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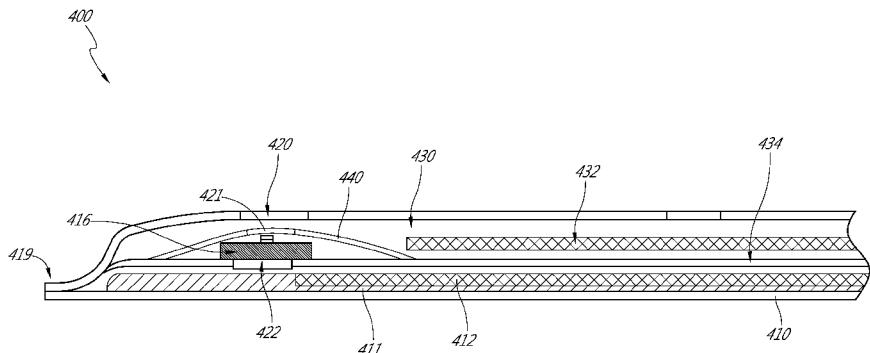


FIG. 4

(57) Abstract: Disclosed embodiments relate to apparatuses for wound treatment. In certain embodiments, a negative pressure wound therapy apparatus includes one or more electronic components configured to be incorporated into layers of the wound dressing or integrated on top of the wound dressing. In some embodiments, a negative pressure source is incorporated into the wound dressing. The negative pressure source can be sealed between two moisture vapor permeable cover layers or enclosed in a moisture vapor permeable pouch, and may be received in a recess of an absorbent layer or spacer layer of a wound dressing apparatus.

## REDUCED PRESSURE APPARATUSES

### CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims the benefit of U.S. Provisional Application No. 62/153483, filed April 27, 2015, and U.S. Provisional Application No. 62/154078, filed April 28, 2015, the entireties of both of which are hereby incorporated by reference.

### BACKGROUND

#### Field

**[0002]** Embodiments described herein relate to apparatuses, systems, and methods for the treatment of wounds, for example using dressings in combination with negative pressure wound therapy.

#### Background

**[0003]** Prior art dressings for use in negative pressure have included a negative pressure source located in a remote location from the wound dressing. Having a remote negative pressure source such as a pump can be inconvenient to a user, who must find a place to locate the negative pressure source and must deal with the inconvenience of having tubing or other components connecting the negative pressure source with the wound dressing. Attempts have been made to incorporate a negative pressure source into the wound dressing. In these wound dressings, moisture from the wound can make it difficult to incorporate electronic components into the dressing.

**[0004]** Prior art dressings for use in negative pressure can also be difficult to apply, particularly around curved or non-flat body surfaces. When additional components are added to the wound dressing, this can make the wound dressing even more difficult to apply and uncomfortable to the user. Dressings which absorb and retain wound exudate can also be aesthetically unpleasing if the wound exudate is visible, making the wound dressing difficult to address in social situations.

## SUMMARY

**[0005]** Embodiments of the present disclosure relate to apparatuses and methods for wound treatment. Some of the wound treatment apparatuses described herein comprise a negative pressure source or a pump system for providing negative pressure to a wound. Wound treatment apparatuses may also comprise wound dressings that may be used in combination with the negative pressure sources and pump assemblies described herein. In some embodiments, a negative pressure source is incorporated into a wound dressing apparatus so that the wound dressing and the negative pressure source are part of an integral or integrated wound dressing structure that is applied simultaneously to a patient's wound.

**[0006]** In some aspects, a wound dressing apparatus comprises a wound contact layer configured to be positioned in contact with a wound, a first cover layer positioned over the wound contact layer, one or more spacer layers positioned between the wound contact layer and the first cover layer, wherein a spacer layer is positioned on an upper surface of the wound contact layer, an absorbent layer positioned over the spacer layer positioned on the upper surface of the wound contact layer, a negative pressure source configured to be in fluid communication with the wound, the negative pressure source configured to draw wound fluid through the one or more spacer layers into the absorbent layer, wherein the negative pressure source is located in one or both of a recess of a spacer layer or the absorbent layer, and a pocket or chamber defined at least in part by the first cover layer, and a first filter provided in a flow path between the negative pressure source and the wound contact layer.

**[0007]** The apparatus of the preceding paragraph may also include any combination of the following features described in this paragraph, among others described herein. The negative pressure source may be located in a recess in the absorbent layer. The absorbent layer may be positioned between the wound contact layer and the first cover layer. The first filter may be located in the first cover layer. The negative pressure source can be located in a chamber defined between the first cover layer and a second cover layer placed over the first cover layer. The apparatus can include a spacer layer or absorbent layer between the first cover layer and the second cover layer. A second filter can be located in the second cover layer. The apparatus can include a third cover layer positioned over the second cover layer, the third cover layer defining a chamber between the second cover layer and the third cover layer. The apparatus can include a further absorbent and/or spacer layer within the

chamber defined between the second cover layer and the third cover layer. The apparatus can include a third filter in the third cover layer. The first cover layer can be positioned on an upper surface of the absorbent layer. The first cover layer can be sealed to the wound contact layer. The apparatus can include one or more ultrasonic oscillators. The one or more spacer layers can comprise a recess or pouch for receiving the absorbent layer and/or the negative pressure source. The negative pressure source can be positioned beneath the absorbent layer. The apparatus can include a pressure fuse configured to discontinue operation of the negative pressure source if the pressure exceeds a threshold pressure. The apparatus can include channels around a perimeter of the absorbent layer and across a middle of the absorbent layer to expose portions of an underlying spacer layer. The apparatus can include a tube filled with magnetic fluid for creating negative pressure in the apparatus. The electronic components associated with the negative pressure source can be positioned in separate recesses within the absorbent layer and/or spacer layers.

**[0008]** Any of the features, components, or details of any of the arrangements or embodiments disclosed in this application, including without limitation any of the pump embodiments and any of the negative pressure wound therapy embodiments disclosed below, are interchangeably combinable with any other features, components, or details of any of the arrangements or embodiments disclosed herein to form new arrangements and embodiments.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** Embodiments of the present disclosure will now be described hereinafter, by way of example only, with reference to the accompanying drawings in which:

**[0010]** FIG. 1 illustrates an embodiment of a topical negative pressure wound treatment apparatus comprising a wound dressing in combination with a pump;

**[0011]** FIG. 2 illustrates an embodiment of a source of negative pressure and battery integrated on top of a dressing layer;

**[0012]** FIG. 3 illustrates an embodiment of layers of a wound dressing with integrated pump and electronic components;

**[0013]** FIG. 4 illustrates an embodiment of a cross-section of an integrated wound dressing;

**[0014]** FIG. 5 illustrates an embodiment of a cross-section of an integrated wound dressing with ultrasonic oscillation;

**[0015]** FIGS. 6A-6D illustrates embodiments of a pump pouch or pockets according to some embodiments;

**[0016]** FIG. 7 illustrates an embodiment of a pressure fuse that can be used to discontinue operation of the pump if the pressure exceeds an acceptable (or safe) threshold pressure;

**[0017]** FIG. 8 illustrates an embodiment of an integrated wound dressing with the pump and electronics package incorporated within the dressing;

**[0018]** FIGS. 9A-9B illustrate another embodiment of an integrated wound dressing;

**[0019]** FIG. 10 illustrates a close up view of one end of an embodiment of an integrated wound dressing;

**[0020]** FIG. 11 shows a top view of an embodiment of a wound dressing where the pump and associated components are visible;

**[0021]** FIG. 12 shows a bottom view of an embodiment of a wound dressing where recesses for the pump and associated components are visible; and

**[0022]** FIGS. 13-15 shows an embodiment a wound dressing with integrated electronic components.

#### DETAILED DESCRIPTION

**[0023]** Embodiments disclosed herein relate to apparatuses and methods of treating a wound with reduced pressure, including a source of negative pressure and wound dressing components and apparatuses. The apparatuses and components comprising the wound overlay and packing materials, if any, are sometimes collectively referred to herein as dressings.

**[0024]** It will be appreciated that throughout this specification reference is made to a wound. It is to be understood that the term wound is to be broadly construed and encompasses open and closed wounds in which skin is torn, cut or punctured or where trauma causes a contusion, or any other superficial or other conditions or imperfections on the skin of a patient or otherwise that benefit from reduced pressure treatment. A wound is thus broadly

defined as any damaged region of tissue where fluid may or may not be produced. Examples of such wounds include, but are not limited to, abdominal wounds or other large or incisional wounds, either as a result of surgery, trauma, sterniotomies, fasciotomies, or other conditions, dehisced wounds, acute wounds, chronic wounds, subacute and dehisced wounds, traumatic wounds, flaps and skin grafts, lacerations, abrasions, contusions, bums, diabetic ulcers, pressure ulcers, stoma, surgical wounds, trauma and venous ulcers or the like.

**[0025]** It will be understood that embodiments of the present disclosure are generally applicable to use in topical negative pressure ("TNP") therapy systems. Briefly, negative pressure wound therapy assists in the closure and healing of many forms of "hard to heal" wounds by reducing tissue oedema; encouraging blood flow and granular tissue formation; removing excess exudate and may reduce bacterial load (and thus infection risk). In addition, the therapy allows for less disturbance of a wound leading to more rapid healing. TNP therapy systems may also assist on the healing of surgically closed wounds by removing fluid and by helping to stabilize the tissue in the apposed position of closure. A further beneficial use of TNP therapy can be found in grafts and flaps where removal of excess fluid is important and close proximity of the graft to tissue is required in order to ensure tissue viability.

**[0026]** As is used herein, reduced or negative pressure levels, such as -X mmHg, represent pressure levels relative to normal ambient atmospheric pressure, which can correspond to 760 mmHg (or 1 atm, 29.93 inHg, 101.325 kPa, 14.696 psi, etc.). Accordingly, a negative pressure value of -X mmHg reflects absolute pressure that is X mmHg below 760 mmHg or, in other words, an absolute pressure of (760-X) mmHg. In addition, negative pressure that is "less" or "smaller" than X mmHg corresponds to pressure that is closer to atmospheric pressure (e.g., -40 mmHg is less than -60 mmHg). Negative pressure that is "more" or "greater" than -X mmHg corresponds to pressure that is further from atmospheric pressure (e.g., -80 mmHg is more than -60 mmHg). In some embodiments, local ambient atmospheric pressure is used as a reference point, and such local atmospheric pressure may not necessarily be, for example, 760 mmHg.

**[0027]** The negative pressure range for some embodiments of the present disclosure can be approximately -80 mmHg, or between about -20 mmHg and -200 mmHg. Note that these pressures are relative to normal ambient atmospheric pressure, which can be

760 mmHg. Thus, -200 mmHg would be about 560 mmHg in practical terms. In some embodiments, the pressure range can be between about -40 mmHg and -150 mmHg. Alternatively a pressure range of up to -75 mmHg, up to -80 mmHg or over -80 mmHg can be used. Also in other embodiments a pressure range of below -75 mmHg can be used. Alternatively, a pressure range of over approximately -100 mmHg, or even -150 mmHg, can be supplied by the negative pressure apparatus.

**[0028]** In some embodiments of wound closure devices described herein, increased wound contraction can lead to increased tissue expansion in the surrounding wound tissue. This effect may be increased by varying the force applied to the tissue, for example by varying the negative pressure applied to the wound over time, possibly in conjunction with increased tensile forces applied to the wound via embodiments of the wound closure devices. In some embodiments, negative pressure may be varied over time for example using a sinusoidal wave, square wave, and/or in synchronization with one or more patient physiological indices (e.g., heartbeat). Examples of such applications where additional disclosure relating to the preceding may be found include U.S. Patent No. 8,235,955, titled "Wound treatment apparatus and method," issued on August 7, 2012; and U.S. Patent No. 7,753,894, titled "Wound cleansing apparatus with stress," issued July 13, 2010. The disclosures of both of these patents are hereby incorporated by reference in their entirety.

**[0029]** International Application PCT/GB2012/000587, titled "WOUND DRESSING AND METHOD OF TREATMENT" and filed on July 12, 2012, and published as WO 2013/007973 A2 on January 17, 2013, is an application, hereby incorporated and considered to be part of this specification, that is directed to embodiments, methods of manufacture, and wound dressing components and wound treatment apparatuses that may be used in combination or in addition to the embodiments described herein. Additionally, embodiments of the wound dressings, wound treatment apparatuses and methods described herein may also be used in combination or in addition to those described in U.S. Provisional Application No. 61/650,904, filed May 23, 2012, titled "APPARATUSES AND METHODS FOR NEGATIVE PRESSURE WOUND THERAPY," International Application No. PCT/IB2013/001469, filed May 22, 2013, titled "APPARATUSES AND METHODS FOR NEGATIVE PRESSURE WOUND THERAPY," and published as WO 2013/175306 on November 28, 2013, U.S. Provisional Application No. 61/678,569, filed August 1, 2012,

titl ed "WOUND DRESSING AND METHOD OF TREATMENT," U.S. Provisional Application No. 61/753,374, filed January 16, 2013, titl ed "WOUND DRESSING AND METHOD OF TREATMENT," U.S. Provisional Application Serial No. 61/753,878 , filed January 17, 2013, titl ed "WOUND DRESSING AND METHOD OF TREATMENT," U.S. Provisional Application No. 61/785,054, filed March 14, 2013, titl ed "WOUND DRESSING AND METHOD OF TREATMENT," U.S. Provisional Application No. 61/823,298, filed May 14, 2013, titl ed "WOUND DRESSING AND METHOD OF TREATMENT," International Application No. PCT/IB2013/002102, filed July 31, 2013, titl ed "WOUND DRESSING AND METHOD OF TREATMENT," and published as WO 2014/020443 on February 6, 2014, and International Application No. PCT/IB2013/002060, filed July 31, 2013, titl ed "WOUND DRESSING," and published as WO 2014/020440 on February 6, 2014, the disclosures of which are hereby incorporated by reference in their entireties. Embodiments of the wound dressings, wound treatment apparatuses and methods described herein may also be used in combination or in addition to those described in U.S. Patent Application No. 13/092,042, filed April 21 2011, published as US2011/0282309, titl ed "WOUND DRESSING AND METHOD OF USE," and which is hereby incorporated by reference in its entirety, including further details relating to embodiments of wound dressings, the wound dressing components and principles, and the materials used for the wound dressings.

**[0030]** FIG. 1 illustrates an embodiment of a TNP wound treatment comprising a wound dressing 2100 in combination with a pump 2800. As stated above, the wound dressing 2100 can be any wound dressing embodiment disclosed herein including without limitation dressing embodiment 100 or have any combination of features of any number of wound dressing embodiments disclosed herein. Here, the dressing 2100 may be placed over a wound, and a conduit 2220 may then be connected to the port 2150, although in some embodiments the dressing 2100 may be provided with at least a portion of the conduit 2220 preattached to the port 2150. Preferably, the dressing 2100 is provided as a single article with all wound dressing elements (including the port 2150) pre-attached and integrated into a single unit. The wound dressing 2100 may then be connected, via the conduit 2220, to a source of negative pressure such as the pump 2800. The pump 2800 can be miniaturized and portable, although larger conventional pumps may also be used with the dressing 2100. In some embodiments, the pump 2800 may be attached or mounted onto or

adjacent the dressing 2100. A connector 2221 may also be provided so as to permit the conduit 2220 leading to the wound dressing 2100 to be disconnected from the pump, which may be useful for example during dressing changes.

**[0031]** In some embodiments, a source of negative pressure (such as a pump) and some or all other components of the TNP system, such as power source(s), sensor(s), connector(s), user interface component(s) (such as button(s), switch(es), speaker(s), screen(s), etc.) and the like, can be integral with the wound dressing. As is illustrated in FIG. 2, the source of negative pressure and battery can be included within the integrated dressing 200. Although FIG. 2 illustrates the source of negative pressure and battery 210 placed on top of the dressing layer 240 (such as an absorbent layer), the source of negative pressure and one or more components can be incorporated into the dressing differently. The source of negative pressure and the one or more components need not all be incorporated into the dressing in the same manner. For example, a pressure sensor can be positioned below (or closer to the wound) the layer 240 while the source of negative pressure can be positioned on top of the layer 240. FIGS. 6A-6D illustrate alternative arrangements for incorporating the negative pressure source and the one or more components into the dressing. The integrated dressing 200 illustrated in FIG. 2 includes a cover layer 230 for securing the dressing to skin surrounding the wound. The cover layer 230 can be formed of substantially fluid impermeable material, such as a film. The cover layer can include an adhesive for securing the dressing to the surrounding skin or to a wound contact layer, described further below.

**[0032]** In some embodiments, the dressing can include the power source and other components, such as electronics, on and/or incorporated into the dressing and can utilize a wound contact layer and a first spacer layer within the dressing. The wound contact layer can be configured to be in contact with the wound. The wound contact layer can include an adhesive on the patient facing side for securing the dressing to the surrounding skin or on the top side for securing the wound contact layer to a cover layer or other layer of the dressing. In operation, the wound contact layer can be configured to provide unidirectional flow so as to facilitate removal of exudate from the wound while blocking or substantially preventing exudate from returning to the wound. The first spacer layer assists in distributing negative pressure over the wound site and facilitating transport of wound exudate and fluids into the wound dressing. Further, an absorbent layer (such as layer 240) for absorbing and retaining

exudate aspirated from the wound can be utilized. In some embodiments, the absorbent layer includes a shaped form of a superabsorber layer with recesses or compartments for the pump, electronics, and accompanying components. These layers can be covered with one layer of a film or cover layer (or a first cover layer). The first cover layer can include a filter set (such as a filter provided at an opening in the first cover layer) that can be positioned within or over one of the recesses. The filter can be configured to align with one of the at least one recesses of the absorbent layer, and the filter can include hydrophobic material to protect the pump and/or other components from liquid exudates. The filter can block fluids while permitting gases to pass through. The pump, electronics, switch and battery can be positioned on top of the first cover layer. Another section of spacer, a second spacer, can be positioned above and/or surrounding the pump. In some embodiments, the second spacer can be smaller than the first spacer used above the wound contact layer. A section of top film or cover layer (or a second cover layer) is positioned over the top of the second spacer with a second filter associated with or positioned within the second cover layer (such as at an opening in the second cover layer). In some embodiments, the first and second cover layer can be made of the same material. In some embodiments, the first and second cover layers can be made of different material.

**[0033]** A second filter can be alternative or additionally used. For example, the second filter 220 can be constructed from antibacterial and/or antimicrobial materials so that the pump can exhaust gases into the atmosphere. Filter 220 can also help to reduce noise produced by the pump.

**[0034]** In certain embodiments, the first and second cover layers include a moisture vapor permeable material that protects the pump and electronic components from liquid exudate removed from the wound and other liquids, while allowing gases through. The pump and electronics can be pouched between the fluid impermeable membranes or cover layers with the only input and output being a filter on each side of the pump. The membranes and filter can protect the electronics from liquid from both sides. In some embodiments, the dressing and integrated electronics pouch can be used in the shower and/or can be in contact with liquid without impeding the operation of the pump and dressing.

**[0035]** In some embodiments, in addition to or instead of one or more batteries, one or more alternative energy generators (such as RF energy harvester, thermal energy

harvester, and the like) can be included into the pump to provide an alternative to traditional power sources. Examples of energy harvesters are described in U.S. Provisional Application No. 62/097,273, filed on December 29, 2014, and titled "Negative Pressure Wound Therapy Apparatus and Methods for Operating the Apparatus," U.S. Provisional Application No. 62/172,704, filed on June 8, 2015, and titled "Negative Pressure Wound Therapy Apparatus and Methods for Operating the Apparatus," and International Application PCT/EP2015/080740, titled " Negative Pressure Wound Therapy Apparatus and Method of Operating the Apparatus" and filed on December 21, 2015 the disclosures of which are incorporated in their entirety.

**[0036]** FIG. 3 illustrates the layers of a wound dressing 300 with integrated pump and electronic components, such as a controller configured to control the pump, according to some embodiments. The dressing layer 240 includes a wound contact layer 310, a spacer layer 311, and an absorbent layer 312. In some embodiments, the spacer layer 311 can be formed at least partially from a three dimensional (3D) fabric. In certain embodiments, a superabsorbent material can be used in the absorbent layer 312. The absorbent layer 312 can include one or more recesses 318 (and 318a) within the layer to accommodate placement of the pump, electronics, and/or power source. A moisture vapor permeable top film or first cover layer 313 is positioned above the absorbent layer 312. The cover layer 313 can include a filter 320. The filter can be positioned in line with and above a recess 318a in the absorbent layer 212.

**[0037]** A pump 316, electronics package 315, and power source 314 (such as a battery) can be positioned above the cover layer 313 as shown in FIG. 3. The pump 316, electronics package 315, and power source 314 can be positioned on top of the cover layer 313 and at least partially depressed into the corresponding recesses 318 (and 318a) in the absorbent layer 312. For example, the pump 316 can be at least partially depressed in the recess 318a. A packing layer 317 can be positioned above and/or surrounding the pump 316, electronics package 315, and power source 314. The packing layer 317 can be formed from spacer material and/or absorbent material. The packing layer 317 can include 3D spacer. In some embodiments, the packing layer 317 additionally or alternatively can include a superabsorbent material. A second moisture vapor permeable top film or second cover layer 319 can be positioned over and seal the packing layer 317, pump 316, electronics package 315, and power source 314. The second cover layer 319 can also include a second filter 220.

**[0038]** In some embodiments, the operation of the pump can vary depending on the environmental humidity level. It can be advantageous to provide mechanisms to drive moisture out of the dressing or otherwise limit or control the humidity of the dressing. In some embodiments, a chamber generated by the layers above the pump can be used to act as a pressurized sink for gases (such as gases exhausted by the pump), thereby increasing the relative humidity (or RH) and delta RH across the outer membrane, which in turn can increase the rate of evaporation.

**[0039]** FIG. 4 illustrates a cross-section of an integrated wound dressing 400 showing the various layers according to some embodiments. The dressing includes a wound contact layer 410, a spacer layer 411, and an absorbent layer 412, and a first cover layer 434. The first cover layer 434 is positioned to cover and form a seal over the absorbent layer 412, spacer layer 411, and wound contact layer 410. The dressing 400 can include three filters 420, 421, 422. First filter 422 can be provided in the first cover layer 434 below the pump and electronic components similar to the first filter 320 in the first cover layer 313 as described with reference to FIG. 3. The dressing 400 can include a second filter 421 positioned above a pump 416 as is shown in FIG. 4. The second filter 421 may be configured to be in fluid communication with the exhaust of the pump 416. In some embodiments, the second filter 421 can be integrated into an optional layer 440 (which may be considered another cover layer, and may be a moisture vapor permeable film) of material that encloses the pump between the first cover layer and the optional layer as shown in FIG. 4. In operation, the pump 416 inflates chamber 430 with gases removed from the wound. After inflation, chamber 430 can provide both bolstering and cushioning of the dressing 400. As shown in FIG. 4, an optional superabsorber 432 can be included in the chamber 430 above layer 434 and below the moisture vapor permeable top film or second cover layer 419. In such embodiments, the superabsorber 432 can draw fluid through the cover layer 434, and the increased pressure in chamber 430 can facilitate an increased evaporation to atmosphere. A third filter 420 can be positioned within or adjacent to the second moisture vapor permeable top film or second cover layer 419 (such as at an opening in the cover layer 419). Filter 420 can function similar to filter 220 illustrated in FIG. 2. In some embodiments, the third filter 420 can be alternative or additionally used to exhaust gas from the dressing to the atmosphere. For example, the third filter 420 can be constructed from antibacterial and/or antimicrobial materials so that the

pump and/or dressing chamber created by the multiple cover layers can exhaust gases into the atmosphere.

**[0040]** In some embodiments, the pump can include a piezoelectric transducer that causes negative pressure to be supplied to the wound. In certain embodiments, a secondary device (such as a secondary piezoelectric device) can be used to generate atomisation of the fluid in the dressing, either accelerating evaporation of the water portion of the wound fluid or firing it through the moisture vapor permeable (MVP) top film where it can then evaporate. This can reduce or eliminate the effect of environmental humidity on the capability of the dressing to evaporate water.

**[0041]** FIG. 5 illustrates a cross-section of an integrated wound dressing 500 according to some embodiments. In the illustrated dressing 500, a top layer or second cover layer 519 is optional. The dressing 500 includes a wound contact layer 510, a spacer layer 511, and an absorbent layer/superabsorber 512 below a top film or first cover layer 513. In some embodiments, one or more ultrasonic oscillators 501 which may be positioned on the first cover layer 513 can be used to atomize water from the superabsorber and/or absorbent layer 512 or from the space between the top film or first cover layer 513 and the optional top film or second cover layer 519. The first cover layer 513 can include a first filter 522 in communication with an inlet of a negative pressure pump 516 positioned over the first cover layer 513, and the optional second cover layer 519 can include a second filter 521 in communication with a pump exhaust of pump 516. In some embodiments, the second filter 521 can be integrated into an optional layer 540 of material that encloses the pump between the first cover layer and the optional layer 540 as shown in FIG. 5. In some embodiments, oscillation can be provided by the pump 516. In such embodiments, the one or more ultrasonic oscillators 501 would not be included in the dressing because the pump 516 is providing the oscillation.

**[0042]** In some embodiments, as described below, the pump, electronics and/or associated components can be contained in single or multiple sealed pockets or pouches. The pockets or pouches can include the pump, electronics, and/or power source(s) (such as batteries) with or without a spacer layer and/or absorbent layer padding. The packets may be designed to allow easy separation of the electronics from the dressing for disposal.

**[0043]** FIGS. 6A-6D illustrate embodiments of a pump pouch or pockets according to some embodiments. FIG. 6A illustrates an integrated wound dressing similar to the dressing described with reference to FIG. 2-4 in which a pump 616 is placed between the first cover layer 613 and the second cover layer 619. The dressing includes, from the bottom up, a wound contact layer 610, a spacer layer 611, an absorbent layer or superabsorber 612, and one or more moisture vapor permeable cover layers. The dressing as shown in FIG. 6A, does not include a spacer layer or absorbent layer between the first cover layer 613 and second cover layer 619. Additionally, the pump 616 is positioned above the first cover layer 613 placed above the absorbent layer 612 and no recess is formed in the absorbent layer 612 for the pump. The electronics and power source(s) can be similarly placed. FIG. 6B illustrates an integrated wound dressing in which a pump 616 is positioned above the first cover layer 613 in a recess of the absorbent layer 612. The dressing includes, from the bottom up, a wound contact layer 610, a spacer layer 611, an absorbent layer or superabsorber 612, and one or more cover layers which may be moisture vapor permeable. The positioning of the pump 616 above the first cover layer 613 in a recess of the absorbent layer 612 is similar to that illustrated in FIG. 3 but the embodiment shown in FIG. 6B does not include a spacer layer or absorbent layer between the first cover layer and second cover layer. Electronics and power source(s) can be similarly placed.

**[0044]** FIGS. 6C-6D illustrate embodiments of wound dressings comprising a pump and electronics package 650. The package 650 can also include power source(s). The dressing includes a wound contact layer 610, a spacer layer 611, an absorbent layer or superabsorber 612, and one or more cover layers which may be moisture vapor permeable. The pump and electronics package 650 can be positioned in the dressing as described with reference to FIG. 3. In other embodiments, the pump and electronics packages 650 can be positioned in alternative positions than what is described with reference to FIG. 3. For example, as depicted in FIG. 6C, the dressing can comprise a wound contact layer 610, a spacer layer 611, a first cover layer 613 positioned above the wound contact layer 610 and spacer layer 611. The pump and electronics package 650 can be positioned above the first cover layer 613. Additionally, the absorbent layer 622 can be positioned above the first cover layer 613 and adjacent to the pump and electronics package 650. In some embodiments, the absorbent layer 622 can include a recess or space to receive the pump and electronics

package. A second cover layer 619 can be positioned above the absorbent layer 622 and can seal at the perimeter of the second cover layer 619 to the wound contact layer 610 at the perimeter of the wound contact layer 610. Filter 620 can be located adjacent to the pump and electronics package 650. The filter 620 can be a hydrophobic filter configured to protect the pump and electronics package from exposure to fluid. In some embodiments, the one or more cover layers can be used to enclose the pump and electronics package 650. For example, a third cover layer can be used to incorporate the filter 620 and form a barrier between the fluid in the absorbent layer and/or spacer layer and the pump inlet. Second filter 621 can be located on the second cover layer 619. The second filter can be located at a position adjacent to an outlet or exhaust of the pump system. Additionally or alternatively, the exhaust of the pump can be gaseously connected to the filter 621 positioned proximate to the exhaust. The gaseous connection can include one or more conduits and/or chambers.

**[0045]** In some embodiments, one or more cover layers can be used to form a pouch enclosing the pump and/or electronics package 650. In some embodiments, one or more portions of spacer layer 611 can be included around the first cover layer 613, the pump and electronics package 650, and the absorbent layer 622. Therefore, one or more spacer layer can run along the wound contact layer 610, can be positioned along the edge or height of the dressing, and/or run along the top of the dressing below the second cover layer 619. The one or more portions of the spacer layer 611 can form a pouch around the first cover layer 613, absorbent layer 622, and electronics package 650. A second filter 621 can be incorporated on a second cover layer 619. The second cover layer 619 can be positioned above the spacer layer 611, the absorbent layer 622, and the pump and/or electronics package 650 and can seal at the perimeter to the perimeter of the wound contact layer 610. The second filter 621 can be located at a position adjacent to an outlet or exhaust of the pump system. Additionally or alternatively, the exhaust of the pump can be gaseously connected to the filter 621 positioned proximate to the exhaust. The gaseous connection can include one or more conduits and/or chambers.

**[0046]** FIG. 6D illustrates an embodiment of a wound dressing with pump and electronics package 650 positioned within the dressing. The dressing can include a wound contact layer 610 and spacer layer 611. A moisture vapor permeable film or first cover layer 613 can be positioned above the wound contact layer 610 and the spacer layer 611. The pump

and electronics package 650 can be positioned above the first cover layer 613. An absorbent layer 622 can be provided above the pump or electronics package 650. A second cover layer 619 can be positioned above the absorbent layer 622 and can seal at the perimeter of the second cover layer 619 to the wound contact layer 610 at the perimeter of the wound contact layer 610.

**[0047]** In some embodiments, the pump and electronics package 650 can be enclosed in a chamber defined by one or more cover layers. The first cover layer 613 could be positioned above the spacer layer 611 and extend up the edge or height of the dressing as shown in FIG. 6D. That first cover layer can then continue over an upper surface of the pump and electronics package 650 to form a pouch that encloses the pump and electronics package 650, or a separate cover layer may be joined to the first cover layer 613 and extend over the absorbent layer 650 to form the pouch. A filter 620 can be provided between the pump and electronics package 650 and the absorbent layer 622 in the cover layer that is on the upper surface of the pump and electronics package 650, as shown in FIG. 6D. The filter 620 can protect the pump and electronics package 650 from exposure to fluid. An additional filter or second filter 621 can be provided on an exhaust side of the pump, such as on a second moisture vapor permeable film or second cover layer 619, or on another cover layer. The filter 621 can be located at a position adjacent to an outlet or exhaust of the pump system or proximate to the exhaust (and connected to the exhaust via one or more conduits and/or chambers). For example, as is illustrated, a chamber 630 can gaseously connect the pump exhaust and the filter 621. In some embodiments, the chamber 630 can function similar to the chamber 430 of FIG. 4. Additionally or alternatively, the chamber 630 can be configured as a silencer to mute noise produced by the pump.

**[0048]** In some embodiments, the dressing can include one or more ports at a perimeter or along a portion or the entire circumference of the dressing to provide negative pressure from the pump to the highest location (with respect to gravity) of the dressing. The circumference port or ports can be used to bring fluid to the uppermost spacer layer or highest portion of the spacer layer first before being drawn down into the superabsorbent layer and pump. In some embodiments, a full circumference port or multiple circumferential ports can be used. The circumference ports can be used at the perimeter of the wound dressing. This can make the fluid behaviour independent of the direction the dressing is applied in. Without

this feature, the capacity can be lower if the port is positioned at the bottom portion of the applied dressing. For example, whether an integrated pump or a remote pump is used, if a dressing is positioned on a patient such that the negative pressure is directed into the dressing at a lower portion (with respect to gravity) of the dressing (such as because the pump is located at the bottom portion of the dressing when applied), the capacity of the dressing may be lower because fluid may tend to pool toward the bottom of the dressing. In some embodiments, multiple ports positioned circumferentially around the dressing, or a single circumferential port, in fluid communication with the negative pressure source, can be used to draw fluid through the spacer layer to higher locations on the dressing. Then, fluid can be drawn downward into the absorbent layer.

**[0049]** In some embodiments, the whole pump pouch as described above can be generated as a specific layer that can be brought into the factory as a reel and/or folded raw material, allowing the manufacture of a full system using the machinery used to manufacture the layers of a wound dressing. The pump and other components can be placed into their respective compartments in the dressing.

**[0050]** In some embodiments, one or more of the following pump additions can be added to the wound dressing with an integrated pump. The pressure sensor can be added onto a substrate of the pump (for example, ceramic substrate). A pressure fuse can be utilized on the pump substrate to discontinue operation of the pump if the pressure generated exceeds an acceptable threshold. Additionally, the pump can be designed for specific pressures. The pump can be designed to disable provision of negative pressure if fluid enters the pump itself.

**[0051]** FIG. 7 illustrates a pressure fuse that can be used to discontinue operation of the pump if the pressure exceeds an acceptable (or safe) threshold pressure according to some embodiments. The pump and pressure fuse illustrated in FIG. 7 can be used in combination with or integrated into the pumps described for use in the dressing embodiments described with reference to FIG. 2-5, 6A-D, 8, and 10-15. As illustrated in FIG. 7, a void or bubble 701 is provided within or adjacent to a piezo element 716 of a pump. The void or bubble 701 includes gas, such as gas stored at a pressure exceeding the operating pressure of the pump. For example, if the pressure at region 2 in FIG. 7 exceeds a pressure threshold (e.g., falls below -200 mmHg or another suitable threshold value), then the void or bubble 701 bursts and thereby stops operation of the pump. For example, if the bubble 701 ruptures, the

piezo element will become inoperative and the pump will no longer work. In other embodiments, the wiring to the piezo element or pump can run across the surface of the bubble (and/or inside the bubble). In such embodiment, bursting of the bubble could sever the wire and thereby stop or discontinue operation of the pump. The illustrated and described embodiments are not limited to pumps operated by piezoelectric transducers. For example, a void or bubble can be used to deactivate or render inoperative voice coil pumps, diaphragm pumps, etc.

**[0052]** Further elements can be incorporated into the device to increase the usability of this device. For example, one or more of speaker(s) and/or vibration indicator(s) can be included. The pump can be operated via a controller. One or more user interface elements for operating the pump can be included.

**[0053]** FIG. 8 illustrates an integrated wound dressing 800 with the pump and electronics package incorporated within the dressing according to some embodiments. The dressing is similar to that described with reference to FIGS. 3-7, except that the dressing 800 includes a different spacer layer and absorbent layer arrangement. From the bottom up, the dressing 800 comprises a wound contact layer, a spacer layer, an absorbent layer or superabsorber 812, and a moisture vapor permeable cover layer. The spacer layer comprises or defines a channel 801 that forms a ring about the wound dressing, and as illustrated forms a ring around the perimeter of the overlying absorbent layer. In some embodiments, the spacer layer has a rectangular shape with a perimeter that is larger than the overlying absorbent layer. Thus, the absorbent layer 812 is surrounded by the spacer channel 801. There are additional channels 802 formed in the absorbent layer that expose the underlying spacer layer when viewed from above. These channels 802 may run diagonally across the rectangular dressing and pass through the middle of the dressing. As illustrated the channels may divide the absorbent layer into four portions. In some embodiments, a pump 816 and/or electronic package may be provided above the moisture vapor permeable cover layer as described in earlier embodiments, and in some embodiments may be positioned in a pouch defined by a first cover layer and optionally a second cover layer over the pump and/or electronics package. In some embodiments, the pump 816 can be positioned in the channels 802 between the portions of the absorbent layer 812. The pump 816 can be positioned on top of and/or embedded in the spacer layer of the channels 802. An outlet port 820 can be provided on the top cover layer

of the dressing. In some embodiments, the outlet port 820 can include one or more filters as described in embodiments described herein. When negative pressure is applied to the wound dressing by the pump 816, the channels 801 and 802 form chambers that can facilitate evaporation of fluid.

**[0054]** FIGS. 9A-9B illustrate integrated wound dressing 900 according to some embodiments. As with at least some of the earlier described embodiments, the wound dressing 900, from the bottom up, comprises a wound contact layer 910, a spacer layer 911, a superabsorber or absorbent layer 912, and a top film or moisture vapor permeable cover layer 913. As illustrated in FIG. 9A, the integrated wound dressing 900 comprises a tube 901 filled with magnetic fluid 901. As illustrated in FIG. 9B, the tube 901 can be positioned on the perimeter of the spacer layer 911 and/or absorbent layer 912, and the tube 901 can run along or across the dressing 900. FIG. 9A also illustrates a coil of wire 902 excited by sinusoidal or other potential difference between points A and B. The dressing further comprises one or more pump chambers 903 positioned on the dressing as illustrated in FIG. 9A. Each of the pump chambers 903 can include one or more one-way valves. In some embodiments, the pump chambers can have an additional membrane or piston positioned between the magnetic fluid and chamber. The magnetic fluid can move within the tube due to the excited coil of wire and, in communication with the one-way valves of the pump chamber, can create a negative pressure in the dressing. In some embodiments, the magnetic fluid in the tube can move linearly to the right or to the left depending on the direction of the magnetic field generated by the potential applied to the coil. The pump chambers on either side of the tube can act as intake and exhaust chambers depending of the direction the fluid is moving. In some embodiments, the chambers on either side of the magnetic tube can include a one-way intake and a one-way exhaust valve.

**[0055]** For example, when the magnetic fluid is actuated to move to the left, it could push a piston to force an exhaust valve on the left chamber to open, and at the same time, the leftward movement of the fluid could pull on a piston adjacent the right pump chamber to open an intake valve to allow air to enter the right chamber. Once the direction of the magnetic field was changed, the fluid could move rightward so that the piston on the right could shut the intake valve and open the exhaust valve on the right chamber to exhaust the air, while at the same time the rightward movement of the magnetic liquid would pull on the

piston adjacent the left pump chamber to open the intake valve of that chamber to allow air in. In some embodiments, a membrane can be used as an alternative to the piston described previously. The membrane can be flexed in one direction to cause the intake valve to open and flexed in an opposite direction to cause the exhaust valve to open, where the intake and exhaust valves are not open at the same time. Therefore, the tube of magnetic fluid can be a sealed tube.

**[0056]** As shown in FIG. 9B, the wound dressing can include a wound contact layer 910 and a moisture vapor permeable top film or cover layer 913. The perimeter of the cover layer 913 can seal to the perimeter of the wound contact layer enclosing the components of the wound dressing apparatus.

**[0057]** FIGS. 10-12 show embodiments of integrated dressings. FIG. 10 illustrates a close up view of one end of the wound dressing in an embodiment where a pump is positioned between two cover layers and/or positioned in a pouch similar to the embodiments described with reference to FIGS. 1-5 and 6A-6D. The pump can also be embedded in a layer of spacer material or absorbent material. The pump 1016 is visible as a dark spot under the top layer.

**[0058]** FIG. 11 shows a top view of a wound dressing where the pump and associated components are visible in a wound dressing embodiment similar to the dressings described with reference to FIGS. 1-5 and 6A-6D. The dressing can have the pump and associated components positioned between two cover layers and they can be embedded in a recess of a spacer layer and/or absorbent layer as described herein. The pump 1116, electronics package 1115, switch 1160 for operating the pump (e.g., turning the pump on/off), and power source 1114 are visible from the top of the dressing.

**[0059]** FIG. 12 shows a bottom view of a wound dressing where recesses for the pump and associated components are visible in a wound dressing embodiment similar to the dressings described with reference to FIGS. 1-5 and 6A-6D. The dressing can have the pump and associated components positioned between two cover layers and they can be embedded in a recess of a spacer layer and/or absorbent layer as described herein. Recess 1216 can be a pump recess, recess 1215 can be an electronics package recess, and recess 1214 can be a power source recess.

**[0060]** FIGS. 13-15 show an embodiment of a wound dressing with integrated electronic components similar to the dressings described with reference to FIGS. 1-5 and 6A-6D. The dressing can have the pump and associated components positioned between two cover layers and they can be embedded in a recess of a spacer layer and/or absorbent layer as described herein. The dressing of FIGS. 13-15 include a pump 1316, pump drive board 1331, battery 1314, and switch 1360 arranged on spacer layer 1311. In some embodiments, the switch 1360 can be arranged on and/or in the electronics package or provide in a recess.

**[0061]** All of the features disclosed in this specification (including any accompanying exhibits, claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. The disclosure is not restricted to the details of any foregoing embodiments. The disclosure extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

**[0062]** Various modifications to the implementations described in this disclosure may be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other implementations without departing from the spirit or scope of this disclosure. Thus, the disclosure is not intended to be limited to the implementations shown herein, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

**[0063]** Certain embodiments of the disclosure are encompassed in the claims presented at the end of this specification, or in other claims presented at a later date. Additional embodiments are encompassed in the following set of numbered embodiments:

Embodiment 1. A wound dressing apparatus comprising:

a wound contact layer configured to be positioned in contact with a wound;

a first spacer layer;

an absorbent layer;

a first cover layer configured to cover and form a seal over the wound contact layer, the first spacer layer, and the absorbent layer, wherein the first cover layer comprises a first filter;

a negative pressure source configured to be positioned above the first cover layer;

a second spacer;

a second cover layer configured to cover and form a seal over the negative pressure source and second spacer, wherein the second cover layer comprising a second filter;

wherein the absorbent layer comprises at least one recess configured to receive the negative pressure source; and

wherein the first filter of the first cover layer is configured to align with one of the at least one recesses of the absorbent layer.

Embodiment 2. The wound dressing apparatus of Embodiment 1, wherein the second cover layer is configured to seal to the first cover layer.

Embodiment 3. The wound dressing apparatus of any of Embodiments 1-2, wherein the negative pressure source comprises a piezoelectric pump.

Embodiment 4. The wound dressing apparatus of any of Embodiments 1-3, further comprising one or more user interface components configured to allow a user to operate the negative pressure source.

Embodiment 5. The wound dressing apparatus of any of Embodiments 1-4, further comprising a switch configured to activate the electronics in the dressing, wherein the switch is incorporated into the dressing.

Embodiment 6. The wound dressing apparatus of any of Embodiments 1-5, further comprising a chamber configured to store at least some gas exhausted by the negative pressure source, thereby increasing rate of evaporation of moisture.

Embodiment 7. A wound dressing apparatus comprising:

a wound contact layer configured to be positioned in contact with a wound;

a spacer layer;

a first absorbent layer;

a first cover layer configured to cover and form a seal over the wound contact layer, the spacer layer, and the first absorbent layer, wherein the first cover layer comprises a first filter;

a negative pressure source configured to be positioned above the first cover layer;

a second filter in communication with the exhaust of the negative pressure source;

a second cover layer configured to cover and form a seal over the negative pressure source and the second filter, and the second cover layer comprising a third filter; and

wherein the first filter of the first cover layer is configured to align with an inlet of the negative pressure source.

Embodiment 8. The wound dressing apparatus of Embodiment 7, further comprising a chamber configured to store at least some gas exhausted by the negative pressure source, thereby increasing rate of evaporation of moisture.

Embodiment 9. The wound dressing apparatus of any of Embodiments 7-8, further comprising a second absorbent layer, wherein the second absorbent layer positioned between the first cover layer and the second cover layer.

Embodiment 10. The wound dressing apparatus of any of Embodiments 7-9, wherein the second absorbent layer is configured to draw fluid through the first cover layer.

Embodiment 11. The wound dressing apparatus of any of Embodiments 7-10, wherein the second cover layer is configured to seal to the first cover layer.

Embodiment 12. The wound dressing apparatus of any of Embodiments 7-11, wherein the negative pressure source comprises a piezoelectric pump.

Embodiment 13. A wound dressing apparatus comprising:

a wound contact layer configured to be positioned in contact with a wound;

a spacer layer;

an absorbent layer;

a first cover layer configured to cover and form a seal over the wound contact layer, the spacer layer, and the absorbent layer, wherein the first cover layer comprises a first filter;

a negative pressure source configured to be positioned above the first cover layer;

a second filter in communication with the exhaust of the negative pressure source; and

at least one ultrasonic oscillator, wherein the ultrasonic oscillator is configured to atomize water from the absorbent layer.

Embodiment 14. The wound dressing apparatus of Embodiment 13, further comprising a second cover layer configured to cover and form a seal over the negative pressure source, the second filter, and the at least one ultrasonic oscillator.

Embodiment 15. The wound dressing apparatus of any of Embodiments 13-14, wherein the first filter of the first cover layer is configured to align with an inlet of the negative pressure source.

Embodiment 16. The wound dressing apparatus of any of Embodiments 13-15, wherein the second cover layer is configured to seal to the first cover layer.

Embodiment 17. The wound dressing apparatus of any of Embodiments 13-16, wherein the negative pressure source comprises a piezoelectric pump.

Embodiment 18. The wound dressing apparatus of any of Embodiments 13-17, further comprising one or more user interface components configured to allow a user to operate the negative pressure source.

Embodiment 19. A wound dressing apparatus comprising:

a wound contact layer configured to be positioned in contact with a wound;

a spacer layer;

an absorbent layer;

a first cover layer configured to cover and form a seal over the wound contact layer, the spacer layer, and the absorbent layer, wherein the first cover layer comprises a first filter;

a negative pressure source configured to be positioned above the first cover layer;

a second cover layer configured to cover and form a seal over the negative pressure source, the second cover layer comprising a second filter;

wherein the first filter of the first cover layer is configured to be in communication with an inlet in the negative pressure source and the second filter of

the second cover layer is configured to be in communication with an exhaust of the negative pressure source.

Embodiment 20. The wound dressing apparatus of Embodiment 19, wherein the absorbent layer comprises at least one recess configured to receive the negative pressure source.

Embodiment 21. The wound dressing apparatus of any of Embodiments 19-20, wherein the second cover layer is configured to seal to the first cover layer.

Embodiment 22. A wound dressing apparatus comprising:

a wound contact layer configured to be positioned in contact with a wound;

a spacer layer;

an absorbent layer;

a negative pressure source configured to be in fluid communication with the wound;

a first cover layer configured to cover and form a seal around the negative pressure source, wherein the first cover layer comprises a first filter; and

a second cover layer configured to cover and form a seal over the absorbent layer, spacer layer, first cover layer with the negative pressure source, the second cover layer comprising a second filter;

wherein the first filter of the first cover layer and the second filter of the second cover layer are configured to be in communication with the negative pressure source.

Embodiment 23. The wound dressing apparatus of Embodiment 22, wherein the second cover layer is configured to seal at a perimeter of the second cover layer to the wound contact layer at a perimeter of the wound contact layer.

Embodiment 24. The wound dressing apparatus of any of Embodiments 22-23, wherein the first cover layer forms a pouch around the negative pressure source, wherein the first cover layer comprises one or more cover layers combined to form the pouch or one single cover layer to form the pouch and wherein the first cover layer pouch comprises an interior surface comprising a surface facing the negative pressure source and an exterior surface opposite the interior surface.

Embodiment 25. The wound dressing apparatus of any of Embodiments 22-24, wherein the spacer layer comprises one or more portions configured to be positioned around the exterior surface of the first cover layer.

Embodiment 26. The wound dressing apparatus of any of Embodiments 22-25, wherein the spacer layer is positioned between the wound contact layer and the first cover layer pouch and the absorbent layer is positioned between the first cover layer pouch and the second cover layer.

Embodiment 27. A wound dressing apparatus comprising:

a wound dressing comprising:

a first cover layer configured to cover and form a seal over the wound forming a negative pressure reservoir between the wound and the first cover layer;

a negative pressure source configured to provide negative pressure to the reservoir; and

a void within or adjacent to the negative pressure source, wherein the void comprises gas at a predefined pressure, wherein the void is configured to burst and thereby stop operation of the negative pressure source when the pressure in the reservoir exceeds a pressure threshold.

Embodiment 28. The wound dressing apparatus of Embodiment 27, wherein the negative pressure source comprises a piezoelectric pump.

Embodiment 29. The wound dressing apparatus of Embodiment 28, wherein the void is in communication with an electrical wiring of the piezoelectric pump and bursting of the void causes the electrical wiring to be severed.

Embodiment 30. The wound dressing apparatus of any of Embodiments 27-29, further comprising:

a wound contact layer configured to be positioned in contact with a wound;  
a spacer layer; and  
an absorbent layer,

wherein the first cover layer is configured to cover and form a seal over the wound contact layer, the spacer layer, and the absorbent layer.

Embodiment 31. The wound dressing apparatus of any of Embodiments 27-30, further comprising a second cover layer configured to cover and form a seal over the negative pressure source, the second cover layer configured to seal to the first cover layer.

Embodiment 32. The wound dressing apparatus of any of Embodiments 27-31, further comprising one or more user interface components configured to allow a user to operate the negative pressure source.

Embodiment 33. A wound dressing apparatus comprising:

- a wound contact layer configured to be positioned in contact with a wound;
- a spacer layer;
- an absorbent layer;
- one or more channels defined by the spacer layer around a perimeter of the absorbent layer and between portions of the absorbent layer extending across a middle of the absorbent layer; and
- a negative pressure source positioned in one of the channels.

Embodiment 34. A wound dressing apparatus comprising:

- a wound contact layer configured to be positioned in contact with a wound;
- a spacer layer;
- an absorbent layer;
- a cover layer configured to cover and form a seal over the wound contact layer, the spacer layer, and the absorbent layer forming a negative pressure reservoir;
- a negative pressure source configured to be positioned within the wound dressing, the negative pressure source comprising:

- a tube positioned on the perimeter of the spacer layer and/or absorbent layer, the tube comprising a magnetic fluid and a coiled wire configured to be excited by potential differences between two points of the tube; and
  - one or more pump chambers positioned in the tube, wherein the one or more pump chambers comprise one or more one-way valves.

Embodiment 35. The wound dressing apparatus of Embodiment 34, wherein the one or more pump chambers comprise a membrane or piston positioned between the magnetic fluid and chamber.

Embodiment 36. The wound dressing apparatus of any of Embodiments 34-35, wherein the one or more pump chambers are positioned on either side of the magnetic tube.

Embodiment 37. The wound dressing apparatus of any of Embodiments 34-36, wherein the one or more pump chambers comprise a one-way intake and a one-way exhaust valve.

Embodiment 38. The wound dressing apparatus of any of Embodiments 34-37, wherein the intake and exhaust valves are not open at the same time creating a sealed tube of magnetic fluid.

WHAT IS CLAIMED IS:

1. A wound dressing apparatus comprising:
  - a wound contact layer configured to be positioned in contact with a wound;
  - a first cover layer positioned over the wound contact layer;
  - one or more spacer layers positioned between the wound contact layer and the first cover layer, wherein a spacer layer is positioned on an upper surface of the wound contact layer;
  - an absorbent layer positioned over the spacer layer positioned on the upper surface of the wound contact layer;
  - a negative pressure source configured to be in fluid communication with the wound, the negative pressure source configured to draw wound fluid through the one or more spacer layers into the absorbent layer, wherein the negative pressure source is located in one or both of:
    - a recess of a spacer layer or the absorbent layer; and
    - a pocket or chamber defined at least in part by the first cover layer; and
    - a first filter provided in a flow path between the negative pressure source and the wound contact layer.
2. The wound dressing apparatus of Claim 1, wherein the negative pressure source is located in a recess in the absorbent layer.
3. The wound dressing apparatus of any of the preceding claims, wherein the absorbent layer is positioned between the wound contact layer and the first cover layer.
4. The wound dressing apparatus of any of the preceding claims, wherein the first filter is located in the first cover layer.
5. The wound dressing apparatus of any of the preceding claims, wherein the negative pressure source is located in a chamber defined between the first cover layer and a second cover layer placed over the first cover layer.
6. The wound dressing apparatus of Claim 5, comprising a spacer layer or absorbent layer between the first cover layer and the second cover layer.
7. The wound dressing apparatus of Claim 5 or 6, wherein a second filter in the second cover layer.

8. The wound dressing apparatus of any of Claims 5-7, further comprising a third cover layer positioned over the second cover layer, the third cover layer defining a chamber between the second cover layer and the third cover layer.

9. The wound dressing apparatus of Claim 8, further comprising a further absorbent and/or spacer layer within the chamber defined between the second cover layer and the third cover layer.

10. The wound dressing apparatus of Claim 8 or 9, further comprising a third filter in the third cover layer.

11. The wound dressing apparatus of any of the preceding claims, wherein the first cover layer is positioned on an upper surface of the absorbent layer.

12. The wound dressing apparatus of any of the preceding claims, wherein the first cover layer is sealed to the wound contact layer.

13. The wound dressing apparatus of any of the preceding claims, comprising one or more ultrasonic oscillators.

14. The wound dressing apparatus of any of the preceding claims, wherein the one or more spacer layers comprise a recess or pouch for receiving the absorbent layer and/or the negative pressure source.

15. The wound dressing apparatus of any of the preceding claims, wherein the negative pressure source is positioned beneath the absorbent layer.

16. The wound dressing apparatus of any of the preceding claims, comprising a pressure fuse configured to discontinue operation of the negative pressure source if the pressure exceeds a threshold pressure.

17. The wound dressing apparatus of any of the preceding claims, further comprising channels around a perimeter of the absorbent layer and across a middle of the absorbent layer to expose portions of an underlying spacer layer.

18. The wound dressing apparatus of any of the preceding claims, further comprising a tube filled with magnetic fluid for creating negative pressure in the apparatus.

19. The wound dressing apparatus of any of the preceding claims, wherein electronic components associated with the negative pressure source are positioned in separate recesses within the absorbent layer and/or spacer layers.

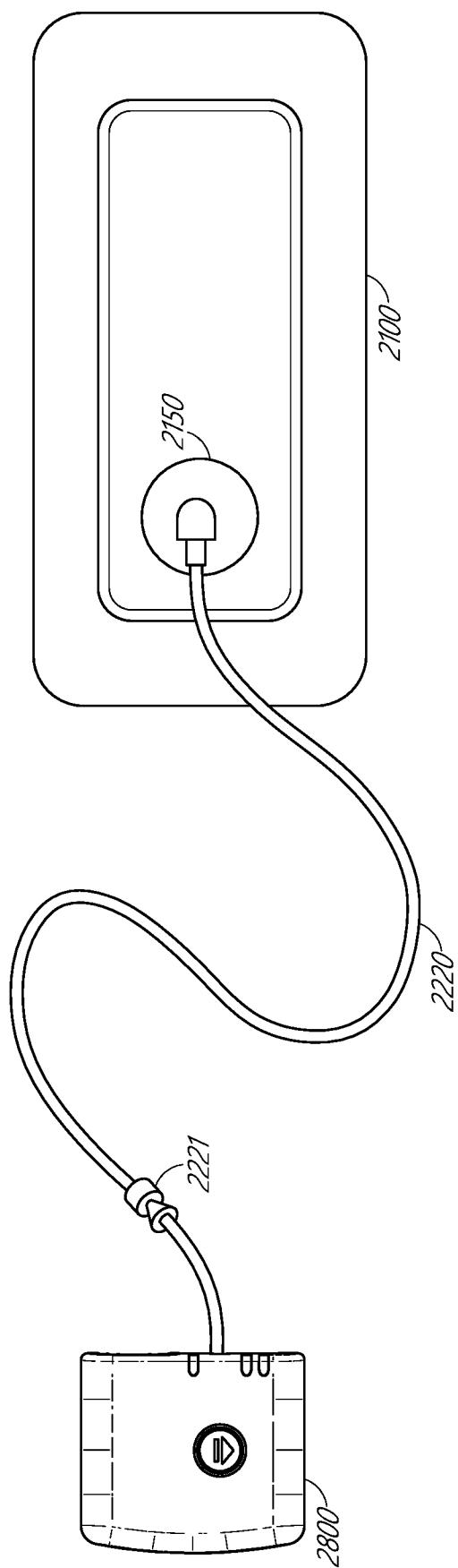


FIG. I

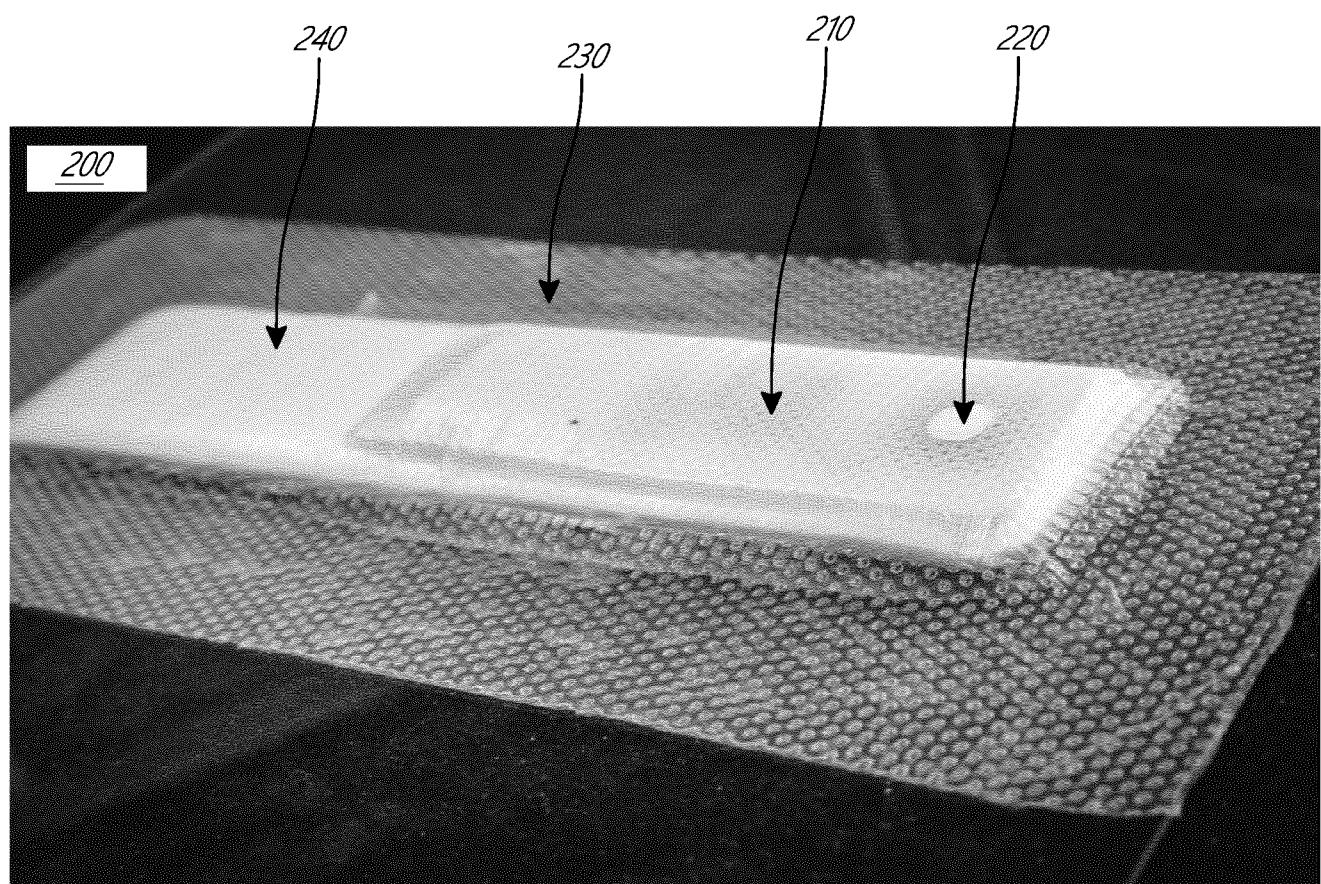


FIG. 2

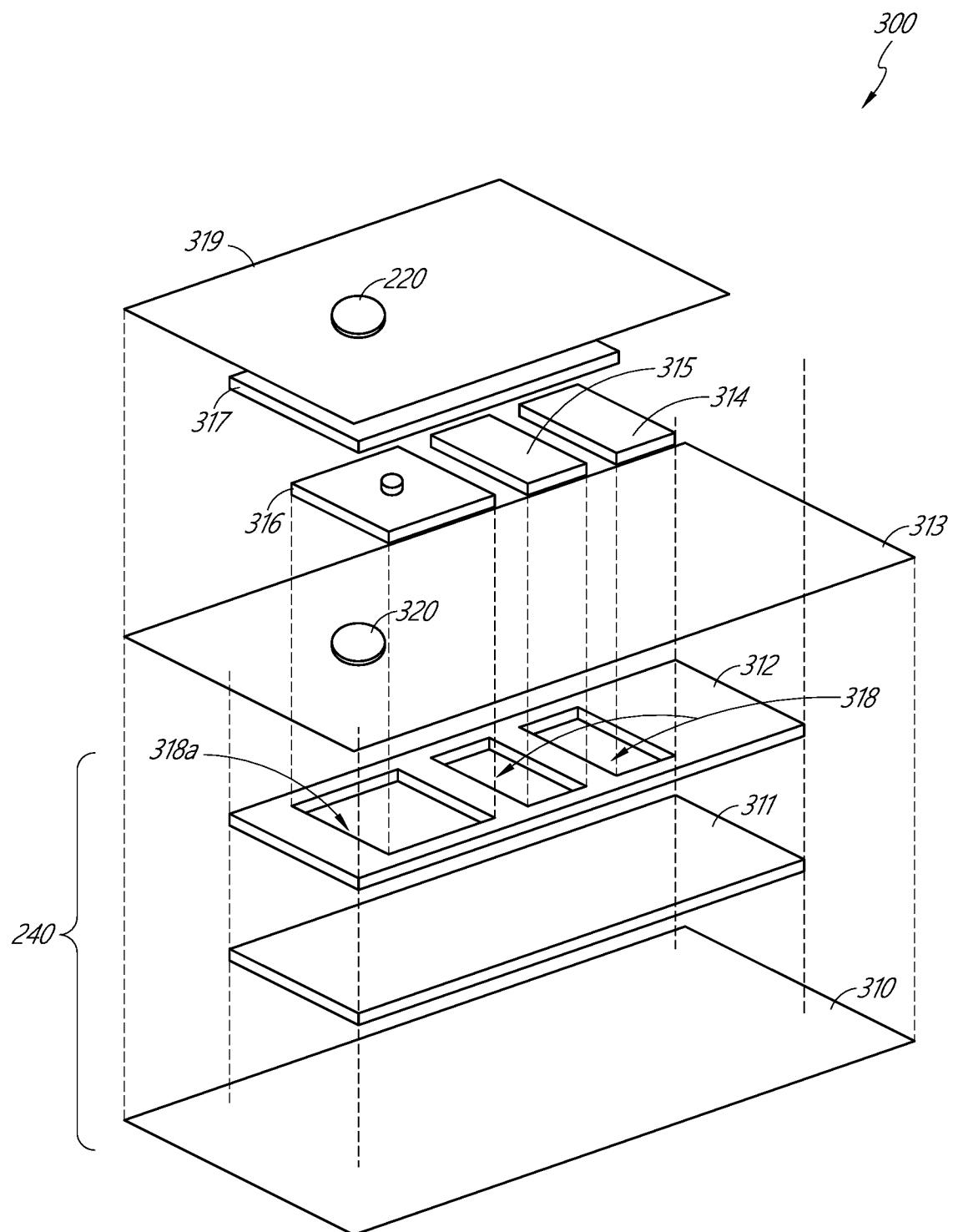


FIG. 3

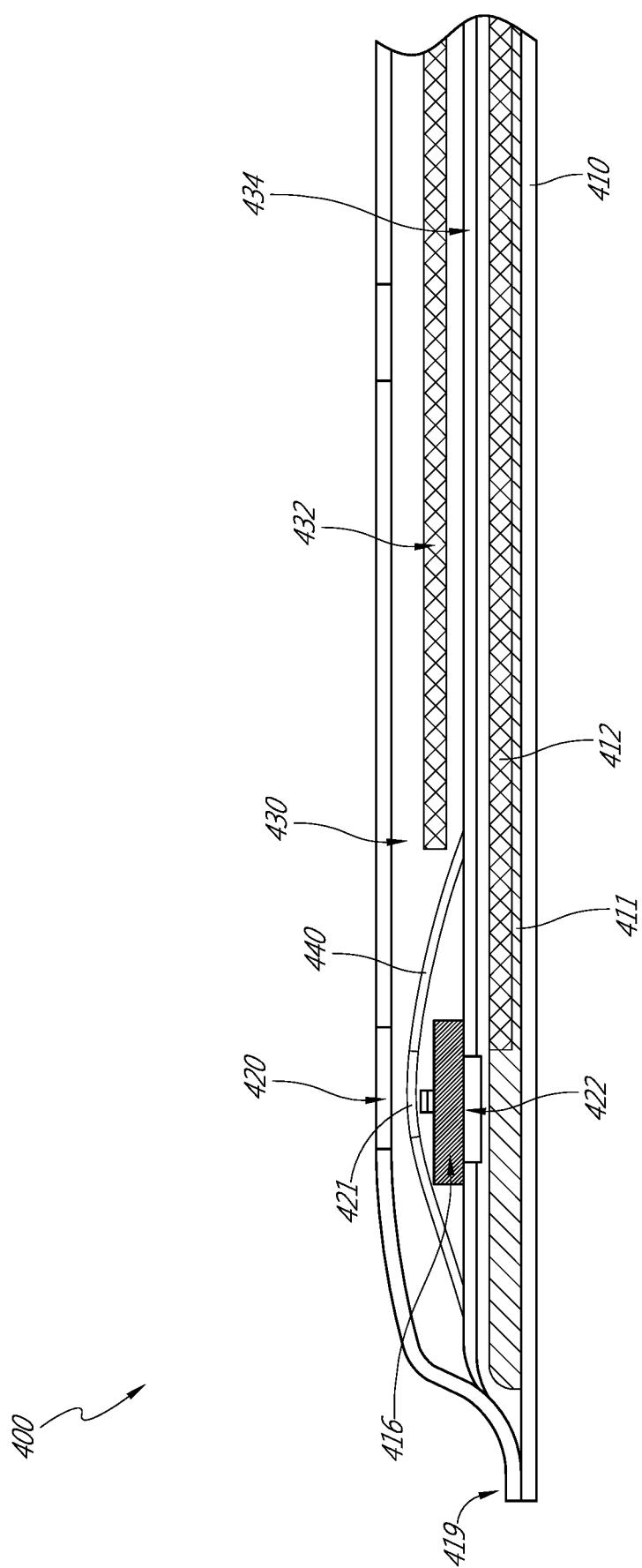


FIG. 4

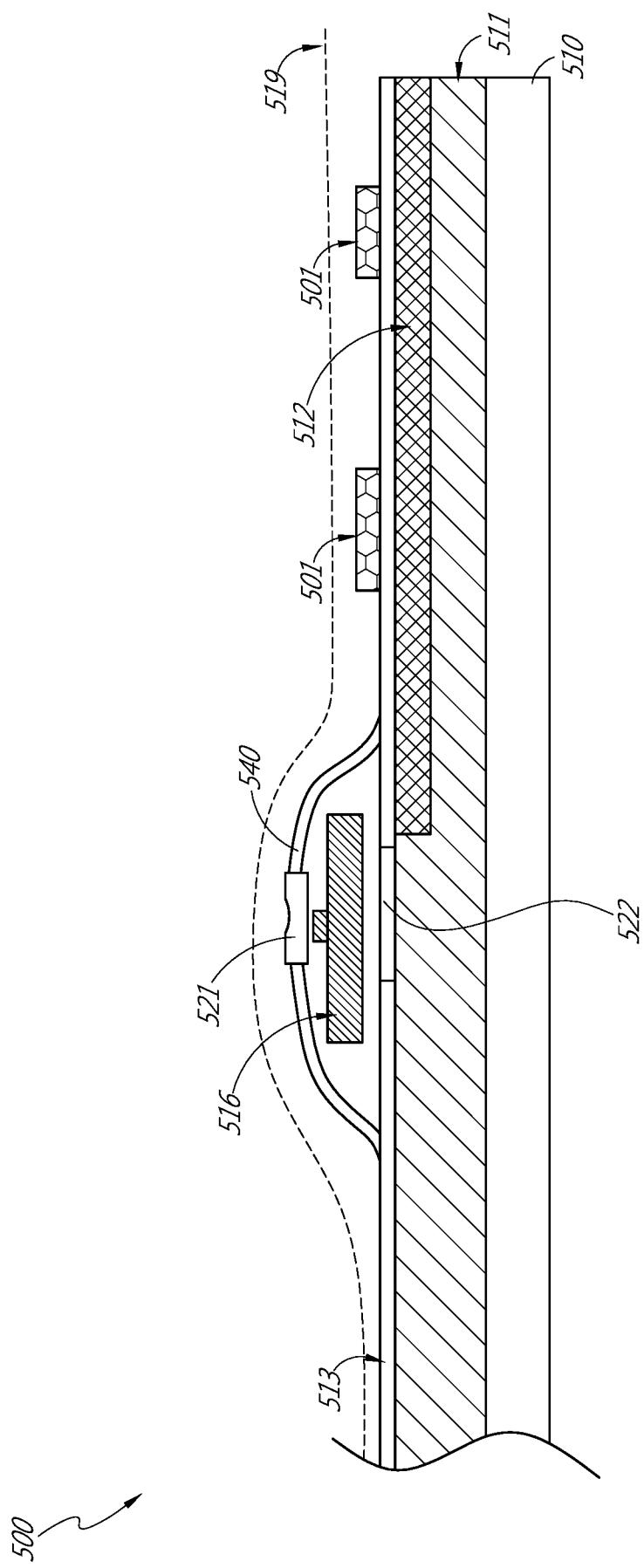


FIG. 5

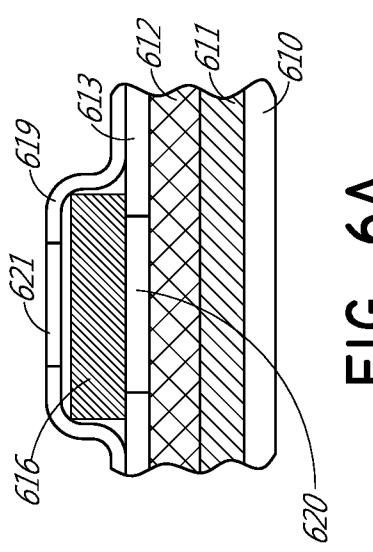


FIG. 6A

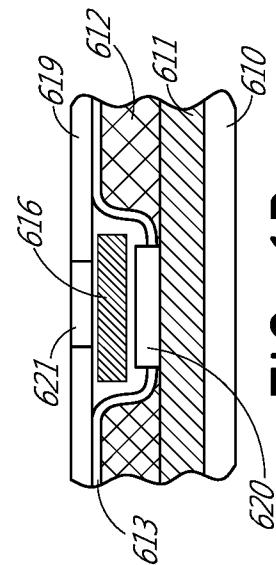


FIG. 6B

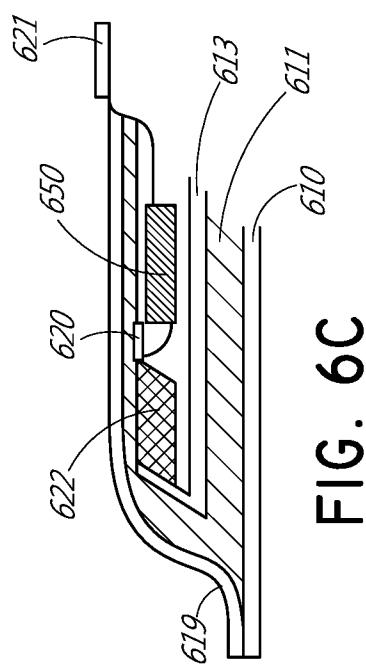


FIG. 6C

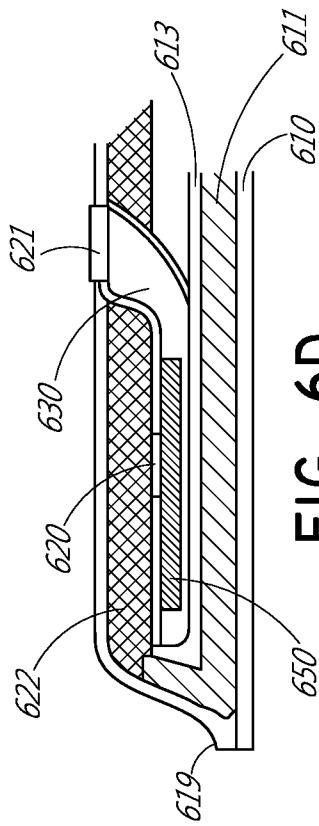


FIG. 6D

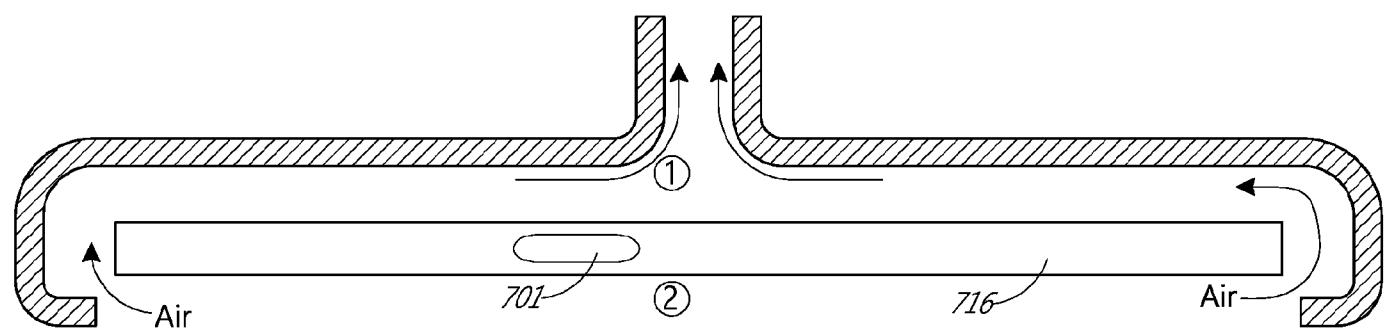


FIG. 7

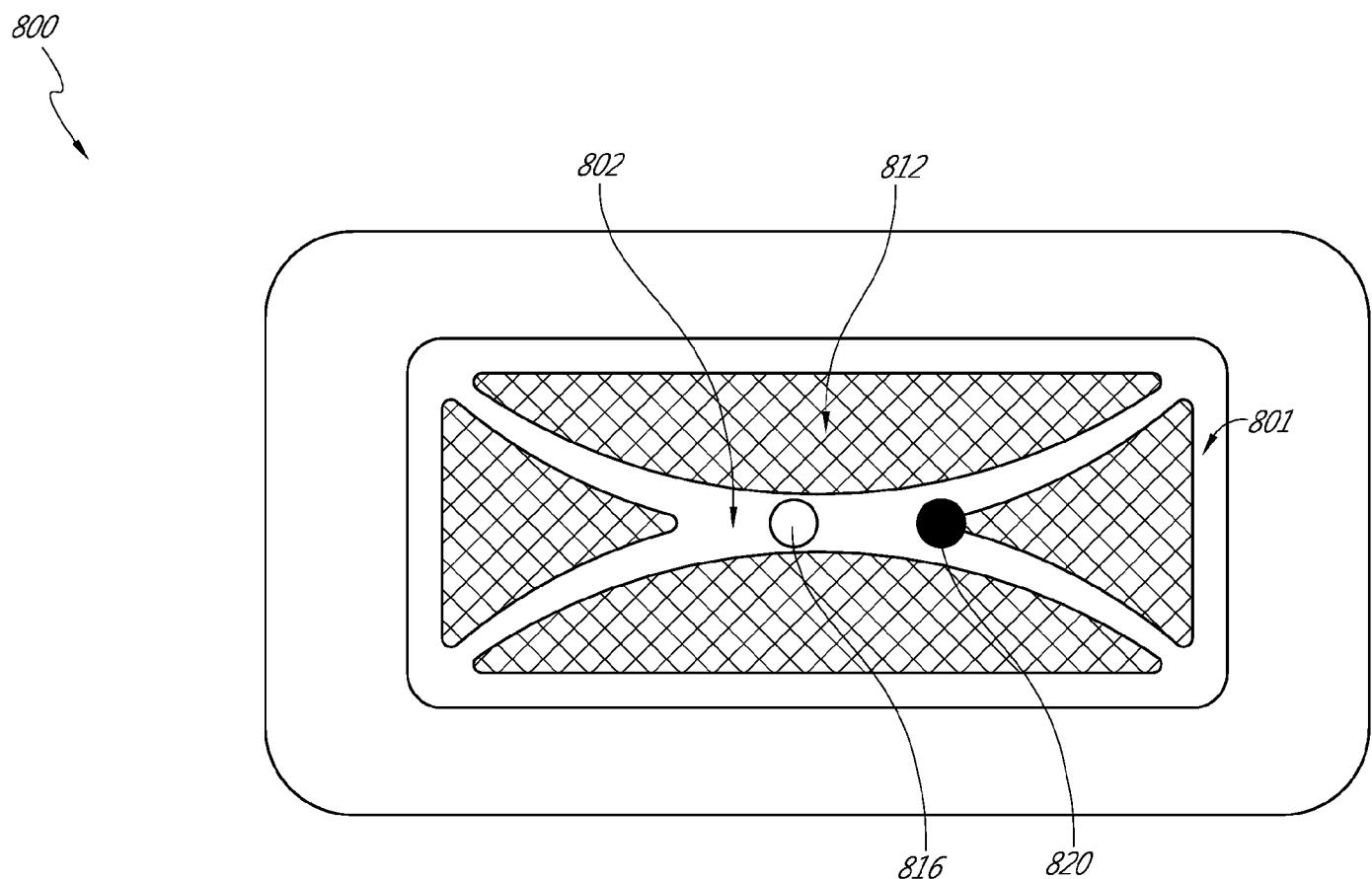


FIG. 8

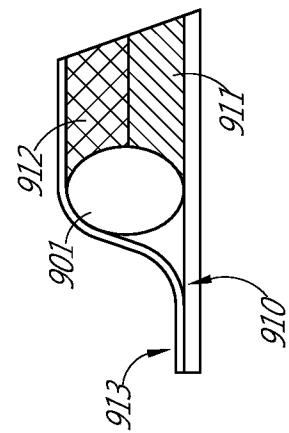


FIG. 9B

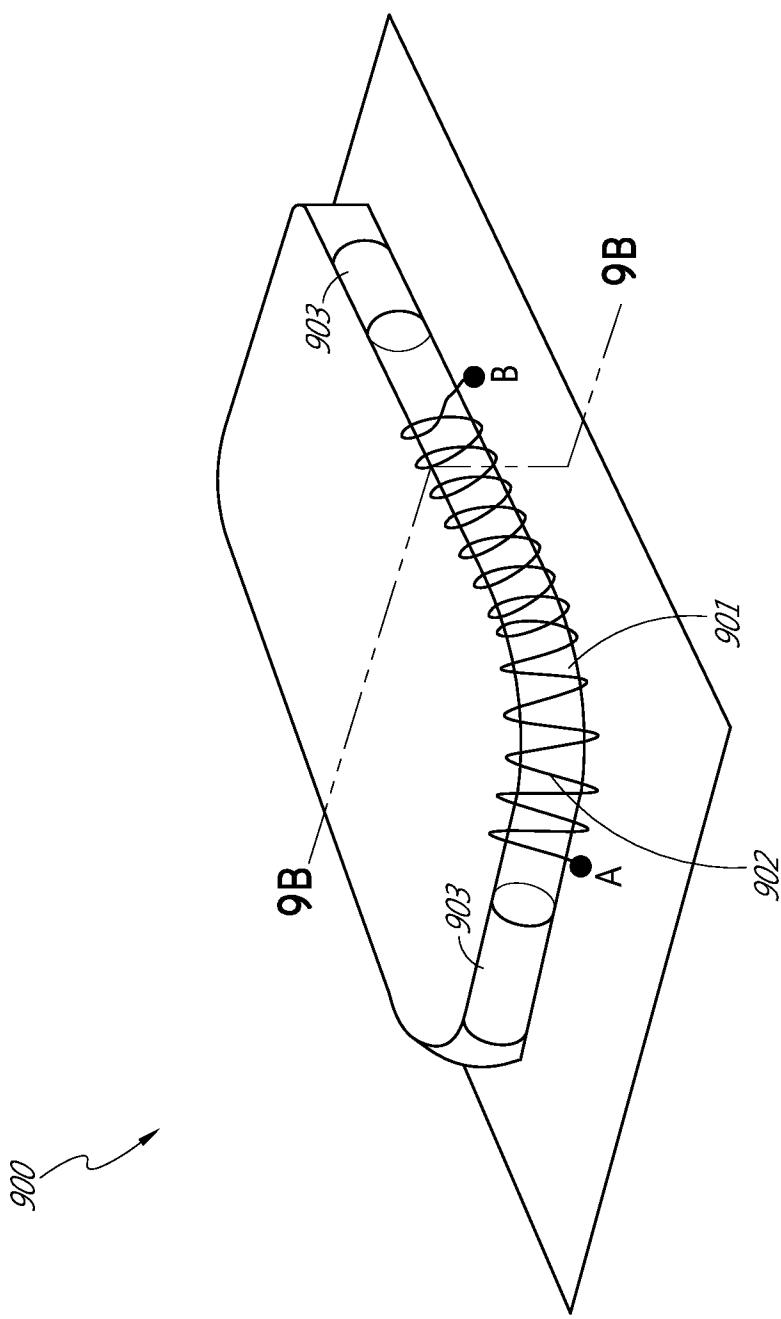


FIG. 9A

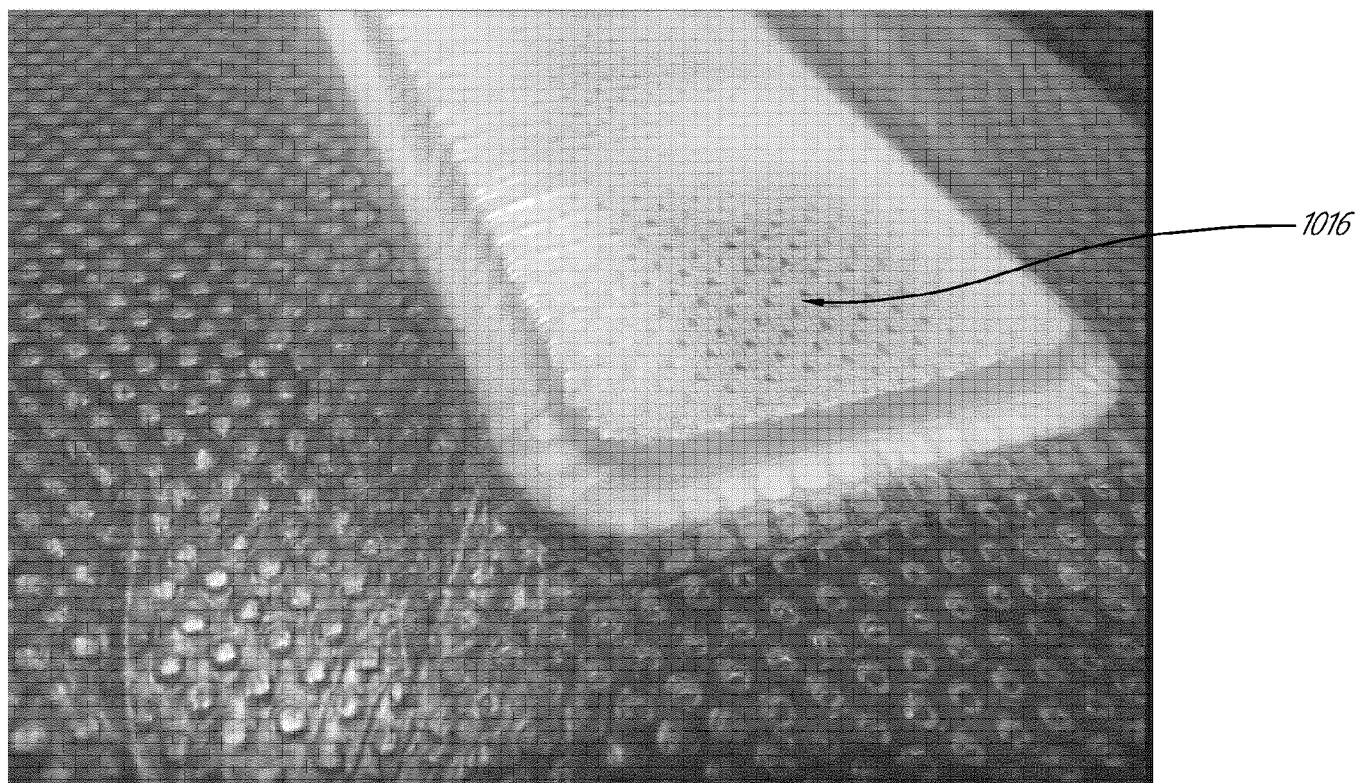


FIG. 10

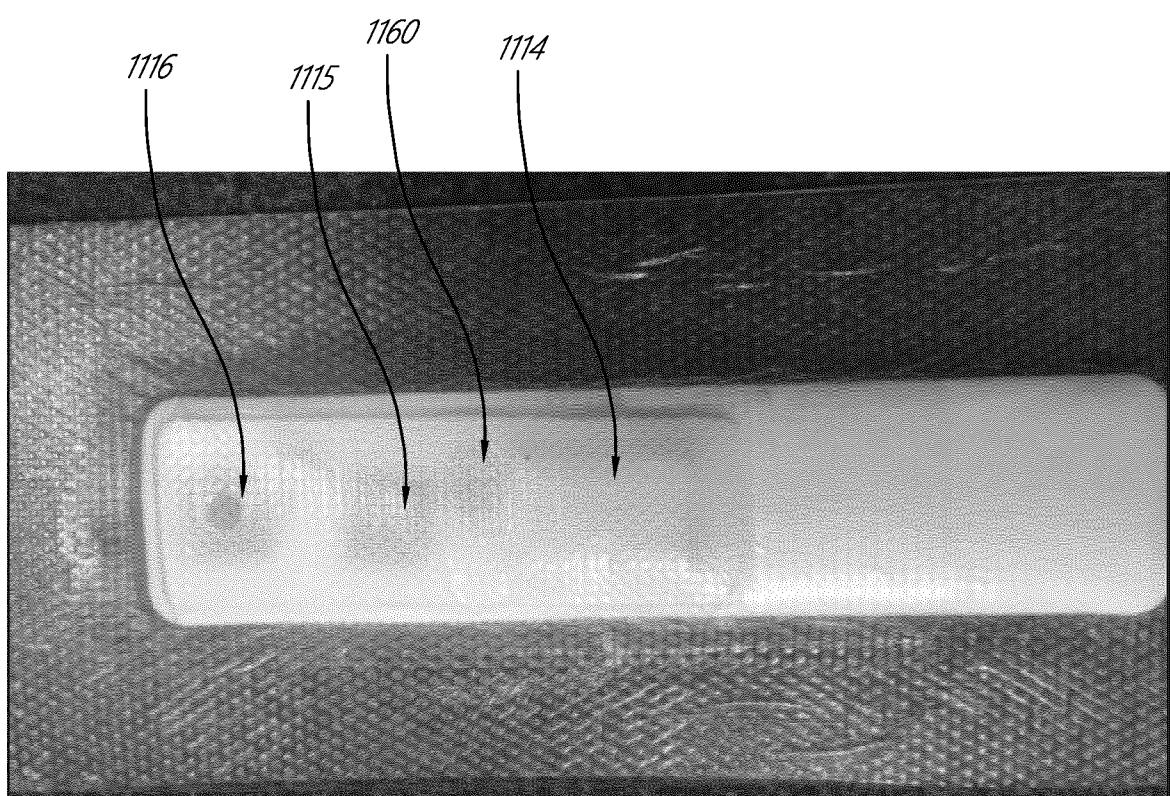


FIG. II

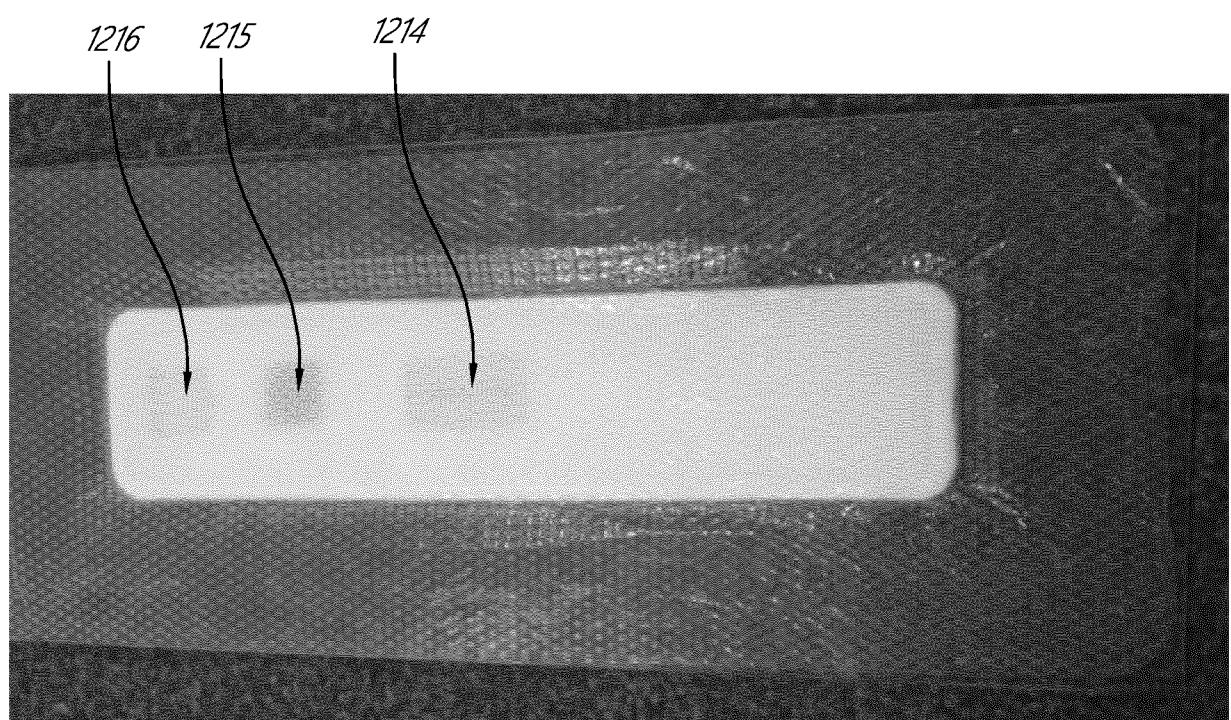


FIG. 12

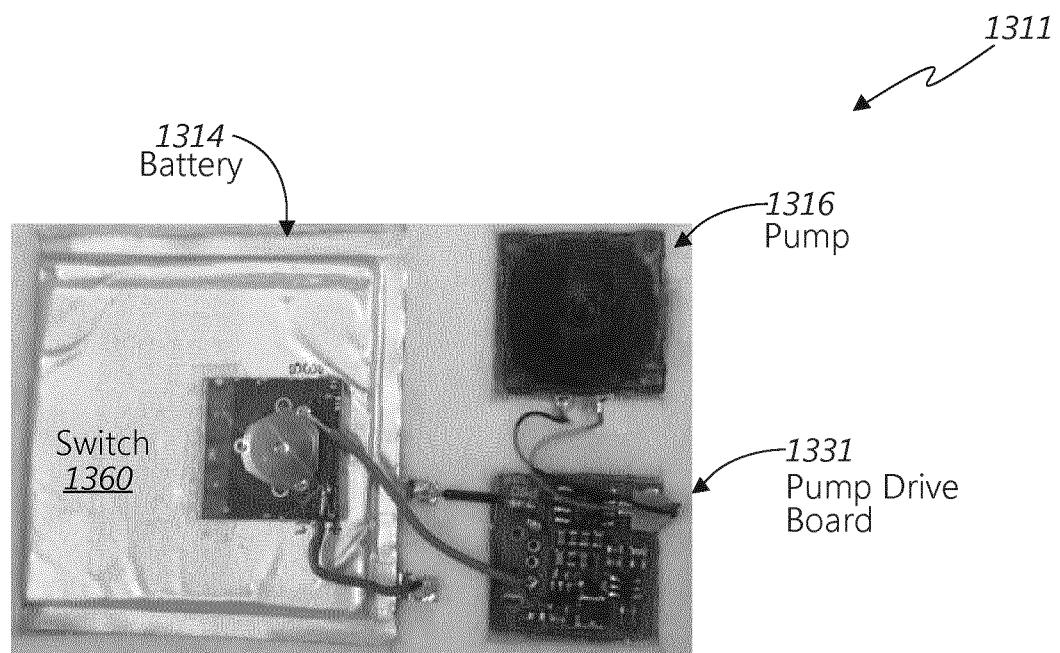


FIG. 13

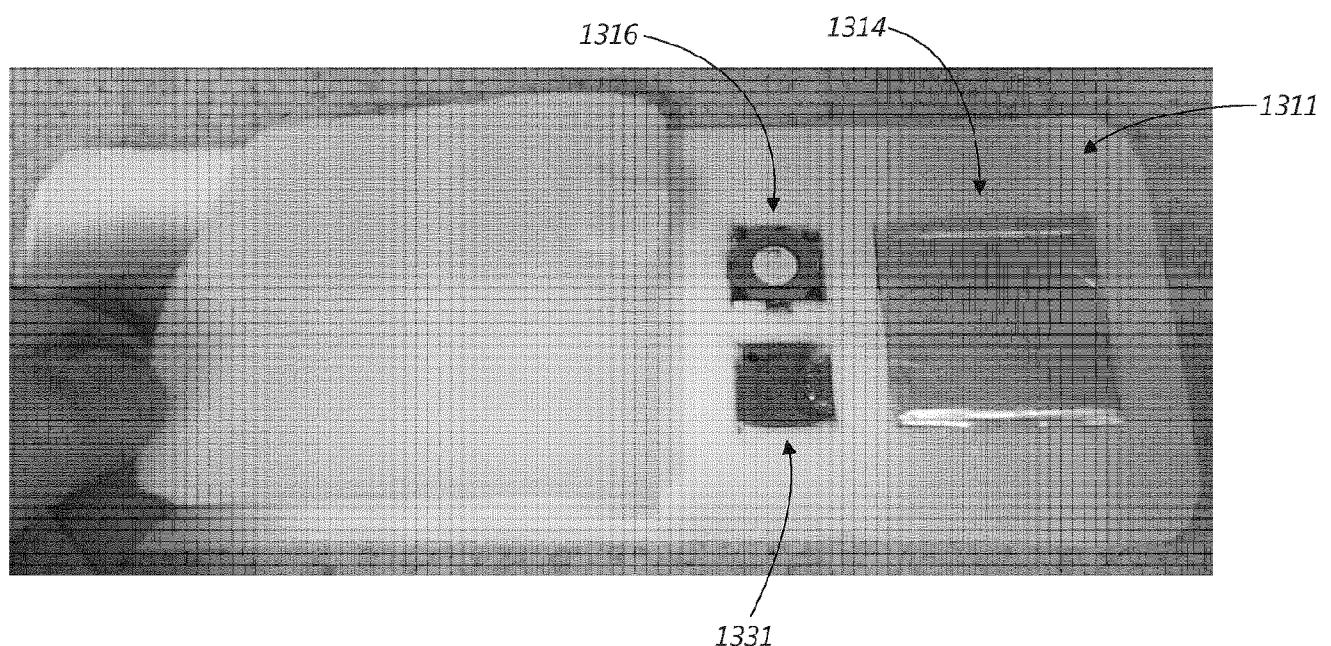


FIG. 14

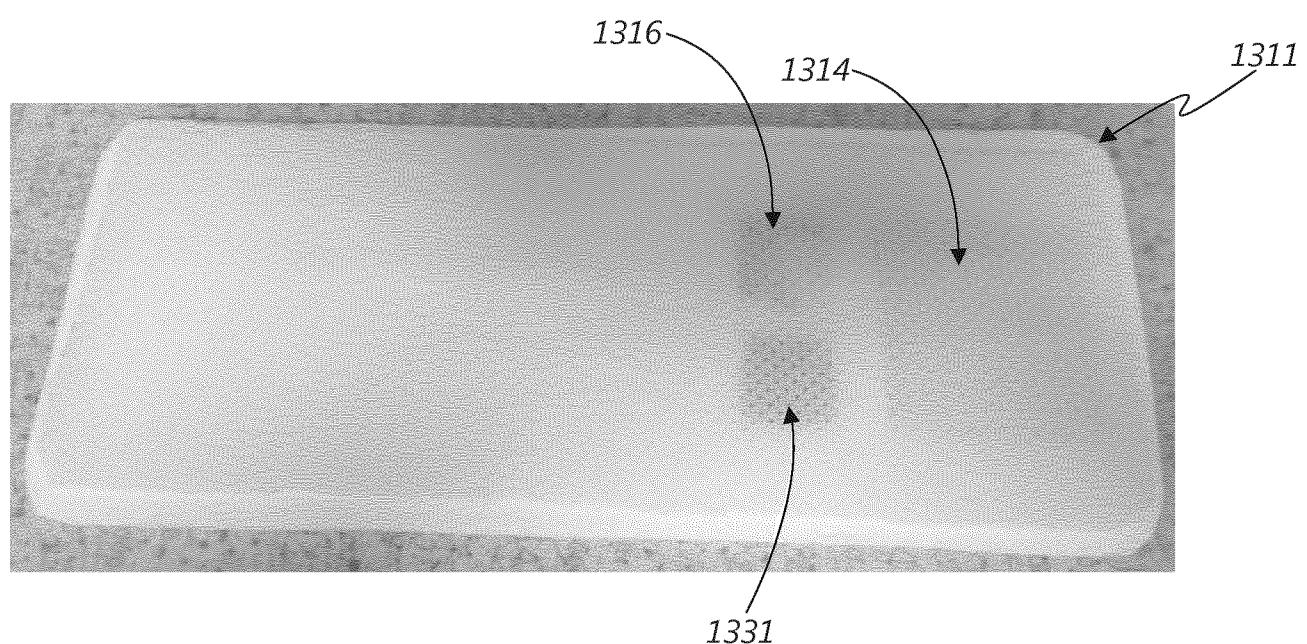


FIG. 15

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2016/059329

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. A61F13/00 A61F13/02 A61M1/00 A61M27/00  
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
A61F A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013/175306 A2 (SMITH & NEPHEW [GB]) 28 November 2013 (2013-11-28)	1-12,14, 15
A	paragraphs [0073], [0074], [0075], [0097], [0104], [0155]; figure 1B -----	13,16-19
Y	US 2011/224631 A1 (SIMMONS TYLER [US] ET AL) 15 September 2011 (2011-09-15)	1-12,14, 15
A	paragraph [0042]; claims 1-38; figure 1 -----	13,16-19
Y	WO 2013/136181 A2 (SMITH & NEPHEW [GB]) 19 September 2013 (2013-09-19)	1-12,14, 15
A	claims 1-72 -----	13,16-19
Y	US 2015/065965 A1 (HAGGSTROM KURT [US] ET AL) 5 March 2015 (2015-03-05)	1-12,14, 15
A	paragraph [0036]; claims 22-48 -----	13,16-19
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Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
4 July 2016	14/07/2016

Name and mailing address of the ISA/  
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Authorized officer

Gennari, Silvia

**INTERNATIONAL SEARCH REPORT**

International application No
PCT/EP2016/059329

**C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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