US 20160274316A1

(19) **United States**
(12) **Patent Application Publication**
VERDIELL
(10) **Pub. No.: US 2016/0274316 A1**
(43) **Pub. Date: Sep. 22, 2016**

(54) **ACTIVE-OPTICAL IC-PACKAGE SOCKET**

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(21) Appl. No.: **15/071,640**

(22) Filed: **Mar. 16, 2016**

Related U.S. Application Data

(60) Provisional application No. 62/134,500, filed on Mar. 17, 2015.

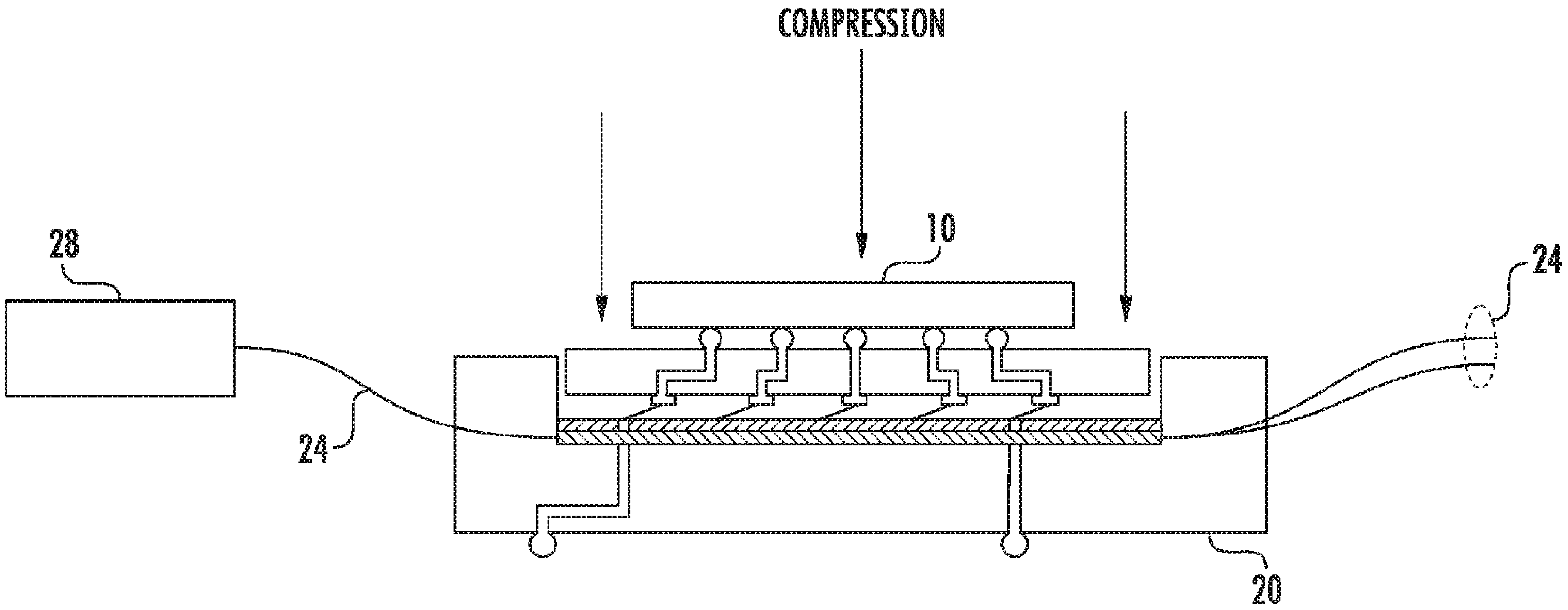
Publication Classification

(51) **Int. Cl.**
G02B 6/42 (2006.01)
G02B 6/12 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 6/428*** (2013.01); ***G02B 6/4284*** (2013.01); ***G02B 6/12004*** (2013.01); ***G02B 6/4245*** (2013.01); *G02B 2006/12142* (2013.01); *G02B 2006/12121* (2013.01); *G02B 2006/12123* (2013.01)

(57) **ABSTRACT**

A socket for an IC package includes a base with which the IC package is capable of being mated and unmated and an optical element integrated with the base. When the IC package is mated with the base, based on electrical signals received from the IC package, the optical element generates light signals or modifies light signals; and/or based on detected light signals, the socket generates electrical signals that are transmitted to the IC package.



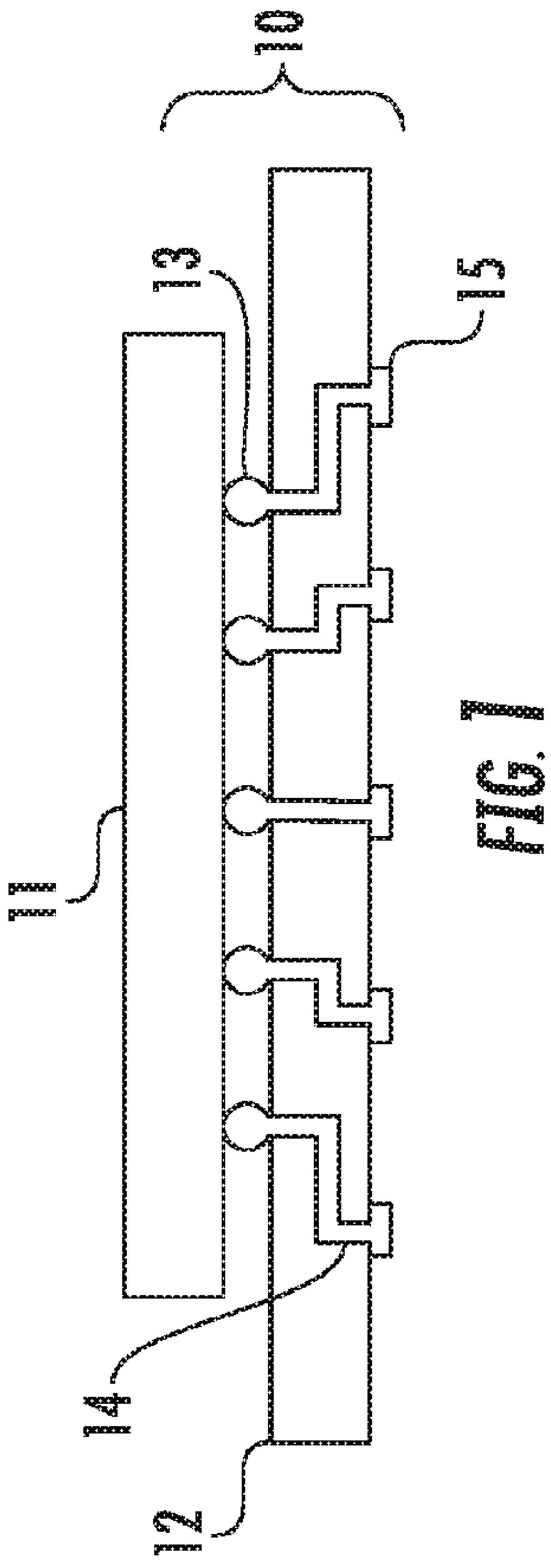


FIG. 1

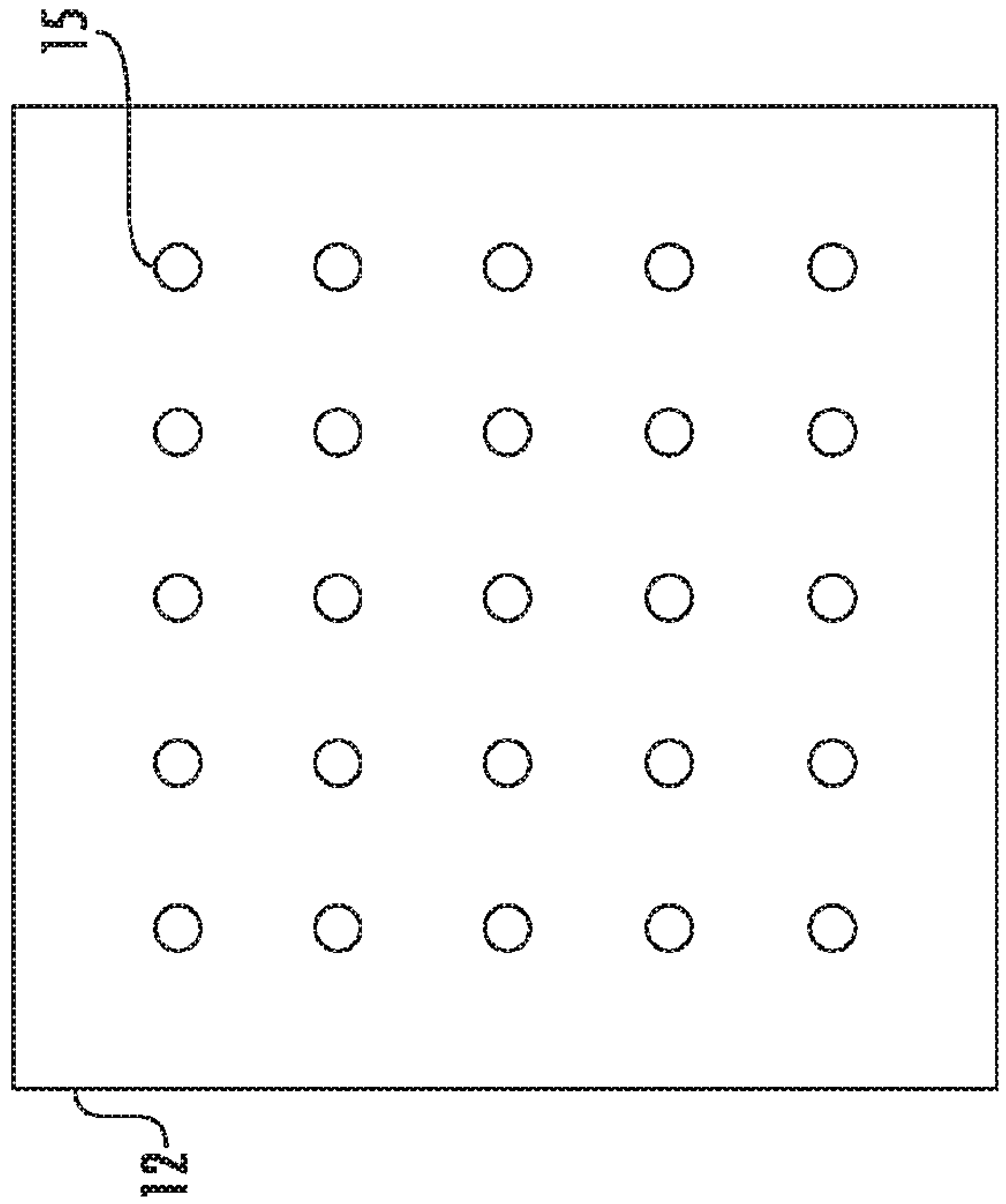


FIG. 2

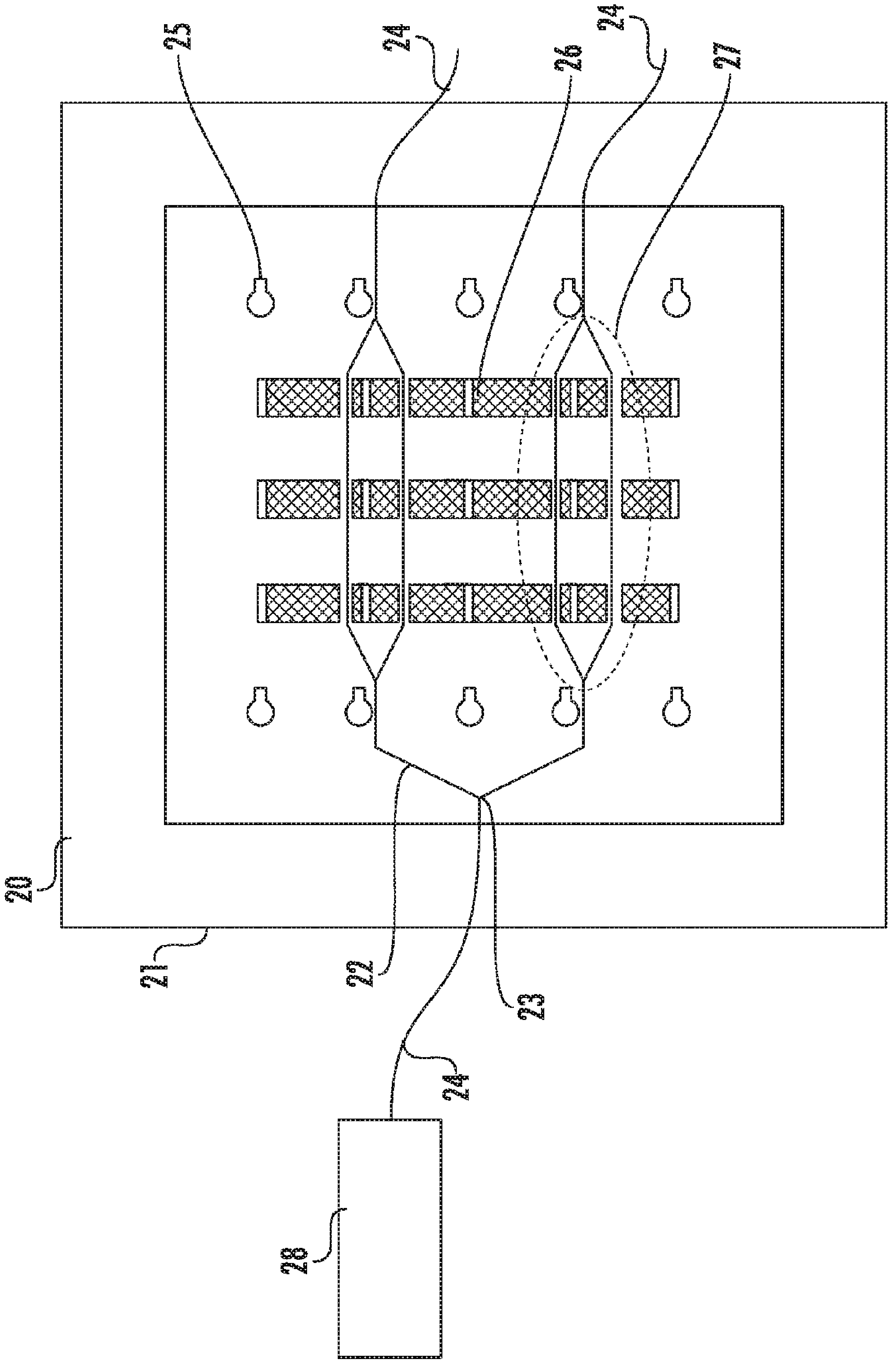


FIG. 3

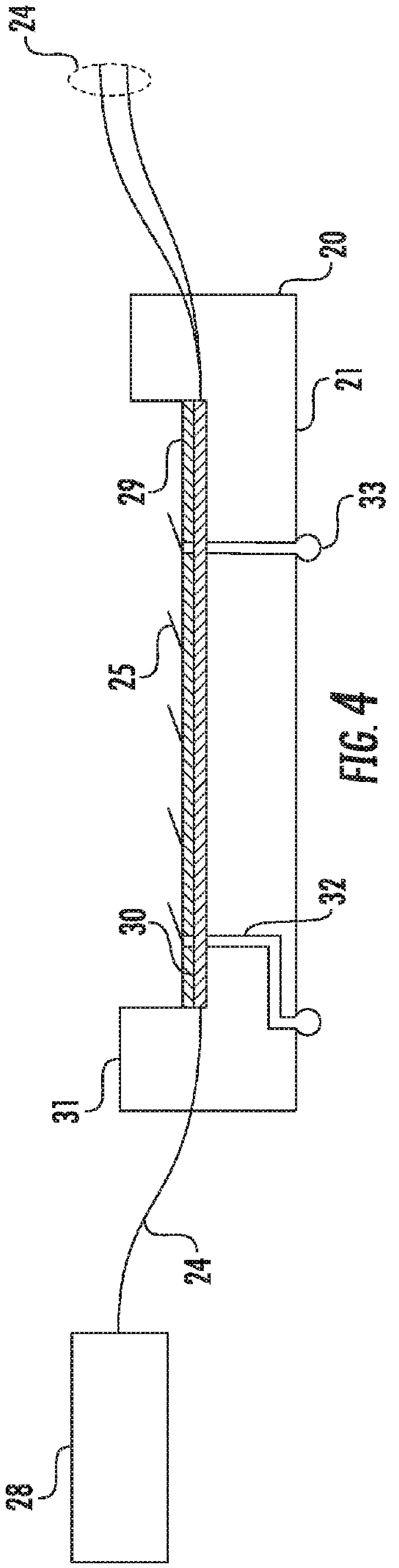


FIG. 4

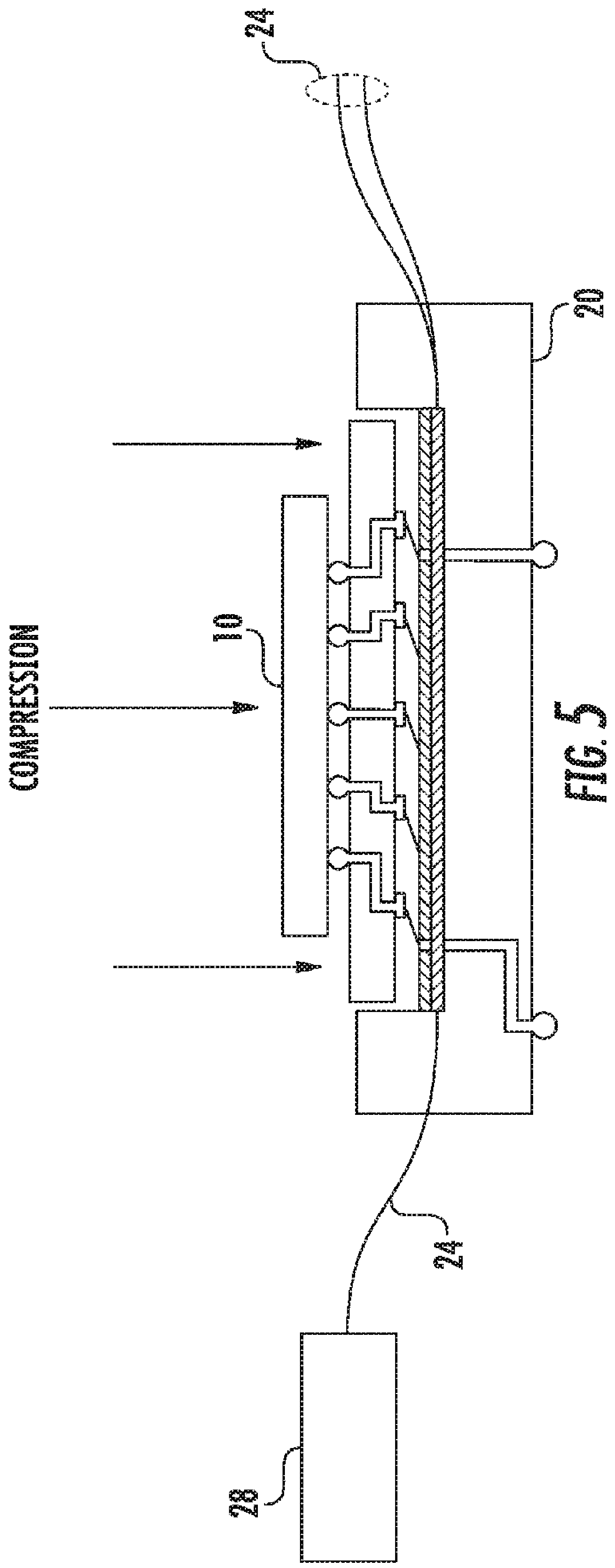


FIG. 5

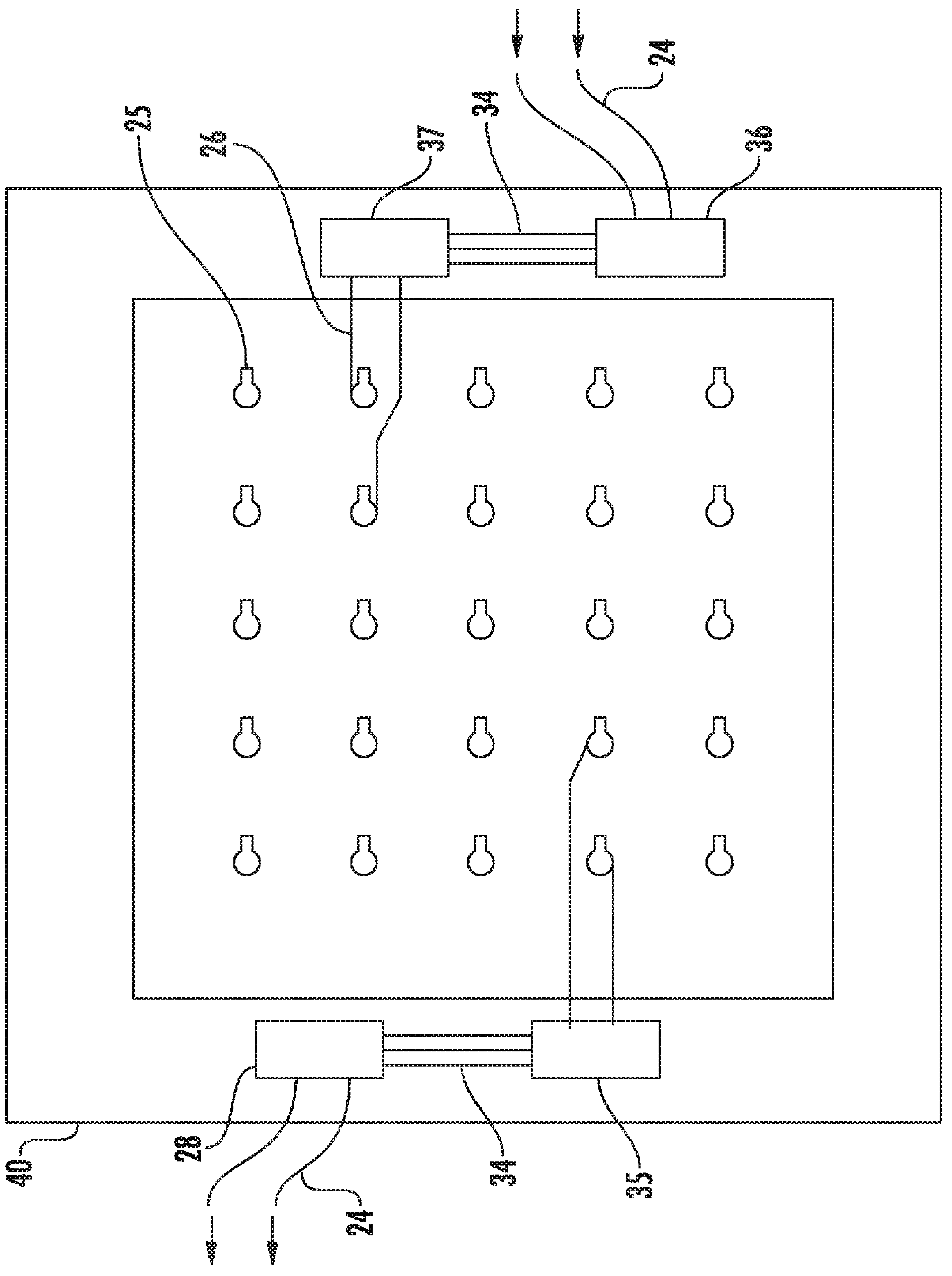


FIG. 6

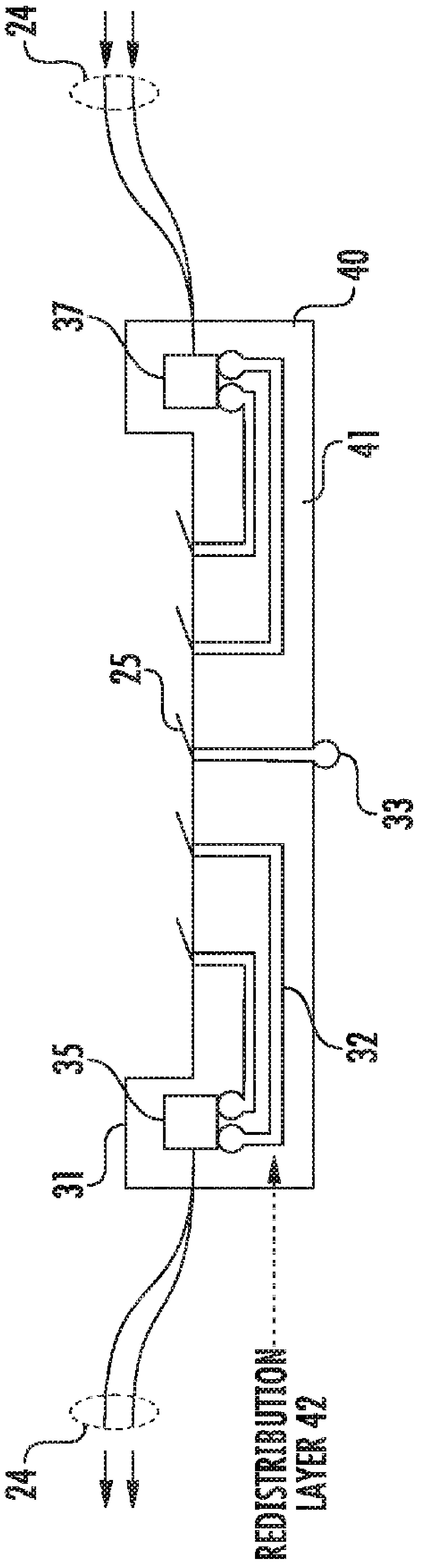

24
37
40
41
25
33
35
31
32
24
REDISTRIBUTION LAYER 42

FIG. 7

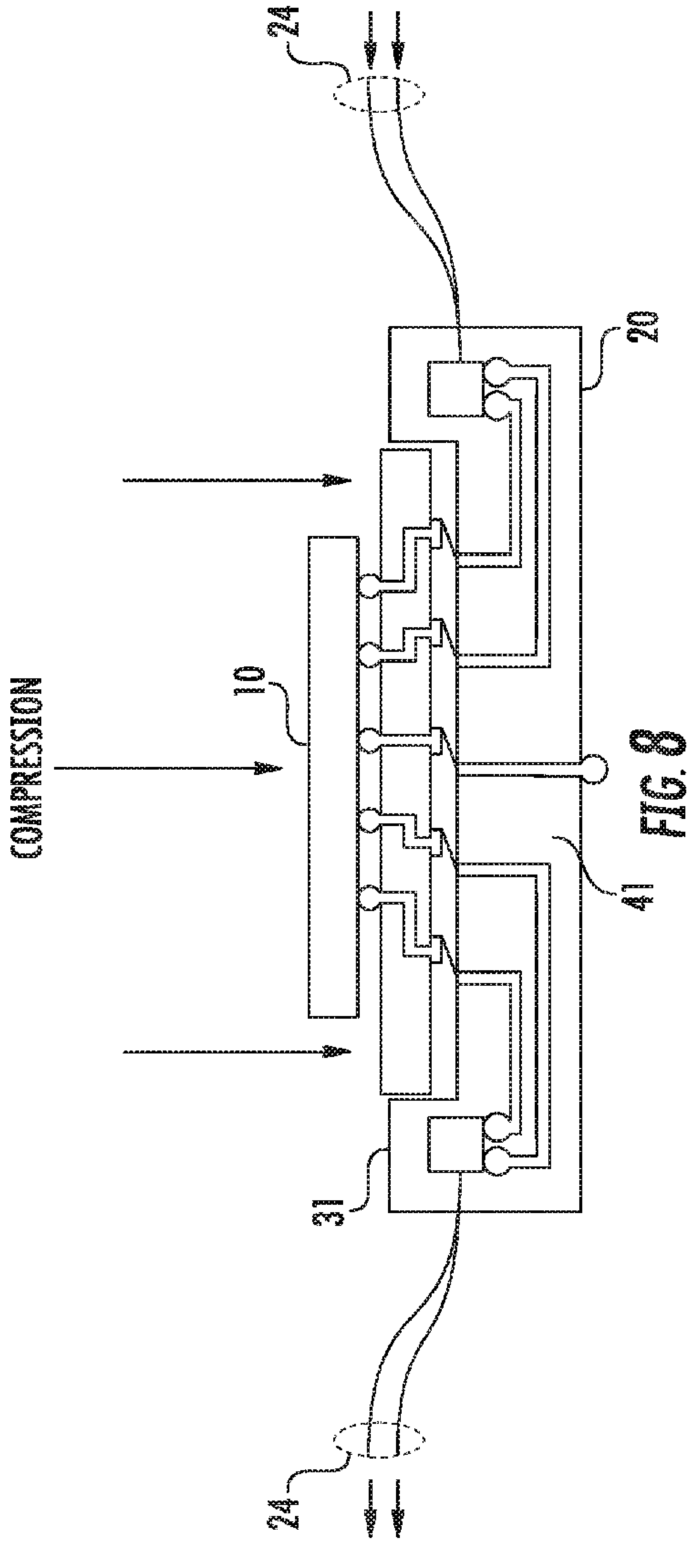

24
20
COMPRESSION
10
41
31
24

FIG. 8

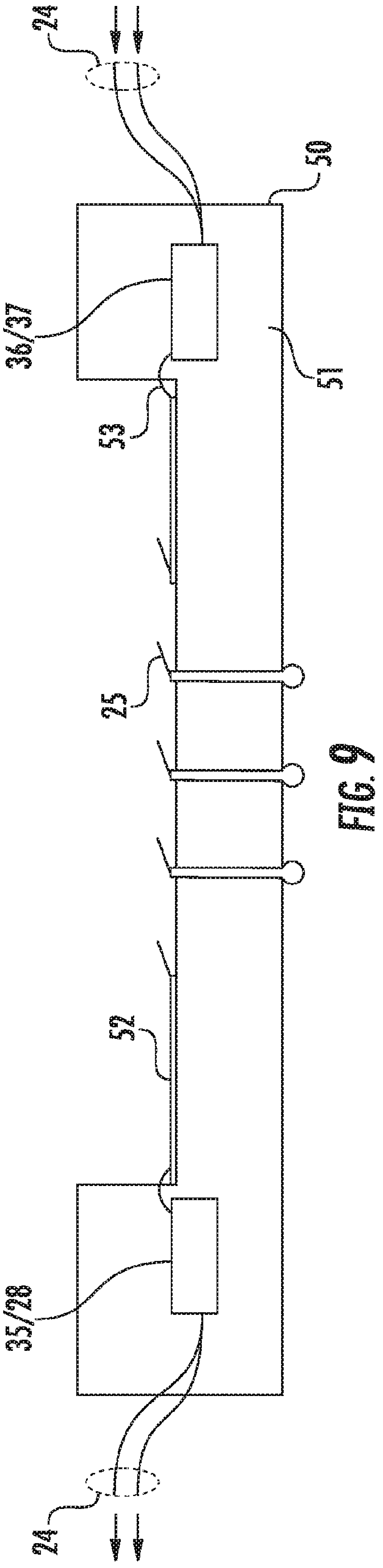
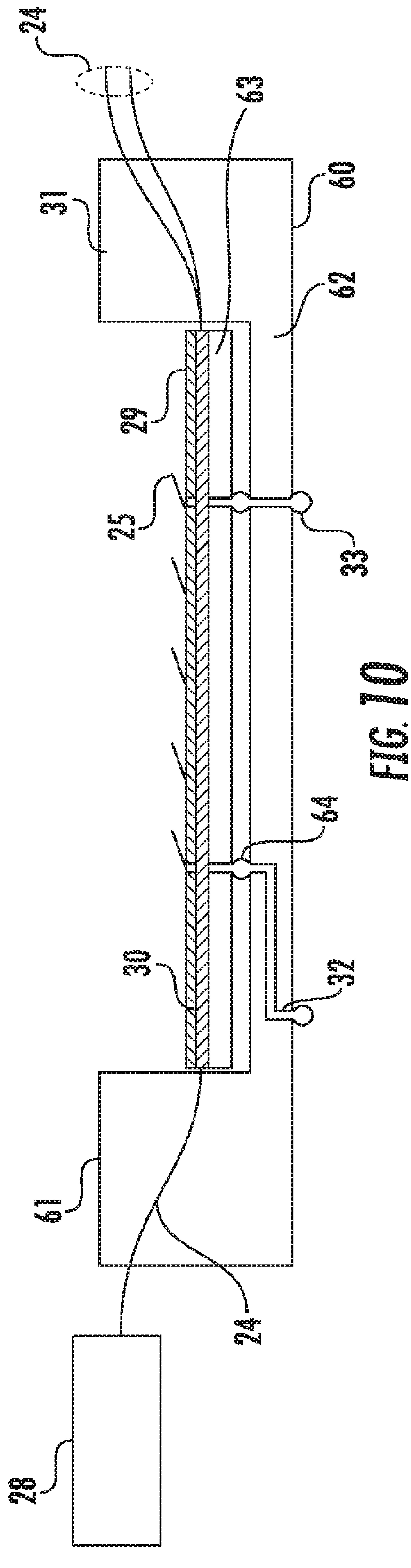

24
50
36/37
51
53
25
52
35/28
24

FIG. 9


24
63
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31
62
29
25
33
64
30
32
61
24
28

FIG. 10

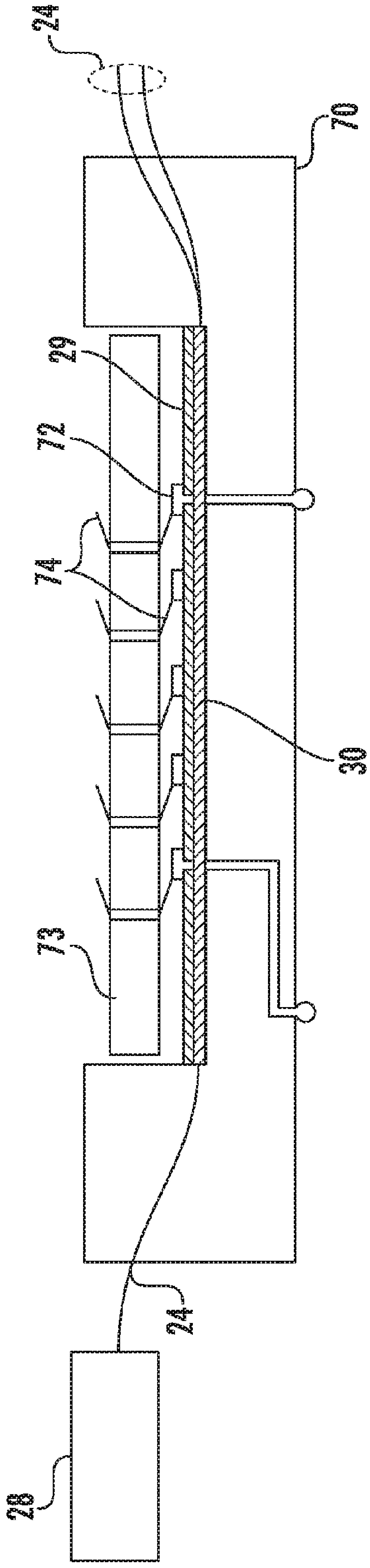

FIG. 11

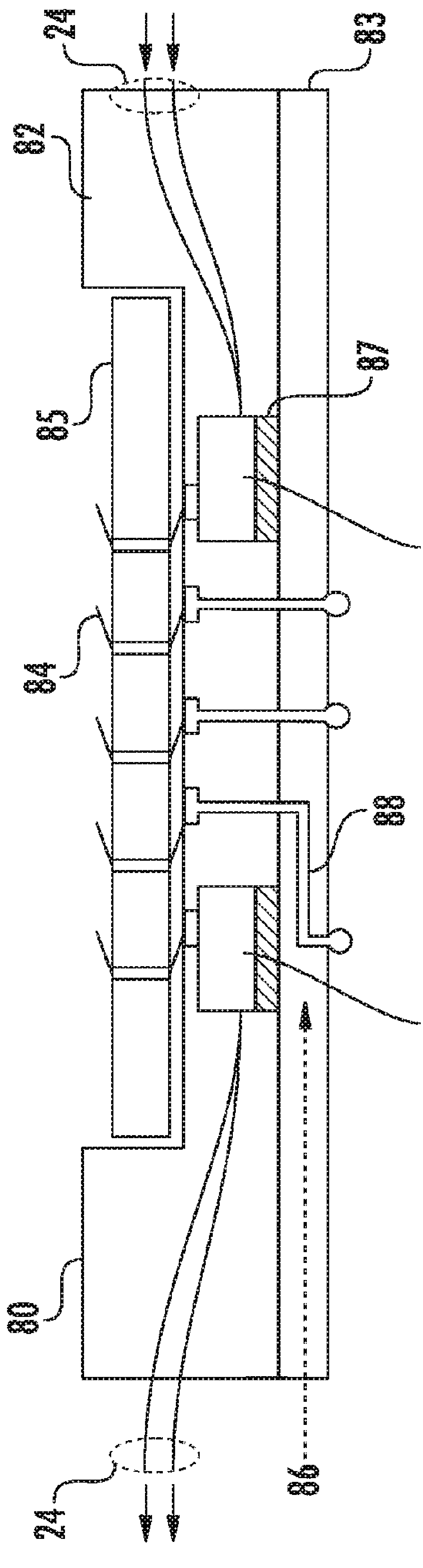

FIG. 12

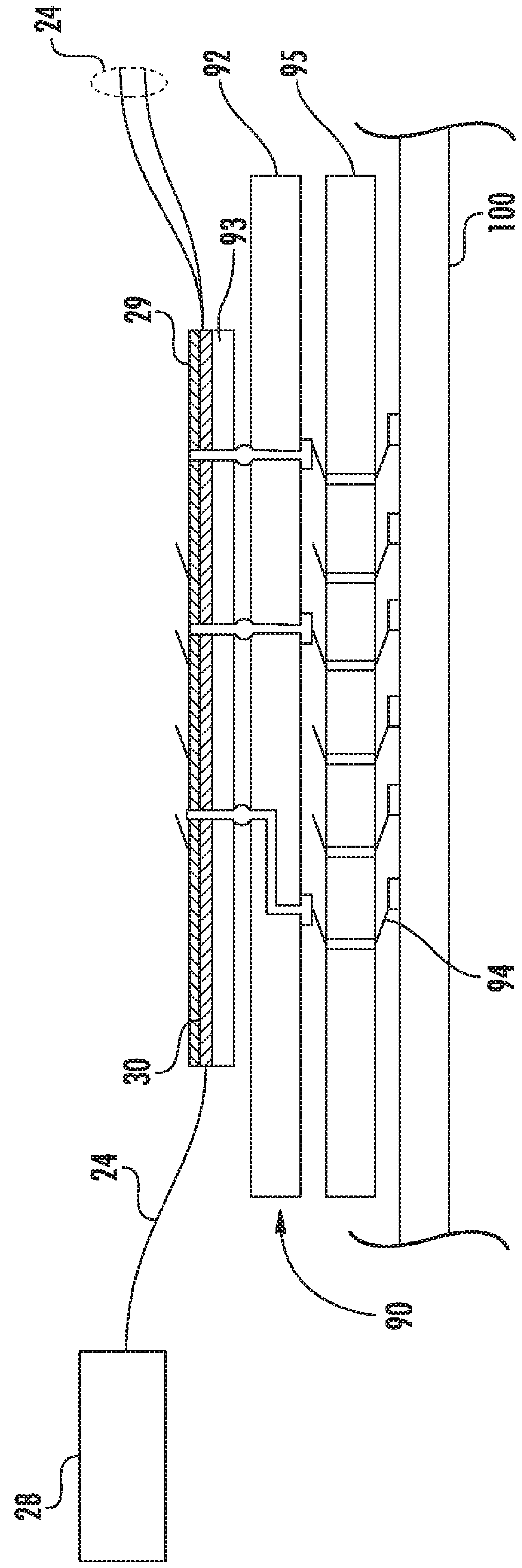

FIG. 13

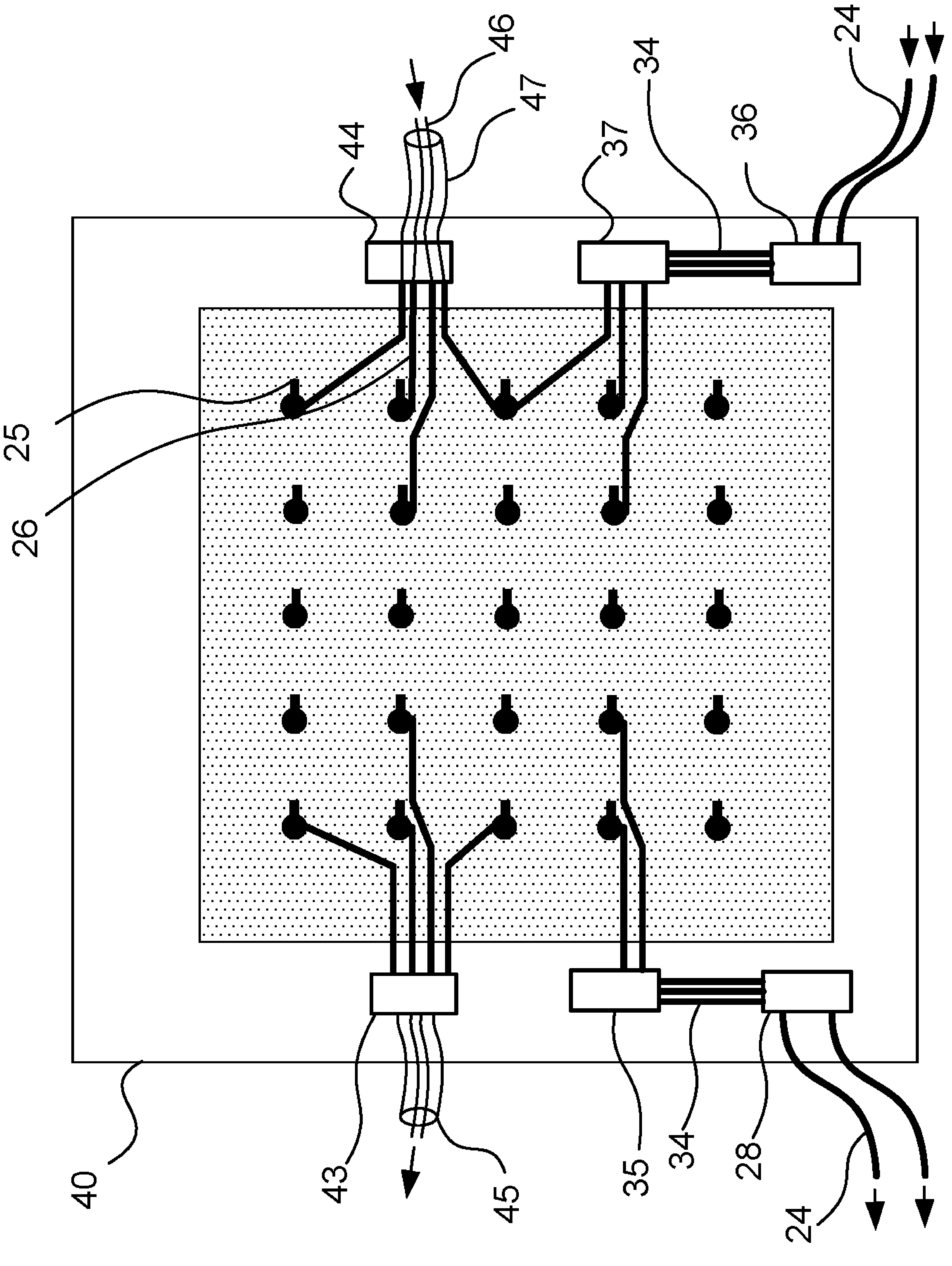

FIG. 14

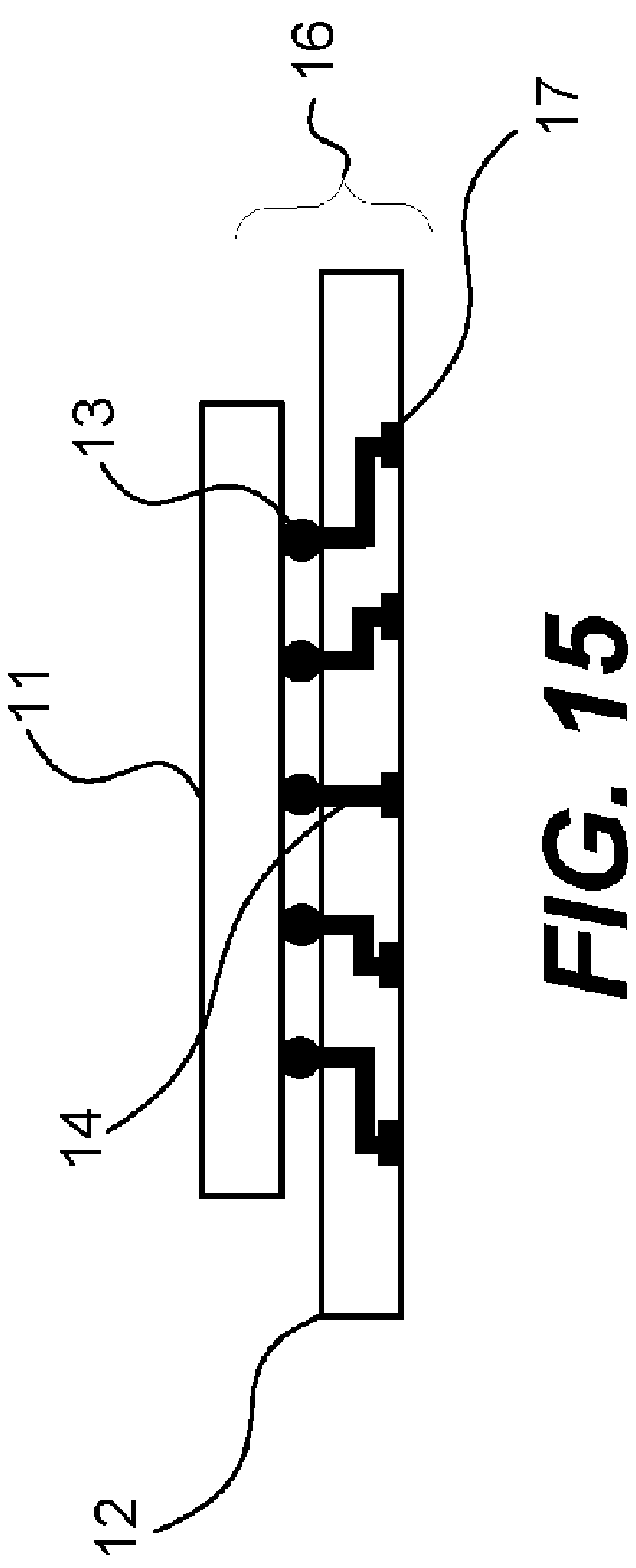

FIG. 15

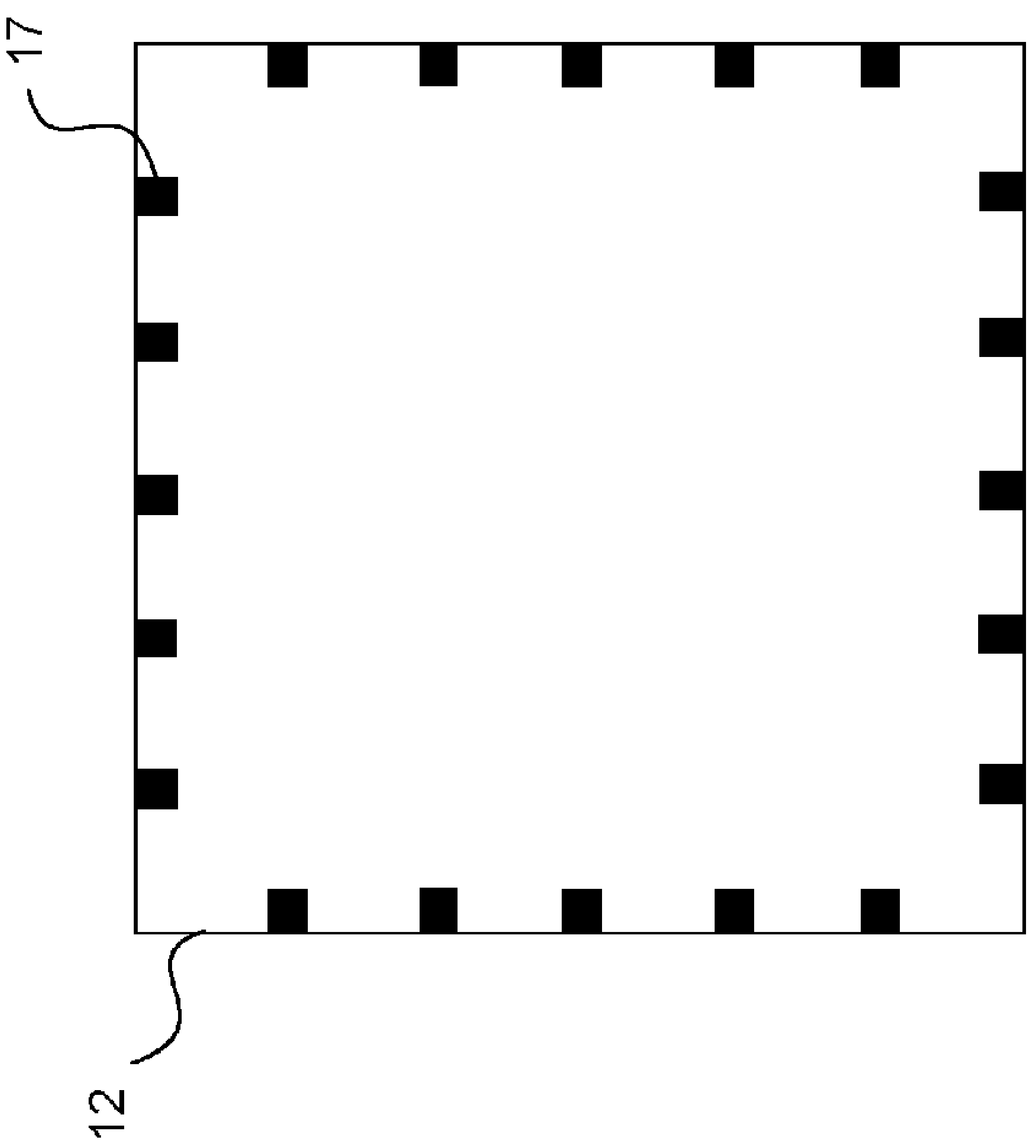

FIG. 16

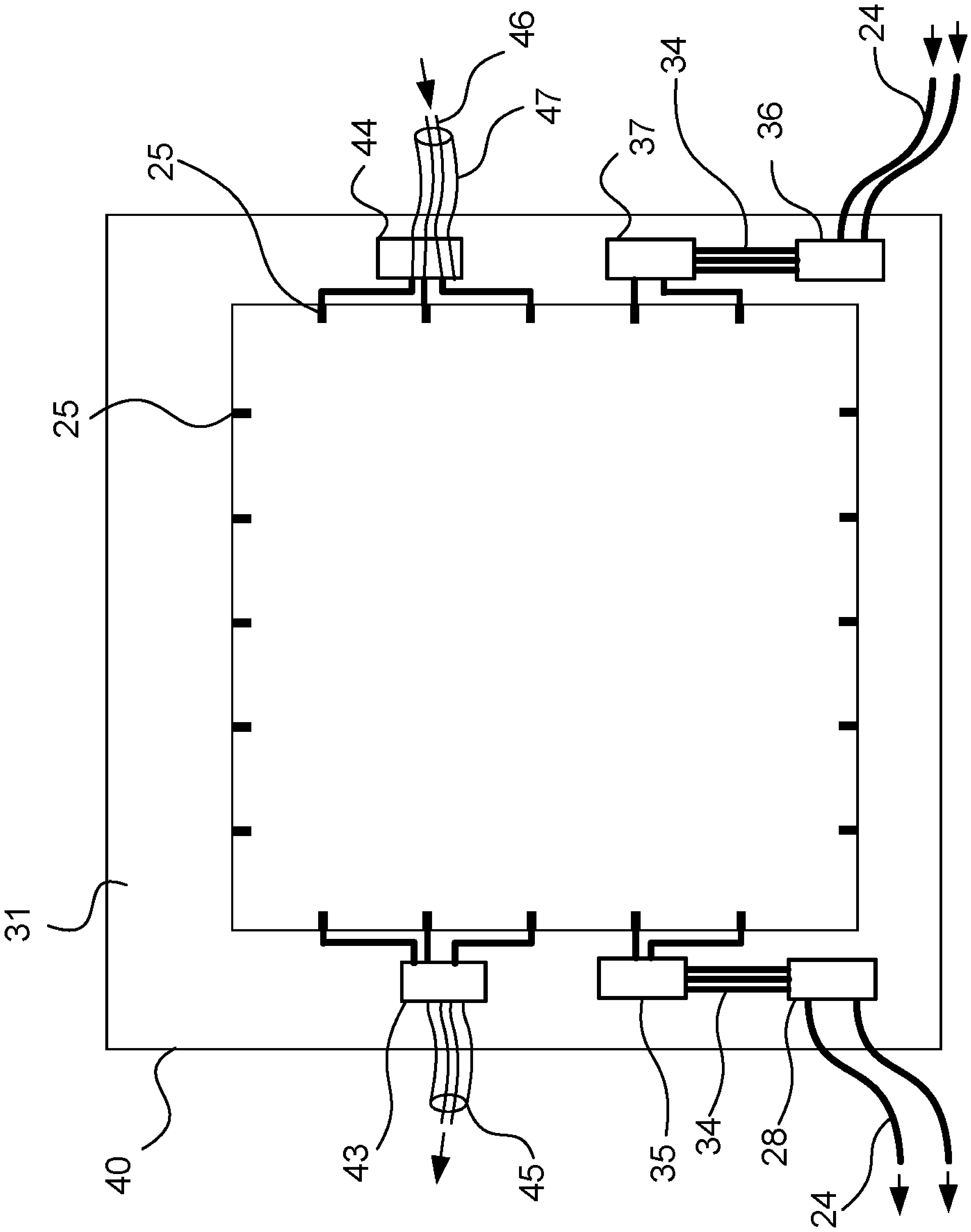

FIG. 17

ACTIVE-OPTICAL IC-PACKAGE SOCKET

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to integrated circuit (IC) package sockets. More specifically, the present invention relates to active-optical IC-package sockets.

[0003] 2. Description of the Related Art

[0004] IC dies are being made to have more digital input/output (I/O) ports and to operate at higher data rates. The increase in data rates motivates the use of optical fibers to transmit signals between different elements of an electronic system. IC dies can manipulate electronic signals, but not optical signals. Thus, there is a need to package the IC die so that signal integrity of the electronic signals is maintained between the IC die and the optical elements, including electrical-to-optical (E/O) conversion elements and optical-to-electrical conversion (O/E) elements. Generally, the shorter the electrical path between the IC die and the optical elements, the better. Electrical paths should be shielded and impedance-matched as much as possible to maintain signal integrity and to minimize crosstalk. There is a need for an IC package socket that achieves high-data transmission rates in a robust, cost-effective manner.

[0005] IC package sockets are known to mount an IC package on a printed circuit board (PCB). Signals from the IC package are then routed through the PCB. Optical elements can be mounted on the PCB near the IC package. However, the electrical path between the IC package and the optical elements is relatively long and has multiple discontinuities in the electrical path due to solder joints, electrical connections, etc. It is also known to mount the IC package adjacent to an optical transceiver. The IC package is permanently mounted, typically with a solder-reflow process. But this requires that the optical transceiver be capable of withstanding solder reflow temperatures, and eliminates the possibility of reworking the IC package if the IC package fails and eliminates the possibility of upgrading the IC package. Testing of the electronic system can be problematic because the integrated system cannot be tested until everything is soldered together. Testing requires specialized optical test equipment.

SUMMARY OF THE INVENTION

[0006] To overcome the problems described above, preferred embodiments of the present invention provide sockets capable of mating and unmating with an IC package, including a short electrical transmission path between the IC die and optical elements, and integrated optical elements. The sockets of the preferred embodiments of the present invention are configured to be tested independently of the IC package; configured to be tested with the IC package mounted in the socket and reworked easily if needed; provide high-bandwidth performance with good signal integrity; and transform any IC package into an optically enabled device.

[0007] According to a preferred embodiment of the present invention, a socket for an IC package includes a base with which the IC package is capable of being mated and unmated and an optical element integrated with the base. When the IC package is mated with the base, based on electrical signals received from the IC package, the optical element generates light signals or modifies light signals; and/or based on detected light signals, the socket generates electrical signals that are transmitted to the IC package.

[0008] The base preferably includes a photonic layer with an optical modulator. Preferably, light is supplied to the socket from an external laser source, or the socket further includes a laser source integrated into the socket. The socket further preferably includes a driver integrated into the socket that drives an electrical transmission cable.

[0009] The base preferably includes compliant electrical contacts that mate and unmate with the IC package. The compliant electrical contacts preferably mate and unmate with sides of the IC package.

[0010] The socket further preferably includes an interposer that includes compliant beams and that is located underneath the base. Preferably, the optical element is located underneath the IC package or adjacent to the IC package. The optical element preferably includes at least one of a photodetector and a laser. Preferably, the base is an overmolded base, and the optical element is integrated into the overmolded base.

[0011] The socket further preferably includes optical fibers connected to the socket. The socket further preferably includes an electrical transmission cable connected to the socket. The electrical transmission cable is preferably a twinax cable.

[0012] According to a preferred embodiment of the present invention, a socket system includes a printed circuit board, the socket according to various preferred embodiments of the present invention connected to the printed circuit board, and an IC package mated with the socket.

[0013] The socket system further preferably includes optical fibers connected to the socket. The socket system further preferably includes an electrical transmission cable connected to the socket. The electrical transmission cable is preferably a twinax cable. The electrical transmission cable preferably flies over the printed circuit board. Preferably, the IC package includes an IC die mounted on a substrate, and the substrate includes pads on a surface opposite to the IC die. Preferably, a compressive force maintains electrical contact between the IC package and the socket.

[0014] According to a preferred embodiment of the present invention, a socket for an IC package includes a base that the IC package is capable of being connected to. The base includes an optical element, conductive contacts on an upper surface of the base, a trace connecting the optical element and the conductive contacts, vias extending from an upper surface of the base to a lower surface of the base, and an aligner that aligns the IC package with the base when the IC package is connected to the base.

[0015] The above and other features, elements, characteristics, steps, and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIGS. **1** and **2** show an IC package that can be used with the various preferred embodiments of the present invention.

[0017] FIGS. **3** and **4** show a socket according to a first preferred embodiment of the present invention.

[0018] FIG. **5** shows an IC package inserted into the socket of FIGS. **3** and **4**.

[0019] FIGS. **6** and **7** show a socket according to a second preferred embodiment of the present invention.

[0020] FIG. **8** shows an IC package inserted into the socket of FIGS. **6** and **7**.

[0021] FIG. **9** shows a socket according to a third preferred embodiment of the present invention.

[0022] FIG. **10** shows a socket according to a fourth preferred embodiment of the present invention.

[0023] FIG. **11** shows a socket according to fifth preferred embodiment of the present invention.

[0024] FIG. **12** shows a socket according to sixth preferred embodiment of the present invention.

[0025] FIG. **13** shows a socket according to a seventh preferred embodiment of the present invention.

[0026] FIG. **14** shows a first modification of the socket according to the second preferred embodiment of the present invention.

[0027] FIGS. **15** and **16** show an IC package that can be used with a second modification of the second preferred embodiment of the present invention.

[0028] FIG. **17** shows a second modification of the socket according to the second preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0029] FIGS. **1** and **2** show an IC package **10** that can be used with the preferred embodiments of the present invention. The IC package **10** includes an IC die **11** mounted to a substrate **12** by a ball grid array (BGA) **13**. The substrate **12** includes vias **14** that connect the BGA **13** to pads **15**. The IC die **11** can be any suitable IC with high-speed I/O data transfer, including, for example, field-programmable gate array (FPGA), microcontroller, microprocessor, application-specific integrated circuit (ASIC), switch, etc. Substrate **12** can be made of any suitable material, including, for example, ceramic, silicon, polymer, etc. The vias **14** are metalized through holes to transmit electrical signals between opposing sides of the substrate **12**. The vias **14** can be straight (see the middle via **14** in FIG. **1**) or can be non-straight (see the outside vias **14** in FIG. **1**). Non-straight vias **14** include vertical vias that are connected by horizontal traces. Non-straight vias **14** allow for signal fan-out from the IC die **11** so that the signal density at the BGA **13** is higher than the signal density at the pads **15**. The vias **14** do not have to connect the opposing sides of the substrate **12** and can redistribute the signals on the top and sides of the substrate **12**.

[0030] The IC die **11** is typically soldered to the substrate **12** by the BGA **13**. Although a 5×5 array is shown in FIG. **2**, any suitable size array could be used. The array can be greater than 30×30, for example. The bottom surface of the substrate **12** preferably includes pads **15** arranged in a land grid array (LGA). Other types of pads or contacts could also be used, including, for example, a quad flat no-lead (QFN) contact. The IC package **10** can include pads located on the sides of the substrate **12** similar to the pads **17**, as shown, for example, in FIGS. **15** and **16** that show a second modification of the second preferred embodiment of the present invention, instead of and/or in addition to being located on the bottom of the substrate **12**. Locating the pads **15** on the sides of the substrate **12** allows the IC package to be inserted into a socket without a compressive force, which reduces the number of hardware components needed. But locating the pads **15** of the sides of the substrate **12** can decrease the signal density.

[0031] FIGS. **3** and **4** show a socket **20** according to a first preferred embodiment of the present invention. Socket **20** can be mounted to a host PCB (not shown) or other suitable substrate. As shown in FIG. **5**, socket **20** receives the IC package **10** of FIG. **1**. Socket **20** includes a base **21** and a registration feature **31** that extends upward from the base **21** and that can be used to align the IC package **10** with the socket **20**. The base **21** includes vias **32** and a BGA **33**. Vias **32** can transport signals between the IC package **10** and the host PCB or substrate. As with vias **15** in the IC package **10**, vias **32** of the socket **20** can be straight or non-straight. Non-straight vias **32** include vertical vias that are connected by horizontal traces. Non-straight vias **32** allow for signal fan-out from the IC package **10** so that the signal density at the pads **15** is higher than the signal density at the BGA **33**. The vias **32** do not have to connect the opposing sides of the socket **20** and can redistribute the signals on the top and sides of socket **20**. BGA **33** can be used to mount the socket **20** to the host PCB or substrate. Socket **20** is not limited to using BGA **33** to electrically and mechanically connect the socket **20** to the host PCB or substrate. It is possible to use other structures or arrangements to electrically and mechanically connect the socket **20** to the host PCB or substrate.

[0032] Socket **20** includes both electrical components and optical components. The base **21** can be made of any suitable material or materials, including, for example, one or more of the following injection molded plastic, ceramic, organic materials, silicon, etc. The electrical components can be included in an electronic layer **29**. The electronic layer **29** can be made of any suitable material or materials, including, for example, a semiconductor such as Si or GaAs or an insulator with patterned metallic conductive traces. The optical components can be included in a photonic layer **30**. The photonic layer **30** can be made of any suitable material or materials, including, for example, typical materials used for photonics integration such as silicon, lithium niobate, indium phosphide, gallium arsenide, and hybrid assemblies of these materials. In FIG. **4**, the electronic layer **29** is located above the photonic layer **30**, but this arrangement could be reversed. The electronic layer **29** and the photonic layer **30** can also be located on opposite surfaces of the base **21**. It is possible to combine the electronic layer **29** and the photonic layers **30**, including, for example, in a monolithically integrated silicon photonics device or in a layer in which they are mounted together, either using 3D packaging or using a hybrid method in which they are flip-chip mounted one on top of the other, or in which they are mounted together on an interposer.

[0033] The electrical components in the electronic layer **29** of the socket **20** include compliant contacts **25** and traces **26**. The compliant contacts **25** are arranged in an array that corresponds to the array of pads **15** on the IC package **25** such that the compliant contacts **25** engage with the pads **15** on the IC package **10**, which allows electrical signals to be transported between the IC package **10** and the socket **20**. The optical components in the photonic layer **30** of the socket **20** include waveguide **22**, splitter **23**, and one or more optical elements **27**. The traces **26** connect the compliant contacts **25** and the optical elements **27**. Optical fibers **24** are connected to the waveguide **22**. The optical fibers **24** can be permanently attached to the socket **20** (i.e., pigtailed optical fibers) or can be detachable from the socket **20** (i.e., connecterized optical fibers). As shown in FIG. **3**, the waveguide **22** is connected to a splitter **23**. A laser source **28** supplies light to the optical fiber **24**, which in turn couples the light into waveguide **22**. The waveguide **22** is connected to the splitter **23** that splits the waveguide into two waveguides **22**. If the optical element **27** is an E/O element such as a modulator, e.g. a Mach-Zehnder modulator, then a digital optical signal can be generated. The digital signal may be generated by the IC package **10** and transmitted to the optical element **27** via compliant contacts **25** and traces **26** thus modulating the light from the laser source **28**.

[0034] In addition to the optical elements **27**, the socket **20** can also include other active elements, including, for example, drivers for electrical transmission cables, such as twin axial (twinax) cables as shown, for example, in FIG. **14** that shows a modification of the second preferred embodiment of the present invention. In such a socket **20**, both optical fibers **24** and electrical transmission cables can fly over the host PCB or substrate.

[0035] A channel is defined by a single path along which signals are transported, i.e., transmitted and/or received. FIG. **3** shows two channels: the first channel is defined by the upper waveguide **22**, and the second channel is defined by the lower waveguide **22**. Any number of channels can be used, including one channel and more than two channels. If only one channel is used, then splitter **23** is not needed.

[0036] Although only one laser source **28** is shown in FIGS. **3**-**5**, it is possible to use a different number of laser sources **28**. For example, in a four-channel socket **20**, four laser sources **28** could be used without a splitter **23**, or two laser sources **28** and two splitters **23** could be used. The laser source(s) **28** can be located external to the socket **20** as shown in FIGS. **3**-**5** or can be located within the socket **20**. External laser source(s) **28** can reduce the cost and the complexity of the socket **20**. Internal laser source(s) **28** might eliminate the need for optical fibers **24** if the light from the laser source(s) **28** is supplied directly to the waveguide **22**. If multiple laser sources **28** are used, then the laser sources **28** can have different wavelengths, which allows the optical signals to be multiplexed into and demultiplexed out of a single optical fiber **24**. The photonic layer **30** can provide multiplexing and demultiplexing.

[0037] As shown in FIG. **5**, the IC package **10** is mounted into the socket **20** by a compressive force as shown by the downward arrows in FIG. **5**. The compressive force can be supplied by any suitable mechanism, including, for example, a latch (not shown). The compressive force presses the pads **15** of the IC package **10** against the compliant contacts **25** of the socket **20**, which provides an electrical connection between the IC package **10** and the socket **20**. Only electrical signals are transported between the IC package **10** and the socket **20**. No optical signals are transported. Because only electrical signals are transported, the design of the socket can be simplified. Advantageously, preferred embodiments of the present invention can be used with commonly available IC packages, which have no optical transmission capability incorporated into the package.

[0038] One or more heatsinks (not shown) can be placed in thermal contact with the IC package **10** and/or the laser source(s) **28**. Instead of or in addition to the one or more heatsinks, vias **32** can be arranged to extend through the base **21** to provide a heat conduction path from the IC package **10** to the host PCB.

[0039] FIGS. **6** and **7** show a socket **40** according to a second preferred embodiment of the present invention. The socket **40** in FIGS. **6** and **7** is similar to the socket **20** in FIGS. **3** and **4**, with similar elements being labeled with the same reference numbers. In the socket **40**, the optical elements are located within the base **41** and on the side of the base **41** instead of underneath the IC package **10** as in socket **20**, which can provide better thermal isolation between the IC package and the optical elements. As shown in FIG. **8**, socket **40** receives the IC package **10** of FIG. **1** in a similar manner as socket **20** receives the IC package **10** in FIG. **5**.

[0040] In FIGS. **6**-**8**, socket **40** includes two channels; however, any number of channels can be used. The channels in socket **40** are defined by the optical fibers **24**. A different number of optical fibers **24** can define a different number of channels. Starting on the right-hand side of FIGS. **6**-**8**, for a single channel, an optical fiber **24** provides an optical signal to photodetector **36**. A current-based electrical signal is supplied from the photodetector **36** by a trace **34** to the transimpedance amplifier **37**, which converts the current-based signal into a voltage-based electrical signal. The voltage-based electrical signal is provided to the IC package **10** through a corresponding complaint contact **25**. A corresponding electrical signal is provided by the IC package **10** to the driver **35**. The driver **35** provides a driving electrical signal by a trace **34** to the laser **28**, which provides a corresponding optical signal that is transported through optical fiber **24**. Although the photodetectors **36** and the TIA **37** are shown on one side and the driver **35** and the laser source **28** are shown on the opposite side, it possible that the photodetectors **36**, the TIA **37**, the driver **35**, and the laser source **28** can be on the same side, which can make connecting the optical fibers **24** easier, especially if the optical fibers **24** are provided in a ribbon.

[0041] The socket **40** can include a redistribution layer **42**. The vias **32** in the redistribution layer **42** can be straight or non-straight. Non-straight vias **32** include vertical vias that are connected by horizontal traces in the redistribution layer. Although a single straight via **32** is shown in FIGS. **7** and **8**, the redistribution layer **42** can have more vias **32**. The vias **32** of the redistribution layer **42** do not have to connect the opposing sides of the socket **40** and can redistribute the signals on the top and sides of socket **40** as well as providing signals to the optical elements. The redistribution layer **42** can include traces that transport signals between the IC package **10** and the optical elements. The traces in the redistribution layer **42** can include transmission lines to provide impedance matching, which can improve signal integrity.

[0042] In FIGS. **3**-**5**, the optical elements include a light source and a modulator, while the optical elements include E/O elements and **0**/E elements in FIGS. **6**-**8**. However, the optical elements are not so limited. The optical elements in FIGS. **3**-**5** can include E/O elements and/or O/E elements, and the optical elements in FIGS. **6**-**8** can include a light source and a modulator. In addition, other optical elements could also be used.

[0043] E/O elements include light sources and supporting electronics. Light sources include vertical-cavity, surface-emitting lasers (VCSELs), edge-emitters, and cw lasers (steady-state) with external modulators, etc. The light sources can be integrated into the socket **20**, **40** or can be external to the socket **20**, **40**. The output of a single light source can be split into different channels, with each channel being separately modulated. If multiple light sources are used and if the light sources have different wavelengths, then the optical signals can be multiplexed into and demultiplexed out of a single optical fiber. Any suitable external modulator can be used, including, for example, Mach-Zehnder modulator, electro-absorption modulator, ring resonator, etc. The external modulator can be made in silicon (i.e., silicon photonics). Supporting electronics can include devices such as drivers, encoding IC (i.e. PAM4, NRZ (non-return to zero), etc.), signal conditioning circuitry, or a gearbox. A gearbox is a device that performs a logic function or that maps data between an input and an output, where the input and output data path lane widths and line rates are not evenly divisible. The gearbox does this by performing multiplexing, demultiplexing, and shift operations on the data signals.

[0044] O/E elements include photodetectors and supporting electronics. The photodetectors can be a discrete element or a waveguide. Waveguide photodetector can be made in silicon, i.e., silicon photonics. Supporting electronics include devices such as TIAs, decoding IC, signal conditioning circuitry, or gearbox.

[0045] FIG. **14** shows a first modification to the socket **40** according to the second preferred embodiment of the present invention shown in FIGS. **6-8**. The socket **40** in FIG. **14** is similar to the socket **40** shown in FIGS. **6-8**, but the socket **40** in FIG. **14** includes driver **43** and receptacle **44**. The driver **43** and receptacle **44** can be connected to twinax cables **45**. The twinax cables **45** include two conductors **46** surrounded by an outer shield **47**. Twinax cables **45** transmit differential electrical signals and provide additional receiving/transmitting channels to/from the socket **40**. Sockets with twinax cables **45** provide increased flexibility compared to sockets with only optical transmit and/or receive channels. Twinax cables **45** generally support lower bandwidths and shorter signal path lengths compared to optical fibers **24**, but these more limited capabilities may be appropriate in some applications because using twinax cables **45** is generally less expensive than using optical fibers **24**. Although twinax cables **45** are shown in FIG. **14**, other suitable electrical transmission cables can also be used.

[0046] Driver **43** can transmit electrical signals between the IC package **10** (not shown in FIG. **14**) and the twinax cables **45**, and the receptacle **44** can transmit electrical signals between the twinax cables **45** and the IC package **10**. Receptacle **44** can permanently connect a twinax cable **45** to the socket **40** or can allow mating and unmating of the twinax cable **45**. Preferably, receptacle **44** minimizes the impedance mismatch between the twinax cable **45** and the electrical circuitry of the socket **40**, which helps to maintain signal integrity. Although driver **43** and receptacle **44** are shown on opposite sides of the socket **40** in FIG. **14**, driver **43** and receptacle **44** can be located in other locations, including, for example, on the same side.

[0047] FIG. **17** shows a second modification to the socket **40** according to the second preferred embodiment of the present invention shown in FIGS. **6-8**. FIGS. **15** and **16** show an IC package **16** that can be used with the socket **40** shown in FIG. **17**. Socket **40** shown in FIG. **17** is similar to the socket **40** shown in FIGS. **6-8** and **14**, but the socket **40** shown in FIG. **17** includes compliant contacts **25** arranged only around the inner periphery of the registration feature **31**, in addition to the driver **43** and the receptacle **44** of the first modification of the second preferred embodiment of the present invention. Any number of compliant contacts **25** can be used. Generally, the compliant contacts **25** provide electrical contact between the pads **17** shown in FIGS. **15** and **16** and the socket **40** shown in FIG. **17** when the IC package shown in FIGS. **15** and **16** is mated with the socket **40** shown in FIG. **17**. In addition to the compliant contacts **25** arranged around the inner periphery of the registration feature **32**, it is also possible to arrange compliant contacts **25** in an array in the area inside of the registration feature **31** as shown, for example, in FIGS. **6** and **14**. The socket **40** shown in FIG. **17** includes driver **43** and receptacle **44** connected to twinax cables **45**, but driver **43** and receptacle **44** are not necessary and can be omitted.

[0048] FIG. **9** shows a socket **50** according to a third preferred embodiment of the present invention. The socket **50** shown in FIG. **9** is similar to the socket **40** shown in FIGS. **6-8** in that the optical elements are included in the base **51**. The difference between socket **50** and socket **40** is that socket **50** uses wirebonds **53** and traces **52** to transport signals instead of redistribution layer **42**. Wirebonds **53** can transport high-speed signals as well as control signals and power. The wirebonds used in FIG. **9** reduces the number of components that need to be flip chip mounted.

[0049] FIG. **10** shows a socket **60** according to a fourth preferred embodiment of the present invention. Socket **60** shown in FIG. **10** is similar to socket **20** shown in FIGS. **3-5**. Socket **60** is different in that the base **61** of socket **60** includes a frame **62** and a platform **63** that can be bonded together. The frame **62** and the platform **63** can be bonded together in any suitable manner, including using BGA **64**. The platform **63** includes the electronic layer **29** and the photonic layer **30**. The frame **62** includes the vias **32** and BGA **33**. The frame **62** can also include registration feature **31**. The frame **62** and/or the platform **63** can also be fabricated from multiple components bonded together. Dividing the base **61** into frame **62** and platform **63** can make it easier to fabricate or integrate the optical elements. Base **41** in the second preferred embodiment can also be divided into a frame and a platform.

[0050] FIG. **11** shows a socket **70** according to fifth preferred embodiment of the present invention. Socket **70** shown in FIG. **11** is similar to socket **20** shown in FIGS. **3-5**. Socket **70** is different in that that socket **70** does not use compliant contacts **25**. Instead, socket **70** uses pads **72**. The pads **72** can be arranged in an LGA. Socket **70** includes an interposer **73** with compliant beams **74**. Using pads **72** instead of compliant contacts **25** in the socket **70** and using an interposer **73** with compliant beams **74**, reduces the cost and increases the yield of manufacturing the individual components.

[0051] FIG. **12** shows a socket **80** according to sixth preferred embodiment of the present invention. Socket **80** shown in FIG. **12** is similar to socket **40** shown in FIGS. **6-8**. Socket **80** is different in that optical elements, including, for example, the photodetectors **36**, the TIA **37**, the driver **35**, and the laser source **28**, are bonded to platform **83** with adhesive **87** and then frame **82** is molded over the optical elements. Overmolding the optical elements provides a shorter distance between the IC package **10** (not shown in FIG. **12**) and the optical elements. The platform **83** can include a redistribution layer **86** in which signals are redistributed using traces **88**. Socket **80** can also include an interposer **85** with compliant beams **84** as shown in FIG. **12**, or socket **80** can include compliant contacts **25** in a similar arrangement as shown in FIGS. **6-8**. Overmolding the frame **82** can shrink the footprint of the socket **80**.

[0052] FIG. **13** shows a socket **90** according to a seventh preferred embodiment of the present invention. Socket **90** shown in FIG. **13** is similar to socket **60** shown in FIG. **10** in that socket **90** includes frame **92** and platform **93**. Socket **90** is different in that it includes an interposer **95** with compliant beams **94** that connect the socket **90** to the PCB **100**. Using interposer **95** allows the socket **90** to be replaceable and to be made of a material that does not need to withstand solder-reflow temperatures. Although not shown in FIG. **13**, socket **90** can include a registration feature that aligns the IC package **10** with the socket **90**. An interposer similar to interposer **90**

in between the socket and the host PCB can be used with any of the previous preferred embodiments.

[0053] It should be understood that the foregoing description is only illustrative of the present invention. Various alternatives and modifications can be devised by those skilled in the art without departing from the present invention. Accordingly, the present invention is intended to embrace all such alternatives, modifications, and variances that fall within the scope of the appended claims.

What is claimed is:

1. A socket for an IC package comprising:
a base with which the IC package is capable of being mated and unmated; and
an optical element integrated with the base; wherein
when the IC package is mated with the base:
  based on electrical signals received from the IC package, the optical element generates light signals or modifies light signals; and/or
  based on detected light signals, the socket generates electrical signals that are transmitted to the IC package.

2. The socket of claim **1**, wherein the base includes a photonic layer with an optical modulator.

3. The socket of claim **1**, wherein light is supplied to the socket from an external laser source.

4. The socket of claim **1**, further comprising a laser source integrated into the socket.

5. The socket of claim **1**, further comprising a driver integrated into the socket that drives an electrical transmission cable.

6. The socket of claim **1**, wherein the base includes compliant electrical contacts that mate and unmate with the IC package.

7. The socket of claim **6**, wherein the compliant electrical contacts mate and unmate with sides of the IC package.

8. The socket of claim **1**, further comprising an interposer that includes compliant beams and that is located underneath the base.

9. The socket of claim **1**, wherein the optical element is located underneath the IC package when the IC package is mated with the socket.

10. The socket of claim **1**, wherein the optical element is located adjacent to the IC package.

11. The socket of claim **1**, wherein the optical element includes at least one of a photodetector, a modulator, and a laser.

12. The socket of claim **1**, wherein:
the base is an overmolded base; and
the optical element is integrated into the overmolded base.

13. The socket system of claim **1**, further comprising optical fibers connected to the socket.

14. The socket system of claim **1**, further comprising an electrical transmission cable connected to the socket.

15. The socket system of claim **14**, wherein the electrical transmission cable is a twinax cable.

16. A socket system comprising:
a printed circuit board;
the socket of claim **1** connected to the printed circuit board; and
an IC package mated with the socket.

17. The socket system of claim **15**, further comprising an electrical transmission cable that is connected to the socket and that flies over the printed circuit board.

18. The socket system of claim **13**, wherein:
the IC package includes an IC die mounted on a substrate; and
the substrate includes pads on a surface opposite to the IC die.

19. The socket system of claim **13**, wherein a compressive force maintains electrical contact between the IC package and the socket.

20. A socket for an IC package comprising:
a base that the IC package is capable of being connected to, the base including:
  an optical element;
  conductive contacts on an upper surface of the base;
  a trace connecting the optical element and the conductive contacts;
  vias extending from an upper surface of the base to a lower surface of the base; and
  an aligner that aligns the IC package with the base when the IC package is connected to the base.

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