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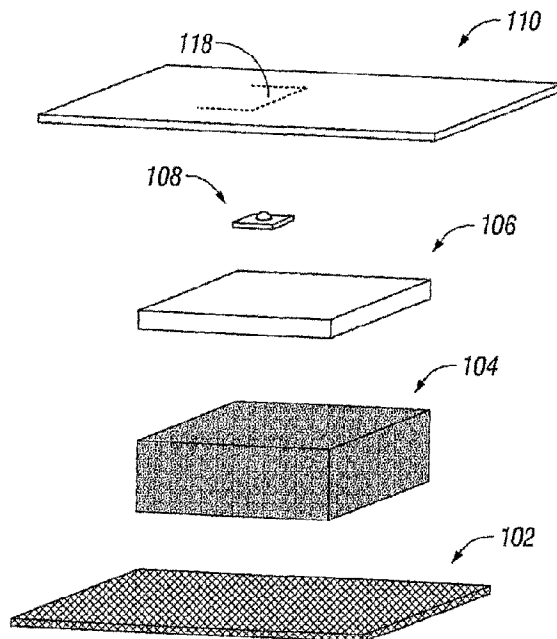
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(54) Title: SELF CONTAINED WOUND DRESSING WITH MICROPUMP



(57) Abrégé/Abstract:

A wound treatment apparatus promotes healing of a wound via the use of a negative pressure system. The negative pressure system applies negative pressure to the wound through perforations in a contact layer of a wound dressing. The wound dressing also includes a capillary layer and an absorbent layer above the contact layer. The capillary layer allows transmission of fluid away from the wound site. The absorbent layer comprises a super absorbent polymer material and forms a reservoir for fluid removed from the wound site.

Abstract

A wound treatment apparatus promotes healing of a wound via the use of a negative pressure system. The negative pressure system applies negative pressure to the wound through perforations in a contact layer of a wound dressing. The wound dressing also includes a capillary layer and an absorbent layer above the contact layer. The capillary layer allows transmission of fluid away from the wound site. The absorbent layer comprises a super absorbent polymer material and forms a reservoir for fluid removed from the wound site.

SELF CONTAINED WOUND DRESSING WITH MICROPUMP

BACKGROUND

1. Technical Field

The present disclosure relates to an apparatus for treating an open wound, and, more specifically, relates to a self contained wound dressing with a micropump system which draws wound fluids into a vacuum zone of the dressing to facilitate the wound healing process.

2. Description of Related Art

Wound closure involves the migration of epithelial and subcutaneous tissue adjacent the wound towards the center of the wound until the wound closes. Unfortunately, closure is difficult with large wounds or wounds that have become infected. In such wounds, a zone of stasis (i.e. an area in which localized swelling of tissue restricts the flow of blood to the tissues) forms near the surface of the wound. Without sufficient blood flow, the epithelial and subcutaneous tissues surrounding the wound not only receive diminished oxygen and nutrients, but, are also less able to successfully fight microbial infection and, thus, are less able to close the wound naturally. Such wounds have presented difficulties to medical personnel for many years.

Wound dressings have been used in the medical industry to protect and/or facilitate healing of open wounds. One technique has been to use negative pressure therapy, which is also known as suction or vacuum therapy. A variety of negative pressure devices have been developed to allow excess wound fluids, i.e., exudates to be removed while at the same time isolating the wound to protect the wound and,

consequently, affect recovery time. Various wound dressings have been modified to promote the healing of open wounds.

Issues that continually need to be addressed when using a wound dressing include ease of use, efficiency of healing a wound, and a source of constant negative pressure. Thus, there remains a need to constantly improve negative pressure wound dressings for open wounds.

SUMMARY

In one preferred embodiment, a wound dressing apparatus is disclosed which may include a wound dressing member dimensioned for positioning relative to a wound bed and a micropump system. The micropump system may include a micropump for applying subatmospheric pressure to at least the wound dressing member to facilitate removal of fluid from the wound bed. The micropump is preferably mounted relative to the wound dressing member. The preferred micropump is adapted to produce subatmospheric pressure ranging between about 20 mmHg and about 500 mmHg.

The micropump system may include control means to control operation of the micropump. The micropump system may further include a pressure sensor adapted to detect pressure at a predetermined location relative to the wound dressing member, and send a corresponding signal to the control means. The control means may include a motor controller adapted to control or vary the output of the micropump in response to the pressure sensed by the pressure sensor. The micropump system may also include a power source, e.g., a battery, for actuating the micropump. The battery may be adapted for

implantation within the wound dressing member or external to the wound dressing member. Rechargeable batteries are envisioned.

The preferred wound dressing member includes a lower member positionable adjacent the wound bed, an upper absorbent member positionable adjacent the lower member, and a top member. The micropump is at least partially positioned within the upper absorbent member. The top member is an adhesive member which is adapted to be secured about the wound bed or wound bed perimeter to provide a seal between the wound dressing member and tissue surrounding the wound bed. The lower member may include at least one of a medicament, an anti-infective agent, an antimicrobial, polyhexamethylene biguanide (hereinafter, "PHMB"), antibiotics, analgesics, healing factors, vitamins, growth factors, and nutrients and/or one of a microbead packing and/or absorbent foam. The upper absorbent member may comprise a material selected from the group consisting of foams, nonwoven composite fabrics, cellulose fabrics, super absorbent polymers, and combinations thereof.

The top member may include an occlusive material which may or may not be transparent. The wound dressing member includes a visual pressure indicator for indicating a level of pressure within the wound dressing member. The wound dressing member may include a saturation indicator to identify a degree of saturation of the wound dressing member. The top member includes an access door associated therewith and being selectively movable between a closed position substantially enclosing the wound dressing member and an open position permitting internal access to the wound dressing member.

In another embodiment, the wound dressing apparatus is disclosed which may include a wound dressing member including an absorbent member positionable relative to a wound bed and a micropump system contained within the wound dressing member. The micropump system may include a micropump for applying subatmospheric pressure to the wound bed to facilitate removal of fluid from the wound bed and an implantable or attachable power source for supplying power to the micropump. The micropump system may include a control means to control operation of the micropump and a pressure sensor to detect pressure at a predetermined location relative to the wound dressing member.

According to an aspect, there is provided a negative pressure wound treatment apparatus, comprising: a wound dressing configured to be positioned over a wound site, the wound dressing comprising: a contact layer comprising a plurality of perforations through the contact layer that allow for fluid to pass there through; a capillary layer located above the contact layer configured to allow transmission of fluid away from the wound site; an absorbent layer located above the capillary layer configured to form a reservoir for fluid removed from the wound site, wherein the absorbent layer comprises super absorbent polymer material; and a cover layer located above the absorbent layer; and a negative pressure source configured to apply negative pressure to the wound site through the perforations in the contact layer and through the capillary layer and configured to draw fluid from the wound site into the absorbent layer.

According to another aspect, there is provided a negative pressure wound treatment apparatus, comprising: a wound dressing configured to be positioned over a wound site, the wound dressing comprising: a contact layer comprising a plurality of

perforations through the contact layer that allow for fluid to pass there through; a capillary layer located above the contact layer configured to allow transmission of fluid away from the wound site; an absorbent layer located above the capillary layer configured to form a reservoir for fluid removed from the wound site, wherein the absorbent layer comprises super absorbent polymer material; a cover layer located above the absorbent layer; and a port connected to the cover layer; and a compressible suction device configured to connect to the port to apply suction through the port to the wound dressing.

According to another aspect, there is provided a wound dressing apparatus, which comprises: a wound dressing member including a cover member dimensioned for positioning over a wound bed; and a micropump system including: a micropump for applying subatmospheric pressure to at least the wound dressing member to facilitate removal of fluid from the wound bed, the micropump being disposed beneath the cover member adjacent the wound bed; a pressure sensor adapted to detect pressure at a predetermined location relative to a wound dressing member, and send a corresponding signal to the control means the the control means include a motor controller adapted to control or vary the output of the micropump in response to the pressure sensed by the pressure sensor.

According to another aspect, there is provided a wound dressing apparatus, which comprises: a wound dressing member including an absorbent member positionable relative to a wound bed; and a micropump system contained within or adjacent to the wound dressing member, the micropump system including: a micropump for applying subatmospheric pressure to the wound bed to facilitate removal of fluid from the wound bed, the micropump being at least partially encapsulated within the absorbent member; a

pressure sensor to detect pressure at a predetermined location relative to the wound dressing member and a control means includes a motor controller adapted to control or vary the output of the micropump in response to the pressure sensed by the pressure sensor.

According to another aspect, there is provided an apparatus for treating a wound, which comprises: a wound dressing member dimensioned for positioning adjacent a wound bed; a subatmospheric pressure mechanism including: a subatmospheric pressure generator supported by the wound dressing member, the subatmospheric pressure generator dimensioned and adapted to generate subatmospheric pressure at predefined therapeutic levels and to supply the subatmospheric pressure adjacent the wound bed to facilitate healing; an electronic controller for controlling operation of the subatmospheric pressure generator; and a pressure sensor dimensioned and adapted to detect pressure associated with the subatmospheric generator and send a corresponding signal to the controller; and a pressure level indicator independent of the subatmospheric pressure mechanism and in fluid communication with the wound dressing member for indicating a pressure condition within the wound bed.

According to another aspect, there is provided an apparatus for treating a wound, which comprises: a wound dressing member dimensioned for positioning adjacent a wound bed; and a subatmospheric pressure mechanism including: a subatmospheric pressure generator is enclosed within the wound dressing member, the subatmospheric pressure generator dimensioned and adapted to generate subatmospheric pressure at predefined therapeutic levels and to supply the subatmospheric pressure adjacent the

wound bed to facilitate healing; and an electronic controller for controlling operation of the subatmospheric pressure generator.

According to another aspect, there is provided an apparatus for treating a wound, which comprises: a wound dressing member dimensioned for positioning adjacent a wound bed; a subatmospheric pressure mechanism including: a subatmospheric pressure generator supported by the wound dressing member, the subatmospheric pressure generator dimensioned and adapted to generate subatmospheric pressure at predefined therapeutic levels and to supply the subatmospheric pressure adjacent the wound bed to facilitate healing, the subatmospheric pressure mechanism including a battery for actuating the subatmospheric pressure generator, the battery being dimensioned and adapted for implantation within the wound dressing member; and an electronic controller for controlling operation of the subatmospheric pressure generator.

According to another aspect, there is provided an apparatus for treating a wound, comprising a wound dressing dimensioned and configured for positioning adjacent a wound bed, the wound dressing including a top member for at least partially enclosing the wound bed and a packing member positionable adjacent the wound bed beneath the top member, and further including a subatmospheric generator is at least partially disposed within the packing member, the subatmospheric generator dimensioned and adapted to generate subatmospheric pressure at predefined therapeutic levels and to supply the subatmospheric pressure adjacent the wound bed to displace fluid relative thereto to facilitate healing.

According to another aspect, there is provided an apparatus for treating a wound, comprising: a wound dressing member dimensioned for positioning adjacent a

wound bed, the wound dressing member including at least a top member for at least partially enclosing the wound bed; a subatmospheric pressure generator mounted to the wound dressing member beneath the top member, the subatmospheric pressure generator dimensioned and adapted to generate subatmospheric pressure at predefined therapeutic levels and to supply the subatmospheric pressure adjacent the wound bed to facilitate healing; and a power source for actuating the subatmospheric pressure generator.

According to another aspect, there is provided an apparatus for treating a wound, which comprises: a wound dressing member dimensioned for positioning adjacent a wound bed, the wound dressing member including a base layer dimensioned and adapted for positioning in contact with the wound bed and a packing member, the base layer comprising a plurality of unidirectional apertures dimensioned and adapted to permit flow of exudates substantially solely in one direction from the wound bed through the base layer for collection by the packing member; and a subatmospheric pressure mechanism including: a subatmospheric pressure generator dimensioned and adapted to generate subatmospheric pressure at predefined therapeutic levels and to supply the subatmospheric pressure adjacent the wound bed to facilitate healing; an electronic controller for controlling operation of the subatmospheric pressure generator; and a sensor dimensioned and adapted to detect at least one parameter and send a corresponding signal to the controller.

According to another aspect, there is provided an apparatus for treating a wound, which comprises: a wound dressing member dimensioned for positioning adjacent a wound bed; a subatmospheric pressure mechanism including: a pump supported by the wound dressing member, the pump adapted to generate subatmospheric pressure at

predefined therapeutic levels and to supply the subatmospheric pressure adjacent the wound bed to facilitate healing; and a controller for controlling operation of the pump, a pressure level indicator independent of the subatmospheric pressure mechanism and in fluid communication with the wound dressing member for indicating a pressure condition within the wound dressing.

According to another aspect, there is provided an apparatus for treating a wound, which comprises: a wound dressing member dimensioned for positioning adjacent a wound bed; and a subatmospheric pressure mechanism including: a pump dimensioned and adapted to generate subatmospheric pressure at predefined therapeutic levels and to supply the subatmospheric pressure adjacent the wound bed to facilitate healing; and an electronic controller for controlling operation of the pump; and a saturation indicator in fluid communication with the wound dressing member for indicating a degree of saturation thereof.

According to another aspect, there is provided a negative pressure wound treatment apparatus, comprising: a wound dressing configured to be positioned over a wound site, the wound dressing comprising: a contact layer comprising a plurality of perforations through the contact layer that allow for fluid to pass there through; a capillary layer located above the contact layer configured to allow transmission of fluid away from the wound site; an absorbent layer located above the capillary layer configured to form a reservoir for fluid removed from the wound site; a negative pressure source configured to apply negative pressure to the wound site through the perforations in the contact layer and through the capillary layer and configured to draw fluid from the wound site into the

absorbent layer; and an ultrasound transducer for directing mechanical energy toward the wound site.

According to another aspect, there is provided a wound dressing apparatus, which comprises: a wound dressing member dimensioned for positioning over a wound bed; and a micropump system including: a micropump for applying subatmospheric pressure to at least the wound dressing member to facilitate removal of fluid from the wound bed; a pressure sensor adapted to detect pressure and send a corresponding signal to the control means to control or vary the output of the micropump in response to the pressure sensed by the pressure sensor; and an ultrasound transducer for directing mechanical energy toward the wound bed.

According to another aspect, there is provided an apparatus for treating a wound, which comprises: a wound dressing member dimensioned for positioning adjacent a wound bed; and a subatmospheric pressure mechanism including: a subatmospheric pressure generator is enclosed within the wound dressing member, the subatmospheric pressure generator dimensioned and adapted to supply subatmospheric pressure adjacent the wound bed to facilitate healing; an electronic controller for controlling operation of the subatmospheric pressure generator; and an ultrasound transducer for directing mechanical energy toward the wound bed.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the subject wound dressing are described herein with reference to the drawings wherein:

Figure 1 is a perspective view of a self contained wound dressing and micropump system in accordance with the principles of the present disclosure;

Figure 2 is a side cross-sectional view illustrating the wound dressing on a wound bed and in a normal expanded condition in the absence of a vacuum;

Figure 3 is a schematic view of the micropump system;

Figure 4 is a view similar to the view of Figure 2 illustrating the wound dressing in a contracted condition when subjected to subatmospheric pressure generated by the micropump system;

Figure 5 is a view illustrating the access door of the wound dressing in an open condition to permit removal of the absorbent layer and/or micropump system;

Figure 6 is a side cross-sectional view of another embodiment of the self contained wound dressing and micropump system of the present disclosure; and

Figure 7 is a side cross-sectional view of yet another embodiment of the self contained wound dressing and micropump system of the present disclosure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The composite wound dressing apparatus of the present disclosure promotes healing of a wound via the use of a micropump system housed within a wound dressing. The micropump system includes a miniature pump that applies a subatmospheric pressure to the wound to effectively draw wound fluid or exudate away from the wound bed without the need for an external vacuum source. Hence, the wound dressing apparatus in the form of wound dressing and micropump system is portable which allows the patient mobility that is unavailable when an external vacuum source is used. The patient does not need to be restricted for any period of time while exudate is being removed from the wound.

Referring now to Figures 1 and 2, the composite wound dressing apparatus 10 in accordance with a preferred embodiment of the present disclosure is illustrated in the form of a wound dressing 100 with multiple layers arranged in juxtaposed or

superposed relation. The multiple layers include, but are not limited to a base, or lower layer 102, a packing layer 104, an absorbent layer 106 which houses a micropump system 108, and a occlusive adherent top layer 110.

The base layer 102 is in direct contact with the wound bed “w” and may be adherent to the tissue or non-adherent. The base layer 102 is typically porous. “Non-adherent” as used herein refers to a material that does not adhere to tissues in and around the wound bed. “Porous” as used herein refers to a material which contains numerous small perforations or pores which allow wound fluids of all kinds to pass through the material to the dressing layers above. The passage of wound fluid through the non-adherent material is preferably unidirectional such that wound exudate does not flow back to the wound bed. This direction flow feature could be in the form of directional apertures imparted into the material layer, a lamination of materials of different absorption to the base layer 102 or specific material selection that encourages directional flow. Bidirectional flow materials are also contemplated for base layer 102 to permit infusion of fluids medicants into the wound. Exemplary materials used as the base layer 102 include a contact layer sold under the trademark XEROFLO™ by Kendall Corp, a division of TycoHealthcare.

In addition, agents such as hydrogels and medicaments could be bonded or coated to the base layer 102 to reduce bioburden in the wound, promote healing and reduce pain associated with dressing changes or removal. Medicaments include, for example, antimicrobial agents, growth factors, antibiotics, analgesics, debridement agents, and the like. Furthermore, when an analgesic is used, the analgesic could include

a mechanism that would allow the release of that agent prior to dressing removal or change.

The layer proximal to the base layer 102 is the packing layer 104. The packing layer 104 is intended to absorb and capture wound fluid and exudates. Exemplary materials used as the packing layer 104 include the antimicrobial dressing sold under the trademark KERLIX™ by Kendall Corp., a division of TycoHealthcare. Those skilled in the art will recognize that the packing layer 104 can be formed into any suitable shape. One preferred characteristic as to shape is that the packing layer 104 is suitable to conform to a particular shape of the wound.

A further use for the packing layer 104 is to decrease the incidence of infection in the wound bed. Hence, the packing layer 104 may be treated with medicaments. Medicaments include, for example, an anti-infective agent such as an antiseptic or other suitable antimicrobial or combination of antimicrobials, polyhexamethylene biguanide (hereinafter, "PHMB"), antibiotics, analgesics, debridement agents, healing factors such as vitamins, growth factors, nutrients and the like, as well as a simple flushing with agents such as isotonic saline solution.

The layer proximal to the packing layer 104 is the absorbent layer 106. The absorbent layer 106 of the wound dressing apparatus 10 is intended to absorb and capture wound fluid and exudates. The absorbent layer 106 also houses the micropump system 108. Preferably, the absorbent layer 106 is preformed or shaped to accept the micropump system 108. In this regard, the absorbent layer 106 may have a concavity or recess 112 to accommodate the micropump system 108. Alternatively, the absorbent

layer 106 may be pliable so as to be shaped or formed to receive and/or confine the micropump system 108. Exemplary absorbent materials include foams, nonwoven composite fabrics, cellulosic fabrics, super absorbent polymers, and combinations thereof. Preferably, the absorbent layer 106 can absorb a substantial volume of exudates, e.g., up to at least 100 cubic centimeters (cc) or more of wound fluid. The absorbent layer 106 may include multiple layers.

The absorbent layer 106 also may be treated with medicaments. Medicaments include, for example, an anti-infective agent such as an antiseptic or other suitable antimicrobial or combination of antimicrobials, polyhexamethylene biguanide, antibiotics, analgesics, healing factors such as vitamins, debridement agents, growth factors, nutrients and the like, as well as a flushing agents such as isotonic saline solution.

The absorbent layer 106 may further include a pressure indicator 114 independent from the micropump system 108. The pressure indicator 114 may be mounted to, secured to, or embedded within the absorbent layer 106 or within the confines of wound dressing apparatus 10. Alternatively, the pressure indicator 114 is external to the wound dressing 100 and communicates with the interior of the wound dressing through a pressure tube or the like. The pressure indicator 114 may be in the form of the commercially available pressure sensor sold under the tradename Dynamic IP[®] Pressure Sensors by PCB[®] Piezotronics. The pressure indicator 114 may be color coded where one color on the device (e.g., red) indicates a non vacuum state and a second color (e.g., green) indicates a suitable vacuum state. The absorbent layer 106 may further include a saturation indicator 116 mounted to, or embedded within, the surface of the

absorbent layer 106. The saturation indicator 116 may be a litmus paper such as but not limited to PEHANAL[®] and PANPEHA[®] which indicates to the user of the level or degree of saturation of the absorbent layer 106 with exudates and wound fluids. The saturation indicator 116 will assist the user in determining the remaining capacity of the absorbent layer 106, or if the absorbent layer 106 needs replacing. Although disclosed as being mounted to or embedded within absorbent layer 106, the saturation indicator 116 may be positioned within any component of wound dressing 100.

With reference still to Figures 1 and 2, the adherent top layer 110 encompasses the perimeter of the wound dressing 100 to surround the wound bed “w” to provide a seal around the perimeter of the wound bed “w”. For instance, the sealing mechanism may be any adhesive bonded to a layer that surrounds the wound bed “w”. The adhesive must provide acceptable adhesion to the tissue “t” surrounding the wound bed “w” skin, e.g., the periwound area, and be acceptable for use on skin without contact deterioration (for example, the adhesive should preferably be non-irritating and non-sensitizing.) The adhesive may be permeable to permit the contacted skin to breathe and transmit moisture. Additionally, the adhesive could be activated or de-activated by an external stimulus such as heat or a given fluid solution or chemical reaction. Adhesives include, for example, Ultac[®] Hydrocolloid Dressing or Curagel[®] Hydrogel by Kendall Corp., a division of Tyco Healthcare Group LP.

The adherent top layer 110 is preferably in the form of a sheet mounted proximal to the absorbent layer 106. Preferably, the top layer 110 is not bonded to the absorbent layer 106 to allow for easy replacement of the absorbent layer 106. In a

preferred embodiment, the peripheral portions 110P of the top layer 110 are bonded to the periphery 102P of the base layer 102 and secured to the tissue “t” about the wound bed “w”. It is anticipated that removable liners may also be used to protect the adhesive surface of the adherent layer 110 prior to use.

The top layer 110 is typically a flexible material, e.g., resilient or elastomeric, that seals the top of the wound dressing 100. An exemplary flexible material includes the fully or partially transparent dressing manufactured under the trademark Polyskin® II by Kendall Corp, a division of Tyco Healthcare Group LP. Polyskin® II is a transparent, semi-permeable material which permits passage of moisture from the wound site, and provides a barrier to microbes and fluid containment. In the alternative, the top layer 110 may be impermeable to moisture. The transparency of the top layer 110 provides visual indicia of the status of the wound dressing and more particularly, the status of the saturation level of the layers of the wound dressing. More specifically, the transparency of the top layer 110 permits the clinician to view the respective statuses of the pressure indicator 114 and the saturation indicator 116.

The top layer 110 may include an access door 118 to provide access to the interior of the wound dressing 100 and/or the wound bed “w”. The door 118 could be a flap integrally formed with the top layer 110 or a separate component connected to the top layer 110 via a hinge or the like. The door 118 is preferably resealable to maintain the integrity of the wound dressing 100 and to provide a seal relative to the top layer 110. One suitable means for releasably sealing the door 118 includes a snap fit arrangement, tongue and groove arrangement, “zip lock[®]” arrangement, adhesives, VELCRO[®], etc.

The door 118 preferably provides access to the wound bed “w” to enable the clinician to monitor the status of the wound, change the absorbent layer 106, change the micropump system 108, or apply additional medical treatment to the wound such as growth factors, debriders, or other wound healing agents as needed. Once the desired procedure is completed, the access door 118 would be resealed relative to the top layer 110 to maintain the integrity of the wound dressing 100.

Referring now to the schematic diagram of Figure 3, in conjunction with Figures 1 and 2, the micropump system 108 will be discussed. The micropump system 108 includes a miniature pump or micropump 120 with a length ranging from about 1 to 3 inches and a relatively small diameter, preferably, no greater than about one inch. The micropump 120 may be any type of pump that is biocompatible and maintains or draws adequate and therapeutic vacuum levels. The micropump 120 may be embedded within the absorbent layer 106 or mounted to the layer 106, or alternatively associated within the confines of the wound dressing 100. “Therapeutic vacuum levels” as used herein refers to a vacuum level that draws wound fluid and exudate away from the wound bed. Preferably, the vacuum level to be achieved is in a range between about 75 mmHg and about 125 mmHg. The micropump 120 may be disposable, removable, reusable, and/or rechargeable. Typically, the micropump 120 is a pump of the diaphragmatic or peristaltic type, or the like, in which the moving part(s) draw exudate out of the wound bed into the wound dressing by creating areas or zones of decreased pressure e.g., vacuum zones with the wound dressing 100. This area of decreased pressure preferably communicates with the wound bed “w” to facilitate removal of the fluids therefrom and into the absorbent layer 106. The micropump 120 may be actuated by any means known by those skilled in

the art. In a preferred embodiment of the present disclosure, the micropump 120 is a peristaltic pump. One suitable micropump is manufactured by Piab Vacuum Products in Hingham, MA. Preferably, the peristaltic pump produces subatmospheric pressure ranging from about 20mmHg to about 500mmHg.

The micropump system 108 preferably includes an internal self contained battery source 122, a pressure sensor or transducer 124 to monitor pressure adjacent the micropump 120 or selected locations displaced from the micropump 120, and regulation or control means 126. The control means 126 may incorporate a motor controller/driver 128 including processing and drive circuitry to control or vary the drive voltage to the motor of the micropump 120 responsive to the pressure sensed by the pressure sensor 124. The output of the motor of the micropump 120 may be increased or decreased, or initiated or discontinued, as controlled by the control means 126. The pressure sensor 124 would also provide information to assist in detecting a leak in the wound closure apparatus 10 if the optimal subatmospheric pressure is not achieved. The regulation or control means 126 may also have an alarm such as a visual, audio or tactile sensory alarm (e.g., vibratory etc.) to indicate to the user when specific conditions have been met (e.g., the desired vacuum level or loss of vacuum).

The micropump system 108 is preferably adapted for implantation within the wound dressing 100, i.e., it is an implantable self-contained unit. The battery source 122 and control means 126 may be built into the housing of the micropump 120. The pressure sensor 124 may be mounted to the external surface of the housing of the micropump 120 or communicate through a port in the housing. The pressure sensor 124

may also be displaced from the housing of the micropump 118, e.g., embedded within the absorbent layer 106 at a location displaced from the micropump 120, and connected to the control means 126 through an electrical connection. The micropump 120 and battery 122 may be disposable or rechargeable. Preferably, the micropump system 108 is entirely disposable, e.g., after a single use, and is disposed of along with the absorbent layer 106 of the wound dressing 100. Alternatively, the micropump system 108 may be removed or disconnected from the absorbent layer 106 and reinstalled into another absorbent layer 106 for placement within the wound closure 100.

It is also envisioned that the micropump system 108 may be externally controlled via radio transmitter means. In this alternate embodiment, an external radio frequency (RF) transmitter or antenna 130 (shown in phantom on Figure 3) may send/receive signals to a receiving transmitter 132 associated with the control means 126 to operate the control means to control functioning of the micropump system 108. One skilled in the art may readily adapt the micropump system 108 to operate via remote radio frequency (RF) means. The micropump system 108 may incorporate circuitry to communicate with a computer, e.g., a hand-held PALM device.

In use, the wound dressing 100 is positioned within the wound bed "w" as shown in Figure 2. Thereafter, the micropump 120 is initiated to create a zone of subatmospheric pressure (i.e., a state of vacuum) within the wound dressing 100. The micropump 120 may be initiated via a manual switch associated with the control means 126, or may be started via the pressure sensor 124 which detects the lack of subatmospheric pressure within the wound dressing 100 and sends a corresponding signal

to the control means 126. The control means 126, in turn, activates the micropump 120. As the subatmospheric pressure within the wound closure 100 increases, the top layer 110 collapses to the position depicted in Figure 4. Once the desired level of subatmospheric pressure is achieved as detected by, e.g., the pressure sensor 124, the pressure sensor 124 sends a signal to the control means 126. The control means 126 may either terminate operation of the micropump 120 or alternatively vary the speed or output (e.g., decrease) of the micropump 120. In the vacuum state, wound fluid and exudates are drawn into the absorbent layer 106 to be collected therein. After a period of time, the wound dressing 100 may lose its vacuum state as detected by the pressure sensor 124. Visual confirmation of the loss of vacuum state may also be ascertained by viewing the vacuum indicator 114 through the top layer 110. When the loss of a desired vacuum level is achieved, the pressure sensor 124 sends a signal to the control means 126 to activate or increase the output of the micropump 120. This process may continue several times during wound healing.

Once the absorbent layer 106 is fully saturated as detected by viewing the saturation indicator 116 through the top layer 110, the access door 118 may be opened as shown in Figure 5. The absorbent layer 106 and the micropump system 108 may be removed through the door. As discussed, a new absorbent layer 106 and/or new micropump system 108 subsequently may be introduced through the door 118 and installed within the wound dressing 100.

Figure 6 illustrates an alternate embodiment of the present disclosure. In accordance with this embodiment, wound dressing 200 includes a bead packing 202,

contact layer 204, capillary layer 206, packing layer 208 and occlusive layer 210. Bead packing 202 may incorporate a plurality of antimicrobial beads, beads with growth factors, medicaments, antibiotics, analgesics, and healing factors such as vitamins, growth factors, nutrients and the like. These beads are preferably non-adherent and may be bioabsorbable over a predetermined period of time. Alternatively, the beads may be non-absorbable. The beads may be injectable into the wound site. Multiple applications of the beads are also contemplated.

Alternatively, contact layer 204 may be similar to the base layer 102 discussed hereinabove and is preferably porous. Capillary layer 206 includes a plurality of capillary fibers defining microchannels that permit controlled directional flow of a liquid, e.g., to permit drainage of the exudates from the wound. These channels formed in sheets, films, or tubes may be uniform in dimension or random and extend along the length of the layer. The microchannels desirably permit fluid flow in one direction, i.e., away from the wound for wound drainage, for example, similar to dialysis filters. Packing layer 208 and micropump 212 are substantially similar to their counterparts discussed hereinabove. Occlusive layer 210 may comprise a silicon or hydrogel material that can be adherent on the skin contact side and non-adherent to the outer side, and is preferably adherent in moist/oily environments. The occlusive layer 210 may also be a film forming liquid material which is dispensed from a spray mechanism for application over the dressing with the same surface characteristics described above. Wound dressing 200 may further incorporate a supplemental port 214 for connection to an external drainage canister or such as a drainage bag.

Figure 7 illustrates an alternate wound dressing 300 which incorporates biocompatible foam 302 in lieu of the bead layer. The foam 302 may be a resilient, liquid absorbent, porous, polymer-based foam. The foam 302 may be a dispensable liquid which at least partially solidifies to a crystal-like arrangement defining hollow tubes to allow exudates drainage. The foam 302 is dispensed within the wound bed and is potentially collapsible to expel air from the foam channels. The foam 302 may be an expandable hydrophilic foam which is capable of absorbing fluid from a wound and maintain the wound bed moist. The hollow tubes or voids defined by the foam 302 also provide a means to conduct electricity, heat, cold, and ultrasound. The hollow tubes or voids also provide a bioactive scaffold for tissue growth. Wound dressing 300 further includes an accordion style bag or canister 304 connected to the interior of dressing 300 through port 306. Canister 304 may be compressed to impart energy to the wound exudates to drain the fluid into the bag. One suitable system is disclosed in commonly assigned U.S. Patent No. 5,549,584 to Gross. A one-way valve may be incorporated into the port leading to canister 304 if desired.

It is further contemplated that the wound dressing apparatus may incorporate external means or applications to stimulate tissue growth and/or healing. For example, an ultrasonic transducer may be incorporated into the wound dressing apparatus to impart mechanical energy for the treatment of the tissue such as, for instance, directing thermal or vibratory energy on the wound area and/or introducing various drugs into the human body through the skin. Other sensor types are also contemplated for incorporation into the wound dressing apparatus including oxygen, chemical, microbial, perfusion and/or temperature sensors. The detection of oxygen adjacent the wound area would

assist the clinician in determining the status of wound healing. The presence of an elevated temperature may be indicative of an infection.

While the disclosure has been illustrated and described, it is not intended to be limited to the details shown, since various modifications and substitutions can be made. As such, further modifications and equivalents of the invention herein disclosed can occur to persons skilled in the art using no more than routine experimentation.

WHAT IS CLAIMED IS:

1. A negative pressure wound treatment apparatus, comprising:
 - a wound dressing configured to be positioned over a wound site, the wound dressing comprising:
 - a contact layer comprising a plurality of perforations through the contact layer that allow for fluid to pass there through;
 - a capillary layer located above the contact layer configured to allow transmission of fluid away from the wound site;
 - an absorbent layer located above the capillary layer configured to form a reservoir for fluid removed from the wound site, wherein the absorbent layer comprises super absorbent polymer material; and
 - a cover layer located above the absorbent layer; and
 - a negative pressure source configured to apply negative pressure to the wound site through the perforations in the contact layer and through the capillary layer and configured to draw fluid from the wound site into the absorbent layer.
2. The apparatus according to claim 1, wherein the cover layer comprises a transparent material.
3. The apparatus according to claim 1, wherein the cover layer comprises an adhesive configured to adhere to skin surrounding the wound site.

4. The apparatus according to claim 3, wherein the cover layer does not adhere to the absorbent layer.
5. The apparatus according to claim 1, wherein the capillary layer comprises a plurality of capillary fibers.
6. The apparatus according to claim 1, further comprising a pressure indicator configured to indicate a level of pressure within the wound dressing.
7. The apparatus according to claim 6, wherein the pressure indicator utilizes color to indicate a non-vacuum state.
8. The apparatus according to claim 6, wherein the pressure indicator is located within the wound dressing.
9. The apparatus according to claim 1, further comprising a saturation indicator configured to indicate a level of saturation of the absorbent layer.
10. The apparatus according to claim 1, wherein the negative pressure source is positioned within the wound dressing.
11. The apparatus according to claim 1, wherein the wound dressing further comprises a port connected to the cover layer.

12. The apparatus according to claim 1, further comprising a canister configured to be connected to the wound dressing.

13. A negative pressure wound treatment apparatus, comprising:

a wound dressing configured to be positioned over a wound site, the wound dressing comprising:

a contact layer comprising a plurality of perforations through the contact layer that allow for fluid to pass there through;

a capillary layer located above the contact layer configured to allow transmission of fluid away from the wound site;

an absorbent layer located above the capillary layer configured to form a reservoir for fluid removed from the wound site, wherein the absorbent layer comprises super absorbent polymer material;

a cover layer located above the absorbent layer; and

a port connected to the cover layer; and

a compressible suction device configured to connect to the port to apply suction through the port to the wound dressing.

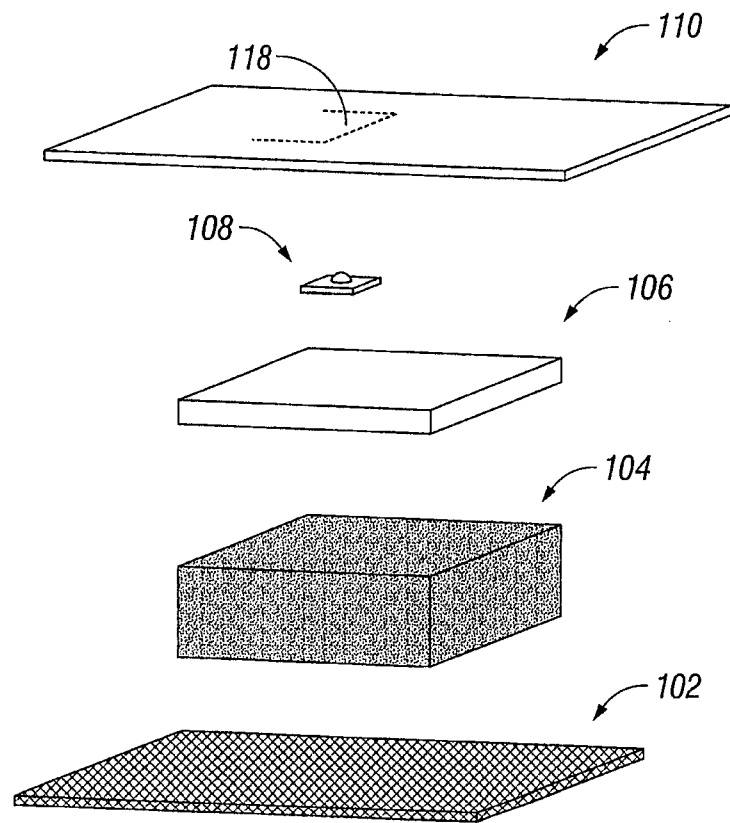
14. The apparatus according to claim 13, wherein the cover layer comprises a transparent material.

15. The apparatus according to claim 13, wherein the capillary layer comprises a plurality of capillary fibers.

16. The apparatus according to claim 13, further comprising a color indicator configured to indicate a non-vacuum state within the wound dressing.
17. The apparatus according to claim 13, further comprising an adhesive for adhering the wound dressing to skin surrounding the wound.
18. A negative pressure wound treatment apparatus, comprising:
a wound dressing configured to be positioned over a wound site, the wound dressing comprising:
a contact layer comprising a plurality of perforations through the contact layer that allow for fluid to pass there through;
a capillary layer located above the contact layer configured to allow transmission of fluid away from the wound site;
an absorbent layer located above the capillary layer configured to form a reservoir for fluid removed from the wound site;
a negative pressure source configured to apply negative pressure to the wound site through the perforations in the contact layer and through the capillary layer and configured to draw fluid from the wound site into the absorbent layer; and
an ultrasound transducer for directing mechanical energy toward the wound site.
19. The apparatus according to claim 18, comprising a cover layer above the absorbent layer, the cover layer comprising a transparent material.

20. The apparatus according to claim 18, comprising a cover layer above the absorbent layer, the cover layer comprising an adhesive configured to adhere to skin surrounding the wound site.
21. The apparatus according to claim 20, wherein the cover layer does not adhere to the absorbent layer.
22. The apparatus according to claim 18, wherein the capillary layer comprises a plurality of capillary fibers.
23. The apparatus according to claim 18, further comprising a pressure indicator configured to indicate a level of pressure within the wound dressing.
24. The apparatus according to claim 23, wherein the pressure indicator utilizes color to indicate a non-vacuum state.
25. The apparatus according to claim 23, wherein the pressure indicator is located within the wound dressing.
26. The apparatus according to claim 18, further comprising a saturation indicator configured to indicate a level of saturation of the absorbent layer.

27. The apparatus according to claim 18, wherein the negative pressure source is positioned within the wound dressing.
28. The apparatus according to claim 18, comprising a cover layer above the absorbent layer, wherein the wound dressing further comprises a port connected to the cover layer.
29. The apparatus according to claim 18, further comprising a canister configured to be connected to the wound dressing.
30. The apparatus according to any one of claims 18 to 29, wherein the ultrasound transducer is configured to direct vibratory energy toward the wound site.
31. The apparatus according to any one of claims 18 to 30, wherein the ultrasound transducer is configured to direct thermal energy toward the wound site.
32. The apparatus according to any one of claims 18 to 31, wherein the ultrasound transducer is configured to promote introduction of drugs to the body through the skin.

1/1**FIG. 1**

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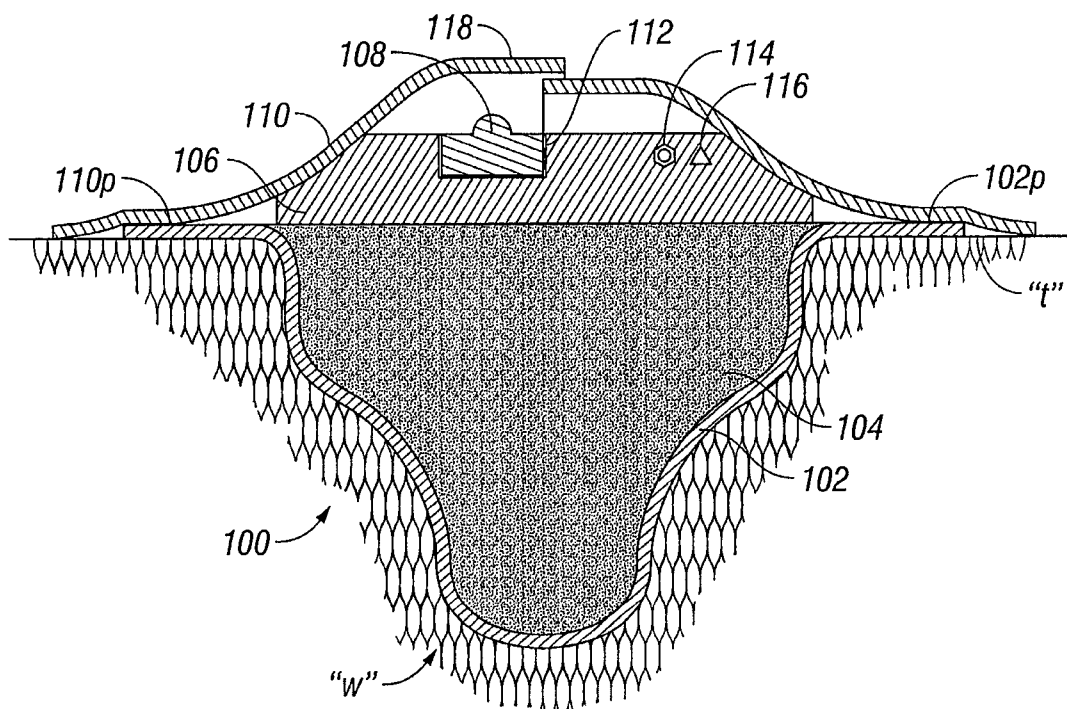


FIG. 2

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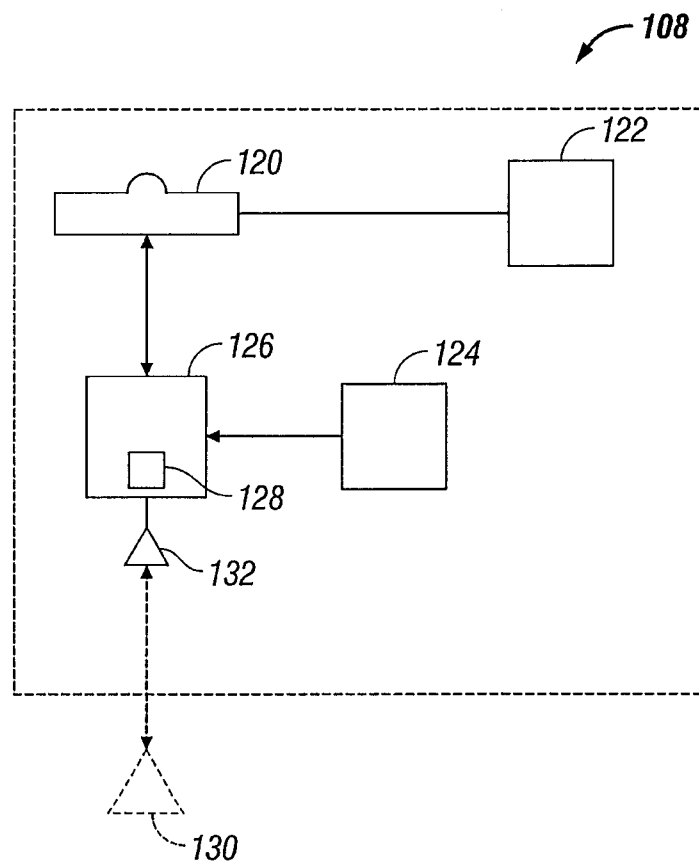
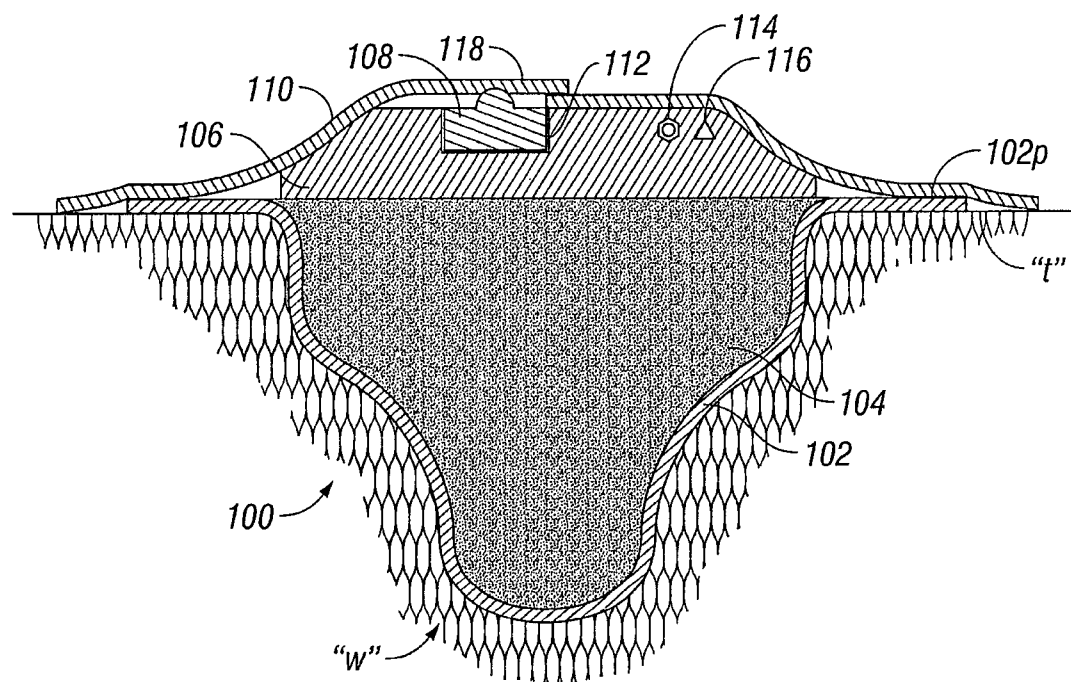


FIG. 3

4/1**FIG. 4**

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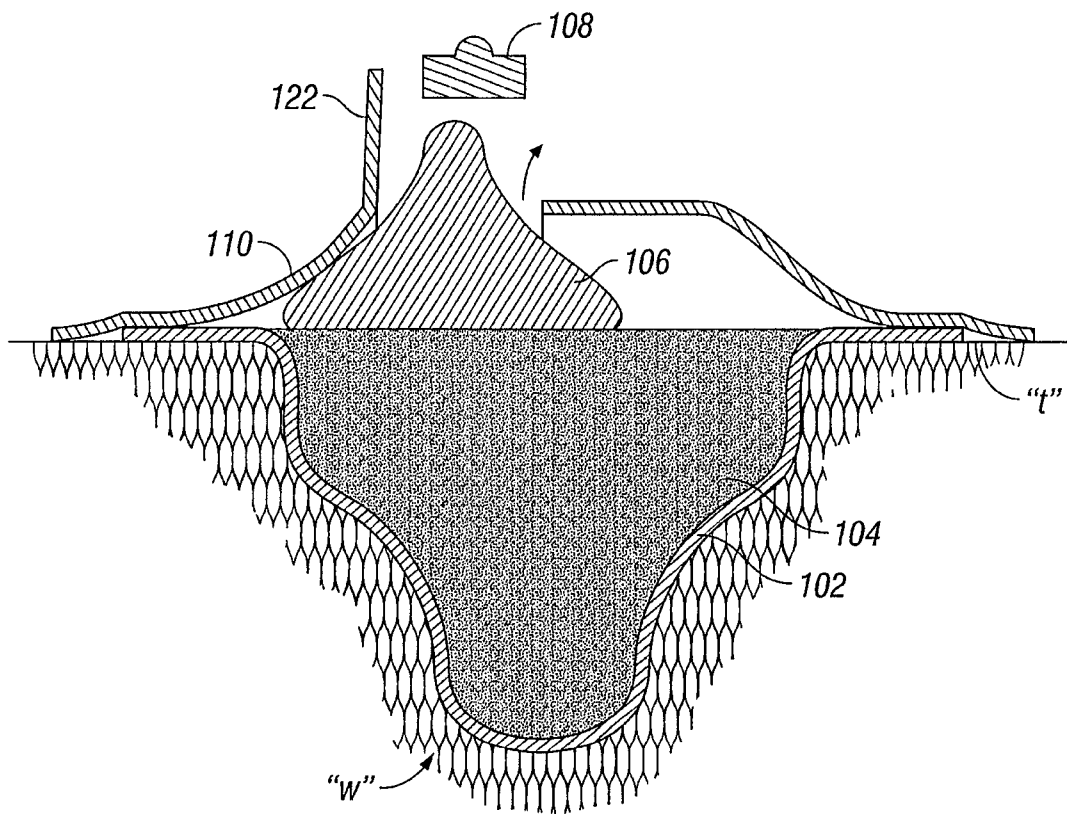
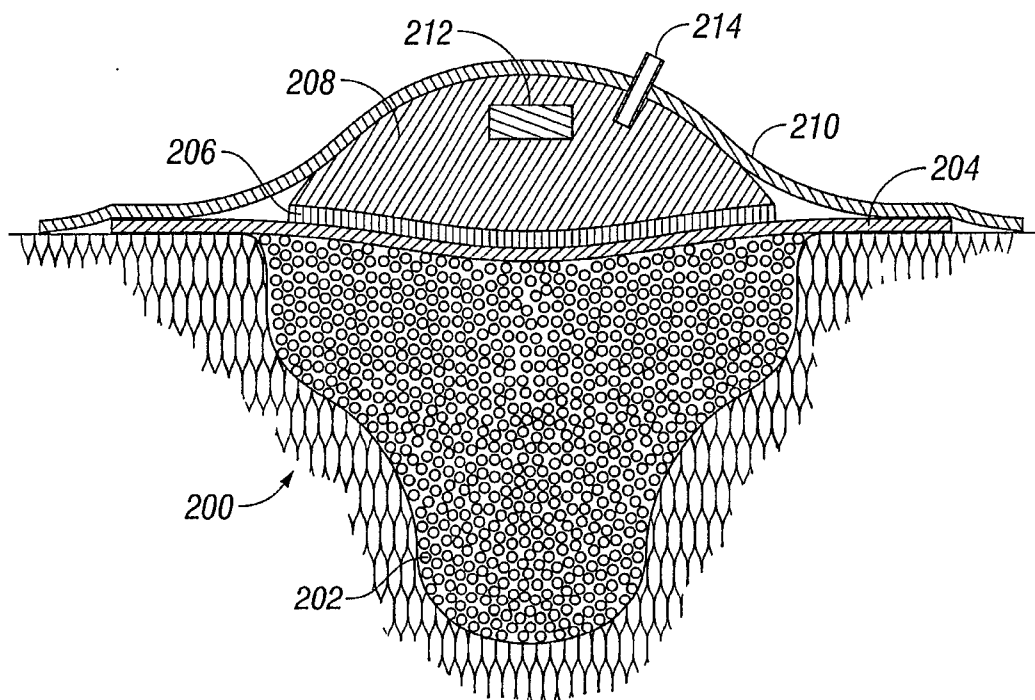
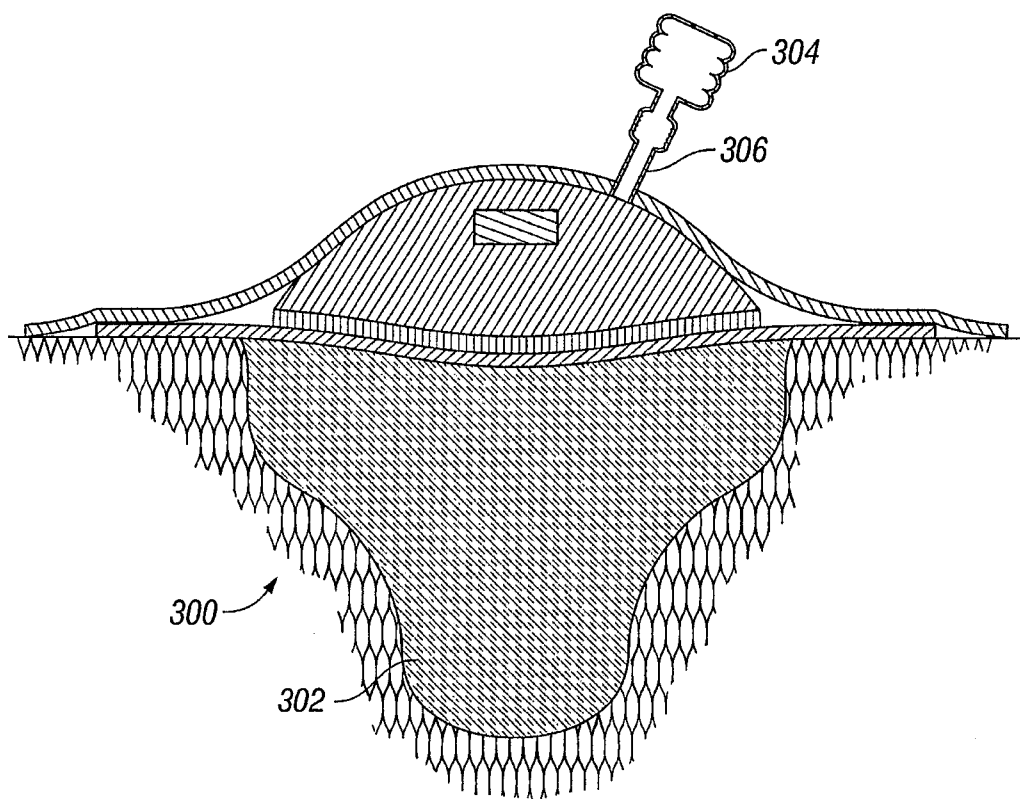


FIG. 5

U/I**FIG. 6**

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**FIG. 7**

