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(54) **WOUND TREATMENT SYSTEM AND METHOD**

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A61B 5/00	(2006.01)

(52) **U.S. Cl.**

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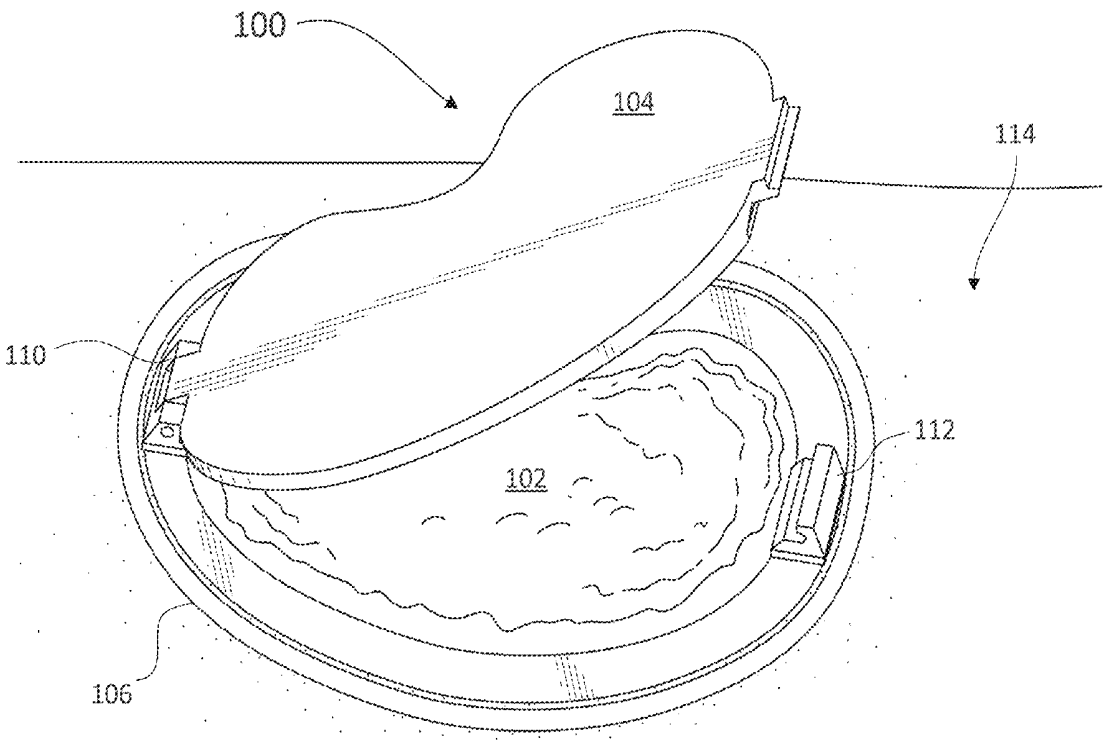
(57) **ABSTRACT**

A bandage for treating a wound includes a carrier plate and a peripheral support to affix to skin area surrounding a wound. The carrier plate and the peripheral support define an enclosure encompassing the wound and provide access to the wound for monitoring and treatment.



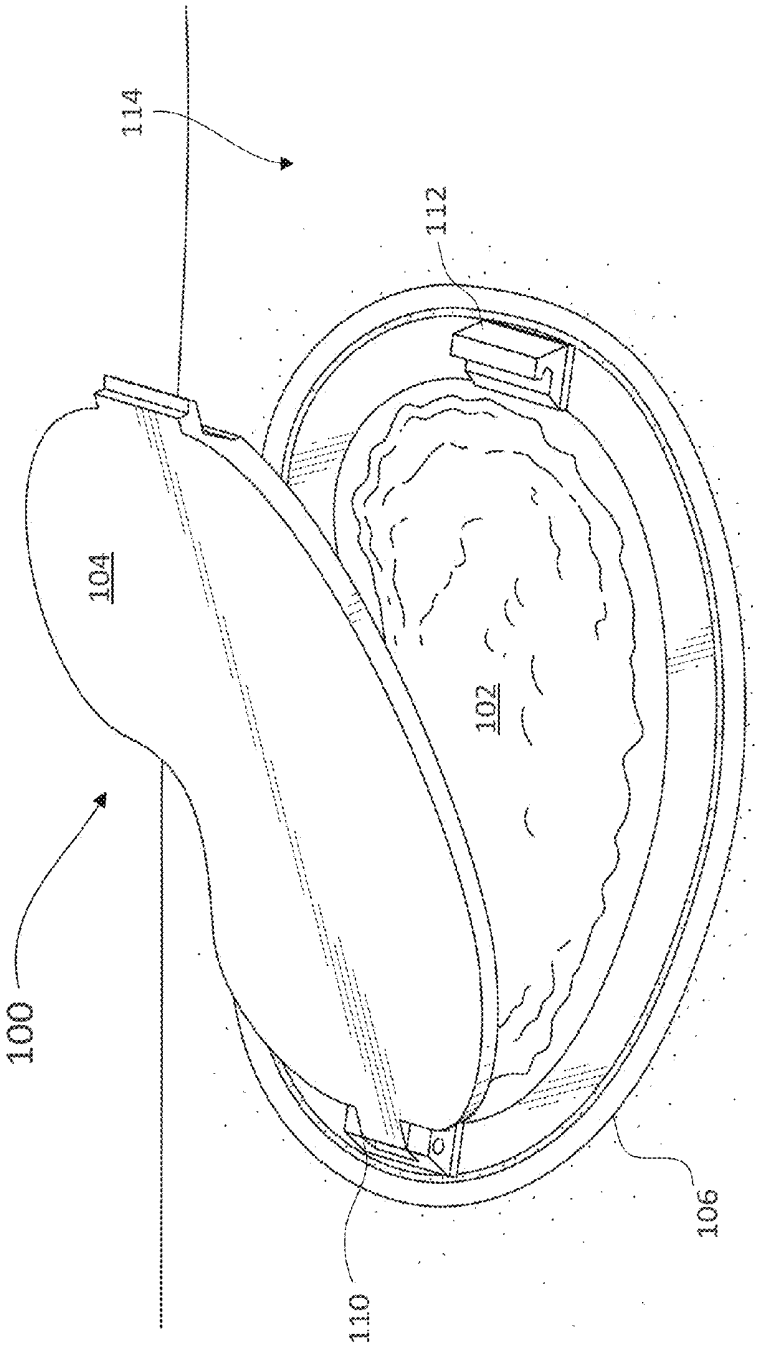


Fig. 1

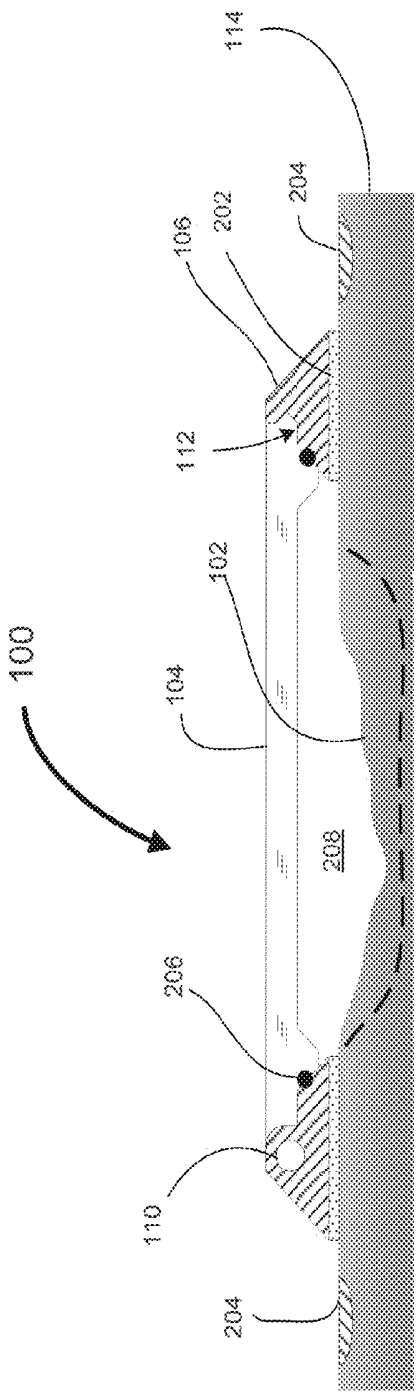

100
102
104
106
110
112
114
202
204
206
208

Fig. 2a

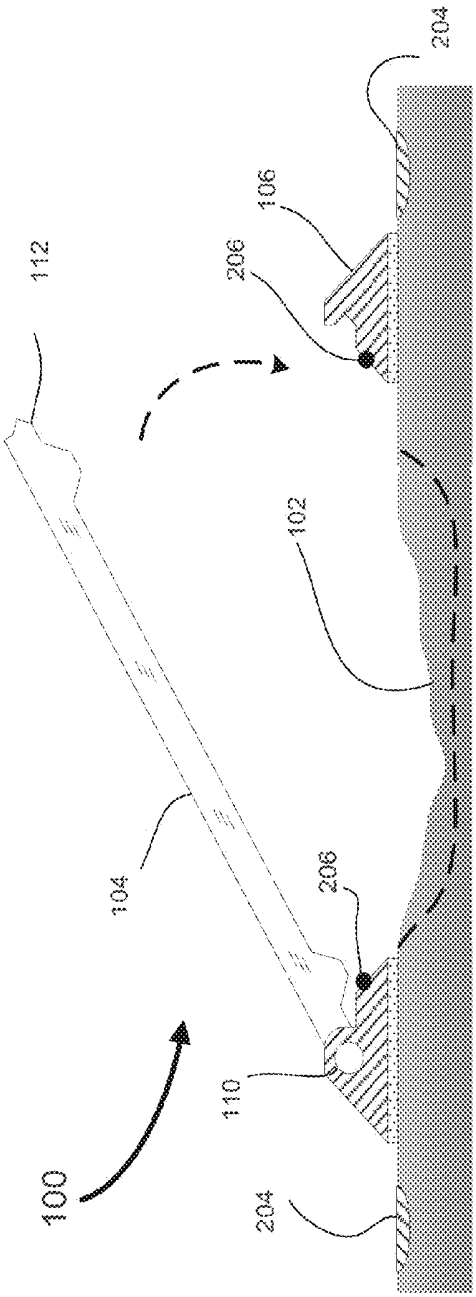

100
102
104
106
110
112
204
206

Fig. 2b

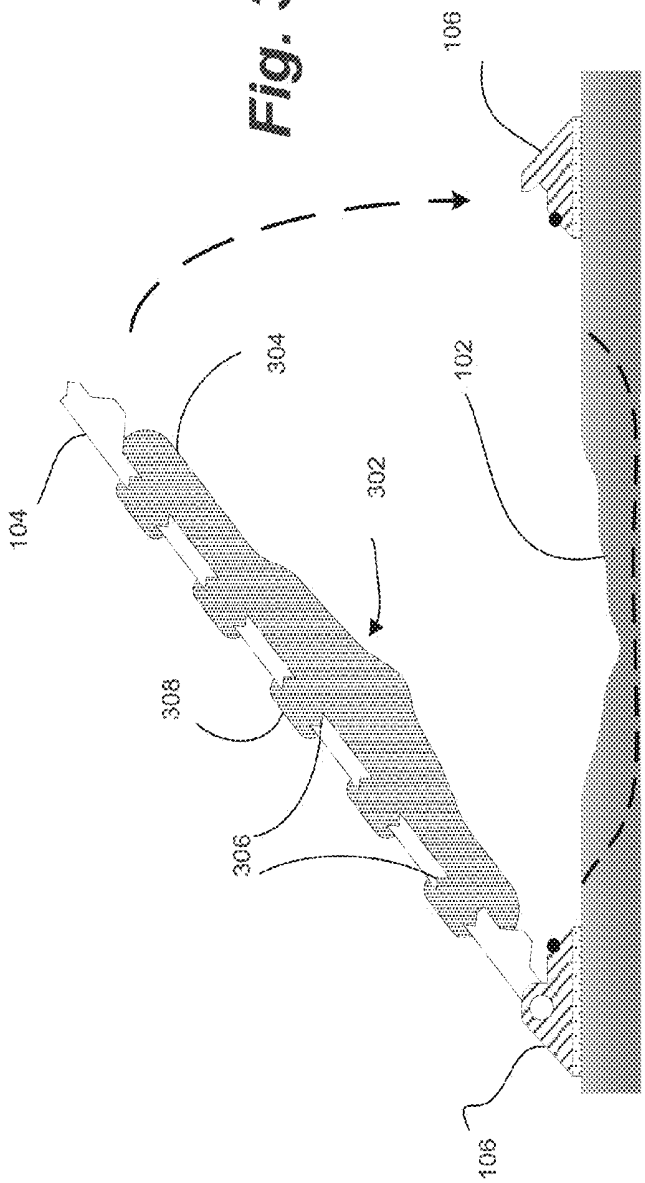


Fig. 3a

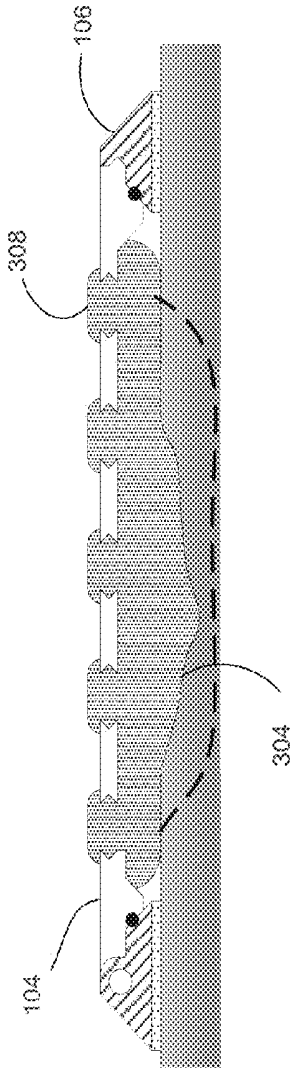


Fig. 3b

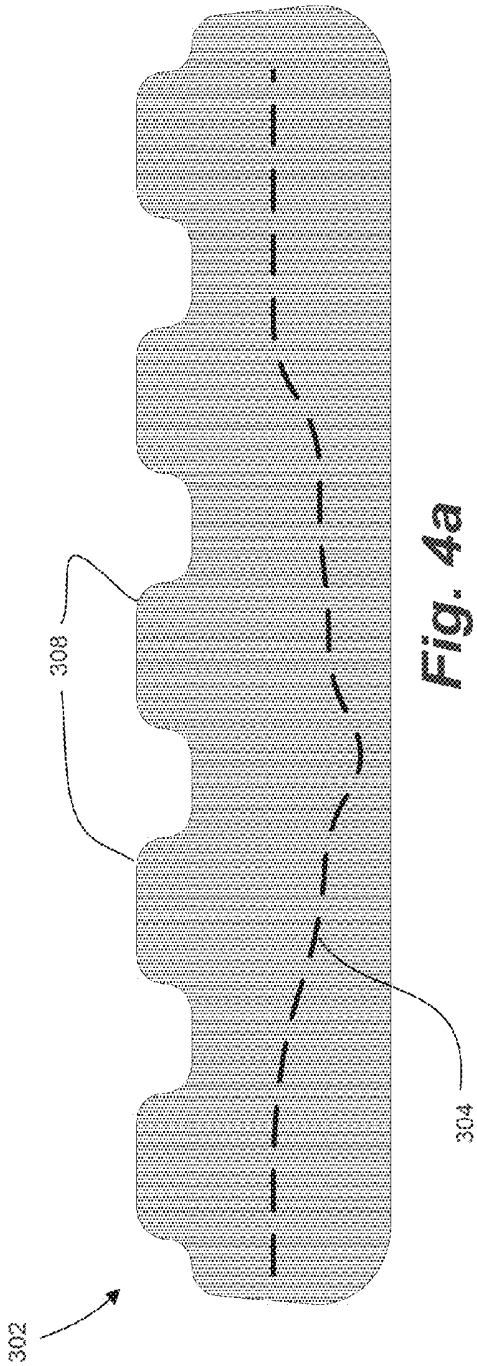


Fig. 4a

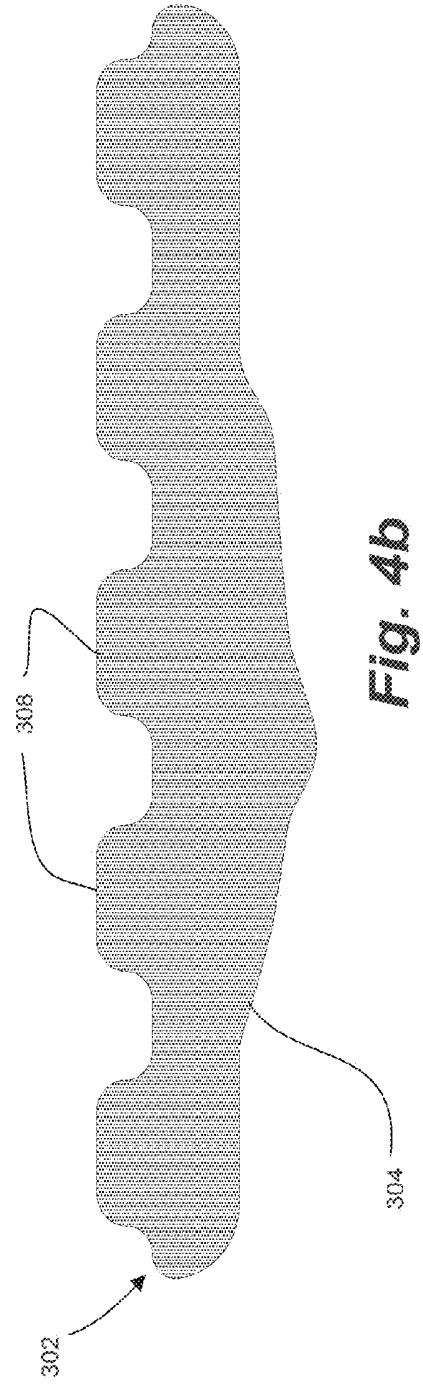


Fig. 4b

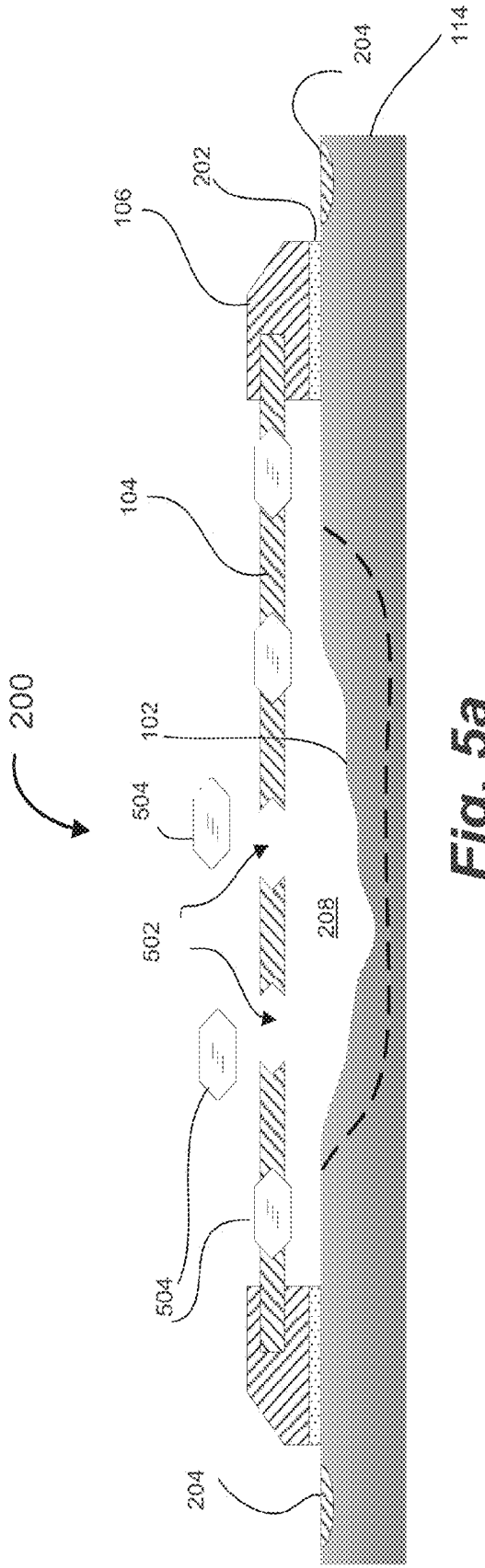

200
204
114
202
106
104
102
504
502
208
504
204

Fig. 5a

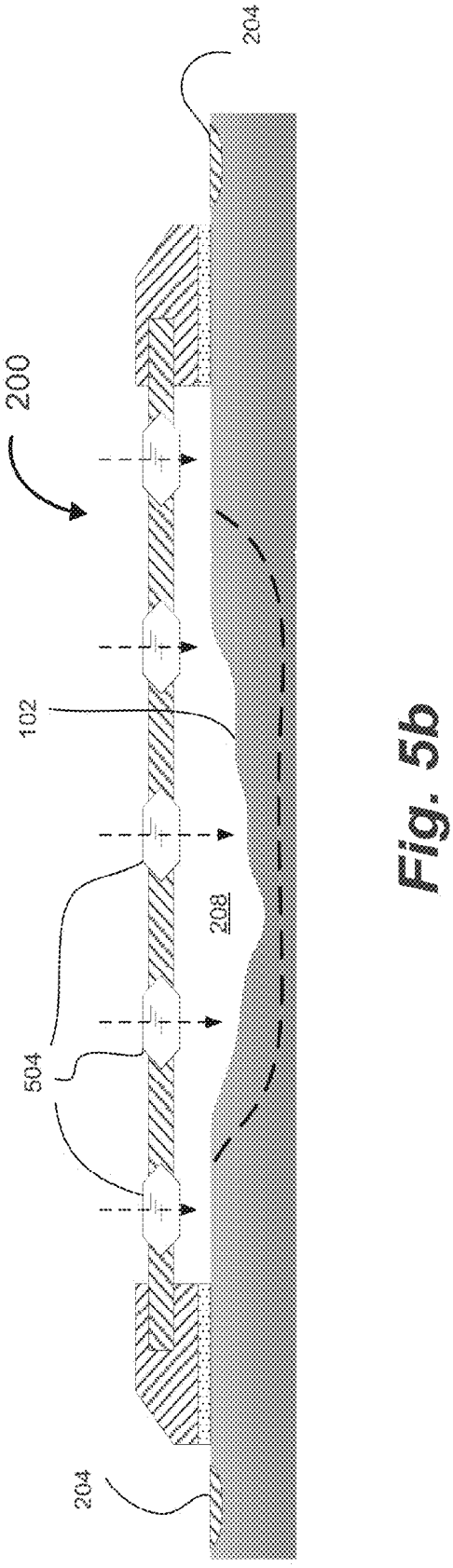

200
204
102
208
504
204

Fig. 5b

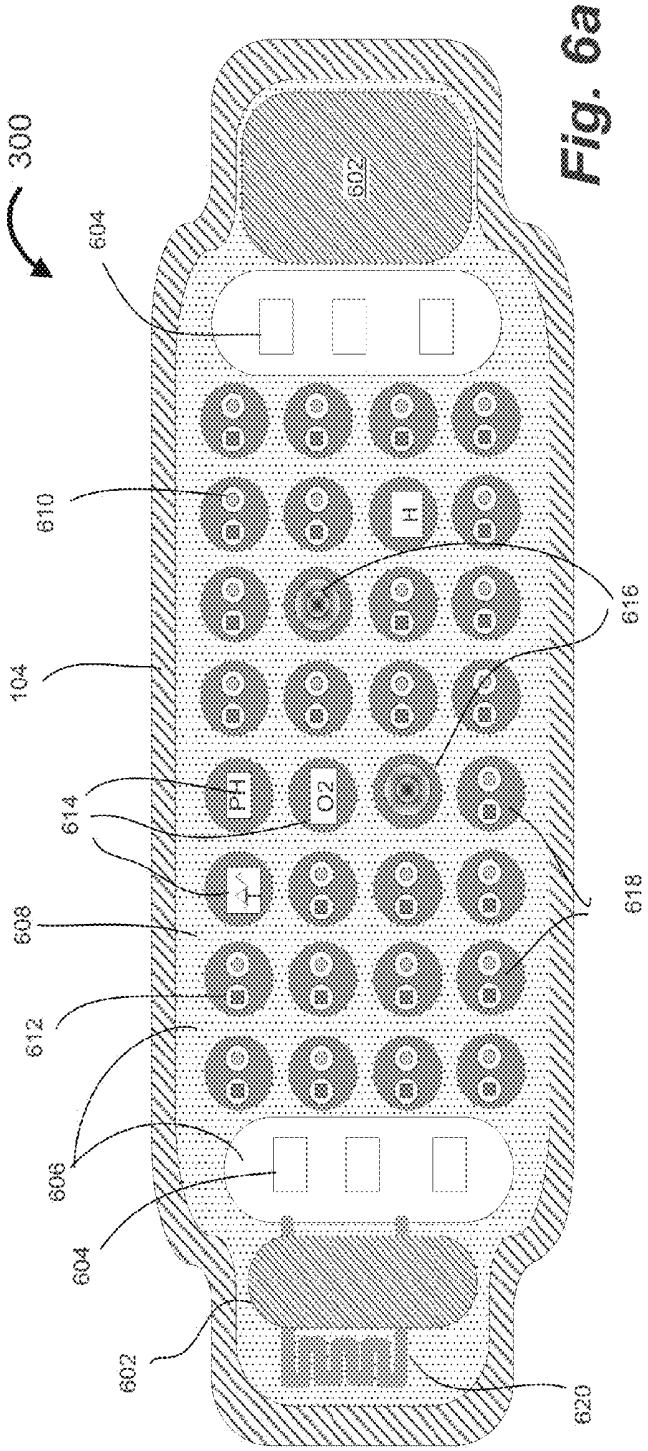

300
602
604
610
104
614
608
612
606
604
602
620
616
618
H
PH
O2

Fig. 6a

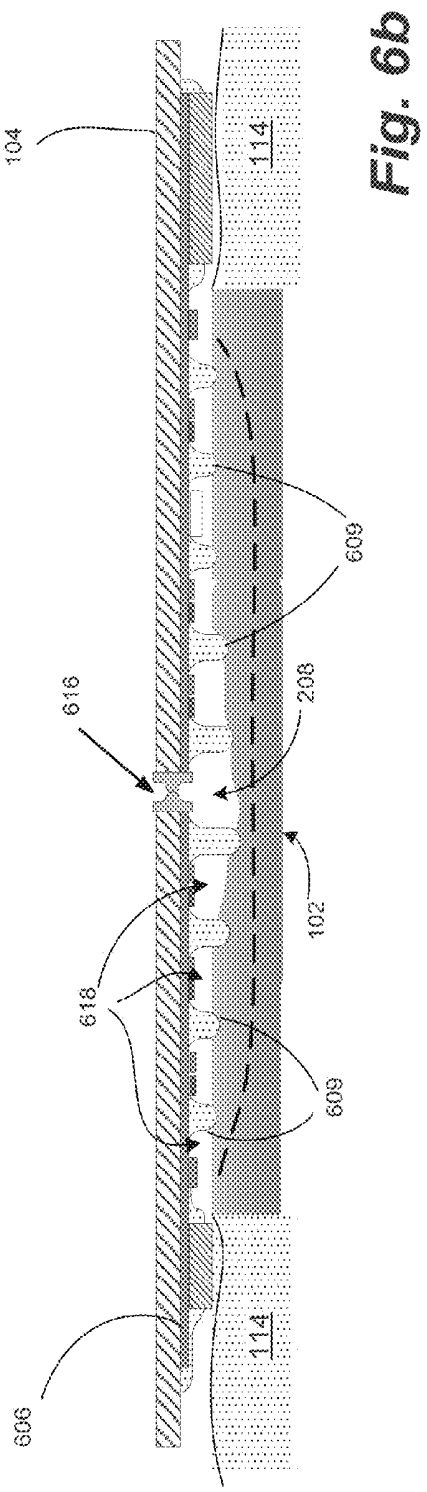

104
114
609
616
208
102
618
609
114
606

Fig. 6b

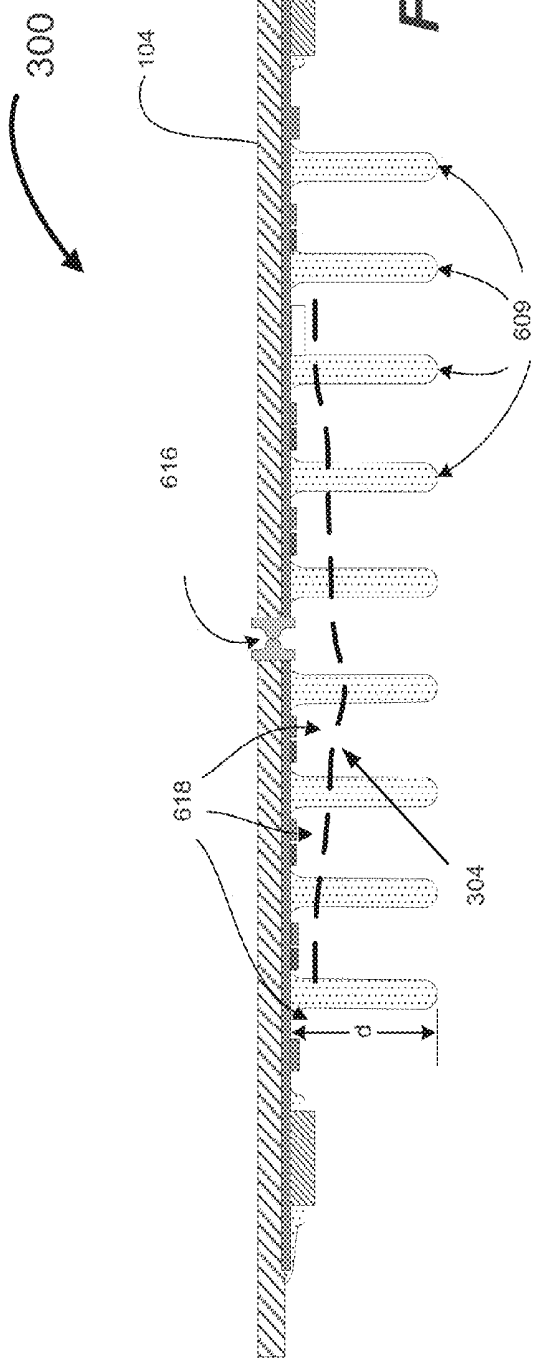


Fig. 7a

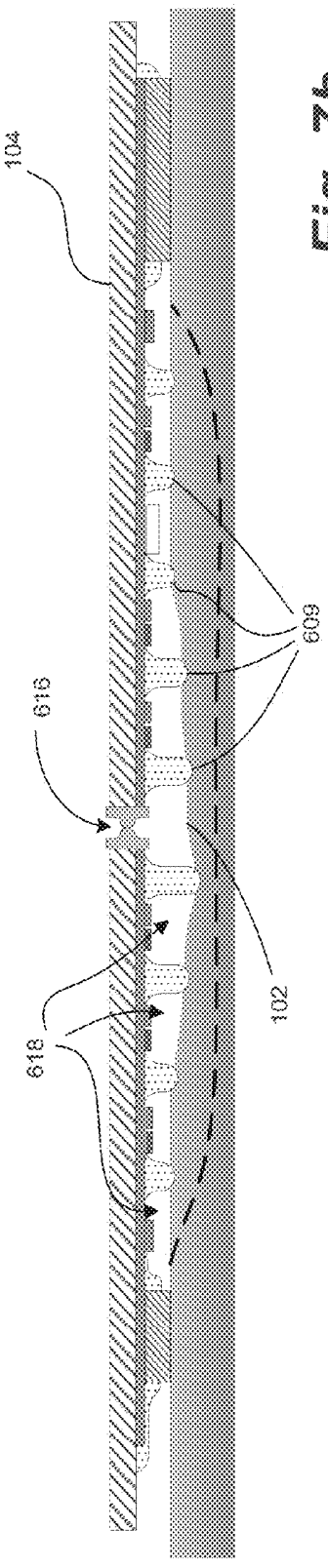


Fig. 7b

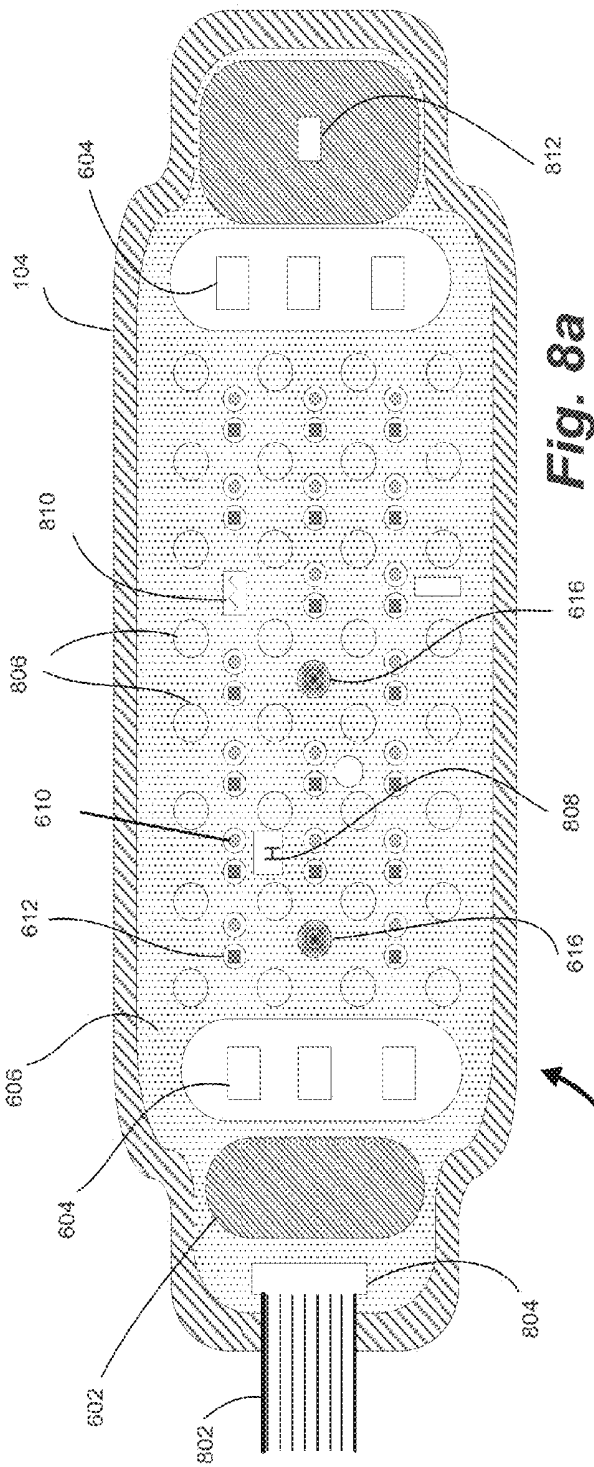


Fig. 8a

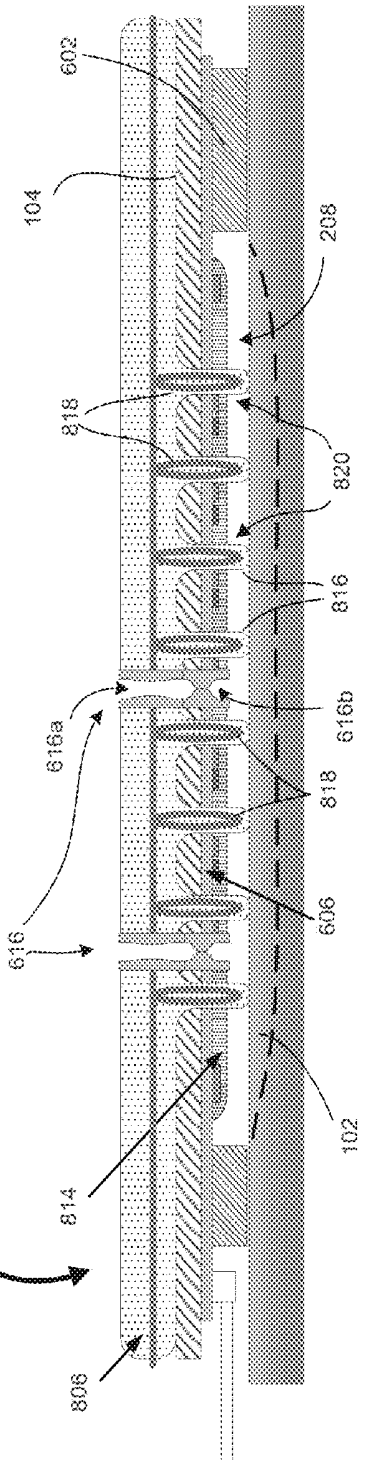


Fig. 8b

200

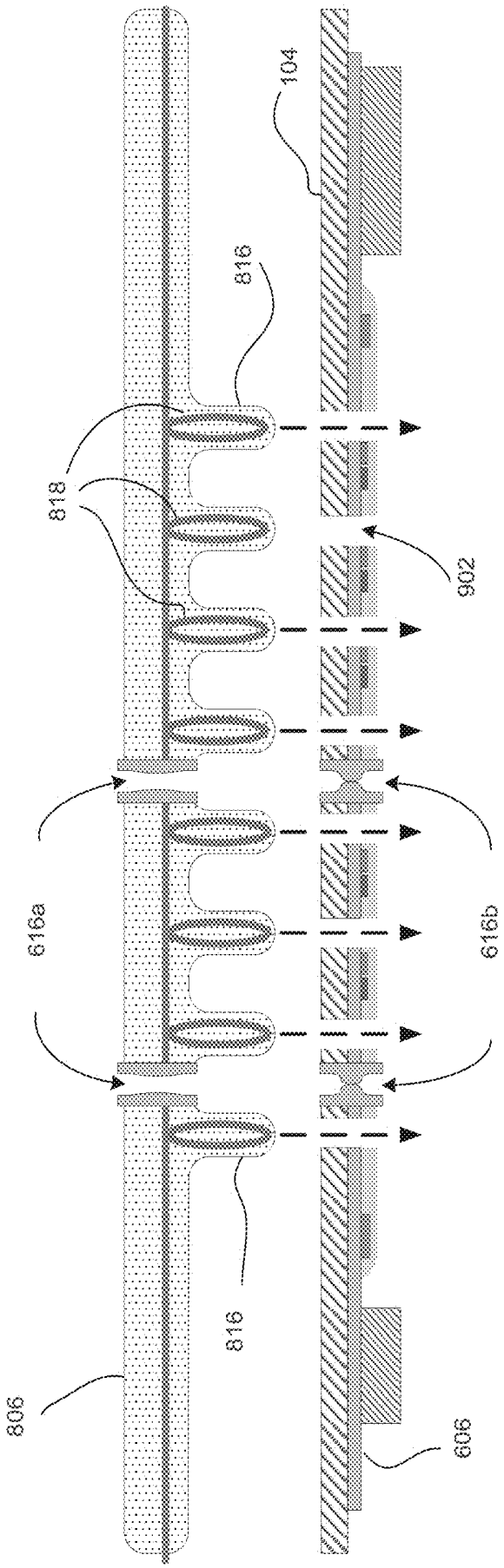


Fig. 9

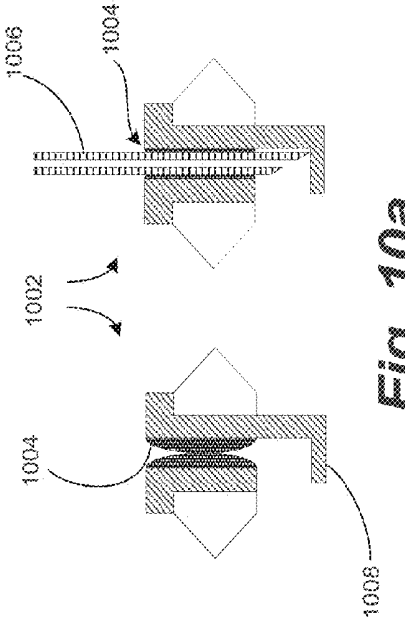


Fig. 10a

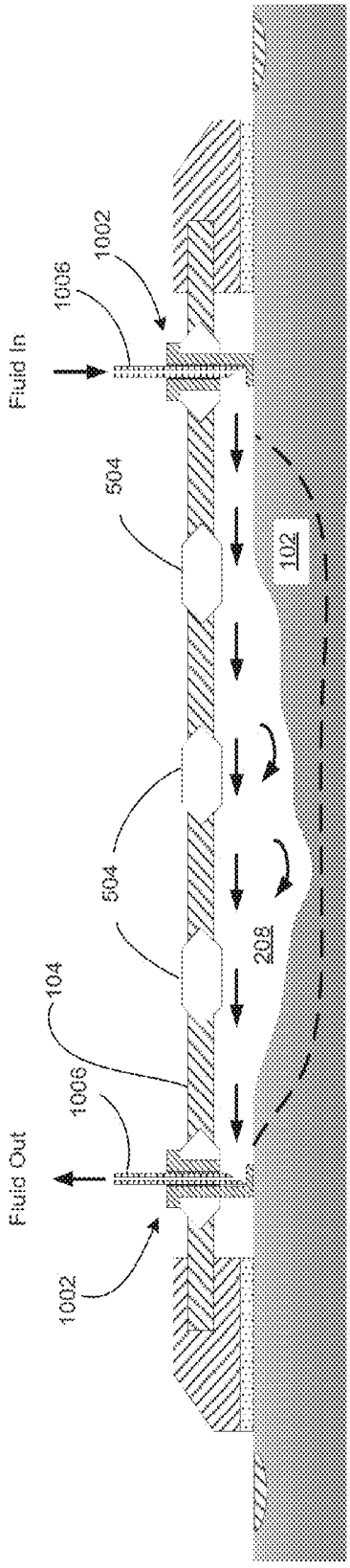


Fig. 10b

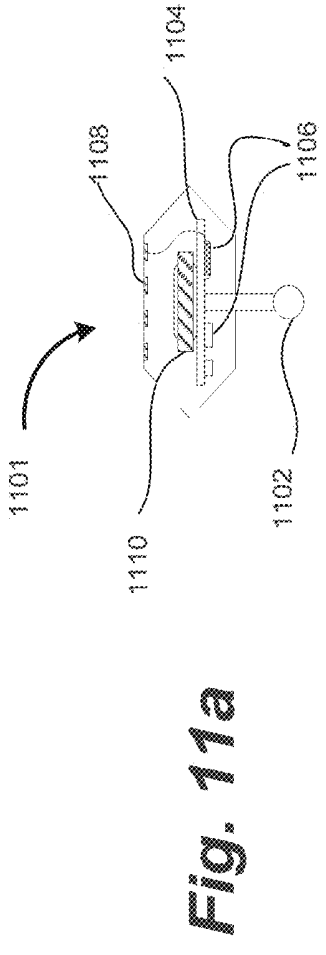


Fig. 11a

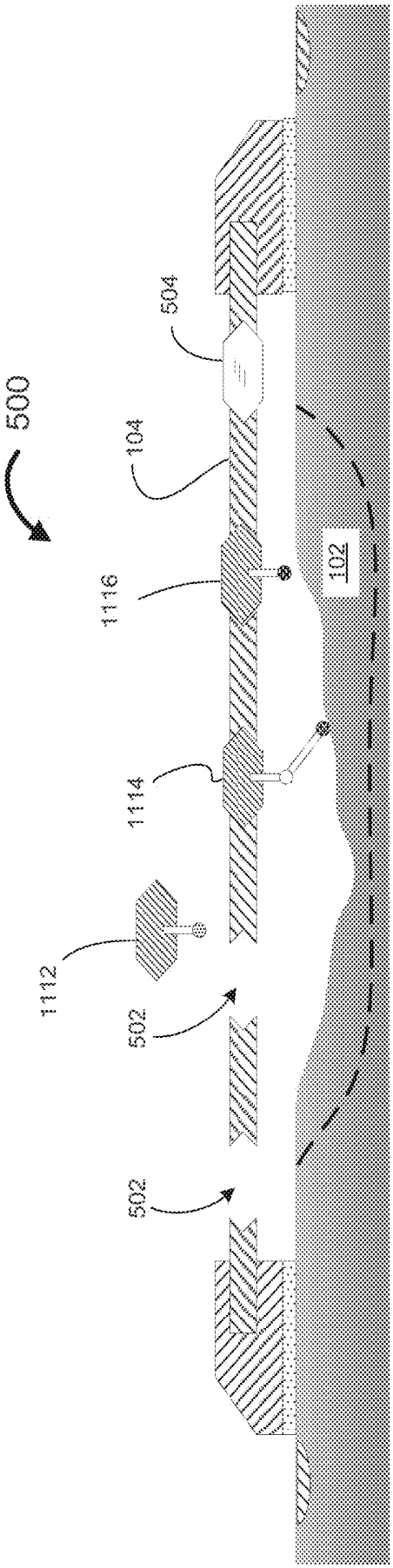


Fig. 11b

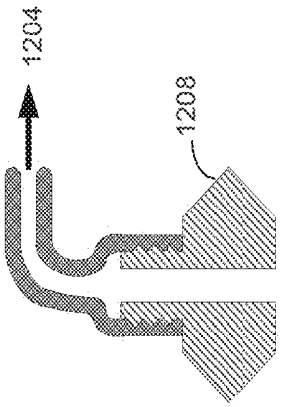


Fig. 12a

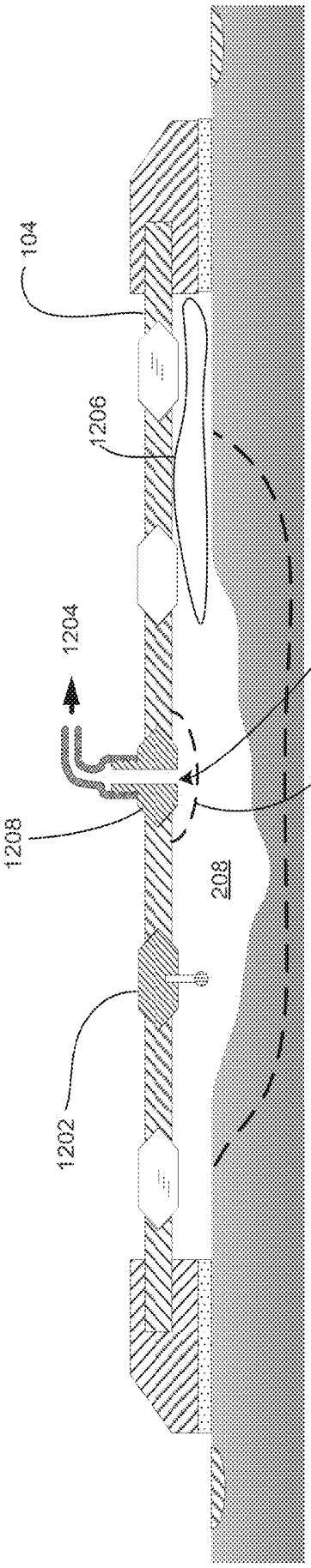


Fig. 12b

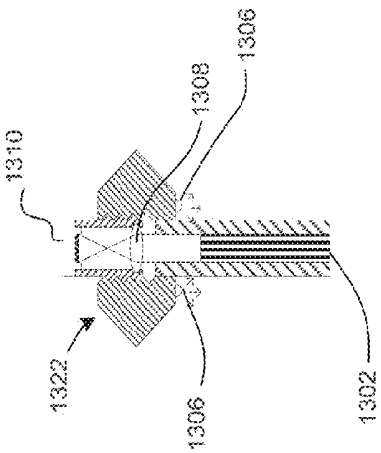


Fig. 13a

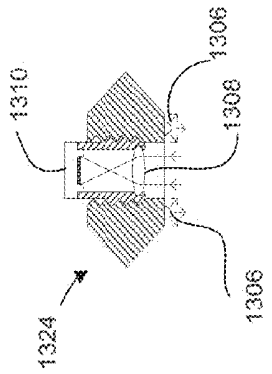


Fig. 13b

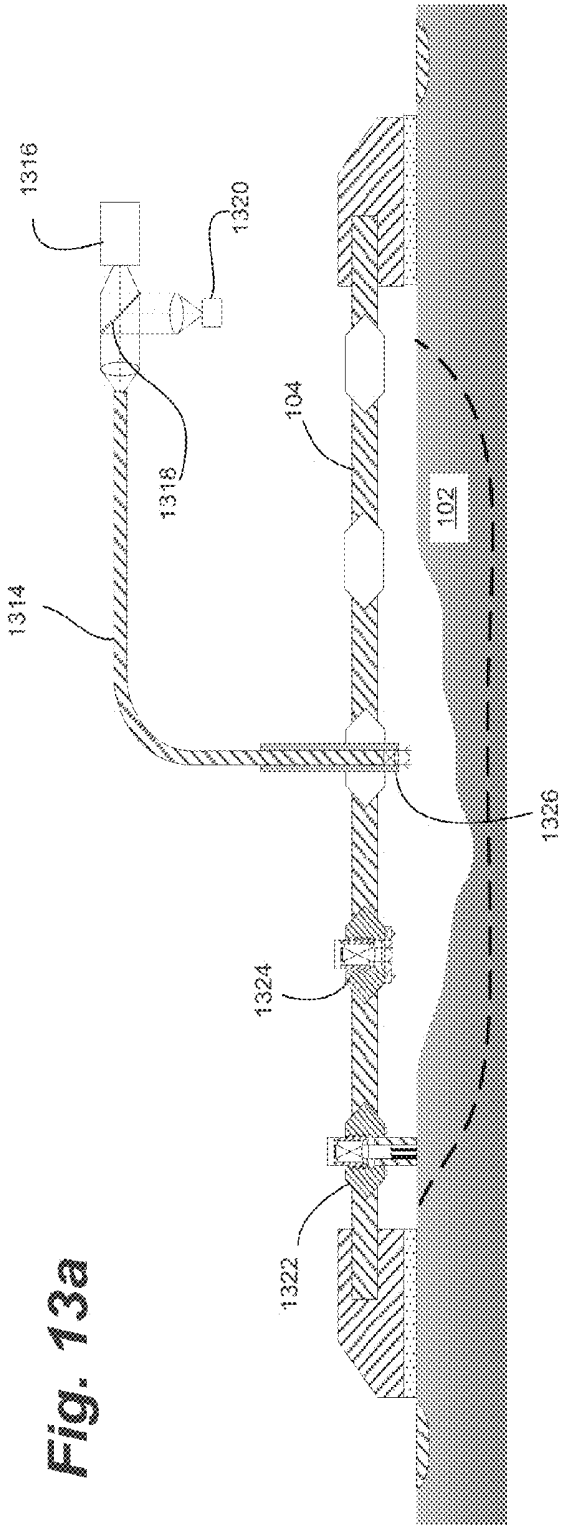


Fig. 13c

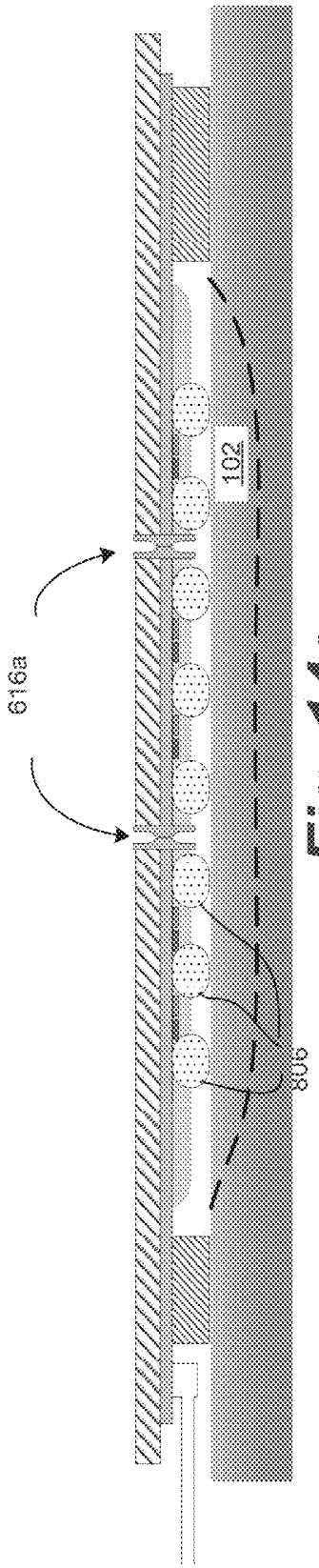


Fig. 14a

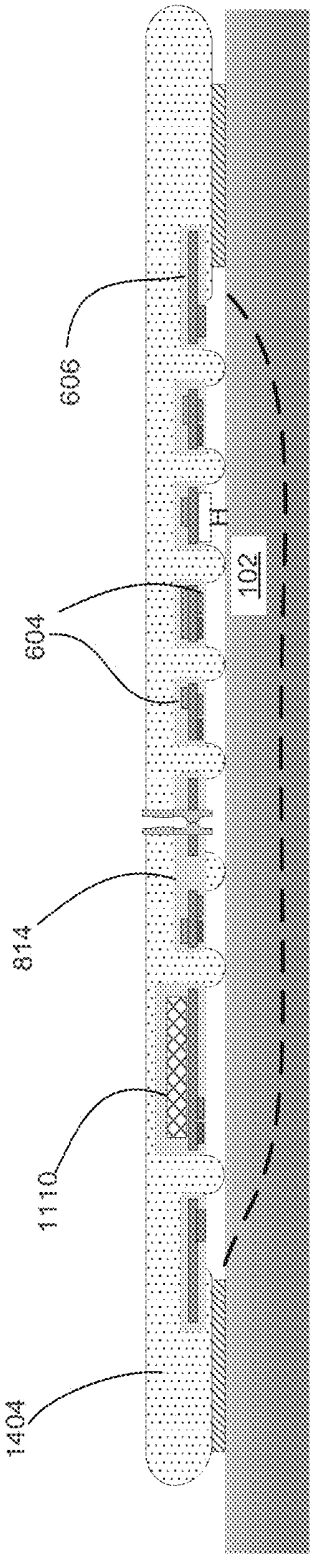


Fig. 14b

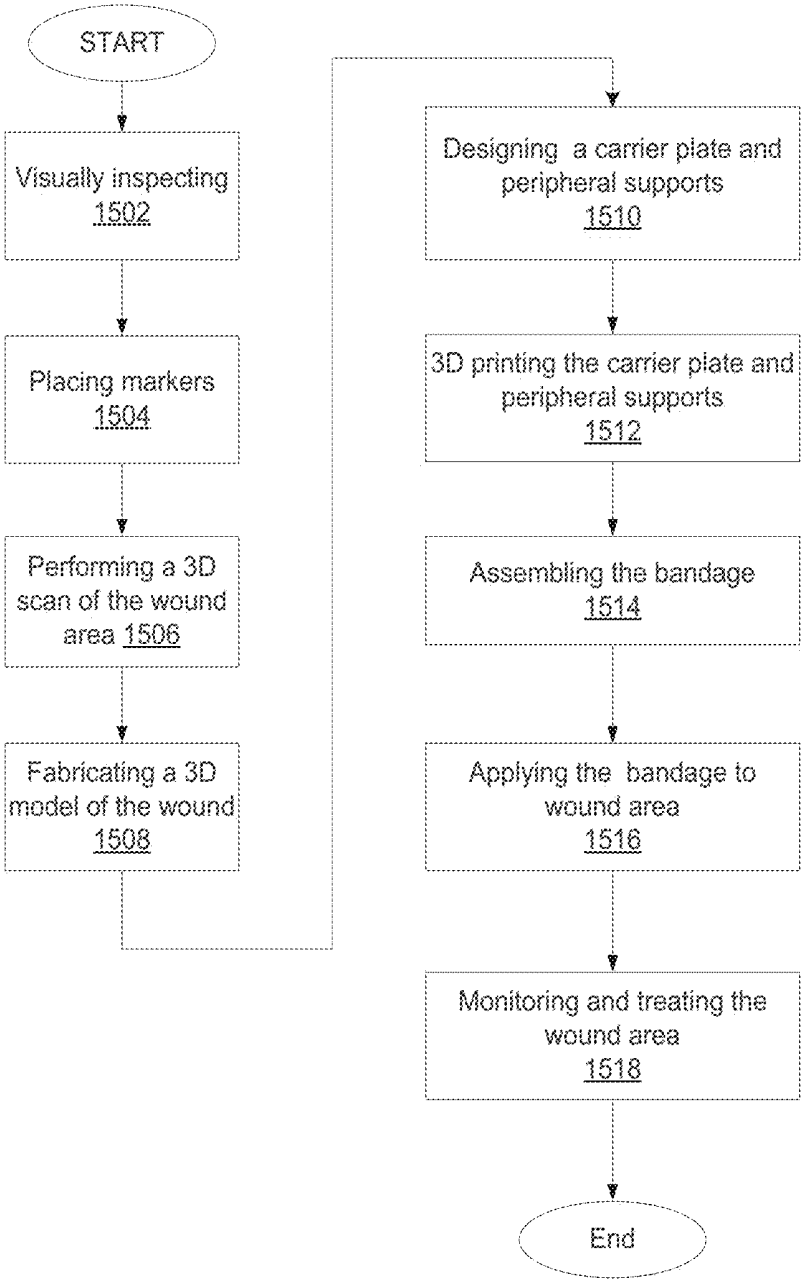

START
Visually inspecting 1502
Placing markers 1504
Performing a 3D scan of the wound area 1506
Fabricating a 3D model of the wound 1508
Designing a carrier plate and peripheral supports 1510
3D printing the carrier plate and peripheral supports 1512
Assembling the bandage 1514
Applying the bandage to wound area 1516
Monitoring and treating the wound area 1518
End

Fig. 15

WOUND TREATMENT SYSTEM AND METHOD

CLAIM FOR PRIORITY

[0001] The present Application for Patent claims priority to U.S. Provisional Application No. 62/280,510 entitled "WOUND TREATMENT SYSTEM AND METHOD" filed Jan. 19, 2016, assigned to the assignee hereof and hereby expressly incorporated by reference herein.

TECHNICAL FIELD

[0002] The disclosed apparatus and methods generally relate to wound treatment, particularly, bandages for treating chronic wounds.

BACKGROUND

[0003] Bandages are known to include a piece of material used either to support a medical device such as a dressing or splint and/or restrict the movement of a part of the body. A dressing is a sterile pad or compress applied to a wound to promote healing and/or prevent further harm. A dressing is designed to be in direct contact with the wound, as distinguished from a bandage, which is most often used to hold a dressing in place. Other types of bandages are used without dressings, such as elastic bandages that are used to reduce swelling or provide support to a sprained ankle. Tight bandages can be used to slow blood flow to an extremity, such as when a leg or arm is bleeding heavily.

[0004] The estimated costs of treating chronic wounds range from 18 to 50 billion dollars per year. The average cost is over $3900 per wound while the average length of each treatment is 15 weeks. The average length of hospital stays for pressure ulcer treatments is 13 days.

[0005] A vast majority of treatments involve periodic cleanings, visual monitoring of wounds, and packing of wounds with a dressings, devices, and compounds, depending on the depth of the wound, presence of infection, presence of discharges, and state of the healing process. The timing of treatments varies, from daily to weekly, depending on the state of the wound.

BRIEF DESCRIPTION OF DRAWINGS

[0006] The disclosed wound treatment device and method is described in detail in the following description with reference to the examples illustrated in the following figures.

[0007] FIG. **1** illustrates an area of skin protected with a wound treatment device, (hereinafter referred to as a 'bandage"), according to an example of the present disclosure.

[0008] FIGS. **2***a* and **2***b* illustrate the bandage in FIG. **1** as applied to a wound area according to an example.

[0009] FIGS. **3***a* and **3***b* illustrate the bandage depicted in FIG. **1**, including biocompatible material attached to a cover plate of the bandage according to an example.

[0010] FIGS. **4***a* and **4***b* illustrate the biocompatible material depicted in FIGS. **3***a* and **3***b* according to examples of the present disclosure.

[0011] FIGS. **5***a* and **5***b* illustrate the bandage including ports in the cover plate according to examples of the present disclosure.

[0012] FIGS. **6***a* and **6***b* illustrate the bandage, including test and treatment wells, according to an example of the present disclosure.

[0013] FIGS. **7***a* and **7***b* illustrate the bandage according to examples of the present disclosure.

[0014] FIGS. **8***a* and **8***b* illustrate the bandage as including electrical components and pad protrusions according to an example of the present disclosure.

[0015] FIG. **9** illustrates additional details of the bandage depicted in FIGS. **8***a* and **8***b*.

[0016] FIGS. **10***a* and **10***b* illustrate a mechanism to pump fluid through a wound enclosure of the bandage according to an example of the present disclosure.

[0017] FIGS. **11***a* and **11***b* illustrate the bandage of FIG. **1**, including at least one wireless sensor, according to an example of the present disclosure.

[0018] FIGS. **12***a* and **12***b* illustrate the bandage of FIG. **1**, according to other examples of the present disclosure.

[0019] FIGS. **13***a*, **13***b*, and **13***c* illustrate the bandage according to the present disclosure that facilitates visual monitoring of the wound.

[0020] FIGS. **14***a* and **14***b* illustrate another embodiment of the bandage of FIG. **1**, according to an example of the present disclosure.

[0021] FIG. **15** illustrates a flowchart for designing, fabricating, and using the bandage of FIG. **1**, according to an example of the present disclosure.

DETAILED DESCRIPTION

[0022] For simplicity and illustrative purposes, the principles of the embodiments are described by referring mainly to examples thereof. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the embodiments. It is apparent that the embodiments may be practiced without limitation to all the specific details. Furthermore, the embodiments may be used together in various combinations.

[0023] FIG. **1** depicts an example of a bandage **100** for treating chronic wounds. The bandage **100** is adaptable to the unique characteristics of each wound (size, depth, drainage, infections). Bandage **100** provides comfort to the patient while minimizing the frequency of major interventions and/or product replacements.

[0024] Bandage **100** includes a carrier plate **104** matched to a peripheral support **106**. In the example shown in FIG. **1**, a peripheral support **106** is attached to non-wounded skin **114**, i.e., healthy skin, surrounding wound **102**. As shown in the example of FIG. **1**, the carrier plate **104** is mounted to the peripheral support **106** via a hinge **110** and a latch **112**. In another example, the carrier plate **104** and peripheral support **106** are integrated into a single fabricated unit.

[0025] In FIGS. **2***a* and **2***b*, a bandage **100** is attached to the skin **114** using an adhesive **202** that affixes the peripheral support **106** to the surface of the skin **114**. In another example, the carrier plate **104** may be pressed against the skin **114** by a strap (not shown) without a peripheral support. Markers **204** identify a perimeter of the wound **102**. In an example, markers **204** are used to identify the wound area when the wound is scanned by optical devices including cameras and 3D scanning equipment. Additionally, the markers **204** may be used to accurately place a wound treating appliance, including bandage **100**. At least a portion of carrier plate **104** is transparent and allows the care giver to observe the healing process through the transparent portion of the carrier plate **104**. In an example, the care giver may access the wound **102** by opening latch **112** and rotating the carrier plate **104** around hinge **110** to expose the wound

102. A sealing gasket **206** runs along a contact edge between the carrier plate **104** and the peripheral support **106**. The carrier plate **104** behaves as a treatment door that provides easy access to the wound **102** without requiring the unwrapping and wrapping of bandages or removal and reapplication of adhesive strips.

[0026] FIGS. **3***a* and **3***b* depict the carrier plate **104** including ports **306**, which can be used to fasten biocompatible material **302**, such as sponge or gauze used to absorb exudates, extending to the wound **102** to the carrier plate **104**. The material **302** may be pre-shaped to present protrusions **308** which mate with the ports **306**.

[0027] The wound enclosure **208**, defined by the skin surface and inside surface of the carrier plate **104**, is modeled and the biocompatible material **302** is shaped along cut line **304** to match the shape of the wound. In an example, the biocompatible material **302** is shaped to fill the wound enclosure **208**, but not to apply pressure to the wound **102**. If there is bleeding to be stopped, the biocompatible material **302** is shaped to apply pressure to a surface of the wound **102**.

[0028] In an example, the biocompatible material **302** is fastened to a moveable portion of the carrier plate **104**, which is snapped in its closed position as shown in FIG. **3***b*. FIGS. **4***a* and **4***b* illustrate biocompatible material **302** prior to, and after being shaped along cut line **304**.

[0029] In an example, FIGS. **5***a* and **5***b* depict bandage **200**, in which carrier plate **104** and peripheral support **106** are fabricated as a single unit. Peripheral support **106** is attached to the skin **114** surrounding the wound **102** using an adhesive **202** or alternate mechanism, such as a strap (not shown) that secures the bandage **200** to the skin.

[0030] FIGS. **5***a* and **5***b* depict carrier plate **104** having multiple ports **502** that facilitate sensing and/or treatment of the underlying wound **102**. In an example one or more of plugs **504** is transparent and is inserted into selected ports **502**, depending on treatment requirements. In FIG. **5***b*, plugs **504** are transparent and allow for visual monitoring of the wound enclosure **208**.

[0031] FIGS. **6***a* and **6***b* depict a bandage **300** that includes a closed loop monitoring and treatment system that includes sensing and actuating components **614** and intervention ports, i.e., test and treatment wells (hereinafter "wells") **618** for treating chronic wounds. The sensing and actuating components **614** monitor and communicate to a care giver the status of the wound **102** on a continuous basis and wells **618** give the care giver access to the wound **102** on short notice and with minimal effort. The sensing and actuating components **614** may be interchanged and are appropriate to the type of wound being treated (pressure ulcer, burn, etc.).

[0032] In an example, wells **618** are defined by protrusions **609** extending from a pad **608** formed of biocompatible material **302** (see FIGS. **3-4**) that is affixed to carrier plate **104**. In the example shown, pad **608** and protrusions **609** are made of gauze, foam, or any other suitable material. In different examples, carrier plate **104** includes multiple wells **618**. Although wells **618** are depicted as being cylindrical in shape, in other examples, wells **618** may take other shapes appropriate to the wound **102** and the specific treatment for the wound **102**. Within each well **618**, the sensing and actuating components **614** provide interaction with the wound **102**.

[0033] Sensing and actuating components **614** may include an oxygen sensor (O2), a Ph sensor (PH), a temperature sensor (T), or other type of sensor, which may be positioned in the bandage **300** to provide information regarding the state of healing of the wound **102**. Humidity sensor (H) may provide an indication of whether the wound enclosure **208**, i.e., the area encompassed by the bandage **300**, is properly insulated. Sensing and actuating components **614** are not limited to the sensors and actuators listed above and may be replaced or augmented by other sensors and actuators as needed to monitor and treat a wound. In other examples, laser diodes provide phototherapy effects. Pairs of LEDs **610** and photo detectors **612** may be incorporated to ascertain the color of the wound in the visible, as well as the infra-red spectrum.

[0034] The sensing and actuating components **614**, as well as electronic components **604** that communicate with the sensing and actuating components **614**, are, in an example, mounted on a circuit board **606**, which is affixed to carrier plate **104**. In examples, the circuit board **606** is flexible and the carrier plate **104** is fabricated as a single structure.

[0035] In an example, bandage **300** includes at least one input/output (I/O) channel **616** that extend through the carrier plate **104** and provide access to the wound **102**. In an example, I/O channel **616** includes deformable sidewalls to provide a self-sealable access port to the wound **102** in order to extract tissue samples and/or apply treatments to the wound **102**.

[0036] Still further, FIGS. **6***a* and **6***b* depict adhesive strips **602** to affix the bandage **300** to the skin **114**. Further still, electronic components **604** include devices to facilitate communication with external devices via a radio frequency (RF) link that supports at least one of Wi-Fi, BLUETOOTH™, Near Field Communication (NFC) and other protocols. Antenna **620** may support these or similar communication channels.

[0037] A wound **102** has its own shape and size. FIGS. **7***a* and **7***b* depict examples of a bandage **300** in which a depth (d) of each well **618** may be individually adjusted for a specific wound **102** being treated. FIG. **7***a* shows the bandage **300** having the protrusions **609** in an original and unadjusted state. FIG. **7***b* depicts the protrusions **609** cut based on a 3D model of the wound, so that the wells **618** conform to the wound **102**.

[0038] FIG. **8***a* depicts an example of bandage **200** that includes a cable **802** attached to a connector **804** in electrical communication with electronic components **604** and sensors and actuators disposed on the carrier plate **104**. The sensors and actuators include, but are not limited to photo detector **612**, light emitting diode (LED) **610**, humidity sensor **808**, thermometer **810**, and a Galvanic Skin Response Sensor (GSR) **812** to measure electrical conductance of the skin.

[0039] FIG. **8***b* further depicts biocompatible pad **806** making contact with the wound via pad protrusions **816**. In an example biocompatible pad **806** is secured to the carrier plate **104** via pad protrusions **816**, which may be forced through apertures **902** (FIG. **9**) within carrier plate **104** and/or circuit board **606**. The pad protrusions **816** include a spring **818** or similar feature to hold the biocompatible pad **806** in place applying tension against an inner surface of the apertures **902**. I/O channels **616** are formed by the alignment of I/O channels **616***a* and I/O channel **616***b*, through biocompatible pad **806**, carrier plate **104**, and circuit board **606**. In an example, a biocompatible coating **814** isolates the

electronic components **604** mounted on the circuit board **606** from the wound enclosure **208** and to avoid contact with wound **102**.

[0040] FIG. **9** depicts an example of the bandage **200** shown in FIGS. **8***a* and **8***b* in which biocompatible pad **806** is separated from, and is reattached to the carrier plate **104** as required. The removed biocompatible pad **806** may be discarded, recycled, cleaned, and/or reused. As depicted in FIG. **9**, spring loaded pad protrusions **816** are urged through apertures **902** in the carrier plate **104** and circuit board **606**.

[0041] FIG. **10***a* depicts an example of a bandage **400** similar to the bandage **200** in FIGS. **5***a* and **5***b*. Bandage **400** includes plugs **504** and needle ports **1002**. Needle ports **1002** allows a needle **1006** to access to the wound enclosure **208**. Needle ports **1002** features a seal **1004**, which is flexible and compressible to allow needle **1006** passage through the seal **1004** when the needle **1006** is pressed through the seal **1004**. Needle port **1002** has a hard needle stop **1008** to stop the needle **1006** from accidentally sticking the skin underneath the needle port **1002**. In the example shown in FIG. **10***b*, two needle ports **1002** circulate a fluid over the wound **102**. In an example, the fluid may be a cleansing solution, an antibiotic gel, or other fluid treatment component. Any remaining I/O ports may be sealed by plugs **504**.

[0042] FIG. **11***a* depicts a bandage **500** that includes a wireless sensor **1101** designed to fit within the ports **502** formed within carrier plate **104**. Wireless sensor **1101** includes a sensing device **1102**, electronic circuitry **1106** mounted on a printed circuit board **1104**, a battery **1110** and an antenna **1108**. Wireless sensor **1101** communicates readings of sensing device **1102** to an external device (not shown). Examples of the wireless sensor **1101** are depicted in FIG. **11***b* and include wireless temperature sensor **1112**, wireless Ph sensor **1114**, and wireless oxygen sensor **1116**. Plug **504** is transparent and allows viewing of the wound **102** without requiring the removal of the bandage **500**.

[0043] FIGS. **12***a* and **12***b* depict an example of a bandage **600** to deliver Negative Pressure Wound Therapy (NPWT) to the wound **102**. As shown in FIGS. **12***a* and **12***b*, plug **1208** includes a pump inlet **1210** that couples the wound enclosure **208** to an external vacuum pump **1204**. In an example, pressure sensor plug **1202** monitors the process and a filter **1214** protects the pump inlet **1210** to the plug **1208** from being clogged by packing material **1206**.

[0044] FIGS. **13***a-c* depict at least one optical device to allow visual monitoring of the wound. FIGS. **13***a* depicts a contact camera **1322** that includes an optical fiber bundle **1302** that is brought in contact with the wound **102**. Illumination of the wound **102** is provided by at least one LED **1306**. An optical lens **1308** allows a surface image of the wound **102** to be transmitted through the optical fiber bundle **1302** to optical sensor **1310**. FIG. **13***b* depicts a camera plug **1324** that in an example includes LED(s) **1306** and lens **1308**.

[0045] FIG. **13***c* depicts a remote optical processor arrangement in which an image of the wound **102** is captured by lens **1326** and is transmitted through a coherent optical fiber bundle **1314** to a remote optical sensor **1316**. In examples, the remote optical sensor **1316** includes a camera, a spectrometer, a near infrared imager, and other sensing devices. In an example, FIG. **13***c* depicts the wound **102** illuminated by a source **1320** through beam splitter **1318**.

[0046] FIG. **14***a* depicts an example in which individual biocompatible pads **806** are placed permanently or temporarily, onto the carrier plate **104** and/or circuit board **606**. In FIG. **14***b*, the circuit board **606** is double sided and has electronic components **604**, e.g., sensors, memory devices, and a processor, mounted on both sides of the circuit board **606**. In an example, the circuit board **606** and the electronic components **604** mounted thereon are enclosed in a pouch **1404** made of biocompatible material.

[0047] FIG. **15** depicts an example of a flowchart depicting a method of constructing and applying a bandage **100** that is custom made for a specific wound **102** on the surface of the skin **114**. At step **1502**, the method includes identifying a perimeter of the wound **102**.

[0048] At step **1504**, markers **204** are placed on the skin at various areas of interest, including skin areas which are determined healthy enough to support the peripheral support **106**. In embodiments, skin areas, e.g., which cannot be touched, are differently marked, such as with a different color.

[0049] At step **1506**, a 3-dimensional (3D) scan of the wound is performed.

[0050] At step **1508**, a 3D model of the wound **102** is created based on the markers **204** and on the results of the 3D scan. A visual comparison of the wound **102** and the 3D model of the wound **102** may be performed to verify that the 3D model is a correct representation of the wound **102**.

[0051] At step **1510**, the 3D model of the wound **102** is communicated to an engineering or bio-engineering professional in order to design the carrier plate **104** and the peripheral support **106**.

[0052] At step **1512**, the carrier plate **104** and the peripheral support **106** are fabricated. The fabrication is done by various fabrication techniques including 3D printing.

[0053] Under certain circumstances, e.g., when the wound **102** is small, the scanning of the wound (step **1506**), the building of the 3D model (step **1508**), and the fabrication of the carrier plate and the peripheral support may not be necessary. Under these circumstances, pre-fabricated versions of the carrier plate **104** and the peripheral support **106** may be quickly assembled to treat the wound.

[0054] At step **1514**, assembling the bandage is described as attaching one or more of biocompatible material **302**, electronic components **604**, sensors and actuators **614**, antenna **620**, and circuit board **606**, to the carrier plate **104**.

[0055] At step **1516**, the peripheral support **106**, the carrier plate **104**, and bandage **100** is applied to the wound area, and as shown in FIGS. **6***b*, **7***a*, and **7***b*, applying bandage **300** to the wound may include adjusting a height d of biocompatible pad **608** to the contours of wound **102**. In an embodiment, the peripheral support **106** is secured to the skin **114** via adhesive **202**.

[0056] At step **1518**, monitoring and treating the wound area are facilitated by the capabilities of the bandage **100**, which in some embodiments, does not require opening the plate and exposing the wound to the atmosphere.

[0057] In embodiments, electronic components **604** include one or more hardware processors, a computer readable medium, which may be non-transitory, such as hardware storage devices (e.g., RAM (random access memory), ROM (read only memory), EPROM (erasable, programmable ROM), EEPROM (electrically erasable, programmable ROM), and flash memory). The methods, functions and other processes described herein may be embodied as machine readable instructions stored on the computer readable medium.

[0058] While the embodiments have been described with reference to examples, various modifications to the described embodiments may be made without departing from the scope of the claimed embodiments.

1. A bandage to be applied to a wound on a surface of a body, comprising:

a peripheral support to affix to skin area surrounding the wound; and

a carrier plate mounted to the peripheral support, wherein the carrier plate and peripheral support define an enclosure encompassing the wound and provide access to the wound.

2. The bandage according to claim **1**, comprising a hinge and a latch to secure the carrier plate to the peripheral support, wherein the hinge is to allow the carrier plate to be opened to allow access to the wound.

3. The bandage according to claim **1**, wherein the bandage includes:

a biocompatible material disposed within the defined enclosure, wherein the biocompatible material is attached to the carrier plate, and wherein the biocompatible material is pre-shaped to conform to a shape of the wound.

4. The bandage according to claim **1**, the carrier plate including:

at least one port to allow access to the wound; and

a plug removeably inserted in the at least one port.

5. The bandage according to claim **4** wherein the plug comprises at least one of a transparent plug, a sensor, and an actuator.

6. The bandage according to claim **4**, wherein the plug comprises at least one of a needle port, a temperature sensor, a Ph sensor, an oxygen sensor, a pump inlet, and an optical device.

7. The bandage according to claim **4**, wherein the plug comprises a wireless sensor, the wireless sensor comprising at least one of a temperature sensor, a Ph sensor, and an oxygen sensor.

8. The bandage according to claim **7**, wherein the plug comprising the optical lens further comprises a optical fiber bundle extending from the optical lens towards the wound.

9. The bandage according to claim **1**, further comprising:

a biocompatible pad affixed to the carrier plate;

at least one of a test and treatment well defined by protrusions in the biocompatible pad; and

at least one of a sensor and an actuator affixed to the carrier plate.

10. The bandage according to claim **1**, wherein the carrier plate includes a self-sealable access port to provide access to the wound.

11. The bandage according to claim **1**, wherein the carrier plate includes a biocompatible pad, the biocompatible pad including pad protrusions urged through apertures defined within the carrier plate.

12. The bandage according to claim **1**, wherein the carrier plate comprises at least one of a transparent window, a sensor and an actuator.

13. The bandage according to claim **1**, wherein the peripheral support is integral to the carrier plate.

14. A method of treating a wound, comprising:

forming a bandage comprising a peripheral support to attach to skin surrounding the wound, and a carrier plate affixed to the peripheral support, the peripheral support and the carrier plate defining an enclosure encompassing the wound; and

at least one of monitoring and treating the wound via at least one port disposed within the carrier plate.

15. The method of claim **14**, wherein forming the bandage comprises:

inserting a plug within the at least one port, the plug comprising at least one of a sensor plug, an actuator plug, and a transparent plug;

monitoring a status of the wound via the transparent plug and the sensor plug; and

treating the wound via at least one of the actuator plug and the at least one port.

16. The method of claim **15**, wherein inserting the plug within the at least one port includes inserting at least one of an optical sensor, a pressure sensor, an oxygen sensor, a Ph sensor, a humidity sensor, a temperature sensor, pump plug, and a needle port within the at least one port.

17. The method of claim **14**, wherein the carrier plate includes a biocompatible pad and a circuit board comprising electronic components, the biocompatible pad including pad protrusions urged through apertures defined within the carrier plate and the circuit board.

18. The method of claim **14**, wherein forming the bandage comprises:

performing a 3-dimensional scan of the wound;

fabricating a 3-dimensional model of the wound based on the 3-dimensional scan of the wound; and

forming the bandage for the wound based on the 3-dimensional model.

19. The method of claim **14**, wherein the carrier plate is hinged to the peripheral support.

* * * * *

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摘要(译)

用于治疗伤口的绷带包括承载板和外围支撑件，以固定到伤口周围的皮肤区域。承载板和外围支撑件限定了包围伤口的外壳，并提供了进入伤口的通路以进行监测和治疗。