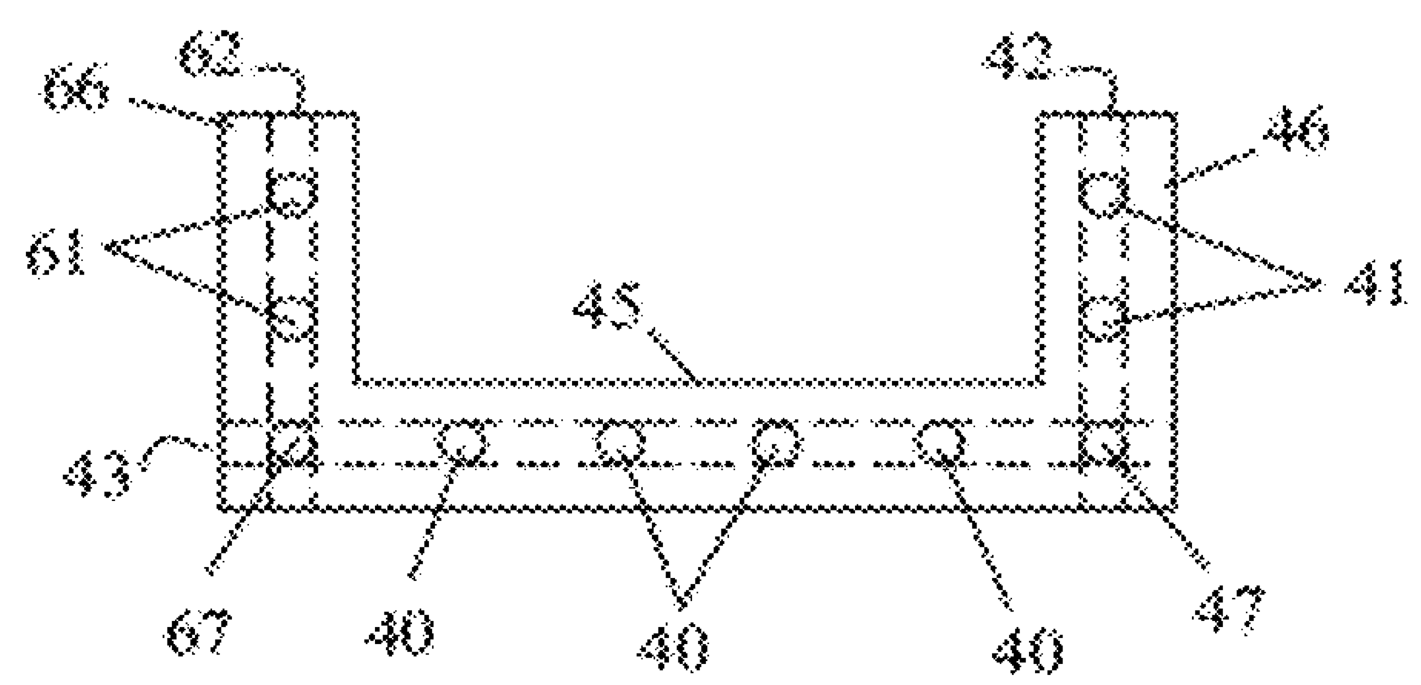


Fig. 10

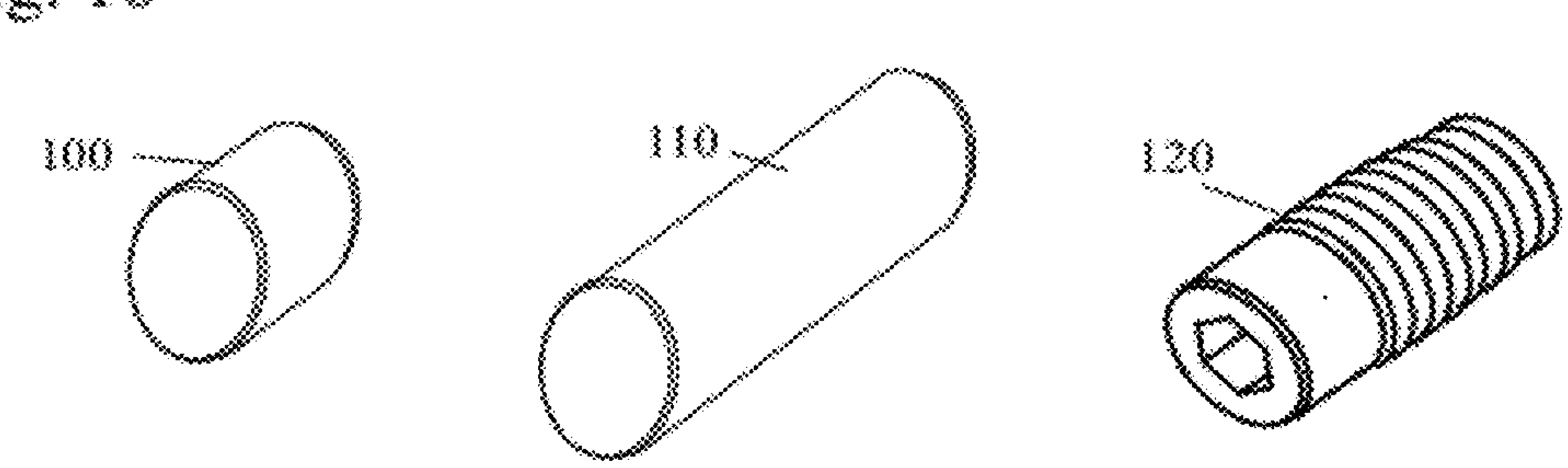


Fig. 8a

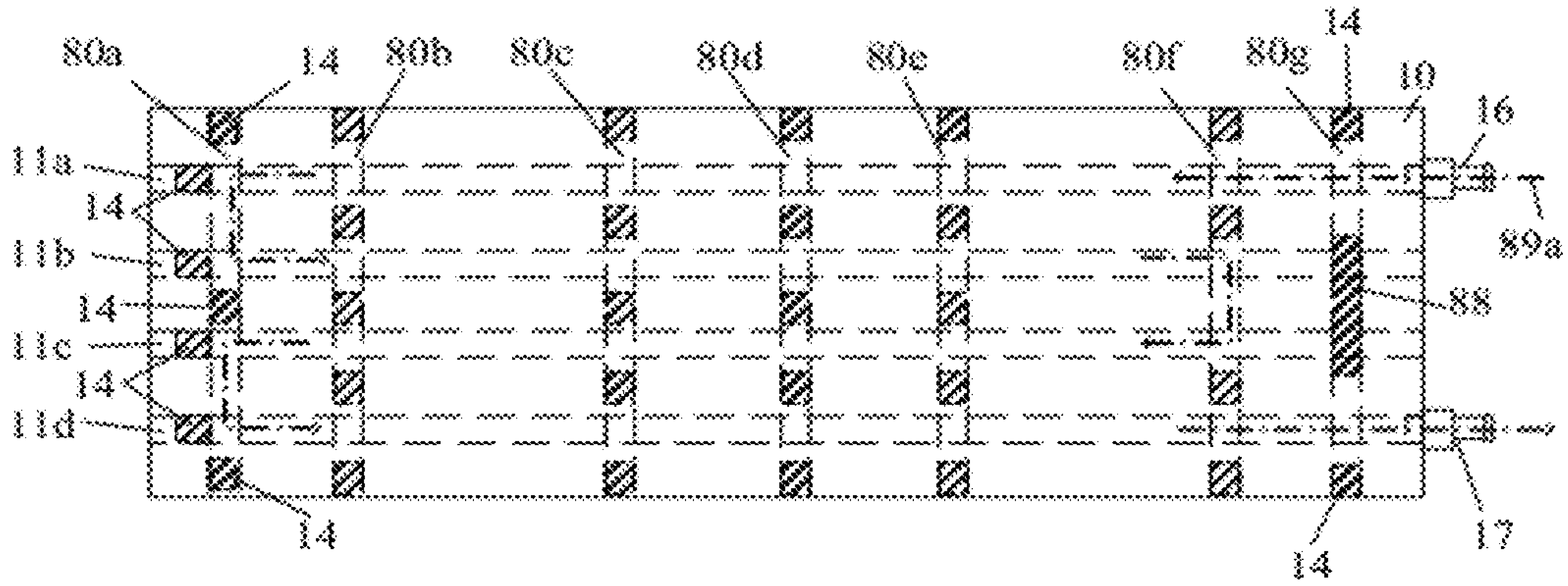


Fig. 8b

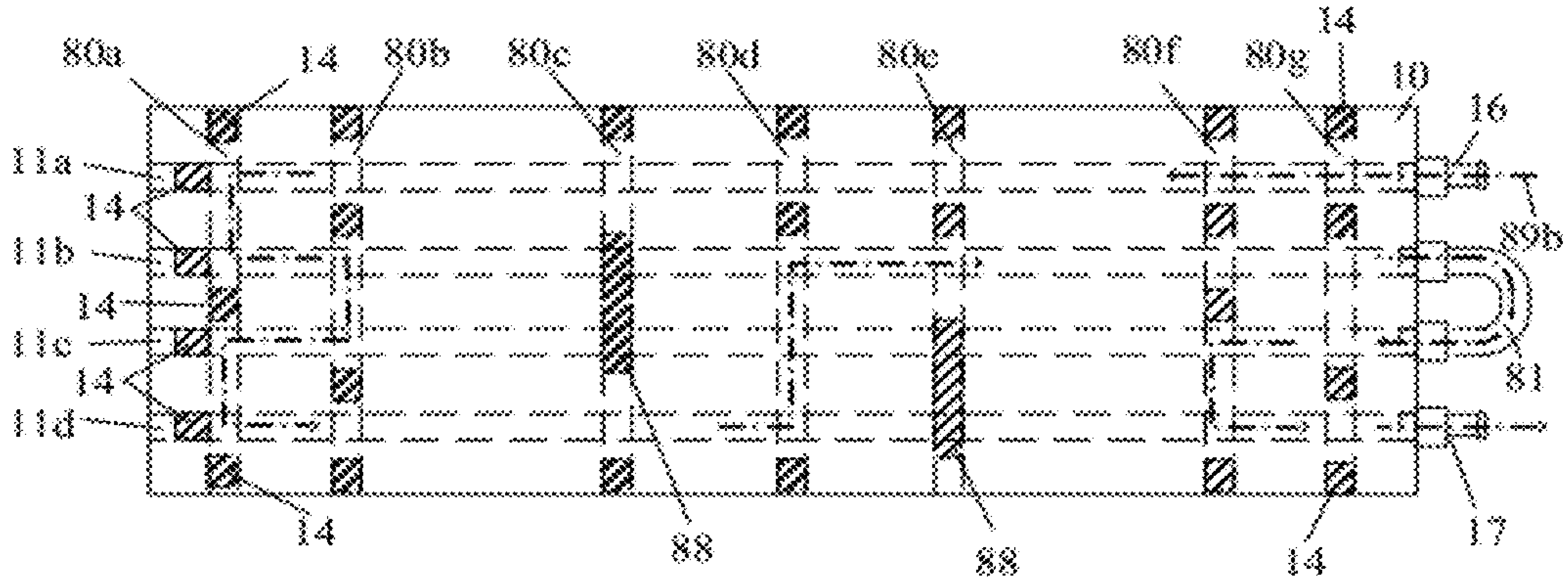


Fig. 8c

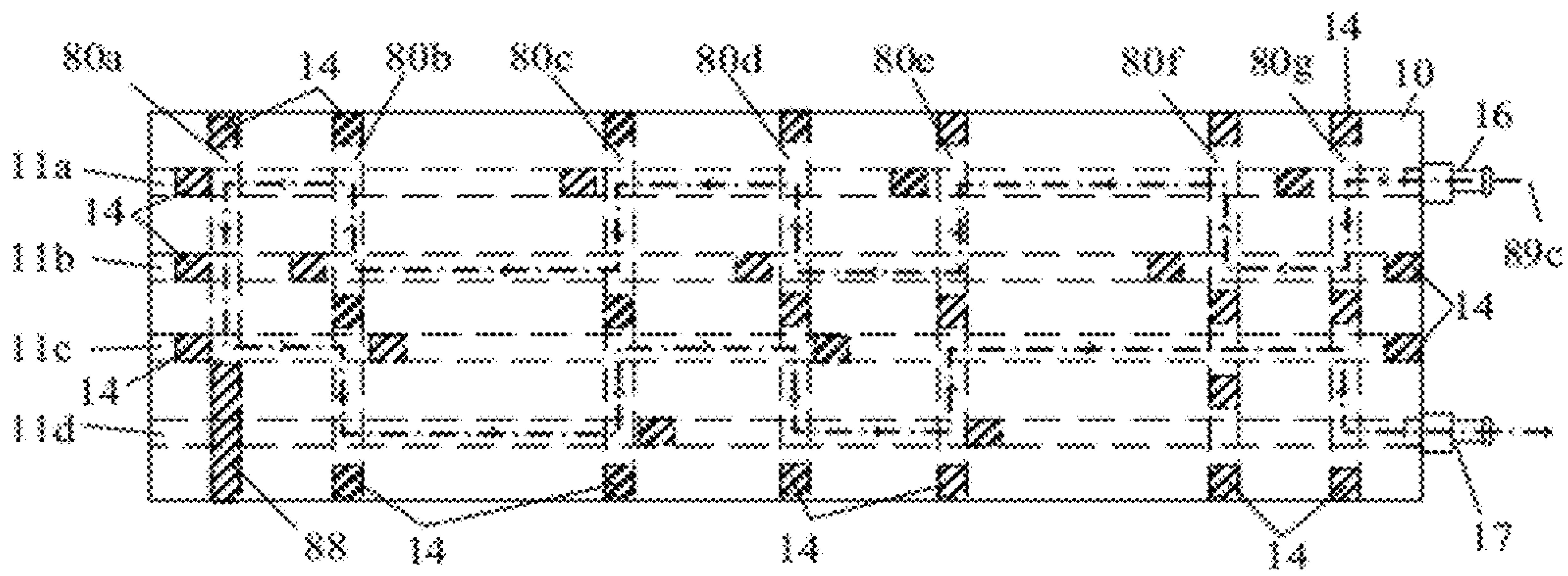
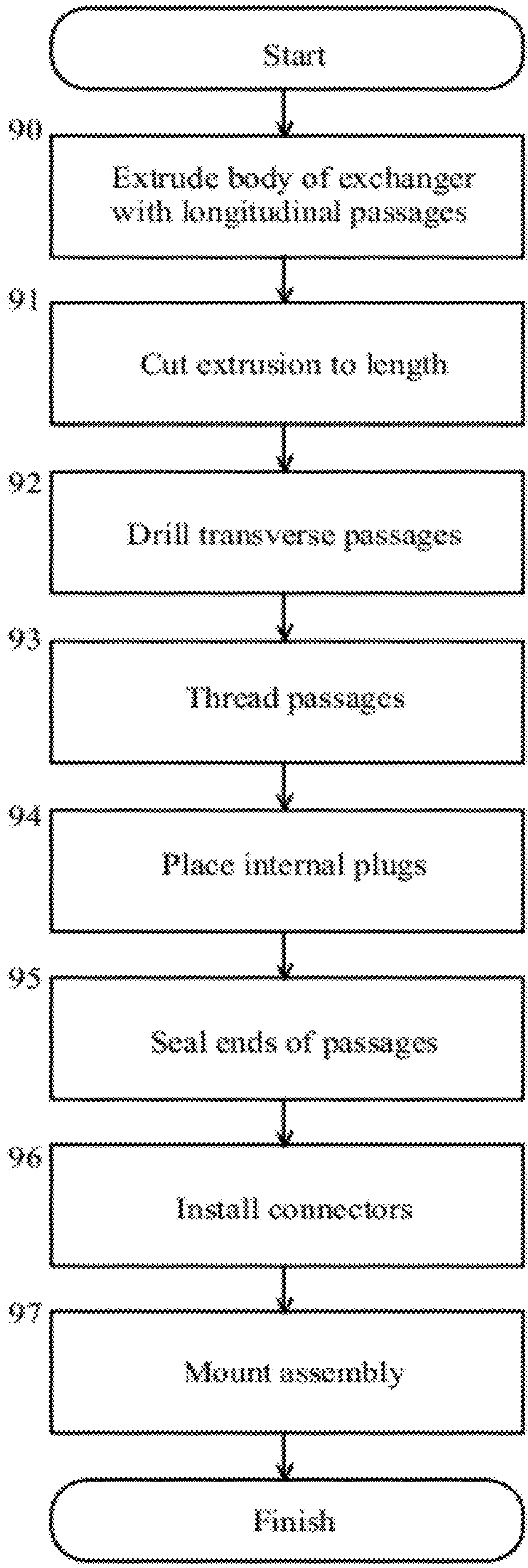


Fig. 9


Start
90
Extrude body of exchanger with longitudinal passages
91
Cut extrusion to length
92
Drill transverse passages
93
Thread passages
94
Place internal plugs
95
Seal ends of passages
96
Install connectors
97
Mount assembly
Finish

HEAT EXCHANGER FOR ELECTRONIC ASSEMBLIES

REFERENCE TO RELATED APPLICATIONS

[0001] This application claims one or more inventions which were disclosed in Provisional Application No. 61/419,930, filed Dec. 6, 2010. The benefit under 35 USC §119(e) of the United States provisional application is hereby claimed, and the aforementioned application is hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention pertains to the field of heat exchangers. More particularly, the invention pertains to liquid-cooled heat exchangers and methods of manufacture thereof.

[0004] 2. Description of Related Art

[0005] Electronic circuits must frequently operate in demanding physical environments in which liquid cooling is a preferred method for managing the heat associated with power losses. Conventional heat exchange systems use a monolithic air-to-liquid or surface-to-liquid heat exchangers to accomplish the cooling tasks. These conventional heat exchange systems have proven to be less than optimal when considering the aspects of cost and thermal management.

[0006] In many instances, it has become impossible to effectively couple all of the heat being generated in the system to the liquid cooling utilized to provide heat exchange, which results in excessive temperatures within the liquid-cooled structures. In addition, it is generally difficult to scale a particular solution either up or down in power, thereby requiring a ground up effort to support different power requirements.

[0007] Modern electronic equipment is often designed for mounting in racks or cabinets with only a small clearance between modules. This does not leave much room for large heat sinks or piping which might extend outward from the modules.

[0008] Heat exchangers for such modular assemblies are often in the form of flat plates which form one or more sides of the module case, to which circuit boards or heat-generating components may be mounted. If the heat exchangers are liquid cooled, the cooling liquid passes through pipes or tubes soldered or otherwise bonded to a surface of the plates or inset into a surface of the plate, with the fluid being supplied and exhausted from the exchangers through connections on an end of the plate. U.S. Pat. No. 5,829,516 or 6,333,849 show such an arrangement of tubes mounted to or inset into flat plates.

[0009] Liquid cooled heat exchanger plates have also been provided with internal cooling chambers through which liquid is circulated. U.S. Pat. No. 5,159,529 is an example of such an exchanger, in which essentially the entire interior of the plate forms a fluid chamber.

[0010] It is known to provide drilled holes through solid plates for cooling. U.S. Pat. No. 5,829,516, noted above, also, in prior art FIGS. **3-5**, shows a heat exchange plate in which four parallel holes are drilled from one end through most of the length of a solid plate. Two cross-holes are drilled at least part-way through from the sides near the opposite end to cross-connect the two outer pairs of longitudinal holes. The ends of the cross-holes are plugged, and an external pipe is provided to interconnect the drilled end of the two inner holes, to provide a single serpentine path for the fluid.

[0011] White Paper TW0055, "Next Generation Military Vehicle Power Conversion Modules", published in March 2008 by TDI Power (Transistor Devices, Inc.), shows, in FIGS. **9** and **10**, a U-shaped water-cooled heat exchanger housing a power converter. Holes are drilled the length of the three sides of the "U" for coolant circulation, similar to the arrangement in the 5,829,516 patent discussed above. While this arrangement has advantages in providing liquid cooling, drilling these long holes for coolant has proven problematic in manufacture.

[0012] U.S. Pat. No. 7,624,791 shows, in FIGS. **2**A and **2**B, a tubular cooling body having a central passageway, formed by using a hollow, drawn or extruded raw material. The body is then bent into a U-shaped configuration.

SUMMARY OF THE INVENTION

[0013] The invention presents a liquid-cooled heat exchanger for electronic assemblies and a method of making the heat exchanger. The exchanger has a solid metal body in the form of an elongated flat plate to which an electronic assembly can be mounted, or a number of such plates formed in an L- or U-shaped configuration to enclose two or more sides of the assembly. The elongated body is formed by extrusion, with parallel enclosed longitudinal passages formed along a length of the body during the extrusion process. Transverse passages are drilled to intersect the extruded longitudinal passages. The longitudinal passages and transverse passages are plugged on at least one of their outside ends, and optionally at points along their lengths, to create desired patterns of liquid flow through the heat exchanger.

BRIEF DESCRIPTION OF THE DRAWING

[0014] FIG. **1** shows a perspective view of an electronic assembly mounted within a U-shaped heat exchanger.

[0015] FIG. **2** shows a top view of a plate-type heat exchanger.

[0016] FIG. **3** shows a cut-through view of the heat exchanger of FIG. **2**, along the lines **3-3**.

[0017] FIG. **4** shows a perspective view of an L-shaped heat exchanger.

[0018] FIG. **5** shows a cut-through view of the heat exchanger of FIG. **4**, along the lines **5-5**.

[0019] FIG. **6** shows a perspective view of a U-shaped heat exchanger.

[0020] FIG. **7** shows a cut-through view of the heat exchanger of FIG. **6**, along the lines **7-7**.

[0021] FIGS. **8***a*-**8***c* show sectional views of a plate-type heat exchanger, showing differing patterns of liquid flow.

[0022] FIG. **9** is a flowchart of a method of making a heat exchanger.

[0023] FIG. **10** shows examples of plugs for use with the heat exchanger.

DETAILED DESCRIPTION OF THE INVENTION

[0024] The invention presents a liquid-cooled heat exchanger for electronic assemblies and a method of making the heat exchanger. The exchanger has a solid metal body in the form of an elongated flat plate to which the electronic assembly can be mounted, or a number of such plates formed in an L- or U-shaped configuration to enclose two or more sides of the assembly. The elongated body is formed by extrusion, with parallel enclosed longitudinal passages formed along a length of the body during the extrusion process.

Cross-passages are drilled to intersect the extruded longitudinal passages. The longitudinal passages and cross-passages are plugged on at least one of their outside ends, and optionally at points along their lengths, to create desired patterns of liquid flow through the heat exchanger.

[0025] FIG. **1** shows a perspective view of an electronic assembly **8**. The electrical components of the assembly, in this case a power supply, are conventionally mounted on a printed circuit board **6** which has a connector **7** allowing the assembly to connect to wiring or a bus in a rack or other mounting arrangement (not shown).

[0026] The assembly **8** is mounted within a U-shaped heat exchanger formed of a base plate **1** and sides **2** and **3**, which closely surround the components and to which the circuit board **6** is mounted. Heat generated by the components is removed by liquid circulating in passages through the plate **1** and the sides **2** and **3**, as will be described in greater detail below. Appropriate pipes or connectors **4** and **5** are provided to connect to a circulating supply of cooling liquid and to carry away heated liquid, as is conventional in a liquid-cooled apparatus.

[0027] Looking at the heat exchanger in greater detail, FIG. **2** shows a top view of an embodiment of the invention in the form of a flat plate-type heat exchanger, and FIG. **3** shows a cut-through view of the heat exchanger of FIG. **2**, along the lines **3-3**.

[0028] The heat exchanger in this embodiment is a flat plate **10** made of a heat-conductive material such as aluminum or other metal, having a thickness, width and length. The dimensions of the plate **10** would be determined in a manner known to the art, so as to fit the electronic assembly which it is intended to cool and to fit in whatever mounting arrangement might be required.

[0029] The plate **10** is formed by extrusion, and in the process of extrusion a number of parallel passages are formed running longitudinally through the plate. In the example shown in FIG. **2**, four such passages are shown—**11***a*, **11***b*, **11***c* and **11***d*—but it will be understood that any number of passages could be included within the teachings of the invention. FIG. **2** shows a simple arrangement of evenly spaced longitudinal passages **11***a-d*, but it will be understood that the passages could be arranged to have more liquid coolant through parts of the plate where more heat load is expected, or, conversely, to avoid areas where holes might need to be drilled to mount larger components. Liquid inlet **16** and outlet **17** connectors provide connections to the circulating cooling liquid system (not shown).

[0030] Transverse passages are drilled across the width of the plate **10**, intersecting some or all of the longitudinal passages **11***a-d*. In the example of FIG. **2**, parallel transverse passages **13** and **15** are drilled completely across the width of the plate **10**, on the end of the plate **10** having connectors **16** and **17**, intersecting all four longitudinal passages **11***a*-**11***d*. On the other hand, transverse passages **12***a* and **12***b*, on the opposite end of the plate **10**, are only drilled part-way across the width of the plate, so that transverse passage **12***a* only intersects longitudinal passages **11***a* and **11***b*, while transverse passage **12***b* intersects longitudinal passages **11***c* and **11***d*. As with the longitudinal passages, it will be understood that the particular arrangement of transverse passages shown in the figure are for example only. More or fewer transverse passages could be drilled, in different locations and arrangements, within the teachings of the invention. Transverse passages can be drilled to provide additional passages in areas needing additional cooling, or to avoid areas where mounting holes are needed. FIGS. **8***a*-**8***c*, discussed below, show a plate with four longitudinal passages and seven transverse passages, for example.

[0031] It will be appreciated that, at the least, the outside ends of the transverse and longitudinal passages will need to be plugged to prevent the cooling liquid from the fluid input **16** from simply flowing out of the ends of the passages. This can be done by welding or brazing, or by inserting plugs **14** into the outer ends of the passages as shown in the figure.

[0032] FIG. **10** shows several examples of plugs as might be used within the teachings of the invention. Plugs **100** and **110**, of differing lengths as will be discussed in greater detail below, could be made of resilient material and compressed into the passages, or the plugs **14** could be made of rigid material and press-fit into the passages and secured by a sealant or adhesive. Alternatively, the passages may be threaded along at least the outermost portion of their lengths, to facilitate screwing plug **120** into the plate.

[0033] The arrangement of intersecting longitudinal and transverse passages makes it possible to use additional plugs to create a desired internal liquid flow. Plugs can be relatively short and pushed into the transverse or longitudinal passages until they lodge between passages, thus blocking flow from one passage to another parallel to it. In the example of FIG. **2**, this has been done in transverse passage **13**, where plugs **20** block liquid flow through transverse passage **13** from longitudinal passage **11***a* to longitudinal passage **11***b*, or from **11***c* to **11***d*. Because there is no plug between longitudinal passages **11***b* and **11***c*, liquid can flow from one passage to the other through transverse passage **13**.

[0034] Longer plugs can be used to block two or more longitudinal and transverse passages simultaneously, such as plug **18**, shown pushed into transverse passage **15** across longitudinal passages **11***b* and **11***c*. This not only blocks flow along transverse passage **15**, but also prevents flow between the intersecting longitudinal passages **11***b* and **11***c*.

[0035] Dash-dot line **19** shows the flow of fluid through the heat exchanger shown in FIG. **2**. Fluid flows in connector **16**, then along longitudinal passage **11***a* and through transverse passage **12***a* to longitudinal passage **11***b*. Plug **18** blocks passage **11***b*, so the fluid flows across transverse passage **13** to longitudinal passage **11***c*, then to transverse passage **12***b*, and back on longitudinal passage **11***d* to exit at connector **17**.

[0036] FIG. **4** shows a perspective view of an L-shaped heat exchanger, and FIG. **5** shows a cut-through view of the heat exchanger of FIG. **4**, along the lines **5-5**.

[0037] An L-shaped heat exchanger would have a base plate **45** and side plate **46**, preferably formed as a single unit by extrusion. Parallel longitudinal passages **40** and **47** are formed during the extrusion process along the length of the base plate **45**, and a number of parallel transverse passages **43** are drilled across the plate to intersect the longitudinal passages **40**. Similarly, parallel longitudinal passages **41** are formed in side plate **46**, and transverse passages **42** are drilled to intersect the longitudinal passages **41** and also longitudinal passage **47** in the base plate **45**. By having longitudinal passage **47** intersected by both sets of transverse passages **42** and **43**, it is possible by appropriate insertion of plugs to direct fluid flow between connectors **16** and **17** through both base plate **45** and side plate **46**.

[0038] FIG. **6** shows a perspective view of a U-shaped heat exchanger, and FIG. **7** shows a cut-through view of the heat exchanger of FIG. **6**, along the lines **7-7**. An electronic assembly can be mounted to the U-shaped heat exchanger, as shown in FIG. **1**, forming a modular liquid cooled electronic component.

[0039] As with the L-shaped heat exchanger described above, the U-shaped heat exchanger would have a base plate **45** and side plate **46**, and would also have a second side plate **66**. Preferably, all three plates **45**, **46** and **67** are formed as a single unit by extrusion. Parallel longitudinal passages **40**, **47** and **62** are formed during the extrusion process along the length of the base plate **45**, and a number of parallel transverse passages **43** are drilled across the plate to intersect the longitudinal passages **40**. Similarly, parallel longitudinal passages **41** are formed in side plate **46**, and transverse passages **42** are drilled to intersect the longitudinal passages **41** and also longitudinal passage **47** in the base plate **45**. Also, parallel longitudinal passages **61** are formed in side plate **66**, and transverse passages **62** are drilled to intersect the longitudinal passages **61** and also longitudinal passage **67** in the base plate **45**. By having longitudinal passages **47** and **67** intersected by all of the of transverse passages **42**, **62** and **43**, it is possible by appropriate insertion of plugs to direct fluid flow between connectors **16** and **17** through base plate **45** and both side plates **46** and **66**.

[0040] Other designs of heat exchangers are possible within the teachings of the invention, in addition to the plate, L- and U-shaped exchangers described in detail above. For example, if the side walls **46** and **66** from the U-shaped exchanger were put on opposite surfaces of the plate **45**, a Z-shaped heat exchanger could be produced. Alternatively, a full tube heat exchanger could be made by adding another plate parallel to plate **45**, closing off the open side of the "U". More or fewer passages could be provided than is shown in the examples, and either longitudinal or transverse passages could be omitted entirely on one side wall **46** or **66** as might be required for a particular application.

[0041] The use of the intersecting transverse and longitudinal passages and long and short plugs allows for flexibility and efficiency, by allowing a designer to use a standardized heat exchanger and then customize the fluid flow as required by the electronic components to be cooled. To illustrate this process, FIGS. **8***a*-**8***c* show sectional views of a plate-type heat exchanger similar to that of FIG. **2**, showing differing patterns of liquid flow created by different arrangements of plugs.

[0042] The heat exchanger of FIGS. **8***a*-**8***c* has four longitudinal passages **11***a*-**11***d*, formed as part of the extrusion process of making the plate **10**. Seven transverse passages **80***a*-**80***g* are drilled to intersect the longitudinal passages **11***a*-**11***d*. It will be understood that the specific number and location of these passages are shown for explanatory purposes only, and the number and location of longitudinal and transverse passages can be varied within the teachings of the invention.

[0043] FIG. **8***a* shows a heat exchanger configured for a relatively simple fluid flow, similar to that of FIG. **2**. As in FIG. **2**, plugs **14** are placed at the ends of longitudinal passages **11***a*-**11***d* opposite the end with connectors **16** and **17**. Plugs **14** are also placed to block the ends of all of the transverse passages **80***a*-**80***g*. Plugs **14** are also placed in transverse passage **80***a* between longitudinal passages **11***b* and **11***c*, and in transverse passages **80***b*-**80***f* between longitudinal passages **11***a* and **11***b*, between longitudinal passages **11***b* and **11***c*, and between longitudinal passages **11***c* and **11***d*. A long plug **88** is placed in transverse passage **80***g*, blocking longitudinal passages **11***b* and **11***c*.

[0044] This results in a simple back-and-forth fluid flow shown by dot-dashed line **89***a*. Fluid flows in connector **16**, then along longitudinal passage **11***a* and through transverse passage **80***a* to longitudinal passage **11***b*. Plug **88** blocks passage **11***b*, so the fluid flows across transverse passage **80***f* to longitudinal passage **11***c*, then to transverse passage **80***a*, and back on longitudinal passage **11***d* to exit at connector **17**.

[0045] FIG. **8***b* shows a heat exchanger configured for a more circuitous flow, shown by dot-dashed line **89***b*. In this example, a U-shaped external fluid connector **81** is used at the end of the plate **10** which has connectors **16** and **17**, to route fluid between longitudinal passages **11***b* and **11***c*. It will be understood that such external connectors could be used within the teachings of the invention to route fluid flow between other passages, as might be required for a particular flow pattern.

[0046] In the example of FIG. **8***b*, plugs **14** are placed at the ends of longitudinal passages **11***a*-**11***d* opposite the end with connectors **16** and **17**. Plugs are placed in the transverse passages **80***a*-**80***g* as follows:

- **[0047]** in transverse passage **80***a*, a plug **14** at each end and between longitudinal passages **11***b* and **11***c*.
- **[0048]** in transverse passage **80***b*, a plug **14** at each end, between longitudinal passages **11***a* and **11***b* and between longitudinal passages **11***c* and **11***d*.
- **[0049]** in transverse passage **80***c*, a plug **14** at each end, and a long plug **88** is placed across longitudinal passages **11***c* and **11***d*.
- **[0050]** in transverse passage **80***d*, a plug **14** is placed at each end and between longitudinal passages **11***a* and 1l*b*.
- **[0051]** in transverse passage **80***e*, plugs **14** are placed at the end of the passage adjacent longitudinal passage **11***a*, and between longitudinal passages **11***a* and **11***b*, and a long plug **88** is placed across longitudinal passages **11***c* and **11***d*.
- **[0052]** in transverse passage **80***f*, plugs **14** are placed at each end, between longitudinal passages **11***a* and **11***b* and between longitudinal passages **11***b* and **11***c*.
- **[0053]** in transverse passage **80***g*, a plug **14** at each end, between longitudinal passages **11***a* and **11***b* and between longitudinal passages **11***c* and **11***d*.

[0054] This arrangement of plugs **14** and long plugs **88** results in a flow **89***b* from inlet connector **16** down the length of longitudinal passage **11***a*, through transverse passage **80***a* to longitudinal passage **11***b*, across transverse passage **80***b* to longitudinal passage **11***c*, across transverse passage **80***a* to longitudinal passage **11***d*. Fluid passes along **11***d* to transverse passage **80***d*, crosses over along **80***d* to longitudinal passage **11***b*. The fluid then exits the plate **10** through connector **81**, and back into the plate **10** through longitudinal passage **11***c*, across transverse passage **80***f* to longitudinal passage **11***d*, then out through outlet connector **17**.

[0055] FIG. **8***c* illustrates still another example of fluid flow **89***c* from connector **16** to connector **17**, the flow being more complex than in FIG. **8***a* or **8***b*, as might be required by a particular electronic assembly.

[0056] In the example of FIG. **8***c*, plugs are placed in the transverse passages **80***a*-**80***g* as follows:

- **[0057]** in transverse passage **80***a*, a plug **14** at the end of the passage adjacent longitudinal passage **11***a*, and a long plug **88** is inserted from the opposite end, blocking longitudinal passage **11***d*.

[0058] in transverse passages **80***b*, **80***c*, **80***d* and **80***e*, a plug **14** at each end and between longitudinal passages **11***b* and **11***c*.

[0059] in transverse passage **80***f*, a plug **14** at each end and between longitudinal passages **11***b* and **11***c* and between longitudinal passages **11***c* and **11***d*.

[0060] in transverse passage **80***g*, a plug **14** at each end and between longitudinal passages **11***b* and **11***c*.

[0061] Plugs **14** are placed in longitudinal passages **11***a*-**11***d* as follows:

[0062] in longitudinal passage **11***a*, at the end opposite connector **16**, between transverse passages **80***b* and **80***c*, between transverse passages **80***d* and **80***e*, and between transverse passages **80***f* and **80***g*.

[0063] in longitudinal passage **11***b*, at both ends, between transverse passages **80***a* and **80***b*, between transverse passages **80***c* and **80***d*, and between transverse passages **80***e* and **80***f*.

[0064] in longitudinal passage **11***c*, at both ends, between transverse passages **80***b* and **80***c*, and between transverse passages **80***d* and **80***e*.

[0065] in longitudinal passage **11***d*, between transverse passages **80***c* and **80***d*, and between transverse passages **80***e* and **80***f*.

[0066] This arrangement of plugs **14** and long plugs **88** results in a flow **89***c* from inlet connector **16** into longitudinal passage **11***a*, through transverse passage **80***g* to longitudinal passage **11***b*, across transverse passage **80***f* to longitudinal passage **11***a*, across transverse passage **80***e* to longitudinal passage **11***b*. Fluid passes along **11***b* to transverse passage **80***d*, crosses over along transverse passage **80***d* to longitudinal passage **11***a*, back to longitudinal passage **11***b* through transverse passage **80***c*, then back to longitudinal passage **11***a* through transverse passage **80***b*. From longitudinal passage **11***a*, the flow crosses transverse passage **80***a* to longitudinal passage **11***c*, then up **11***c* to transverse passage **80***b*, across **80***b* to longitudinal passage **11***d*. From longitudinal passage **11***d*, flow crosses transverse passage **80***c* to longitudinal passage **11***c*, then back to longitudinal passage **11***d* on transverse passage **80***d*, back to longitudinal passage **11***c* on transverse passage **80***e*. The flow continues on longitudinal passage **11***c* to transverse passage **80***g*, where it crosses to longitudinal passage **11***d*, then out through outlet connector **17**.

[0067] FIG. **9** is a flowchart of a method of making a heat exchanger of the kind described above. It will be understood that the method is applicable to the plate, L- and U-shaped exchangers.

[0068] **90**. First, the body of the heat exchanger is produced by extrusion. By methods known to the art, the body shape and dimensions can be determined as required. The longitudinal passages are formed as part of the extrusion process.

[0069] **91**. Optionally, the extrusion can be made much longer than the actual device, in which case the extrusion will be cut to length. Alternatively, the extrusion can be made to the desired length, and a cutting step will not be necessary.

[0070] **92**. The transverse passages are drilled.

[0071] **93**. If desired, all or some of the lengths of the longitudinal passages and transverse passages are threaded to accept plugs or connectors.

[0072] **94**. Internal plugs are inserted into the transverse passages and/or longitudinal passages, and located as needed to produce the desired flow patterns.

[0073] **95**. The ends of the transverse passage and longitudinal passages are sealed with plugs, as needed.

[0074] **96**. Connectors are installed on the ends of one or more passages as desired.

[0075] **97**. An electronic assembly is mounted to the heat exchanger.

[0076] Accordingly, it is to be understood that the embodiments of the invention herein described are merely illustrative of the application of the principles of the invention. Reference herein to details of the illustrated embodiments is not intended to limit the scope of the claims, which themselves recite those features regarded as essential to the invention.

What is claimed is:

1. A heat exchanger for electronic assemblies, comprising:

a) a solid heat-conductive base plate having a length, a width and a thickness, the plate being formed by extrusion with a plurality of parallel longitudinal passages enclosed in the thickness along the length of the base plate; the base plate also having a plurality of parallel transverse passages drilled across at least part of the width, perpendicular to the plurality of longitudinal passages, such that each transverse passage intersects at least two longitudinal passages;

b) a fluid inlet at an end of a longitudinal passage or a transverse passage;

c) a fluid outlet at an end of a longitudinal passage or a transverse passage; and

d) a plurality of plugs for blocking fluid flow, inserted into the plurality of longitudinal passages and the plurality of transverse passages,

the plugs being located such that fluid is constrained to flow from the fluid inlet through the plurality of longitudinal passages and the plurality of transverse passages to the fluid outlet.

2. The heat exchanger of claim **1**, in which the exchanger further comprises a solid heat-conductive side wall having a length, a height and a thickness, formed by extrusion with the base plate to form an L-shaped unit, the side wall having a plurality of parallel longitudinal passages enclosed in the thickness along the length of the side wall; the side wall also having a plurality of parallel transverse passages drilled across at least part of the height, perpendicular to the plurality of longitudinal passages, such that each transverse passage intersects at least two longitudinal passages.

3. The heat exchanger of claim **2**, in which at least one of the transverse passages is drilled to intersect at least one longitudinal passage on the base plate and at least one longitudinal passage on the side wall.

4. The heat exchanger of claim **1**, in which the exchanger further comprises two solid heat-conductive side walls having a length, a height and a thickness, formed by extrusion with the base plate to form a U-shaped unit, at least one of the side walls having a plurality of parallel longitudinal passages enclosed in the thickness along the length of the side walls; and at least one of the side walls also having a plurality of parallel transverse passages drilled across at least part of the height, perpendicular to the plurality of longitudinal passages, such that each transverse passage intersects at least two longitudinal passages.

5. The heat exchanger of claim **4**, in which at least one of the transverse passages in a side wall is drilled to intersect at least one longitudinal passage on the base plate and at least one longitudinal passage on the side wall.

6. The heat exchanger of claim **4**, in which both side walls are extruded with longitudinal passages and drilled with transverse passages.

7. The heat exchanger of claim **1**, in which the plugs are made of resilient material.

8. The heat exchanger of claim **1**, in which at least an end portion of the transverse passages and the longitudinal passages is threaded.

9. The heat exchanger of claim **8**, in which at least some of the plugs are threaded to mate with a threaded end portion of the longitudinal passages and the transverse passages.

10. The heat exchanger of claim **1**, in which at least one plug has a length sufficient to block more than one passage when the plug is inserted into an intersecting passage.

11. The heat exchanger of claim **1**, further comprising a U-shaped connector for insertion into an end of two parallel longitudinal passages or two transverse passages, for fluid flow therebetween.

12. A method of making a heat exchanger for electronic assemblies, comprising:

a) extruding a solid heat-conductive plate having a length, a width and a thickness, with a plurality of parallel longitudinal passages enclosed in the thickness along the length of the plate;

b) drilling a plurality of parallel transverse passages drilled across at least part of the width, perpendicular to the plurality of longitudinal passages, such that each transverse passage intersects at least two longitudinal passages;

c) inserting a plurality of plugs for blocking fluid flow into the plurality of longitudinal passages and the plurality of transverse passages, the plugs being located such that fluid is constrained to flow from a fluid inlet at an end of a longitudinal passage or a transverse passage through the plurality of longitudinal passages and the plurality of transverse passages to a fluid outlet at an end of a longitudinal passage or a transverse passage.

13. The method of claim **12**, further comprising sealing an open end of at least one longitudinal passage or transverse passage.

14. The method of claim **12**, further comprising installing a connector at the fluid input and at the fluid output.

15. The method of claim **12**, further comprising mounting an electronic assembly to the base plate.

16. The method of claim **12**, further comprising cutting the base plate to a determined length.

17. The method of claim **12**, in which the plate is formed with a base plate and a side wall forming an L-shaped heat exchanger.

18. The method of claim **12**, in which the plate is formed with a base plate and two side walls forming a U-shaped heat exchanger.

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