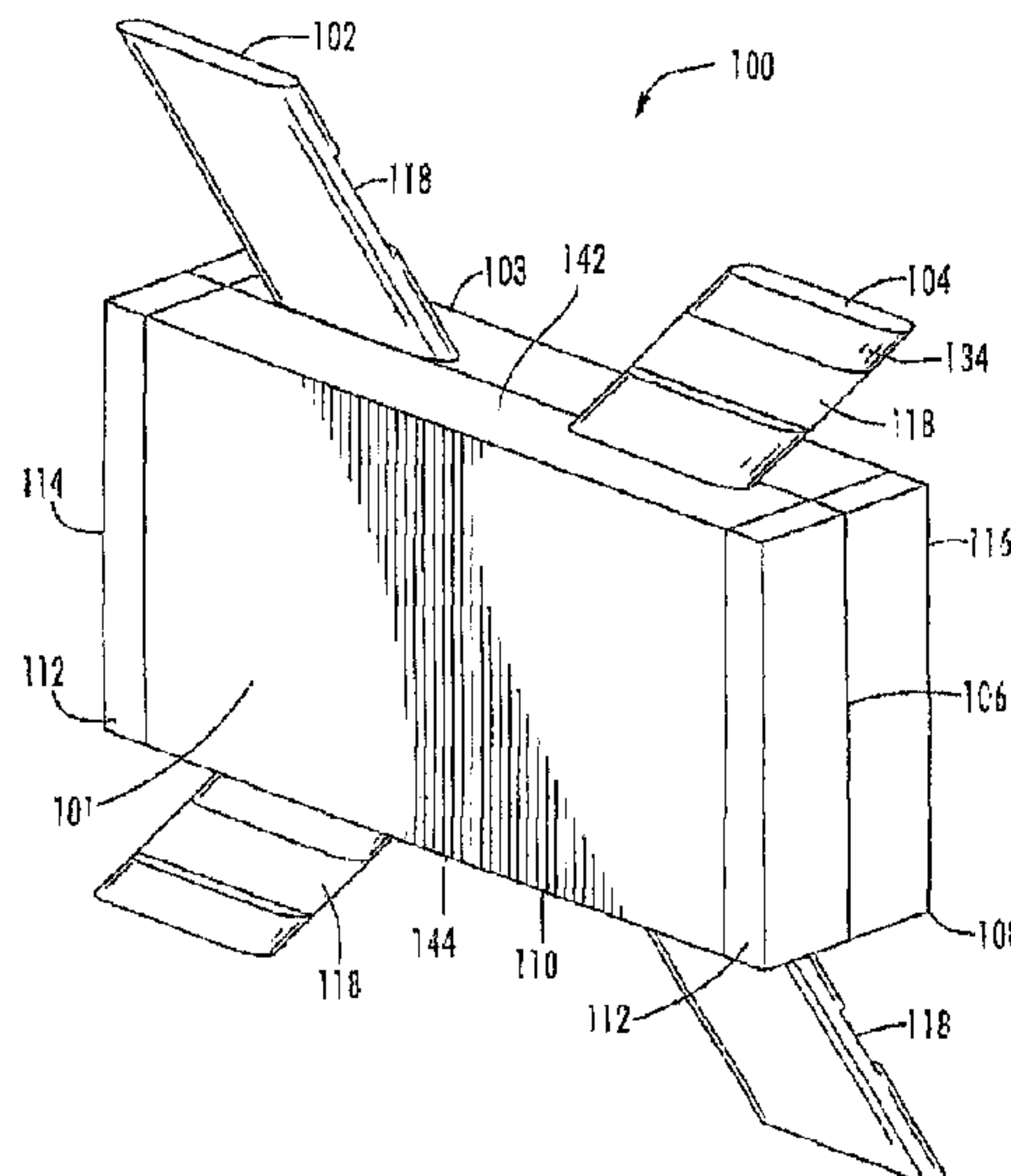




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(57) **Abrégé/Abstract:**

A load transfer device is provided to connect concrete elements including, but not limited to, sandwich and double wall panel wythes, roof, floor, balcony and canopy members, and pavement. The device may be used to connect and transfer loads between the components of sandwich and double wall panels. The device includes two load transfer members positioned at an angle with respect to one another. Additionally provided are a retention housing for retaining one or more load transfer members at their angled positions and a depth locating means for retaining one or more load transfer members at their proper depth. Also provided are sandwich wall panels and double wall panels employing the load transfer device and methods for manufacturing sandwich wall panels and double wall panels employing the disclosed load transfer device.

**ABSTRACT OF THE DISCLOSURE**

A load transfer device is provided to connect concrete elements including, but not limited to, sandwich and double wall panel wythes, roof, floor, balcony and canopy members, and pavement. The device may be used to connect and transfer loads between the components of sandwich and double wall panels. The device includes two load transfer members positioned at an angle with respect to one another. Additionally provided are a retention housing for retaining one or more load transfer members at their angled positions and a depth locating means for retaining one or more load transfer members at their proper depth. Also provided are sandwich wall panels and double wall panels employing the load transfer device and methods for manufacturing sandwich wall panels and double wall panels employing the disclosed load transfer device.

## **LOAD TRANSFER DEVICE**

### **FIELD OF THE INVENTION**

[0001] This application relates generally to connectors and load transfer devices for interconnecting components, such as pavement or the structural components of a building, including the concrete wythes and insulation of a concrete sandwich wall panel or double wall panel, roof and floor members, balconies, canopies, and other insulated connections.

### **BACKGROUND**

[0002] Sandwich wall panels, also called integrally insulated concrete panels, are well known in the construction industry. Most sandwich panels are composed of interior and exterior concrete layers, called wythes, and one or more insulation layers between the two concrete layers. The insulation layer is generally rigid insulation, such as expanded or extruded polystyrene or polyisocyanurate. Also included in the sandwich wall panel are connectors that connect the two concrete wythes through the layer(s) of insulation. The connectors hold the components of the sandwich wall panel together and also provide a mechanism whereby loads can be transferred between the components of the wall and the structure's foundation. Common loads include tension, shear, and moments induced by wind, gravity, and seismic loads, as well as combinations thereof. In composite and partially composite sandwich wall panels, connectors must cause the two concrete wythes to function together as one structure. Depending on the application, load transfer devices may be many different shapes and composed of many different materials. One material in particular, metal, has been used in the past, but metal has undesirable thermal connectivity properties and may suffer corrosion in some situations. These problems can also be present in sandwich panels containing metal trusses or reinforcing. Accordingly, there is a need in the art for a shear connector and load transfer device that reduces the need for metal components to be used as connectors and trusses.

[0003] Alternatively, non-composite insulated concrete sandwich walls allow the components of the sandwich wall to work independently of each other. Generally, there is a structural concrete wythe, an insulation layer, and an architectural, exterior wythe. The independent behavior eliminates problems associated with large temperature differentials

between interior and exterior wythes and the thermal bowing that can be present in some structural composite panels.

[0004] Sandwich wall panels can be manufactured in a variety of ways known in the art. The entire panel may be manufactured in a plant and transported to a job site, a process known as plant precast. The panel may be constructed on the ground at the job-site and then tilted up and into place, a process known as site-cast tilt-up. Sandwich walls may also be vertically cast in place at the job site, commonly known as cast-in-place construction or vertically cast in a precast factory as part of the individual rooms of a building, this method is commonly known as modular precast construction. Accordingly, the panels may be constructed in both a vertical and horizontal manner.

[0005] Also known in the industry are double wall panels, which can provide weight and structural connection improvements over traditional sandwich panels. In addition to interior and exterior concrete wythes and an insulation layer, a double wall panel also includes an air void, also called an air gap. Oftentimes, the air void is filled with concrete and/or additional insulation materials or another material upon delivery to the job site. Because double wall panels are typically lighter than sandwich panels, double wall panels may cost less to manufacture and ship. Because of these advantages, double wall panels may be manufactured to a larger size prior to shipment.

[0006] Sandwich and double wall panels may reduce the energy requirements of buildings and are becoming more popular as energy conservation is a growing concern among building owners and is increasingly present in construction codes. Integration of thicker insulation can provide even higher energy savings. Sustainable building construction is also gaining in popularity. Sandwich panels can provide means for sustainable construction by providing structural composite panels, increasing the thickness of the insulation, and reducing wythe thickness. However, sandwich panels with these features require use of either more or stronger connectors. Accordingly, there is a need in the industry for a connector to provide the strength necessary for these applications.

[0007] Green roofs are known in the industry and are growing in popularity. In this application, the roof slab should be insulated and provide a watertight surface. Oftentimes, these issues are addressed by including a layer of insulation between two concrete layers. Additionally, floor slabs present many of the same issues. The load

transfer devices connecting the components of the roof and floor slabs must transfer the necessary loads and be thermally non-conductive so as to prevent condensation on the roof and floor slabs.

**[0008]** In addition, the double wall panels discussed above require devices such as standoff connectors to define the thickness of the double wall panel and/or support the weight of one of the concrete wythes during the manufacturing process. Accordingly, there is a need in the industry for a shear connector that can provide these functions in addition to connecting the components of the double wall panel and transferring loads between same.

**[0009]** As is known in the art, sandwich wall panels may be constructed either horizontally or vertically. When constructed horizontally, a first concrete layer is poured, and the insulation layer is placed on top of the wet concrete layer. The insulation layer is designed to receive the connectors or ties that will be used to interconnect the components, usually having precut or pre-machined holes. Oftentimes, these holes are much larger than the connectors themselves. This decreases the thermal efficiency of the panel and may require application of another insulation, such as foam insulation, to fill the remaining volume of the hole not taken up by the connector. Moreover, connectors of the prior art are designed to be placed between side-by-side sections of insulation, leaving behind gaps in the insulation layer that must be filled with another insulation. Accordingly, there is a need in the industry for a shear connector that will eliminate the need to fill the space remaining in the insulation after insertion of the connectors. Sandwich panels that are constructed vertically are often constructed using a method known as "cast-in-place". In this method, the walls are created at their service location. Vertical forms are erected, and the insulation and connectors are placed into the vertical forms. The vertical forms are open at the top. Both layers of concrete are then poured simultaneously from the top of the forms. Alternatively, the concrete may be pumped into the form from one or more openings near the bottom. Accordingly, the concrete surrounds the insulation as in the horizontal methods of manufacture.

**[0010]** Connectors of the prior art are connected to internal reinforcing, which makes installation difficult. Accordingly, there is a need in the art for a connector that is a load transfer device that does not require connection to reinforcing or use of trusses in the wall

panel and, therefore, provides ease of assembly and installation. In addition, there is a need in the art for a load transfer device that is composed of discrete load transfer members that can be selectively positioned as the application requires. Moreover, there is a need in the art for a load transfer device which provides for simple and cost-effective handling and transport.

[0011] Accordingly, a load transfer device is provided that is also a shear connector which can be used in all methods of manufacturing concrete sandwich and double wall panels, including vertical, horizontal, and modular methods. The shear connector of the present invention provides increased strength and load transfer properties over the prior art. Additionally, the present connector eliminates the need to provide foam or other insulation to fill voids left in the insulation layer after insertion of the connector. The connector is thermally nonconductive. Further, the connector can reduce or eliminate the need to include trusses that span the insulation layer. The connector can provide a standoff or spacing function during the manufacture of double wall panels. Further, the connector holds the concrete wythes of the panel from shifting during handling and transport. The connector provides for simple and cost-effective handling and transport. The load transfer device of the present application provides superior shear transfer capacity and can be placed easily in rigid insulation material.

## **SUMMARY**

[0012] The present invention provides a load transfer device, which is a shear connector for interconnecting components, such as the components of wall panels, including sandwich wall panels and double wall panels, and transferring the loads placed upon the connected components. The device includes at least two load transfer members that, in a sandwich wall panel, each span the insulation layer and extend into the two concrete wythes. In a double wall panel, the load transfer device of the present invention spans the insulation and air void layers, extending into the concrete layers. The two load transfer members are positioned at a selectively adjustable angle with respect to one another and to the normal of the plane at which the components meet. In many embodiments, the load transfer members of the load transfer device cross each other. However, in some applications, the load transfer members may not cross each other.

[0013] The invention also provides a retention housing, which may be manufactured in one or more pieces. Preferably, the retention housing is made of rigid insulation material. The retention housing fills the voids in the insulation layer for inserting the load transfer device and also provides a means, such as a recessed portion cut in the rigid insulation, for retaining the load transfer members at the proper angle. Optionally, a depth locator may be used to provide a means for inserting and retaining the members at the proper depth during the manufacturing or building process. The load transfer members may include means to anchor the connector in the components of the wall panel. For example a groove or a hole, alone or in combination with short members that extend into the concrete, may be used for anchoring purposes.

[0014] Also included in the present invention is a sandwich wall panel employing the load transfer device. The sandwich wall panel of the present invention includes interior and exterior concrete layers, an insulation layer, and at least one load transfer device. The load transfer device is a shear connector and provides for load sharing between the components of the sandwich wall panel. Because the load transfer device is thermally nonconductive, the sandwich wall panel of the present invention provides superior thermal properties. A method for manufacturing the sandwich wall panel is disclosed, which includes cast-in-place, vertical, horizontal, and modular methods. The sandwich panel may or may not include reinforcing or trusses. In the preferred embodiment of the method, the insulation is disposed to receive a rectangular cuboid-shaped retention housing made of insulation. The retention housing is disposed to accept load transfer members of the exact shape and size to be used in the application. Accordingly, the method does not include the need for additional foam or other types of insulation to fill space not taken up by the load transfer device.

[0015] Further disclosed is a double wall panel using the load transfer device. The double wall panel includes interior and exterior concrete wythes, an insulation layer, and an air void. The air void may be filled with another material, such as concrete and/or additional insulation materials, if desired. The double wall panel may or may not include reinforcing or trusses. A method for manufacturing the double wall panel is disclosed, which includes plant precast double wall panels, double wall panels constructed at the job site, and double wall panels manufactured both on and off the job site. In addition to being a shear connector, the load transfer device of the present invention may provide a standoff

function, which means that it can be used to define the thickness of the double wall panel and support part of the double wall panel during the manufacturing process. In the method, first concrete and insulation layers are provided. At least one load transfer device is inserted into the insulation and wet concrete. Another concrete layer is then provided, leaving space for an air void between the insulation layer and second concrete layer. In the preferred embodiment, upon curing, the first concrete and insulation layers and the load transfer device(s) are lifted, rotated 180 degrees, and lowered into a second, wet concrete layer such that the load transfer members of the load transfer device(s) extend into the new concrete layer while leaving the air void. In this method, the load transfer device provides means for supporting the first concrete and insulation layers while they are elevated above the second concrete layer.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0016] FIG. 1 is a perspective view according to one embodiment of a load transfer device of the present invention.

[0017] FIG. 2 is an exploded view of the load transfer device of FIG. 1.

[0018] FIG. 3 is a perspective view of a second embodiment of a load transfer device of the present invention.

[0019] FIG. 4 is a perspective view of a third embodiment of a load transfer device of the present invention.

[0020] FIG. 5 is a perspective view of a fourth embodiment of a load transfer device of the present invention.

[0021] FIG. 6 is a perspective view of the front face of a load transfer member of the load transfer device of FIG. 1.

[0022] FIG. 7 is a perspective view of the back face of a load transfer member of the load transfer device of FIG. 1.

[0023] FIG. 8 is a perspective view of the anchoring groove of the load transfer device of FIG. 1.

[0024] FIG. 9 is a perspective view of an alternate embodiment of an anchoring means of the load transfer device.

[0025] FIG. 10 is a perspective view of a second alternate embodiment of an anchoring means of the load transfer device.



[0026] FIG. 11 is a front elevation view of a retention member of a retention housing of the load transfer device of FIG. 1.

[0027] FIG. 12 is a perspective view of a depth locator of the load transfer device of FIG. 1.

[0028] FIG. 13 is a side elevation view of a section of a sandwich panel according to one embodiment of a sandwich panel of the present invention.

[0029] FIG. 14 is a flow chart describing a method for manufacturing a sandwich panel in accordance with the present invention.

[0030] FIG. 15 is an illustration of a form assembly used in the method for manufacturing a sandwich wall panel or a double wall panel in accordance with the present invention.

[0031] FIG. 16 is an illustration of the form assembly used in the method for manufacturing a sandwich wall panel or a double wall panel further showing reinforcing in accordance with the present invention.

[0032] FIG. 17 is an illustration of the form assembly used in the method for manufacturing a sandwich wall panel or a double wall panel, wherein a first layer of concrete has been placed in the form assembly in accordance with the present invention.

[0033] FIG. 18 is an illustration of the form assembly used in the method for manufacturing a sandwich wall panel or a double wall panel, wherein an insulating panel has been added to the first concrete layer in accordance with the present invention.

[0034] FIG. 19 is an illustration of the load transfer device used in the method for manufacturing a sandwich wall panel or a double wall panel in accordance with the present invention.

[0035] FIG. 20 is an illustration of the method for manufacturing a sandwich wall panel or a double wall panel, wherein retention housings for the the load transfer devices have been inserted into the insulating panel in accordance with the present invention.

[0036] FIG. 21 is an illustration of the method for manufacturing a sandwich wall panel, wherein load transfer members have been inserted into the retention housings in accordance with the present invention.

[0037] FIG. 22 is an illustration of the method for manufacturing a sandwich wall panel wherein a second concrete layer has been poured, completely surrounding the load transfer devices in accordance with the present invention.

[0038] FIG. 23 is a perspective view of a form assembly used in a second method for manufacturing a sandwich wall panel wherein the sandwich wall panel is cast-in-place in accordance with the present invention.

[0039] FIG. 24 is a side elevation view of a section of a double wall panel including the load transfer device in accordance with the present invention.

[0040] FIG. 25 is a flow chart describing a method for manufacturing a double wall panel in accordance with the present invention.

[0041] FIG. 26 is an illustration of a form assembly used in a method for manufacturing a double wall panel, further showing one embodiment of the load transfer device which has been inserted along with standoff devices in accordance with the present invention.

[0042] FIG. 27 is an illustration of the form assembly used in the method for manufacturing a double wall panel, wherein a second concrete layer has been provided, and the first concrete layer, insulation panel, load transfer devices, and standoff devices are rotated 180° and lowered into the second concrete layer in accordance with the present invention.

[0043] FIG. 28 is a front elevation view of a non-composite vertical sandwich panel in accordance with the present invention.

[0044] FIG. 28A is a cross-sectional view of the non-composite vertical sandwich panel of FIG. 28 taken along lines 28A-28A.

[0045] FIG. 29 is a front elevation view of a non-composite horizontal sandwich panel in accordance with the present invention.

[0046] FIG. 30 is a front elevation view of a partial composite vertical sandwich panel in accordance with the present invention.

[0047] FIG. 30A is a cross-sectional view of the partial composite vertical sandwich panel of FIG. 30 taken along lines 30A-30A.

[0048] FIG. 31 is a front elevation view of a partial composite vertical sandwich panel in accordance with the present invention.

[0049] FIG. 31A is a cross-sectional view of the partial composite vertical sandwich panel of FIG. 31 taken along the lines 31A-31A.

## DETAILED DESCRIPTION

[0050] The following is a detailed description of an embodiment of a load transfer device 100, sandwich wall panel 200, methods for manufacturing a sandwich wall panel, double wall panel 300, and a method for manufacturing a double wall panel of the present invention. For ease of discussion and understanding, the following detailed description and illustrations refer to the load transfer device 100 for use with wall panels, namely, concrete sandwich wall panels and double wall panels. It should be appreciated that the load transfer device 100 may be used to interconnect components of other structural building components, such as roof, floor, balcony, and canopy members, and in other concrete applications. For example, the load transfer device 100 may also be used to connect and transfer loads in concrete pavement applications. The load transfer device 100 of the present invention is sometimes illustrated and described in an embodiment where two load transfer members 102, 104 form an "X" shape. However, it should be appreciated that more than two load transfer members may be employed. Furthermore, the load transfer members 102, 104 need not form an "X".

[0051] Referring to FIG. 1, a load transfer device 100 of the present invention is shown. The load transfer device 100 is primarily a shear connector. The load transfer device 100 includes a first load transfer member 102 and a second load transfer member 104. In the preferred embodiment and the illustration shown, the load transfer members 102, 104 are elongated, flat, linear bars, the ends of which are embedded in and connect first and second concrete elements. As can be seen in FIG. 1, the ends extending into the same concrete element are positioned in a spaced relationship with one another. However, one of skill in the art will recognize that the load transfer members 102, 104 may be any elongated shape with any shape cross-section as the application may so require without departing from the scope of the present invention. It is contemplated that the load transfer members 102, 104 will be made of a material of sufficient strength to hold and transfer the required loads. In the preferred embodiment, the load transfer members 102, 104 are made of fiber reinforced polymer material, although one of skill in the art will recognize that the load transfer members 102, 104 may be made from any appropriate material. For best results, a thermally nonconductive material should be used. In applications where concrete components are to be interconnected, the preferred fiber reinforced polymer expands and contracts at the same rate as concrete when exposed to differing thermal

conditions. In the preferred embodiment, the load transfer members **102**, **104** are identical and may be interchanged during assembly of the load transfer device **100**, which provides for cost and time savings in the manufacturing process, and ease of assembly in the construction process. One of skill in the art will recognize that the load transfer members **102**, **104** need not be identical and may differ from each other depending on the application. In its simplest form, the load transfer device **100** includes the load transfer members **102**, **104** as its only components. Optionally, the load transfer members **102**, **104** may each include a collar to appropriately position the load transfer members **102**, **104** in the sandwich panel. However, in the preferred embodiment, the load transfer device **100** includes further components, including a depth locator **120**, which provides means for locating the load transfer members **102**, **104** at the appropriate depth in the concrete elements they are connecting, and a retention housing **106**, which provides means for retaining the load transfer members **102**, **104** at their appropriate angle within the concrete elements. In the embodiment illustrated in FIG. 1, two load transfer members **102**, **104** are shown. As will be discussed below, it is contemplated that more than two load transfer members **102**, **104** may be used. Further, the load transfer members **102**, **104** may not cross at their centers or at all.

[0052] As is shown in FIG. 1, the load transfer device **100** may include a retention housing **106**. In the preferred embodiment for use with wall panels, the retention housing is made of insulating material. The retention housing **106** is preferably made of the same material as the rigid insulation layer of the wall panel, although it may be made of a different insulating material. In the preferred embodiment, the retention housing **106** is made of a first retention member **108** and a second retention member **110**. One skilled in the art will recognize that the retention housing **106** may be made of any number of insulation pieces. The retention housing **106** has a front surface **101**, back surface **103**, left side **114**, right side **116**, top **142**, and bottom **144**. The two retention members **108**, **110** may be held in place by adhesive or other connecting means, including mechanical means. In the preferred embodiment, the retention members **108**, **110** are held together at the left side **114** and right side **116** by a strip of self-adhesive tape **112** that wraps all the way around the perimeter of the left side **114** and right side **116**. When assembled, the load transfer members **102**, **104** extend outward in opposite directions from said retention housing **106**. The load transfer members **102**, **104** may include one or more anchoring

means 118. The anchoring means 118 help anchor the load transfer members 102, 104 in the concrete or other components to be connected. As is shown in FIG. 1, the anchoring means 118 may be a horizontal groove cut in the load transfer members 102, 104, near both the top and bottom ends, such that the grooves will be in communication with the concrete of a sandwich panel. In the preferred embodiment, the anchoring means 118 are located on the exterior surface 134 of the load transfer member 102, 104, although they may be located on the interior surface. As will be discussed in more detail, other anchoring means 118 may also be employed.

[0053] FIG. 2 provides an exploded view of components of the load transfer device 100. Specifically, FIG. 2 shows the first and second retention members 108, 110, the first and second load transfer members 102, 104, and the depth locator 120. The retention members 108, 110 each have a left side 114, right side 116, top 142, and bottom 144, corresponding to the same sides on the assembled retention housing 106 of FIG. 1. Referring again to FIG. 2, the retention members 108, 110 may optionally include a recessed portion 122, 124 to accept the load transfer members 102, 104. Recessed portion 124 is shown in FIG. 2. Recessed portion 122 is blocked from view as it is located directly behind load transfer member 102. The retention members 108, 110 and the recessed portions 122, 124 may be formed by any method, now known in the art or later developed, such as but not limited to pre-machining or molding. Further, the load transfer device 100 may include a depth locator 120. The depth locator 120 is held in place by a channel 126 in the first retention member 108 and a channel 126 in the second retention member 110. The channel 126 can be seen in the first retention member 108 in FIG. 2. The channel 126 in the second retention member 110 is identical to the channel 126 in the first retention member 108, but is not shown in FIG. 2 due to the angle. The depth locator 120 is designed to accept the first and second load transfer members 102, 104 and lock same in place using a pair of slightly flexible tabs 128, 130. The load transfer members 102, 104 each include a first 132 and second indentation 133, which can be seen in FIG. 6. Referring again to FIG. 2, the load transfer members 102, 104 are each inserted from the top 142 of the retention housing 106. The load transfer members are inserted until the tab 128 or 130 snaps into the first indentation 132 and locks into place. When the load transfer members 102, 104 have reached their appropriate depth, the tab 128 or 130 and its corresponding indentation 132 create an audible noise, letting the user know that the load transfer member 102 or 104

has been inserted to the appropriate depth. As one skilled in the art will appreciate, the appropriate depth is important for proper anchorage in the concrete wythes and is determined depending on the application. Accordingly, the position of the indentations 132, 133 will vary with the application.

[0054] The embodiment shown in FIGS. 1 and 2 includes two load transfer members 102, 104 which cross each other at their center. Depending on the application, the load transfer device 100 may include more than two load transfer members 102, 104. In addition, the load transfer members 102, 104 need not cross each other. Because the load transfer members 102, 104 are independent, discrete components, the user may construct the load transfer device 100 of the present invention to provide greater load transfer capacity in necessary areas of the application. Illustrated in FIG. 3 is a load transfer device 100 of the present invention wherein the retention housing 106 is long enough to accommodate three load transfer members 102, 104, and 105. Also shown in FIG. 3, the anchoring means 118 may be positioned to face inward, outward, or a combination of the two. FIG. 4 provides an illustration of an embodiment wherein two load transfer members 102, 104 are provided that do not cross each other. FIG. 5 illustrates an embodiment wherein two retention housings 106, 107 and four load transfer members 102, 104 are used. The second retention housing 107 is located in-line with the first retention housing 106. In the illustrated embodiment, the two retention housings 106, 107 are located parallel to each other. However, the retention housings 106, 107 may be located at angle with respect to each other. As can be seen in the FIG. 5, the load transfer members 102, 104 need not be positioned at the same angle. The retention housings 106, 107 may include any number of load transfer members 102, 104 located at any position. Furthermore, the user need not use two separate retention housings 106, 107 to create the load transfer device illustrated in FIG. 5. Rather, one retention housing 106 that can receive numerous load transfer devices may be used.

[0055] FIGS. 6-7 provide further illustrations of the load transfer members 102, 104. In the preferred embodiment, the load transfer members 102, 104 are identical. Accordingly in FIGS. 6-7, one load transfer member is shown to represent all. However, one skilled in the art will recognize that the load transfer members 102, 104 need not be identical, which may be advantageous depending on the application. FIG. 6 shows the exterior face 134 of a load transfer member 102, 104. In the illustrated embodiment, the exterior face 134 of

the load transfer member includes two anchoring means **118**. As is shown in FIG. 1, the exterior face **134** of the load transfer member **102, 104** faces outward when inserted into the retention housing **106** and depth locator **120**. Referring again to FIG. 6, the load transfer members **102, 104** each include two indentations **132, 133**. The first indentation **132** communicates with and accepts the appropriate tab **128, 130** of the depth locator **120**. The second indentation **133** is provided for versatility, allowing the load transfer member **102, 104** to be used interchangeably. The load transfer members **102, 104** each include a top edge **136** and a bottom edge **138**. In the exemplary load transfer members **102, 104** shown in FIGS. 6-7, the top edge **136** and bottom edge **138** are each finished at an angle, such that when the load transfer members **102, 104** are inserted into the retention housing **106** and depth locator **120**, the top edge **136** and bottom edge **138** are generally parallel to the planar surface of the concrete wythes of a sandwich panel. Accordingly, the shape and angle of the top edge **136** and bottom edge **138** will vary depending on the angle at which the load transfer members **102, 104** are positioned. Further, the top edge **136** and bottom edge **138** need not be parallel to the planar surface of the connected components, which may be particularly desirable in an embodiment wherein the components of a double wall panel are connected, or in a pavement application.

[0056] FIG. 7 shows the back face **140** of a load transfer member **102** or **104**. As is shown in the drawing, the back does not include anchoring means **118** in this embodiment. However, one skilled in the art will appreciate that anchoring means **118** may also be included on the back of the load transfer member **102, 104**. As can be seen in FIG. 7, the first indentation **132** and second indentation **133** extend all the way through and also cut out the back face **140** of the load transfer member **102, 104**.

[0057] FIG. 8 shows one example of an anchoring means **118** on a load transfer member **102** or **104**. The anchoring means **118** is a depression located near the bottom edge **138** (or identically, on the top edge **136**) of the load transfer member **102** or **104**. The depression extends about one third of the depth of the load transfer member **102** or **104**. The component to be connected, such as the concrete wythes of a sandwich panel or double wall panel, form around the depression, thereby anchoring the load transfer member **102, 104** in the concrete or other component to be connected. One skilled in the art will appreciate that the depression may be any shape or depth necessary for the application and may be moved to a different location on the load transfer member **102** or

**104** as the application may require. In addition, other anchoring means **118** known now or in the future may be employed, such as a hole drilled in the load transfer member **102** or **104**, as illustrated in FIG. 9. In another embodiment of the anchoring means **118**, a short piece of reinforcing bar is placed through a hole drilled in the load transfer member **102** or **104**, as shown in FIG. 10. The reinforcing bar is not part of the optional reinforcing network generally found in the concrete layers of sandwich panels, but is rather a short piece that allows concrete to cure around it, thus anchoring the load transfer member **102** or **104** in the concrete or other component to be connected.

[0058] FIG. 11 shows a retention member **108** or **110**. The retention housing **106**, and accordingly the retention members **108**, **110** are designed to retain the load transfer members **102**, **104** at their proper angles. The retention housing **106**, including the retention members **108**, **110**, is generally made of a rigid insulation material, including, but not limited to, expanded or extruded polystyrene, polyisocyanurate, and high density rockwool. One skilled in the art will appreciate that the retention housing **106** may be made of any material, particularly any type of insulating material. Further, the retention housing **106** may be manufactured in any number of pieces, including one complete retention housing or two or more retention members. The retention members **108**, **110** shown in FIGS. 1-2 are identical. However, when the load transfer device **100** is assembled, the two identical retention members **108**, **110** face each other such that the recessed portions **122**, **124** to accept the load transfer members **102**, **104** and channels **126** to accept the depth locator **120** face each other. Accordingly, when assembled, the two recessed portions **122**, **124** are X-shaped and cross each other rather than being parallel to each other. However, depending on the application, the configuration of the recessed portions **122**, **124** may differ from the described embodiment. The channels **126** are identical and directly across from each other such that they may accept the same depth locator **120**. The retention member **108**, **110** includes a top **142**, bottom **144**, left side **114**, and right side **116**. As is shown in FIG. 11, the channel **126** to accept the depth locator **120** includes two vertical portions **146**, **148** at the ends of a single, horizontal portion **150**. The vertical portions **146**, **148** extend downward from the horizontal portion **150** toward the bottom **144** of the retention member **108**, **110**. Optionally, the retention housing **106** and accordingly the one or more retention members **108**, **110** may be tapered to prevent



the retention housing from slipping through the insulation layer of a sandwich or double wall panel during construction.

[0059] Illustrated in FIG. 12 is an embodiment of the depth locator **120**. The depth locator acts as a retention device to retain the load transfer members at their appropriate depth in the concrete layers. As one skilled in the art will recognize, the appropriate depth may vary depending on the application. The depth locator **120** includes a planar member having a top surface **152** and bottom surface **154**. Further a left leg **156** and a right leg **158** are present and extend downward from the bottom surface **154** of the depth locator **120**. In the preferred embodiment, the depth locator **120** is symmetrical such that it is identical when rotated  $180^\circ$  in the horizontal plane. However, one of skill in the art will recognize that the depth locator **120** may not be symmetrical in certain applications. The depth locator **120** includes a cutout portion **164**, through which the two load transfer members **102**, **104** can be inserted. The depth locator **120** includes two tabs **128**, **130** protruding from the perimeter of the cutout portion **164**. As is shown in FIGS. 6-7, the load transfer members **102**, **104** include indentations **132**, **133**. When the first indentation **132** meets the appropriate tab **128** or **130** the parts click into place. The user will hear an audible noise signaling that the load transfer members **102**, **104** have reached their appropriate depth. In the preferred embodiment, the load transfer members **102**, **104** may only move downward through the depth locator **120**. Once the load transfer members **102**, **104** are inserted, upward movement of the load transfer members **102**, **104** will cause the tabs **128**, **130** to snap and break. As is shown in FIG. 12, the tabs **128**, **130** may taper slightly to accommodate movement of the load transfer members **102**, **104** through the depth locator **120**. Optionally, as shown by tab **130**, the tabs may include a hinge joint **131** to accommodate movement of the load transfer members **102**, **104** through the depth locator and into place. Accordingly, the depth locator **120** provides a means to assist the user in correctly assembling the load transfer device **100** and also to retain the load transfer members **102**, **104** at the appropriate depth.

[0060] The angle at which the load transfer members **102**, **104** are each positioned is precise, but adjustable. Generally, angles of  $20^\circ$  to  $70^\circ$  from normal may be used, with  $30^\circ$  to  $60^\circ$  angles from normal providing optimal load transfer properties, as the force resisted at those angles is mostly tension. In a sandwich wall or double wall panel, the load transfer members **102**, **104** are each positioned at an angle to the normal of the plane at

which the layers meet. In addition, the load transfer members are each positioned at an angle to the planar surface of the concrete layers. However, one of skill in the art will recognize that load transfer members **102**, **104** may be positioned at any angle. In addition, one of skill in the art will recognize that the angle will vary depending on the application and other factors, such as the loads to be transferred and, in a wall panel application, the thickness of the various layers. In the provided illustrations, oftentimes the load transfer members **102**, **104** cross each other at their center. One of skill in the art will recognize that the load transfer members **102**, **104** need not cross at their center, which may be advantageous in some applications, such as a double wall panel. In addition, the load transfer members **102**, **104** need not cross at all.

[0061] In its simplest form, the load transfer device **100** consists of the two load transfer members **102**, **104**. The load transfer members **102**, **104** can be inserted into components to be connected, such as the sections of pavement or the concrete of a wall panel. If the user desires, the retention housing **106** and/or depth locator **120** may also be employed. The retention housing, as will be discussed below, is particularly useful in applications involving wall panels that include a layer of insulation. The device **100**, when using the depth locator **120** and retention housing **106** is assembled by sliding the depth locator **120** into the channel **126** of the first retention member **108** and then the channel **126** of the second retention member **110**. The vertical portions or legs **156**, **158** of the depth locator **120** should extend toward the bottom **144** of the first retention member **108**. The second retention member **110** should then be inserted around the depth locator **120** such that the depth locator **120** is inserted into the channel **126** of the second retention member **110**. Accordingly, the retention housing **106** and depth locator **120** may work in cooperation with each other to retain the load transfer members **102**, **104** at their proper angle and depth. One of skill in the art will recognize that the retention housing may be constructed of any number of retention members or as a single structure. In addition, the depth locator **120** may be included in the retention housing **106** during the molding process, such that the retention housing **106** forms around it. Each retention member **108**, **110** includes a recessed portion **122**, **124** designed to accept and guide the load transfer members **102**, **104**. The depth locator **120** and retention members **108**, **110** should be designed such that the cutout portion **164** of the depth locator **120** is located at the intersection of the recessed portions **122**, **124** of the retention members **108**, **110**. As one skilled in the art will

appreciate, the exact design of the recessed portions **122**, **124** and cutout portion **164** will vary depending on the application, by taking into consideration such factors as the size and shape of the load transfer members **102**, **104** and the angle at which the load transfer members **102**, **104** will be positioned. Once the depth locator **120** and two retention members **108**, **110** are assembled, the two retention members **108**, **110** may optionally be connected by a connecting means. In the preferred embodiment, a strip of self-adhesive tape **112** may be applied to the perimeter of the left end **114** and right end **116** of the assembled retention housing **106**, as is shown in FIG. 1. However, other connecting means may be used, such as other mechanical connection or chemical bonding.

[0062] Next, the load transfer members **102**, **104** should be inserted. When constructing a sandwich or double wall panel, it is generally desirable to insert the retention housing **106** with the depth locator **120** inside into the insulation layer of the panel prior to inserting the load transfer members **102**, **104**. In the preferred embodiment, the anchoring means **118** face outward from the device **100**. Referring to FIG. 1, the retention member **110** that is associated with the front surface **101** of the device **100** accepts a load transfer member **104** whose anchoring means **118** faces in the same direction as the front surface **101**. The retention member **108** that is associated with the back surface **103** of the device **100** accepts a load transfer member **102** whose anchoring means **118** face in the same direction as the back surface **103**. The load transfer members **102**, **104** are inserted through the top end **142** of the retention members **108**, **110** until the indentations **132** click into place with the appropriate tabs **128** or **130** of the depth locator **120**. It is contemplated that the load transfer members **102**, **104** may be used alone, with the depth locator **120**, with the retention housing **106**, or with both the depth locator **120** and retention housing **106**. It will be appreciated by one skilled in the art that the length of the load transfer members **102**, **104**, the angle at which the two load transfer members **102**, **104** are positioned, and the configuration of the components of the device **100** are adjustable and can be varied to fit the selected application. Further, the load transfer device **100** of the present invention may be used alone or in combination with other known connectors and load transfer devices. It will be appreciated that the load transfer device **100** may be shipped to a job site either assembled, partially assembled, or unassembled as the situation requires. Additionally, it is contemplated that the components of the load transfer device **100** may be ordered separately or as a set. When all components of the load transfer device **100** are

shipped together, the unassembled components can be stacked neatly and compactly in a box, thus reducing shipping costs.

[0063] Flexural loads applied to a wall panel are internally resisted by shear in the connector. Similarly, the self-weight of the exterior layer is resisted by shear in the connector. The present invention has a greater shear capacity than connectors of the prior art. Fiber reinforced polymer is stronger in tension than shear. In addition, by placing the load transfer members at an angle, the load transfer device of the present invention resists force due to flexural load and self-weight in tension and thus has a larger capacity. In addition to the increased shear capacity, the load transfer device of the present invention provides many other advantages over the prior art. First, no large voids are left in the insulation layer for placement of the connector that need to be filled by spray foam or another insulation. Because the present connector includes discrete load transfer members, the load transfer members can be strategically placed where the most resistance is required. Further, by using the depth locator, embedment is more accurate during construction. There is no need to tie the load transfer device to the longitudinal steel as required in the prior art. Moreover, the load transfer device can be placed anywhere in the panel as compared to prior art connectors, which must be placed between two insulating sheets.

[0064] The present invention may be used to connect and transfer loads between a variety of components. In one embodiment, the load transfer device 100 may be used with a sandwich wall panel 200, also called an integrally insulated concrete panel. An exemplary sandwich wall panel is shown in FIG. 13. Generally, three layers are present, a first concrete layer 202, a second concrete layer 204, and an insulation layer 206. Although not shown, the sandwich wall panel 200 may further include an exterior façade attached to the exterior layer of concrete. The sandwich panel 200 includes at least one load transfer device 100 to connect the first concrete layer 202, second concrete layer 204, and insulation layer 206, as is illustrated in FIG. 13. FIG. 13 is a cross-sectional view of a sandwich panel 200 looking at the load transfer device 100 from the side when the sandwich panel 200 is in its vertical position. Generally, the load transfer device 100 of the illustrated embodiment is placed in the wall vertically. At minimum, the load transfer device 100 includes two load transfer members 102, 104. Although one skilled in the art will recognize that any material may be used, in the preferred embodiment the load

transfer members 102, 104 are made of fiber reinforced polymer material, which advantageously expands and contracts at the same rate as concrete when exposed to different temperatures and is not as thermally conductive as other materials, such as metal. In the preferred embodiment, the load transfer device 100 further includes a retention housing 106 made of rigid insulation material. Although not shown in the view of FIG. 13, in the preferred embodiment, the retention housing 106 is made of two retention members. The retention members may optionally include recessed portions 122, 124 disposed to accept and guide the load transfer members 102, 104 into place during assembly. The load transfer members 102, 104 may optionally include one or more anchoring means 118. The length of the load transfer members 102, 104 and the angle at which they are positioned are precise, but adjustable and depend on the application and other factors, including but not limited to the thickness of the first concrete layer 202, the second concrete layer 204, and the insulation layer 206. The insulation layer 206 may be made of any insulation, as the application requires, but is most often a rigid insulation. Preferred embodiments include expanded or extruded polystyrene or polyisocyanurate, although many types of insulation are known in the art. The insulation layer is disposed to receive at least one load transfer device 100. The present sandwich panel does not depend on insulation bonding with the concrete wythes for strength and load transferring. Rather, the load transfer device 100 is able to transfer the entire loads associated with the sandwich panel 200.

[0065] The present invention includes methods for manufacturing a sandwich wall panel 200 employing a load transfer device 100, which is described in the flow chart of FIG. 14. The methods can be used with a variety of construction techniques known now or in the future, including but not limited to site-cast tilt-up, plant precast, cast-in-place, and modular precast. As is known in the art, site-cast tilt-up panels are produced horizontally at the job-site, usually using the building floor slab as the primary casting surface. Once the panels are assembled and have cured, the panels are lifted into place to form the building envelope. Precast concrete panels are cast horizontally into shape at a location other than the job-site. Once the panels are assembled and have cured, the panels are transported to the job-site for construction. The precast concrete panels of the present invention may be prestressed. Similar to the site-cast tilt-up method, cast-in-place

sandwich panels are manufactured at the job site. Cast-in-place wall panels are manufactured vertically and in place at their final location.

[0066] Referring to FIG. 14, a method for manufacturing a sandwich wall panel generally begins by providing a first concrete layer, as is shown by block 208. As illustrated in FIG. 15, the concrete may be poured into a mold or form 226 for plant precast methods to make sections of sandwich panel 200 which will then be shipped to a job site. Alternatively, the first concrete layer 202 may be poured into a large mold as part of a site-cast tilt-up method with cutouts such as windows and doors included in the mold. As shown in FIG. 16, the form 226 may include reinforcing 229 placed into the mold before the concrete is poured into the form 226. Alternatively, the reinforcing may be pushed into the wet concrete after it has been poured into the form 226. As discussed above, the reinforcing is optional. The form 226 is then filled with wet concrete, as shown in FIG. 17.

[0067] Next, as provided in FIG. 14 block 210 and illustrated in FIG. 18, an insulation panel 228 is placed on top of the first concrete layer while the concrete is still wet or plastic. Optionally, this is accomplished by providing small sections of insulation in a predetermined pattern. One of skill in the art will recognize that more than one piece and/or layer of insulation may be provided. The insulation panel 228 is disposed to receive at least one load transfer device 100. In the preferred embodiment, this means that the insulation panel 228 is disposed to receive at least one retention housing 106 of the load transfer device, generally by having cavities 230 at predetermined locations. In addition, the insulation panel 228 may be disposed to receive one or more connectors of a different type.

[0068] Next, referring to block 212 of FIG. 14, at least one load transfer device 100 is inserted into the insulation panel 228 such that the load transfer members 102, 104 are positioned at an angle to the normal of the planes at which the first concrete layer 202 and the insulation panel 228 meet and the second concrete layer 204 and the insulation layer meet. As previously discussed, the load transfer device 100 may be composed solely of the two load transfer members 102, 104. Optionally, the load transfer device 100 may include a depth locator 120, a retention housing 106, or, as in the preferred embodiment, both. When using only the two load transfer members 102, 104, they are inserted through the insulation panel 228 and into the wet concrete. In the preferred embodiment, as

illustrated in FIG. 19, the depth locator **120** is inserted into the channel **126** to accept the depth locator **120** of the first insulating retention member **108**. The second insulating retention member **110** is then added, such that the channel **126** of the second insulating retention member **110** receives the depth locator **120**. Optionally, an adhesive or other connecting means may be used to hold the retention members **108**, **110** in place. In the preferred embodiment, a piece of self-adhesive tape **112** is wrapped around the perimeter of the left end **114** and right end **116** of the retention housing, which is illustrated in FIG. 13.

[0069] The assembled depth locator **120** and retention housing **106** are then inserted into the cavities **230** of the insulation panel **228**, as is illustrated by FIG. 20. Generally the depth of the retention housing **106** is the same distance as the depth of the insulation layer **206**, which for purposes of this illustration is one insulation panel **228**. Therefore, the retention housing is flush with the insulation layer **206** where the insulation layer **206** meets the first concrete layer **202** and second concrete layer **204**. Accordingly, once the one or more retention housings **106** are inserted into the insulation panel **228**, the only voids in the insulation are the recessed portions **122**, **124** in the one or more retention housings **106** to accept and guide the load transfer members **102**, **104**, as is shown in FIG. 20. The ends of the retention housing **106** may taper downward and correspond to a tapering in the cavities **230** of the insulation panel to hold the retention housing **106** in the insulation panel **228**. Alternatively, the retention housings **106** may already be inserted into the insulation panel **228** when it is placed on top of the wet concrete.

[0070] Next, the load transfer members **102**, **104** are inserted, as is shown in FIG. 21. The load transfer members **102**, **104** are inserted through the top of the retention housing **106** until the indentation **132** of each load transfer member **102**, **104** reaches the appropriate tab **128** or **130** of the depth locator **120**, as shown in FIG. 2. This creates an audible clicking noise. When the indentation **132** snaps into place with the appropriate tab **128** or **130**, it also becomes significantly harder to continue to insert the load transfer member **102**, **104**, thus creating another way for the user to determine that the load transfer member **102**, **104** has reached the appropriate depth. As is shown in in FIG. 13, the bottom portion **166** of the load transfer member **102**, including the optional anchoring means **118**, extends into the first concrete layer **202**. The second load transfer member **104** is then inserted through the retention housing **106** and into the first concrete layer **202**. As is shown in

FIGS. 13 and 21, the top portion **168** of both load transfer members **102**, **104** extend beyond the insulation panel **228**.

[0071] Referring to block **214** of FIG. 14, the second concrete layer **204** is then poured atop the insulation layer, such that it completely surrounds and encloses all parts of the load transfer device **100**, as is shown in FIG. 22. The method eliminates any remaining spaces or voids, which decrease thermal efficiency, in the insulation layer **206**. Oftentimes, these spaces or voids are present in the sandwich panels of the prior art and require a second application of insulation, such as foam insulation, in the spaces or voids to increase the thermal efficiency of the panel. The present sandwich panel eliminates the need to apply a second form of insulation, thus providing time and cost savings. Once the concrete cures, the sandwich wall panel is complete. It may be removed from the form and used to construct a building or other structure.

[0072] Alternatively, the sandwich panel **200** may be constructed vertically using a cast-in-place method. To do so, a cast-in-place form **232** is used, as shown in FIG. 23. The cast-in-place form **232** includes an interior form wall **234** and exterior form wall **236**, which are erected at the wall's service position. A piece of insulation **238** is then placed between the interior form **234** and exterior form **236**. Before the insulation **238** is set into place, one or more load transfer devices **100** are inserted into the insulation **238** at predetermined locations in the manner described above. Concrete is then introduced into the cast-in-place form **232** on both sides of the insulation **238** to create interior and exterior concrete wythes.

[0073] The present invention also includes a double wall panel **300** engaging the disclosed load transfer device **100**. Referring to FIG. 24, the double wall panel **300** includes a first concrete layer **302**, a second concrete layer **304**, an insulation layer **306**, and an air void **308**. The double wall panel **300** further includes at least one load transfer device **100**. In its simplest form, the load transfer device includes two load transfer members **102**, **104**. Optionally, the load transfer device **100** may further include a depth locator **120** (not shown in FIG. 24), a retention housing **106**, or, as in the preferred embodiment, both. The load transfer members **102**, **104** may include anchoring means **118**. As is shown in FIG. 24, in the preferred embodiment of the double wall configuration, the load transfer member **104** includes three anchoring means **118**. The load transfer member **102** also



includes three anchoring means **118**, which are not shown in this view. If desired, the air void **308** may be filled with another material, such as concrete and/or additional insulation materials, once the double wall panel has been set into place at the construction site. Accordingly, the anchoring means **118** located in the air void **308** provides anchoring with the optional air void material. As can be seen in FIG. 24, the top edges **136** and bottom edges **138** of the two load transfer members **102**, **104** are not parallel with the planar surface of the concrete layers **302**, **304** or insulation layer **306**, as is the case with the preferred embodiment of the sandwich wall panel **200**. Rather, the top edges **136** and bottom edges **138** are at an angle to the planar surface of the concrete layers **302**, **304** and insulation layer **306**. Further, the load transfer device **100** can be a standoff connector, with the lower tip **332** extending to the outside surface of the second concrete layer **304**. The load transfer members further include a portion **324** that spans the first concrete layer **302**, a portion **326** that spans the insulation layer **306** through the retention housing **106**, a portion **328** that spans the air void **308**, and a portion **330** that spans the second concrete layer **304**.

[0074] Also provided in the present invention is a method for manufacturing a double wall panel **300** employing the disclosed load transfer device **100**. Referring to FIG. 25, as shown in block **310**, the first step in the method for manufacturing a double wall panel is to provide a first concrete layer **302**. In horizontal applications, such as the plant precast and site-cast tilt-up methods discussed above, the first concrete layer **302** is generally poured into a form **226**, such as a steel pallet in the plant. An exemplary form **226** is provided in FIG. 15. Optionally, reinforcing **229** may be provided in the first concrete layer. The reinforcing **229** may be placed in the form before the wet concrete is added, as shown in FIG. 16, or, alternatively, the reinforcing **229** may be placed in the wet concrete after it is poured. As illustrated in FIG. 17, wet concrete is then poured into the form **226**. Next, referring to block **312**, an insulation panel **228** is provided on top of the wet concrete in the form **226**, as is shown in FIG. 18. One of skill in the art will recognize that the insulation layer may be provided in multiple panels with one or more pieces and/or layers of insulation provided. Generally, the insulation panel **228** is added while the concrete is still wet or plastic. The insulation panel **228** is disposed to receive at least one load transfer device **100**. In the preferred embodiment, this means that the insulation panel **228**

is designed with rectangular-shaped cavities **230** to receive at least one retention housing **106**, as shown in FIG. 18.

[0075] Next, referring to block **314** of FIG. 25, while the concrete is still wet, at least one load transfer device **100** is inserted into the insulation panel **228** and wet concrete, such that the load transfer members **102**, **104** are positioned at an angle to the normal of the plane at which the wet concrete and insulation panel **228** meet, as well as the planes at which the insulation panel **228** and air gap **308** will meet and the air gap **308** and second concrete layer will meet. In its simplest form, the load transfer device **100** of the present invention includes two load transfer members **102**, **104**. The load transfer members **102**, **104** are inserted through the rigid insulation, which is designed to accept the load transfer members **102**, **104**. Generally, the cavities are just large enough to accept and guide the load transfer device **100**, whether it is the load transfer members **102**, **104** only or the retention housing **106** which will in turn accept the load transfer members **102**, **104** and the depth locator **120**. In the preferred embodiment, the cavities accept the retention housing **106** of the load transfer device **100**.

[0076] Optionally, the load transfer device **100** may include a depth locator **120** also. The retention housing **106** and depth locator **120** are assembled prior to insertion into the insulation panel **228**. As is shown in FIG. 19, the depth locator **120** is inserted into the channel **126** designed to accept the depth locator **120** of the first retention member **108**. The second retention member **110** is then added, such that the depth locator is inserted into its channel **126** to accept the depth locator **120**. Optionally, as in the preferred embodiment, the retention members **108**, **110** may be held together with an adhesive, or other connecting means. In the preferred embodiment, the retention members **108**, **110** are held together by a strip of self-adhesive tape **112** at the left end **114** and right end **116** of the retention housing **106**, as illustrated in FIG. 1. The retention housing **106**, with the depth locator **120** inside, is then inserted into a cavity **230** of the insulation panel **228**. In the preferred embodiment, the retention members **108**, **110** include two recessed portions **122**, **124** to accept and guide the load transfer members **102**, **104**, which become the only voids present in the insulation panel **228**, as shown in FIG. 20. The first load transfer member **102** is inserted into the retention housing **106** and through the depth locator **120**. As discussed above and shown in FIGS. 2 and 12, the depth locator **120** includes a set of slightly flexible tabs **128**, **130**. The load transfer members **102**, **104** each include an

indentation 132. The indentation 132 accepts the appropriate tab 128 or 130 of the depth locator. The first load transfer member 102 is inserted until the indentation 132 accepts the appropriate tab 128 or 130. At that point, an audible clicking sound is created. In addition, it becomes more difficult to continue pushing the load transfer member 102 through the depth locator. Accordingly, the user can be sure that the load transfer member 102 is inserted to the appropriate depth for the application. The same process is repeated for the second load transfer member 104 which also includes an indentation 132 that corresponds to a tab 128 or 130.

[0077] FIG. 26 provides an illustration of the double wall panel 300 at this point. The wet concrete has been poured, and the insulation panel 228 has been provided on top of the wet concrete. The retention housing 106 of the load transfer device 100 has been inserted into the cavities 230 of the insulation panel 228. Further, the load transfer members 102, 104 have been inserted into the retention housing 106, clicking into place with the depth locator 120 (not shown), and with portions 324 extending into the wet concrete. The load transfer members 102, 104 also extend above the retention housing 106 into the air above the wet concrete and insulation panel 228. The anchoring means 118 of load transfer member 104 can be seen.

[0078] In addition to the load transfer device 100, other connectors known now or in the future, may also be used to connect the layers of the double wall panel 300 without departing from the scope of the present invention. Referring again to FIG. 26, standoff connectors 334 may be used. The standoff connectors 334 span the entire double wall panel and define its thickness. The standoff connectors 334 are inserted at the same time as the load transfer device 100 and extend all the way to the bottom of the form and accordingly through the entire first concrete layer 302. The standoff connectors 334 further span the insulation layer and extend into the air above the insulation layer. When the second layer of concrete 304 is added, the standoff connector 334 further spans it and hits the bottom of the form, thus defining the thickness of the double wall panel, while leaving a space for the air gap. As will be described below, in the preferred embodiment, the first concrete layer 302, insulation layer 306, load transfer device 100, and any other connectors are lifted, rotated 180° and lowered into the second concrete layer. In this embodiment the standoff connectors 334 hit the bottom of the form and may help support those layers that are suspended above the second concrete layer 304. Alternatively, the

second concrete layer 304 may be added above the other layers. Optionally, means may be added to transport the first concrete layer 302, insulation layer 306, load transfer device 100, and optional standoff connector 334. The standoff connector 334 may further include the means for transporting the first concrete layer 302, insulation layer 306, and load transfer device 100.

[0079] After the first concrete layer 302, insulation layer 306, at least one load transfer device 100, and any other connectors, including standoff connectors 334, and transporting means are added, the concrete of the first concrete layer 302 is allowed to cure, as shown by block 316 of FIG. 25. In the preferred embodiment, the panel thus far is moved to an oven or steam chamber for curing. Alternatively, the panel may be left at room temperature for a prescribed period of time, such as twenty four (24) hours. Once the first concrete layer 302 has cured, the first concrete layer 302, insulation layer 306, load transfer device 100, and any other connectors such as standoff connectors 334 are one unit and may be moved or transported as such. Accordingly, the double wall panel 300 in progress may be transported, and the panel need not be finished in the same location as where it was started. For example, the double wall panel 300 in progress may be transported to the job-site for the remaining steps. In the alternative, the remaining steps may take place in a plant.

[0080] The next step is providing a second layer of concrete 304, as shown by block 318 of FIG. 25. In methods where the double wall panel is manufactured horizontally, the second concrete layer 304 may be added on top of the existing panel. Alternatively, referring to block 320 of FIG. 25, as in the preferred embodiment, the double wall panel in progress, including the first concrete layer 302, insulation layer 306, at least one load transfer device 100, and any other connectors, including standoff connectors 334, and transporting means, are lifted, rotated 180°, and lowered into the second concrete layer 304, which is still wet or plastic concrete that has been poured into a form 226, as shown by FIG. 27. In this embodiment, the second concrete layer 304 may be provided with optional reinforcing. The reinforcing may be present in the form when the concrete is poured, or may be lowered into the concrete after it has been poured. At this point, the top layers, the first concrete layer 302, insulation layer 306, at least one load transfer device 100, and any other connectors, including standoff connectors 334, and transporting means, may be mechanically held in place, such as by a steel suspension apparatus. Alternatively,

the load transfer device(s) **100** in combination with one or more standoff connectors **334** may provide means for supporting the top layers above the air void **308**. Finally, the load transfer device **100** may support the layers above the air void **308** without assistance from other means. The second concrete layer **304** is then allowed to cure, either in a steam chamber or oven, or at room temperature for a prescribed period of time.

[0081] At this point, the double wall panel is complete. It may be removed from the form and used to construct a building or other structure. If the double wall panel **300** was manufactured, in whole or in part, horizontally at the job-site, the double wall panel **300** will then be tilt-up into the appropriate position. If the double wall panel **300** was wholly manufactured by plant precast methods, the double wall panel will then be shipped to a job-site. Oftentimes, double wall panels **300** are lighter than sandwich panels of the same area. Accordingly, double wall panels **300** manufactured using the plant precast method may be shipped in larger sections than sandwich panels **200**. Once in place at the job site, the double wall panel **300** air void **308** may be filled with another material, such as concrete and/or additional insulation materials.

[0082] Generally, the sandwich panel **200** and double wall panel **300** will include more than one load transfer device **100** and other connectors known now or in the future. The number of load transfer devices **100** and other connectors will vary depending on the application, and can be designed using methods known now or later developed. FIGS. 28-31a provide examples of embodiments of panels of the present invention engaging at least one load transfer device **100**. Although FIGS. 28-31A are directed to sandwich panels **200** of the present invention, one skilled in the art will recognize that the configurations may be used to manufacture double wall panels **300** of the present invention.

[0083] FIG. 28 provides an embodiment of a non-composite vertical sandwich panel **218**, while FIG. 28A provides a cross-sectional view of the panel illustrated in FIG. 28. As is known in the art, in a non-composite sandwich panel, the layers of the panel, although connected, work independently of each other. The non-composite vertical sandwich panel **218** is connected using ten load transfer devices **100** and one hundred thirty other connectors **220**. The load transfer devices **100** are represented by dashes (—), and the other connectors **220** are represented by dots (·). It can be desirable to employ the load transfer device **100** and other connectors **220** in combination, because the practice can provide cost

savings. The load transfer device **100** provides significantly higher load transfer properties than other connectors **220**; however, the other connectors **220** are smaller, and therefore provide cost savings in manufacturing and shipping compared to the load transfer device **100**. Accordingly, one skilled in the art will be able to design panels using both types of connectors by considering the loads required for the application and the cost of each type of connector. In the illustrated embodiment, there are two rows of five load transfer devices **100** in the middle of the panel **218**. The remaining area of the panel is connected using other connectors **220**. The other connectors **220** are used around the entire perimeter of the panel **218**.

[0084] FIG. 29 provides an embodiment of a non-composite horizontal panel **222**. The load transfer devices **100** are provided in one horizontal row. The other connectors **220** are provided at regular intervals in the remaining area of the panel, including around the entire perimeter.

[0085] FIG. 30 provides an embodiment of a partially composite vertical panel **224** while FIG. 30A provides a cross-sectional view of the panel illustrated in FIG. 30. As is known in the art, a partially composite sandwich panel combines the properties of a non-composite panel, wherein the layers of the panel work independently of each other, and a composite sandwich panel, wherein the layers work in unison. The illustrated partially composite vertical panel **224** includes ten load transfer devices **100** and one hundred thirty other connectors **220**. In FIG. 30, the load transfer devices **100** are represented by long horizontal lines, and the other connectors **220** are represented by shorter horizontal lines. In this illustration, the load transfer devices **100** are present in two rows of five. One row is at the top of the panel **224**, and the second row is at the bottom of the panel **224**. The other connectors **220** are present in the middle of the panel **224** and in the corners of the panel **224**.

[0086] FIG. 31 provides a second embodiment of a partially composite vertical panel **224**, while FIG. 31A provides a cross-sectional view of the panel illustrated in FIG. 31. In this embodiment, only load transfer devices **100** are employed. Because the load transfer device **100** has a higher capacity to transfer loads than other connectors, this embodiment is advantageous in applications where more shear transfer is needed due to prominent vertical loading and excessive wind or seismic loads, such as in the case of a tornado

shelter. The partially composite vertical panel **224** of FIG. 31 includes eighty load transfer devices **100**, arranged in four vertical rows of twenty.

**[0087]** Although various representative embodiments of this invention have been described above with a certain degree of particularity, those skilled in the art could make numerous alterations to the disclosed embodiments without departing from the spirit or scope of the inventive subject matter set forth in the specification and claims. Joinder references (e.g. attached, adhered) are to be construed broadly and may include intermediate members between a connection of elements and relative movement between elements. As such, joinder references do not necessarily infer that two elements are directly connected and in fixed relation to each other. In some instances, in methodologies directly or indirectly set forth herein, various steps and operations are described in one possible order of operation, but those skilled in the art will recognize that steps and operations may be rearranged, replaced, or eliminated without necessarily departing from the spirit and scope of the present invention. It is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative only and not limiting. Changes in detail or structure may be made without departing from the spirit of the invention as defined in the appended claims.

**[0088]** Although the present invention has been described with reference to the embodiments outlined above, various alternatives, modifications, variations, improvements and/or substantial equivalents, whether known or that are or may be presently foreseen, may become apparent to those having at least ordinary skill in the art. Listing the steps of a method in a certain order does not constitute any limitation on the order of the steps of the method. Accordingly, the embodiments of the invention set forth above are intended to be illustrative, not limiting. Persons skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention. Therefore, the invention is intended to embrace all known or earlier developed alternatives, modifications, variations, improvements, and/or substantial equivalents.

## CLAIMS

1. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element having a first surface closest to said second concrete element;

said second concrete element having a first surface closest to said first concrete element;

an insulation layer located between said first and second concrete elements;

a load transfer member having a first end and a second end;

a retention housing having a recessed portion corresponding in shape to receive and said load transfer member;

said retention housing received by said insulation layer;

a depth locator comprising:

a first planar member having a first end and a second end;

a first leg extending from said first end;

a second leg extending from said second end; and

said planar member having a cutout portion receiving the at least one load transfer member, said cutout portion comprising a tab protruding from the perimeter of said cutout portion wherein said tab is received by an indentation in said load transfer member;

wherein said first load transfer member is positioned at an angle to the normal of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said first end of said load transfer member is at least partially embedded in said first concrete element and said second end of said load transfer member is at least partially embedded in said second concrete element; and

wherein said first and second ends of said first load transfer member are not in contact with any other load transfer members in said first and second concrete elements.



2. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element having a first surface closest to said second concrete element;

said second concrete element having a first surface closest to said first concrete element;

a first load transfer member having a first end and a second end, said first load transfer member only in contact with said first and second concrete elements at said first and second ends respectively;

a second load transfer member having a first end and a second end, said second load transfer member only in contact with said first and second concrete elements at said first and second ends respectively;

wherein said first load transfer member and said second load transfer member are positioned at an angle to the normal of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said first ends of said first and second load transfer members are at least partially embedded in said first concrete element in a spaced relationship with one another and said second ends of said first and second load transfer members are at least partially embedded in said second concrete element in a spaced relationship with one another; and

wherein said first and second load transfer members transfer all loads independently of each other.

3. The load transfer device of claim 2 wherein said first and second concrete elements are separated by a layer of insulation and wherein said first load transfer member and said second load transfer member are positioned at an angle to the normal of the planes at which said first and second concrete elements meet said layer of insulation.

4. The load transfer device of claim 3 wherein said layer of insulation and said second concrete layer are separated by a space and wherein said first load transfer member and said second load transfer member are positioned at an angle to the normal of the planes at which

said first concrete element meets said layer of insulation, said layer of insulation meets said space, and said space meets said second concrete layer.

5. The load transfer device of claim 2 wherein the first and second concrete elements are selected from the group consisting of sandwich wall panel wythes, double wall panel wythes, roof members, floor members, balcony members, canopy members, and sections of pavement.

6. The load transfer device of claim 2 wherein the angles at which said first and second load transfer members are positioned with respect to the normal of the first surface of said first concrete element and the normal of said first surface of said second concrete element are adjustable.

7. The load transfer device of claim 2 wherein at least one of said first load transfer member and said second load transfer member further comprises at least one anchoring means.

8. The load transfer device of claim 2 wherein said angles are between twenty and seventy degrees.

9. The load transfer device of claim 8 wherein said angles are between forty-five and sixty degrees.

10. A sandwich wall panel comprising:  
a first concrete layer having a first surface nearest to a second concrete layer;  
said second concrete layer having a first surface nearest to said first concrete layer;  
an insulation layer located between said first concrete layer and said second concrete layer; and  
at least one load transfer device connecting said first concrete layer to said second concrete layer and spanning said insulation layer comprising:

a first load transfer member having a first end and a second end;

a second load transfer member having a first end and a second end;

wherein said first load transfer member and said second load transfer member are positioned at an angle to the normal of said first surface of said first concrete layer and at an angle to the normal of said first surface of said second concrete layer;

wherein said first ends of said first and second load transfer members are at least partially embedded in said first concrete layer in a spaced relationship with one another and said second ends of said first and second load transfer members are at least partially embedded in said second concrete layer in a spaced relationship with one another;

wherein said first and second ends of said first and second load transfer members are not in contact with any other load transfer members in said first and second concrete layers; and

wherein said first and second load transfer members are positioned in a plane that is perpendicular to shear force acting on said first and second concrete elements and wherein said shear force is coplanar with said first and second concrete layers.

11. The sandwich wall panel of claim 10 wherein said load transfer device further comprises a retention housing to retain said first and second load transfer members at said angle.

12. The sandwich wall panel of claim 11 wherein said load transfer device further comprises a depth locating means for locating said first load transfer member and said second load transfer member at the proper depth in said first and second concrete layers.

13. A double wall panel comprising:

a first concrete layer comprising a first surface nearest to a second concrete layer;

an insulation layer located adjacent to said first concrete layer;

a space located adjacent to said insulation layer and opposite said insulation layer from said first concrete layer;

said second concrete layer located adjacent said space and opposite said space from said insulation layer;

said second concrete layer comprising a first surface nearest to said first concrete layer; and

at least one load transfer device comprising:

a first load transfer member having a first end and a second end;

a second load transfer member having a first end and a second end;

wherein said first load transfer member and said second load transfer member are positioned at an angle to the normal of said first surface of said first concrete layer and at an angle to the normal of said first surface of said second concrete layer;

wherein said first ends of said first and second load transfer members are at least partially embedded in said first concrete layer in a spaced relationship with one another and said second ends of said first and second load transfer members are at least partially embedded in said second concrete layer in a spaced relationship with one another;

wherein said first and second ends of said first and second load transfer members are not in contact with any other load transfer members in said first and second concrete layer; and

wherein said first and second load transfer members are positioned in a plane that is perpendicular to shear force acting on said first and second concrete elements and wherein said shear force is coplanar with said first and second concrete layers.

14. The double wall panel of claim 13 wherein said load transfer device further comprises a retention housing to retain said first and second load transfer members at said angle.

15. The double wall panel of claim 14 wherein said load transfer device further comprises a depth locating means for locating said first load transfer member and said second load transfer member at the proper depth in said first and second concrete layers.

16. The double wall panel of claim 13 further comprising at least one standoff device.
17. A load transfer device for connecting at least first and second concrete elements comprising:  
said first concrete element having a first surface closest to said second concrete element;  
said second concrete element having a first surface closest to said first concrete element;  
a first linear load transfer member having a first end and a second end;  
a second linear load transfer member having a first end and a second end;  
wherein said first load transfer member and said second load transfer member are positioned at an angle to the normal of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;  
wherein said first ends of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said second ends of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another; and  
wherein said first and second load transfer members do not depend on each other to transfer any loads.
18. A load transfer device connecting at least first and second concrete elements comprising:  
said first concrete element comprising a first surface nearest to said second concrete element;  
said second concrete element comprising a first surface nearest to said first concrete element;  
a first load transfer member having a first end and a second end;  
a second load transfer member having a first end and a second end;

wherein said first load transfer member and said second load transfer member are positioned at an angle to the normal of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said first ends of said first and second load transfer members are at least partially embedded in said first concrete element in a spaced relationship with one another and said second ends of said first and second load transfer members are at least partially embedded in said second concrete element in a spaced relationship with one another;

wherein said first and second ends of said first and second load transfer members are not in contact with any other load transfer members in said first and second concrete elements; and

wherein the loads transferred by the first and second load transfer members are not transferred to the other load transfer member.

19. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element comprising a first surface nearest to said second concrete element;

said second concrete element comprising a first surface nearest to said first concrete element;

a first load transfer member having a first end and a second end;

a second load transfer member having a first end and a second end;

wherein said first load transfer member and said second load transfer member are positioned at an angle to the normal of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said first ends of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said second ends of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another;

wherein said first and second ends of said first and second load transfer members are not in contact with any other load transfer members in said first and second concrete elements; and

wherein said first and second load transfer members are positioned in a plane that is perpendicular to shear force acting on said first and second concrete elements and wherein said shear force is coplanar with said first and second concrete elements.

20. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element having a first surface closest to said second concrete element;

said second concrete element having a first surface closest to said first concrete element;

a first load transfer member having a first end and a second end, said first load transfer member only in contact with said first and second concrete elements at said first and second ends respectively;

a second load transfer member having a first end and a second end, said second load transfer member only in contact with said first and second concrete elements at said first and second ends respectively;

wherein said first load transfer member and said second load transfer member are positioned at an angle to the normal of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said first ends of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said second ends of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another; and

wherein said first and second load transfer members transfer at least one shear load between said first and second concrete elements when said first and second concrete elements are in a service position.

21. The load transfer device of claim 20 wherein said first and second load transfer members transfer additional loads.

22. The load transfer device of claim 21 wherein said additional loads are compression and tension forces.

23. The load transfer device of claim 20 wherein said first and second load transfer members are indirectly connected to one another.

24. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element having a first surface closest to said second concrete element;

said second concrete element having a first surface closest to said first concrete element;

a first load transfer member having a first concrete engaging portion and a second concrete engaging portion, said first load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a second load transfer member having a first concrete engaging portion and a second concrete engaging portion, said second load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

wherein said first load transfer member and said second load transfer member each include a longitudinal axis and said longitudinal axes are positioned at an angle to the normal of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said first concrete engaging portions of said first and second load transfer members are at least partially embedded in said first concrete element in a spaced relationship with one another and said second concrete engaging portions of said first and



second load transfer members are at least partially embedded in said second concrete element in a spaced relationship with one another;

wherein said first and second load transfer members transfer all loads independently of each other; and

wherein said first and second load transfer members cause said first and second concrete elements to have at least partial composite structural behavior.

25. The load transfer device of claim 24 wherein said first and second concrete elements are separated by a layer of insulation and wherein said longitudinal axes are positioned at an angle to the normal of the planes at which said first and second concrete elements meet said layer of insulation.

26. The load transfer device of claim 24 wherein the first and second concrete elements are selected from the group consisting of sandwich wall panel wythes, double wall panel wythes, roof members, floor members, balcony members, canopy members, and sections of pavement.

27. The load transfer device of claim 24 wherein said angles are between twenty and seventy degrees.

28. The load transfer device of claim 27 wherein said angles are between forty-five and sixty degrees.

29. A sandwich wall panel comprising:

a first concrete layer having a first surface nearest to a second concrete layer;

said second concrete layer having a first surface nearest to said first concrete layer;

an insulation layer located between said first concrete layer and said second concrete layer; and

at least one load transfer device connecting said first concrete layer to said second concrete layer and spanning said insulation layer comprising:

a first load transfer member having a first end and a second end;

a second load transfer member having a first end and a second end;

wherein said first load transfer member and said second load transfer member each include a longitudinal axis and said longitudinal axes are positioned at an angle to the normal of said first surface of said first concrete layer and at an angle to the normal of said first surface of said second concrete layer;

wherein said first ends of said first and second load transfer members are at least partially embedded in said first concrete layer in a spaced relationship with one another and said second ends of said first and second load transfer members are at least partially embedded in said second concrete layer in a spaced relationship with one another;

wherein said first and second ends of said first and second load transfer members are not in contact with any other load transfer members in said first and second concrete layers;

wherein said first and second load transfer members are positioned in a plane that is perpendicular to shear force acting on said first and second concrete elements layers and wherein said shear force is coplanar with said first and second concrete layers; and

wherein said first and second load transfer members cause said first and second concrete layers to have at least partial composite structural behavior.

30. The sandwich wall panel of claim 29 wherein said load transfer device further comprises a retention housing to retain said first and second load transfer members at said angle.

31. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element comprising a first surface nearest to said second concrete element;

said second concrete element comprising a first surface nearest to said first concrete element;

a first load transfer member having a first end and a second end;

a second load transfer member having a first end and a second end;

wherein said first load transfer member and said second load transfer member each include a longitudinal axis and said longitudinal axes are positioned at an angle to the normal of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said first ends of said first and second load transfer members are at least partially embedded in said first concrete element in a spaced relationship with one another and said second ends of said first and second load transfer members are at least partially embedded in said second concrete element in a spaced relationship with one another;

wherein said first and second ends of said first and second load transfer members are not in contact with any other load transfer members in said first and second concrete elements;

wherein the loads transferred by the first and second load transfer members are not transferred to the other load transfer member; and

wherein said first and second load transfer members cause said first and second concrete elements to have at least partial composite structural behavior.

32. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element comprising a first surface nearest to said second concrete element;

said second concrete element comprising a first surface nearest to said first concrete element;

a first load transfer member having a first end and a second end;

a second load transfer member having a first end and a second end;

wherein said first load transfer member and said second load transfer member each include a longitudinal axis and said longitudinal axes are positioned at an angle to the normal

of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said first ends of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said second ends of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another;

wherein said first and second ends of said first and second load transfer members are not in contact with any other load transfer members in said first and second concrete elements;

wherein said first and second load transfer members are positioned in a plane that is perpendicular to shear force acting on said first and second concrete elements and wherein said shear force is coplanar with said first and second concrete elements; and

wherein said first and second load transfer members cause said first and second concrete elements to have at least partial composite structural behavior.

33. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element having a first surface closest to said second concrete element;

said second concrete element having a first surface closest to said first concrete element;

a first load transfer member having a first concrete engaging portion and a second concrete engaging portion, said first load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a second load transfer member having a first concrete engaging portion and a second concrete engaging portion, said second load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

wherein said first load transfer member and said second load transfer member each include a longitudinal axis and said longitudinal axes are positioned at an angle to the normal

of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said first concrete engaging portions of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said second concrete engaging portions of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another; and

wherein said first and second load transfer members transfer at least one shear load between said first and second concrete elements when said first and second concrete elements are in a service position and cause said first and second concrete elements to have at least partial composite structural behavior.

34. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element having a first surface closest to said second concrete element;

said second concrete element having a first surface closest to said first concrete element;

a first load transfer member having a first concrete engaging portion including a top edge and a second concrete engaging portion including a bottom edge, said first load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a second load transfer member having a first concrete engaging portion including a top edge and a second concrete engaging portion including a bottom edge, said second load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

wherein said first load transfer member and said second load transfer member each include a longitudinal axis and said longitudinal axes are positioned at an angle to the normal of said first surface of said first concrete element and at an angle to the normal of said first surface of said second concrete element;

wherein said top edges of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said bottom edges of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another; and

wherein said first and second load transfer members cause said first and second concrete elements to have at least partial composite structural behavior.

35. The load transfer device of claim 34 wherein composite structural behavior resists flexural shear loads.

36. The load transfer device of claim 35 wherein said flexural shear loads are applied to said first and second concrete elements in an in-service position.

37. The load transfer device of claim 36 further comprising a retention housing.

38. The load transfer device of claim 37 wherein said retention housing retains said first and second load transfer members at said angle.

39. The load transfer device of claim 38 wherein said first and second concrete elements are sandwich wall panel wythes.

40. The load transfer device of claim 39 wherein a layer of insulation is located between said first and second concrete elements.

41. The load transfer device of claim 40 wherein said retention housing is received by said insulation layer.

42. The load transfer device of claim 41 wherein said retention housing includes at least one retention member having a recessed portion corresponding in shape to receive and retain at least one of said first and second load transfer member.

43. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element having a first surface closest to said second concrete element;

said second concrete element having a first surface closest to said first concrete element;

a first load transfer member having a first concrete engaging portion including a top edge, a second concrete engaging portion including a bottom edge, and a longitudinal axis, said first load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a second load transfer member having a first concrete engaging portion including a top edge, a second concrete engaging portion including a bottom edge, and a longitudinal axis, said second load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a retention housing retaining said first and second load transfer members such that said longitudinal axes are positioned at an angle to the normal of the first surfaces of said first and second concrete elements;

wherein said top edges of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said bottom edges of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another; and

wherein said first and second load transfer members cause said first and second concrete elements to have at least partial composite structural behavior.

44. The load transfer device of claim 43 wherein said composite structural behavior resists flexural shear loads.

45. The load transfer device of claim 44 wherein said flexural shear loads are applied to said first and second concrete elements in an in-service position.

46. The load transfer device of claim 43 wherein said first and second concrete elements are sandwich wall panel wythes.

47. The load transfer device of claim 46 wherein a layer of insulation is located between said first and second concrete elements.

48. The load transfer device of claim 47 wherein said retention housing is received by said insulation layer.

49. The load transfer device of claim 43 wherein said retention housing includes at least one retention member having a recessed portion corresponding in shape to receive and retain at least one of said first and second load transfer member.

50. A load transfer device connecting at least first and second concrete elements comprising:

said first concrete element having a first surface closest to said second concrete element;

said second concrete element having a first surface closest to said first concrete element;

a first load transfer member having a first concrete engaging portion including a top edge, a second concrete engaging portion including a bottom edge, and a longitudinal axis, said first load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a second load transfer member having a first concrete engaging portion including a top edge, a second concrete engaging portion including a bottom edge, and a longitudinal axis, said second load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a retention housing retaining said first and second load transfer members such that said longitudinal axes are positioned at an angle to the normal of the first surfaces of said first and second concrete elements;



wherein said top edges of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said bottom edges of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another; and

wherein said first and second load transfer members cause said first and second concrete elements to have at least partial composite structural behavior to resist in-service flexural shear loads.

51. The load transfer device of claim 50 wherein said first and second concrete elements are sandwich wall panel wythes.

52. The load transfer device of claim 51 wherein a layer of insulation is located between said first and second concrete elements.

53. The load transfer device of claim 52 wherein said retention housing is received by said insulation layer.

54. A sandwich wall panel comprising:  
a first concrete layer having a first surface nearest to a second concrete layer;  
said second concrete layer having a first surface nearest to said first concrete layer;  
an insulation layer located between said first concrete layer and said second concrete layer; and

at least one load transfer device connecting said first concrete layer to said second concrete layer and spanning said insulation layer comprising:

a first load transfer member having a first concrete engaging portion including a top edge, a second concrete engaging portion including a bottom edge, and a longitudinal axis, said first load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a second load transfer member having a first concrete engaging portion including a top edge, a second concrete engaging portion including a bottom edge, and a longitudinal axis, said second load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a retention housing received by said insulation layer and retaining said first and second load transfer members such that said longitudinal axes are positioned at an angle to the normal of the first surfaces of said first and second concrete elements;

wherein said top edges of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said bottom edges of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another; and

wherein said first and second load transfer members cause said first and second concrete layers to have at least partial composite structural behavior to resist in-service flexural shear loads.

55. A sandwich wall panel comprising:

a first concrete layer having a first surface nearest to a second concrete layer;  
said second concrete layer having a first surface nearest to said first concrete layer;  
an insulation layer located between said first concrete layer and said second concrete layer; and

at least one load transfer device connecting said first concrete layer to said second concrete layer and spanning said insulation layer comprising:

a first load transfer member having a first concrete engaging portion including a top edge, a second concrete engaging portion including a bottom edge, and a longitudinal axis, said first load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

a second load transfer member having a first concrete engaging portion including a top edge, a second concrete engaging portion including a bottom edge,

and a longitudinal axis, said second load transfer member only in contact with said first and second concrete elements at said first and second concrete engaging portions respectively;

said longitudinal axes positioned at an angle to the normal of the first surfaces of said first and second concrete elements;

wherein said top edges of said first and second load transfer members are embedded in said first concrete element in a spaced relationship with one another and said bottom edges of said first and second load transfer members are embedded in said second concrete element in a spaced relationship with one another; and

wherein said first and second load transfer members cause said first and second concrete layers to have at least partial composite structural behavior to resist in-service flexural shear loads.

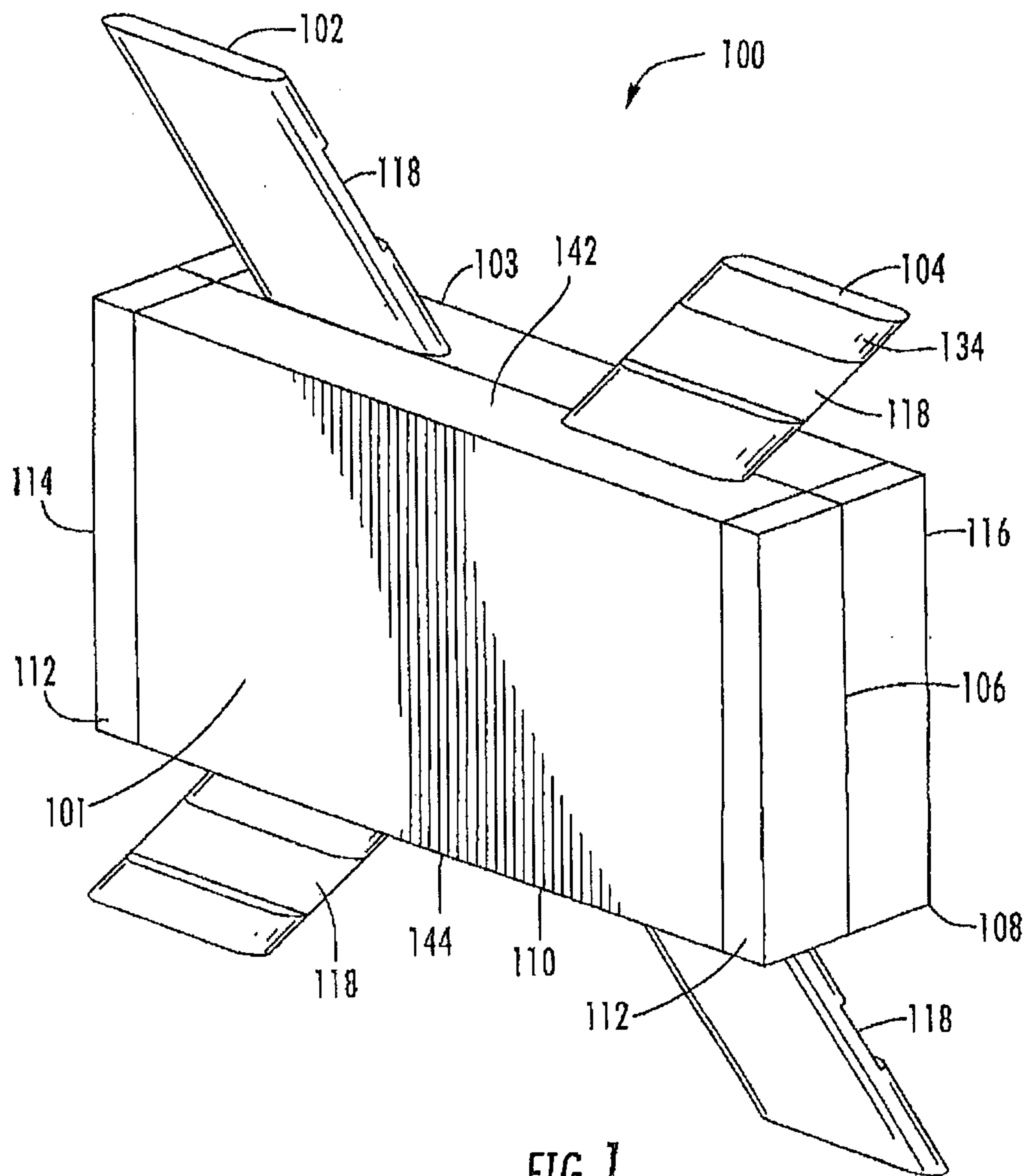
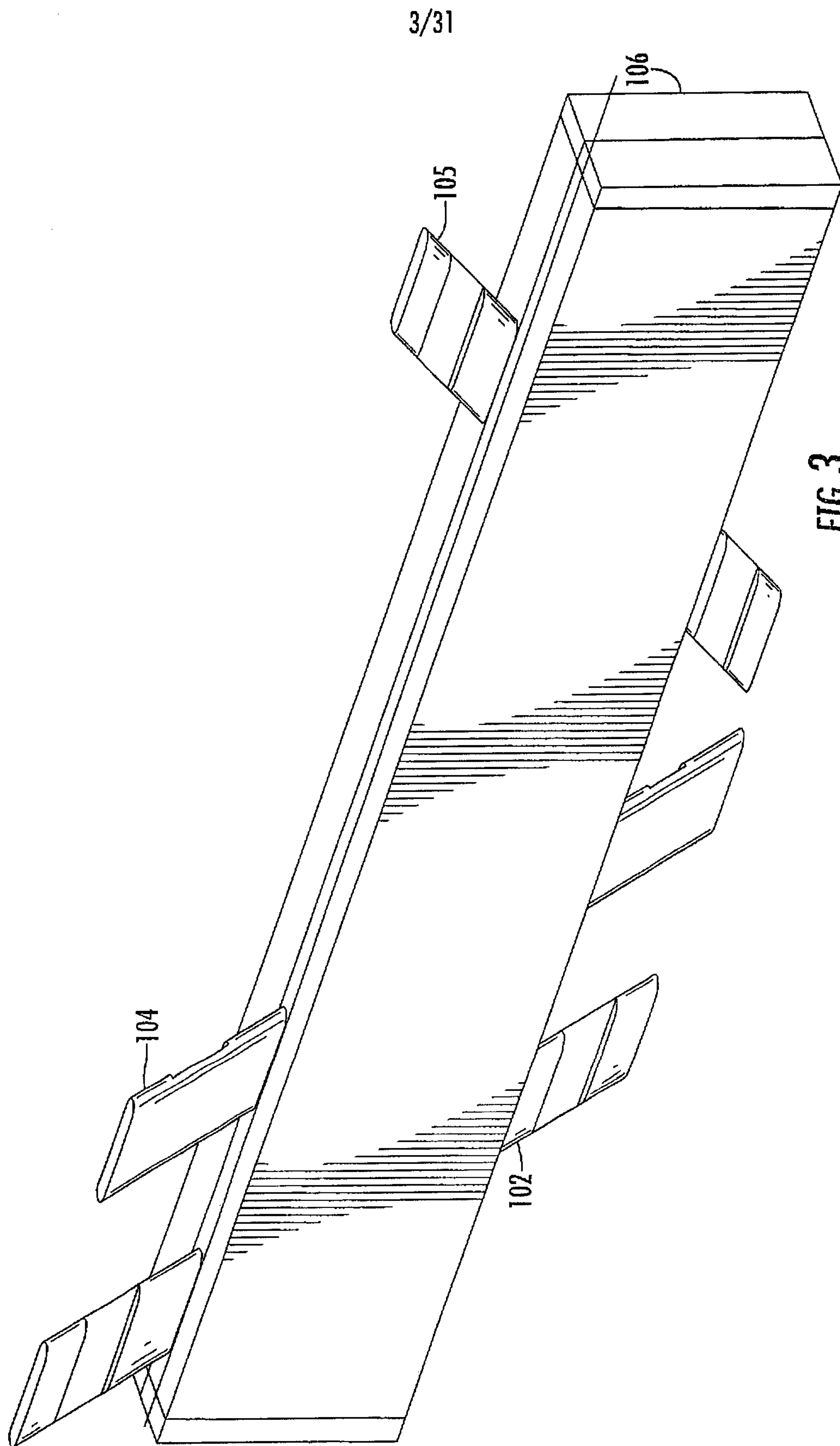


FIG. 1





4/31

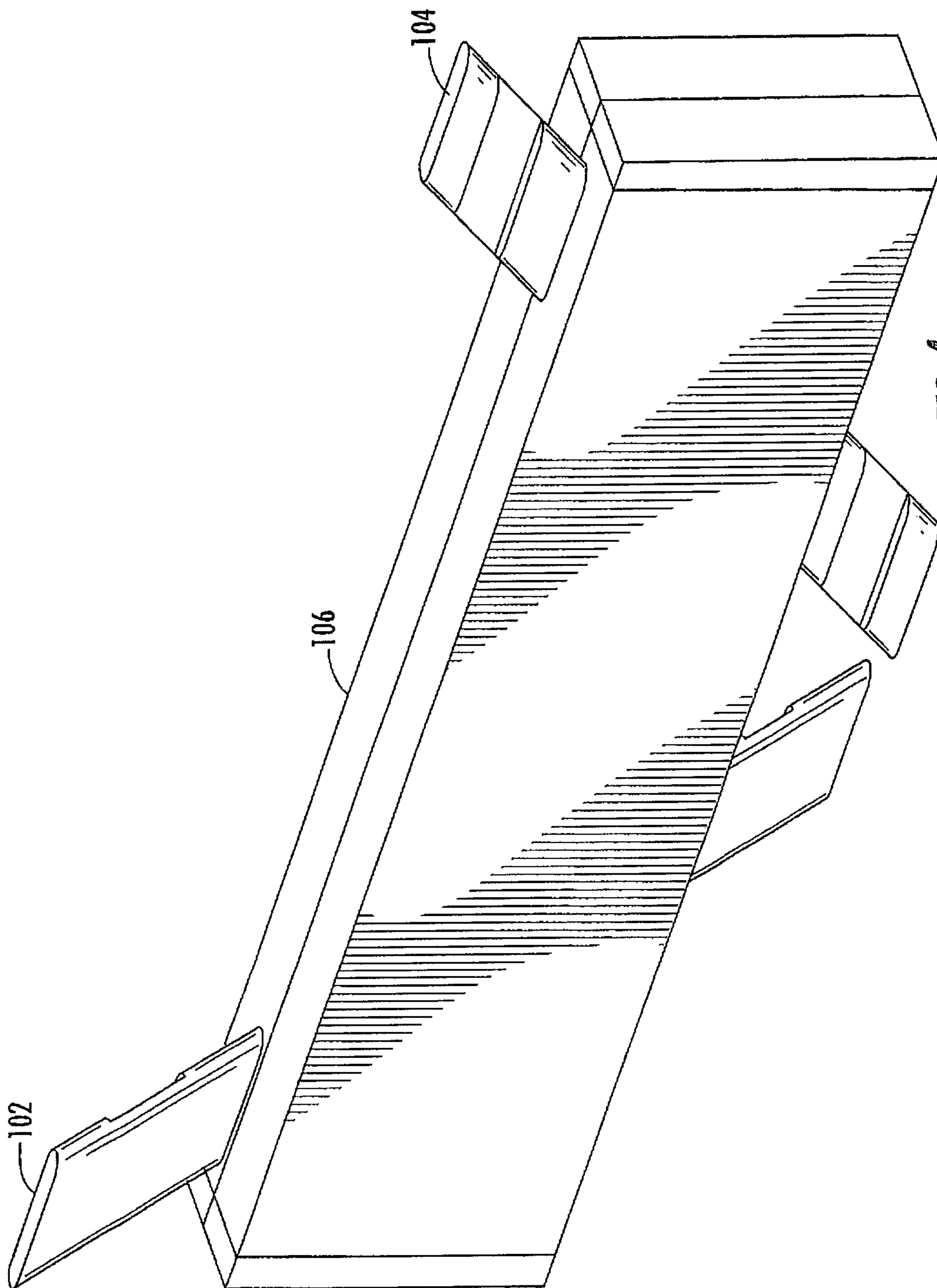


FIG. 4

5/31

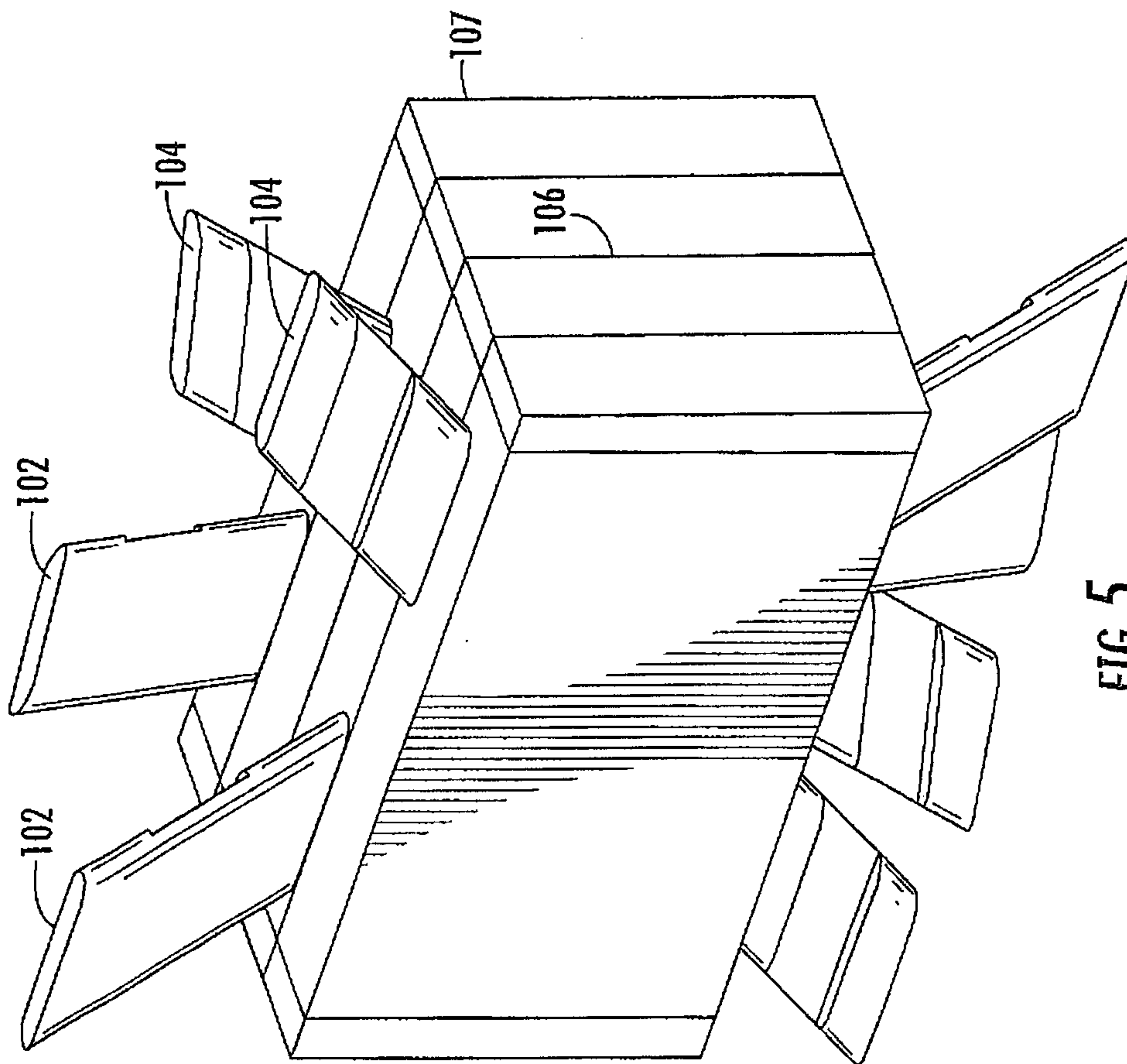
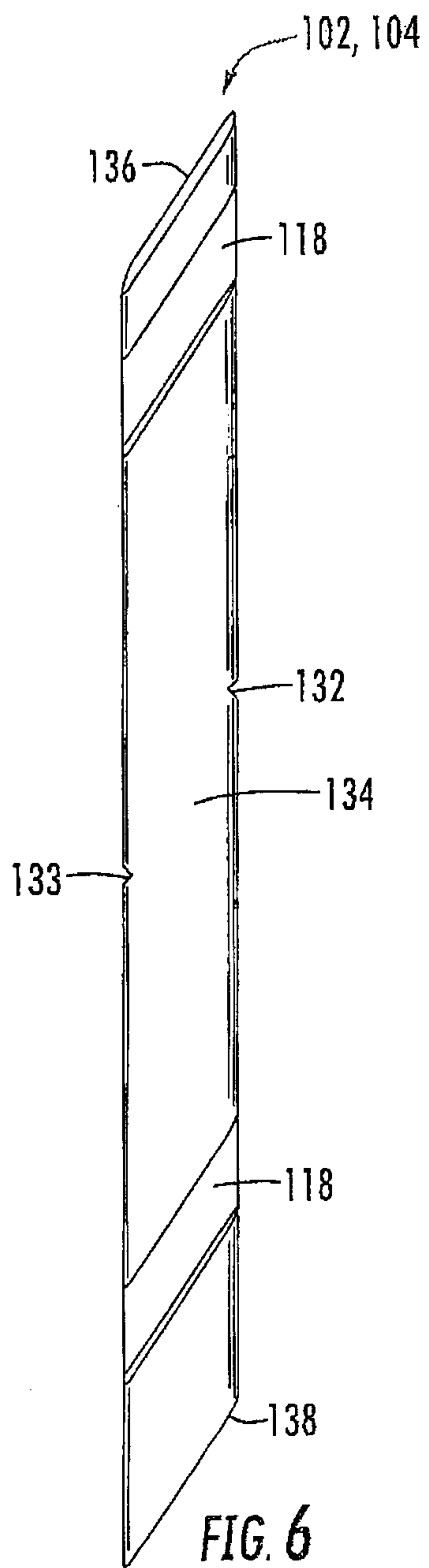


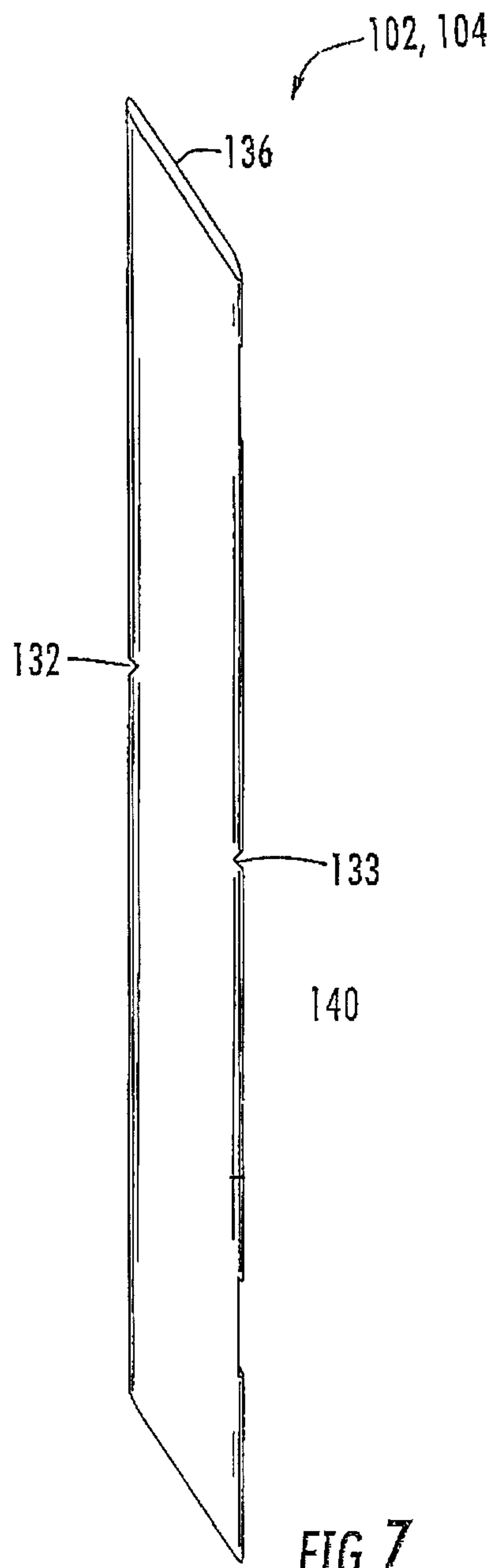
FIG. 5



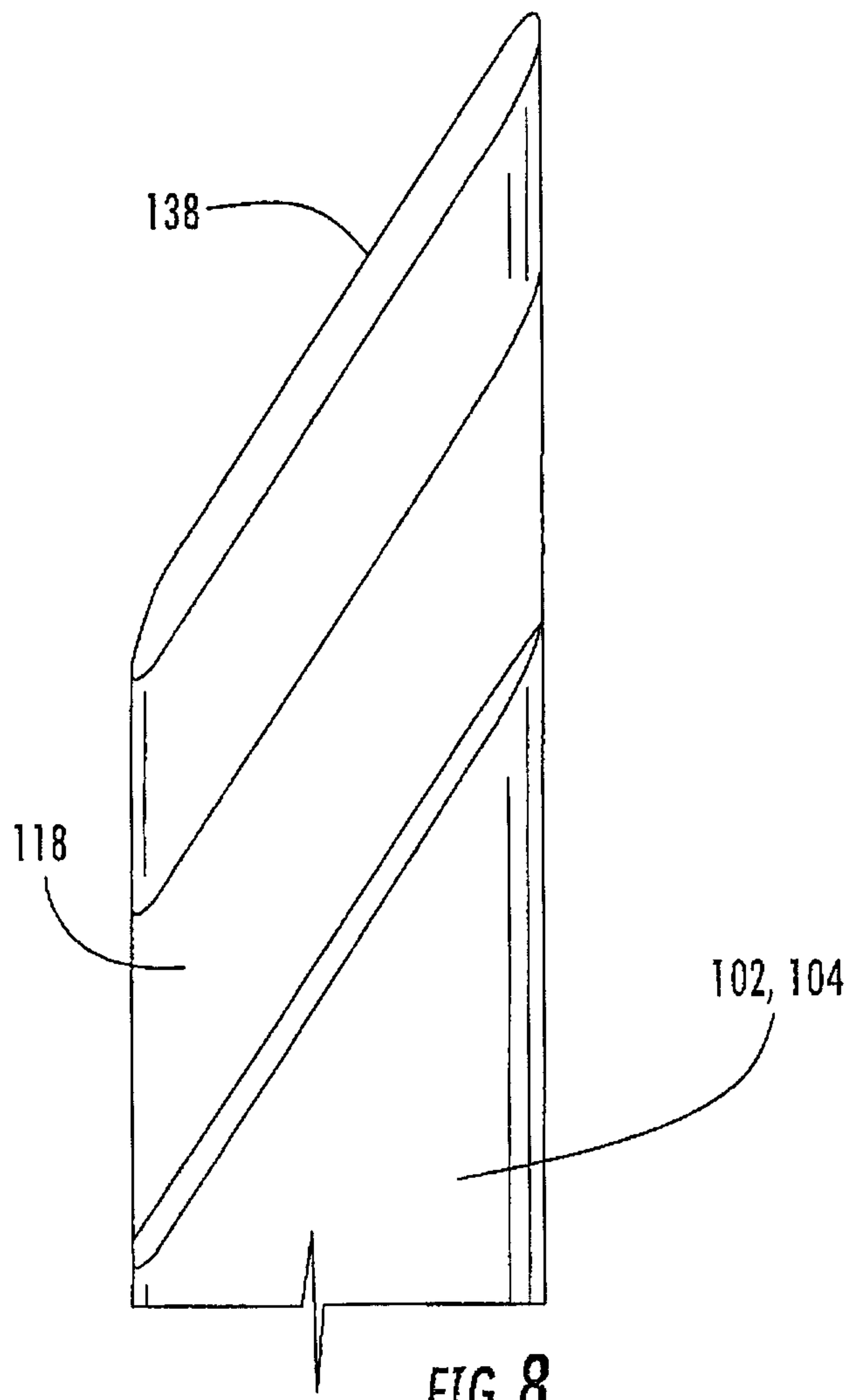
6/31



7/31



8/31



9/31

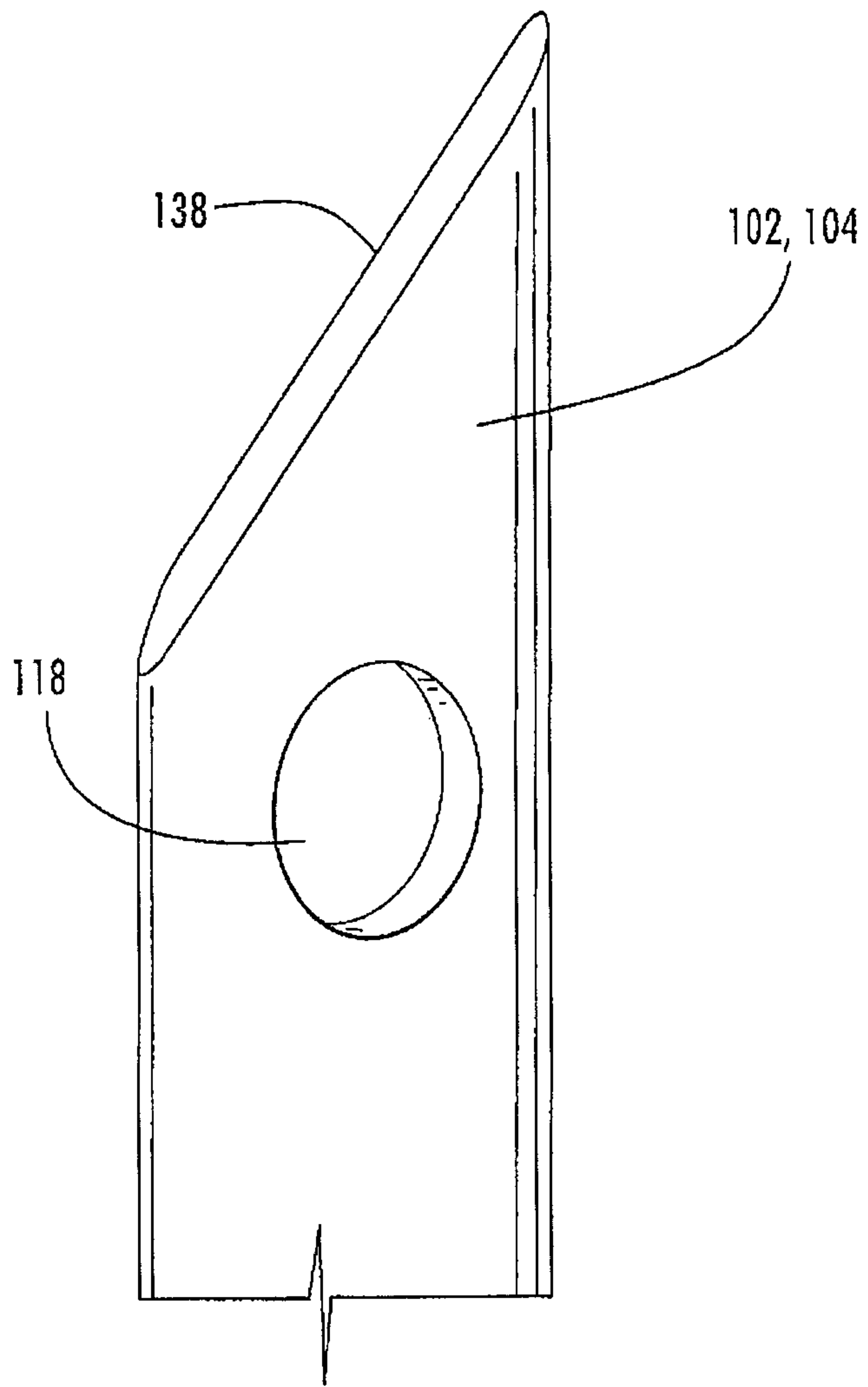


FIG. 9

10/31

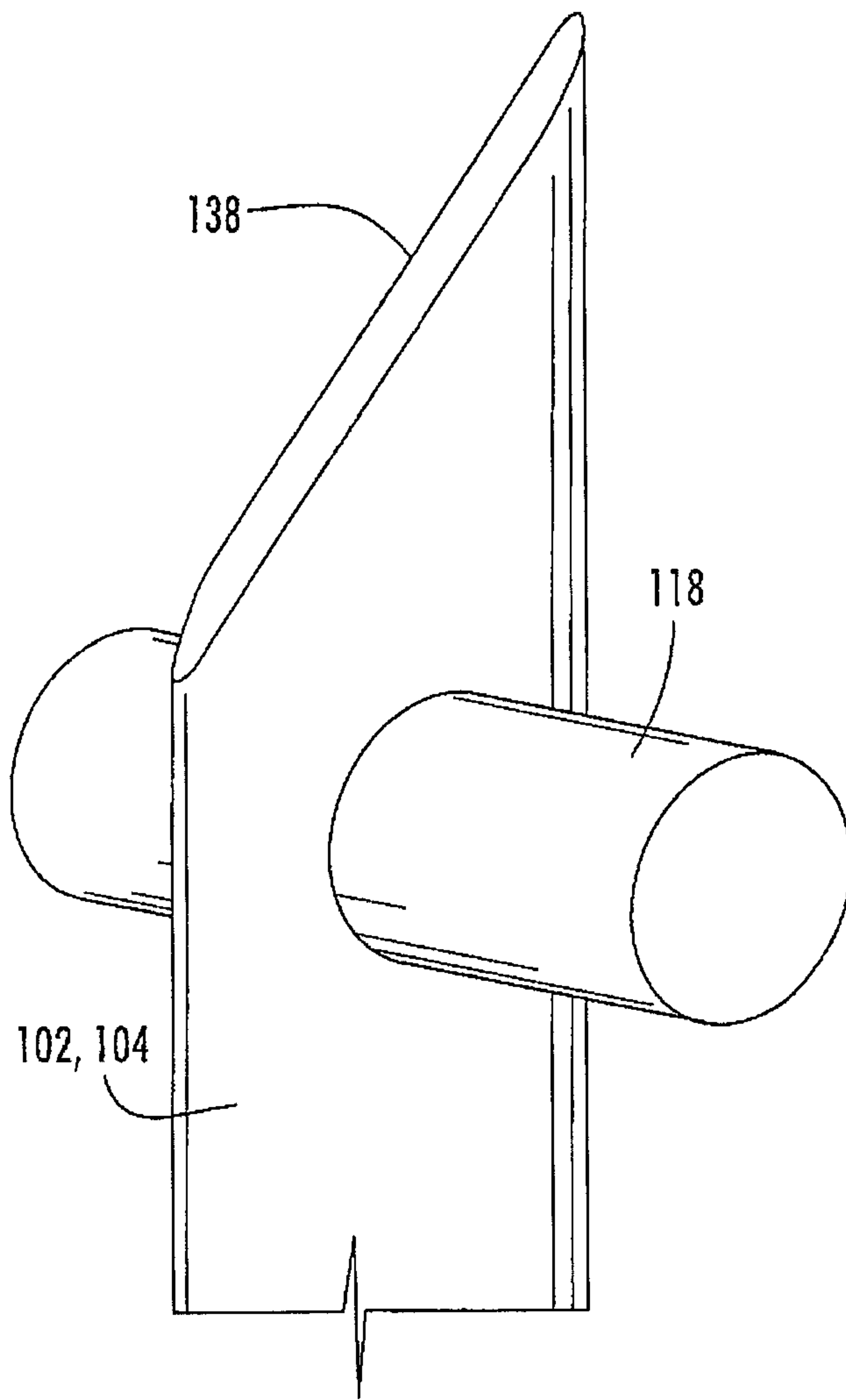
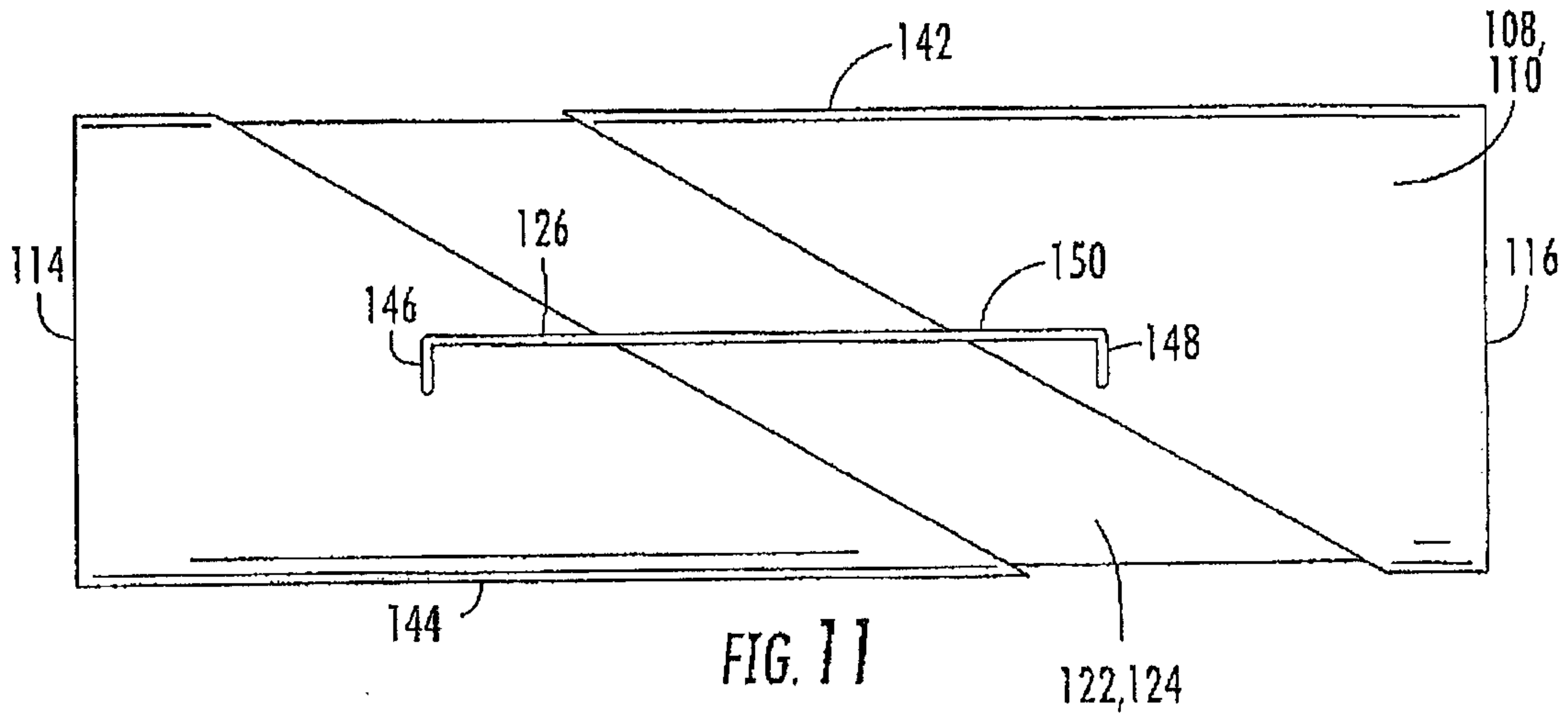
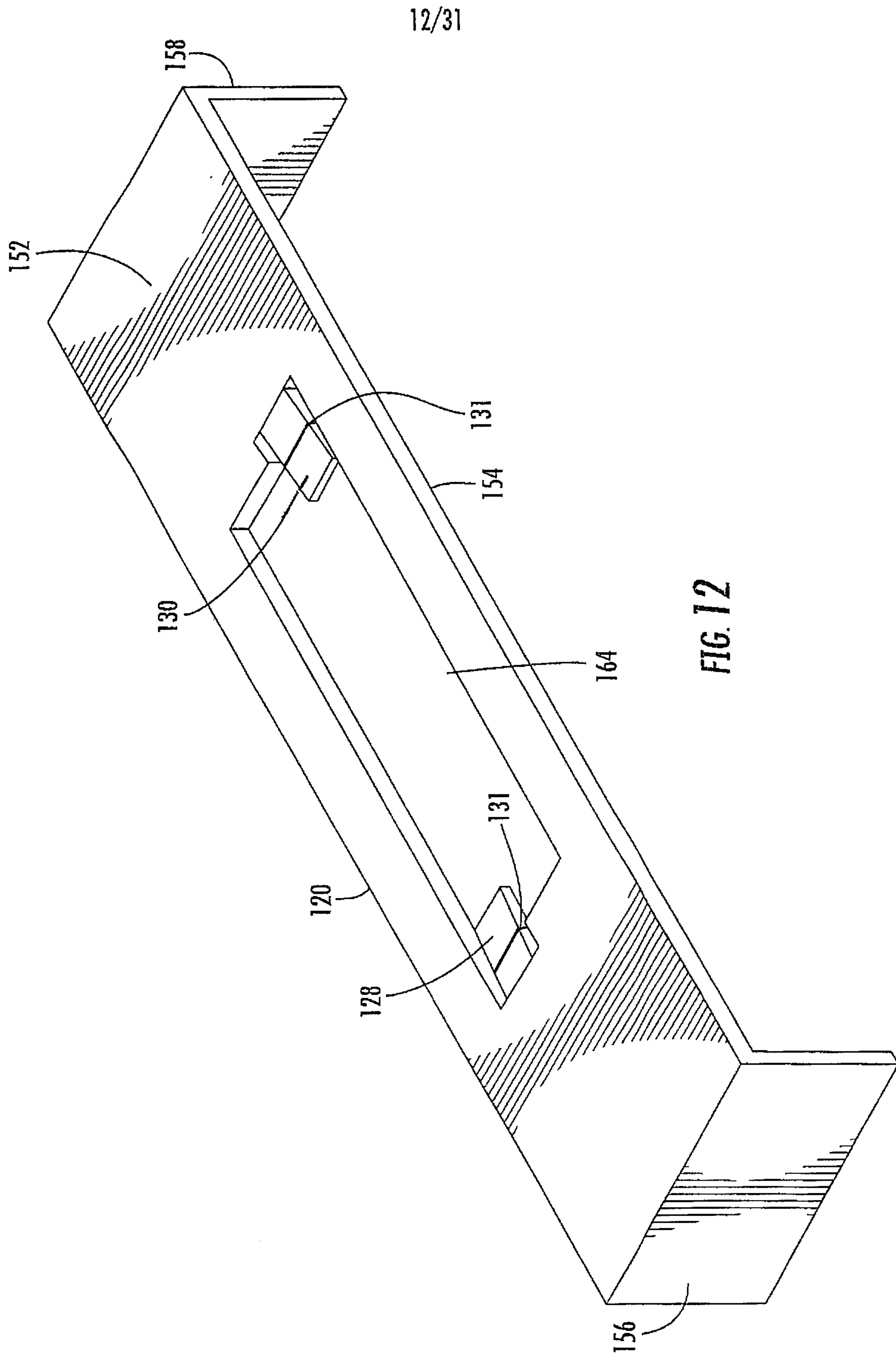


FIG. 10

11/31





12/31

FIG. 12

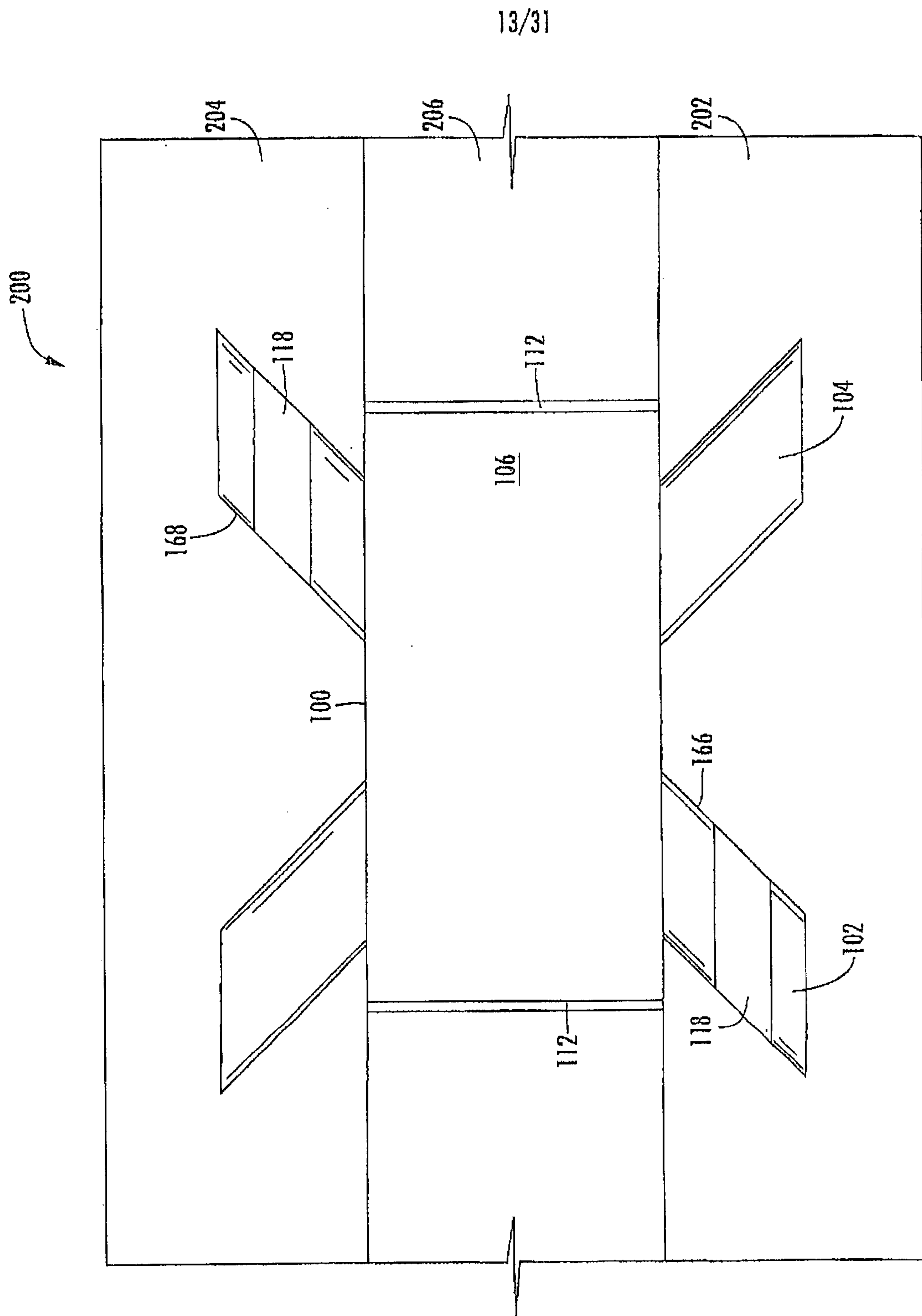


FIG. 13



14/31

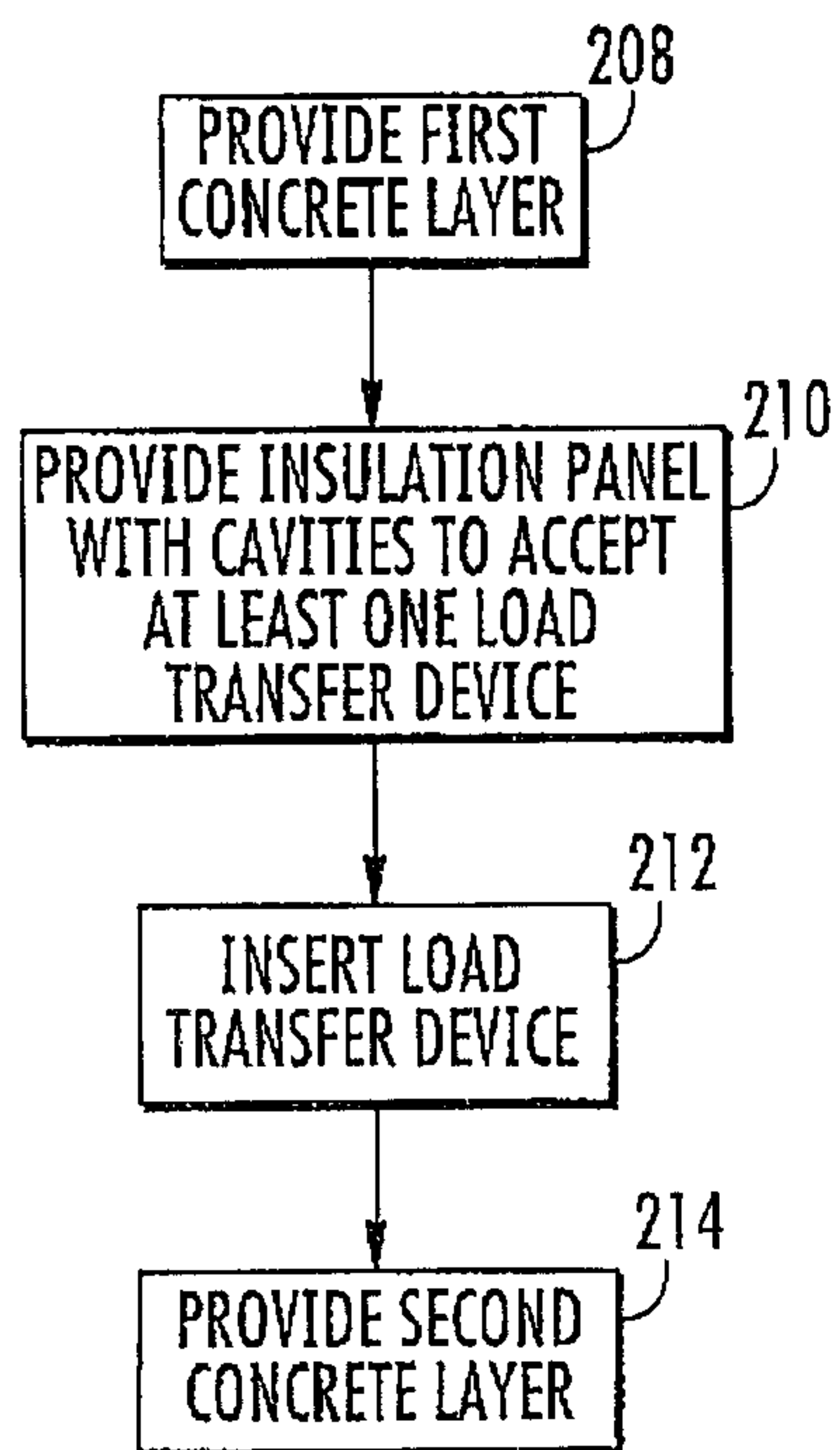


FIG. 14

15/31

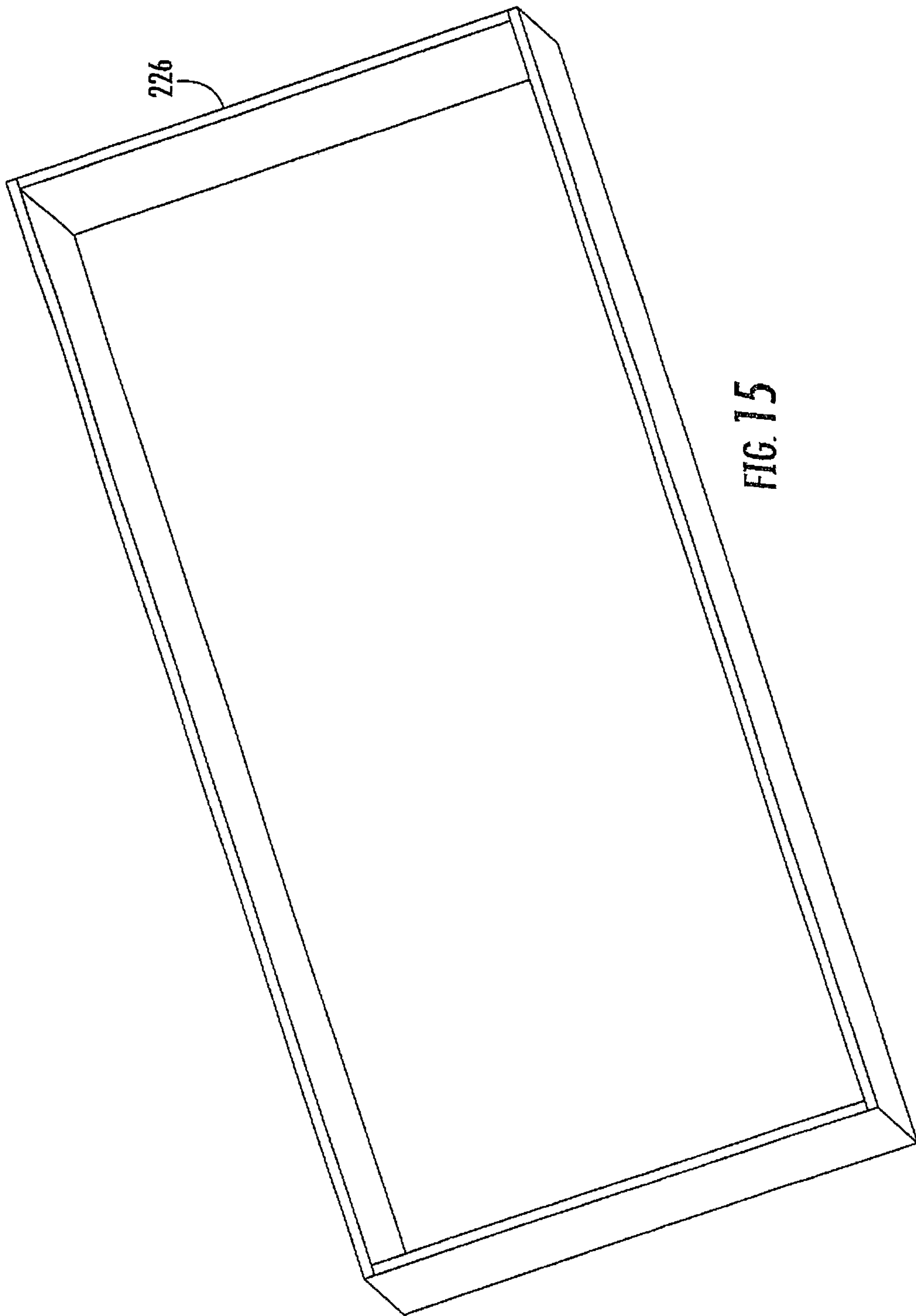


FIG. 15

16/31

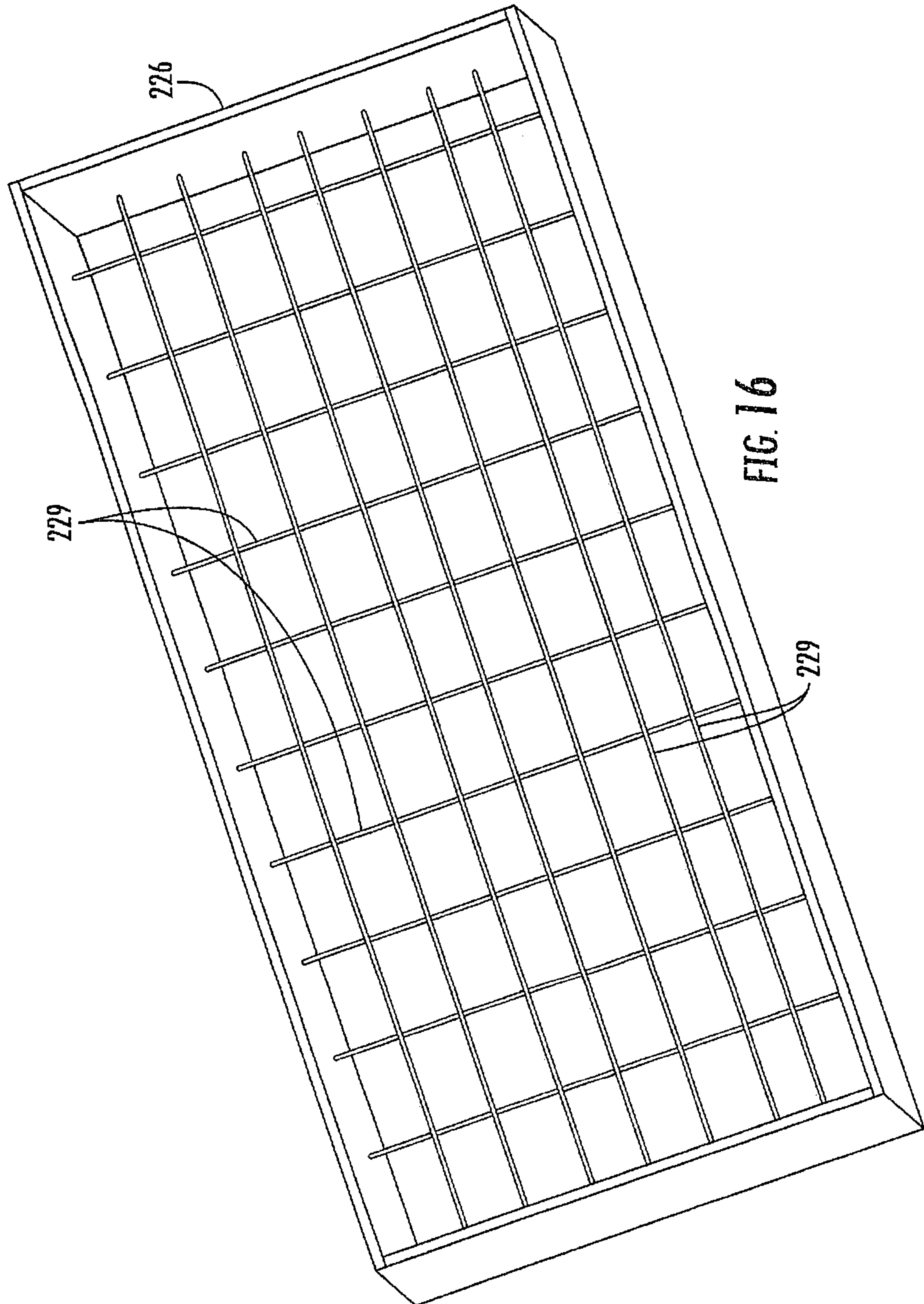


FIG. 16

17/31

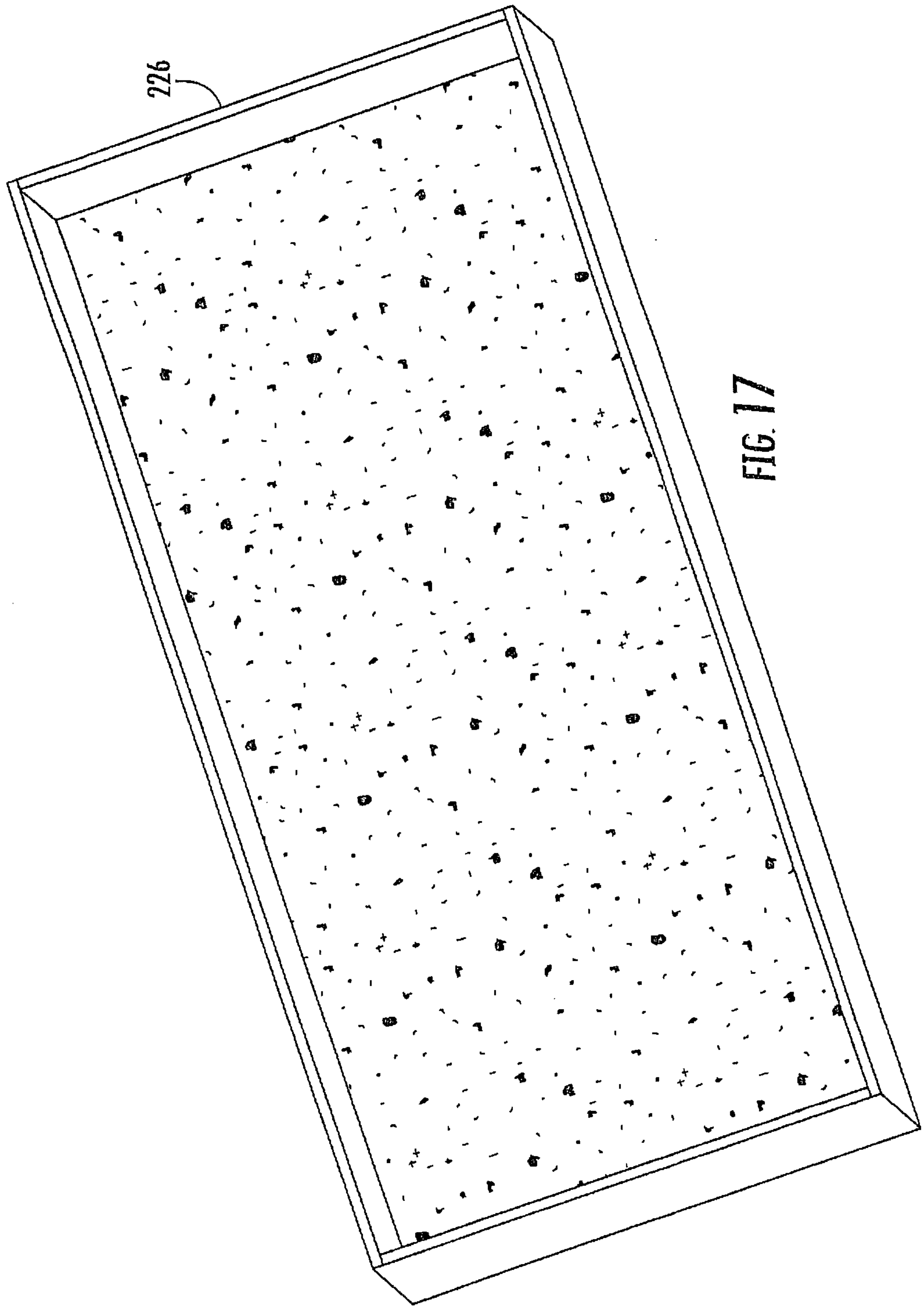


FIG. 17

18/31

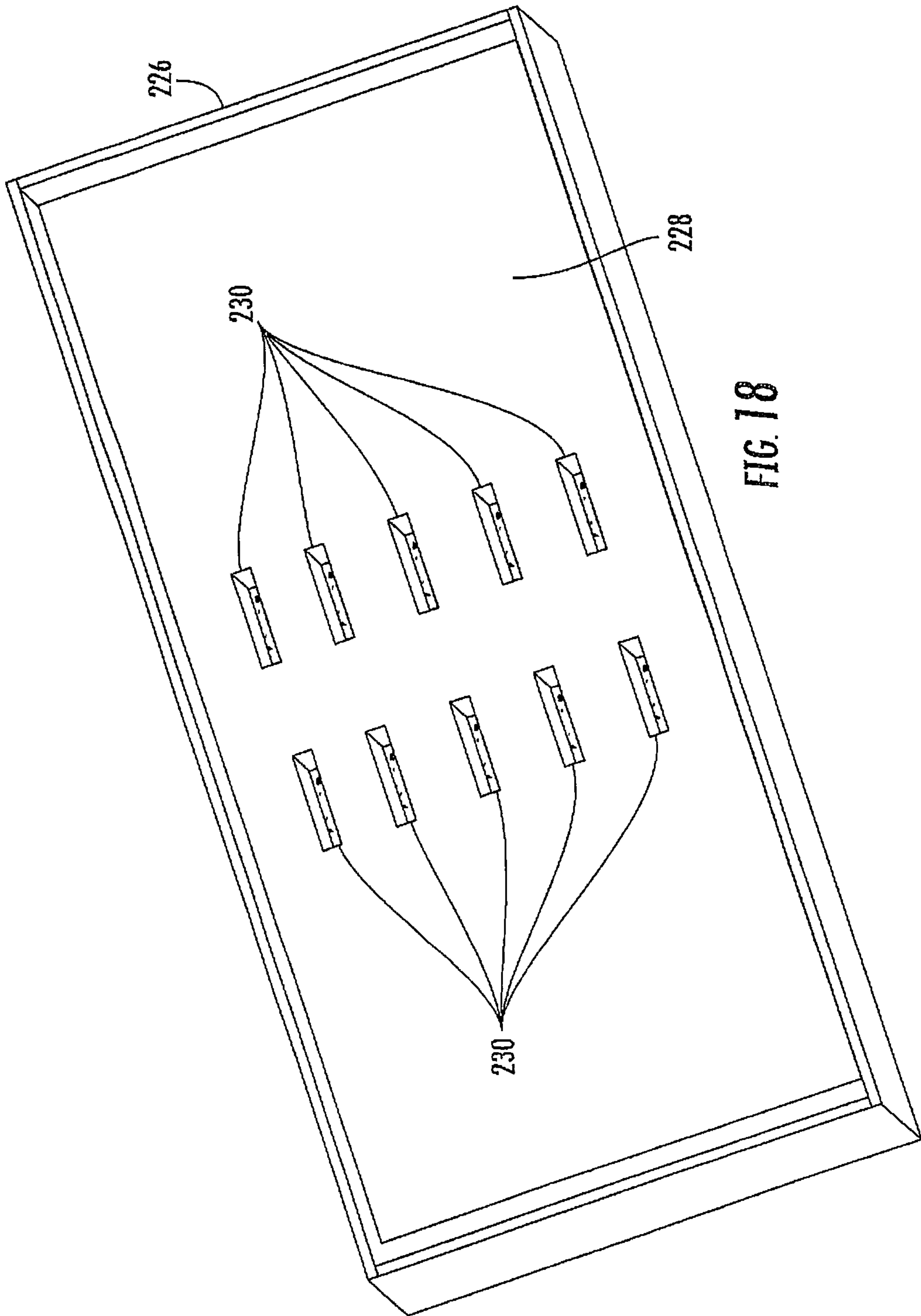


FIG. 18

19/31

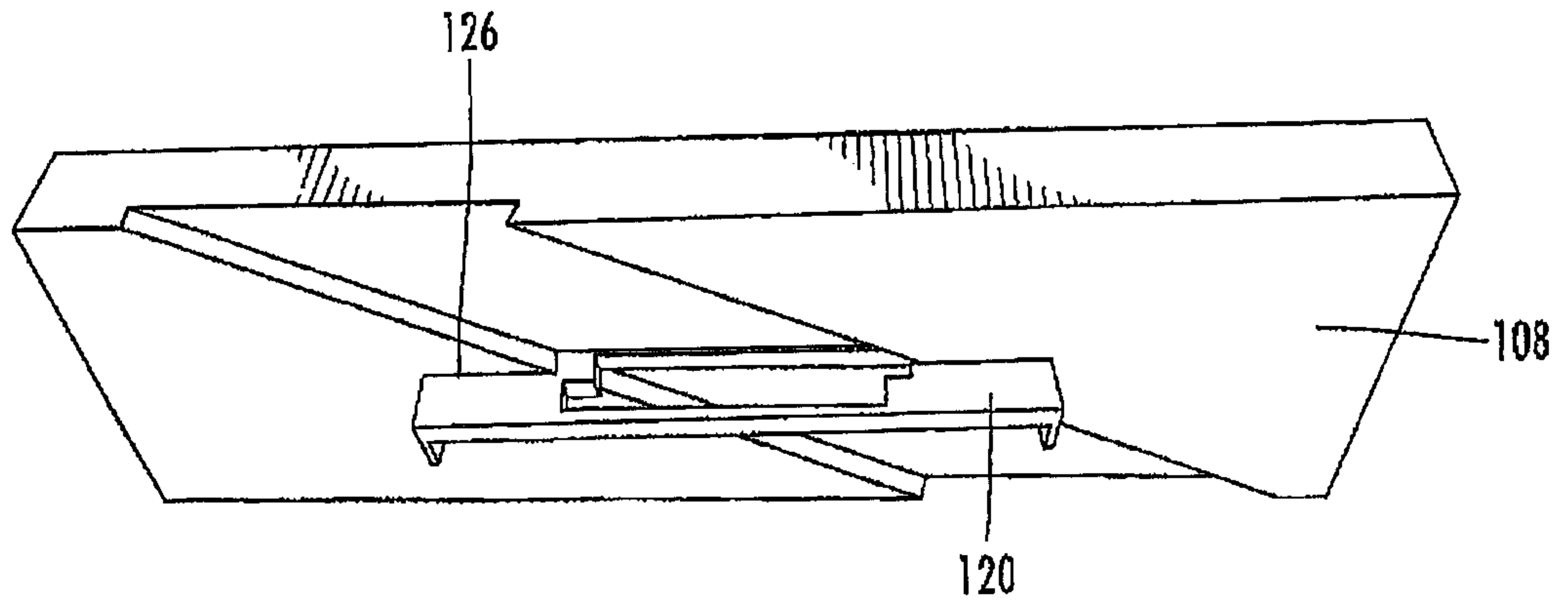


FIG. 19

20/31

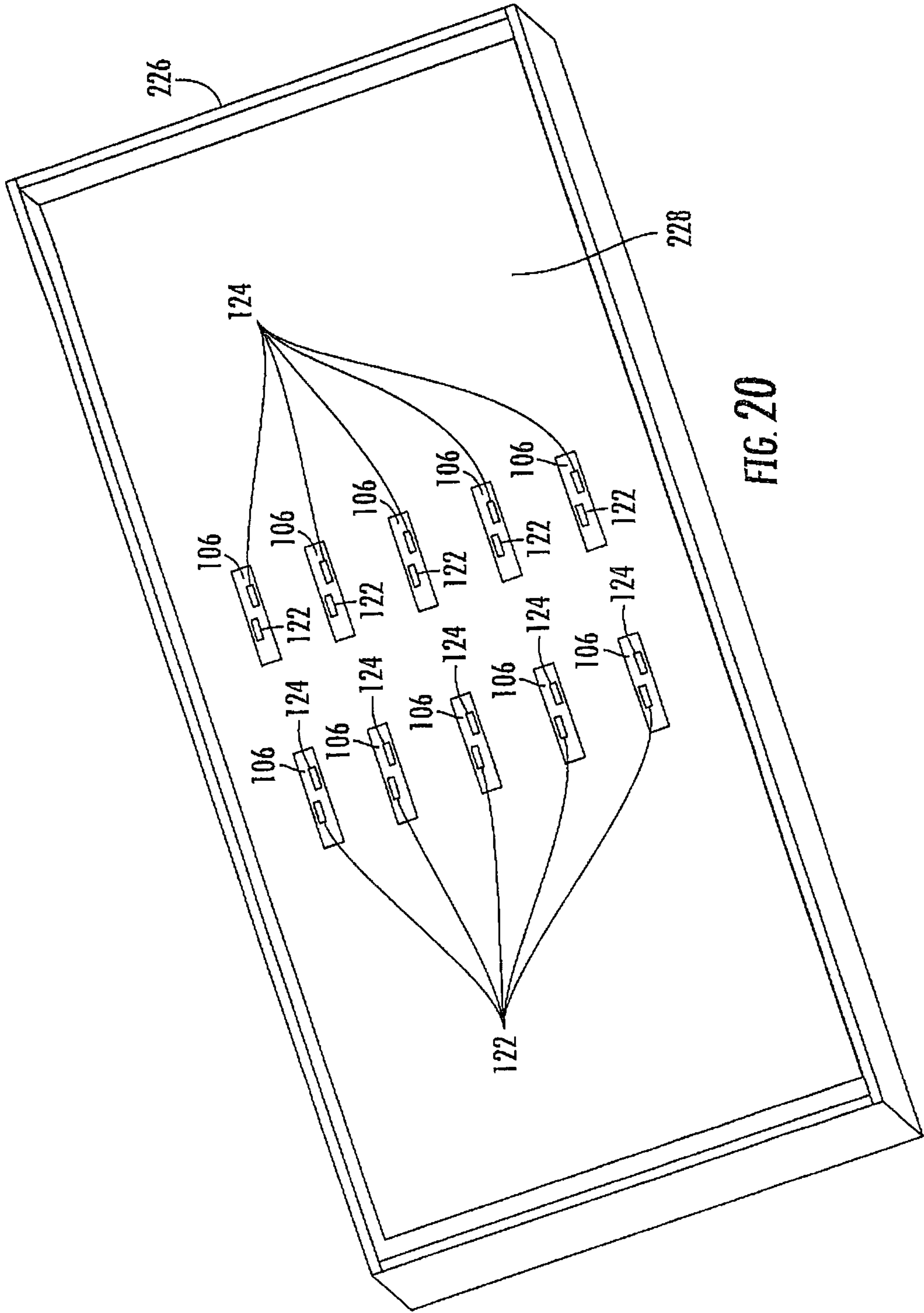


FIG. 20

21/31

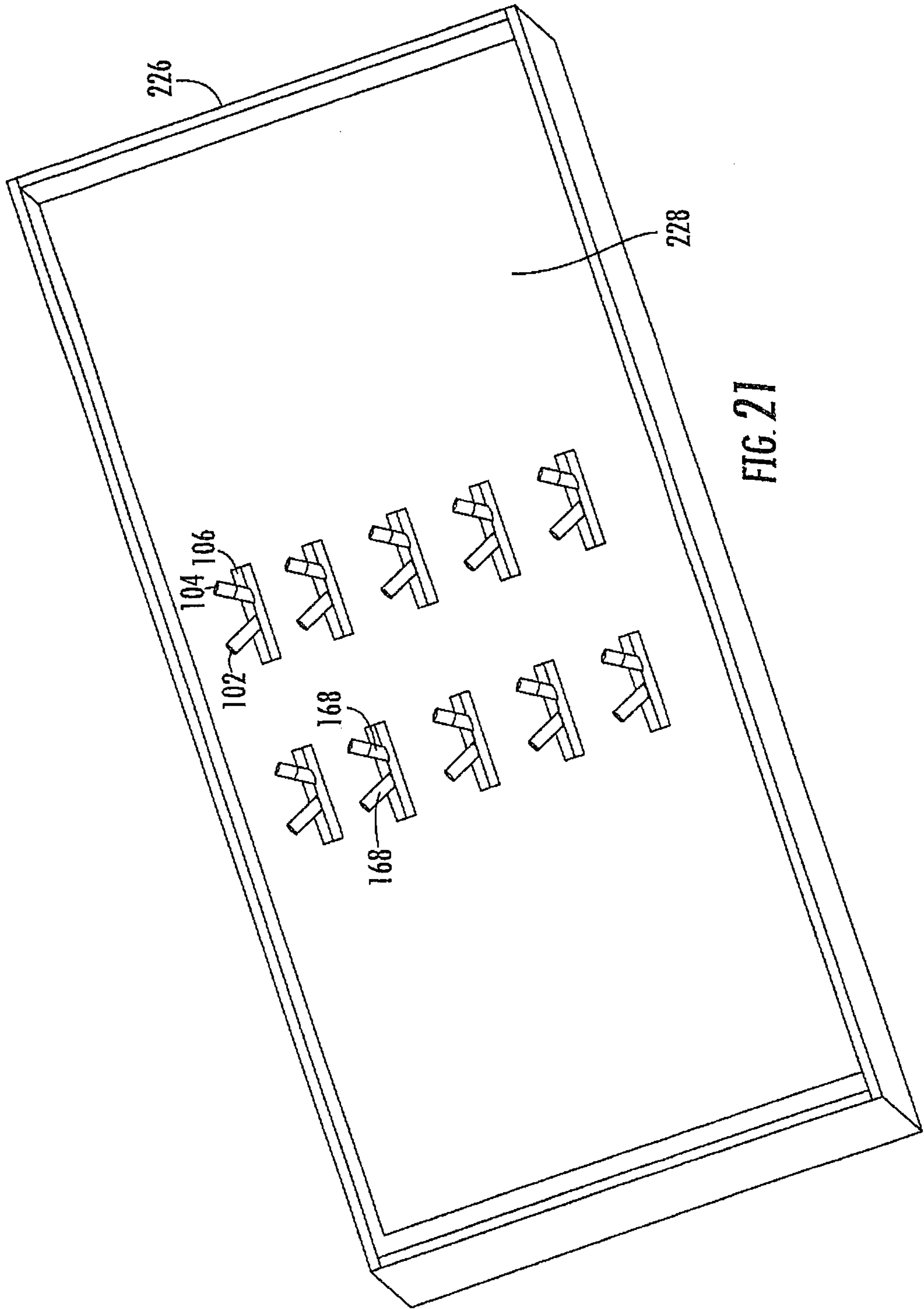


FIG. 21



22/31

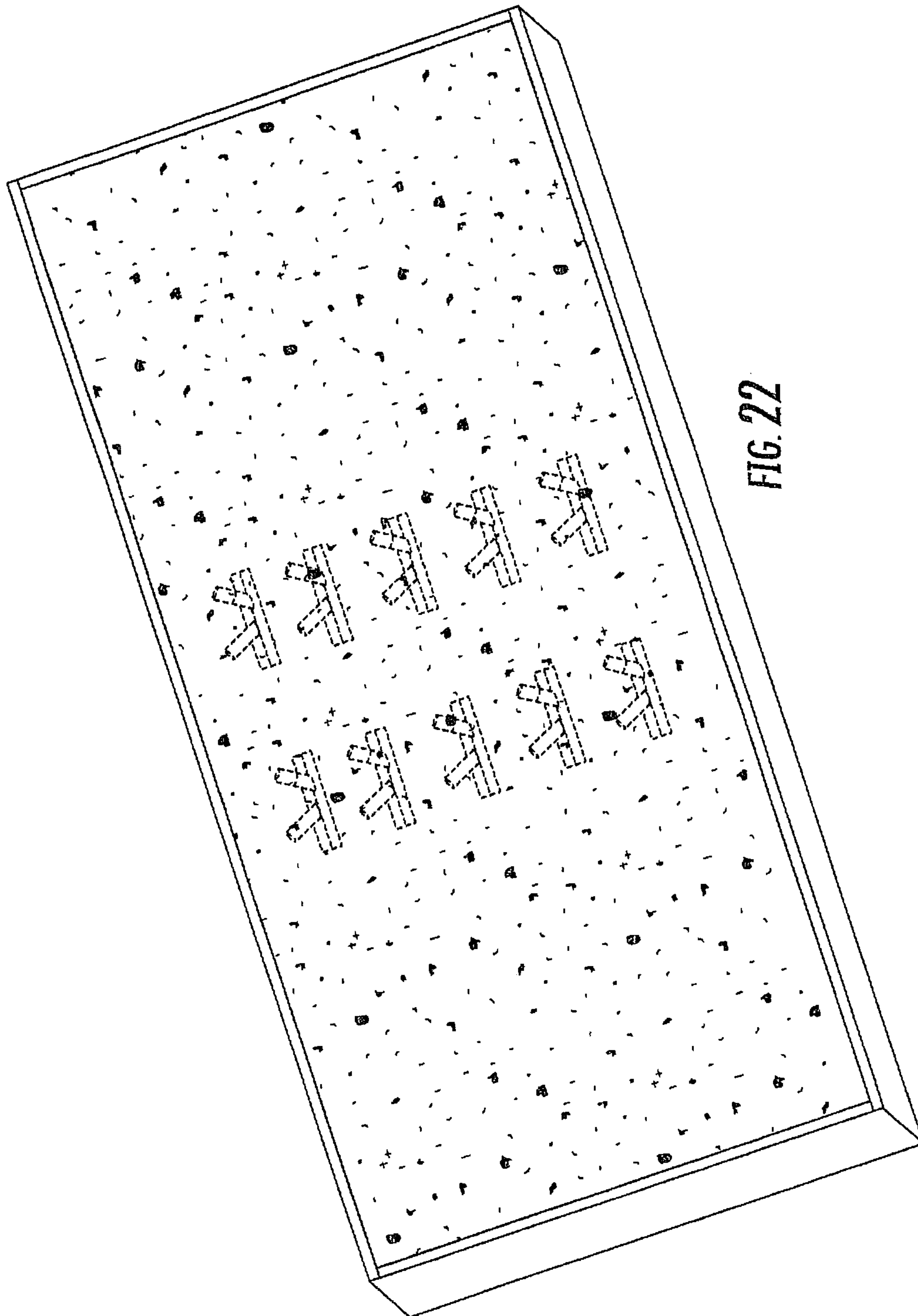


FIG. 22

23/31

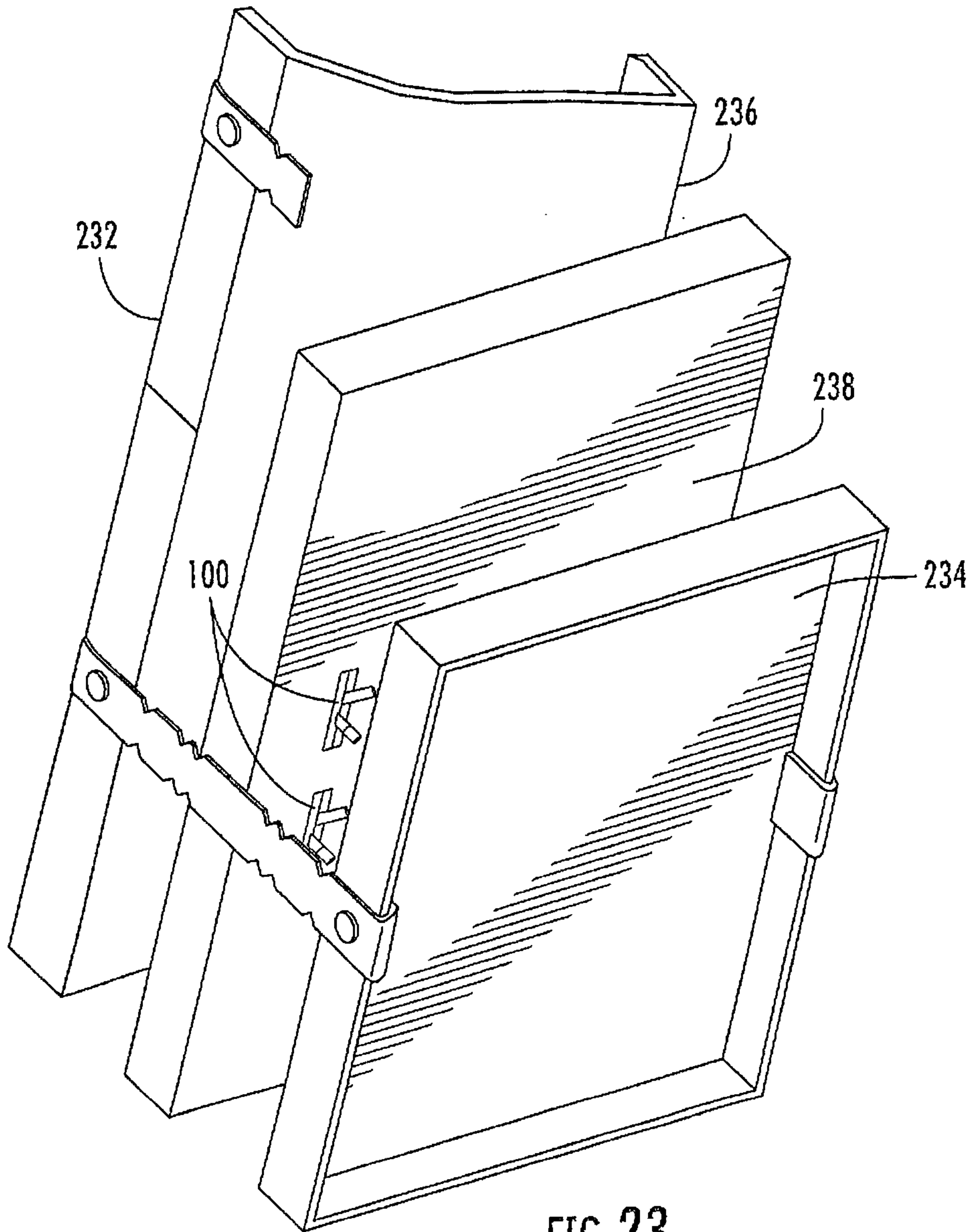


FIG. 23

24/31

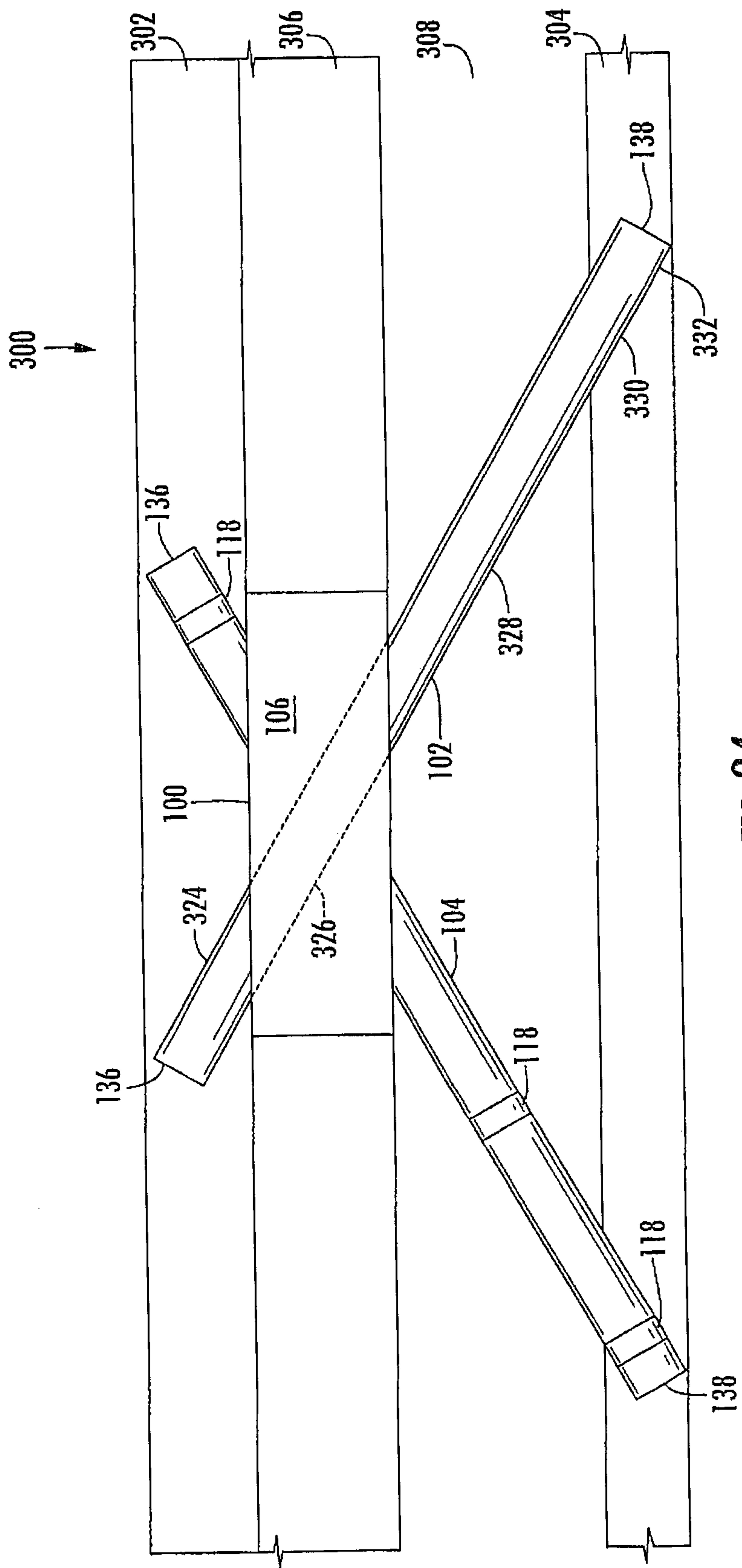


FIG. 24

25/31

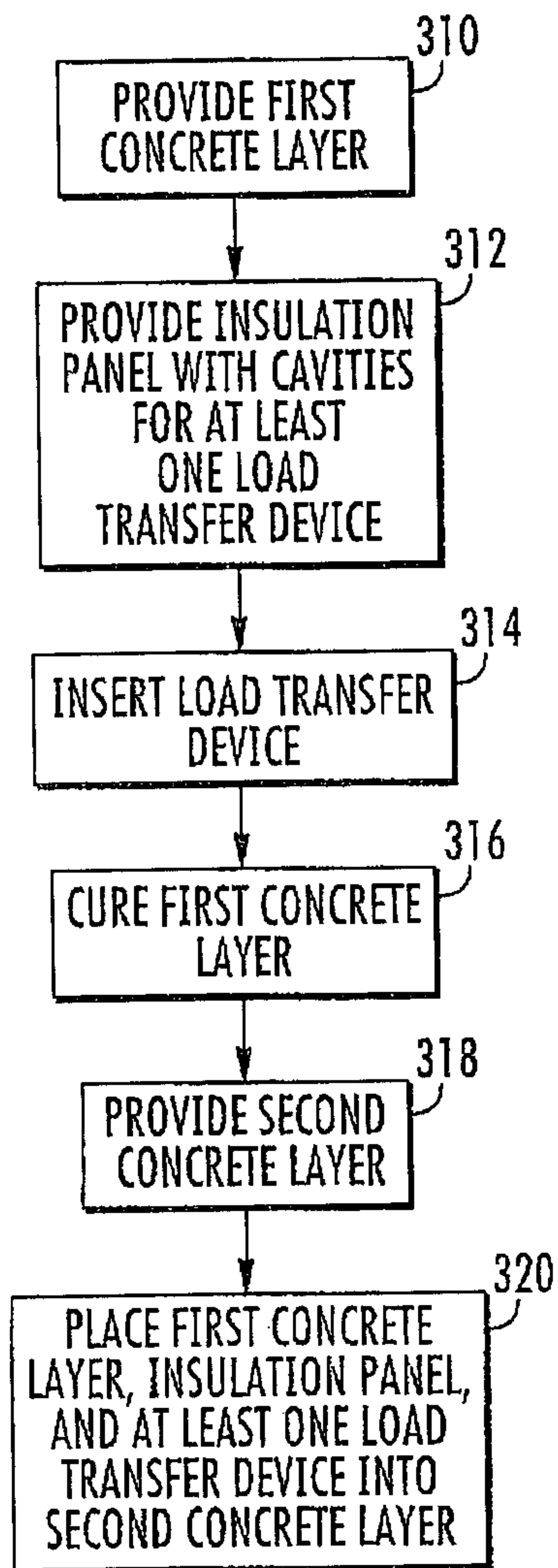


FIG. 25

26/31

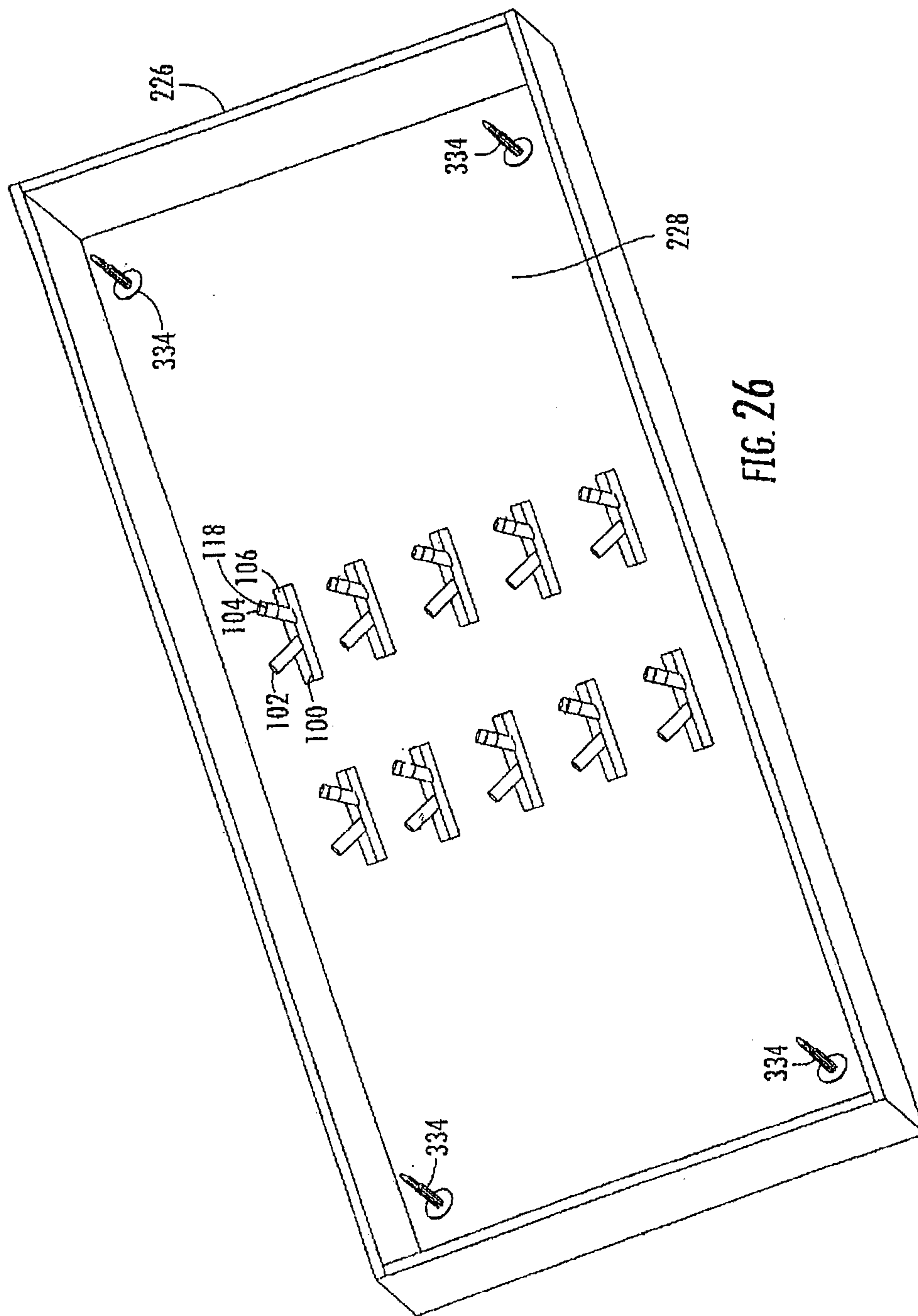


FIG. 26

27/31

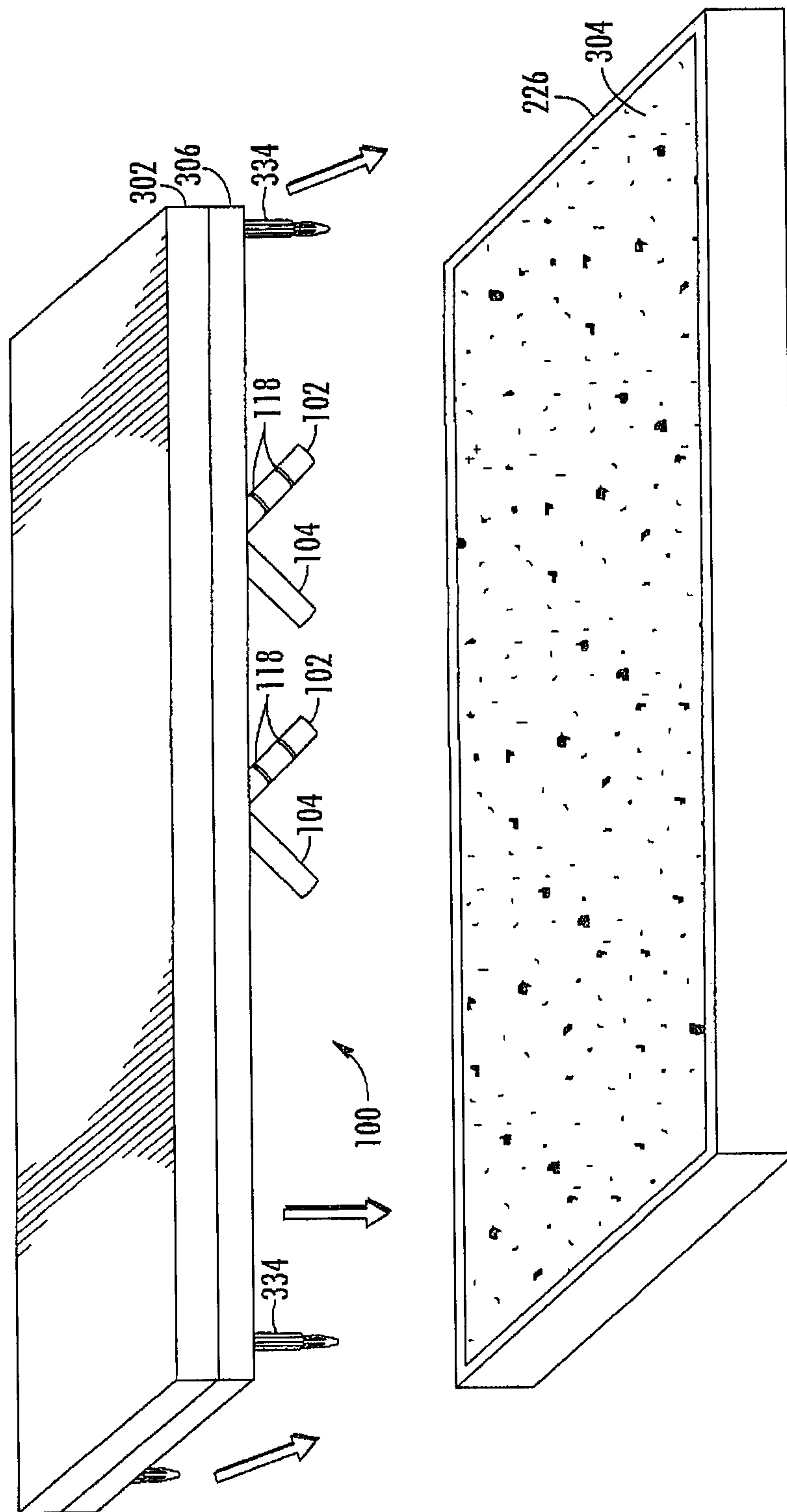


FIG. 27

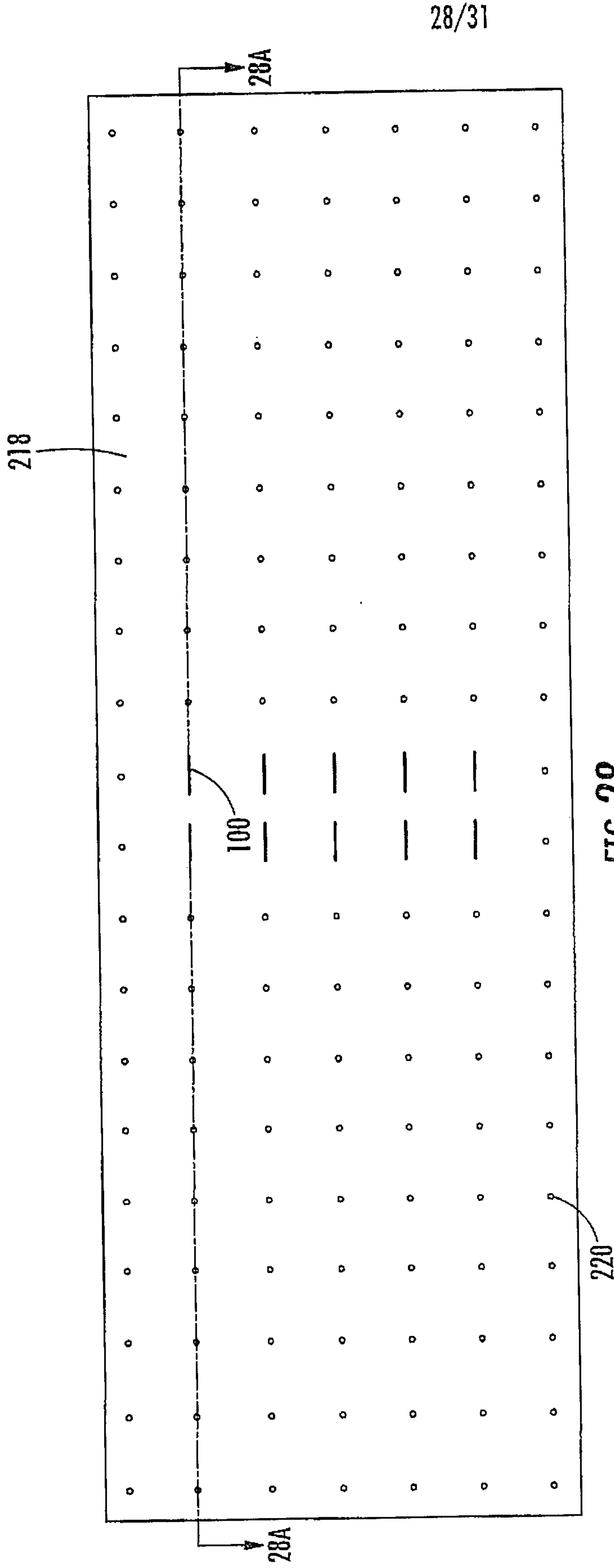


FIG. 28

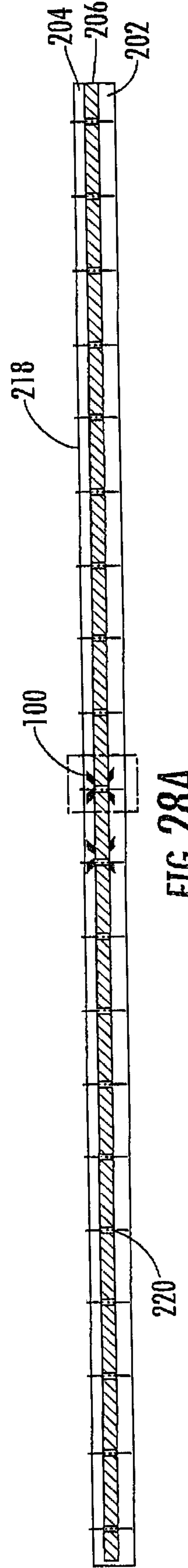


FIG. 28A

29/31

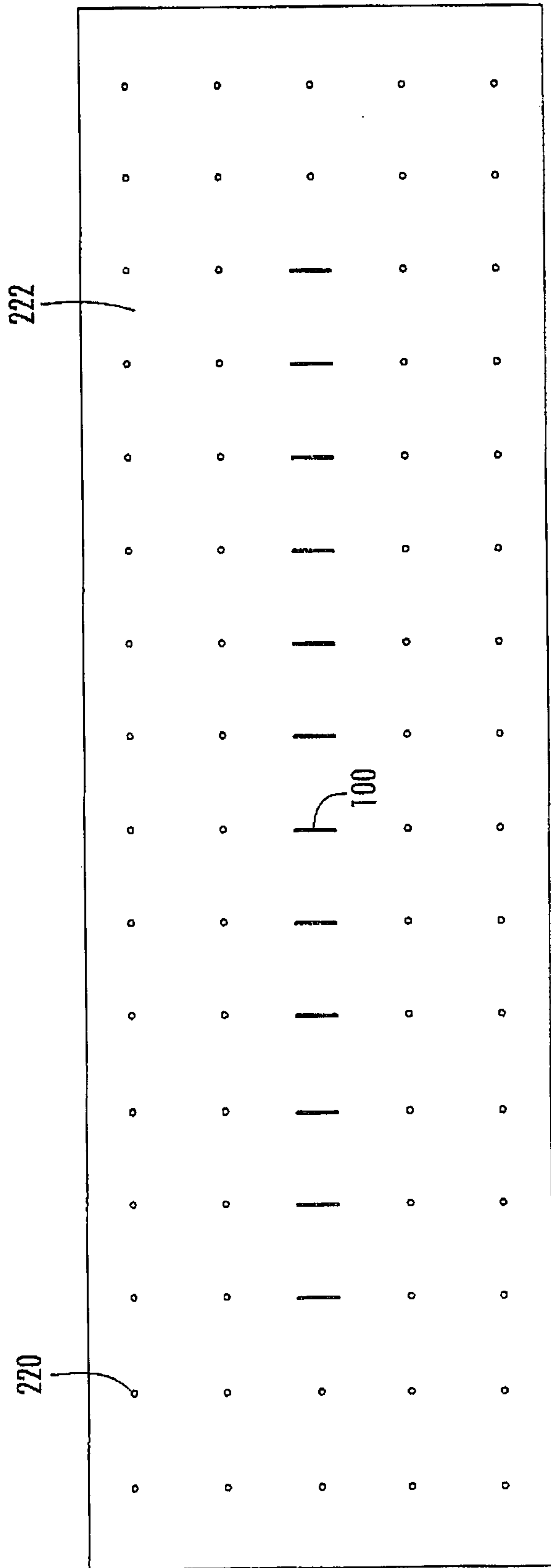


FIG. 29



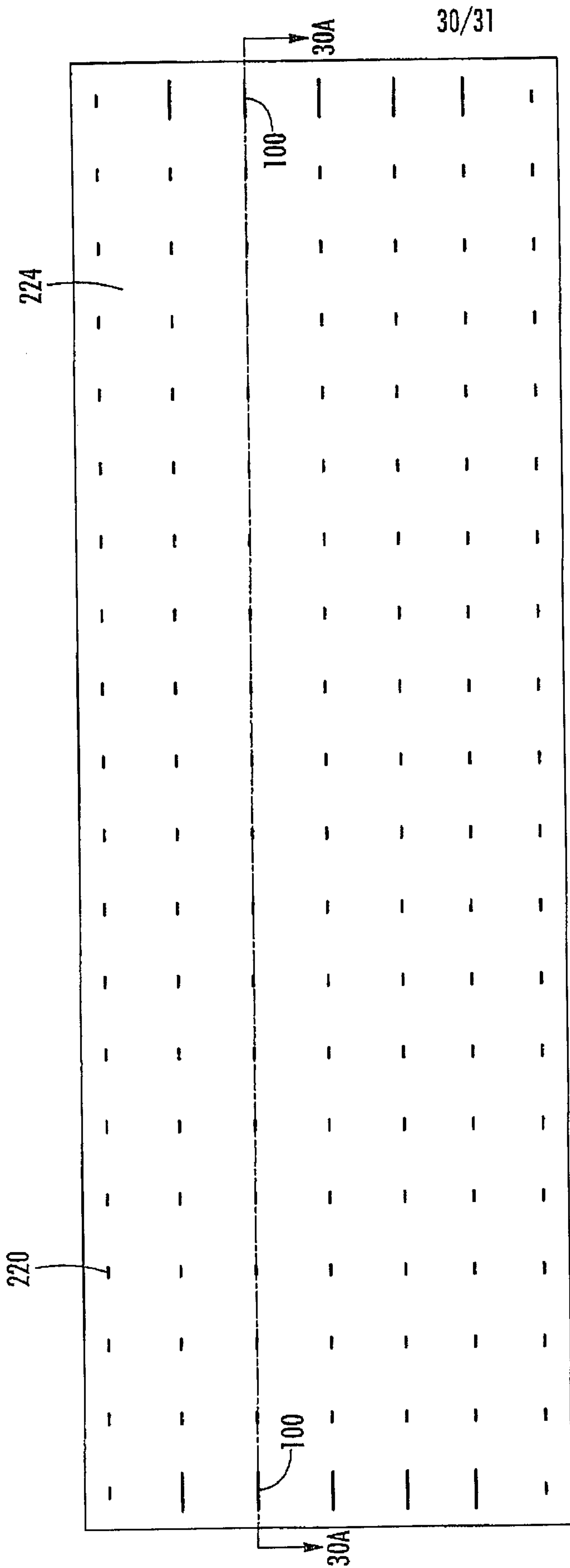


FIG. 30

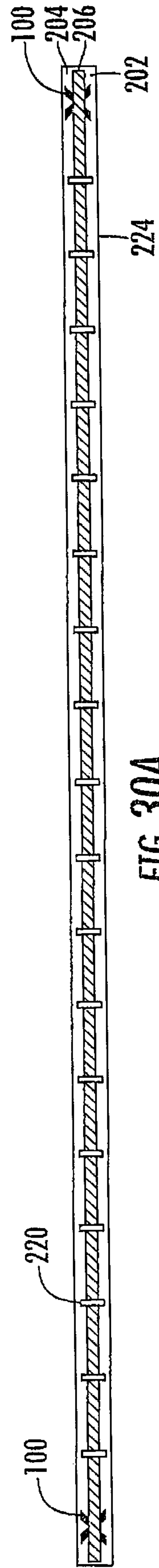


FIG. 30A

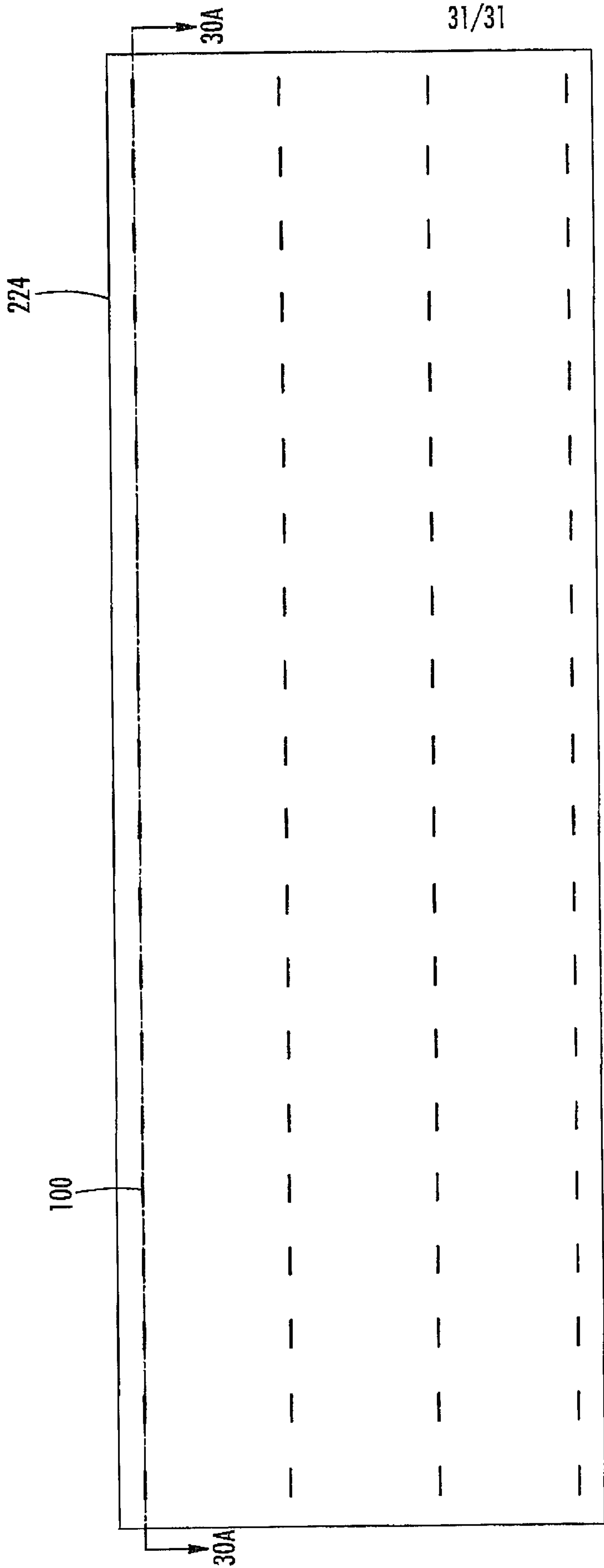


FIG. 31

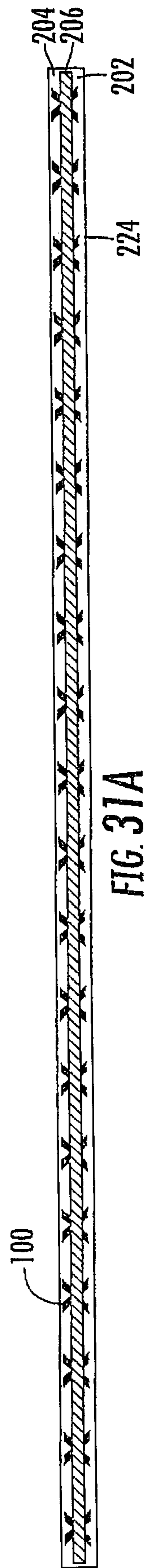


FIG. 31A

