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(54) MICROFLUIDIC DEVICE FOR PROFILING BIOCHEMICAL SAMPLES

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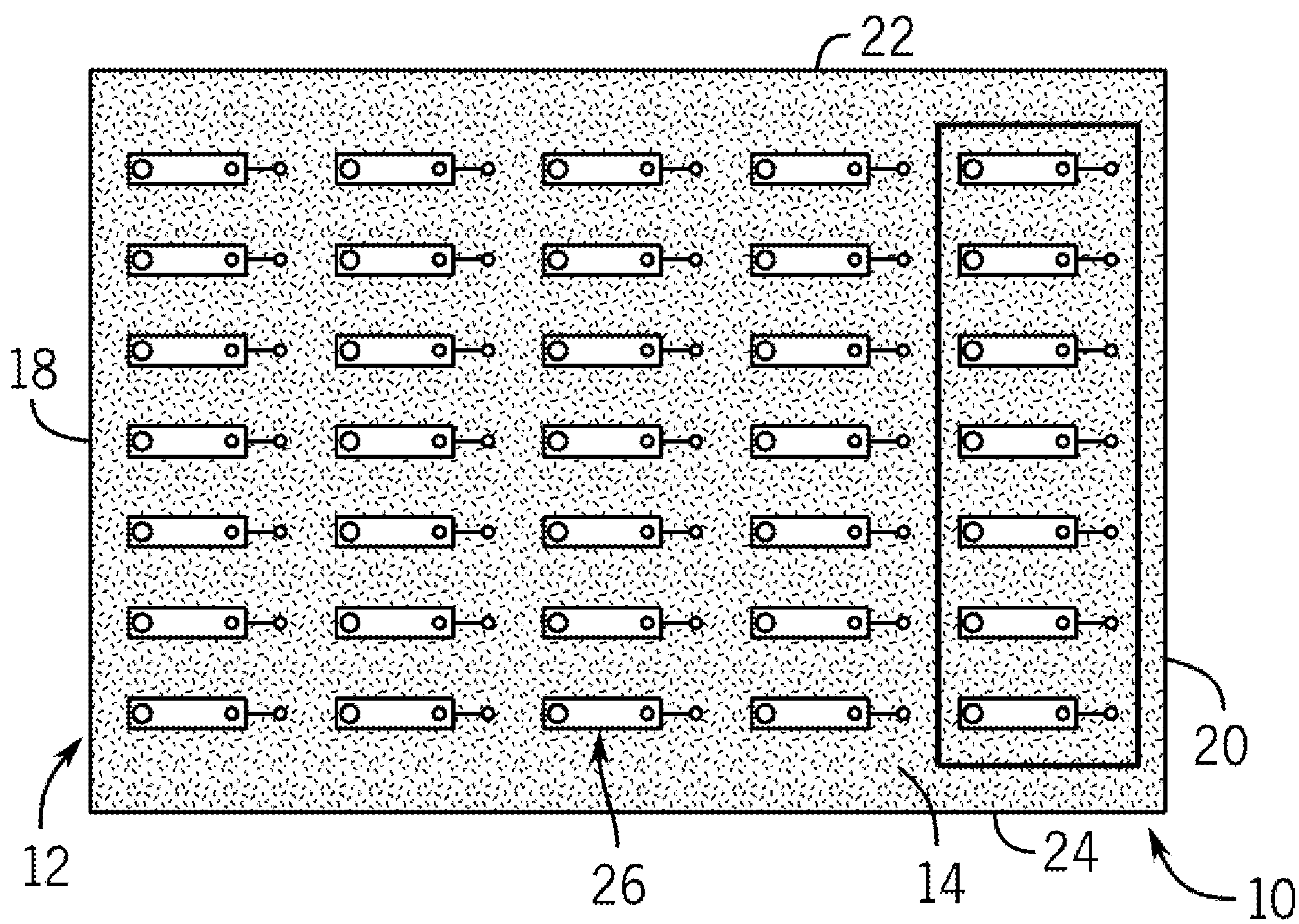
(57) **ABSTRACT**

A microfluidic device for profiling biochemical samples is provided. The microfluidic device includes a cartridge defining a channel network. The channel network includes a channel having first and second opposite ends. A first loading port is in communication with the channel. A well is in communication with the channel through a second loading port and is located between the first loading port and the second end of the channel. The second well is adapted for receiving a second fluid therein. An air outlet is in communication with channel at a location adjacent to the second end of the channel. The second loading port has a dimension to pin the second fluid in the second well. The first fluid received in the first well flows into the channel toward the air outlet. At least a portion of the first fluid flowing through the channel flows into the second well through the second loading port.



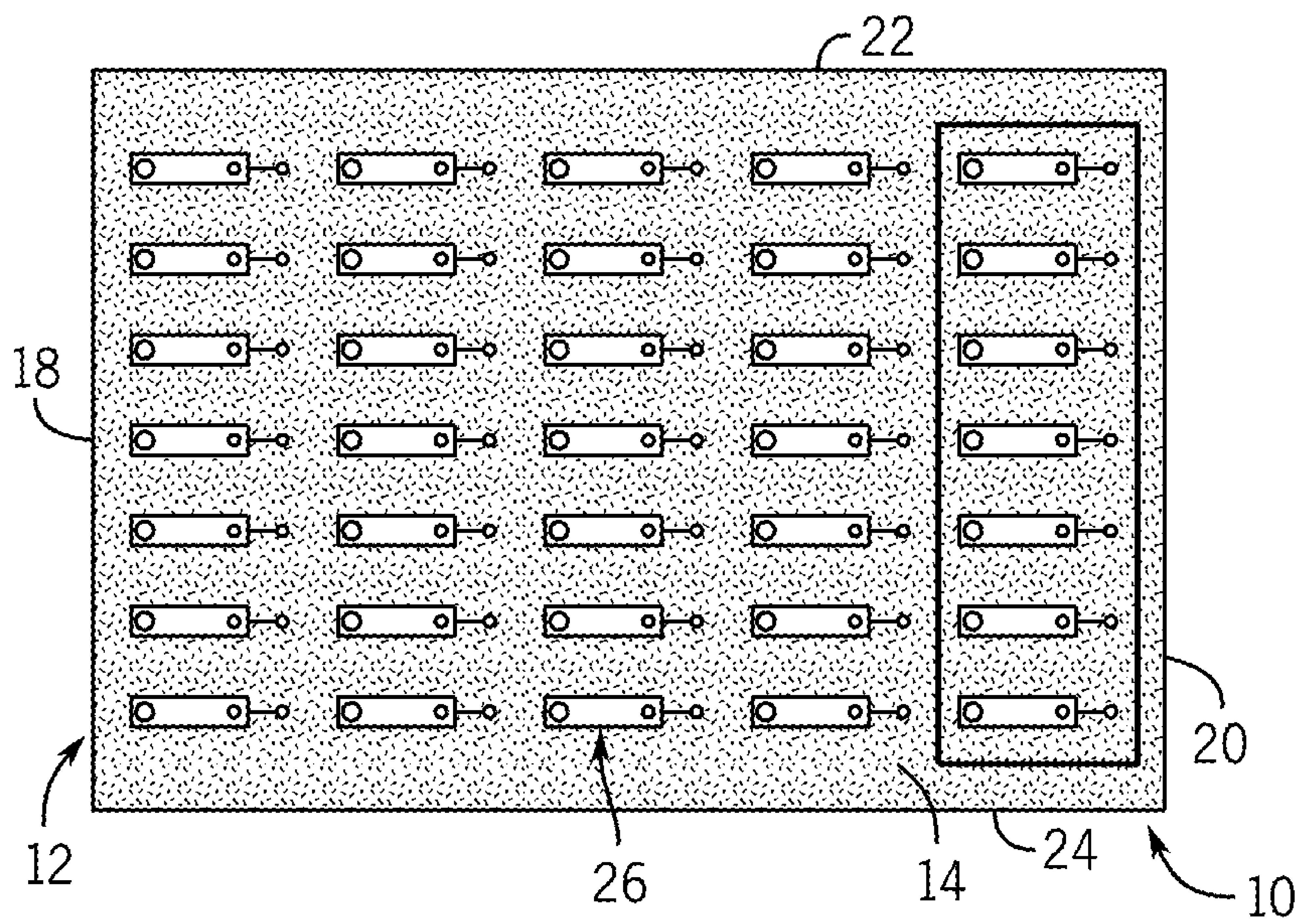


FIG. 1

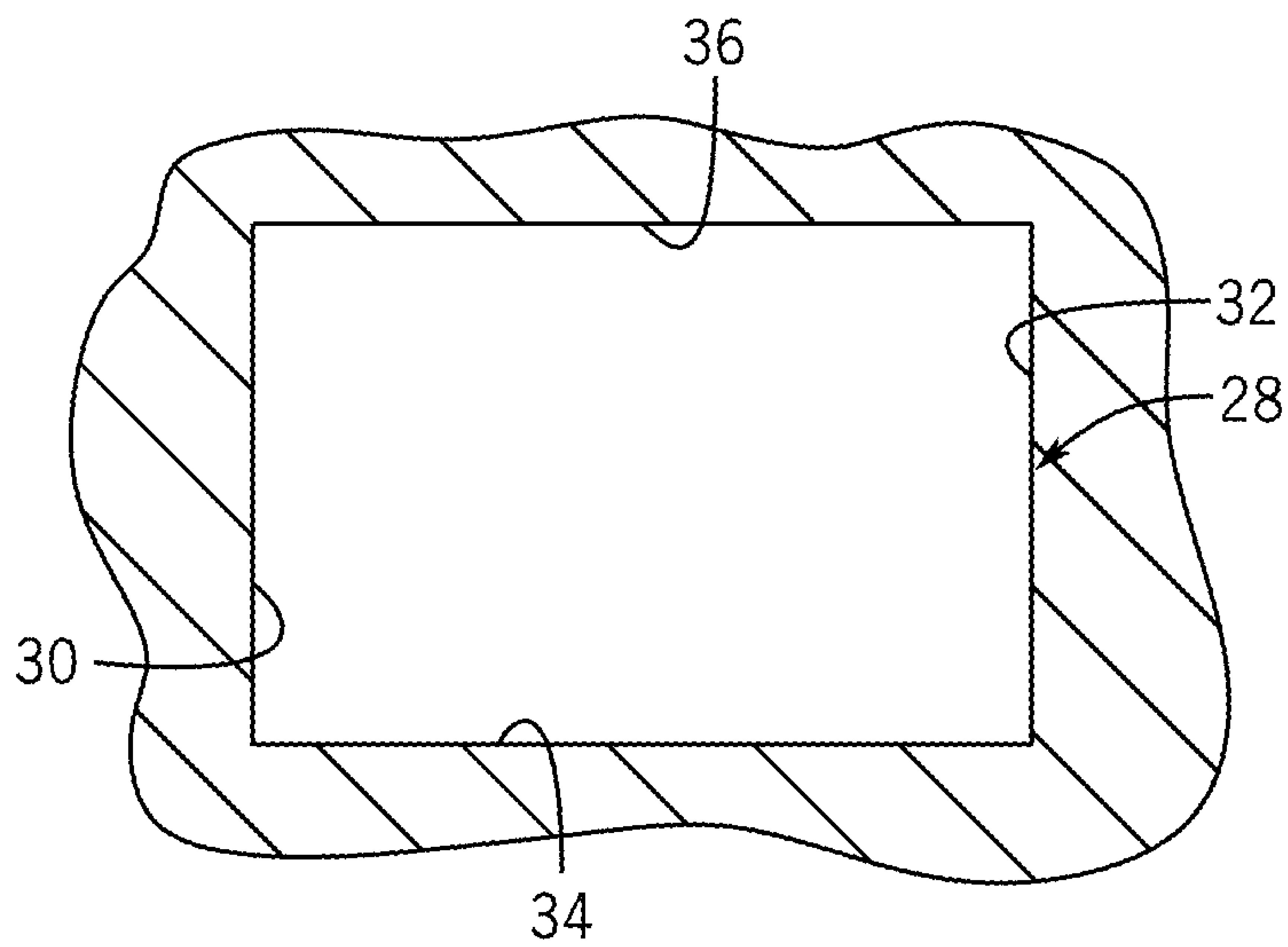


FIG. 4

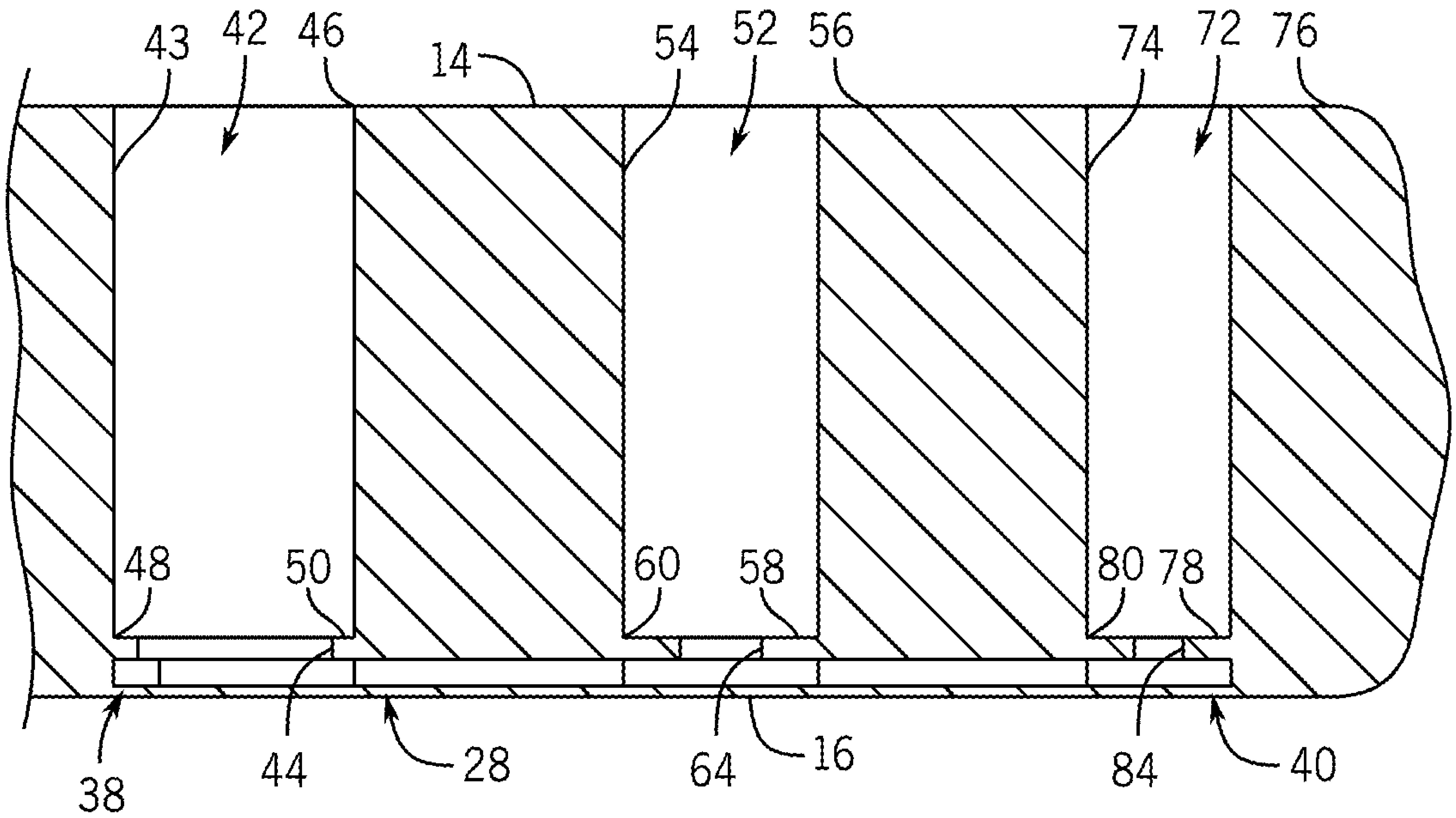

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FIG. 3

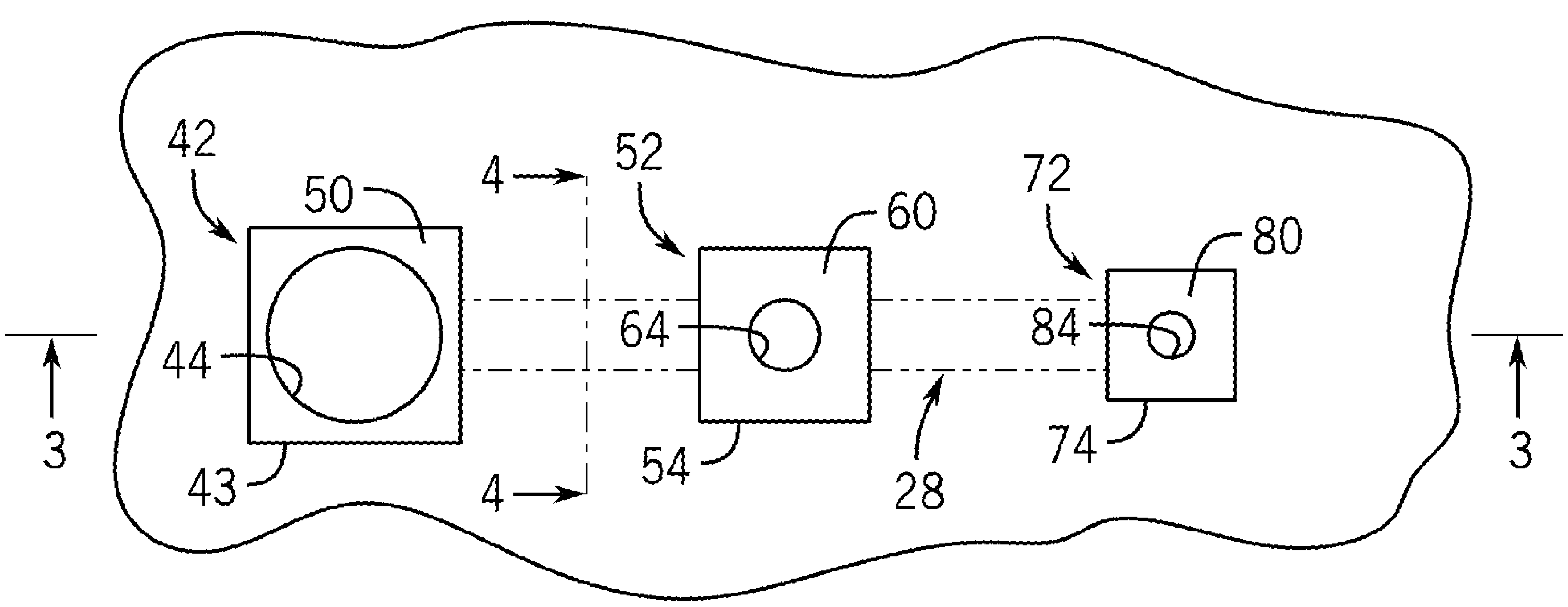
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FIG. 2

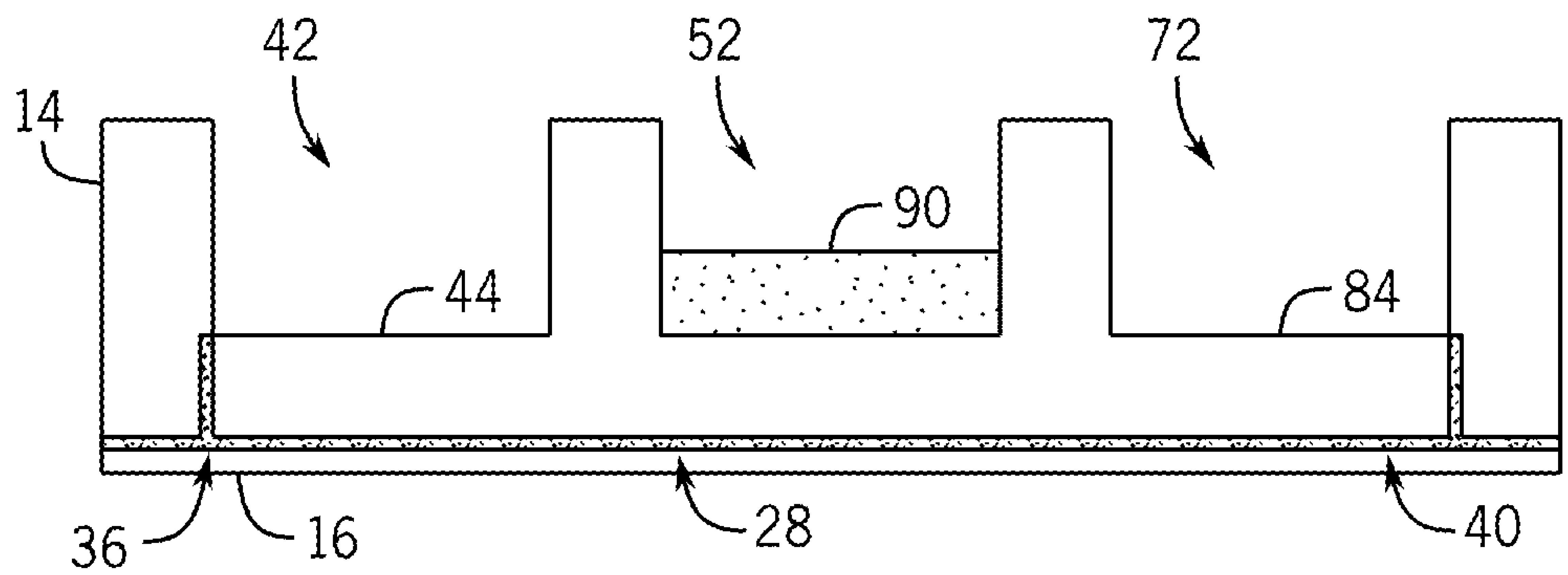

FIG. 5

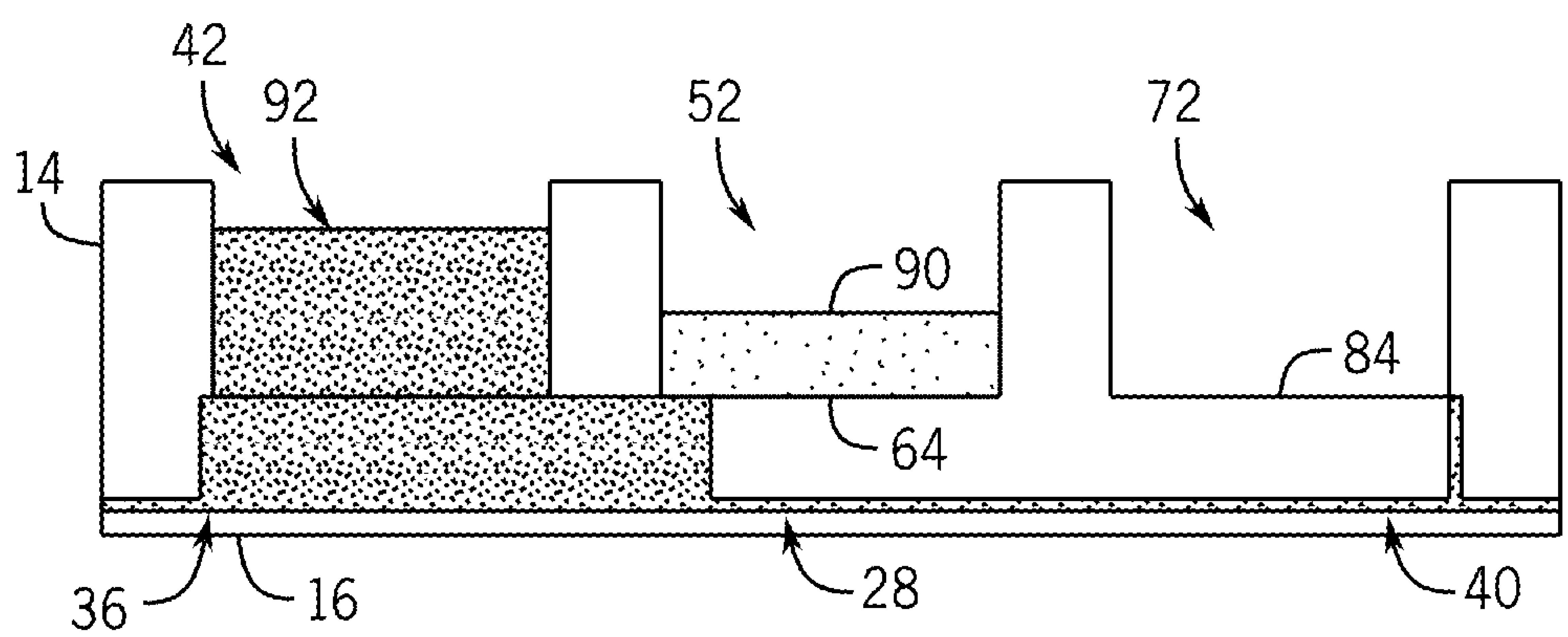

FIG. 6

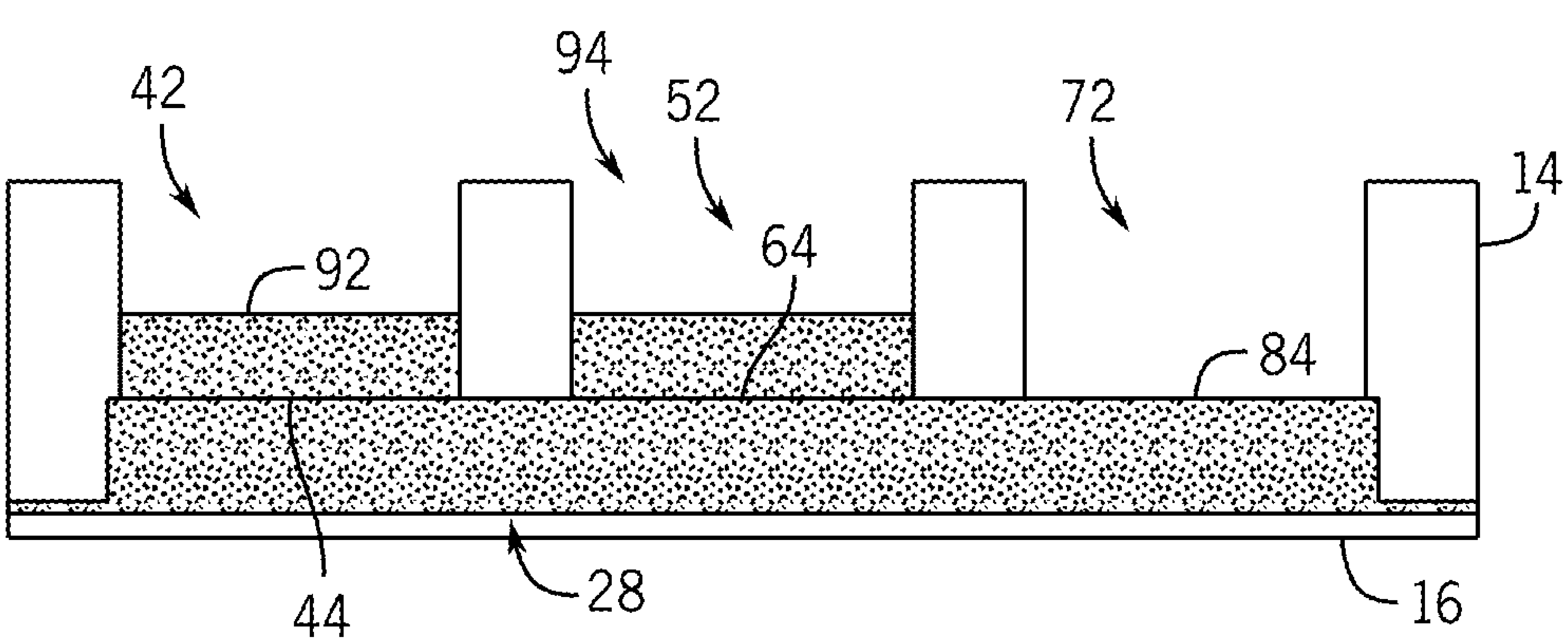

FIG. 7

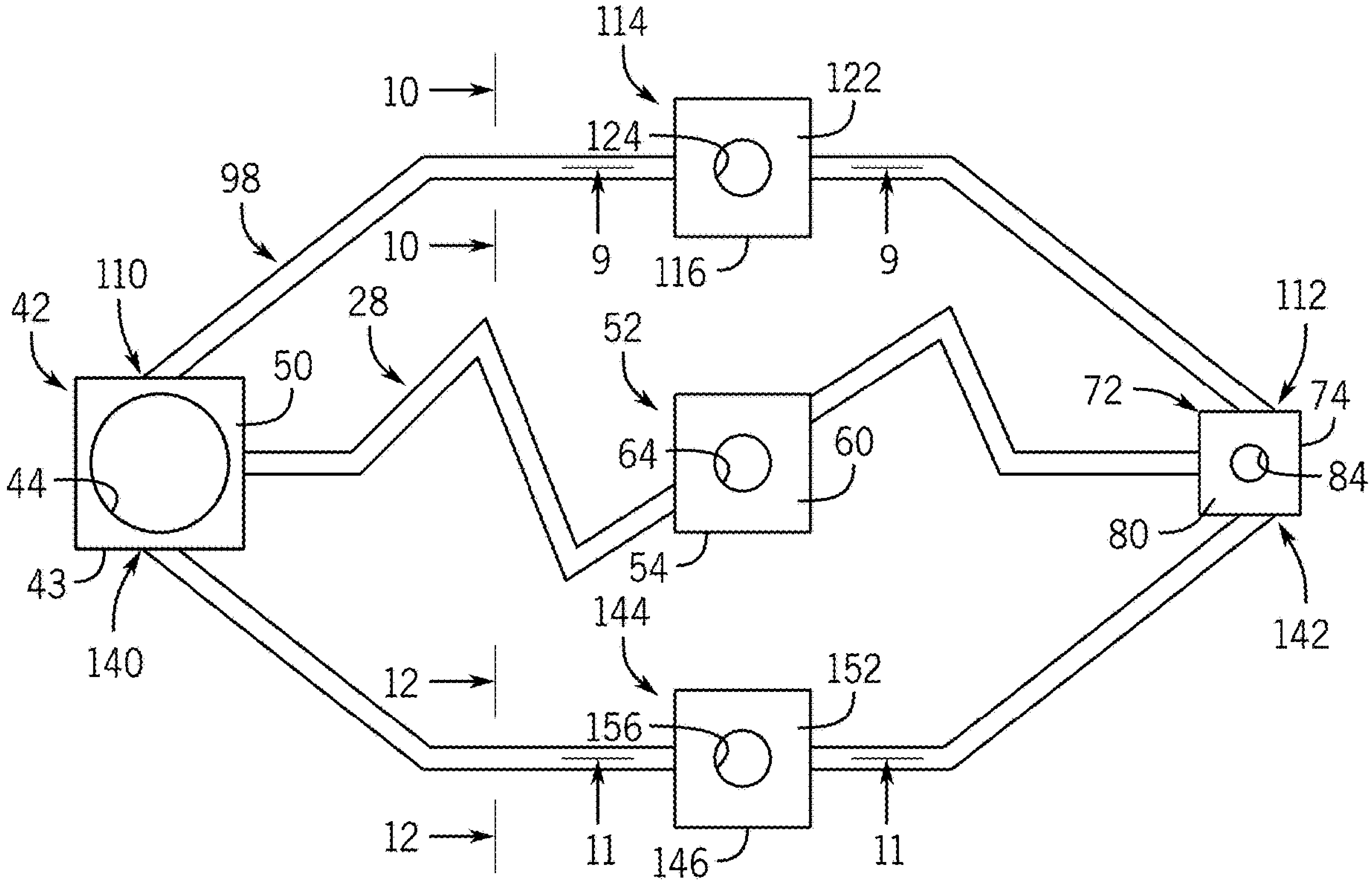
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FIG. 8

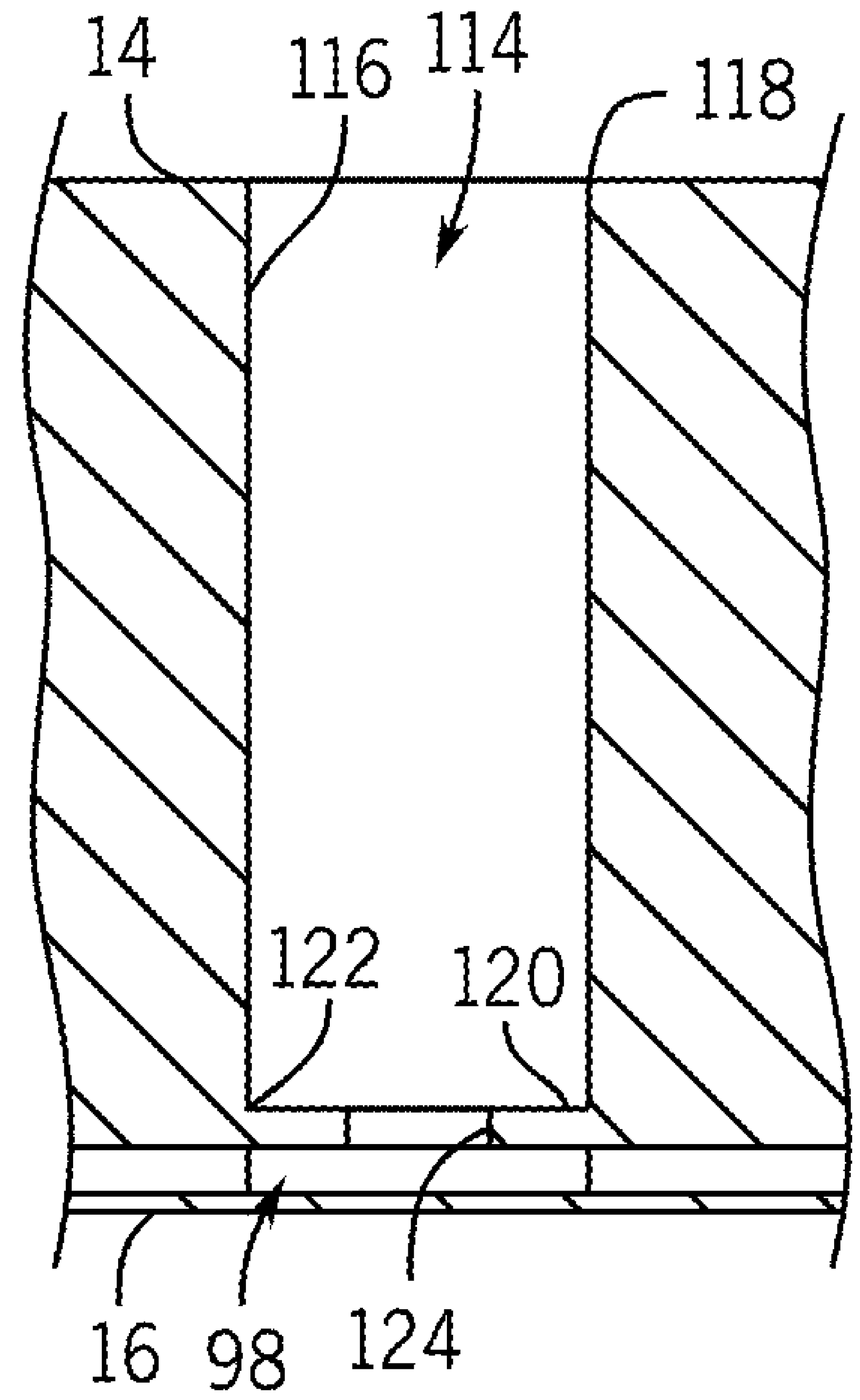


FIG. 9

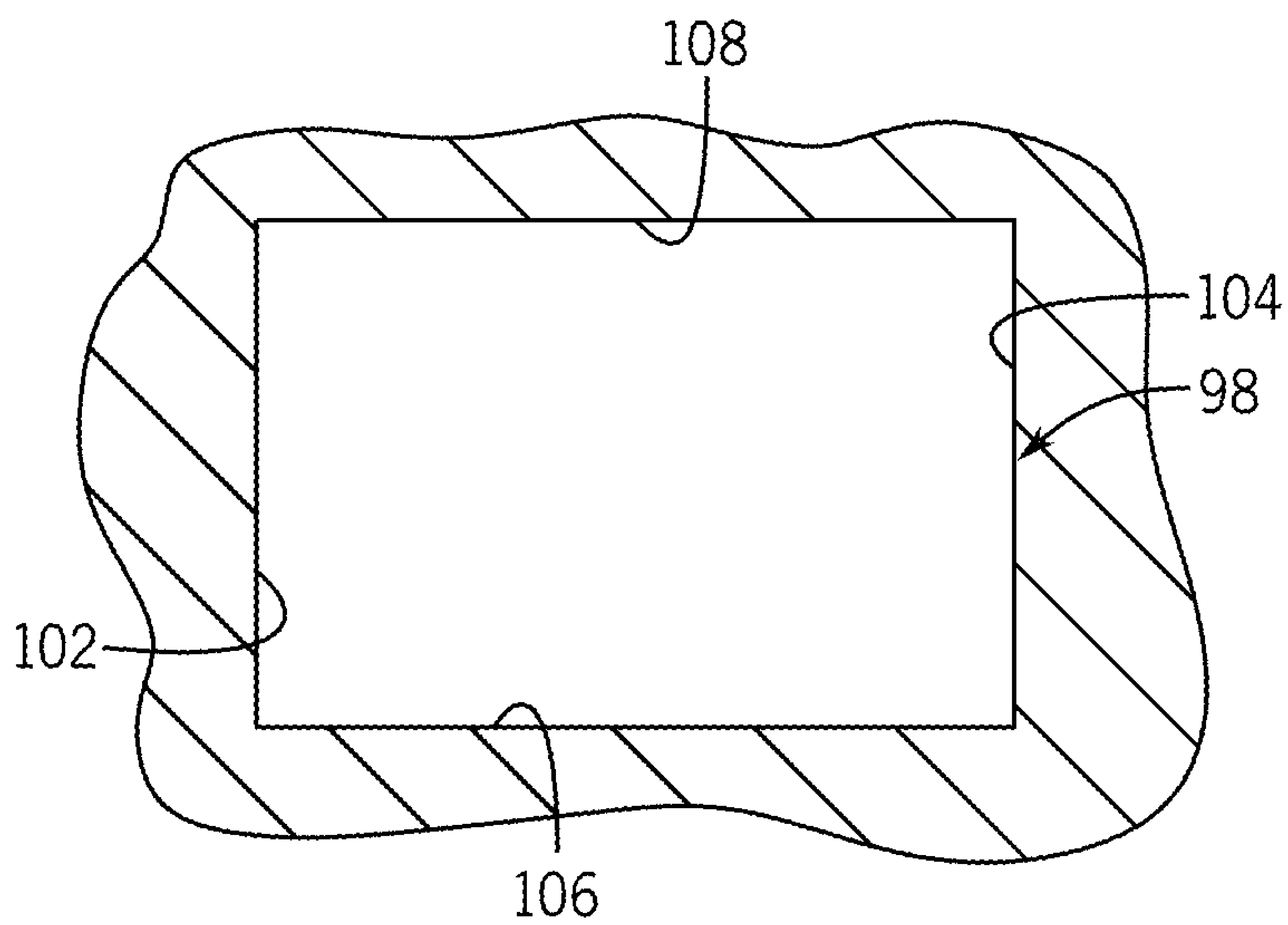


FIG. 10

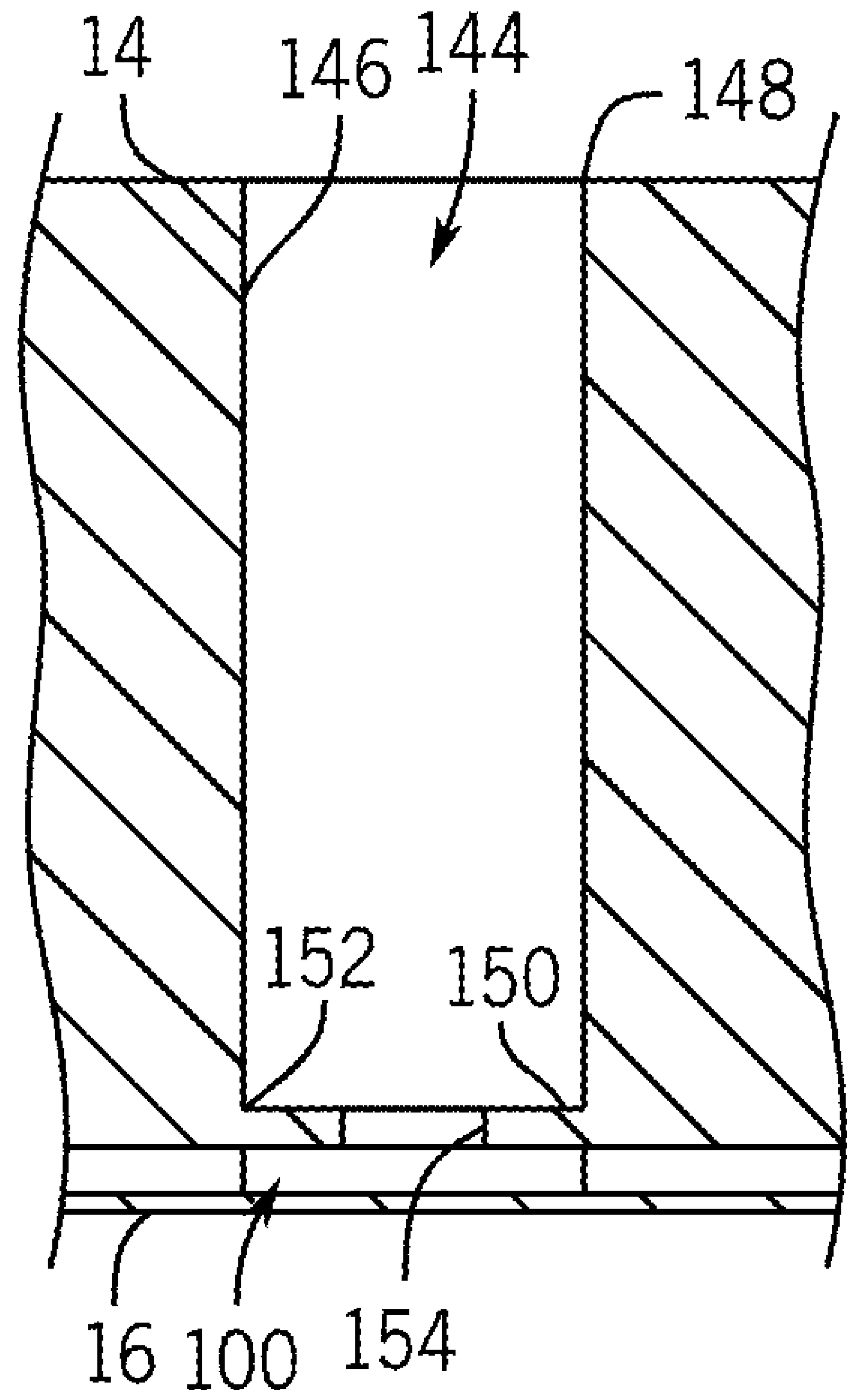


FIG. 11

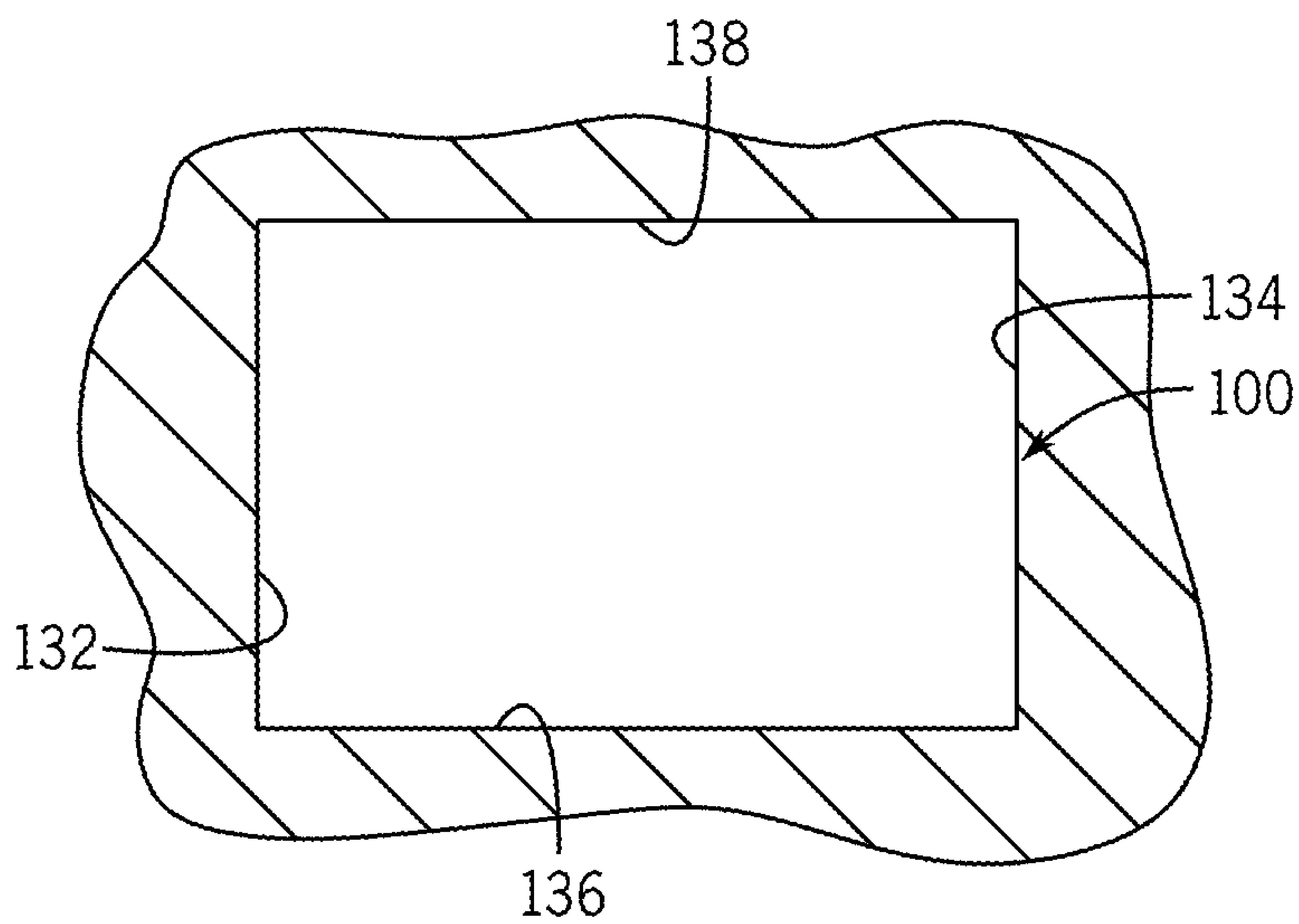
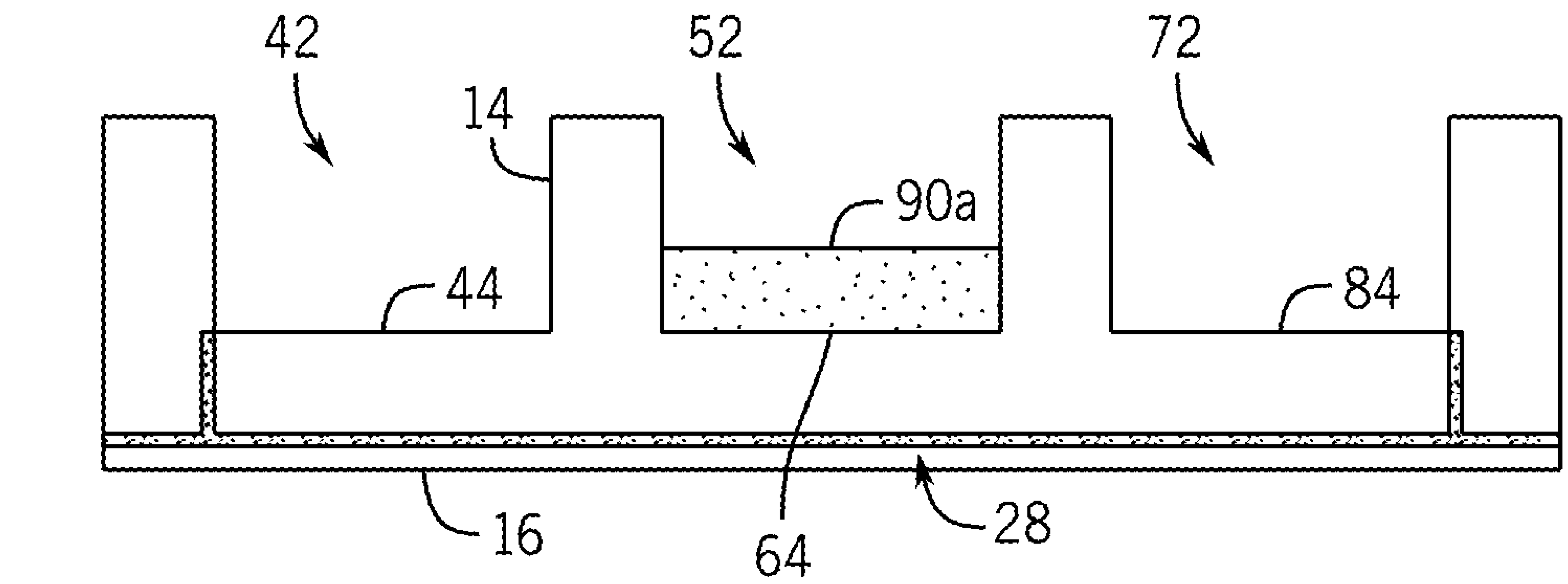


FIG. 12



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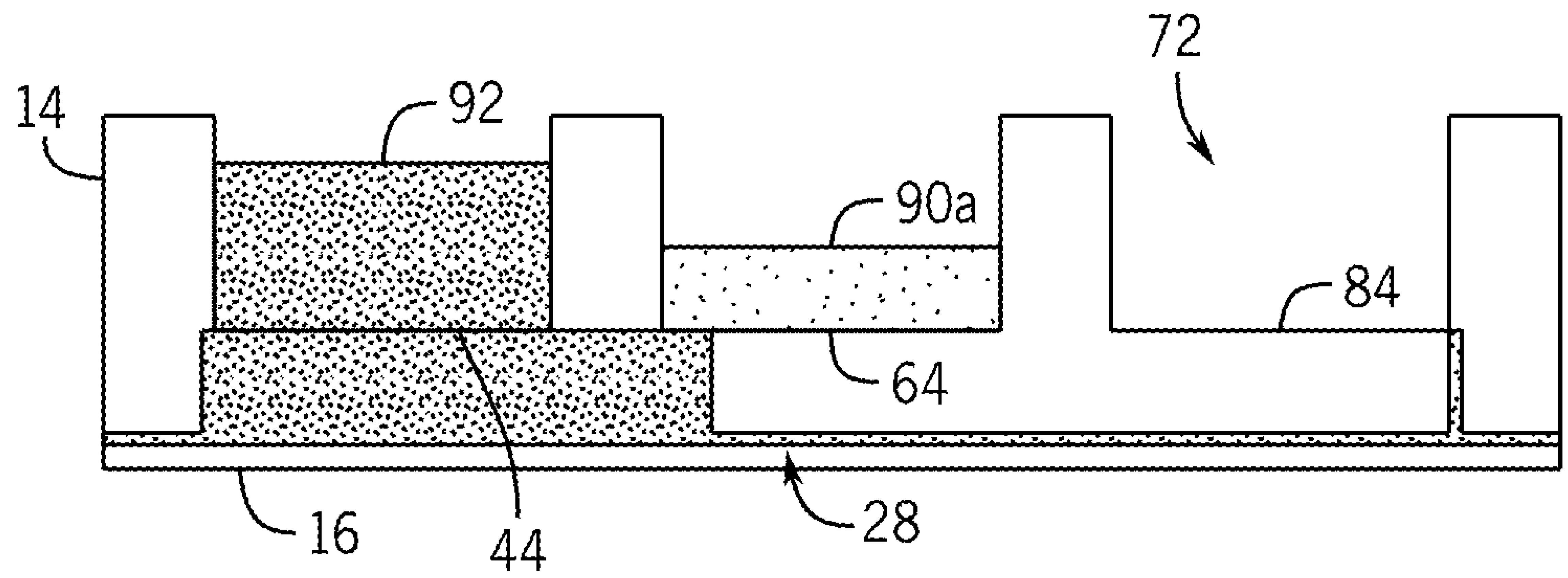

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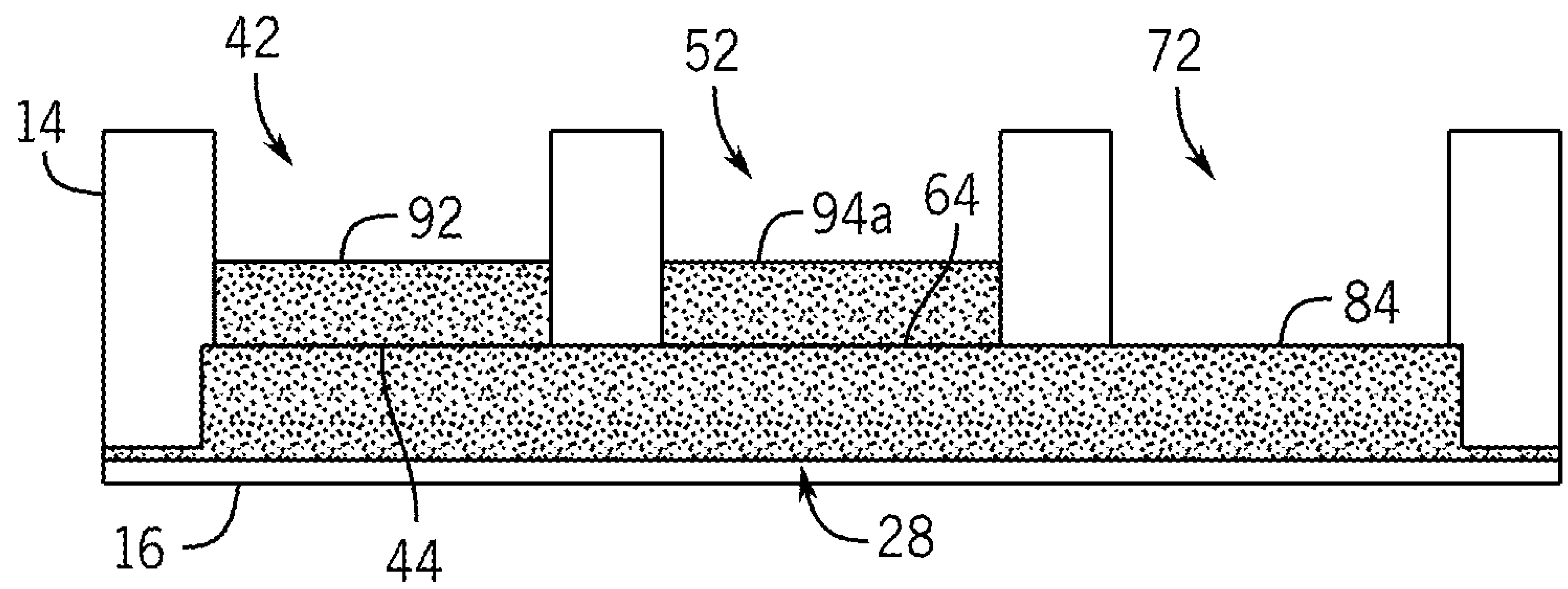

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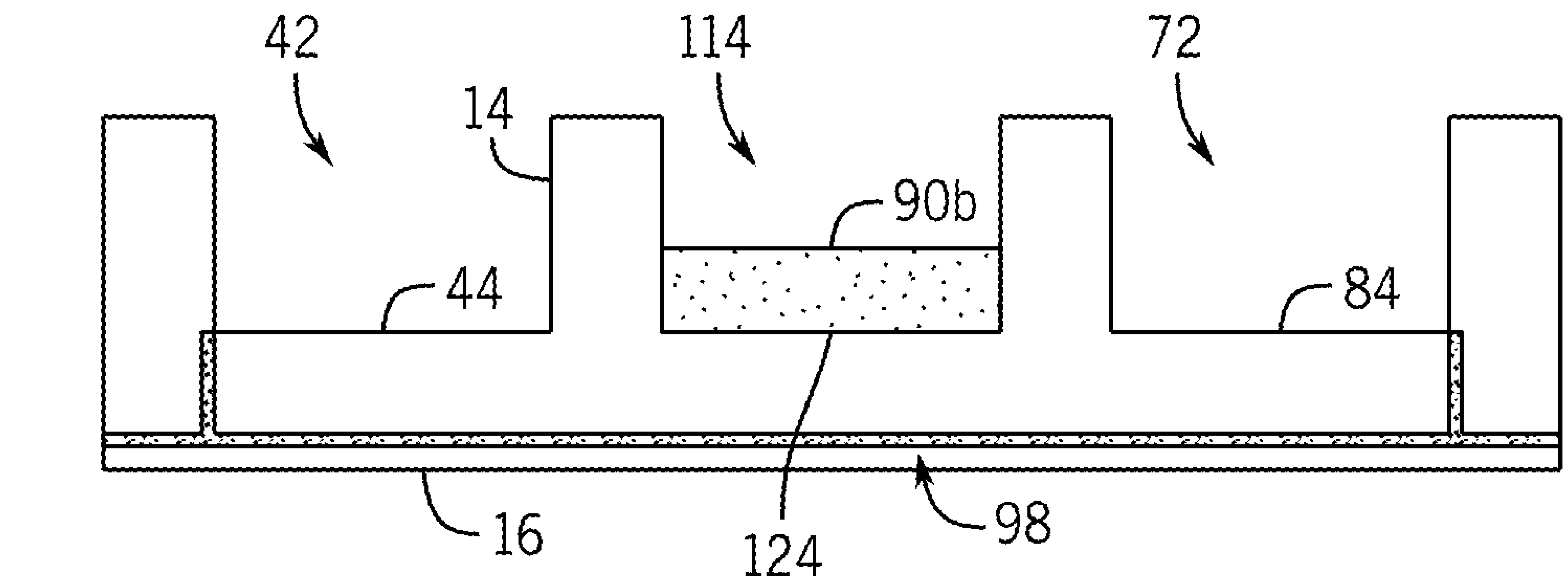
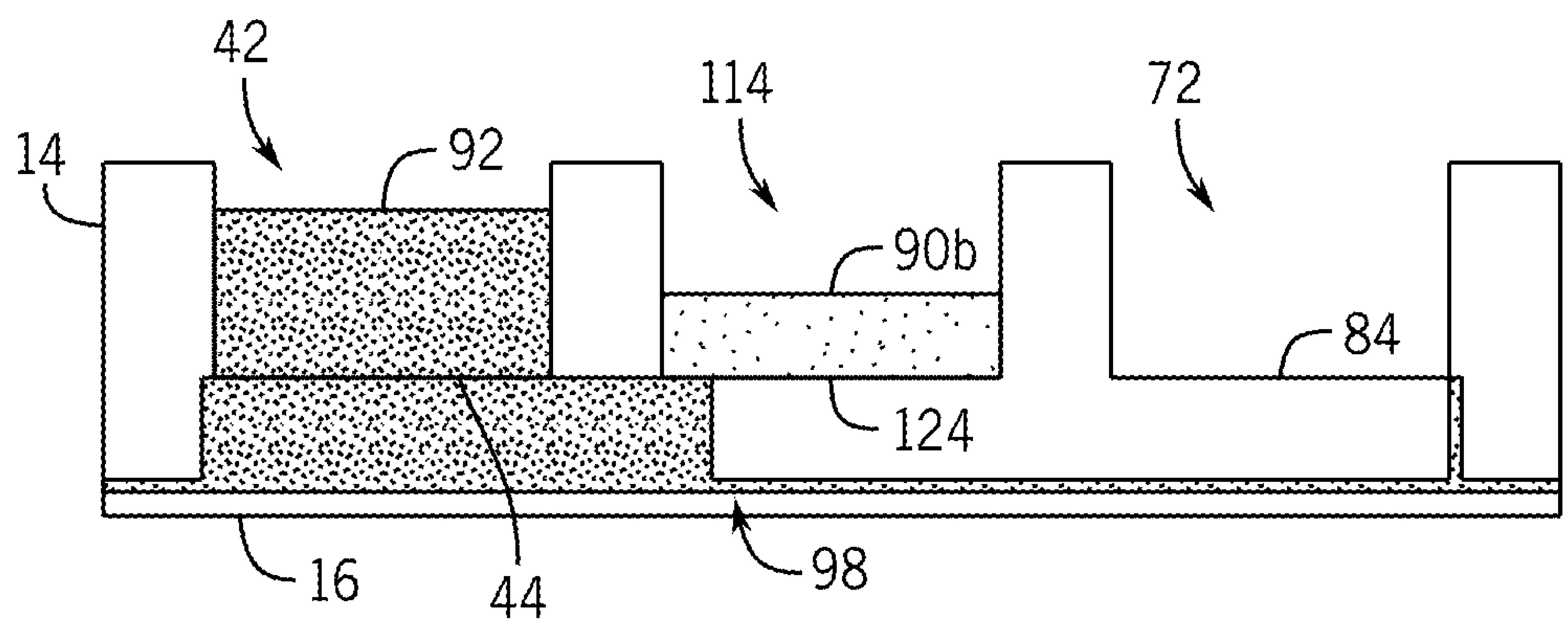


FIG. 16



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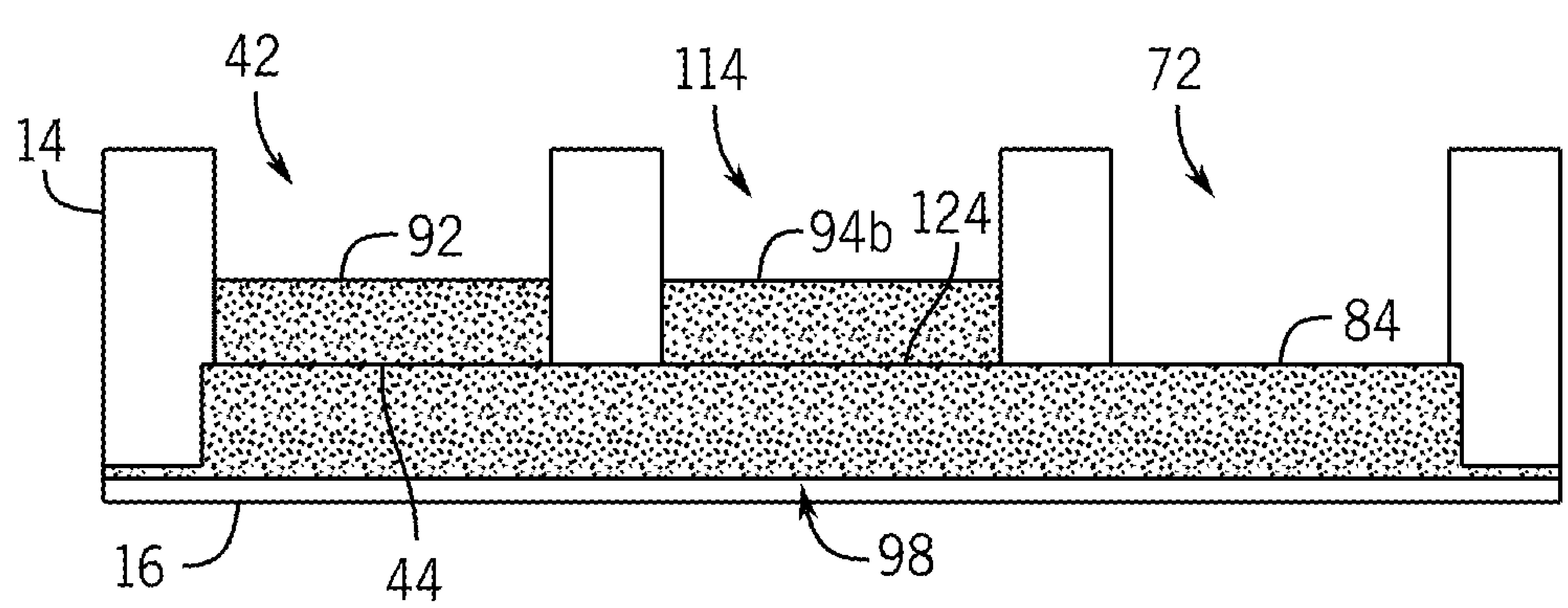

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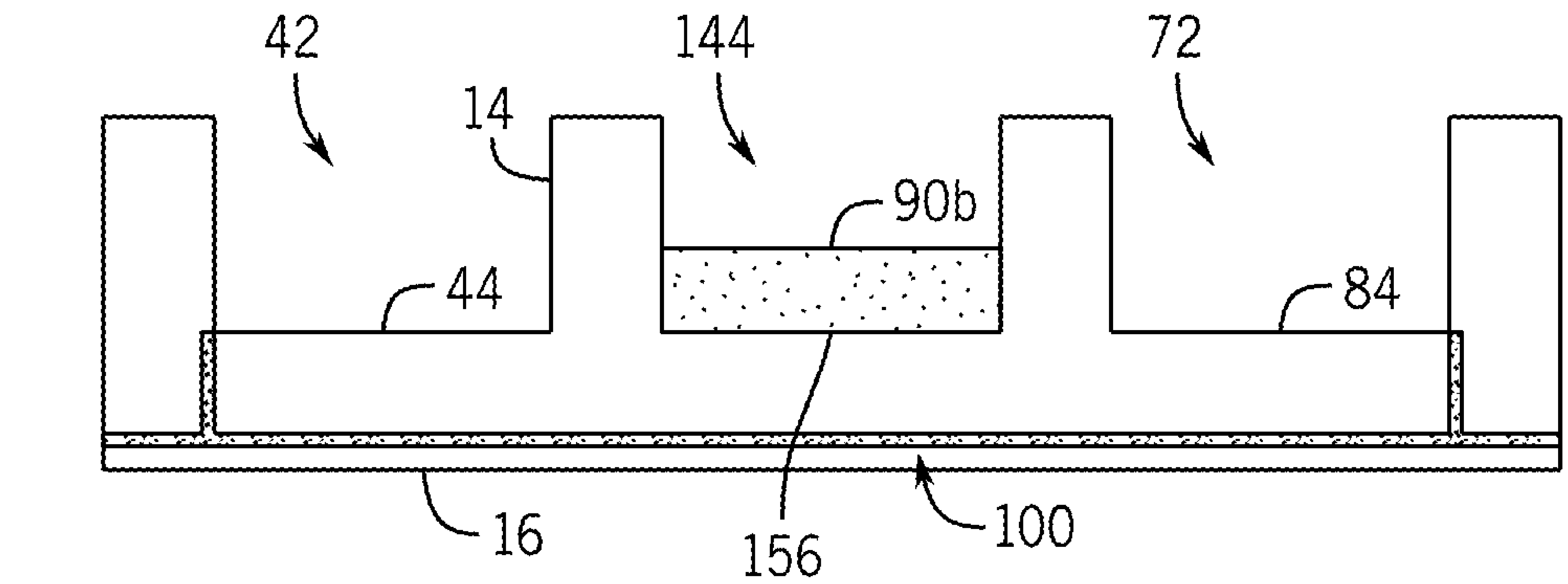


FIG. 19

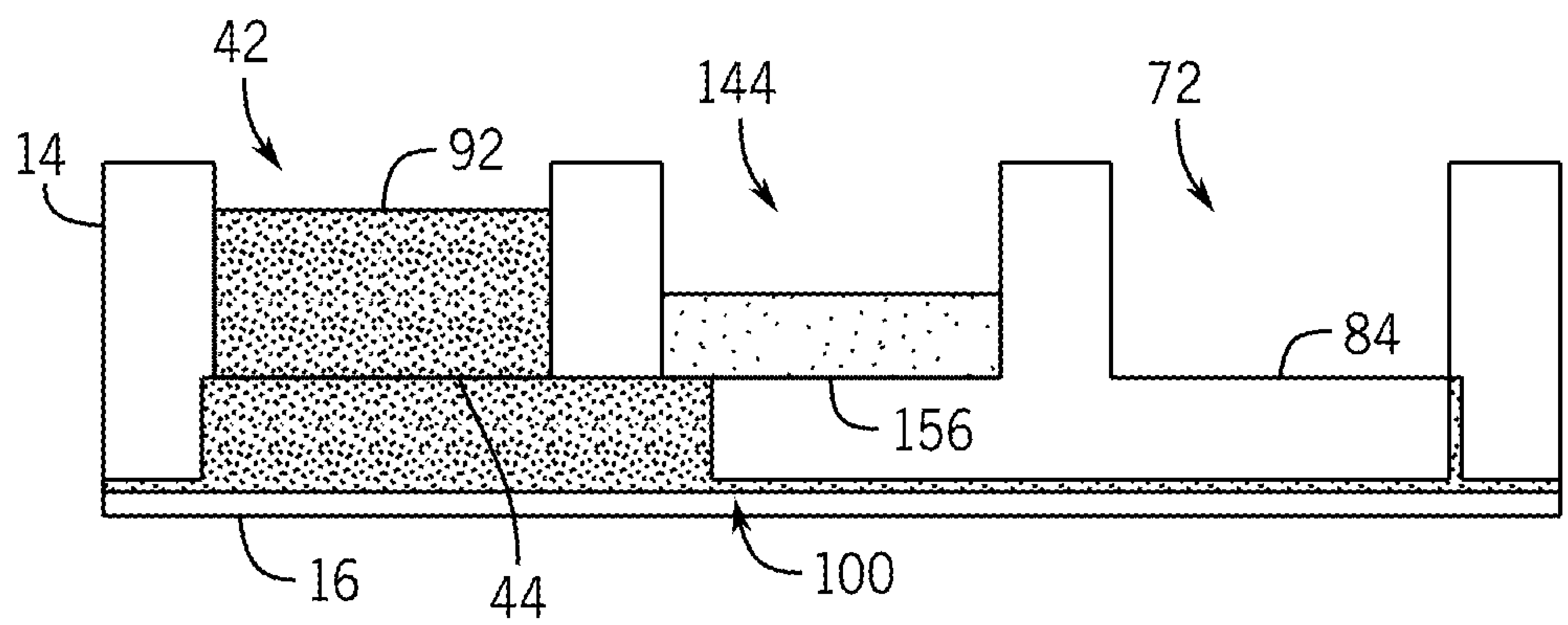
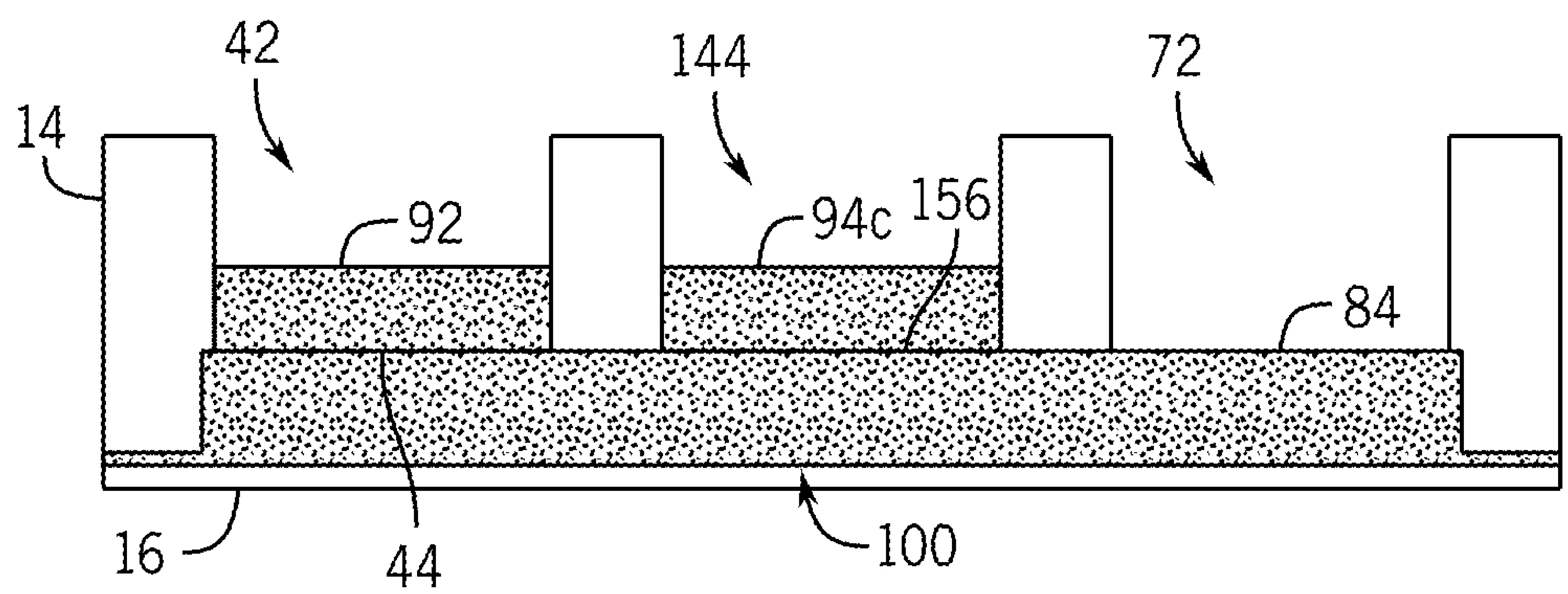


FIG. 20



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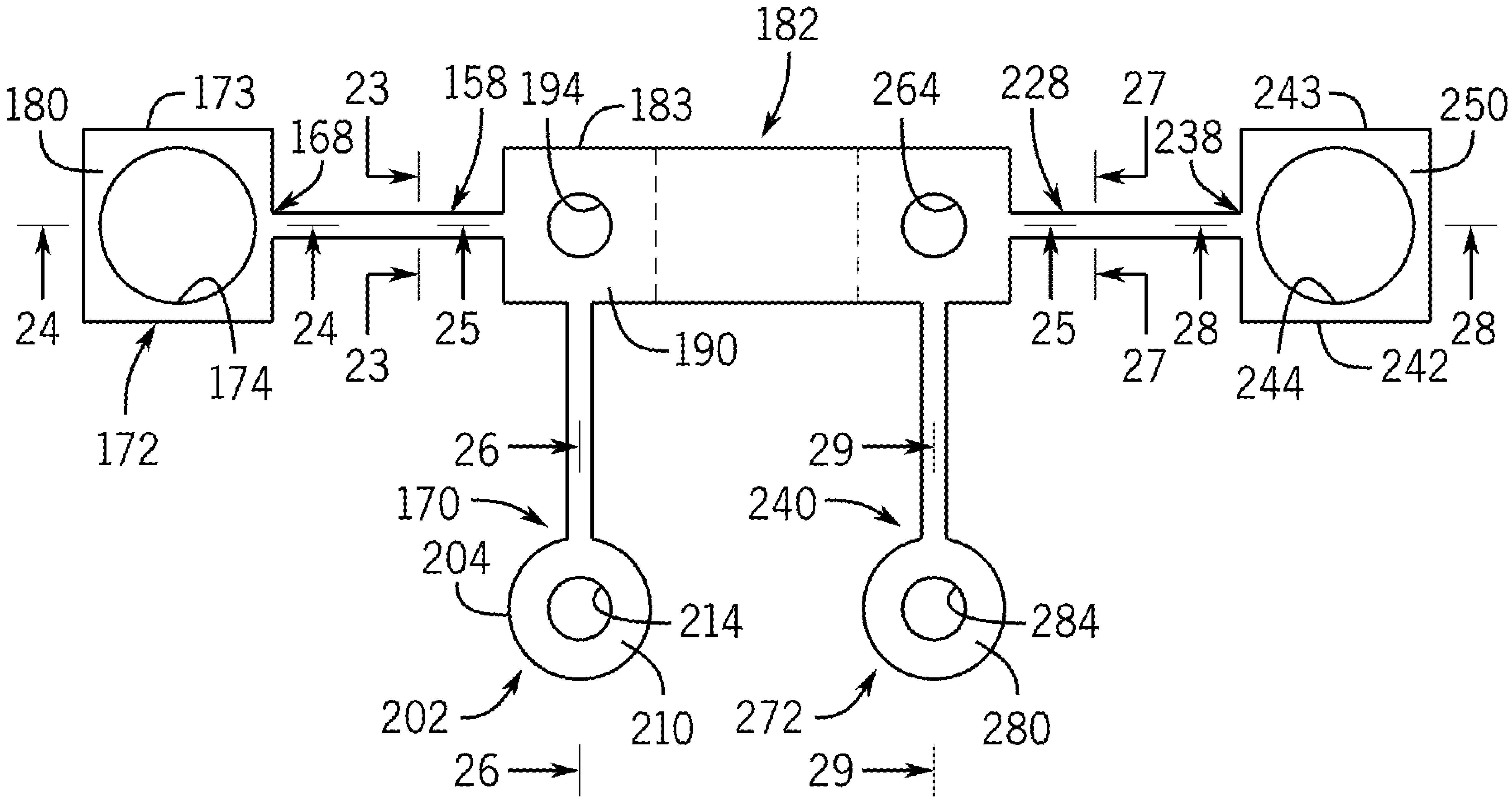
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FIG. 22

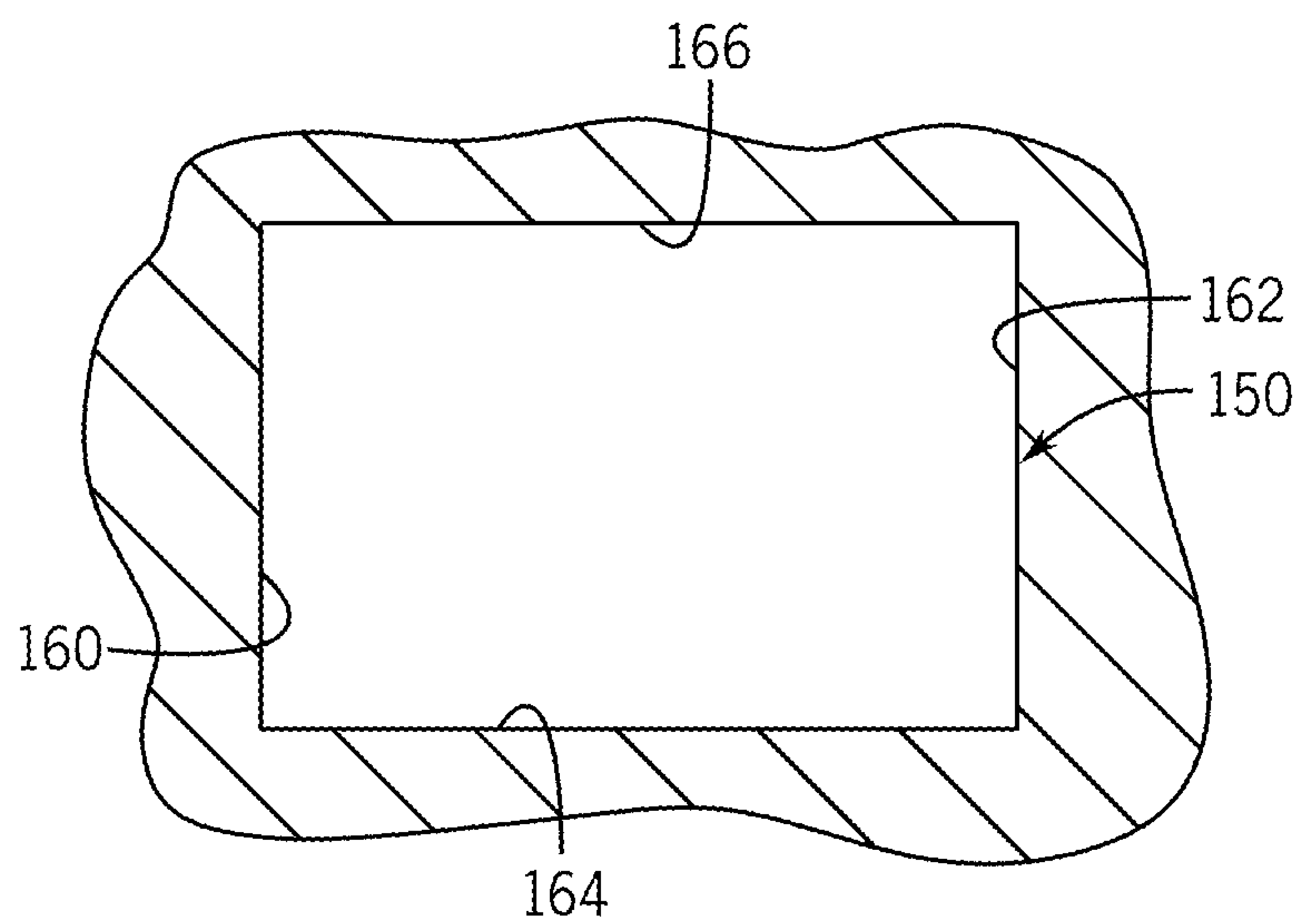
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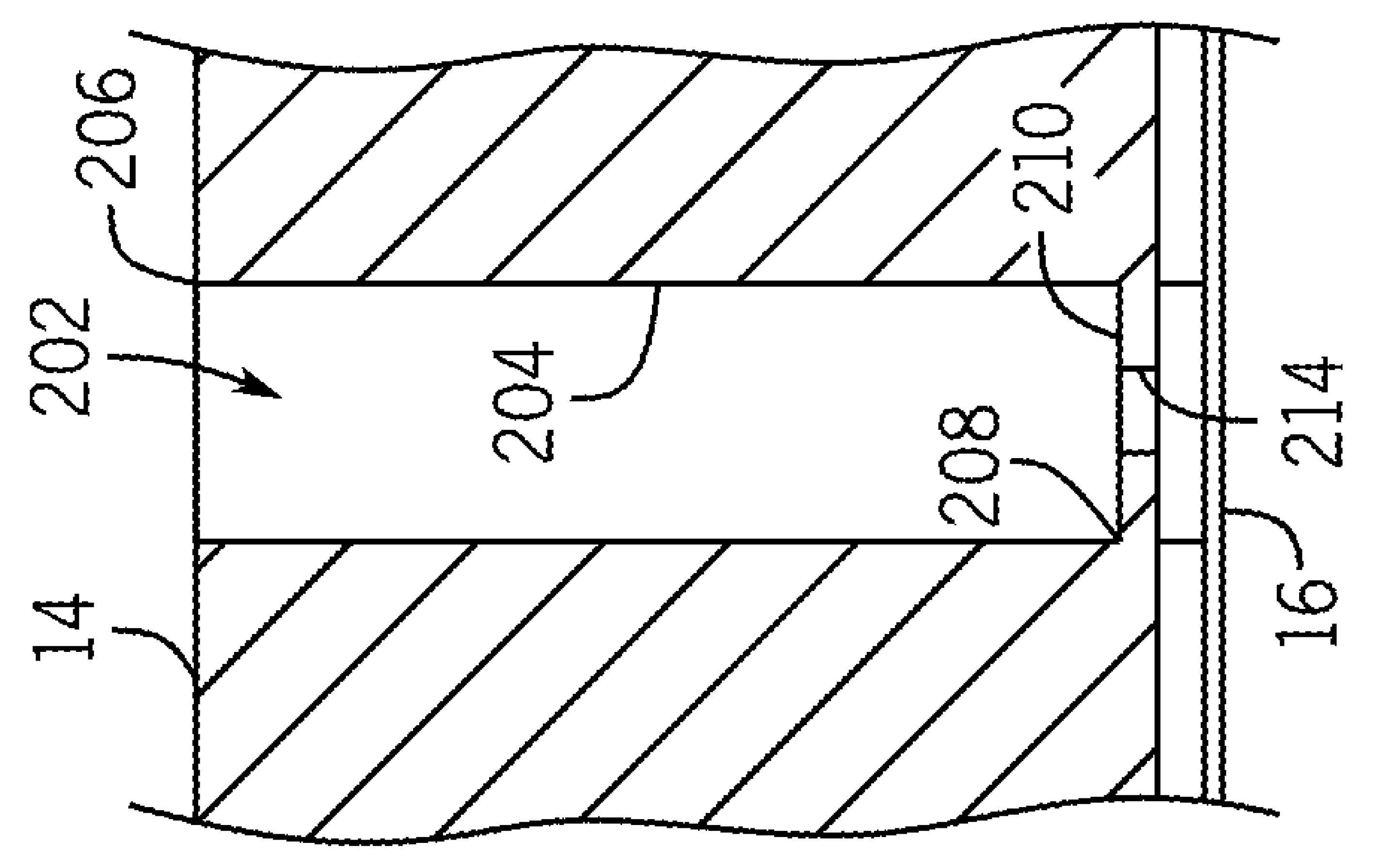
FIG. 23



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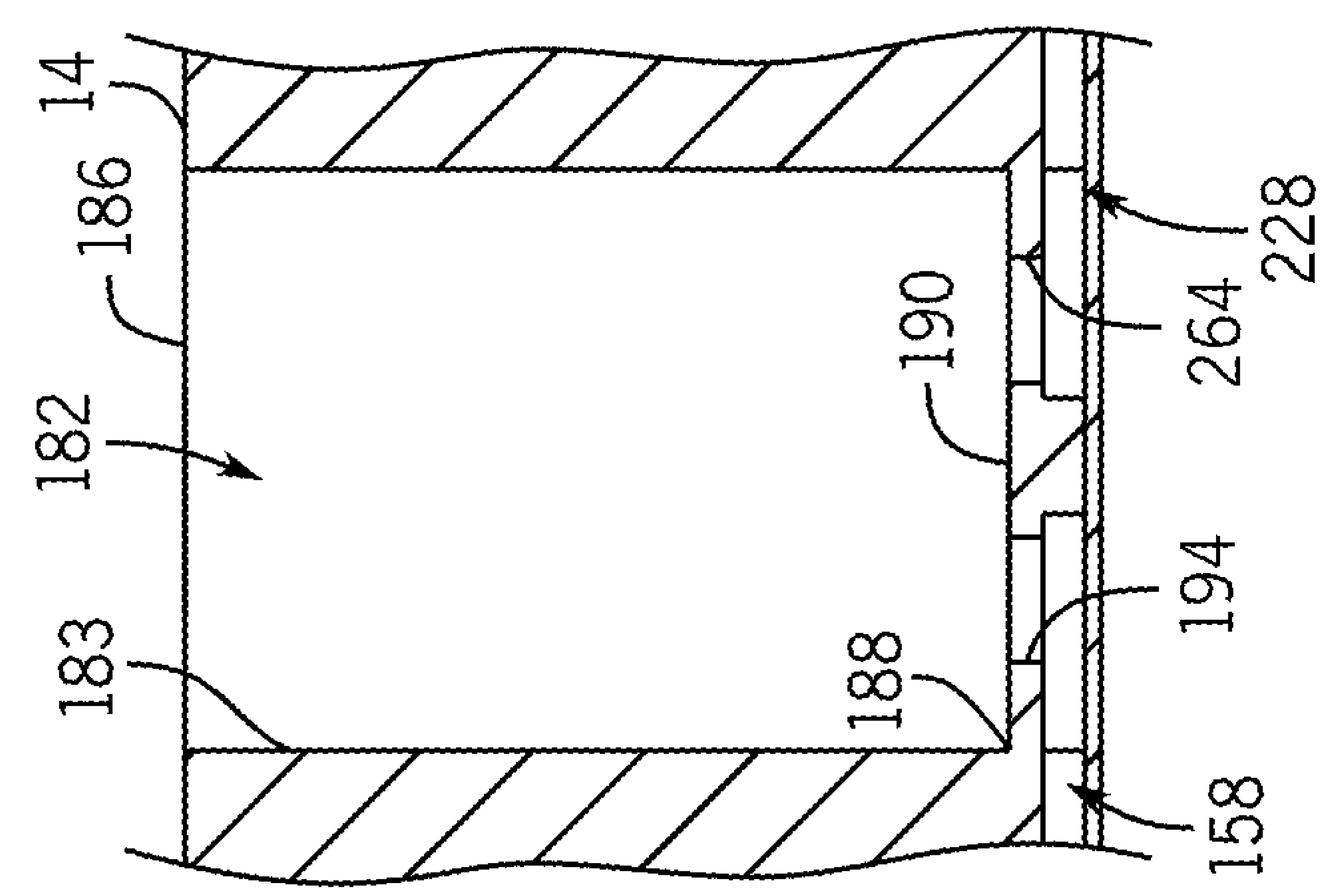

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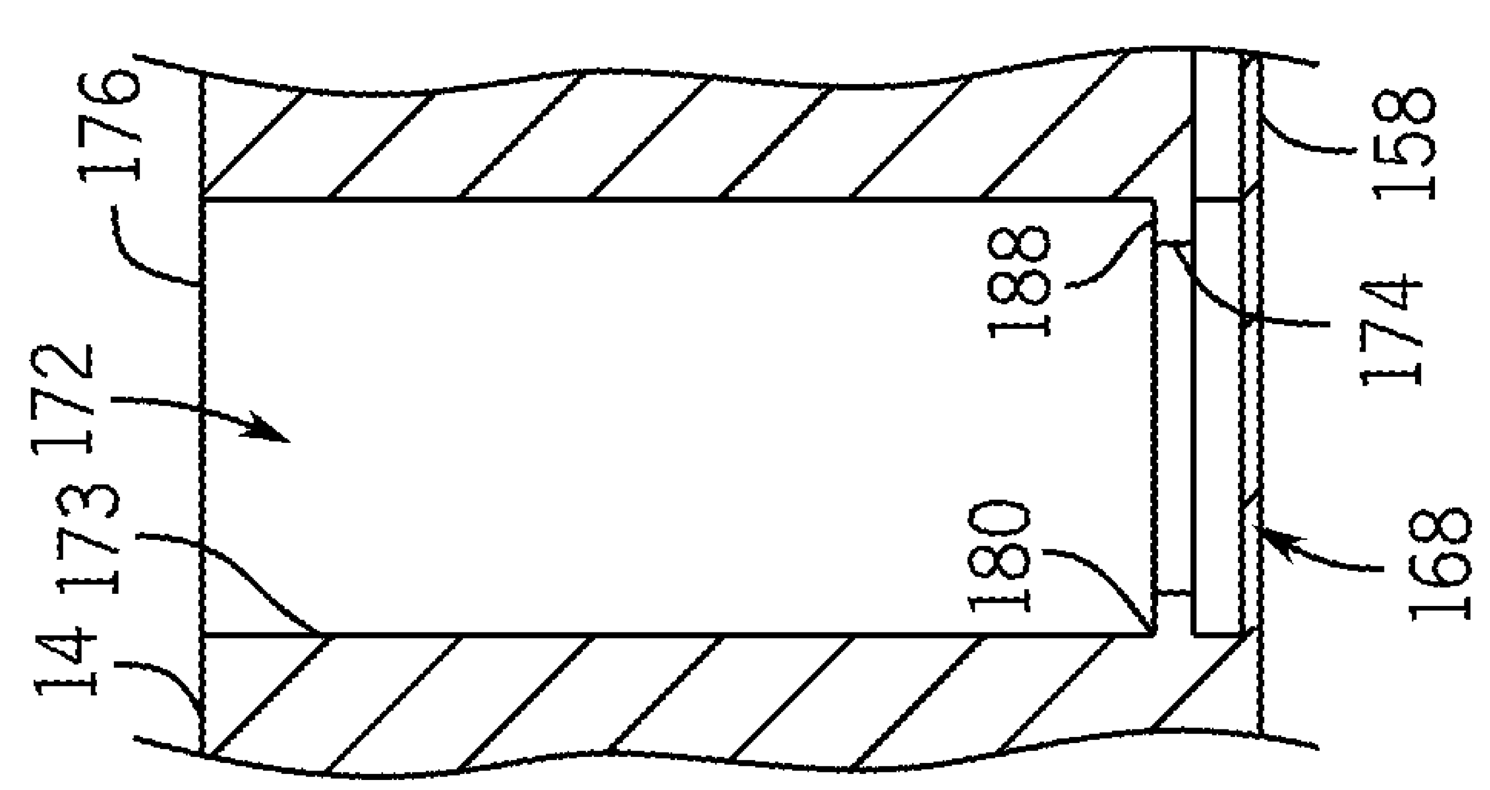

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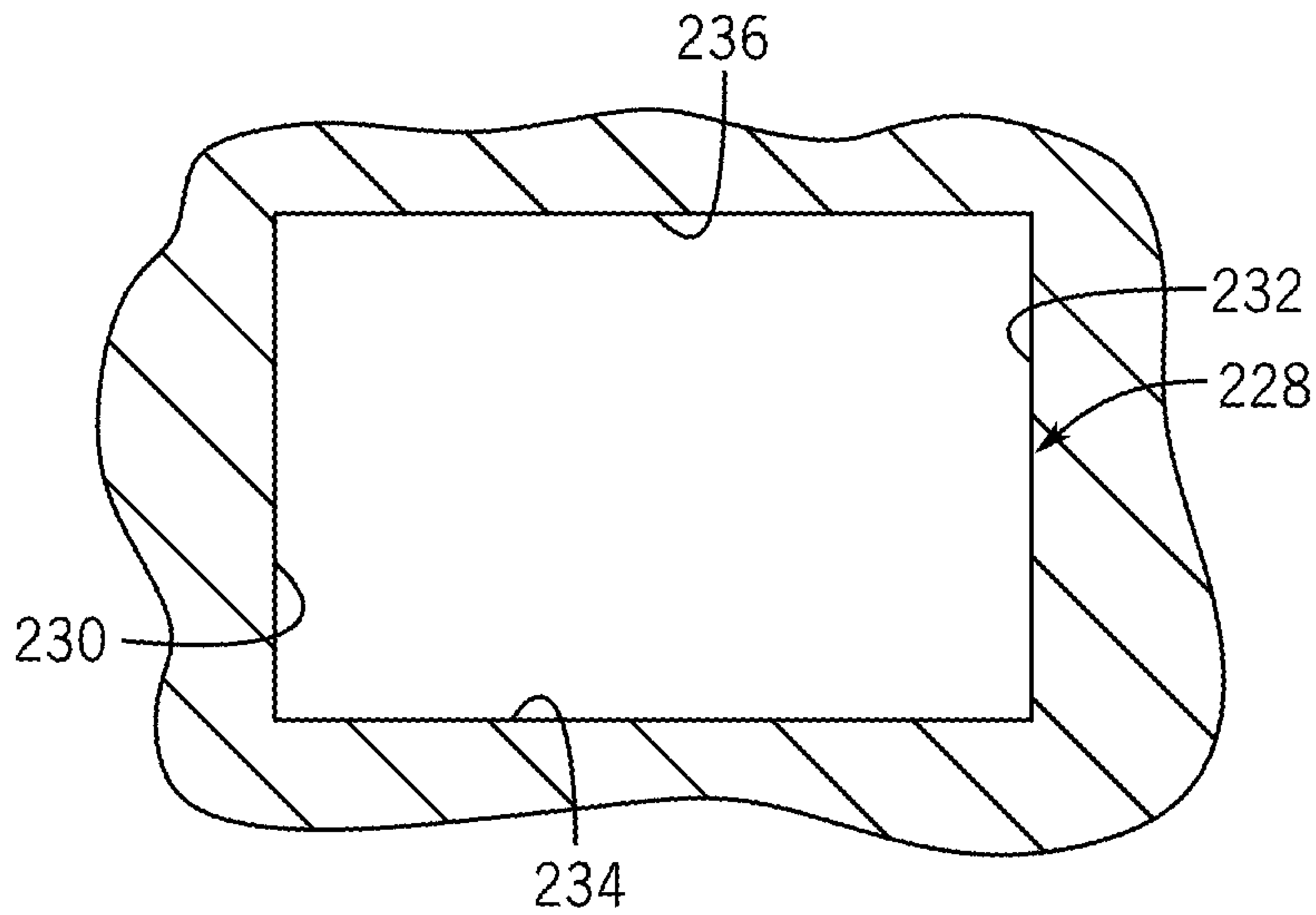

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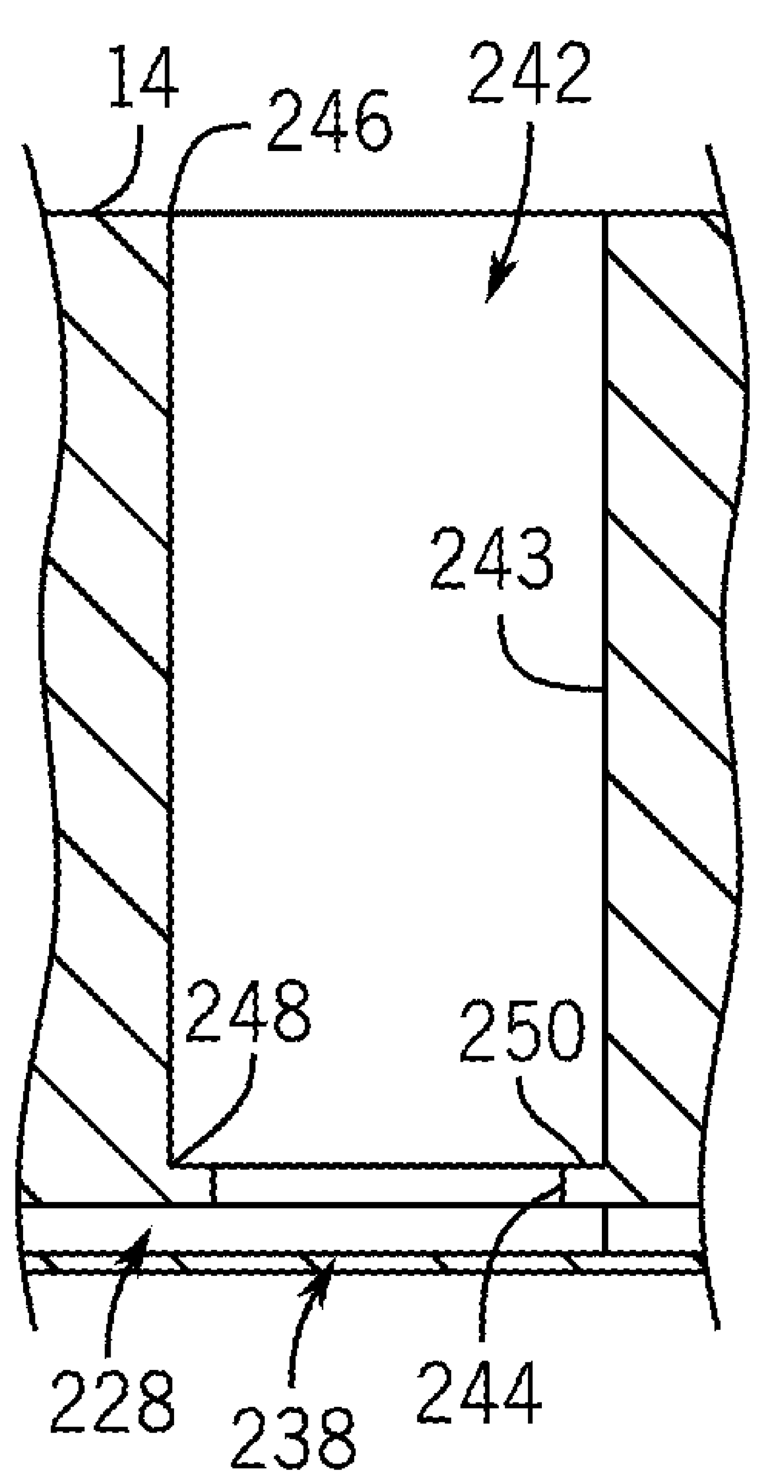


FIG. 28

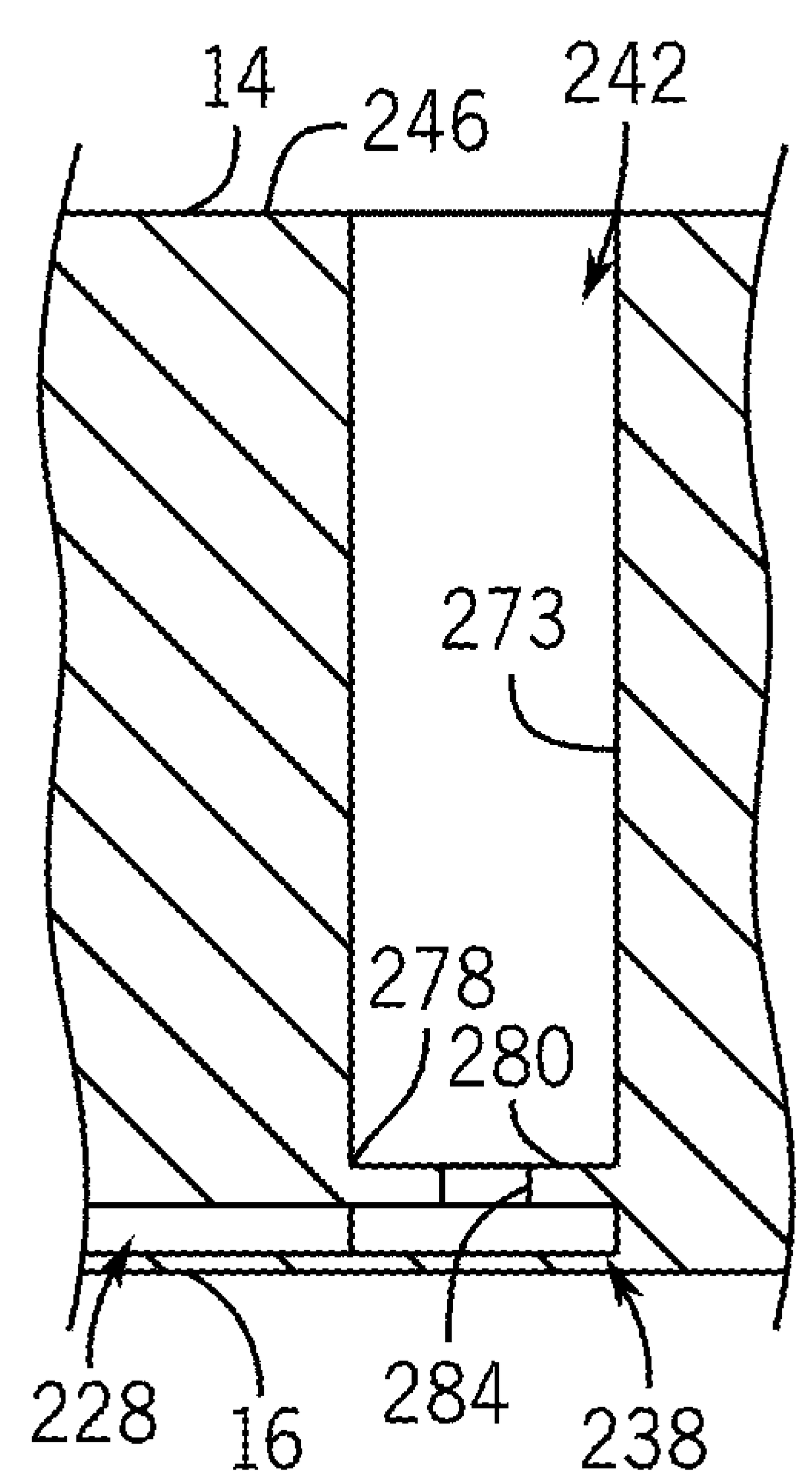
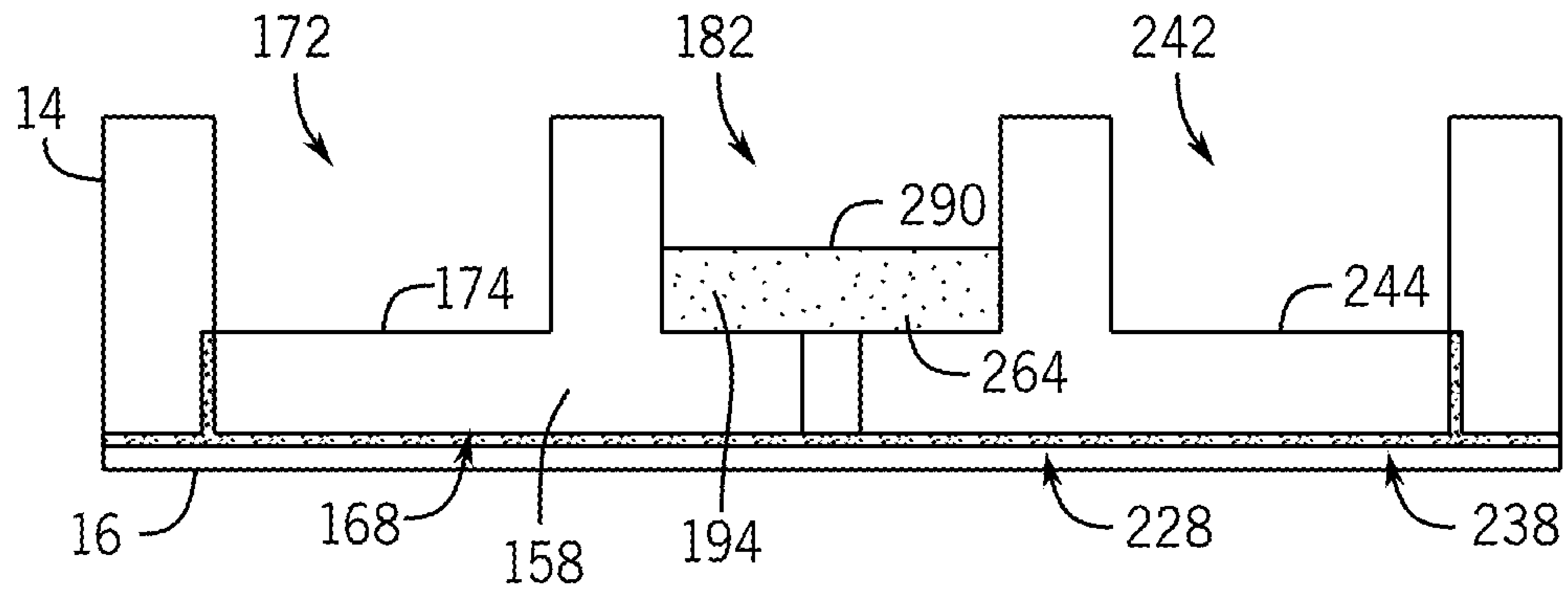


FIG. 29



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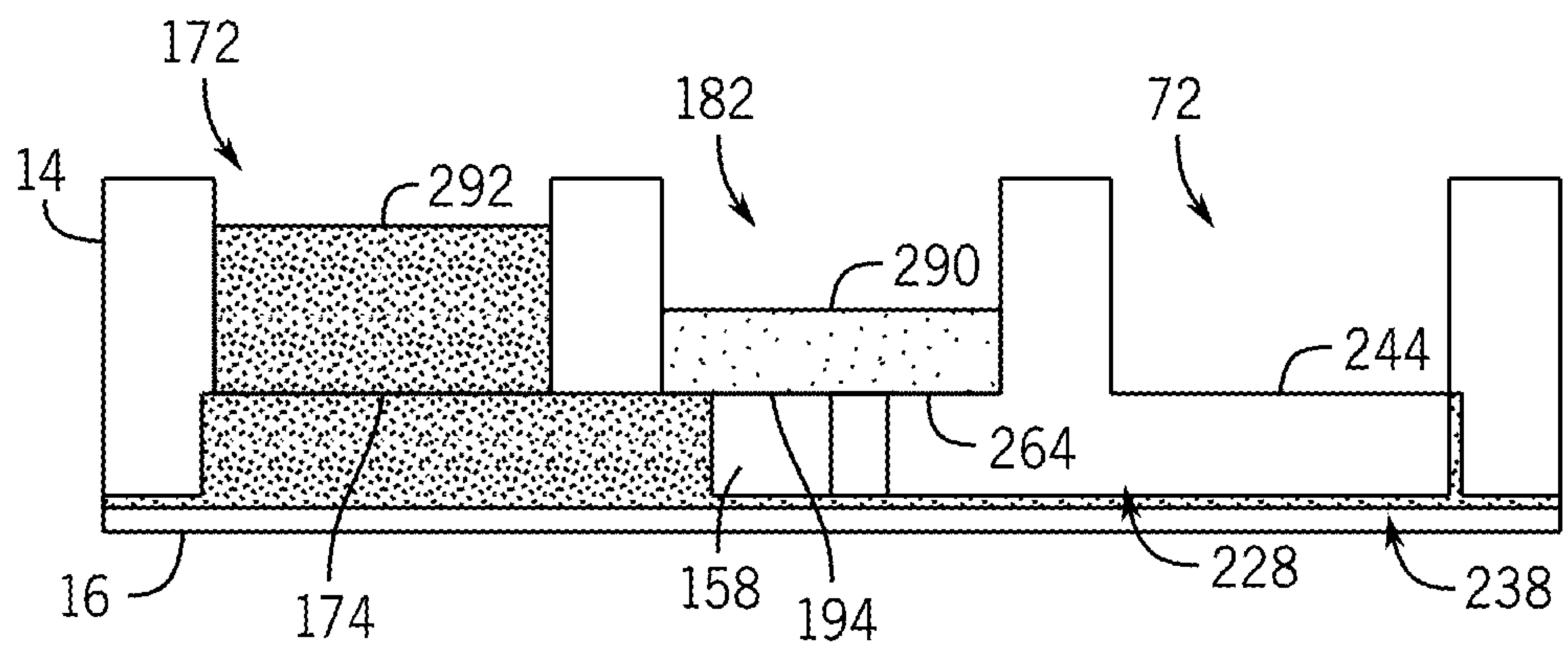

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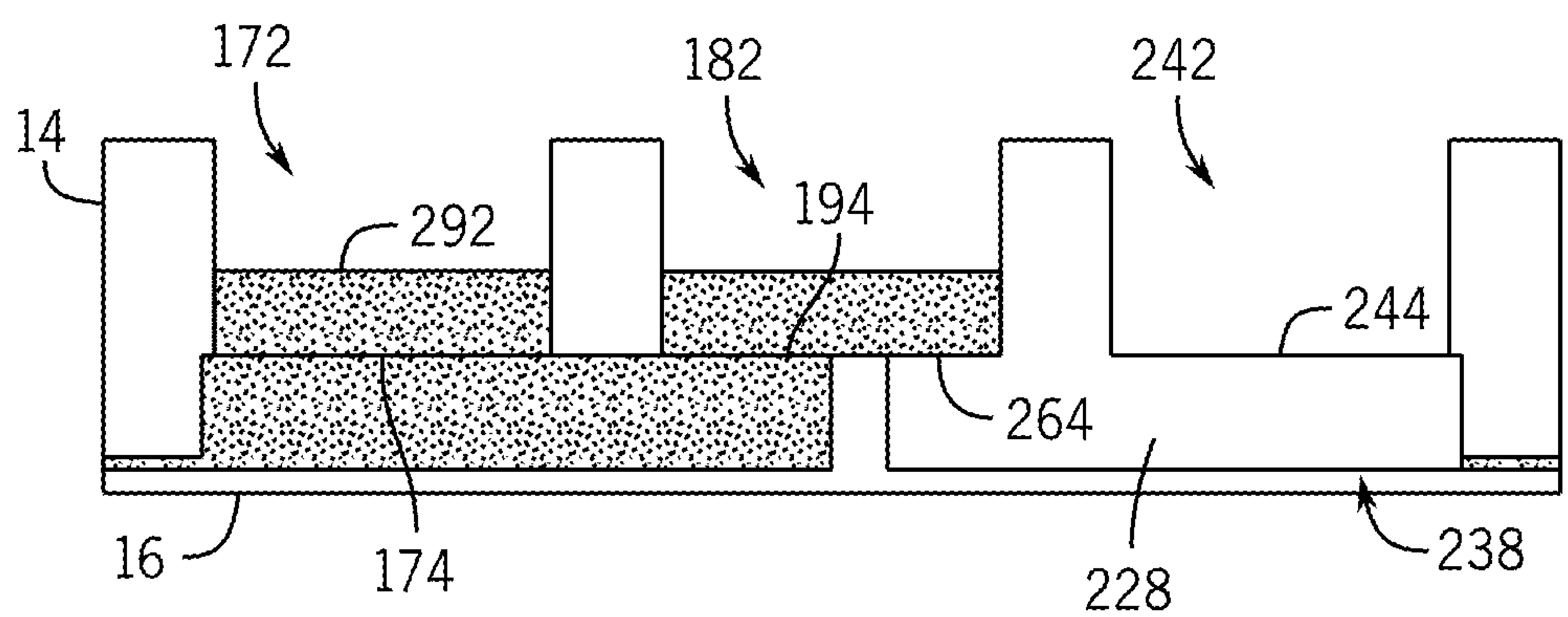

FIG. 32

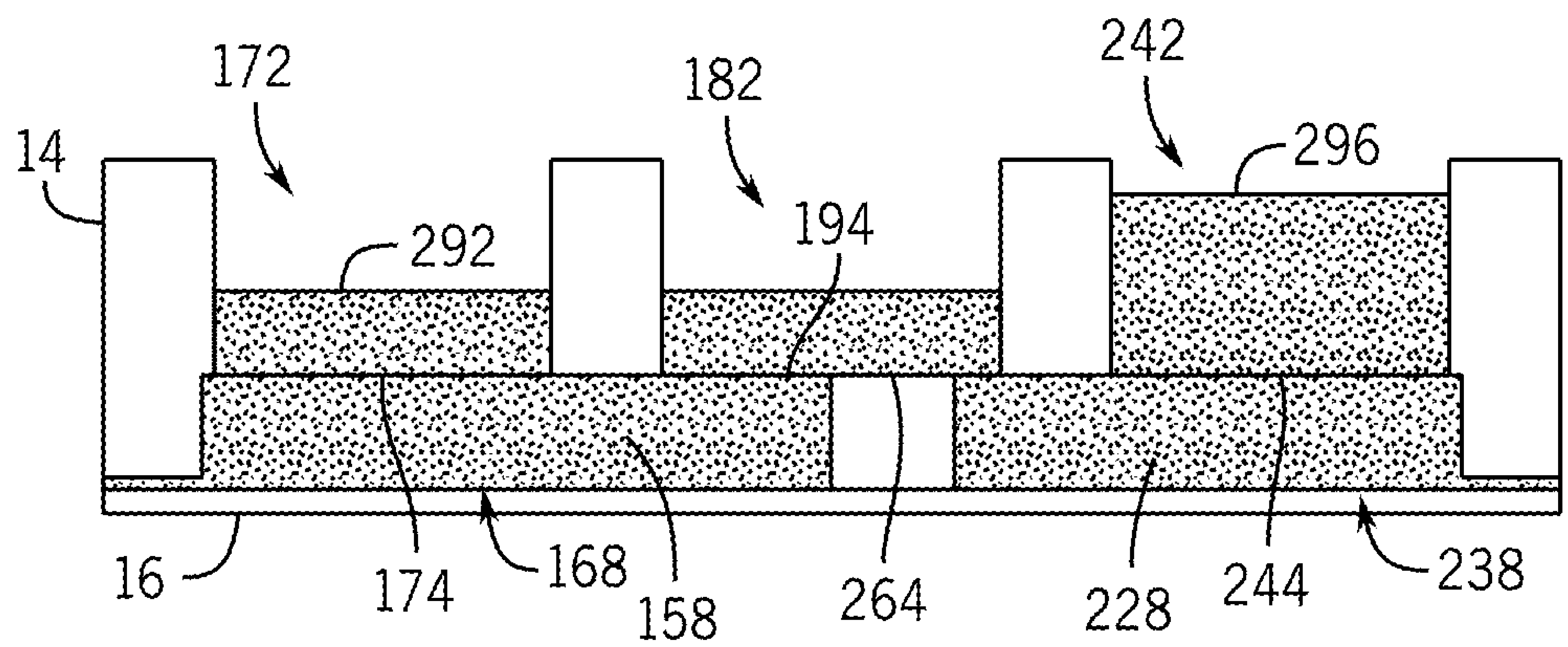
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FIG. 33

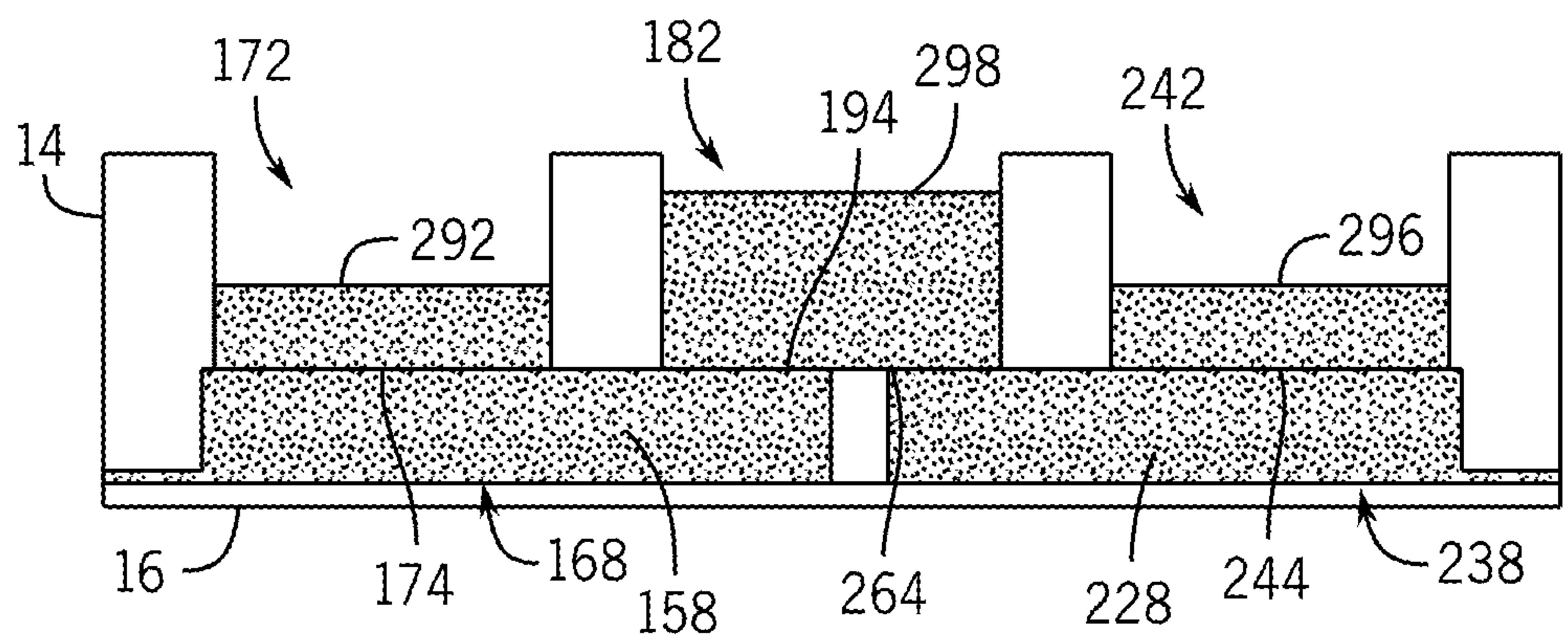
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FIG. 34

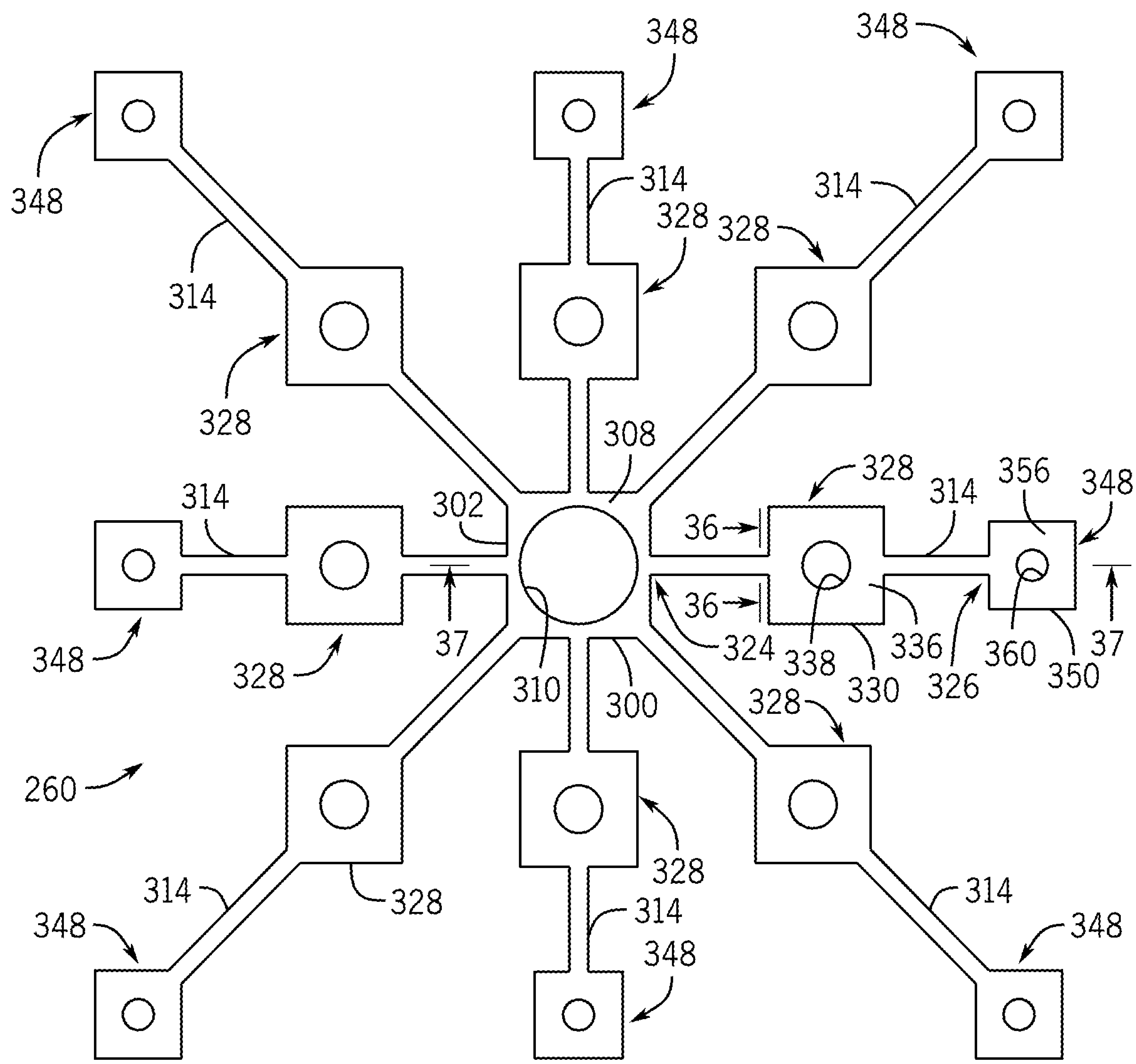
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FIG. 35

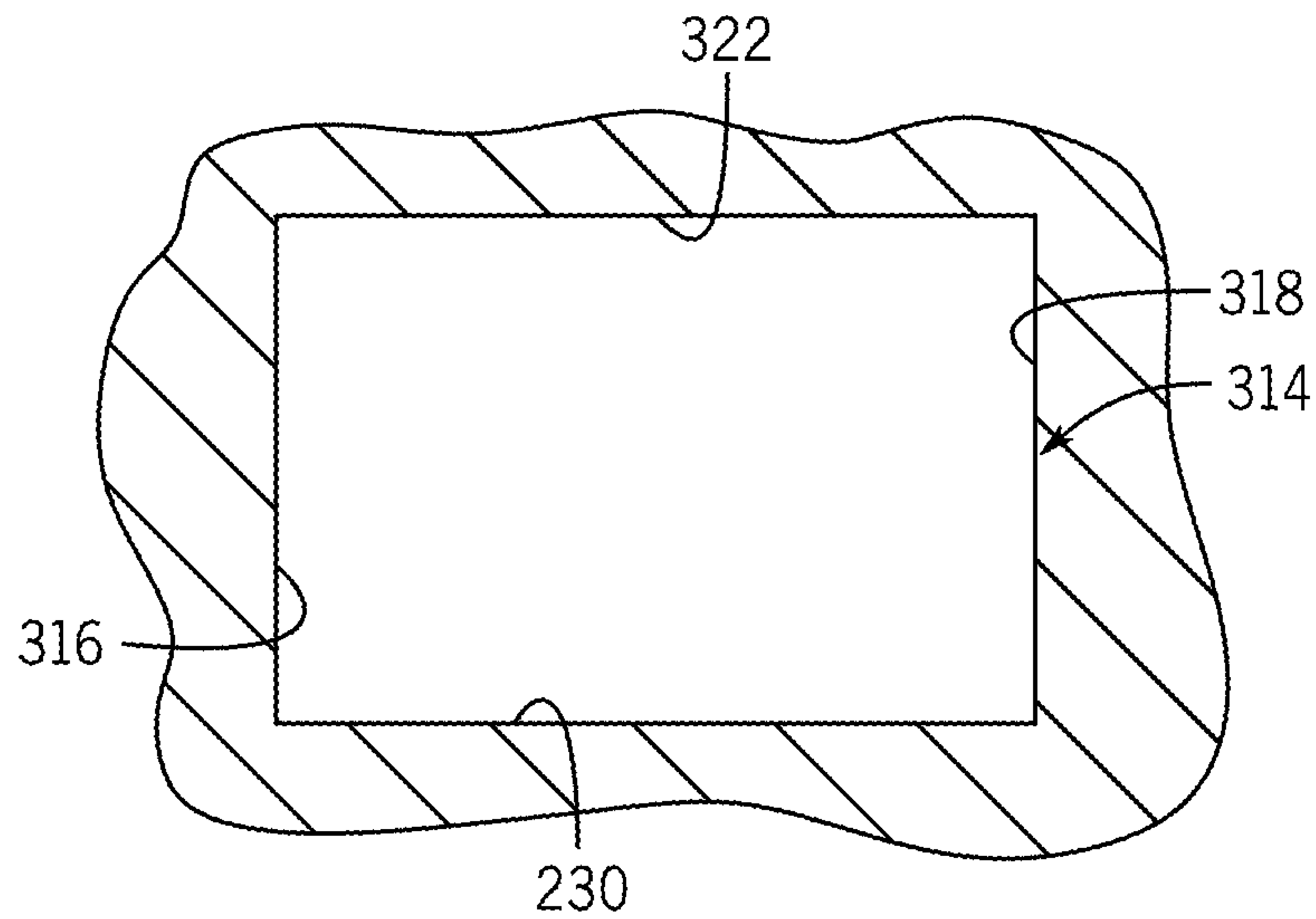
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FIG. 36

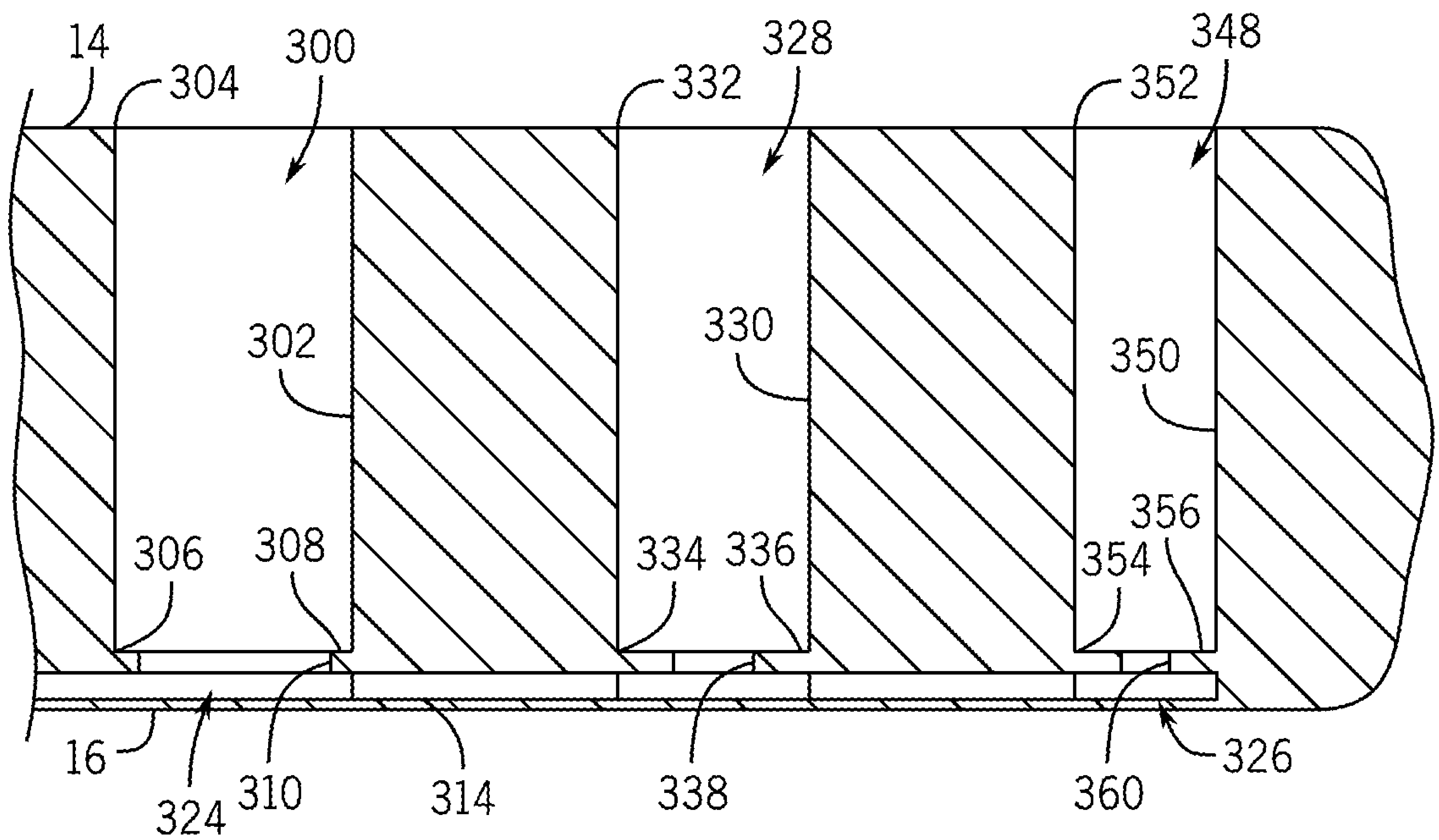
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FIG. 37

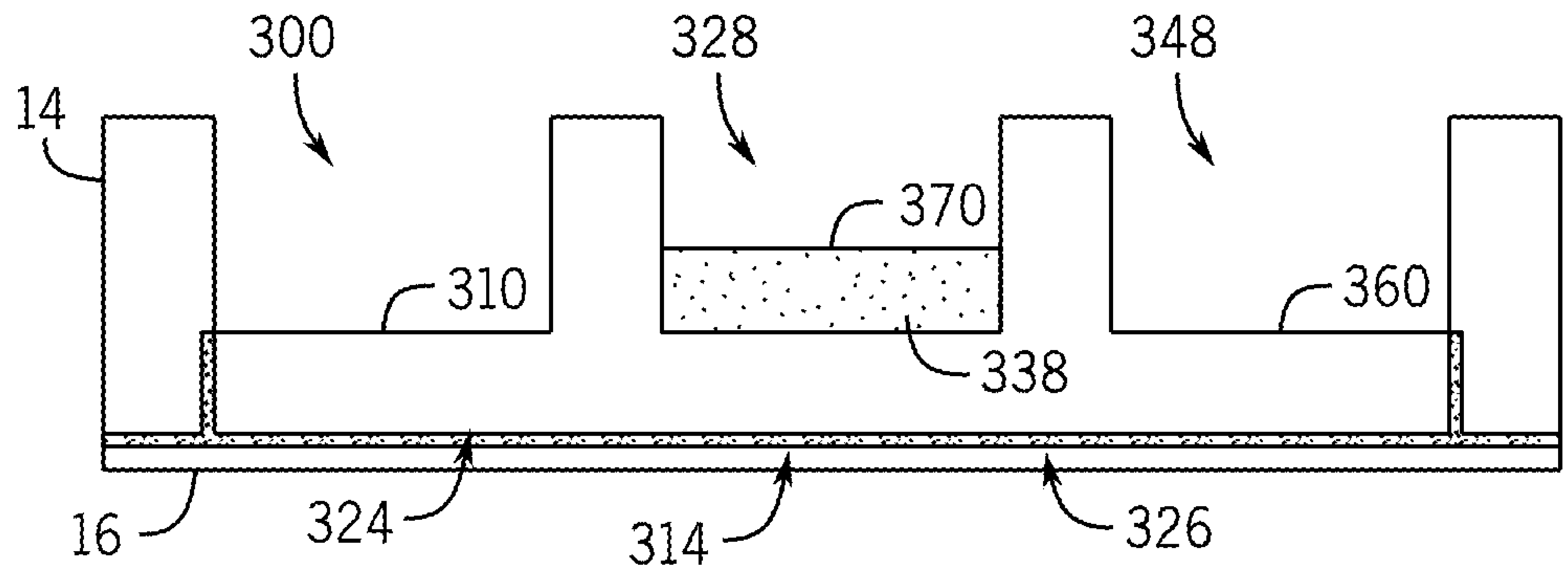

FIG. 38

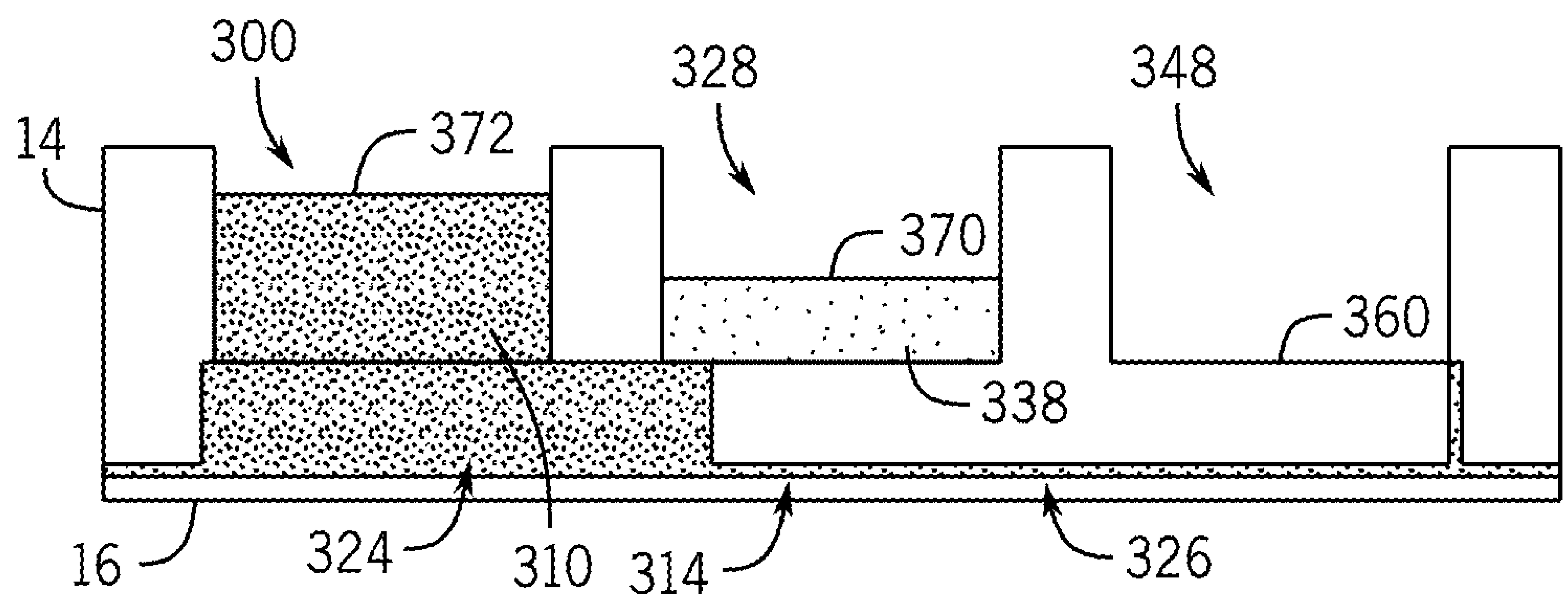

FIG. 39

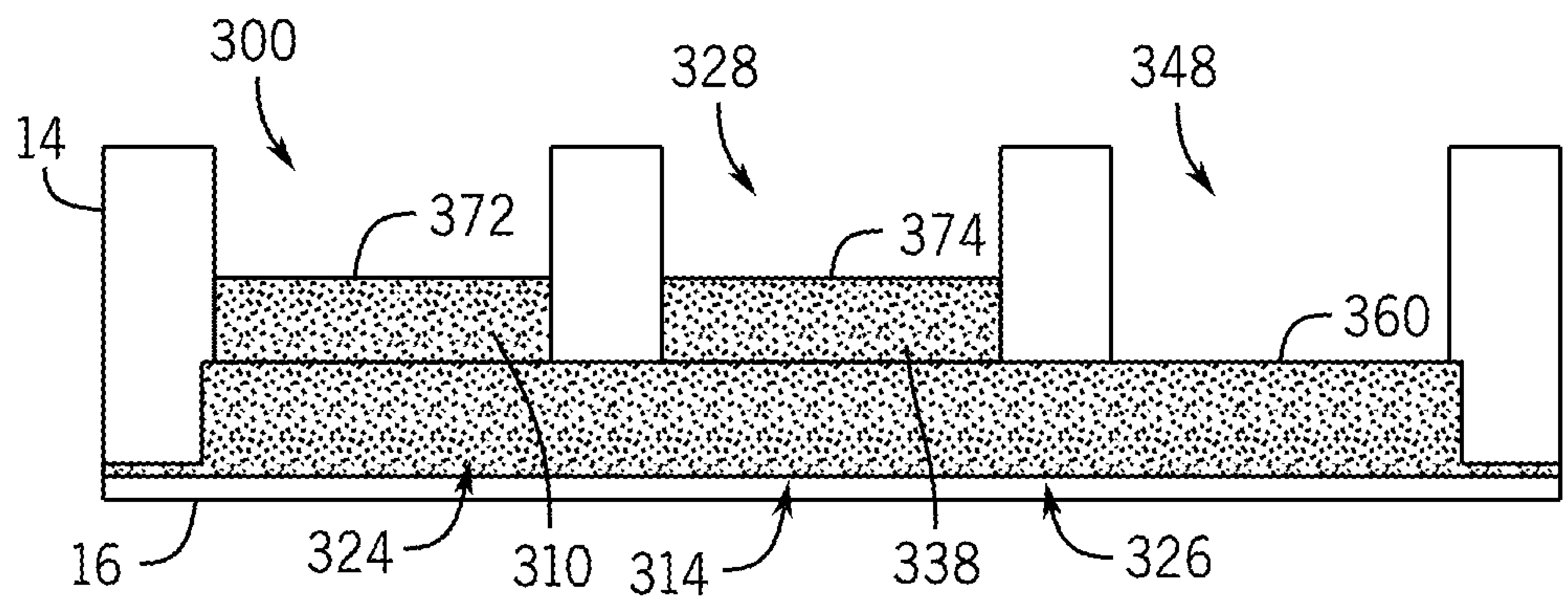

FIG. 40

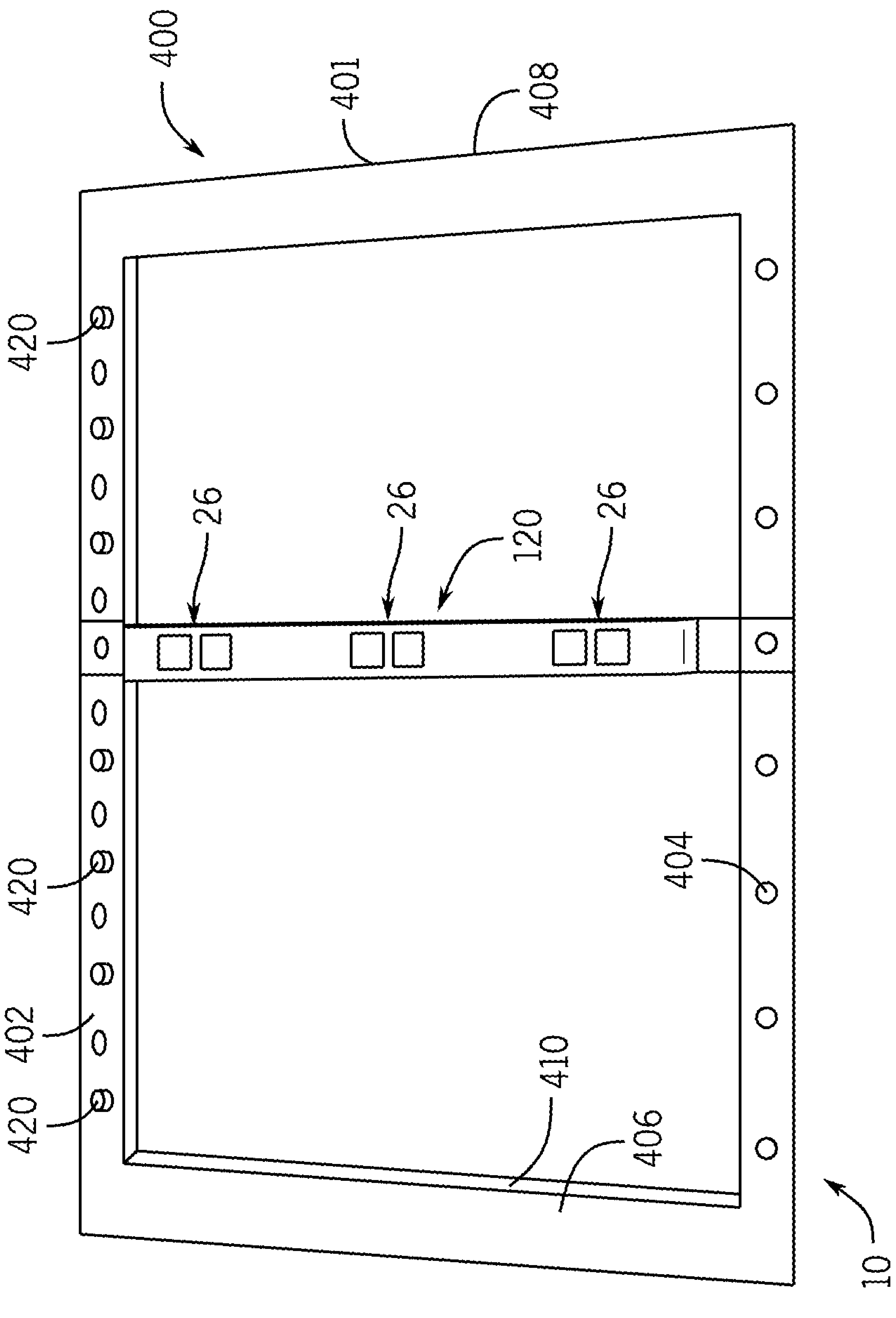
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FIG. 41

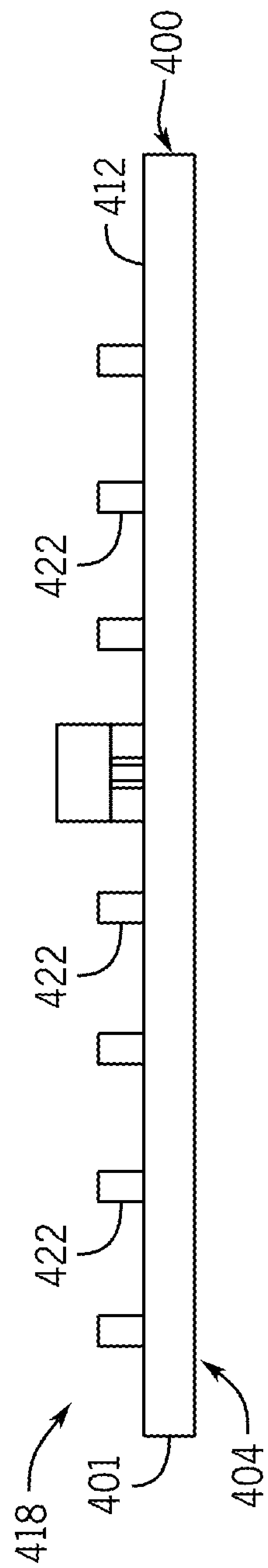
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FIG. 42

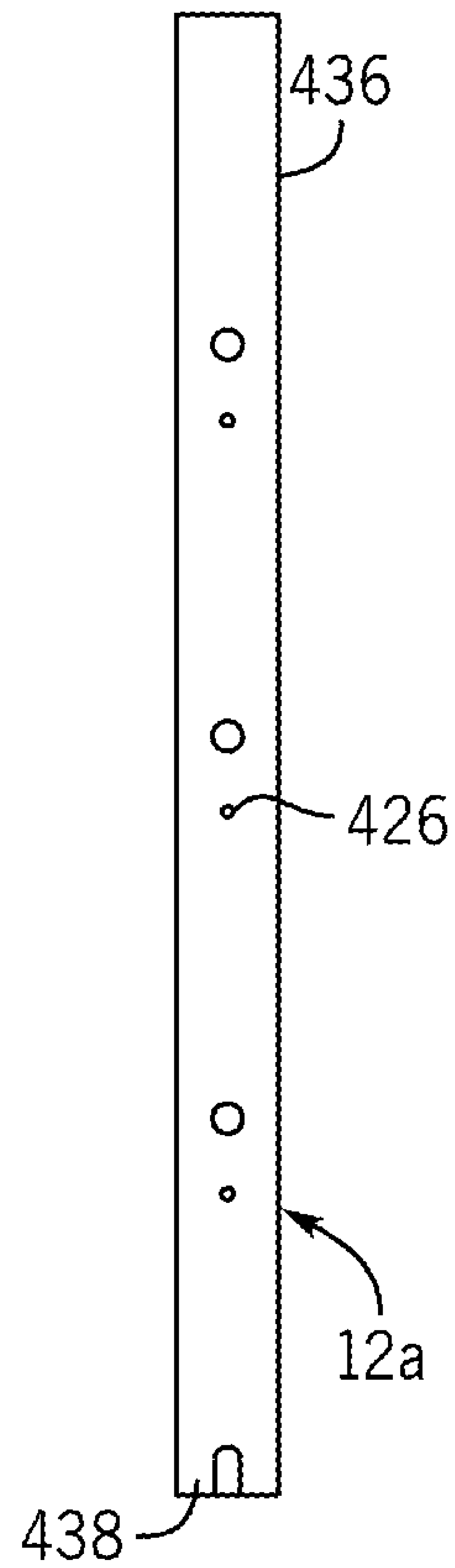

FIG. 43

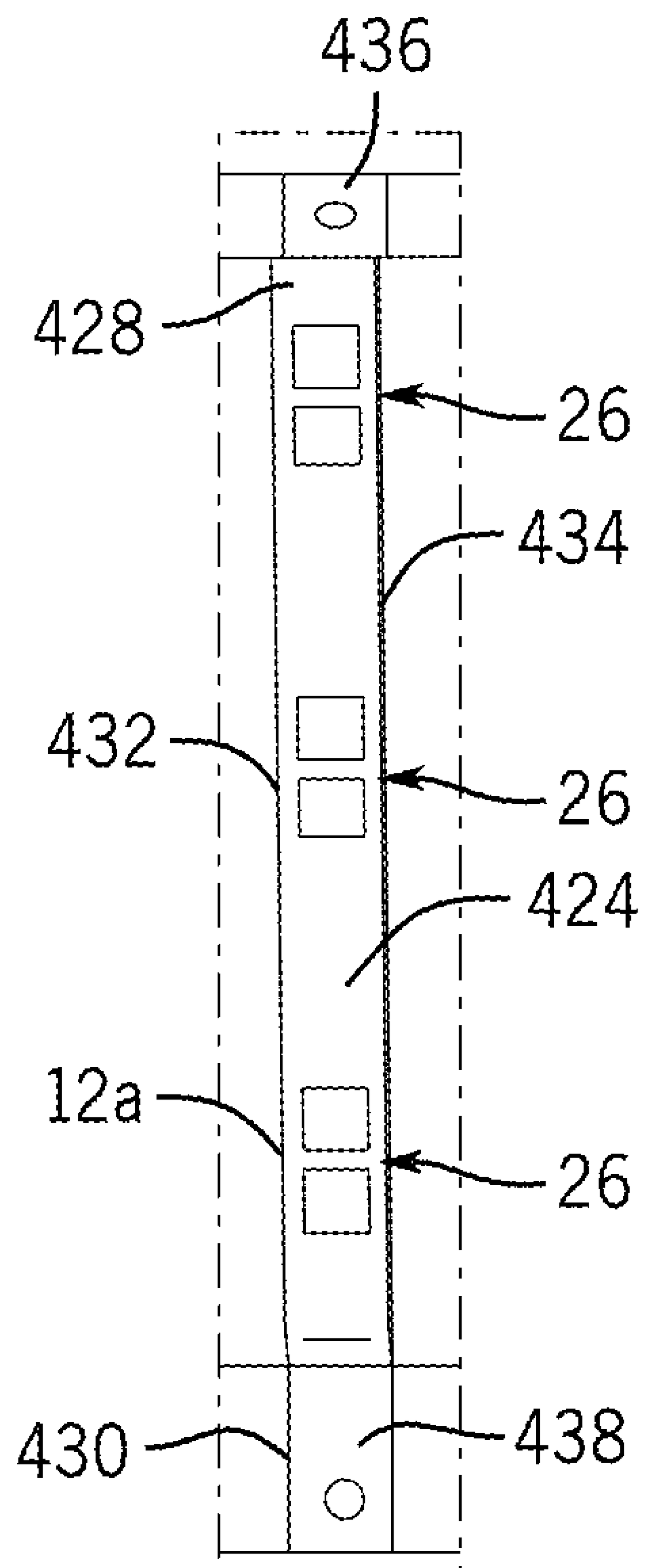

FIG. 44

MICROFLUIDIC DEVICE FOR PROFILING BIOCHEMICAL SAMPLES

FIELD OF THE INVENTION

[0001] This invention relates generally to biochemical profiling, and in particular, to a microfluidic device for profiling biochemical samples, such as biochemical analytes and/or cell types, which allows a user to evaluate multiple functional and molecular readouts in an efficient, user-friendly, high-throughput manner.

BACKGROUND AND SUMMARY OF THE INVENTION

[0002] Profiling is a process whereby biochemical analytes and/or cell populations in a biological sample are identified and quantified according to their physical properties and functional characteristics. Current methods for profiling are time consuming, laborious, and/or require highly specialized equipment to perform. For example, an enzyme-linked immunosorbent assay (ELISA) may be used to measure antibodies, antigens, proteins and glycoproteins in biological samples. However, ELISAs require a great deal of time, expensive antibodies, and many pipetting steps.

[0003] Alternatively, profiling may be conducted using flow cytometry. In flow cytometry, a sample containing cells or particles is suspended in a fluid and injected into the flow cytometer instrument, which rapidly analyzes single cells or particles as they flow past single or multiple lasers. While functional for its intended purpose, the use of flow cytometry to conduct profiling requires large volumes of blood, typically on the order of milliliters. As such, a trained phlebotomist is often needed to draw the blood for use, thereby increasing the cost of the procedure. Further, flow cytometry also requires high amounts of sample and reagents, which can be difficult and costly to obtain, as well as, training for processing the raw data generated.

[0004] In a still further alternative, microfluidic devices and/or platforms have been developed to perform cell-based assays. These microfluidic devices/platforms are usually made from polydimethylsiloxane (PDMS), which requires specialized equipment to fabricate, are usually difficult to load, and are typically highly specific in their usage. Further, these microfluidic devices/platforms are usually distributed already assembled and are challenging to customize without expertise in microfabrication and soft lithography techniques. In addition, these microfluidic devices and/or platforms often require the use of specialized pumping equipment, such as a syringe pump, to drive fluid flow throughout the device. This, in turn, increases the cost and complexity of the microfluidic devices and/or platforms.

[0005] In view of the foregoing, it is primary object and feature of the present invention to provide a microfluidic device for profiling biochemical samples, such as biochemical analytes and/or cell types, which allows a user to evaluate multiple functional readouts in an efficient, user-friendly, high-throughput manner.

[0006] It is further object and feature of the present invention to provide a microfluidic device for profiling biochemical samples, such as biochemical analytes and/or cell types, which utilizes smaller volumes of blood than prior devices/methods.

[0007] It is a further object and feature of the present invention to provide a microfluidic device for profiling biochemical samples, such as biochemical analytes and/or cell types, which does not require specialized pumping equipment and is highly compatible with many common laboratory instruments.

[0008] It is a still further object and feature of the present invention to provide a microfluidic device for profiling biochemical samples, such as biochemical analytes and/or cell types, which is simple to use and inexpensive to manufacture.

[0009] In accordance with the present invention, a microfluidic device is provided for profiling biochemical samples. The microfluidic device includes a cartridge defining a channel network. The channel network includes a channel having first and second opposite ends. A first well is adjacent the first end of the channel. The first well is adapted for receiving a first fluid therein. A first loading port extends between the first well and the channel. The first loading port has a sufficient dimension to allow the first fluid to flow into the channel. A second well is disposed between the first and second ends of the channel. The second well adapted for receiving a second fluid therein. A second loading port extends between the second well and the channel. The second loading port has a dimension to pin the second fluid in the second well. An air outlet is adjacent to the second end of the channel. The air outlet allows an interior of the channel to communicate with an environment external of the cartridge. Capillary action causes the first fluid received in the first well to flow into the channel through the first loading port and toward the air outlet. At least a portion of the first fluid flowing through the channel flows into the second well through the second loading port.

[0010] The channel may be a first channel and the air outlet may be a first air outlet. The channel network may also include a second channel having first and second opposite ends. A third well is adjacent the first end of the second channel. The third well is adapted for receiving a third fluid therein. A third port extends between the third well and the second channel. The third loading port has a sufficient dimension to allow the third fluid to flow into the second channel. A fourth loading port extends between the second well and the second channel. A second air outlet is adjacent to the second end of the second channel. The second air outlet allows an interior of the second channel to communicate with an environment external of the cartridge. It is intended for capillary action to cause the third fluid received in the third well to flow into the second channel through the third loading port and toward the second air outlet. At least a portion of the third fluid flowing through the second channel flows into the second well through the fourth loading port.

[0011] It is contemplated for the channel network to be a first channel network and for the cartridge to includes a second channel network. The second channel network is defined by a channel having first and second opposite ends. A first well is adjacent the first end of the channel of the second channel network. The first well of the second channel network is adapted for receiving a third fluid therein. A first loading port extends between the first well of the second channel network and the channel of the second channel network. The first loading port of the second channel network has a sufficient dimension to allow the third fluid to flow into the channel of the second channel network. A second well is disposed between the first and second ends of the channel of the second channel network. The second well of the second channel network is adapted for receiving a fourth fluid therein. A second loading port extends between the second well of the second channel network and the channel of the second channel network. The second loading port of the second channel network has a dimension to pin the fourth fluid in the second well of the second channel network.

[0012] The second channel network may be further defined by an air outlet adjacent to the second end of the second channel network. The air outlet of the second channel network allows an interior of the channel of the second channel network to communicate with an environment external of the cartridge. Capillary action causes the third fluid received in the first well of the second channel network to flow into the channel of the second channel network through the first loading port of the second channel network and toward the air outlet of the second channel network. At least a portion of the third fluid flowing through the channel of the second channel network flows into the second well of the second channel network through the second loading port of the second channel network.

[0013] Alternatively, the channel of the second channel network may communicate with the air outlet adjacent to the second end of the channel of the second channel network. The air outlet allows an interior of the channel of the second channel network to communicate with an environment external of the cartridge. Capillary action causes the third fluid received in the first well of the second channel network to flow into the channel of the second channel network through the first loading port of the second channel network and toward the air outlet. At least a portion of the third fluid flowing through the channel of the second channel network flows into the second well of the second channel network through the second loading port of the second channel network.

[0014] Alternatively, the channel is first channel and the channel network may also include a second channel having first and second opposite ends. A third well is disposed between the first and second ends of the second channel. The third well is adapted for receiving a third fluid therein. A third loading port extends between the third well and the second channel. The third loading port has a dimension to pin the third fluid in the third well. The first loading port communicates with the second channel adjacent the first end of the second channel.

[0015] The air outlet may communicate with the second end of the second channel, or alternatively, the air outlet may be a first air outlet and the channel network may include a second air outlet adjacent to the second end of the second channel. The second air outlet allows an interior of the second channel to communicate with an environment external of the cartridge. Capillary action causes the first fluid received in the second channel to flow into the second channel through the first loading port and toward the second air outlet. A length of the first channel between the first loading port and the second loading port is generally equal to a length of the second channel between the first loading port and the third loading port.

[0016] A microfluidic device may also include a frame having first and second sides and first and second ends. The cartridge may include first and second ends. A first connector is connected to the cartridge adjacent the first end of the cartridge/The first connector is removably connectable to the first side of the frame. A second connector is connected to the cartridge adjacent the second end of the cartridge. The second connector is removably connectable to the second side of the frame.

[0017] In accordance with a further aspect of the present invention, a microfluidic device for profiling biochemical samples types. A cartridge defines a channel network. The channel network includes a channel having first and second opposite ends. A first well communicating with the first end of the channel. The first well is adapted for receiving a first fluid therein. A second well is in communication with the channel through a loading port at a location between the first and second ends of the channel. The second well is adapted for receiving a second fluid therein. An air outlet is in communication with the channel at a location adjacent to the second end of the channel. The air outlet allows an interior of the channel to communicate with an environment external of the cartridge. Capillary action causes the first fluid received in the first well to flow into the channel toward the air outlet. The second loading port has a dimension to pin the second fluid in the second well. At least a portion of the first fluid flowing through the channel flows into the second well.

[0018] The channel may be a first channel, the loading port may be a first loading port, and the air outlet may a first air outlet. The channel network includes a second channel having first and second opposite ends. A third well communicates the first end of the second channel. The third well is adapted for receiving a third fluid therein. A second loading port extends between the second well and the second channel. A second air outlet is adjacent to the second end of the second channel. The second air outlet allows an interior of the second channel to communicate with an environment external of the cartridge. It is intended for capillary action to cause the third fluid received in the third well to flow into the second channel toward the air outlet. At least a portion of the third fluid flowing through the second channel flows into the second well through the second loading port.

[0019] It is contemplated for the channel network to be a first channel network and for the cartridge to further include a second channel network. The second channel network is defined by a channel having first and second opposite ends, a first well communicating with the channel of the second channel network at a location adjacent the first end of the channel of the second channel network and a second well communicating with the channel of the second channel network through a loading port at a location between the first and second ends of the channel of the second channel network. The first well of the second channel network is adapted for receiving a third fluid therein and the second well of the second channel network adapted for receiving a fourth fluid therein. The loading port of the second channel network has a dimension to pin the fourth fluid in the second well of the second channel network

[0020] The second channel network may also include an air outlet in communication with the channel of the second channel network at a location adjacent to the second end of the second channel network. The air outlet of the second channel network allows an interior of the channel of the second channel network to communicate with an environment external of the cartridge. Capillary action causes the third fluid received in the first well of the second channel network to flow into the channel of the second channel network toward the air outlet of the second channel network. At least a portion of the third fluid flowing through the channel of the second channel network flows into the second well of the second channel network through the loading port of the second channel network.

[0021] Alternatively, the channel of the second channel network may communicate with the air outlet of the first channel network at a location adjacent to the second end of the channel of the second channel network. The air outlet allows an interior of the channel of the second channel network to communicate with an environment external of the cartridge. Capillary action causes the third fluid received in the first well of the second channel network to flow into the channel of the second channel network toward the air outlet. At least a portion of the third fluid flowing through the channel of the second channel network flows into the second well of the second channel network through the loading port of the second channel network.

[0022] It is further contemplated for the channel to be a first channel and for the loading port to be a first loading port. In such configuration, the channel network may further include a second channel having first and second opposite ends. A third well is in communication with the second channel through a second loading port at a location between the first and second ends of the second channel. The third well is adapted for receiving a third fluid therein. The first well is in communication with the second channel at a location adjacent the first end of the second channel.

[0023] The air outlet may be in communication with the second end of the second channel, or alternatively, the air outlet may be a first air outlet and the channel network further includes a second air outlet in communication with the second channel at a location adjacent to the second end of the second channel. The second air outlet allows an interior of the second channel to communicate with an environment external of the cartridge. Capillary action causes the first fluid received in the second channel to flow into the second channel toward the second air outlet.

[0024] In accordance with a still further aspect of the present invention, a microfluidic device for profiling biochemical samples is provided. The microfluidic device includes a cartridge defining a channel network. The channel network includes a channel having first and second opposite ends. A first loading port is in communication with the channel. The first loading port is configured to allow introduction of a first fluid into the channel. A well is in communication with the channel through a second loading port and is located between the first loading port and the second end of the channel. The second well is adapted for receiving a second fluid therein. An air outlet is in communication with channel at a location adjacent to the second end of the channel. The air outlet allows an interior of the channel to communicate with an environment external of the cartridge. The second loading port has a dimension to pin the second fluid in the second well. The first fluid received in the first well flows into the channel toward the air outlet. At least a portion of the first fluid flowing through the channel flows into the second well through the second loading port.

[0025] The channel network may be a first channel network and the cartridge may further includes a second channel network. The second channel network is defined by a channel having first and second opposite ends; a first loading port in communication with the channel of the second channel network, and a well in communication with the channel of the second channel network through a second loading port and located between the first loading port of the second channel network and the second end of the channel of the second channel network. The first loading port of the second channel network is configured to allow introduction of a third fluid into the channel of the second channel network. The well of the second channel network is adapted for receiving a fourth fluid therein. The second loading port of the second channel network has a dimension to pin the fourth fluid in the second well of the second channel network.

[0026] The second channel network may also include an air outlet in communication with the channel of the second channel network at a location adjacent to the second end of the second channel network. The air outlet of the second channel network allows an interior of the channel of the second channel network to communicate with an environment external of the cartridge. Alternatively, the channel of the second channel network communicates with the air outlet of the first channel network at a location adjacent to the second end of the channel of the second channel network. The air outlet allows an interior of the channel of the second channel network to communicate with an environment external of the cartridge.

[0027] It is further contemplated for the channel to be a first channel and for the channel network to further include a second channel having first and second opposite ends. The second channel may be in communication with the first loading port. A second well is in communication with the second channel through a third loading port at a location between the first loading port and the second end of the second channel. The second well is adapted for receiving a third fluid therein.

[0028] The air outlet may be in communication with the communication with the second channel at a location adjacent the second end of the second channel. Alternatively, the air outlet may be a first air outlet and the channel network may further includes a second air outlet in communication with the second channel at a location adjacent to the second end of the second channel. The second air outlet allows an interior of the second channel to communicate with an environment external of the cartridge.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The drawings furnished herewith illustrate a preferred construction of the present invention in which the above advantages and features are clearly disclosed, as well as others which will be readily understood from the following description of the illustrated embodiment.

[0030] In the drawings:

[0031] FIG. **1** is a top plan view of a microfluidic device in accordance with the present invention;

[0032] FIG. **2** is an enlarged, top plan view showing a portion of the microfluidic device of FIG. **1**;

[0033] FIG. **3** is a cross-sectional view of the microfluidic device of the present invention taken along line **3-3** of FIG. **2**;

[0034] FIG. **4** is a cross-sectional view of the microfluidic device of the present invention taken along line **4-4** of FIG. **2**;

[0035] FIG. **5** is a schematic view showing the microfluidic device of the present invention in a first operative step;

[0036] FIG. **6** is a schematic view showing the microfluidic device of the present invention in a second operative step;

[0037] FIG. **7** is a schematic view showing the microfluidic device of the present invention in a third operative step;

[0038] FIG. **8** is schematic view showing an alternate configuration of a channel network for the microfluidic device of the present invention;

[0039] FIG. **9** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **9-9** of FIG. **8**;

[0040] FIG. **10** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **10-10** of FIG. **8**;

[0041] FIG. **11** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **11-11** of FIG. **8**;

[0042] FIG. **12** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **12-12** of FIG. **8**;

[0043] FIG. **13** is a schematic view showing a first channel of the channel network of FIG. **8** in a first operative step;

[0044] FIG. **14** is a schematic view showing the first channel of the channel network of FIG. **8** in a second operative step;

[0045] FIG. **15** is a schematic view showing the first channel of the channel network of FIG. **8** in a third operative step;

[0046] FIG. **16** is a schematic view showing a second channel of the channel network of FIG. **8** in a first operative step;

[0047] FIG. **17** is a schematic view showing the second channel of the channel network of FIG. **8** in a second operative step;

[0048] FIG. **18** is a schematic view showing the second channel of the channel network of FIG. **8** in a third operative step;

[0049] FIG. **19** is a schematic view showing a third channel of the channel network of FIG. **8** in a first operative step;

[0050] FIG. **20** is a schematic view showing the third channel of the channel network of FIG. **8** in a second operative step;

[0051] FIG. **21** is a schematic view showing the third channel of the channel network of FIG. **8** in a third operative step;

[0052] FIG. **22** is schematic view showing a further alternate configuration of a channel network for the microfluidic device of the present invention;

[0053] FIG. **23** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **23-23** of FIG. **22**;

[0054] FIG. **24** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **24-24** of FIG. **22**;

[0055] FIG. **25** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **25-25** of FIG. **22**;

[0056] FIG. **26** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **26-26** of FIG. **22**;

[0057] FIG. **27** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **27-27** of FIG. **22**;

[0058] FIG. **28** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **28-28** of FIG. **22**;

[0059] FIG. **29** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **29-29** of FIG. **22**;

[0060] FIG. **30** is a schematic view showing the channel network of FIG. **22** in a first operative step;

[0061] FIG. **31** is a schematic view showing the channel network of FIG. **22** in a second operative step;

[0062] FIG. **32** is a schematic view showing the channel network of FIG. **22** in a third operative step;

[0063] FIG. **33** is a schematic view showing the channel network of FIG. **22** in a fourth operative step;

[0064] FIG. **34** is a schematic view showing the channel network of FIG. **22** in a fifth operative step;

[0065] FIG. **35** is schematic view showing a still further alternate configuration of a channel network for the microfluidic device of the present invention;

[0066] FIG. **36** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **36-36** of FIG. **35**;

[0067] FIG. **37** is a cross-sectional view of the channel network for the microfluidic device of the present invention taken along line **37-37** of FIG. **35**;

[0068] FIG. **38** is a schematic view showing an exemplary channel of the channel network of FIG. **35** in a first operative step;

[0069] FIG. **39** is a schematic view showing the exemplary channel of the channel network of FIG. **35** in a second operative step;

[0070] FIG. **40** is a schematic view showing the exemplary channel of the channel network of FIG. **35** in a third operative step;

[0071] FIG. **41** is a top plan view of an alternate configuration of a microfluidic device in accordance with the present invention;

[0072] FIG. **42** is an end view of the microfluidic device of FIG. **41**;

[0073] FIG. **43** is a bottom plan view a cartridge for the microfluidic device of the present invention; and

[0074] FIG. **44** is a top plan view of the cartridge for the microfluidic device of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0075] Referring to FIG. **1**, a microfluidic device for profiling biochemical samples, such as biochemical analytes and/or cell types, is generally designated by the reference numeral **10**. By way of example, microfluidic device **10** may take the form of single cartridge **12** corresponding in size and shape to a conventional **384** well plate. However, as hereinafter described, cartridge **12** may be fabricated in other sizes and shapes without deviating from the scope of the scope of the present invention. Referring to back to FIG. **1**, cartridge **12** is defined by a generally flat, upper surface **14** interconnected to a generally flat, lower surface **16**, FIG. **3**, by first and second ends **18** and **20**, respectively, and first and second sides **22** and **24**, respectively. An array of one or more channel networks (e.g. channel networks **26**, **26***a*, **26***b* and **26***b*) are formed in cartridge **12**, as hereinafter described.

[0076] Referring to FIGS. **2-7**, by way of example, channel network **26** may include central channel **28** extending through cartridge **12** between upper and lower surfaces **14** and **16**, respectively, thereof. Central channel **28** may extend along a longitudinal axis, be nonlinear, be serpentine or be a combination thereof. As best seen in FIG. **4**, central channel **28** extends along a longitudinal axis and is defined by first and second spaced sidewalls **30** and **32**, respectively, interconnecting bottom wall **34** and upper wall **36**. Central channel **28** further includes opposite, first and second ends **38** and **40**, respectively, FIG. **3**.

[0077] First well **42** is formed in upper surface **14** at a location adjacent to and overlapping first end **38** of central channel **28**. First well **42** is defined by inner surface **43** having an upper edge **46** intersecting upper surface **14** and a lower edge **48**, and a lower surface **50** extending radially inward from lower edge **48**. While first well **42** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention. First loading port **44** extends between lower surface **50** partially defining first well **42** and upper wall **36** partially defining central channel **28** such that first well **42** communicates with central channel **28** at a location adjacent first end **38** of central channel **38**. First loading port **44** has a generally circular configuration and a diameter of sufficient dimension (e.g. in the range 1 to 2 millimeters (mm)) to allow loading of central channel **28**, as hereinafter described. While first loading port **44** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0078] Second well **52** is formed in upper surface **14** at a location aligned with central channel **28** between first and second ends **38** and **40**, respectively. Second well **52** is defined by an inner surface **54** having an upper edge **56** intersecting upper surface **14** and a lower edge **58**, and a lower surface **60** extending radially inward from lower edge **58**. While second well **52** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention.

[0079] Second loading port **64** extends between lower surface **60** partially defining second well **52** and upper wall **36** partially defining central channel **28** such that second well **52** communicates with central channel **28** at a location between first and second ends **38** and **40**, respectively, of central channel **38**. Second loading port **44** has a generally circular configuration and a diameter of a dimension sufficient to pin fluid received in second well **52** and retain the fluid therein (e.g. in the range of 10-1000 microns), while allowing fluid received in central channel **28** to flow into second well **52**, as hereinafter described. While second loading port **64** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0080] Third well **72** is formed in upper surface **14** at a location adjacent to and overlapping second end **40** of central channel **28**. Third well **72** is defined by inner surface **74** having an upper edge **76** intersecting upper surface **14** and a lower edge **78**, and a lower surface **80** extending radially inward from lower edge **78**. While first well **72** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention. Air outlet **84** extends between lower surface **80** partially defining third well **72** and upper wall **36** partially defining central channel **28** such that third well **72** communicates with central channel **28** at a location adjacent first end **38** of central channel **28**. Air outlet **84** has a generally circular configuration and a diameter of a dimension sufficient to pin fluid in central channel **28** and prevent the fluid from passing into third well **72** (e.g. in the range of 10-500 microns). While air outlet **84** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0081] In operation, a fluid, e.g. reagent buffer **90**, is loaded in second well **52**. The diameter of second loading port **64** is sufficient to pin reagent buffer **90** in second well **52** and retain reagent buffer **90** therein, FIG. **5**. Thereafter, a fluid, e.g. analyte solution **92**, is loaded into first well **42**, FIG. **6**. First loading port **44** is of sufficient dimension to allow analyte solution **92** to flow into central channel **28**, FIG. **7**. Capillary action causes analyte solution **92** to flow through central channel **28** toward air outlet **84**, thereby urging air out of central channel **28** through air outlet **84**. As noted above, air outlet **84** has a diameter of a dimension sufficient to pin analyte solution **92** in central channel **28** and prevent analyte solution **94** from passing into third well **72** through air outlet **84**. With analyte solution **92** pinned at air outlet **84**, analyte solution **92** flowing through central channel **28** is directed into second well **52** through second loading port **64**, wherein analyte solution **92** and reagent buffer **90** mix via diffusion. The mixture, designated by the reference numeral **94**, may be removed for additional analysis, if so desired.

[0082] Referring to FIGS. **8-21**, an alternate channel network is generally designated by the reference numeral **26*a***. As hereinafter described, channel network **26*a*** incorporates elements/components found in channel network **26**. As such, common reference characters are used to identify these common elements/components.

[0083] In addition to central channel **28**, channel network **26*a*** includes a plurality of additional channels, e.g., second channel **98** and third channel **100**, which extend between first loading port **44** to air outlet **84**. More specifically, second channel **98** extends through cartridge **12** between upper and lower surfaces **14** and **16**, respectively, thereof. Second channel **98** is defined by first and second spaced sidewalls **102** and **104**, respectively, interconnecting bottom wall **106** and upper wall **108**, FIG. **10**. Second channel **98** further includes opposite, first and second ends **110** and **112**, respectively. First end **110** of second channel **98** is in communication with first loading port **44** and second end **112** of second channel **98** is in communication with air outlet **84**.

[0084] As best seen in FIG. **9**, fourth well **114** is formed in upper surface **14** of cartridge **12** at a location aligned with second channel **98** between first and second ends **110** and **112**, respectively, thereof. Fourth well **114** is defined by an inner surface **116** having an upper edge **118** intersecting upper surface **14** and a lower edge **120**, and a lower surface **122** extending radially inward from lower edge **120**. While fourth well **114** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention.

[0085] Third loading port **124** extends between lower surface **122** partially defining fourth well **114** and upper wall **108** partially defining second channel **98** such that fourth well **114** communicates with second channel **98** at a location between first and second ends **110** and **112**, respectively, of second channel **98**. Third loading port **124** has a generally circular configuration and a diameter of a dimension sufficient to pin fluid received in fourth well **114** and retain the fluid therein, while allowing fluid received in second channel **98** to flow into fourth well **114**, as hereinafter described. While third loading port **124** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0086] Referring to FIGS. **8** and **11-12**, third channel **100** extends through cartridge **12** between upper and lower surfaces **14** and **16**, respectively, thereof. Third channel **100** is defined by first and second spaced sidewalls **132** and **134**, respectively, interconnecting bottom wall **136** and upper wall **138**. Third channel **100** further includes opposite, first and second ends **140** and **142**, respectively. First end **140** of third channel **100** is in communication with first loading port **44** and second end **142** of third channel **100** is in communication with air outlet **84**.

[0087] Fifth well **144** is formed in upper surface **14** of cartridge **12** at a location aligned with third channel **100** between first and second ends **140** and **142**, respectively, thereof. Fifth well **144** is defined by an inner surface **146** having an upper edge **148** intersecting upper surface **14** and a lower edge **150**, and a lower surface **152** extending radially inward from lower edge **150**. While fourth well **144** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention.

[0088] Fourth loading port **154** extends between lower surface **152** partially defining fifth well **144** and upper wall **138** partially defining third channel **100** such that fifth well **144** communicates with third channel **100** at a location between first and second ends **140** and **142**, respectively, of third channel **100**. Fourth loading port **154** has a generally circular configuration and a diameter of a dimension sufficient to pin fluid received in fifth well **144** and retain the fluid therein, while allowing fluid received in third channel **100** to flow into fifth well **44**, as hereinafter described. While fourth loading port **154** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0089] In operation, fluids, e.g. the same or different reagent buffers **90***a*-**90***c*, are loaded into second well **52**, fourth well **114** and fifth well **144**, respectively. The diameters of second loading port **64**, third loading port **124** and fourth loading port **154** is sufficient to pin reagent buffers **90***a*-**90***c*, respectively, in corresponding second well **52**, fourth well **114** and fifth well **144**, respectively, and retain reagent buffers **90***a*-**90***c* therein, FIGS. **13**, **16** and **19**. Thereafter, a fluid, e.g. analyte solution **92**, is loaded into first well **42**, FIGS. **14**, **17** and **20**. First loading port **44** is of sufficient dimension to allow analyte solution **92** to flow into central channel **28**, second channel **98** and third channel **100**. Capillary action causes analyte solution **92** to flow through central channel **28** toward air outlet **84**, thereby urging air out of central channel **28** through air outlet **84**. Simultaneously, capillary action causes analyte solution **92** to flow through second channel **98** toward air outlet **84**, thereby urging air out of central channel **28** through air outlet **84**, and through third channel **100** toward air outlet **84**, thereby urging air out of central channel **28** through air outlet **84**.

[0090] In order to prevent cross-contamination and potential backflow between central channel **28**, second channel **98** and third channel **100**, and to generate simultaneous flow through central channel **28**, second channel **98** and third channel **100**, it is contemplated for: 1) the length of central channel **28** between first loading port **44** and second loading port **64** to be generally equal to the length of second channel **98** between first loading port **44** and third loading port **124** and to the length of third channel **100** between first loading port **44** and fourth loading port **154**; and 2) the length of central channel **28** between second loading port **64** and air outlet **84** to be generally equal to the length of second channel **98** between third loading port **124** and air outlet **84** and to the length of third channel **100** between first loading port **44** and fourth loading port **154**. As such, central channel **28**, second channel **98** and third channel **100** may have various configurations (e.g. extend along a longitudinal axis, be nonlinear, be serpentine or be a combination thereof). In addition, the configurations of central channel **28**, second channel **98** and third channel **100** may be designed and arranged so to optimize the number of channel networks **26** in the array of channel networks **26** within cartridge **12**.

[0091] As noted above, air outlet **84** has a diameter of a dimension sufficient to pin analyte solution **92** in central channel **28**, second channel **98** and third channel **100**, thereby preventing analyte solution **92** from passing into third well **72** through air outlet **84**. With analyte solution **92** pinned at air outlet **84**, analyte solution **92** flowing through central channel **28** is directed into second well **52** through second loading port **64**, wherein analyte solution **92** and reagent buffer **90***a* mix via diffusion, FIG. **15**; analyte solution **92** flowing through second channel **98** is directed into fourth well **114** through third loading port **124**, wherein analyte solution **92** and reagent buffer **90***b* mix via diffusion, FIG. **18**; and analyte solution **92** flowing through third channel **100** is directed into fifth well **144** through fourth loading port **154**, wherein analyte solution **92** and reagent buffer **90***c* mix via diffusion, FIG. **21**. The mixtures, designated by the reference numerals **94***a*, **94***b* and **94***c* in second well **52**, fourth well **114** and fifth well **144**, respectively, may be removed for additional analysis, if so desired.

[0092] Referring to FIGS. **22-30**, a still further alternate configuration a channel network is generally designated by the reference numeral **156**. Channel network **156** includes first channel **158** extending through cartridge **12** between upper and lower surfaces **14** and **16**, respectively, thereof. First channel **158** is defined by first and second spaced sidewalls **160** and **162**, respectively, interconnecting bottom wall **164** and upper wall **166**. First channel **158** further includes opposite, first and second ends **168** and **170**, respectively.

[0093] As best seen in FIGS. **22** and **24**, first well **172** is formed in upper surface **14** at a location adjacent to and overlapping first end **168** of first channel **158**. First well **172** is defined by inner surface **173** having an upper edge **176** intersecting upper surface **14** and a lower edge **188**, and a lower surface **180** extending radially inward from lower edge **188**. While first well **172** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention. First loading port **174** extends between lower surface **180** partially defining first well **172** and upper wall **166** partially defining first channel **158** such that first well **172** communicates with first channel **158** at a location adjacent first end **168** of first channel **158**. First loading port **174** has a generally circular configuration and a diameter of sufficient dimension to allow loading of first channel **158**, as hereinafter described. While first loading port **174** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0094] Referring to FIGS. **22** and **25**, second well **182** is formed in upper surface **14** at a location aligned with first channel **158** between first and second ends **168** and **170**, respectively. Second well **182** is defined by an inner surface **183** having an upper edge **186** intersecting upper surface **14** and a lower edge **188**, and a lower surface **190** extending radially inward from lower edge **188**. While second well **182** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention.

[0095] Second loading port **194** extends between lower surface **190** partially defining second well **182** and upper wall **166** partially defining first channel **158** such that second well **182** communicates with first channel **158** at a location between first and second ends **168** and **170**, respectively, of first channel **158**. Second loading port **194** has a generally circular configuration and a diameter of a dimension sufficient to pin fluid received in second well **182** and retain the fluid therein, while allowing fluid received in first channel **158** to flow into second well **182**, as hereinafter described. While second loading port **194** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0096] Referring to FIGS. **22** and **26**, third well **202** is formed in upper surface **14** at a location adjacent to and overlapping second end **170** of first channel **158**. Third well **202** is defined by inner surface **204** having an upper edge **206** intersecting upper surface **14** and a lower edge **208**, and a lower surface **210** extending radially inward from lower edge **208**. While third well **202** has a generally circular cross-section, other configurations are possible without deviating from scope of the present invention. Air outlet **214** extends between lower surface **210** partially defining third well **202** and upper wall **166** partially defining first channel **158** such that third well **202** communicates with first channel **158** at a location adjacent second end **170** of first channel **158**. Air outlet **214** has a generally circular configuration and a diameter of a dimension sufficient to pin fluid in first channel **158** and prevent the fluid from passing into third well **202**. While air outlet **214** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0097] Channel network **26*b*** further includes second channel **228** extending through cartridge **12** between upper and lower surfaces **14** and **16**, respectively, thereof. Second channel **228** is defined by first and second spaced sidewalls **230** and **232**, respectively, interconnecting bottom wall **234** and upper wall **236**, FIG. **27**. Second channel **228** further includes opposite, first and second ends **238** and **240**, respectively.

[0098] Referring to FIGS. **22** and **28**, fourth well **242** is formed in upper surface **14** at a location adjacent to and overlapping first end **238** of second channel **228**. Fourth well **242** is defined by inner surface **243** having an upper edge **246** intersecting upper surface **14** and a lower edge **248**, and a lower surface **250** extending radially inward from lower edge **248**. While fourth well **242** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention. Third loading port **244** extends between lower surface **250** partially defining fourth well **242** and upper wall **236** partially defining second channel **228** such that fourth well **242** communicates with fourth channel **228** at a location adjacent first end **238** of second channel **228**. Third loading port **244** has a generally circular configuration and a diameter of sufficient dimension to allow loading of second channel **228**, as hereinafter described. While third loading port **244** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0099] Referring back to FIGS. **22** and **25**, fourth loading port **264** extends between lower surface **190** partially defining second well **182** and upper wall **236** partially defining second channel **228** such that second well **152** communicates with second channel **228** at a location between first and second ends **238** and **240**, respectively, of second channel **228**. Fourth loading port **264** has a generally circular configuration and a diameter of a dimension sufficient to pin fluid received in second well **182** and retain the fluid therein, while allowing fluid received in second channel **228** to flow into second well **182**, as hereinafter described. While fourth loading port **264** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0100] As best seen in FIGS. **22** and **29**, fifth well **272** is formed in upper surface **14** at a location adjacent to and overlapping second end **240** of second channel **228**. Fifth well **272** is defined by inner surface **273** having an upper edge **276** intersecting upper surface **14** and a lower edge **278**, and a lower surface **280** extending radially inward from lower edge **278**. While fifth well **272** has a generally circular cross-section, other configurations are possible without deviating from scope of the present invention. Air outlet **284** extends between lower surface **280** partially defining fifth well **272** and upper wall **236** partially defining second channel **228** such that fifth well **272** communicates with second channel **228** at a location adjacent second end **240** of second channel **228**. Air outlet **284** has a generally circular configuration and a diameter of a dimension sufficient to pin fluid in second channel **228** and prevent the fluid from passing into fifth well **272**. While air outlet **284** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0101] Referring to FIGS. **30-34**, in operation, a first fluid, e.g. first reagent buffer **290**, is loaded in second well **182**. The diameters of second loading port **194** and fourth loading port **264** are sufficient to pin first reagent buffer **290** in second well **182** and retain first reagent buffer **290** therein. Thereafter, a first fluid, e.g. first analyte solution **292** is loaded into first well **172**, FIG. **30**. First loading port **174** is of sufficient dimension to allow first analyte solution **292** to flow into first channel **158**, FIG. **31**. Capillary action causes first analyte solution **292** to flow through first channel **158** toward air outlet **214**, thereby urging air out of first channel **158** through air outlet **214**. As noted above, air outlet **214** has a diameter of a dimension sufficient to pin first analyte solution **292** in first channel **158** and prevent first analyte solution **292** from passing into third well **72** through air outlet **214**. With first analyte solution **292** pinned at air outlet **214**, first analyte solution **292** flowing through first channel **158** is directed into second well **182** through second loading port **194**, wherein first analyte solution **292** and first reagent buffer **290** mix via diffusion, FIG. **32**.

[0102] Either simultaneously or after first reagent buffer **290** and first analyte solution **292** are loaded into second well **182** and first well **172**, respectively, a second fluid, e.g. second analyte solution **296**, is loaded into fourth well **242**, FIG. **33**. Fourth loading port **264** is of sufficient dimension to allow second analyte solution **296** to flow into second channel **228**. Capillary action causes second analyte solution **296** to flow through second channel **228** toward air outlet **284**, thereby urging air out of second channel **228** through air outlet **284**. As noted above, air outlet **284** has a diameter of a dimension sufficient to pin second analyte solution **296** in first channel **228** and prevent second analyte solution **296** from passing into fifth well **272** through air outlet **284**. With second analyte solution **296** pinned at air outlet **284**, second analyte solution **296** flowing through second channel **228** is directed into second well **182** through fourth loading port **264**, wherein second analyte solution **296** mixes with first analyte solution **292** and first reagent buffer **290** via diffusion to form mixture **298**, FIG. **34**. Mixture **298** may be removed from second well **182** for additional analysis, if so desired.

[0103] Referring to FIGS. **35-40**, a still further alternate configuration of a channel network is generally designated by the reference numeral **26*c***. Channel network **26*c*** includes central well **300** is formed in upper surface **14**, FIG. **37**. Central well **300** is defined by inner surface **302** having an upper edge **304** intersecting upper surface **14** and a lower edge **306**, and a lower surface **308** extending radially inward from lower edge **306**. While central well **300** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention. Central loading port **310** extends through lower surface **308** partially defining central well **300**, as hereinafter described. Central loading port **310** has a generally circular configuration and a diameter of sufficient dimension to allow fluid therein to pass therethrough, as hereinafter described. While central loading port **310** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0104] Channel network **26*c*** further includes a plurality of channels **314** extending through cartridge **12** between upper and lower surfaces **14** and **16**, respectively, thereof. Each channel **314** is identical in structure and as such, the following description is understood to describe each channel **314**. Channel **314** may extend along a longitudinal axis, have angled portions, be serpentine or be a combination thereof. In the embodiment depicted in FIG. **35**, the plurality of channels **314** are circumferentially spaced about and extending radially outward from central loading port **310**. More specifically, each channel **314** extends along a longitudinal axis and is defined by first and second spaced sidewalls **316** and **318**, respectively, interconnecting bottom wall **320** and upper wall **322**. Each channel **314** further includes first end **324** in communication with central loading port **310** and an opposite second end **326**.

[0105] Loading wells **328** are formed in upper surface **14** at a location aligned with a corresponding one of the plurality of channels **314** between first and second ends **324** and **326**, respectively. Each loading well **328** is identical in structure, and as such, the following description is understood to describe each loading well **328**. Loading well **328** is defined by an inner surface **330** having an upper edge **332** intersecting upper surface **14** and a lower edge **334**, and a lower surface **336** extending radially inward from lower edge **334**. While each loading well **328** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention.

[0106] Loading ports **338** extend between lower surfaces **336** partially defining loading wells **328** and upper walls **322** partially defining corresponding channels **314** such that each loading well **328** communicates with a corresponding one of the plurality of channels **314** at a location between first and second ends **324** and **326**, respectively, thereof. Loading ports **338** have a generally circular configurations and diameters of a dimension sufficient to pin fluids received in corresponding loading wells **338** and retain the fluids therein, while allowing the fluids received in corresponding channels **314** to flow into loading ports **338**, as hereinafter described. While loading ports **338** are depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0107] Air outlet wells **348** are formed in upper surface **14** at locations adjacent to and overlapping second ends **326** of corresponding channels **314**. Each air outlet well **348** is identical in structure, and as such, the following description is understood to describe each air outlet well **348**. Each air outlet well **348** is defined by inner surface **350** having an upper edge **352** intersecting upper surface **14**, a lower edge **354**, and a lower surface **356** extending radially inward from lower edge **354**. While each air outlet well **348** has a generally rectangular cross-section, other configurations are possible without deviating from scope of the present invention.

[0108] Air outlets **360** extends between lower surfaces **356** partially defining air outlet wells **348** and upper walls **322** partially defining channels **314** such that each air outlet wells **348** communicates with corresponding channels **314** at locations adjacent second end **326** of corresponding channels **314**. Each air outlet **360** has a generally circular configuration and a diameter of a dimension sufficient to pin fluid in corresponding channel **314** and prevent the fluid from passing into corresponding air outlet well **348**. While each air outlet **348** is depicted as having a generally circular configuration, it can be understood that other configurations are possible without deviating from scope of the present invention.

[0109] In order to prevent cross-contamination and potential backflow between channel **100**, and to generate simultaneous fluid flow through channels **314**, it is contemplated for: 1) the lengths of each channel **314** between central loading port **310** and loading port **338** to be generally equal; and 2) the lengths of each channel **314** between loading port **338** and air outlet **360** to be generally equal. Further, it is contemplated for the configurations to be designed and arranged so to optimize the number of channel networks **26*b*** in the array of channel networks **26** within cartridge **12**. As such, channels **314** may have different configurations (e.g. extend along a longitudinal axis, be nonlinear, be serpentine or be a combination thereof) without deviating from the scope of the present invention.

[0110] In operation, one or more fluids, e.g. reagent buffers **370**, are loaded into loading wells **328**, FIG. **38**. The diameters of loading port **328** are sufficient to pin reagent buffers **370** in corresponding loading wells **328** and retain reagent buffers **370** therein. Thereafter, a fluid, e.g. analyte solution **372**, is loaded into central well **300**. Central loading port **310** is of sufficient dimension to allow analyte solution **372** to flow into channels **314**, FIG. **39**. Capillary action causes analyte solution **92** to flow simultaneously through channels **314** toward air outlet **360**, thereby urging air out of channels **314** through air outlets **360**. As noted above, air outlets **360** have a diameter of a dimension sufficient to pin analyte solution **372** in channels **314** and prevent analyte solution **372** from passing into air outlet wells **348** through corresponding air outlets **360**. With analyte solution **372** pinned at air outlets **360**, analyte solution **372** flowing through channels **314** is directed into loading wells **328** through corresponding loading ports **338**, wherein analyte solution **372** and reagent buffers therein mix via diffusion, FIG. **40**. The mixture, designated by the reference numeral **374**, may be removed for additional analysis, if so desired.

[0111] Referring to FIGS. **41-44**, microfluidic device **10** may include frame **400** having an outer periphery **401** corresponding in size and shape to the outer periphery of a conventional **384** well plate. Frame **400** includes first and second spaced, generally parallel, side members **402** and **404**, respectively, interconnected by first and second spaced, generally parallel, end members **406** and **408**, respectively. Outer periphery **401** and inner edge **410** of frame **400** interconnect first and second sides **412** and **414**, respectively, of frame **400**. Frame **400** further includes a first set of connection pins **416** and a second set of connection pins **418**. Each connection pin **420** of the first set of connection pins **416** projects from first side **412** of frame **400** along first side member **402**. Connection pins **420** of the first set of connection pins **416** are axially spaced form each other and lie along a first axis. Similarly, each connection pin **422** of the second set of connection pins **418** projects from first side **412** of frame **400** along second side member **404**. Connection pins **422** of the second set of connection pins **418** are axially spaced form each other and lie along a second axis, generally parallel to the first axis.

[0112] It is intended for each connection pin **420** of the first set of connection pins **416** to be transversely aligned with a corresponding connection pin **422** of the second set of connection pins **418**.

[0113] An alternate configuration of cartridge **12** is designed by the reference numeral **12***a*. It is contemplated for cartridge **12***a* to include one or more of channel networks **26**, **26***a*, **26***b* and **26***c*, heretofore described. Cartridge **12***a* is defined by a generally flat, upper surface **424** interconnected to a generally flat, lower surface **426** by first and second ends **428** and **430**, respectively, and first and second end members **406** and **408**, respectively. First and second sides **432** and **434**, respectively, of cartridge **12** have lengths generally equal to the lengths of first and second sides **412** and **414**, respectively, of frame **400** along inner edge **410** thereof. First and second C-shaped connectors **436** and **438**, respectively, project from corresponding first and second ends **428** and **430**, respectively, of cartridge **12***a*. First C-shaped connector **436** is adapted to form mating relationships with a corresponding connection pin **420** of the first set of connection pins **416** projects from first side **412** of frame **400** and second C-shaped connector **438** is adapted to form mating relationships with a corresponding connection pin **422** of the second set of connection pins **418** projecting from second side **412** of frame **400**, so as to allow cartridge **12***a* to be selectively connected and disconnected to frame **400**, FIG. **41**. In such manner, cartridges **12***a* having different channel networks **26**, **26***a*, **26***b* and **26***c* therein may be connected and disconnected to frame **400**, thereby allowing a user to customize microfluidic device **10** as needed.

[0114] Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter, which is regarded as the invention.

We claim:

1. A microfluidic device for profiling biochemical samples, comprising:
- a cartridge defining a channel network, the channel network including:
  - a channel having first and second opposite ends;
  - a first well adjacent the first end of the channel, the first well adapted for receiving a first fluid therein;
  - a first loading port extending between the first well and the channel, the first loading port having a sufficient dimension to allow the first fluid to flow into the channel;
  - a second well disposed between the first and second ends of the channel, the second well adapted for receiving a second fluid therein;
  - a second loading port extending between the second well and the channel, the second loading port having a dimension to pin the second fluid in the second well; and
  - an air outlet adjacent to the second end of the channel, the air outlet allowing an interior of the channel to communicate with an environment external of the cartridge;

wherein:
- capillary action causes the first fluid received in the first well to flow into the channel through the first loading port and toward the air outlet; and
- at least a portion of the first fluid flowing through the channel flows into the second well through the second loading port.

2. The microfluidic device of claim **1** wherein the channel is a first channel, the air outlet is a first air outlet, and the channel network includes:
- a second channel having first and second opposite ends;
- a third well adjacent the first end of the second channel, the third well adapted for receiving a third fluid therein;
- a third port extending between the third well and the second channel, the third loading port having a sufficient dimension to allow the third fluid to flow into the second channel;
- a fourth loading port extending between the second well and the second channel; and
- a second air outlet adjacent to the second end of the second channel, the second air outlet allowing an interior of the second channel to communicate with an environment external of the cartridge;

wherein:
- capillary action causes the third fluid received in the third well to flow into the second channel through the third loading port and toward the second air outlet; and
- at least a portion of the third fluid flowing through the second channel flows into the second well through the fourth loading port.

3. The microfluidic device of claim **1** wherein the channel network is a first channel network and wherein the cartridge further includes a second channel network, the second channel network defined by:

a channel having first and second opposite ends;

a first well adjacent the first end of the channel of the second channel network, the first well of the second channel network adapted for receiving a third fluid therein;

a first loading port extending between the first well of the second channel network and the channel of the second channel network, the first loading port of the second channel network having a sufficient dimension to allow the third fluid to flow into the channel of the second channel network;

a second well disposed between the first and second ends of the channel of the second channel network, the second well of the second channel network adapted for receiving a fourth fluid therein; and

a second loading port extending between the second well of the second channel network and the channel of the second channel network, the second loading port of the second channel network having a dimension to pin the fourth fluid in the second well of the second channel network.

4. The microfluidic device of claim **3** wherein the second channel network is further defined by:

an air outlet adjacent to the second end of the second channel network, the air outlet of the second channel network allowing an interior of the channel of the second channel network to communicate with an environment external of the cartridge;

wherein:

capillary action causes the third fluid received in the first well of the second channel network to flow into the channel of the second channel network through the first loading port of the second channel network and toward the air outlet of the second channel network; and

at least a portion of the third fluid flowing through the channel of the second channel network flows into the second well of the second channel network through the second loading port of the second channel network.

5. The microfluidic device of claim **3** wherein the channel of the second channel network communicates with the air outlet adjacent to the second end of the channel of the second channel network, the air outlet allowing an interior of the channel of the second channel network to communicate with an environment external of the cartridge;

wherein:

capillary action causes the third fluid received in the first well of the second channel network to flow into the channel of the second channel network through the first loading port of the second channel network and toward the air outlet; and

at least a portion of the third fluid flowing through the channel of the second channel network flows into the second well of the second channel network through the second loading port of the second channel network.

6. The microfluidic device of claim **1** wherein the channel is first channel, the channel network further includes:

a second channel having first and second opposite ends;

a third well disposed between the first and second ends of the second channel, the third well adapted for receiving a third fluid therein; and

a third loading port extending between the third well and the second channel, the third loading port having a dimension to pin the third fluid in the third well; and

wherein:

the first loading port communicates with the second channel adjacent the first end of the second channel.

7. The microfluidic device of claim **6** wherein the air outlet communicates with the second end of the second channel.

8. The microfluidic device of claim **6** wherein the air outlet is a first air outlet and wherein:

the channel network further includes a second air outlet adjacent to the second end of the second channel, the second air outlet allowing an interior of the second channel to communicate with an environment external of the cartridge; and

capillary action causes the first fluid received in the second channel to flow into the second channel through the first loading port and toward the second air outlet.

9. The microfluidic device of claim **6** wherein a length of the first channel between the first loading port and the second loading port is generally equal to a length of the second channel between the first loading port and the third loading port.

10. The microfluidic device of claim **1** further comprising a frame having first and second sides and first and second ends and wherein the cartridge includes:

first and second ends;

a first connector connected to the cartridge adjacent the first end of the cartridge, the first connector removably connectable to the first side of the frame; and

a second connector connected to the cartridge adjacent the second end of the cartridge, the second connector removably connectable to the second side of the frame.

11. A microfluidic device for profiling biochemical samples, comprising:

a cartridge defining a channel network, the channel network including:

a channel having first and second opposite ends;

a first well communicating with the first end of the channel, the first well adapted for receiving a first fluid therein;

a second well in communication with the channel through a loading port at a location between the first and second ends of the channel, the second well adapted for receiving a second fluid therein; and

an air outlet in communication with the channel at a location adjacent to the second end of the channel, the air outlet allowing an interior of the channel to communicate with an environment external of the cartridge;

wherein:

capillary action causes the first fluid received in the first well to flow into the channel toward the air outlet;

the second loading port having a dimension to pin the second fluid in the second well; and

at least a portion of the first fluid flowing through the channel flows into the second well.

12. The microfluidic device of claim **11** wherein the channel is a first channel, the loading port is a first loading port, and the air outlet is a first air outlet, and the channel network includes:

a second channel having first and second opposite ends;

a third well communicating the first end of the second channel, the third well adapted for receiving a third fluid therein;

a second loading port extending between the second well and the second channel; and a second air outlet adjacent to the second end of the second channel, the second air outlet allowing an interior of the second channel to communicate with an environment external of the cartridge;

wherein:

capillary action causes the third fluid received in the third well to flow into the second channel toward the air outlet; and

at least a portion of the third fluid flowing through the second channel flows into the second well through the second loading port.

13. The microfluidic device of claim **11** wherein the channel network is a first channel network and wherein the cartridge further includes a second channel network, the second channel network defined by:

a channel having first and second opposite ends;

a first well communicating with the channel of the second channel network at a location adjacent the first end of the channel of the second channel network, the first well of the second channel network adapted for receiving a third fluid therein; and

a second well communicating with the channel of the second channel network through a loading port at a location between the first and second ends of the channel of the second channel network, the second well of the second channel network adapted for receiving a fourth fluid therein;

wherein the loading port of the second channel network has a dimension to pin the fourth fluid in the second well of the second channel network.

14. The microfluidic device of claim **13** wherein the second channel network further includes:

an air outlet in communication with the channel of the second channel network at a location adjacent to the second end of the second channel network, the air outlet of the second channel network allowing an interior of the channel of the second channel network to communicate with an environment external of the cartridge;

wherein:

capillary action causes the third fluid received in the first well of the second channel network to flow into the channel of the second channel network toward the air outlet of the second channel network; and

at least a portion of the third fluid flowing through the channel of the second channel network flows into the second well of the second channel network through the loading port of the second channel network.

15. The microfluidic device of claim **13** wherein the channel of the second channel network communicates with the air outlet at a location adjacent to the second end of the channel of the second channel network, the air outlet allowing an interior of the channel of the second channel network to communicate with an environment external of the cartridge;

wherein:

capillary action causes the third fluid received in the first well of the second channel network to flow into the channel of the second channel network toward the air outlet; and

at least a portion of the third fluid flowing through the channel of the second channel network flows into the second well of the second channel network through the loading port of the second channel network.

16. The microfluidic device of claim **11** wherein the channel is first channel and the loading port is a first loading port, the channel network further includes:

a second channel having first and second opposite ends;

a third well in communication with the second channel through a second loading port at a location between the first and second ends of the second channel, the third well adapted for receiving a third fluid therein; and

wherein:

the first well in communication with the second channel at a location adjacent the first end of the second channel.

17. The microfluidic device of claim **16** wherein the air outlet is in communication with the second end of the second channel.

18. The microfluidic device of claim **16** wherein the air outlet is a first air outlet and wherein:

the channel network further includes a second air outlet in communication with the second channel at a location adjacent to the second end of the second channel, the second air outlet allowing an interior of the second channel to communicate with an environment external of the cartridge; and

capillary action causes the first fluid received in the second channel to flow into the second channel toward the second air outlet.

19. A microfluidic device for profiling biochemical samples, comprising:

a cartridge defining a channel network, the channel network including:

a channel having first and second opposite ends;

a first loading port in communication with the channel, the first loading port configured to allow introduction of a first fluid into the channel;

a well in communication with the channel through a second loading port and located between the first loading port and the second end of the channel, the second well adapted for receiving a second fluid therein; and

an air outlet in communication with channel at a location adjacent to the second end of the channel, the air outlet allowing an interior of the channel to communicate with an environment external of the cartridge;

wherein:

the second loading port has a dimension to pin the second fluid in the second well;

the first fluid received in the first well flows into the channel toward the air outlet; and

at least a portion of the first fluid flowing through the channel flows into the second well through the second loading port.

20. The microfluidic device of claim **19** wherein the channel network is a first channel network and wherein the cartridge further includes a second channel network, the second channel network defined by:

a channel having first and second opposite ends;

a first loading port in communication with the channel of the second channel network, the first loading port of the second channel network configured to allow introduction of a third fluid into the channel of the second channel network; and

a well in communication with the channel of the second channel network through a second loading port and located between the first loading port of the second channel network and the second end of the channel of the second channel network, the well of the second channel network adapted for receiving a fourth fluid therein;

wherein the second loading port of the second channel network has a dimension to pin the fourth fluid in the second well of the second channel network.

21. The microfluidic device of claim **20** wherein the second channel network further includes an air outlet in communication with the channel of the second channel network at a location adjacent to the second end of the second channel network, the air outlet of the second channel network allowing an interior of the channel of the second channel network to communicate with an environment external of the cartridge.

22. The microfluidic device of claim **20** wherein the channel of the second channel network communicates with the air outlet at a location adjacent to the second end of the channel of the second channel network, the air outlet allowing an interior of the channel of the second channel network to communicate with an environment external of the cartridge.

23. The microfluidic device of claim **19** wherein the channel is first channel, the channel network further includes:

a second channel having first and second opposite ends, the second channel in communication with the first loading port;

a second well in communication with the second channel through a third loading port at a location between the first loading port and the second end of the second channel, the second well adapted for receiving a third fluid therein.

24. The microfluidic device of claim **23** wherein the air outlet is in communication with the communication with the second channel at a location adjacent the second end of the second channel.

25. The microfluidic device of claim **23** wherein the air outlet is a first air outlet and wherein:

the channel network further includes a second air outlet in communication with the second channel at a location adjacent to the second end of the second channel, the second air outlet allowing an interior of the second channel to communicate with an environment external of the cartridge.

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