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(12) United States Patent
Shuler

(10) Patent No.: US 8,447,375 B2
(45) Date of Patent: May 21, 2013

(54) **METHODS AND DRESSING SYSTEMS FOR PROMOTING HEALING OF INJURED TISSUE**

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(73) Assignee: **J&M Shuler Medical, Inc.**, Athens, GA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 281 days.

(21) Appl. No.: **12/855,019**

(22) Filed: **Aug. 12, 2010**

(65) **Prior Publication Data**

US 2011/0054283 A1 Mar. 3, 2011

Related U.S. Application Data

(60) Provisional application No. 61/233,797, filed on Aug. 13, 2009, provisional application No. 61/234,857, filed on Aug. 18, 2009, provisional application No. 61/245,789, filed on Sep. 25, 2009.

(51) **Int. Cl.**
A61B 5/00 (2006.01)

(52) **U.S. Cl.**
USPC **600/344**; 604/289

(58) **Field of Classification Search**
USPC 600/310, 344; 604/289
See application file for complete search history.

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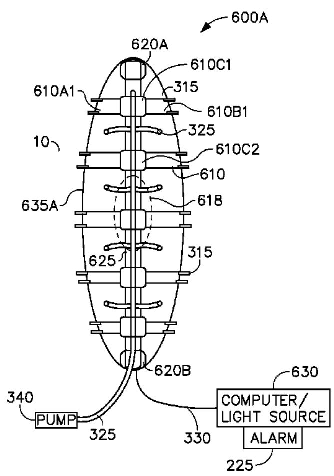
Primary Examiner — Rodney Fuller
Assistant Examiner — Fang-Chi Chang
(74) *Attorney, Agent, or Firm* — Smith Risley; Steven P. Wigmore

(57) **ABSTRACT**

A dressing system is disclosed which has a sponge and a near infrared spectroscopy sensor positioned adjacent to the sponge for monitoring oxygenation levels of tissue adjacent to the sponge. The dressing system may further include a tube coupled to the sponge for removing fluid from the sponge. The dressing system comprises: a sponge; and a tensioning system coupled to the sponge. The tensioning system further comprises a central longitudinal member coupled to the sponge; and at least one tensioning member coupled to the central longitudinal member. A sequential compression system comprises: an envelope sleeve dressing; and a bladder that is both expandable and retractable. A tissue filler system is also described and includes a plurality of tubes; wherein each of the plurality of tubes further comprises apertures; and a pump coupled to at least one of the tubes which obviates the need for any sponge or wound screen.

20 Claims, 34 Drawing Sheets



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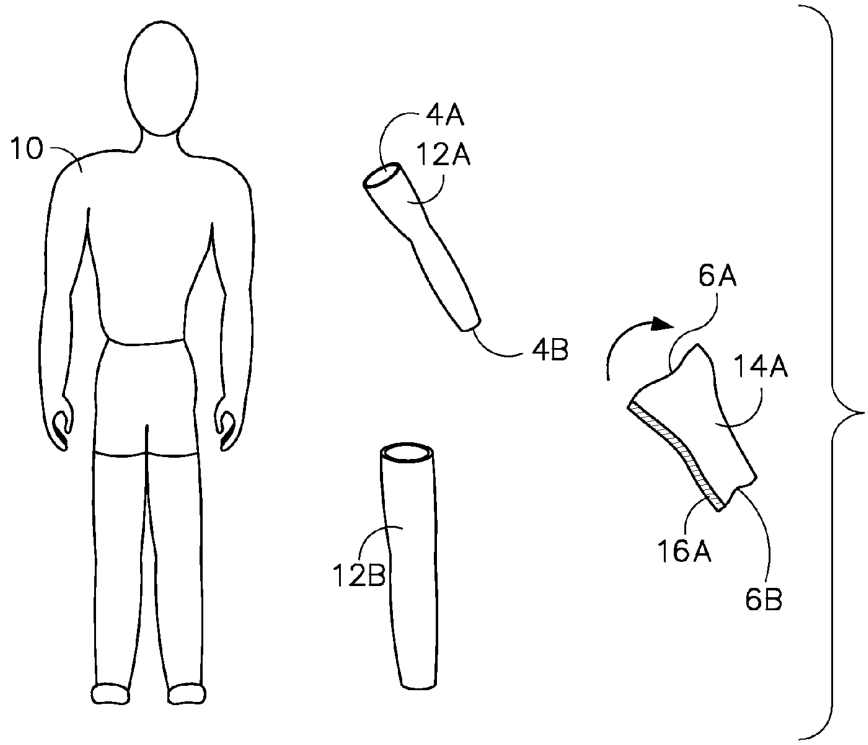

FIG. 1A

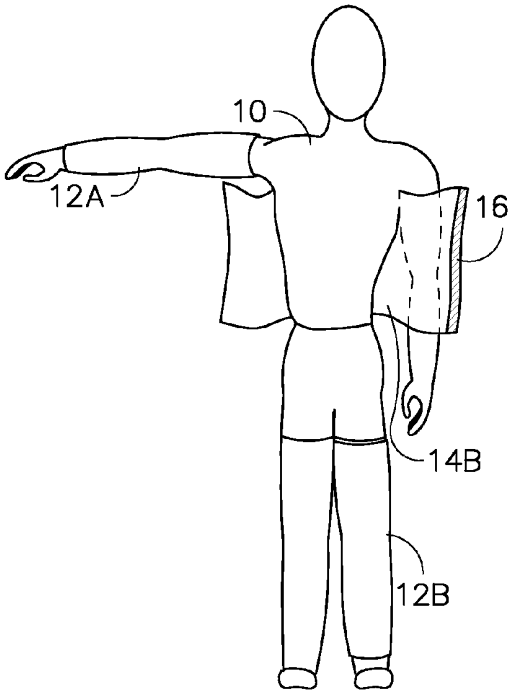

FIG. 1B

FIG. 2A

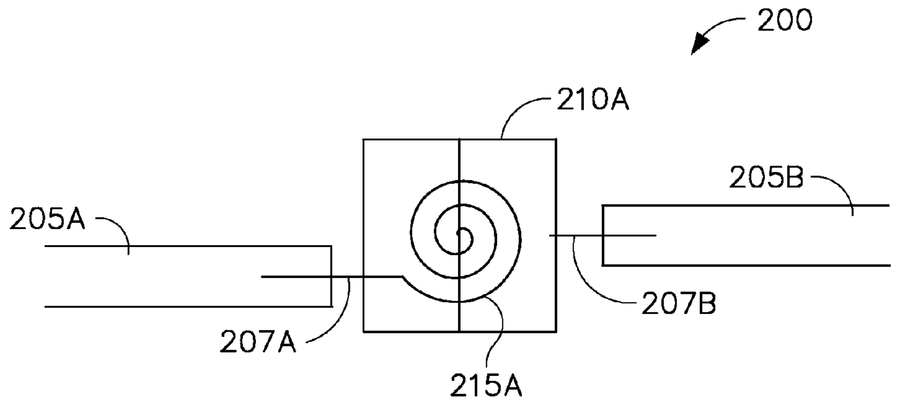
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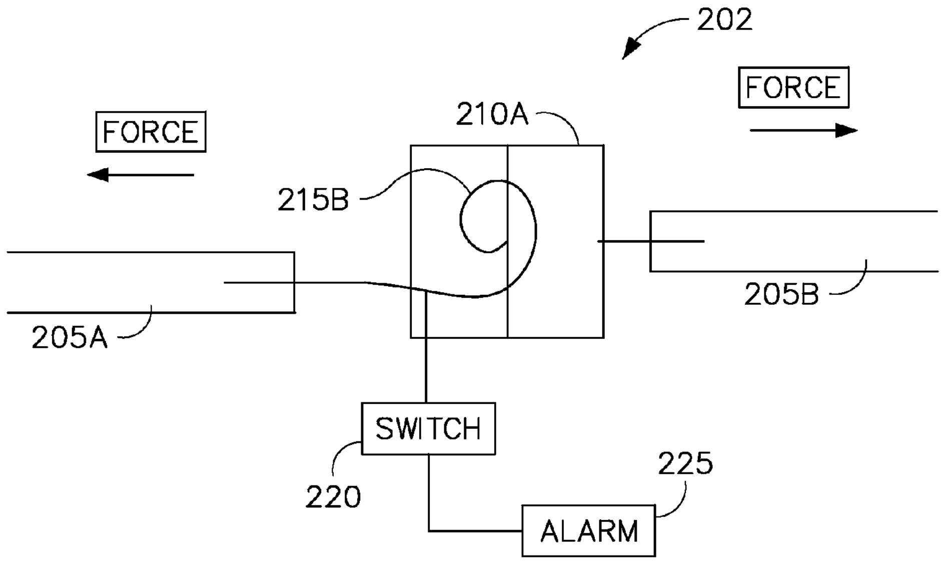
FIG. 2B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ALARM

FIG. 3A

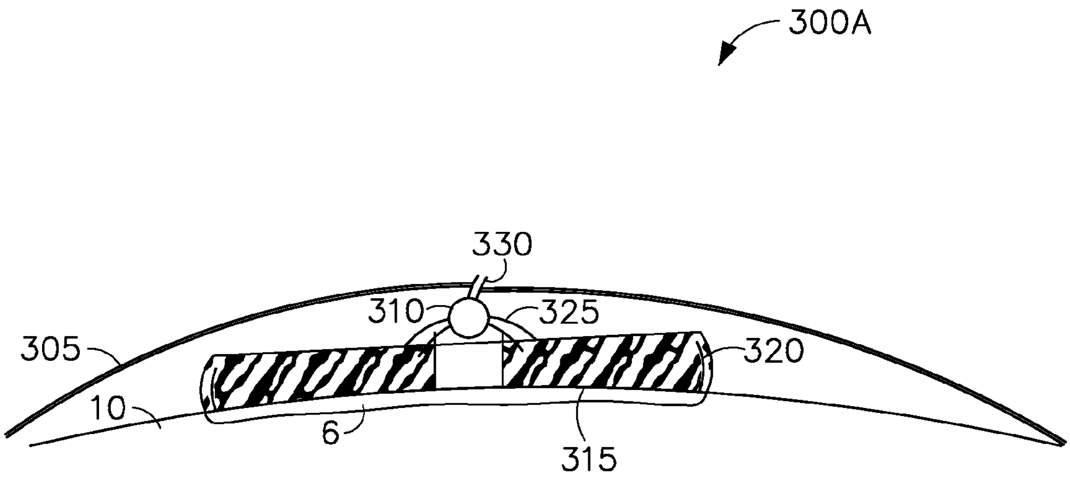
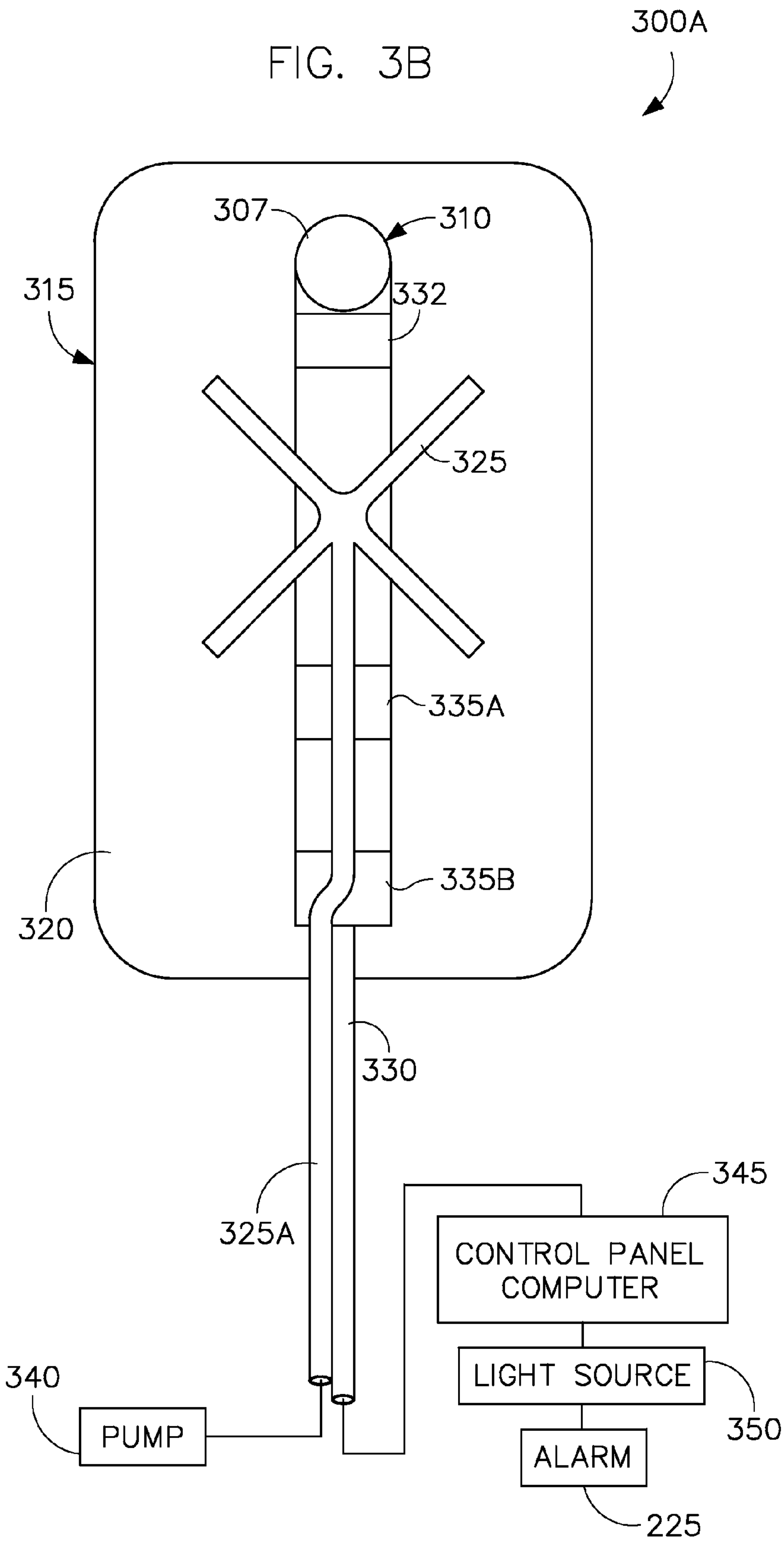


FIG. 3B



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325
335A
335B
320
330
325A
345
CONTROL PANEL
COMPUTER
LIGHT SOURCE
350
340
PUMP
ALARM
225

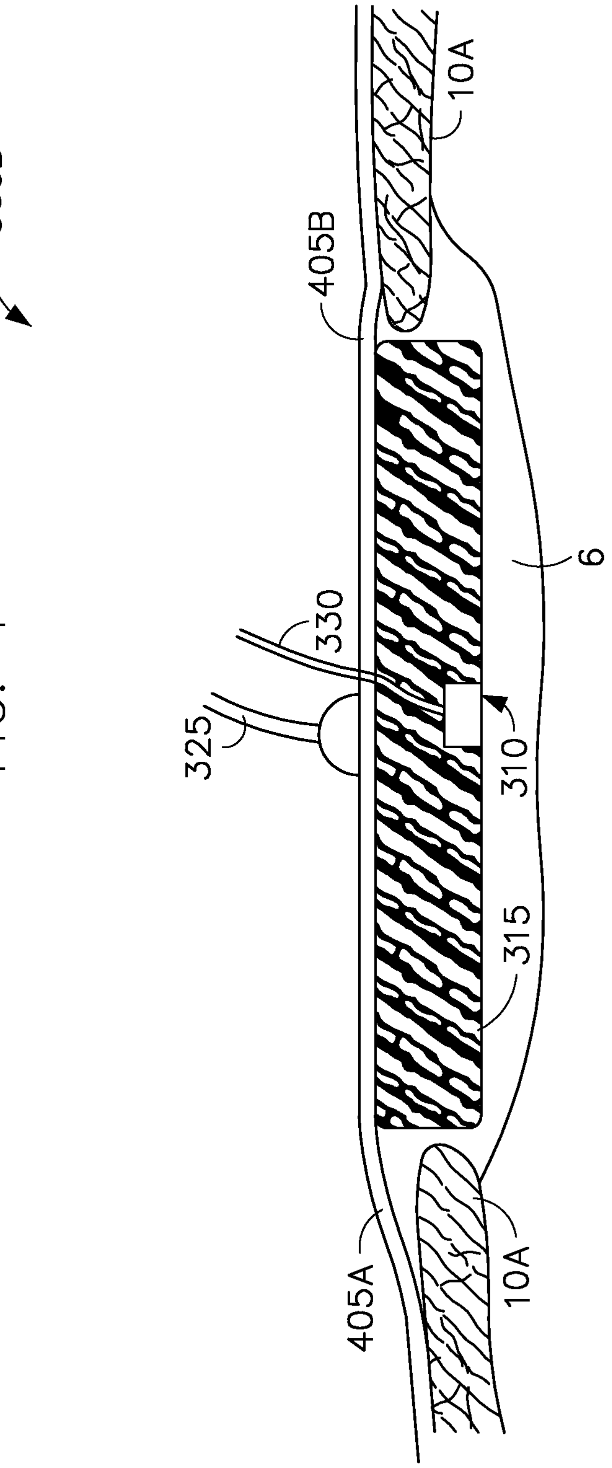
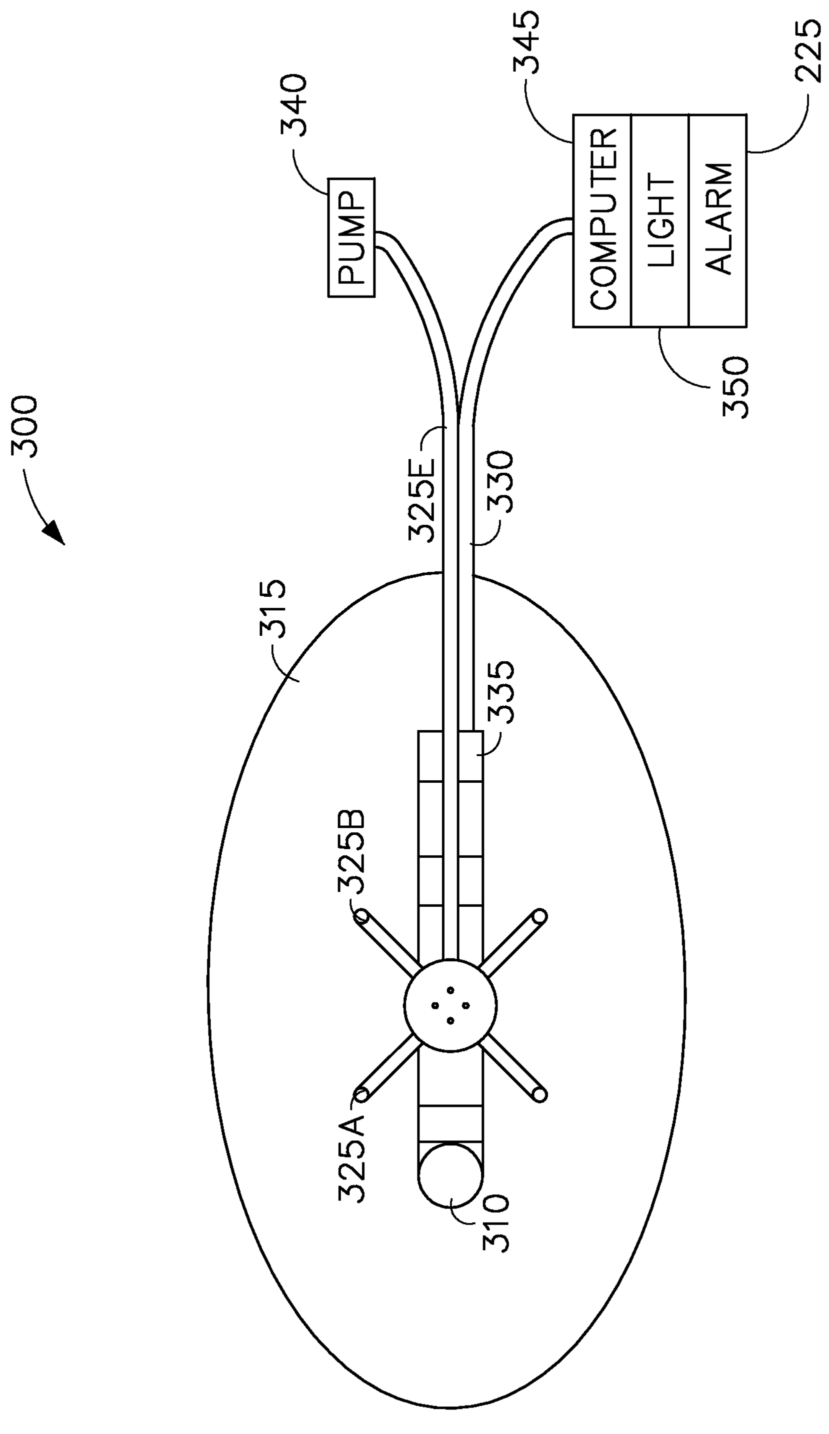


FIG. 4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325B
325A
310

FIG. 5

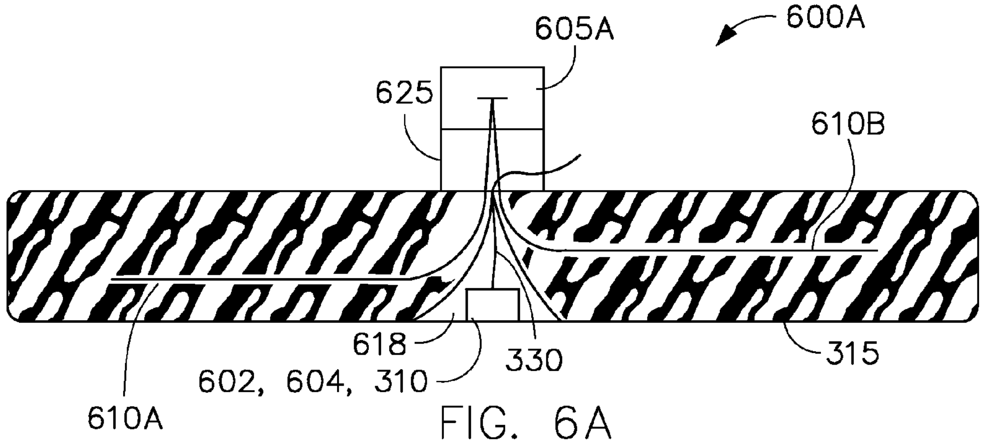


FIG. 6A

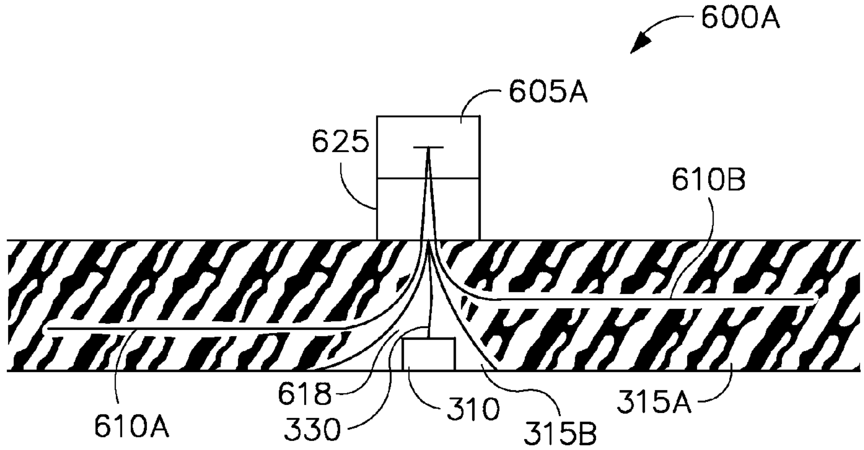


FIG. 6B

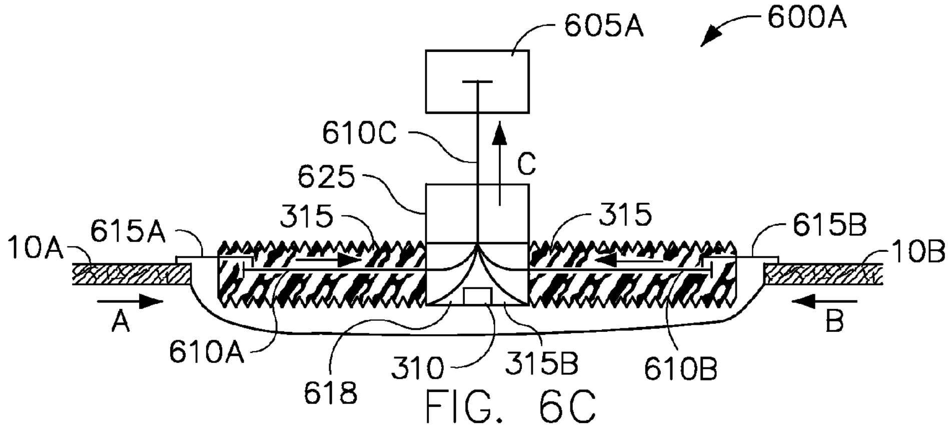
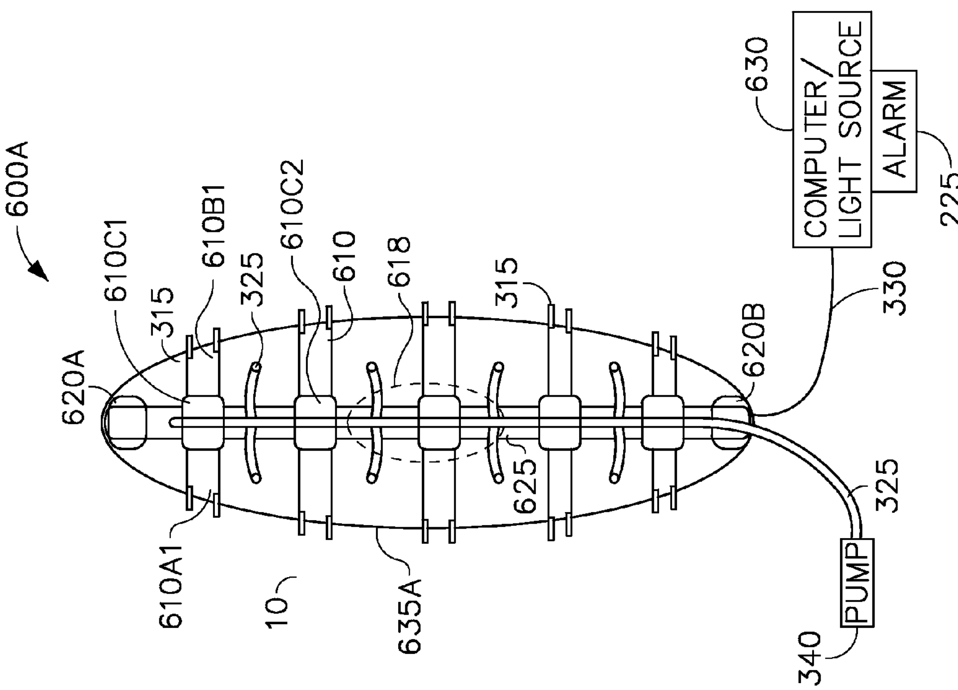


FIG. 6C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610C2
610
618
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620B
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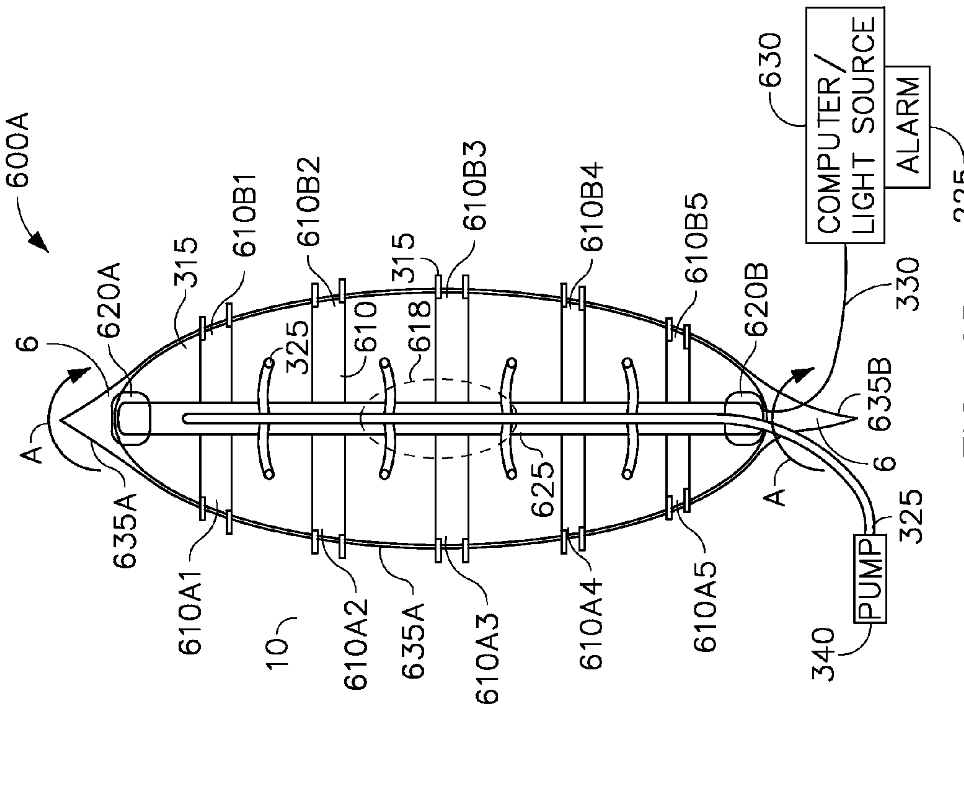
LIGHT SOURCE
ALARM
225
610A1
10
635A
625
325
PUMP
340

FIG. 6E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610B1
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618
315
610B3
610B4
610B5
620B
330
630
COMPUTER/
LIGHT SOURCE
ALARM
225
635B
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A
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610A2
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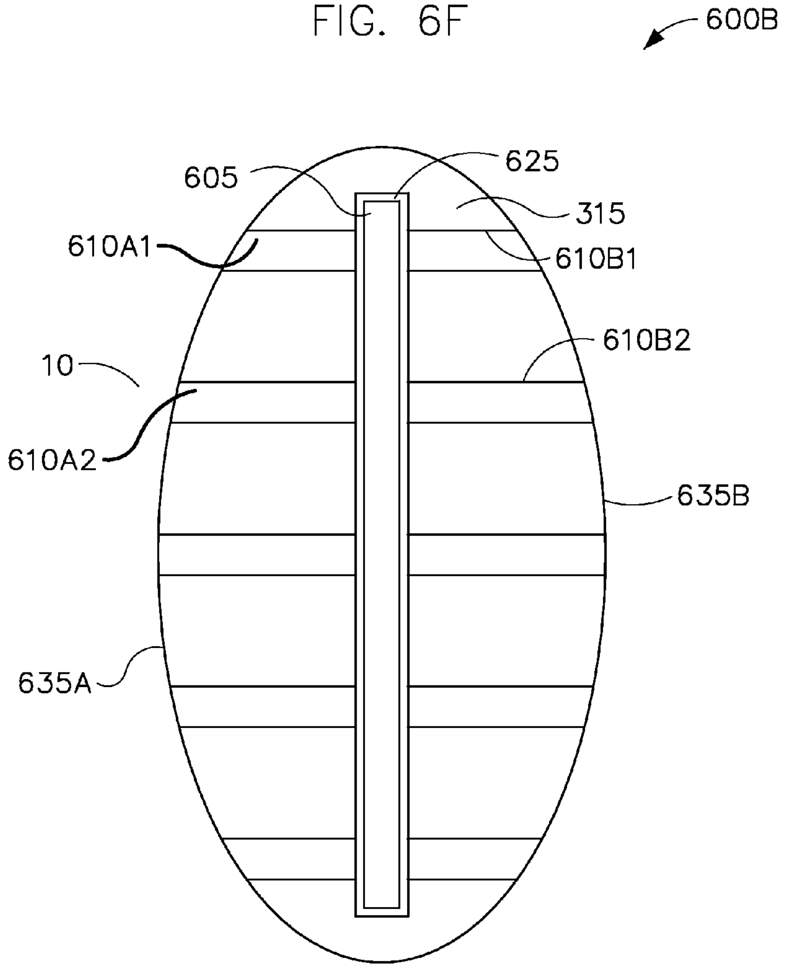
610A4
610A5

FIG. 6D

FIG. 6F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610A2
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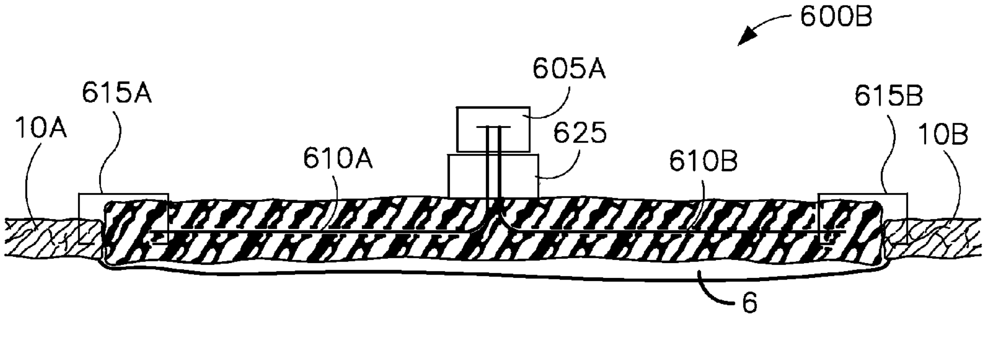
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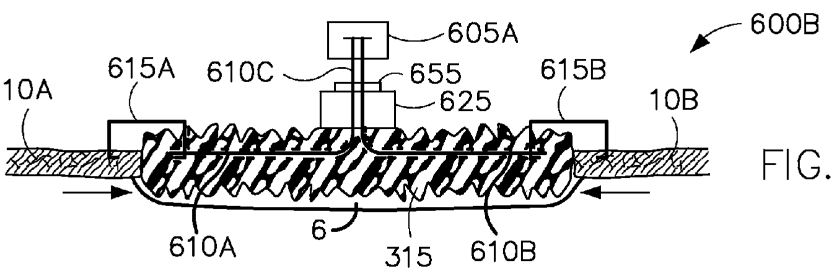
10B
610A
610B
6

FIG. 6G



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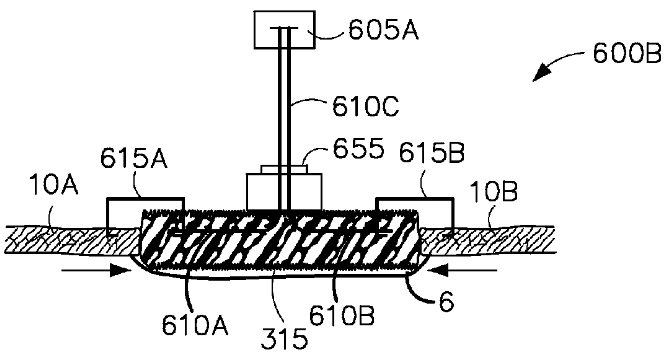


FIG. 6I

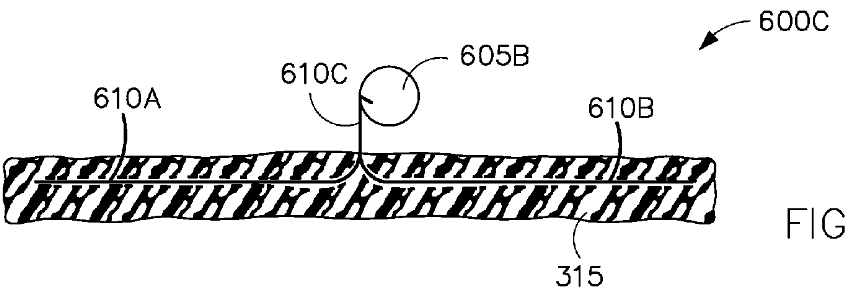


FIG. 6J

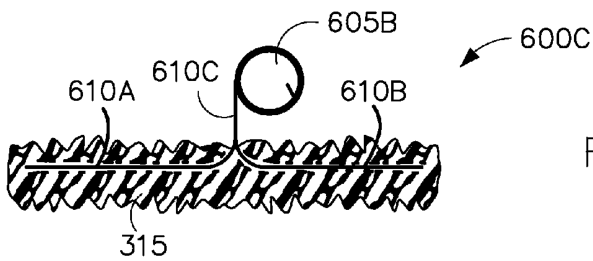
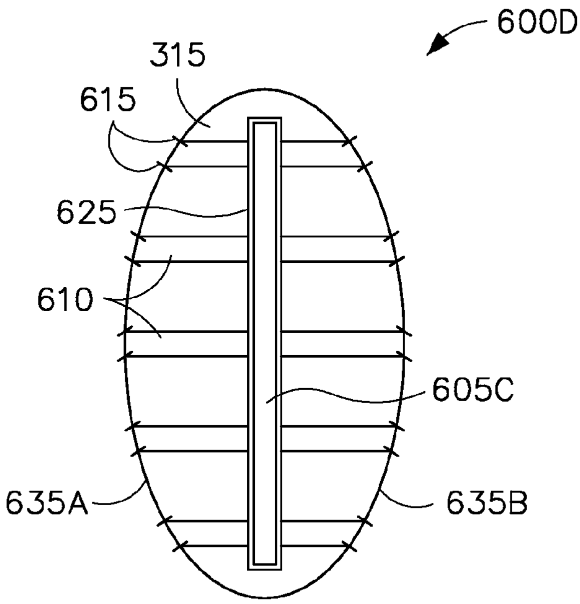


FIG. 6K

FIG. 6L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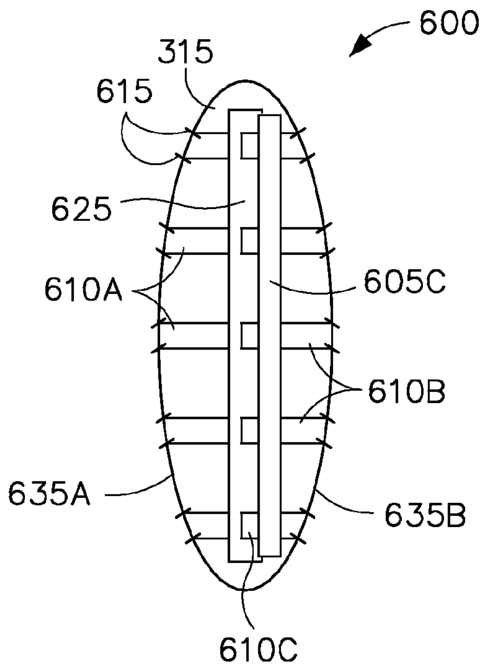
635A
635B

FIG. 6M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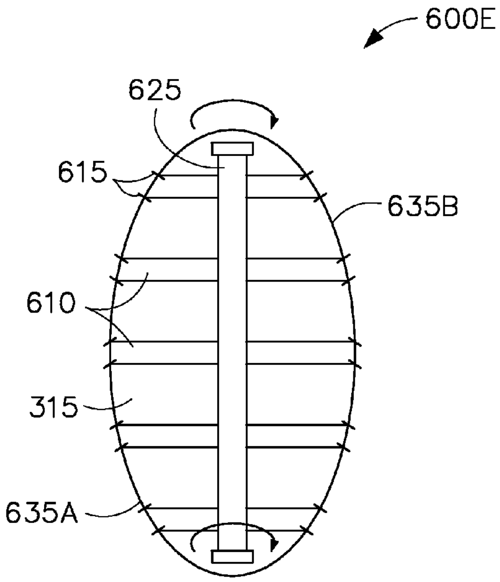
610A
605C
610B
635A
635B
610C

FIG. 6N



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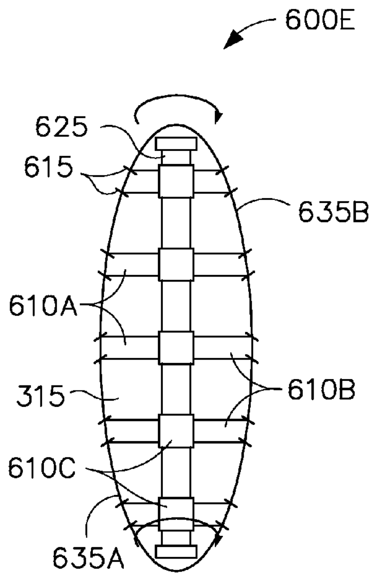

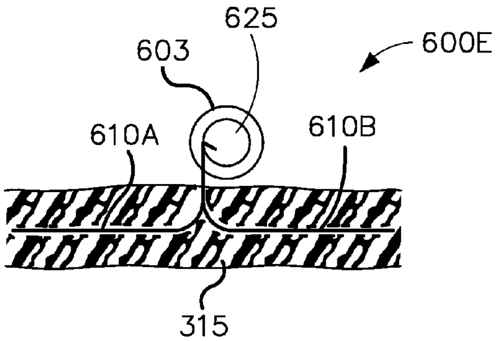

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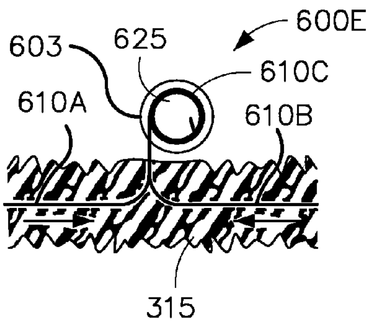

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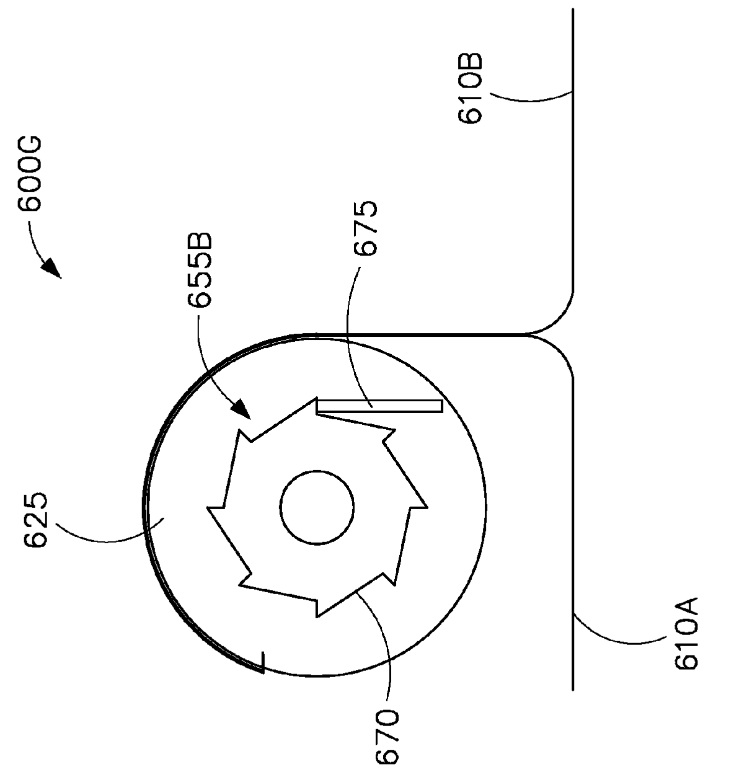
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655B
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670
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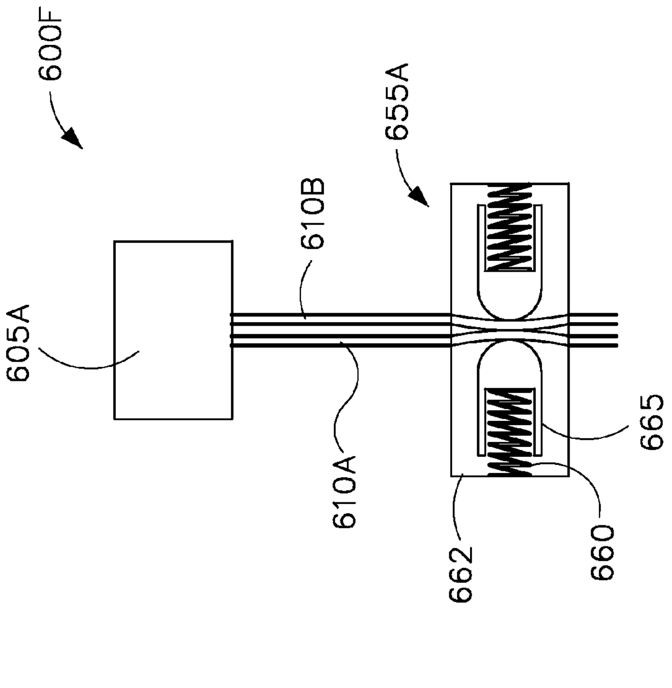
FIG. 6S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655A
610A
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662
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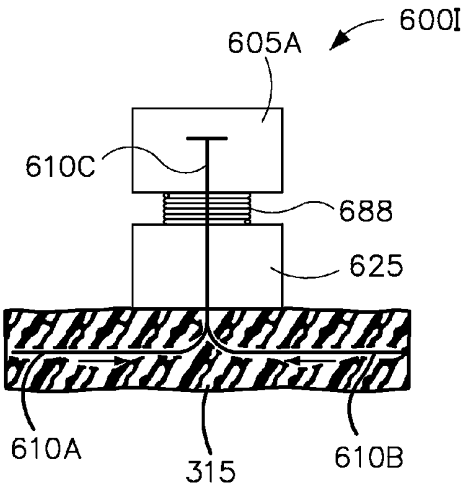
FIG. 6R

FIG. 6T



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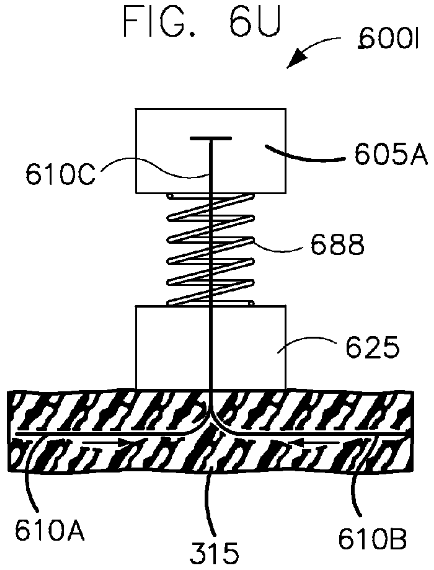

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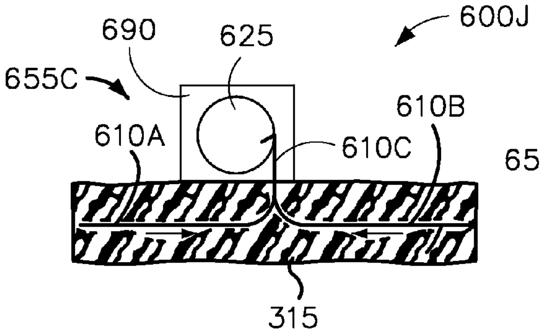

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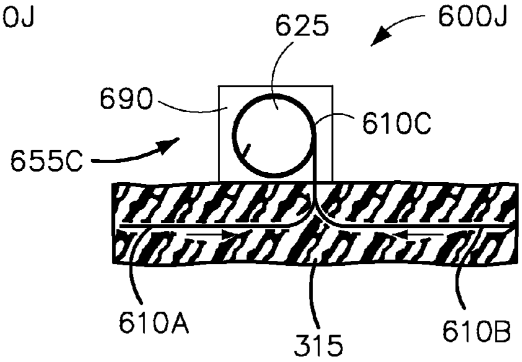


FIG. 6X

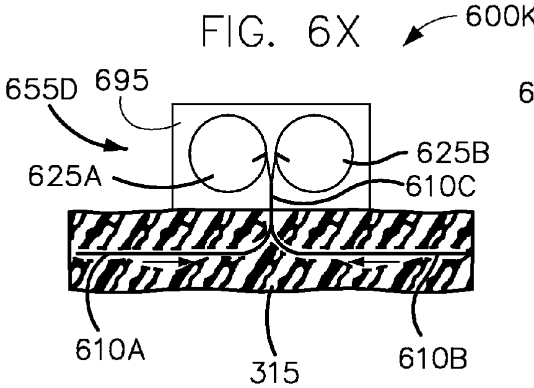
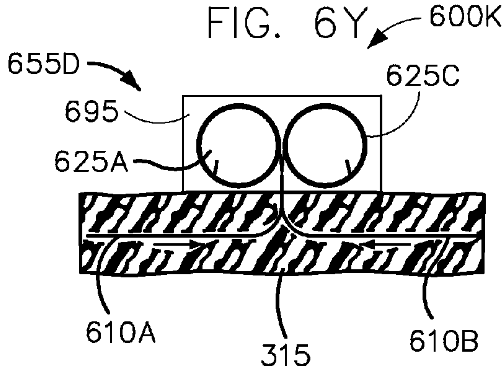


FIG. 6Y



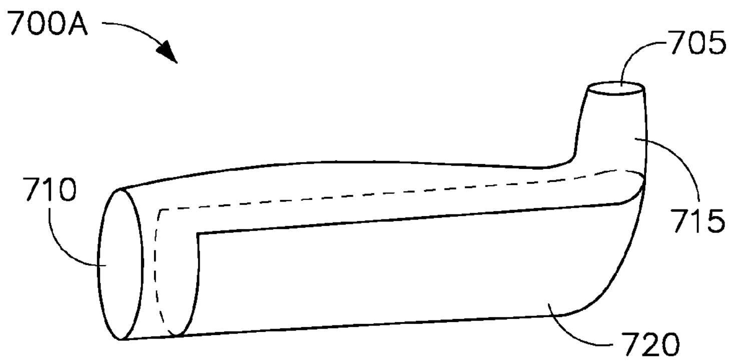


FIG. 7A

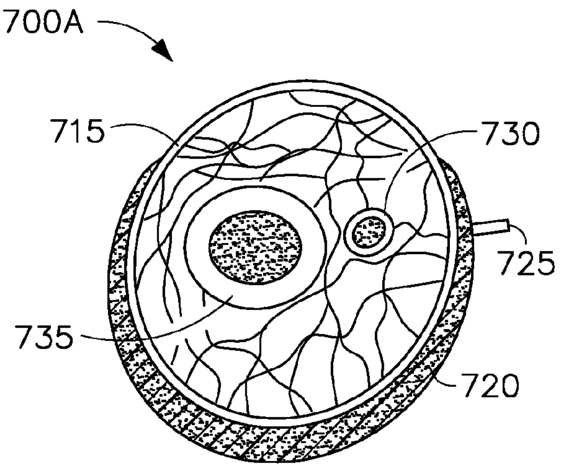


FIG. 7B

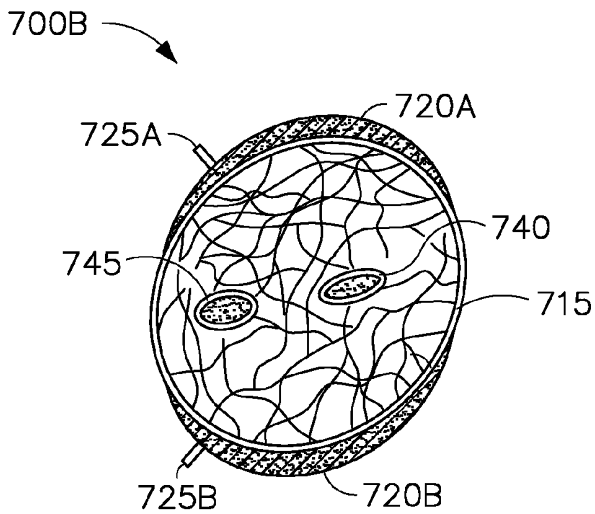


FIG. 7C

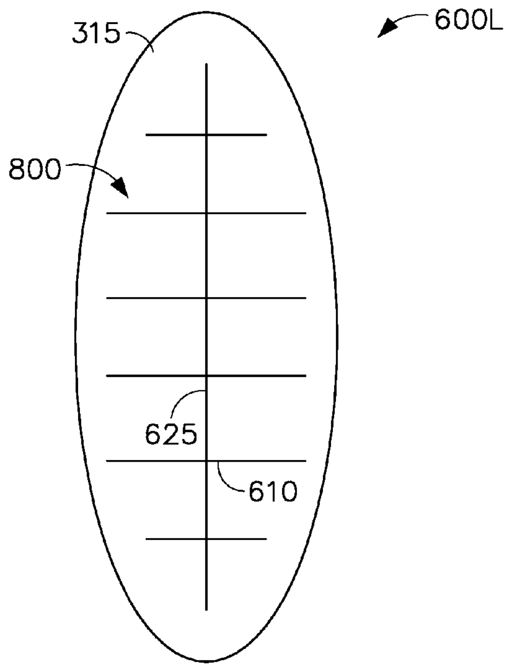


FIG. 8A

FIG. 8B

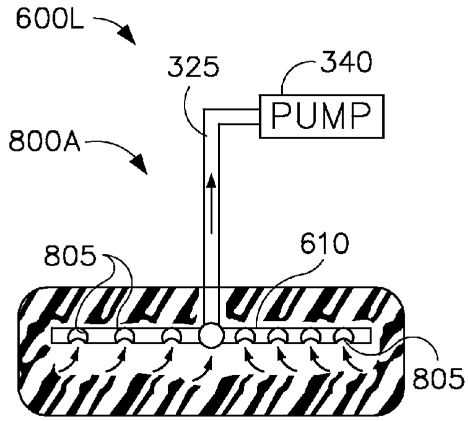
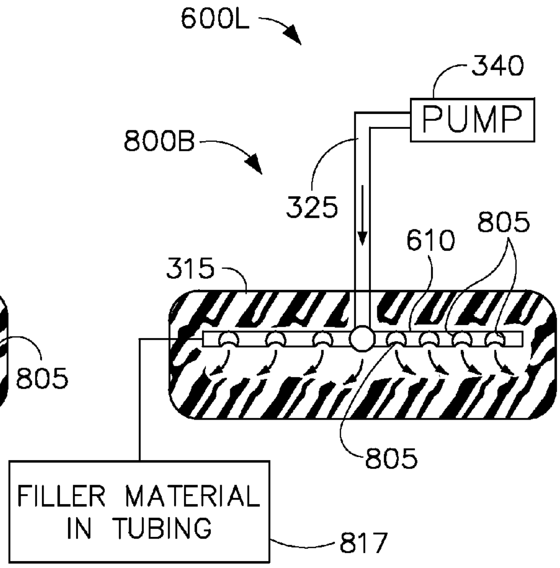
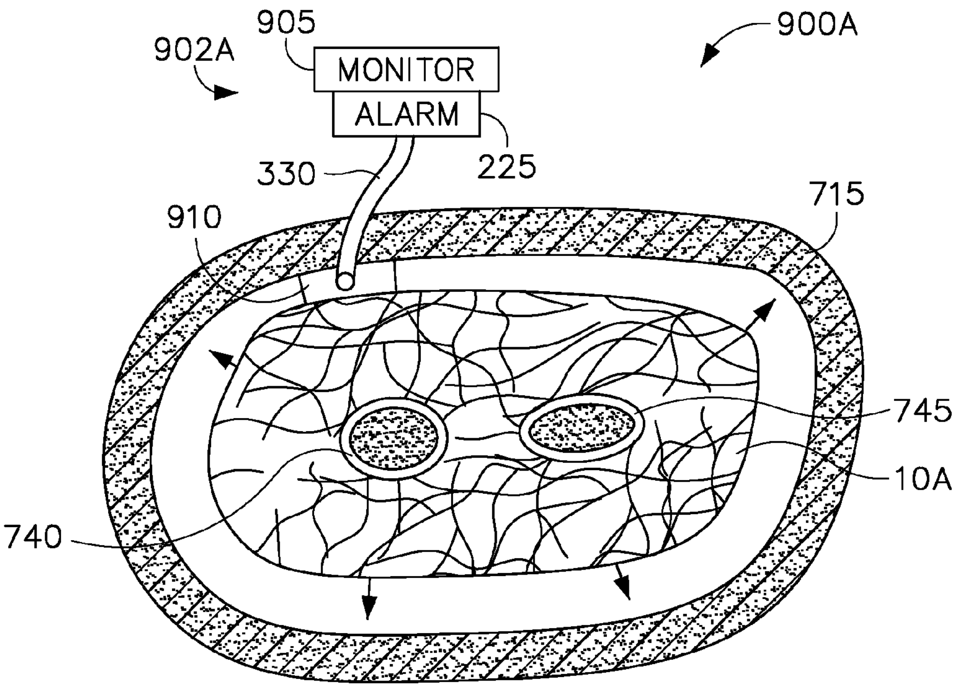


FIG. 8C




905
902A
MONITOR
ALARM
900A
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225
910
715
745
10A
740

FIG. 9A

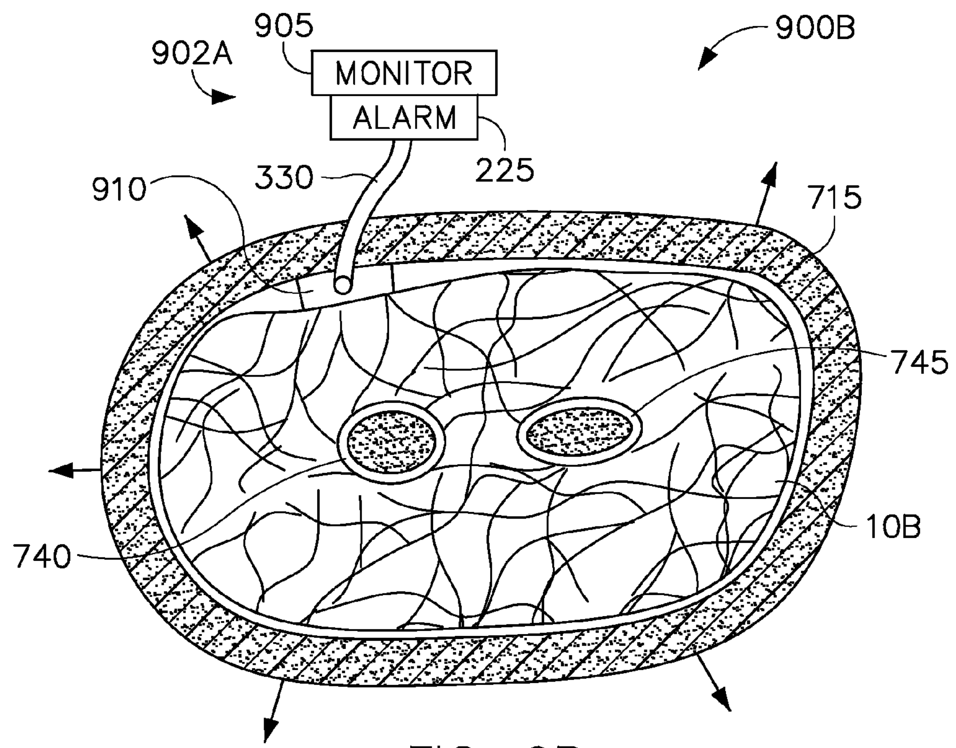
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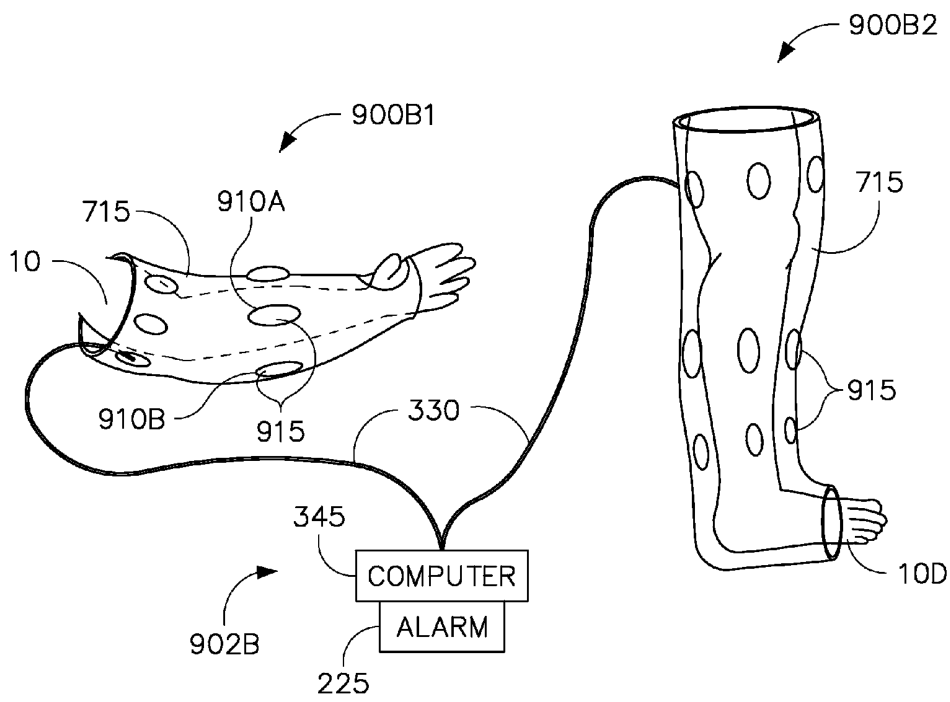
FIG. 9B



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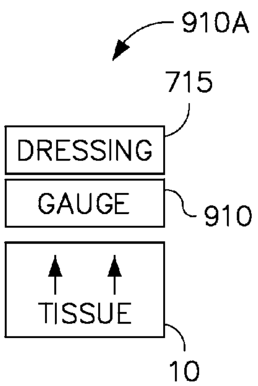


FIG. 9D

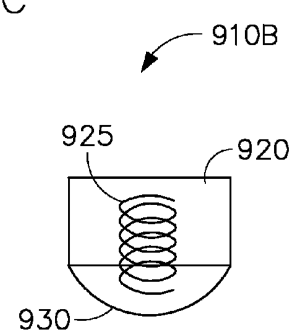


FIG. 9E

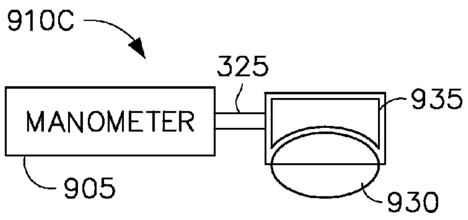


FIG. 9F

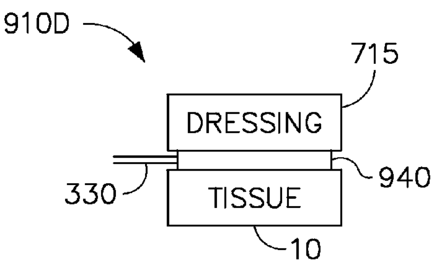


FIG. 9G

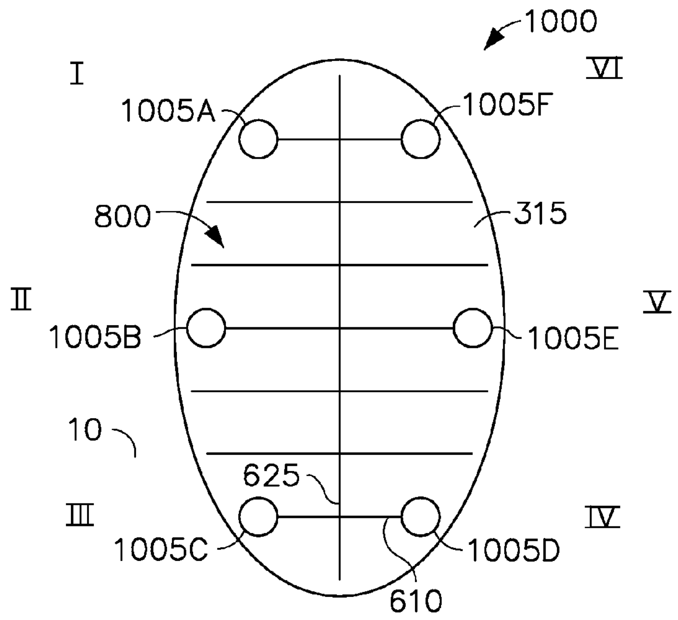


FIG. 10A

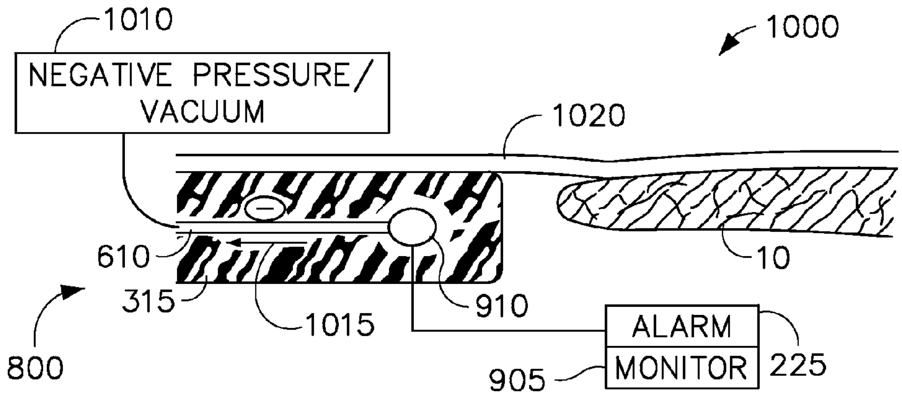


FIG. 10B

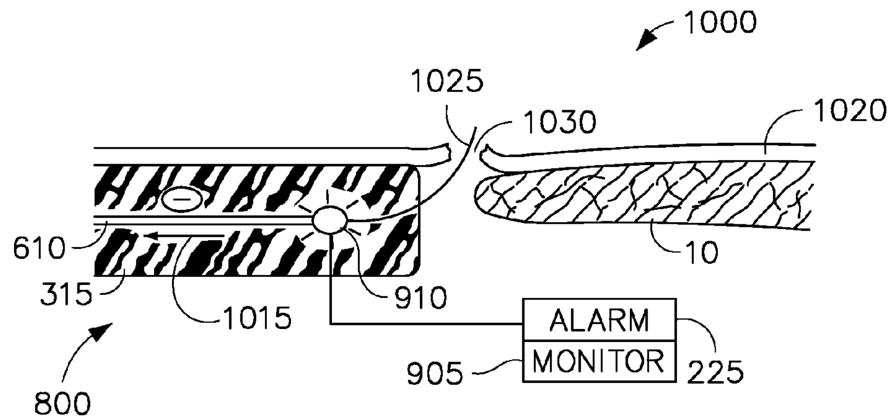


FIG. 10C

FIG. 11A

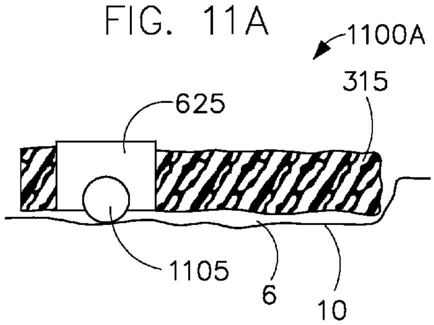


FIG. 11B

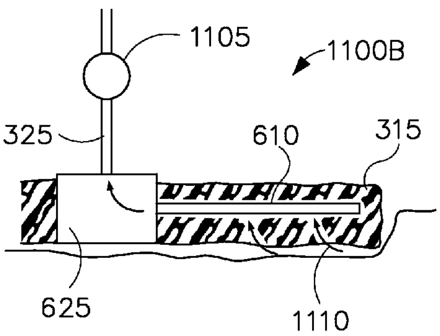
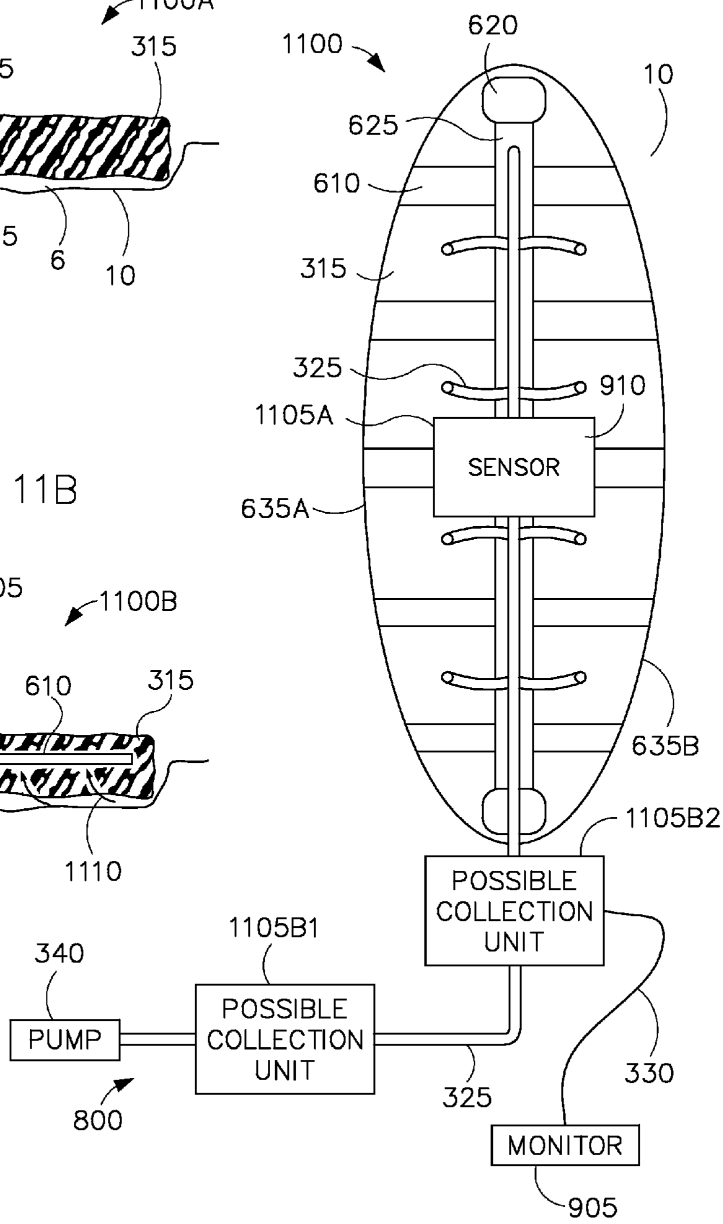


FIG. 11C



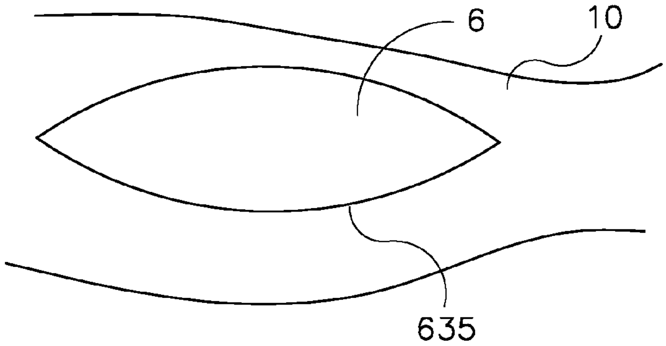


FIG. 12A

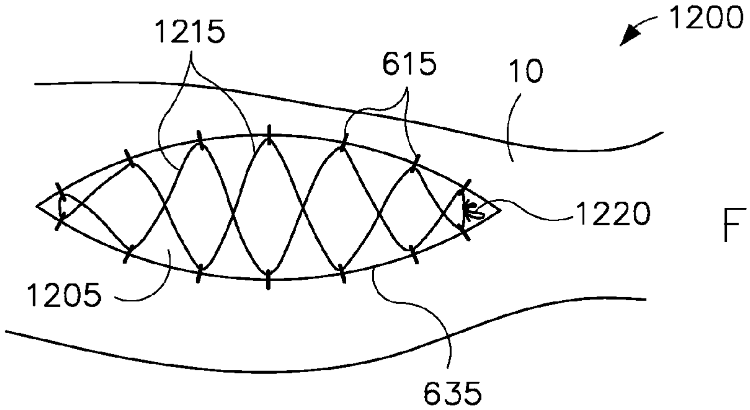


FIG. 12B

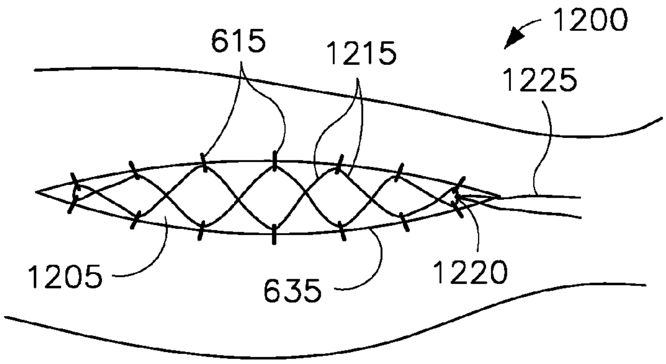


FIG. 12C

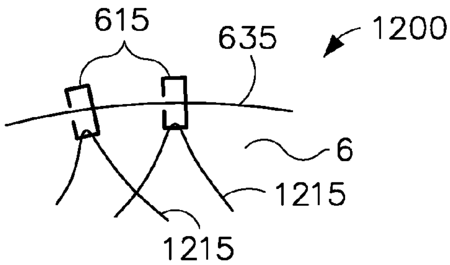
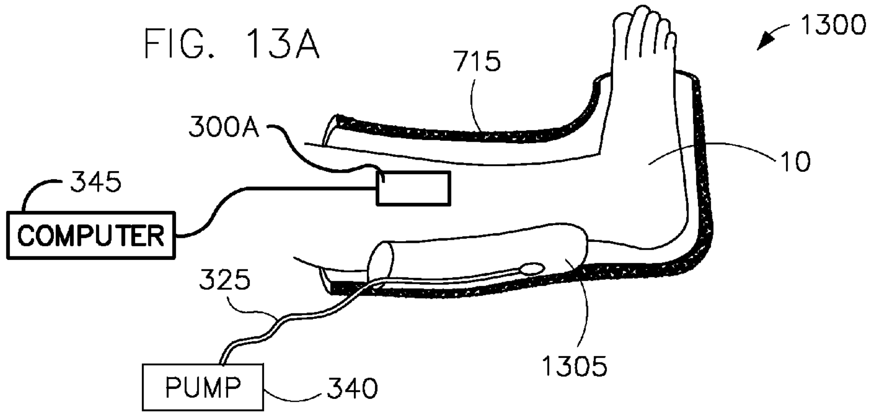


FIG. 12D

FIG. 13A



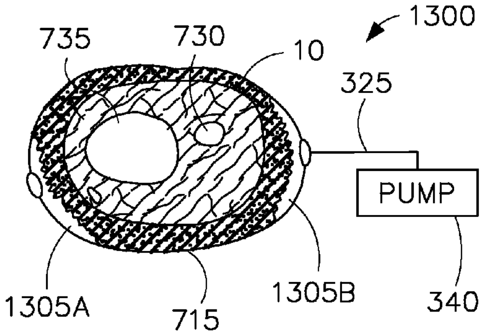


FIG. 13B

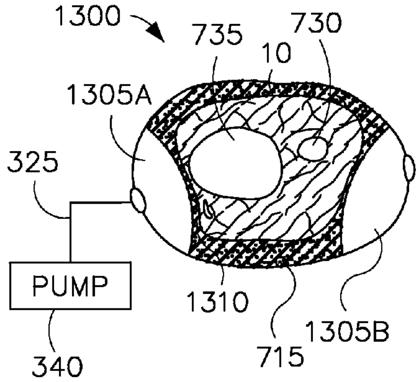
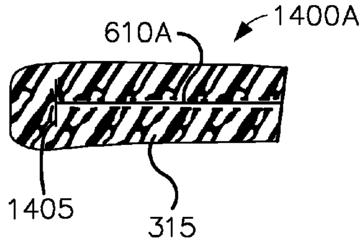


FIG. 13C

FIG. 14A



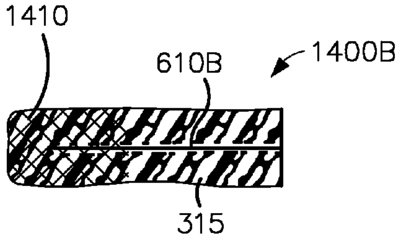
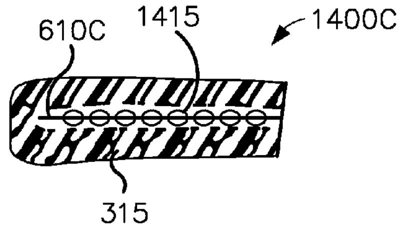


FIG. 14B

FIG. 14C



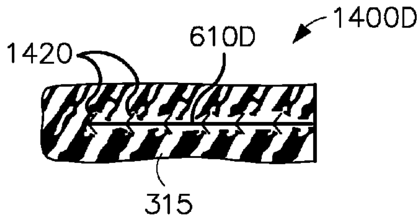


FIG. 14D

FIG. 15A

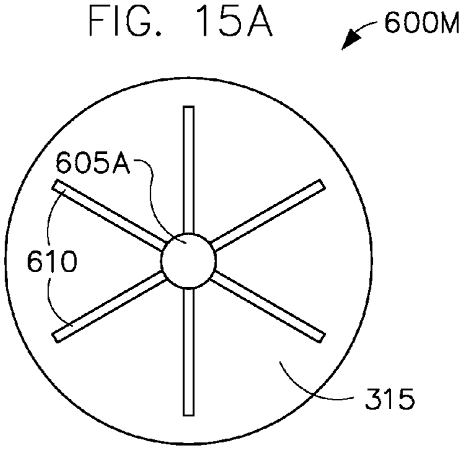
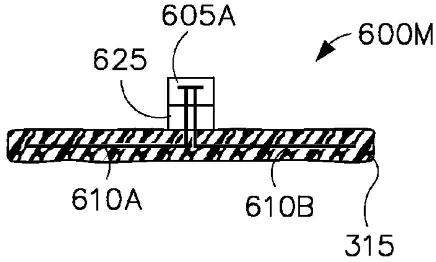


FIG. 15B



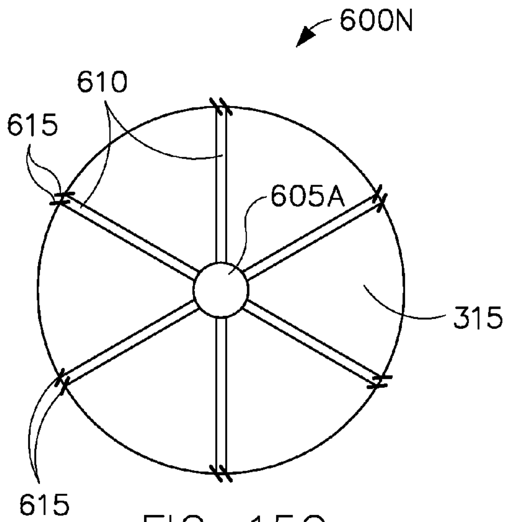


FIG. 15C

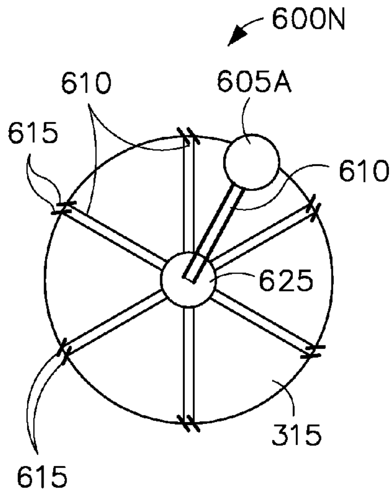


FIG. 15D

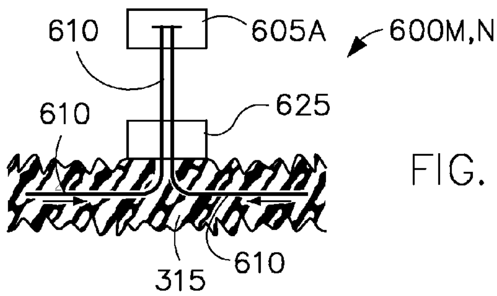


FIG. 15E

FIG. 16A

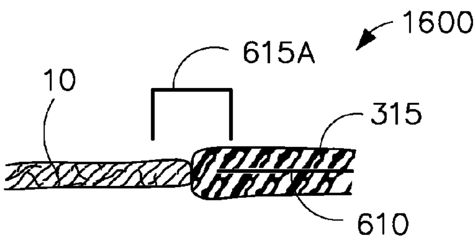


FIG. 17A

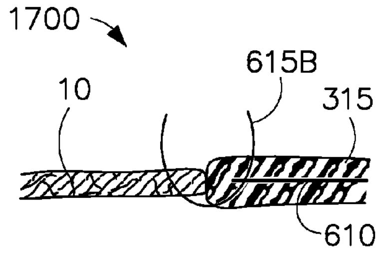


FIG. 16B

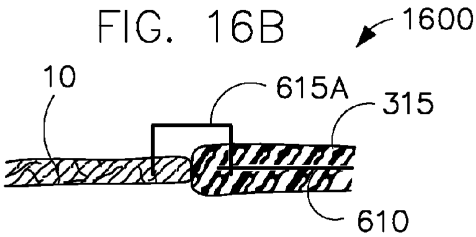


FIG. 17B

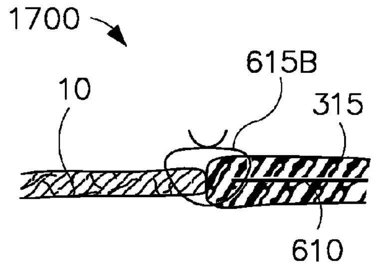


FIG. 16C

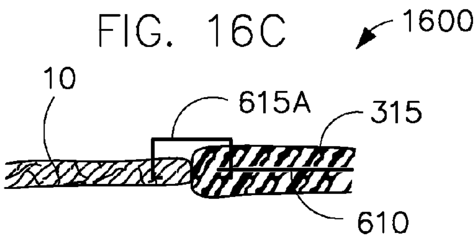


FIG. 17C

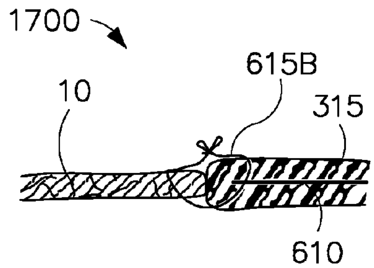


FIG. 18A

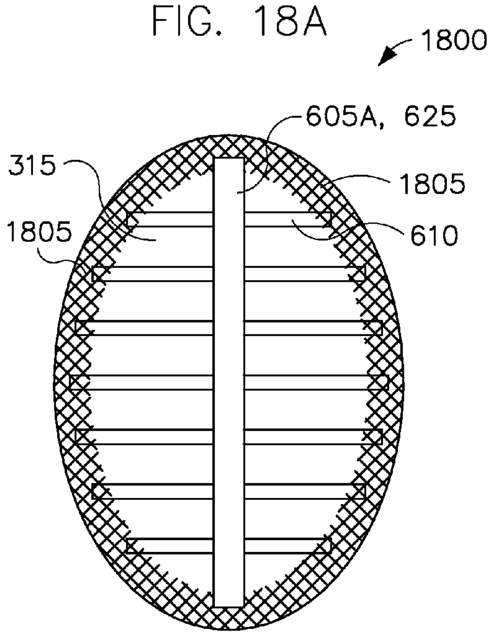


FIG. 18B

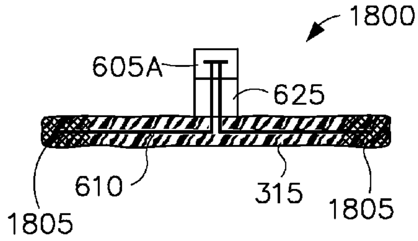


FIG. 19

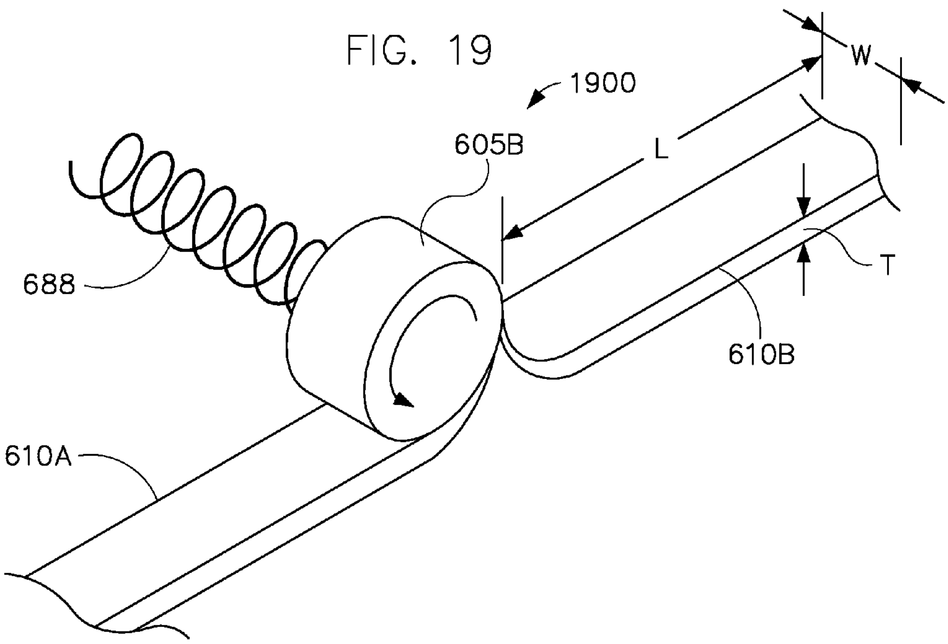


FIG. 20A

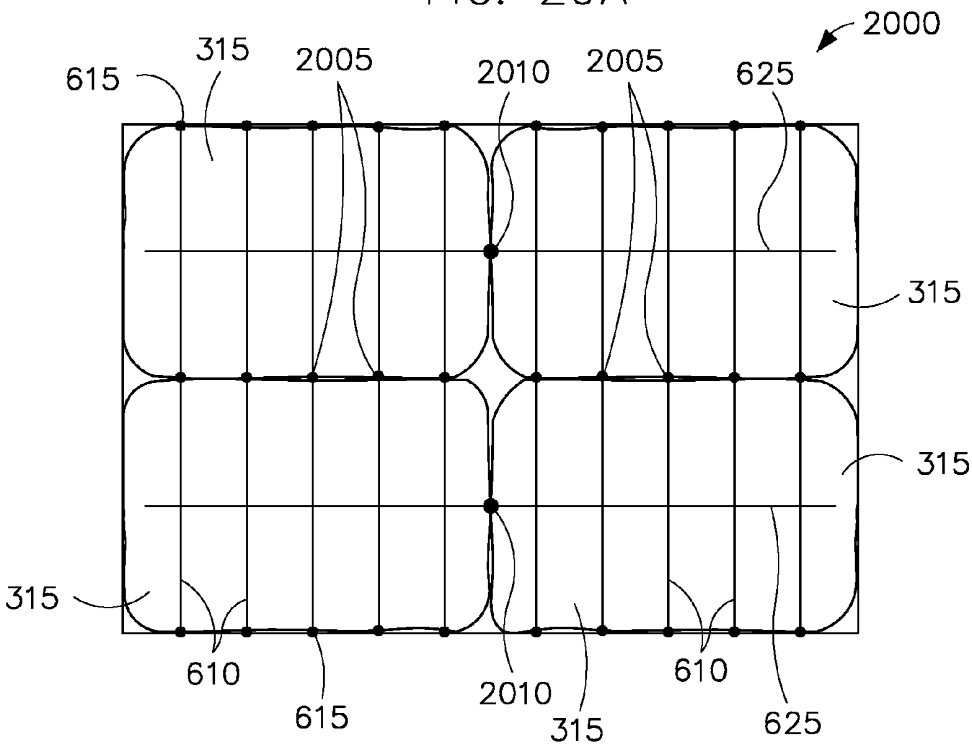


FIG. 20B

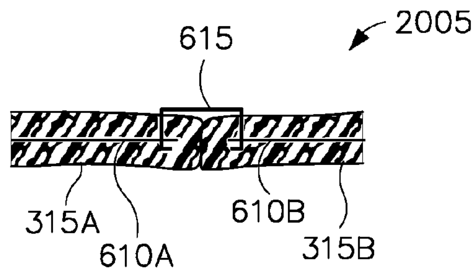


FIG. 20C

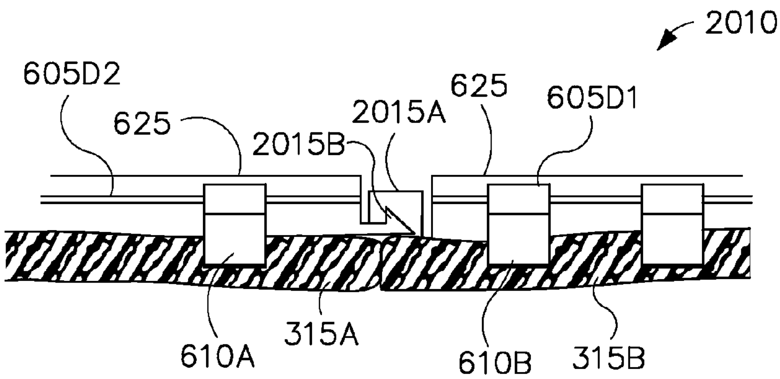


FIG. 21

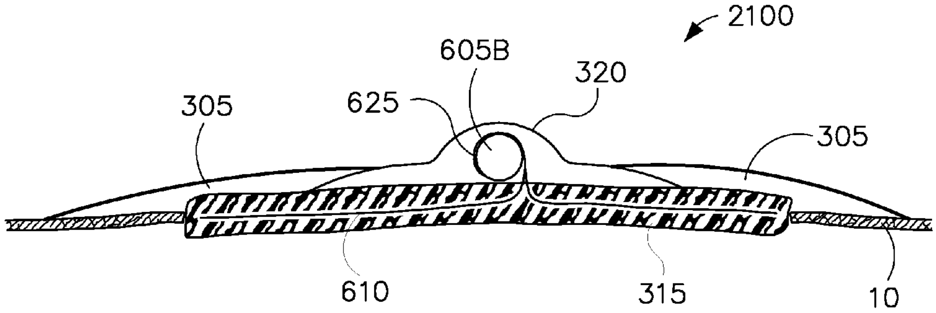


FIG. 22A

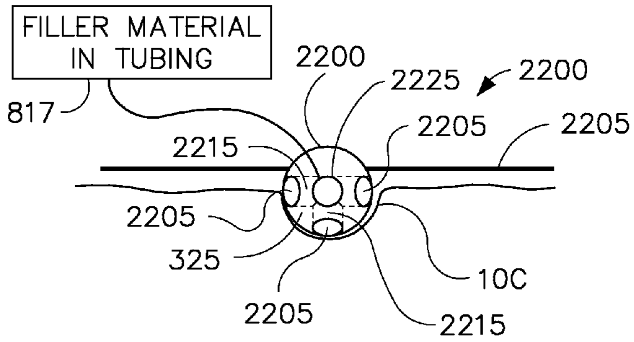
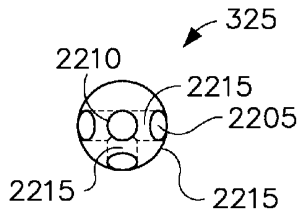


FIG. 22B



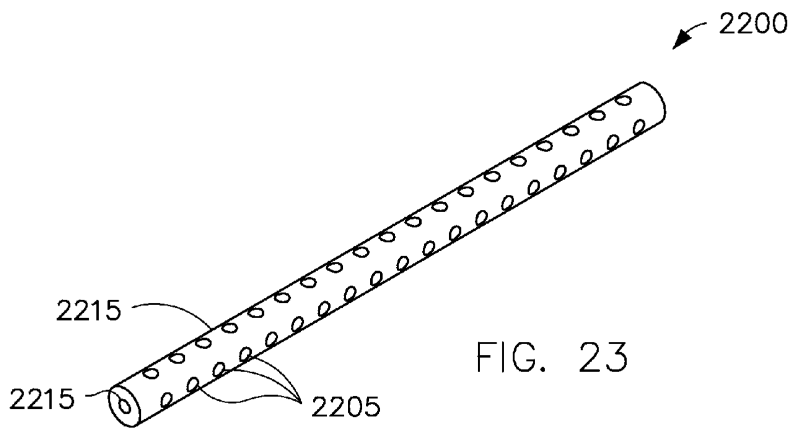


FIG. 23

FIG. 24A

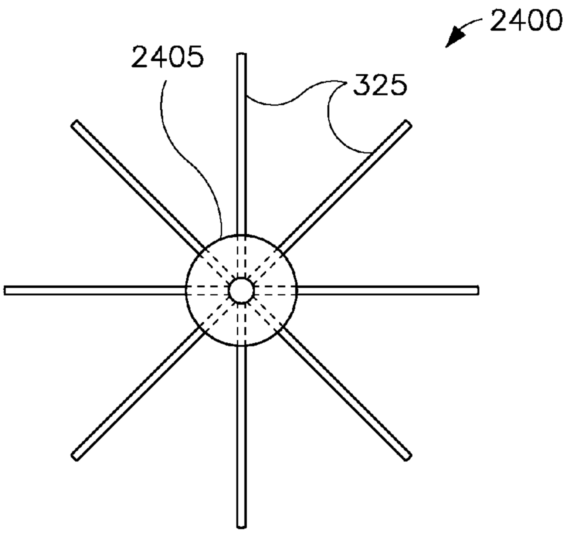


FIG. 24B

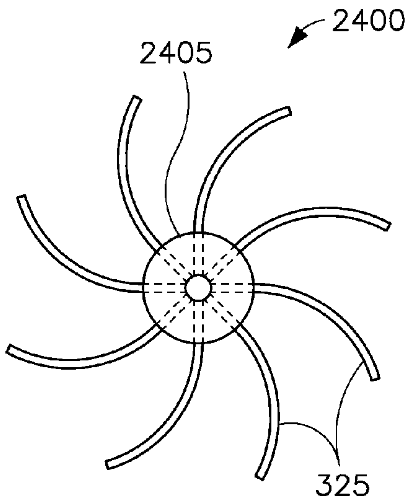


FIG. 24C

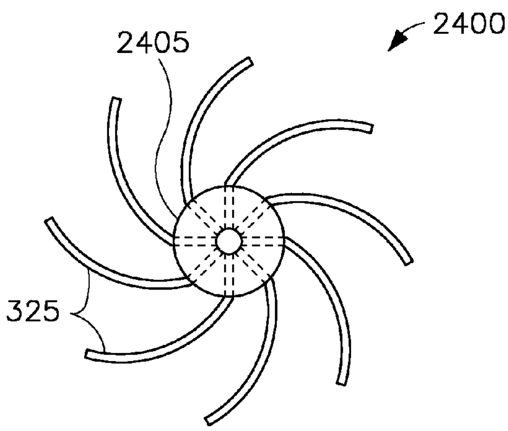
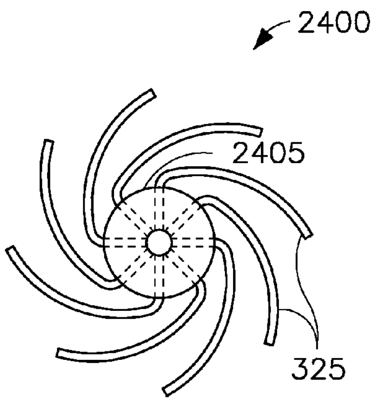


FIG. 24D



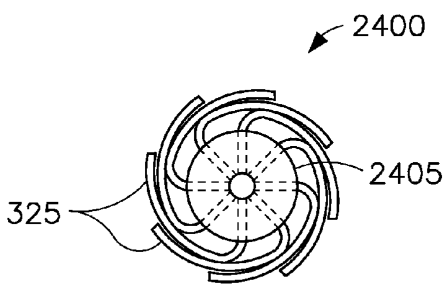


FIG. 24E

FIG. 25A

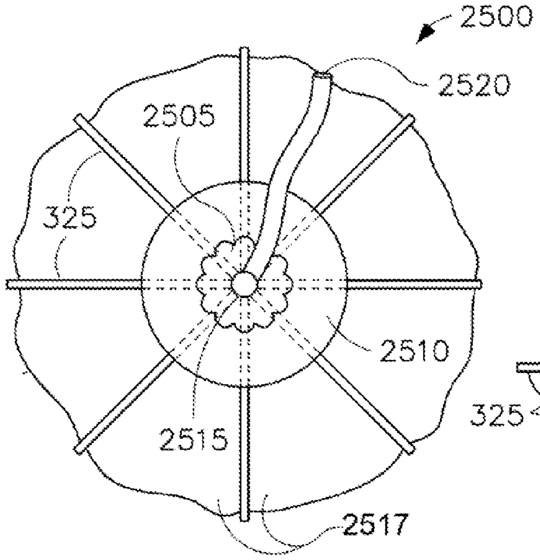
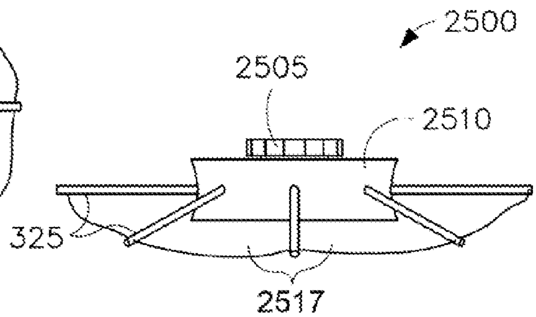


FIG. 25B



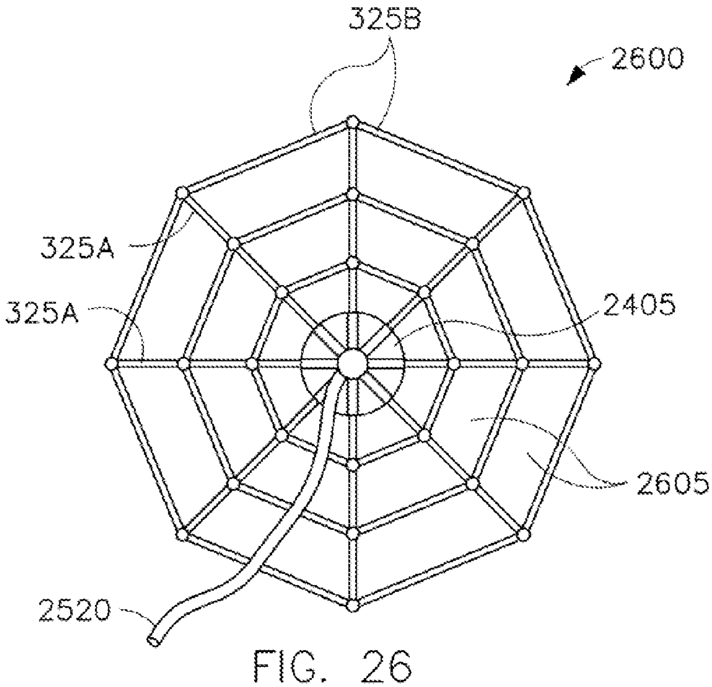


FIG. 26

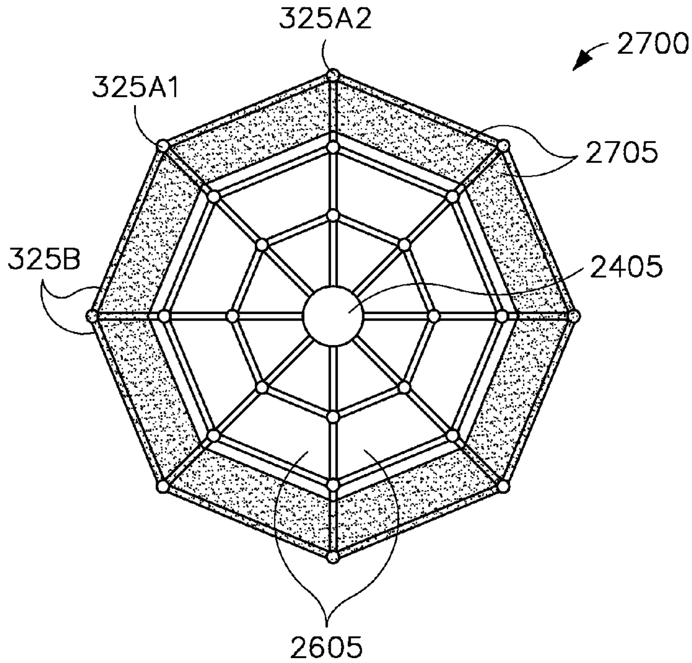


FIG. 27

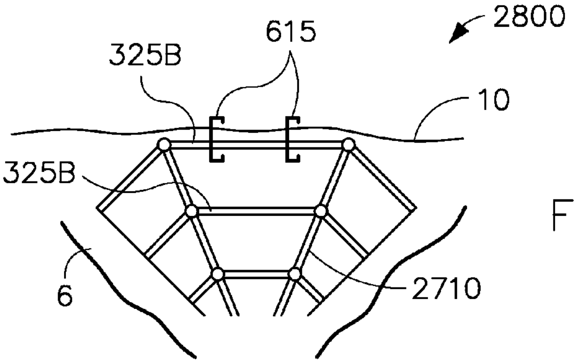


FIG. 28A

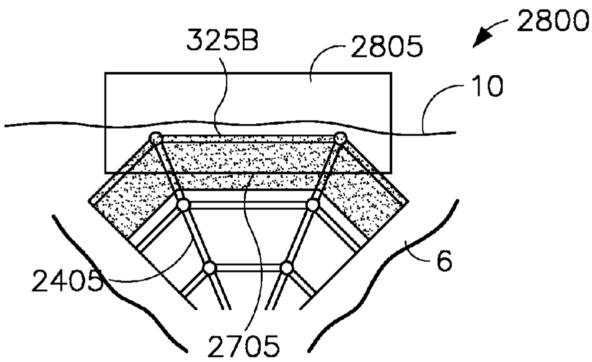


FIG. 28B

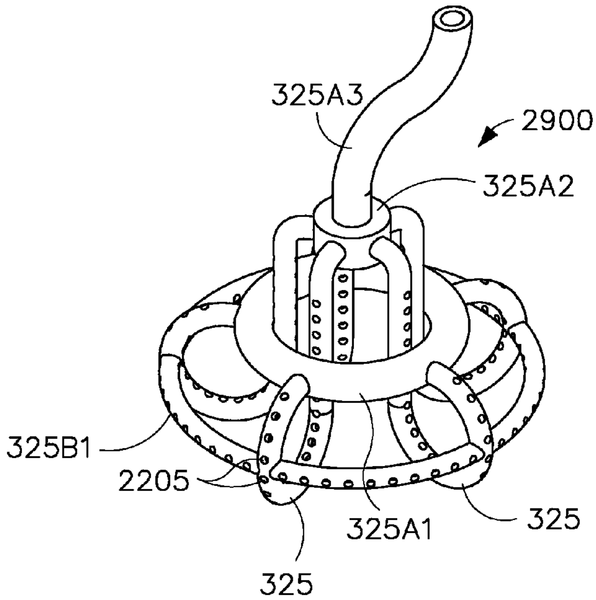
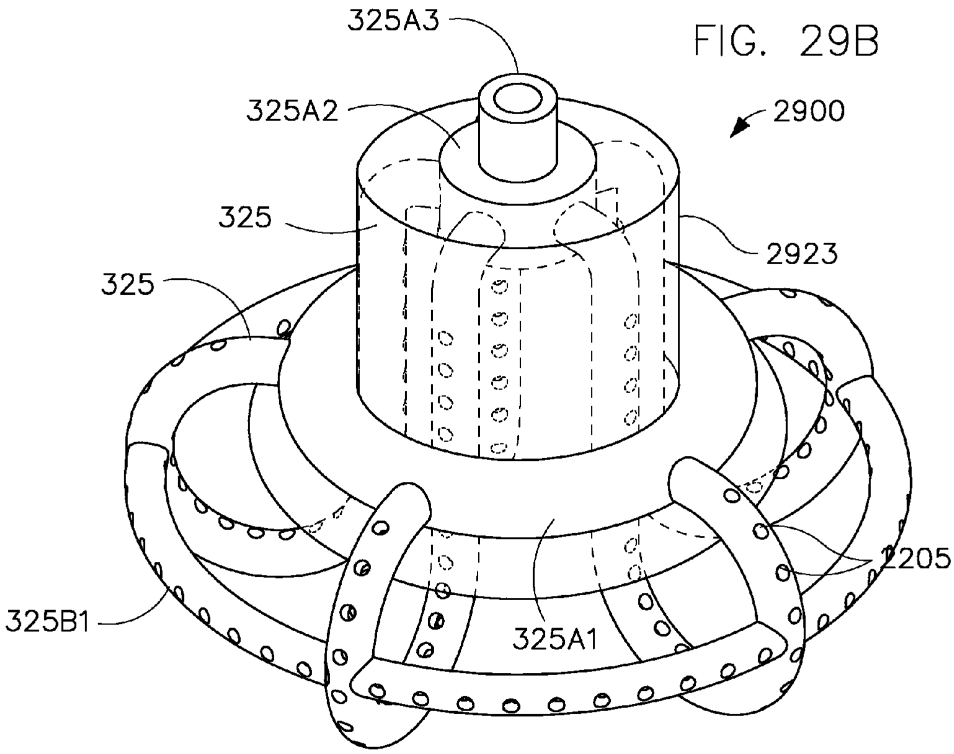


FIG. 29A

FIG. 29B



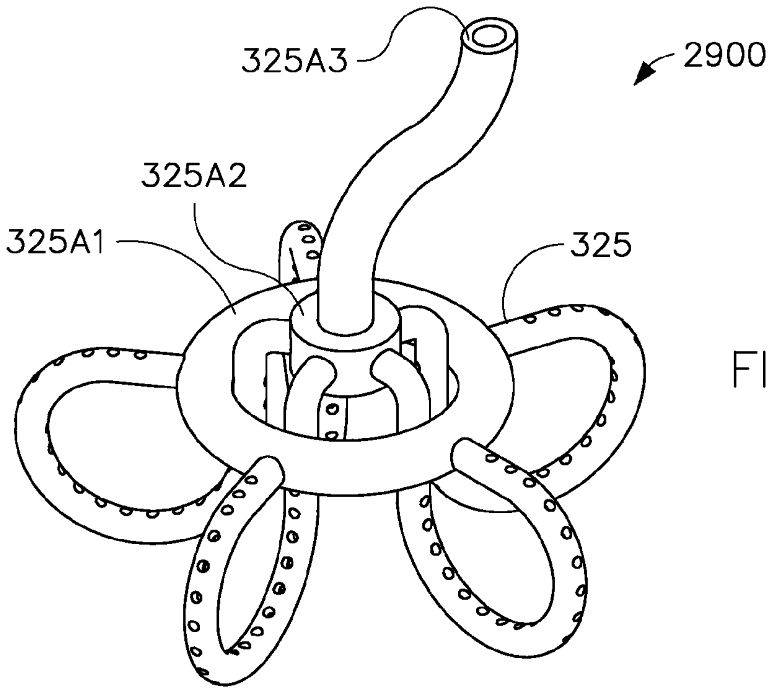


FIG. 29C

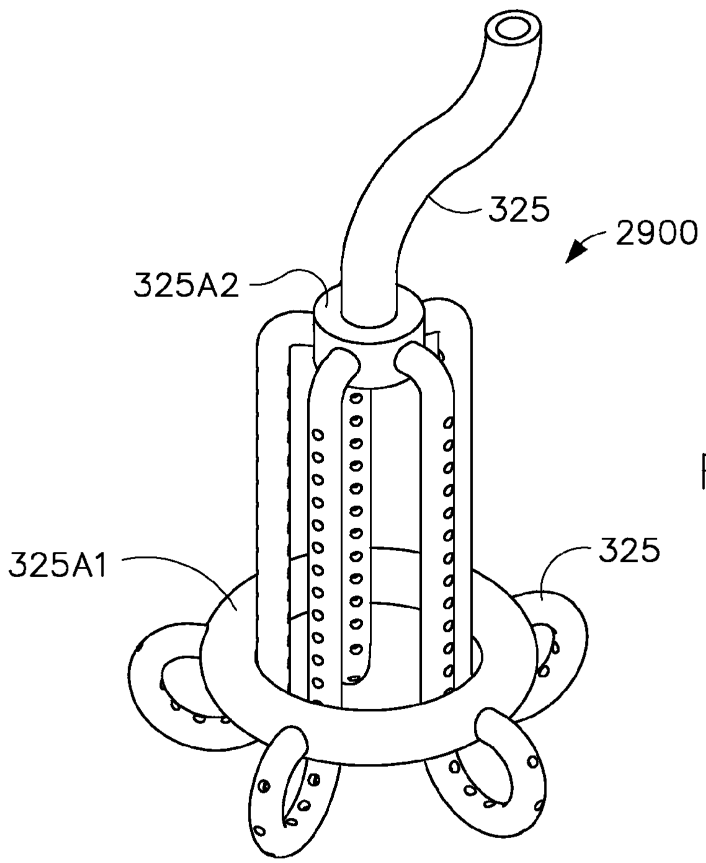


FIG. 29D

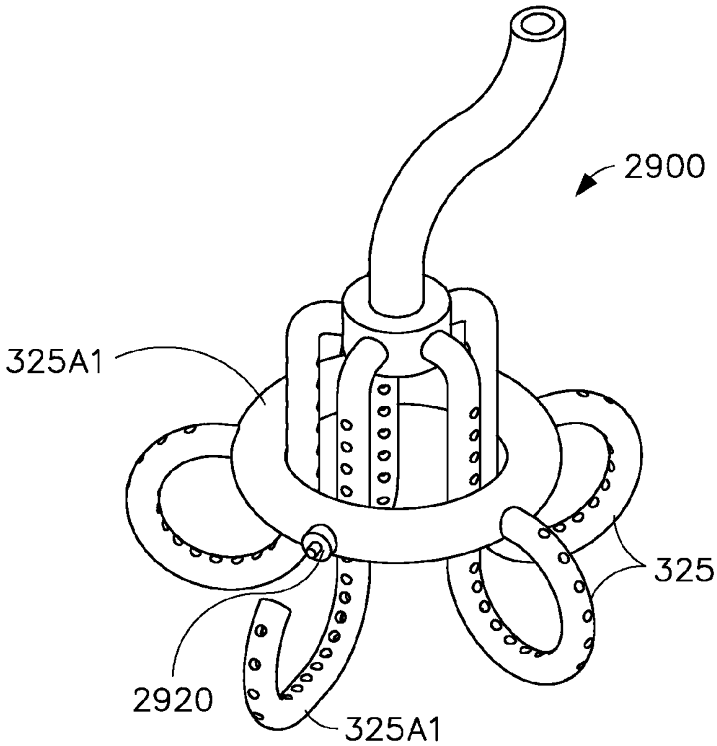


FIG. 29E

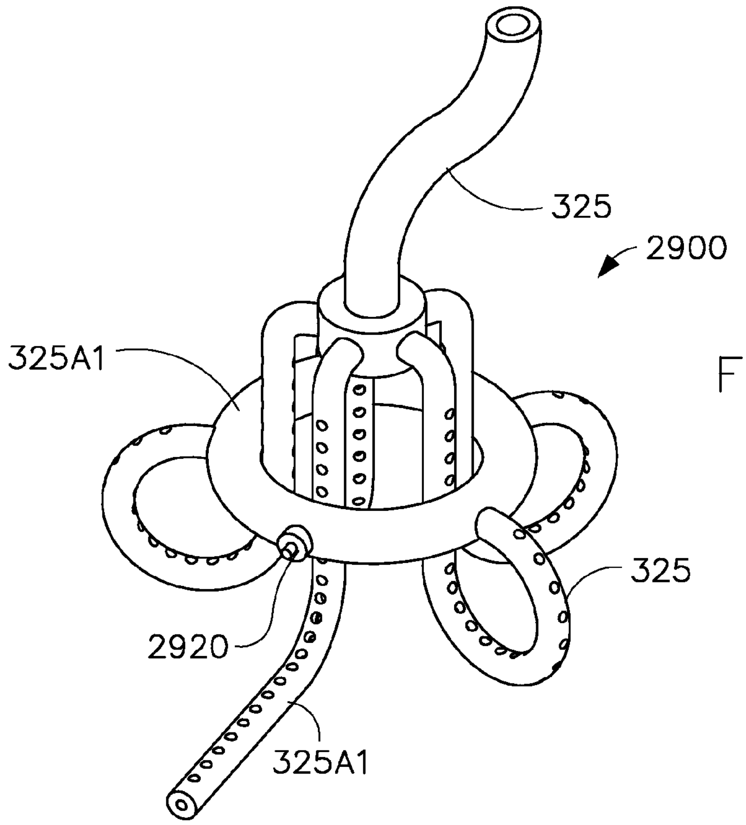


FIG. 29F

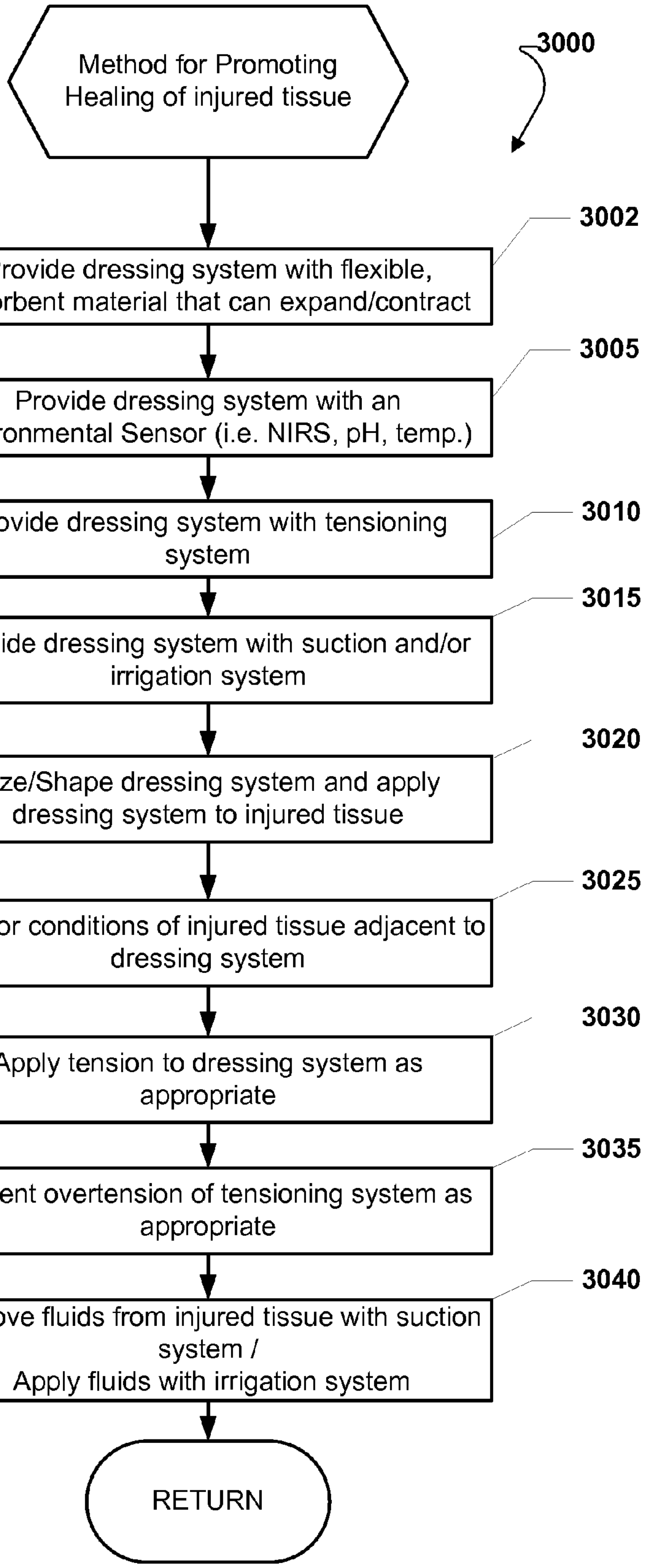

Method for Promoting Healing of injured tissue
3000
Provide dressing system with flexible, absorbent material that can expand/contract
3002
Provide dressing system with an environmental Sensor (i.e. NIRS, pH, temp.)
3005
Provide dressing system with tensioning system
3010
Provide dressing system with suction and/or irrigation system
3015
Size/Shape dressing system and apply dressing system to injured tissue
3020
Monitor conditions of injured tissue adjacent to dressing system
3025
Apply tension to dressing system as appropriate
3030
Prevent overtension of tensioning system as appropriate
3035
Remove fluids from injured tissue with suction system / Apply fluids with irrigation system
3040
RETURN

FIG. 30

METHODS AND DRESSING SYSTEMS FOR PROMOTING HEALING OF INJURED TISSUE

STATEMENT REGARDING RELATED APPLICATIONS

The present application claims priority under 35. U.S.C §119(e) to provisional patent applications entitled, "Smart Dressing for Wounds or Injured Extremities," filed on Aug. 13, 2009 and assigned U.S. Application Ser. No. 61/233,797; provisional patent application entitled, "Smart Dressing for Wounds or Injured Extremities," filed on Aug. 18, 2009 and assigned U.S. Application Ser. No. 61/234,857; provisional patent application entitled, "Smart Dressing for Wounds or Injured Extremities," filed on Sep. 25, 2009 and assigned U.S. Application Ser. No. 61/245,789. The contents of these three provisional patent applications are hereby incorporated by reference in their entirety.

FIELD OF INVENTION

The invention generally relates to patient wound care, and more specifically to systems and methods for treating open wounds.

BACKGROUND

Animal tissue, such as human tissue, is susceptible to injury. Injuries that pierce, tear or cut tissue can be difficult to heal especially when the pierced, torn or cut tissue traverses a large area relative to the entire surface of the animal. Typical injuries which are difficult to heal include those from burns and traumatic injuries. Additionally, chronic diseases such as diabetes results in chronic wounds and tissue break down. Frequently, injured tissue may also be the result of intentional medical procedures, such as a fasciotomy.

A fasciotomy is a surgical procedure where the fascia is cut to relieve tension or pressure (and treat the resulting loss of circulation to an area of tissue or muscle). Complications related to this medical procedure usually involve the formation of scar tissue after the operation. Another challenge of this medical procedure is the ability to cover and/or close the tissue which is intentionally cut during the procedure.

Other medical procedures which are difficult to heal from include skin grafts used to cover open, wounded tissue. While skin grafts are intended to promote healing by covering an open wound, they are difficult to heal because of hematomas, fluid collection, and movement that can occur near or within the skin graft.

Over time as wounds heal, the edges of the skin retract. This retraction ultimately may cause the wound to become larger and more difficult to get closed. Larger wounds typically require more invasive measures to close such as skin graft or free flaps which include skin, soft tissue and typically a blood supply such as an artery and veins.

Conventional dressings, such as bolster dressings, that are frequently used to treat the injured tissue discussed above suffer from many problems and/or drawbacks. One problem is the ability to remove excess fluid build-up that can occur near and/or within the wounded tissue. When such fluid build-up occurs, this increases the chances for higher bacterial counts which in-turn causes infection in the wounded area of the patient. Additionally, hematomas can lift skin grafts off the underlying tissue bed and separate the graft from its blood

and nutrient supply causing graft failure. Other problems include the ability to promote closing of the open wound while the wound heals.

What is needed in the art is a method and system that may promote the healing of wounds in tissue by removing excess fluid from wounds as well as applying appropriate forces to edges of a wound in order to bring the edges closer together for a complete closure of a wound, without the need of other medical procedures, such as skin grafts.

SUMMARY OF THE INVENTION

According to one exemplary aspect, a dressing system comprises: a sponge; a near infrared spectroscopy (NIRS) sensor positioned adjacent to the sponge for monitoring oxygenation levels of tissue adjacent to the sponge; and a tube coupled to the sponge for removing fluid from the sponge and applying a negative pressure gradient to the tissue.

According to another exemplary aspect, a dressing system comprises: a sponge; a tensioning system coupled to the sponge. The tensioning system further comprises a central longitudinal member coupled to the sponge; and at least one transverse tensioning member coupled to the central longitudinal member. This embodiment couples two strategies for would management, a negative pressure device to stimulate local blood flow and healing while reducing soft tissue swelling with a tensioning device to approximate the skin edges as soft tissue swelling reduces while preventing wound contracture. Additional monitoring technologies, such as, but not limited to, NIRS, pH, and temperature can be added to the device.

According to a further exemplary aspect, a sequential compression system comprises: an envelope sleeve dressing; and a bladder that is both expandable and retractable. This sequential compression system may transiently compress tissue to promote blood flow and return of blood to the heart in the venous system to prevent the stasis of blood. Hemostasis as well as endothelial injury are two of the three aspects of Virchow's triad (hypercoagulability, hemostasis and endothelial/blood vessel injury) which is known to promote clotting. By preventing hemostasis with sequential compression, one goal is to prevent deep vein thrombosis (DVT's) or clots (typically in the legs) which cause swelling and pain. Additionally, these DVT's can ultimately migrate towards the heart and cause clots in the lungs known as pulmonary embolism which can be fatal.

According to an additional exemplary aspect, a tissue filler system comprises: a plurality of tubes; each of the plurality of tubes further comprises apertures; and a pump coupled to at least one of the tubes. This tissue filler system may eliminate the need for a sponge all together while allowing for tensioning and negative pressure gradient. By removing the sponge, such a dressing may allow for longer applications without the need for frequent changes of the dressing due to tissue in-growth which are costly and painful to the patient. Additionally, the residue left behind by a sponge dressing can cause inflammatory reactions and is a risk for infection.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Figures, like reference numerals refer to like parts throughout the various views unless otherwise indicated. For reference numerals with letter character designations such as "**102**A" or "**102**B", the letter character designations may differentiate two like parts or elements present in the same figure. Letter character designations for reference numerals may be omitted when it is intended that a reference numeral to encompass all parts having the same reference numeral in all Figures.

FIG. **1**A is a diagram illustrating a few different exemplary embodiments for an envelope dressing applied to wounds on or in animal tissue;

FIG. **1**B is a diagram illustrating another envelope dressing according to one exemplary embodiment of the invention;

FIG. **2**B is a diagram illustrating a tension monitor system comprising the tension sensor of FIG. **2**A that reacts to applied forces according to one exemplary embodiment of the invention;

FIG. **3**A is a diagram illustrating a cross-sectional view of a dressing system comprising a wound-vacuum combined with a near infrared spectroscopy (NIRS) sensor according to one exemplary embodiment of the invention;

FIG. **3**B is a diagram illustrating an elevation view of the dressing system comprising a wound-vacuum combined with a near infrared spectroscopy (NIRS) sensor of FIG. **3**A according to one exemplary embodiment of the invention;

FIG. **4** is a diagram illustrating a cross-sectional view of another dressing system comprising a wound-vacuum combined with a near infrared spectroscopy (NIRS) sensor according to one exemplary embodiment of the invention;

FIG. **5** is a diagram illustrating an elevation view of the wound-vacuum combined with the NIRS device of FIG. **4** according to one exemplary embodiment of the invention;

FIG. **6**A is a diagram illustrating a cross-sectional view of another dressing system comprising a wound-vacuum combined with a NIRS sensor and a tensioning device according to one exemplary embodiment of the invention;

FIG. **6**B is a diagram illustrating an increased magnification of the cross-sectional view of the dressing system of FIG. **6**A according to one exemplary embodiment of the invention;

FIG. **6**C is a diagram illustrating another cross-sectional view of the dressing system in which tension forces are applied to the dressing system according to one exemplary embodiment of the invention;

FIG. **6**D is a diagram illustrating an elevation view of the dressing system without tension applied in full expansion of FIG. **6**A according to one exemplary embodiment of the invention;

FIG. **6**E is a diagram illustrating an elevation view of the dressing system of FIG. **6**A in which tension forces have been exerted by the tensioning device causing the sponge to contract according to one exemplary embodiment of the invention;

FIG. **6**F is a diagram illustrating an elevation view of a dressing system without a NIRS device with the tensioning device of FIGS. **6**A-**6**C according to one exemplary embodiment of the invention;

FIG. **6**G is a diagram illustrating a cross-sectional view of the dressing of FIG. **6**F without any tensile forces applied to the dressing system according to one exemplary embodiment of the invention;

FIG. **6**H is a diagram illustrating a cross-sectional view of the dressing system of FIG. **6**F with tensile forces applied to the dressing system according to one exemplary embodiment of the invention;

FIG. **6**I is a diagram illustrating a cross-sectional view of the dressing system of FIG. **6**H with additional tensile forces applied to the dressing system according to one exemplary embodiment of the invention;

FIG. **6**J is a diagram illustrating a cross-sectional view of another dressing system having another type of end tensioning mechanism in the tensioning device according to one exemplary embodiment of the invention;

FIG. **6**K is a diagram illustrating the dressing system of the FIG. **6**J with tensile forces applied to the dressing system according to one exemplary embodiment of the invention;

FIG. **6**L is a diagram illustrating an elevation view of a dressing system with another type of end tensioning mechanism according to one exemplary embodiment of the invention;

FIG. **6**M is a diagram illustrating an elevation view of the dressing system of FIG. **6**L after further tensile forces have been applied according to one exemplary embodiment of the invention;

FIG. **6**N is a diagram illustrating an elevation view of a dressing system with the tensioning device of FIGS. **6**D-E according to one exemplary embodiment of the invention;

FIG. **6**O is a diagram illustrating an elevation view of the dressing system of FIG. **6**N after further tensile forces have been applied according to one exemplary embodiment of the invention;

FIG. **6**P is a diagram illustrating a cross-sectional view of the dressing system of FIG. **6**N according to one exemplary embodiment of the invention;

FIG. **6**Q is a diagram illustrating a cross-sectional view of the dressing system of FIG. **6**O according to one exemplary embodiment of the invention;

FIG. **6**R is a diagram illustrating a cross-sectional view of a dressing system with another type of locking mechanism for the end tensioning mechanism according to one exemplary embodiment of the invention;

FIG. **6**S is a diagram illustrating a cross-sectional view of a dressing system with another type of locking mechanism according to one exemplary embodiment of the invention;

FIG. **6**T is a diagram illustrating a cross-sectional view of a dressing system with a spring-biased end tensioning mechanism according to one exemplary embodiment of the invention;

FIG. **6**U is a diagram illustrating a cross-sectional view of the dressing system of FIG. **6**T after further tensile forces have been applied according to one exemplary embodiment of the invention;

FIG. **6**V is a diagram illustrating a cross-sectional view of a dressing system with another type of locking mechanism for the longitudinal member according to one exemplary embodiment of the invention

FIG. **6**W is a diagram illustrating a cross-sectional view of the dressing system of FIG. **6**T after further tensile forces have been applied according to one exemplary embodiment of the invention;

FIG. **6**X is a diagram illustrating a cross-sectional view of a dressing system with another type of locking mechanism for the longitudinal member according to one exemplary embodiment of the invention;

FIG. **6**Y is a diagram illustrating a cross-sectional view of the dressing system of FIG. **6**T after further tensile forces have been applied according to one exemplary embodiment of the invention;

FIG. **7**A is a diagram illustrating an expandable splint designed for an extremity of an animal, such as for a leg of a human, according to one exemplary embodiment of the invention;

FIG. **7**B is a diagram illustrating a cross-sectional view of the expandable splint illustrated in FIG. **7**A according to one exemplary embodiment of the invention;

FIG. **7**C is a diagram illustrating a cross-sectional view of an expandable splint for another kind of extremity, such as an arm for human, according to one exemplary embodiment of the invention;

FIG. **8**A is a diagram illustrating an irrigation and/or suction system for a dressing system according to one exemplary embodiment of the invention;

FIG. **8**B is a diagram illustrating a cross-sectional view of a suction system for a dressing system according to one exemplary embodiment of the invention;

FIG. **8**C is a diagram illustrating a cross-sectional view of an irrigation system for a dressing system according to one exemplary embodiment of the invention;

FIG. **9**A is a diagram illustrating a cross-sectional view of a pressure monitor to evaluate the pressure placed on tissue by the external dressing for a dressing system according to one exemplary embodiment of the invention;

FIG. **9**B is a diagram illustrating another cross-sectional view of the pressure monitor of FIG. **9**A according to one exemplary embodiment of the invention;

FIG. **9**C is a diagram illustrating another pressure monitor and possible locations for the monitors for a dressing system according to one exemplary embodiment of the invention;

FIG. **9**D is a diagram illustrating the environment for an exemplary pressure transducer according to one exemplary embodiment of the invention;

FIG. **9**E is a diagram illustrating a pressure transducer for a pressure monitoring system according to one exemplary body of the invention;

FIG. **9**F is a diagram illustrating another pressure transducer for a pressure monitoring system according to one exemplary embodiment of the invention;

FIG. **9**G is a diagram illustrating another pressure transducer for a pressure monitoring system according to one exemplary embodiment of the invention;

FIG. **10**A is a diagram illustrating an irrigation and/or suction system with pressure gauges to monitor the negative pressure being supplied by the device for a dressing system and which are embedded within the sponge or dressing according to one exemplary embodiment of the invention;

FIG. **10**B is a diagram illustrating a cross-sectional view of a suction system with pressure gauges for a dressing system in a non-alarm or inactive state according to one exemplary embodiment of the invention;

FIG. **10**C is a diagram illustrating a cross-sectional view of a suction system with pressure gauges for a dressing system in an alarm state or active state according to one exemplary embodiment of the invention;

FIG. **11**A is a diagram illustrating a cross-sectional view of another dressing system **1100**A comprising a wound-vacuum combined with an environmental sensor and a tensioning device according to one exemplary embodiment of the invention;

FIG. **11**B is a diagram illustrating a cross-sectional view of another dressing system **1100**A comprising a wound-vacuum combined with an environmental sensor and a tensioning device according to one exemplary embodiment of the invention;

FIG. **11**C is a diagram illustrating an elevation view of another dressing system **1100**A comprising a wound-vacuum combined with an environmental sensor and a tensioning device according to one exemplary embodiment of the invention;

FIG. **12**A is a diagram of a side view of a wound **6** that has a wound edge and which is part of the tissue that may comprise a human leg according to an exemplary embodiment of the invention;

FIG. **12**B is a diagram illustrating a Roman sandal or shoelace technique for closing wounds according to an exemplary embodiment of the invention;

FIG. **12**C is a diagram illustrating a Roman sandal or shoelace technique that has further closed the wound illustrated in FIG. **12**B according to one exemplary embodiment of the invention;

FIG. **12**D is a diagram illustrating further details of the fastening mechanisms **615** for the Roman sandal or shoelace technique of FIG. **12** according to one exemplary embodiment of the invention;

FIG. **13**A is a side view of a sequential compression dressing system according to one exemplary embodiment of the invention;

FIG. **13**B is a cross-sectional view of the sequential compression dressing system of FIG. **13**A in a deflated state according to one exemplary embodiment of the invention;

FIG. **13**C is a cross-sectional view of the sequential compression dressing system of FIG. **13**B in an inflated state according to one exemplary embodiment of the invention;

FIG. **14**A is a diagram illustrating a cross-sectional view of a first anchoring mechanism for a tension member of a tensioning device according to one exemplary embodiment of the invention;

FIG. **14**B is a diagram illustrating a cross-sectional view of a second anchoring mechanism for a tension member of a tensioning device according to one exemplary embodiment of the invention;

FIG. **14**C is a diagram illustrating a cross-sectional view of a third anchoring mechanism for a tension member of a tensioning device according to one exemplary embodiment of the invention;

FIG. **14**D is a diagram illustrating a cross-sectional view of a fourth anchoring mechanism for a tension member of a tensioning device according to one exemplary embodiment of the invention;

FIG. **15**A is a diagram illustrating an elevation view of a dressing system with the tensioning device in a radial design for a circular wound according to one exemplary embodiment of the invention;

FIG. **15**B is a diagram illustrating cross-sectional view of the dressing system with the tensioning device of FIG. **15**A according to one exemplary embodiment of the invention;

FIG. **15**C is a diagram illustrating an elevation view of a dressing system **600**N with the tensioning device **610** according to one exemplary embodiment of the invention;

FIG. **15**D is a diagram illustrating an elevation view of the dressing system **600**N of FIG. **15**C with the end tensioning device **605**A in an extended position according to one exemplary embodiment of the invention;

FIG. **15**E is a diagram illustrating cross-sectional view of the dressing systems **600**M, N of FIGS. **15**A and **15**C in an compressed state according to one exemplary embodiment of the invention;

FIGS. **16**A-C are diagrams illustrating the sequence of steps that may be employed to secure a fastening mechanisms to tissue and a combination of a tension member and a sponge **315**.

FIGS. **17**A-C are diagrams illustrating the sequence of steps that may be employed to secure alternate fastening mechanisms to tissue and a combination of a tension member and a sponge according to one exemplary embodiment of the invention.

FIG. **18**A is a diagram illustrating an elevation view of a dressing system with the tensioning device of FIGS. **6**A-**6**C and a reinforced anchoring system/periphery according to one exemplary embodiment of the invention;

FIG. **18**B is a diagram illustrating cross-sectional view of the dressing system of FIG. **18**A according to one exemplary embodiment of the invention;

FIG. **19** is a diagram illustrating a perspective view of a tensioning device of a dressing system comprising two tensioning members which may be wound around a central longitudinal member according to one exemplary embodiment of the invention;

FIG. **20**A is a diagram illustrating an elevation view of a system for attaching multiple dressings together in order to manage larger wounds according to one exemplary embodiment of the invention;

FIG. **20**B is a diagram illustrating a cross-sectional view of a first dressing-to-dressing coupling mechanism according to one exemplary embodiment of the invention;

FIG. **20**C is a diagram illustrating a cross-sectional view of a second dressing-to-dressing coupling mechanism according to one exemplary embodiment of the invention;

FIG. **21** is a diagram illustrating a cross-sectional view of a shell system for covering and protecting a dressing system and allow for an airtight seal according to one exemplary embodiment of the invention;

FIG. **22**A is a diagram illustrating a cross-sectional view of a suction device that may be used without a sponge for a wound according to one exemplary embodiment of the invention;

FIG. **22**B is a diagram illustrating a cross-sectional view of the suction device of FIG. **22**A without the wound environment according to one exemplary embodiment of the invention;

FIG. **23** is a diagram illustrating a side view of the suction device of FIG. **22** according to one exemplary embodiment of the invention;

FIGS. **24**A-**24**E are diagrams illustrating a tubing system going from an expanded state to a compressed state according to exemplary embodiments of the invention;

FIGS. **25**A-**25**B are diagrams illustrating a tubing system with a tension device according to one exemplary embodiments of the invention;

FIG. **26** is a diagram illustrating a web-like tubing system according to one exemplary embodiment of the invention;

FIG. **27** is a diagram illustrating another web-like tubing system according to one exemplary embodiment of the invention;

FIGS. **28**A-**28**B are diagrams illustrating applications of a web-like tubing system with a adhesive perimeter to facilitate an airtight seal on the skin and prevent the need to put an airtight seal over the entire dressing (only a peripheral boarder is required) according to exemplary embodiments of the invention; and

FIGS. **29**A-**29**F are diagrams illustrating a tissue filler system and its relative movement according to exemplary embodiments of the invention.

FIG. **30** is a flow chart illustrating some steps of an exemplary method for promoting healing of injured tissue according to one exemplary embodiment of the invention.

DETAILED DESCRIPTION

The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects.

Referring now to FIG. **1**A, this figure is a diagram illustrating a few different exemplary embodiments for an envelope dressing **12** applied to wounds on animal tissue, such as on a human body **10**. The envelope dressing **12** can be made from materials such as, but not limited to, rubber, plastic, or nylon. One ideal physical property for the material would be that it is elastic so that the material may expand or contract. Additionally, elastic material would allow for compression to control/manage edema/swelling within the soft tissues. The material, in some exemplary embodiments, will not include any latex in order to avoid any potential allergic reactions by an animal, like a human.

The dressings can be designed for specific location on the body such as the torso/chest/abdomen, the pelvis, the face/head, the lower extremity or the upper extremity. Similar to site specific plates for orthopedic stabilization, these dressings can incorporate different designs and applications suited for specific locations on the body. These dressings would be designed based on treatment goals, common problems with the area, anatomy, desired conditions to be monitored.

The material for the envelope dressing **12** may be impervious or non-impervious to liquids. The material for the envelope dressing **12** could also be made from a material that is transparent so that medical personnel can easily view the wound on the body **10** which is being covered by the dressing **12**. The material may have multiple layers to allow for irrigation of wounds.

The material may be meshed in its makeup to allow for expansion and/or irrigation of a wound. The material may comprise elements which are bioabsorbable in order to prevent frequent changing of the dressing **12**. The material may also include an antibacterial embedded therein in order to fight any local infections within the wound being covered by the dressing **12**. The material may also comprise a carrier for bone morphogenic proteins (BMPs) or other biological factors in order to promote tissue healing. The material may also comprise channels or other parts of a delivery system for growth factors. According to one exemplary embodiment, the dressing **12** may comprise silicon for scar therapy softening.

The material for the envelope dressing **12** should allow the dressing **12** to be reusable for the same patient instead of being disposable like common ordinary dressings. The envelope dressing **12** may be made for different sizes and anatomic locations. For example, the first envelope dressing **12**A may comprise a preformed shape designed for a specific area such as the forearm or full arm (from the hand to shoulder).

The preformed shape would dictate that certain portions of the envelope dressing **12**A would have physical features that match its corresponding anatomical region. For example, a first end **4**A of the envelope dressing **12**A may have a first diameter, while the second end **4**B of the envelope dressing **12**A has a second diameter. If the first end **4**A is designed to be close to the shoulder of the human body **10**, then the first diameter will likely have a size which is greater than the second diameter corresponding to the second end **4**B of the envelope dressing **12**A.

The second envelope dressing **12**B may comprise a preformed shape designed for specific areas such as the lower leg, and full leg (from the foot to the groin). Other anatomical areas may include, but are not limited to, the abdomen, chest, pelvis, head, face, hand, foot, etc. The dressing **12** may comprise a preformed tube that is elastic or one that is a wrap type design that allows for attachment of one end to the other, such as wrap **14**A. For tubular embodiments, the employ dressing **12** would slide or cover over an entire extremity or maimed torso region. Application of the dressing could be applied by multiple methods but not limited to a slip on/over design. Alternative methods could include a lace up method, a zipper or Velcro.

The wrap **14**A may comprise a fastening mechanism **16**A that could comprise an adhesive strip or hook and loop fasteners sold under the well-known trade name Velcro™. Like the preformed tube, the wrap **14**A may also have a preformed shape that matches its intended anatomical region. This means if the first wrap **14**A is designed for a human leg, then the first end **6**A of the wrap **14**A may have a first length which is greater than a second length corresponding to the second and **6**B of the rap **14**A, when the wrap **14**A is in an open or on unattached state. The exemplary embodiments of FIG. **1**A illustrate how different parts of human anatomy may have different dressing designs and shapes.

FIG. **1**B is a diagram illustrating another envelope addressing comprising a wrap **14**B according to one exemplary embodiment of the invention. In this exemplary embodiment, the wrap **14**B is designed for the anatomical region of the torso of a human body. Specifically, the wrap **14**B may be shaped for the abdomen and comprises a fastening mechanism **16**B. The fastening mechanism **16**B may be similar to the fastening mechanism **16**A of FIG. **1**A and it may comprise an adhesive strip or strips, or hook, lace, and loop fasteners.

FIG. **2**A is a diagram illustrating a tension sensor or actuator **200** according to one exemplary embodiment of the invention. The tension sensor or actuator **200** and can be incorporated into any of the envelope dressings **12** and perhaps **14** described above and illustrated in FIG. **1**. The tension sensor or actuator **200** may comprise a housing **210** that is coupled to a spring **215**A. The spring **215**A can comprise a torsional spring, however, other springs are within the scope of the invention and may include, but are not limited to, extension or tension springs and the like.

The tension sensor **200** may be coupled to a pair of ends **205** that are part of an envelope dressing **12**. A first end **205**A of the dressing **12** may include a first fastener **207**A that couples to the spring **215**A. A second end **205**B of the dressing **12** may include a second fastener **207**B that couples to the housing **210**A. The first and second fasteners **207**A, B may comprise wires, screws, hooks, clasps, or other like mechanical fasteners. The housing **210** for the tension monitor **200** may comprise any type of durable materials such as metal, plastic, ceramic, and other like materials.

FIG. **2**B is a diagram illustrating a tension monitor system **202** comprising the tension sensor **200** of FIG. **2**A that reacts to applied forces according to one exemplary embodiment of the invention. In this exemplary embodiment, forces are applied to the first and second ends **205**A, **205**B of an envelope dressing **12**. These forces could be the result of an expansion of the due to swelling of a wound in the human body **10**.

The tension monitor system **202** may comprise a switch **220** that is coupled to the expanded spring **215**B. The switch **220**, in turn, may be coupled to an alarm **225**. The switch to **20** may activate the alarm **225** when the spring **215** is in its expanded state as illustrated in FIG. **2**B. The switch to **220** may comprise any one of a mechanical switch or an electrical switch or a combination of both types as apparent to one of ordinary skill in the art. The alarm **225** may comprise an audio type of alerting device such as a speaker. Alternatively, or in addition to, the alarm **225** may comprise a visual device such as a light emitting diode (LED) or other type of light device.

The tension monitor system **202** may monitor the tension placed on the envelope dressing **12** and it may sound alarm **225** is a certain threshold tension with respect to the dressing **12** was exceeded. The alarm **225** will likely be used to alert a clinician. The purpose of the tension monitor system **202** would be to allow for appropriate tension for an envelope dressing **12** or wrap **14** without causing the dressing **12** or wrap **14** to prevent blood flow to a particular wound being covered by the dressing **12** or wrap **14**. The tension monitor system **202** may prevent over tensioning/tightening of the skin edges which would prevent blood flow and healing while causing tissue necrosis/death.

FIG. **3**A is a diagram illustrating a cross-sectional view of a dressing system **300**A comprising a wound-vacuum **340** combined with a near infrared spectroscopy (NIRS) sensor **310** according to one exemplary embodiment of the invention. The dressing system **300**A may comprise a sponge **315**, a shell **320**, suction tubing **325**, conduits **330** for the NIRS sensor **310**, and a covering **305**. Conventional NIRS systems in their current form are usually unable to monitor open wounds/exposed tissue due to exudate build up and scabbing. The combination of a system to remove exudate and prevent light blockage would allow NIRS to monitor open tissue. The inventive system **300**A may allow a NIRS sensor to be placed on an open wound. The vacuum system via suction tubing **325** may remove any wound/tissue exudate that would ultimately block the ability of NIRS sensor to obtain a reading.

The sponge **315** can comprise a porous material that can absorb liquids, such as, but not limited to, blood, and exudate that may be emitted from a wound **6**. The sponge **315** may comprise synthetic materials such as, Polyvinyl acetate (PVA) (very dense, highly absorbent material with no visible pores) and polyester, and other like rubbery synthetic polymers such as a silicone, a plastic mat (not illustrated) with channels, ridges, bumps, or other like fluid channels to allow for suction of fluids and/or transmission of fluids. The porous material can be made from foamed plastic polymers, such as double-blown polyester. The sponge may have a high water retention ability, approaching or equalling PVA, but with visible pores.

The sponge **315** can be used on open wounds **6** within animal tissue **10**. The shape of the sponge **315** can comprise a rectangle having a size on the order of 3 to 5 cm×6 to 8 cm. However, other shapes, such as, but not limited to, oval, elliptical, square, and the like are within the scope of the invention. Further, other sizes for the sponge **315** which are larger or smaller than the exemplary ranges disclosed above are within the scope of the invention.

The sponge **315** can absorb exudate that could interfere with the NIRS sensor **310** if the sponge **315** were not present. The shell **320** which encloses or encompasses the sponge **315** can comprise a solid material such as plastic or rubber. The cover **305** which is positioned over and encompasses the shell **320** and holding the shell in place can comprise an adhesive, cloth like material similar to a bandage. The cover **305** and shell **320** can form an airtight seal over the open wound **6** in the body tissue **10**. According to an alternate exemplary embodiment, an adhesive perimeter may be provided around the sponge **315** to create a airtight seal instead of a film over the sensor.

The NIRS sensor **310** may be positioned between a side of the sponge **315** and the cover **305**. Further details of the NIRS sensor **310** will be described below in connection with FIG. **3**B.

FIG. **3**B is a diagram illustrating an elevation view of the dressing system **300**A comprising a wound-vacuum **340** combined with a near infrared spectroscopy (NIRS) sensor **310** of FIG. **3**A according to one exemplary embodiment of the invention. In this FIG. **3**B, the adhesive cover **305** is not illustrated so that further details of the dressing system **300**A can be seen.

The NIRS sensor **310** may comprise a light emitter **307**, a superficial light sensor **335**A, a deep tissue light sensor **335**B, and a skin sensor **332**. The light emitter **307** can comprise an optical waveguide, such as an optical fiber, which is coupled to a light source **350**, such as a light emitting diode (LED) laser. The light sensors **335** can comprise photodiodes or other similar light detecting equipment.

The superficial light sensor **335**A may detect reflected light from shallow areas of the monitored tissue **10** while the deep tissue light sensor **335**B may detect reflected light from deeper areas of the monitored tissue **10** within the wound **6**. The skin sensor **332** can detect pigmentation of the skin so that the light source **307** can adjust its intensity in response to the detected pigmentation by the skin sensor **332**.

The NIRS sensor **310** can detect oxygenation levels within the blood that flows near or adjacent to the wound **6**. Low oxygenation levels or the absence of any oxygenation levels can indicate a hematoma or poor blood circulation which are undesirable and which would require intervention by medical personnel. Alternatively, the NIRS readings may demonstrate devitalized or dead tissue which could become a nidus for infection and would require surgical debridement.

The NIRS sensor **310** may be coupled to a control panel of a computer **345** by a conduit **330** that can encase communication cables connected to the light emitter **307** and the light sensors **335**. The computer **345** can be coupled to or can comprise an alarm **225**. The alarm **225** can comprise an audible and/or visual indicator. An audible indicator may include a speaker while a visual indicator may comprise a light source such as a blinking LED. The alarm **225** may be activated by the computer **345** when the low absence of an oxygenation level condition discussed above is detected.

The suction tubing **325** can comprise relatively thin, hollow conduits that are positioned within the sponge **315** in order to draw or suck out liquid/exudate absorbed by the sponge **315** from the wound **6** in the tissue **10**. As illustrated in FIG. **3**B, the four ends of the suction tubing **325** form an "X" shape in which each end is positioned within the sponge **315** for creating a vacuum adjacent to the ends. The tubing **325** can be made from a range of polymers, and may include, but is not limited to silicone rubber latex and thermoplastic elastomers. Silicone may be one of the most common choices because it is inert and unreactive to body fluids and a range of medical fluids with which it might come into contact. Other materials may include, but are not limited to, plastic and hard rubbers, or a combination thereof.

The four ends of the suction tubing **325** may meet together at a junction and feed into a single exit tube **325**A which is coupled to a pump **340**. The pump **340** can be of any type which is appropriate for creating a vacuum adjacent to the wound **6** for removing fluids and/or particulates that can be emitted from the wound. Exemplary pumps include, but are not limited to, displacement pumps, buoyancy pumps, compressed-air-powered double-diaphragm pumps, impulse pumps, hydraulic ram pumps, velocity pumps, centrifugal pumps, radial flow pumps, axial flow pumps, mixed flow pumps, and eductor-jet pumps, just to name a few.

The computer **345**, light source **350**, and alarm **225** can be housed within a single unit or housing as appropriate and as determined by one of ordinary skill the art. Alternatively, each component could be separate from one another depending upon the wound care environment and relative sizes of the respective components.

FIG. **4** is a diagram illustrating a cross-sectional view of another dressing system **300**B comprising a wound-vacuum combined with a near infrared spectroscopy (NIRS) sensor **310** according to one exemplary embodiment of the invention. Specifically, this system **300**B comprises a larger wound dressing that incorporates the NIRS sensor **310** as part of the device to monitor tissue viability/perfusion under the dressing. The dressing system **300**B illustrated in FIG. **4** also shares several elements which are similar to those of the dressing system **300**A in FIG. **3**. Therefore, only the differences between these two figures will be discussed and described in further detail below.

In this exemplary embodiment, the NIRS sensor **310** may be positioned within the sponge **315** and adjacent to the wound **6**. This exemplary embodiment allows for monitoring of tissue viability under the sponge **315** and may allow for continued monitoring of perfusion and as well as parameters related to healing for the wound **6**. The dressing system **300**B may further comprise another cover **405** which may be similar to cover **305** of FIG. **3**.

In the exemplary embodiment illustrated in FIG. **4**, the wound **6** may be significantly larger relative to the wound **6** illustrated in FIGS. **3**A-**3**B. Also the wound **6** may have an oval or an elliptical shape. The sponge **315** would be designed to mirror this shape. The relative size of the sponge **315** may include a large diameter of approximately 40 cm and a smaller diameter of approximately 20 cm. However, one of ordinary skill in the art will appreciate that other magnitudes larger or smaller than those disclosed are clearly within the scope of the invention. Further, one of ordinary skill in the art recognizes that other shapes such as square, rectangular, and the like are within the scope of the invention. Additionally, the sponge will be able to be trimmed to fit different size wounds.

FIG. **5** is a diagram illustrating an elevation view of the dressing system **300**B comprising a wound-vacuum combined with a near infrared spectroscopy (NIRS) sensor **310** of FIG. **4** according to one exemplary embodiment of the invention. The sponge **315** in this exemplary embodiment may comprise an oval or elliptical shape as noted above.

In this exemplary embodiment, the computer **345**, light source **350**, and the alarm **225** are illustrated as being housed in a single unit or a unitary casing. As noted previously, these elements may be housed in a single casing or they may occupy separate housings as appropriate for a particular monitoring situation and as determined by one of ordinary skill in the art.

FIG. **6**A is a diagram illustrating a cross-sectional view of another dressing system **600**A comprising a wound-vacuum combined with a NIRS sensor **310** and a tensioning device **610** according to one exemplary embodiment of the invention. In this exemplary embodiment, the dressing system **600**A may comprise two sponges: a first sponge **315** and a second sponge **618**. The first sponge **315** can comprise materials similar to the sponges **315** described above.

However, the second sponge **618** may comprise materials similar to those of the first sponge **315** but with a higher strength, modulus, and/or density such that the stiffness or rigidity of the second sponge **618** is higher relative to the first sponge **315**. The second sponge **618** will generally remain stationary relative to the entire system **600**A while the first sponge **315** may move and contract under compressive or tension type of forces. Relative to the first sponge **315** which may have an elliptical or oval shape, the second sponge **618** may comprise a prismatic shape in which the second sponge **618** may take the form a triangular prismatic shaped beam.

The dressing system **600**A may further comprise an end tensioning mechanism **605**A. The end tensioning mechanism **605**A can comprise an anchor member that can grasp or retain an end section of the tension device **610**, also referred to as an endoskeleton. The end tensioning mechanism **605**A may be positioned upon a central longitudinal member **625** that has holes or apertures through which the tension members **610**A, **610**B can be pulled therethrough.

The tension device or endoskeleton **610** may comprise a first tension member **610**A and a second tension member **610**B. The endoskeleton **610**, end tensioning mechanism **605**A, and central longitudinal member **625** may comprise a heavy duty, repeated use material such as nylon ribbon or a sturdy plastic ribbon. However, other materials, such as, but not limited to metal, are within the scope of the invention. This material for the endoskeleton **610** and particularly, the tension members **610**A, **610**B allow for compression or retraction of the sponge **315** when tensile forces are applied to the tension members **610**A, **610**B with the end tensioning mechanism **605**A. Additionally, the tensioning mechanism **605** may be separated so each side of the wound **6** can be tensioned independently through having two independent longitudinal spines and separate cranks (See FIGS. **6**X & Y described below.)

According to this exemplary embodiment, additional sensors beyond the NIRS sensor **310** can be provided such as a pH sensor **602** and a thermometer **603**. The pH sensor **602** can monitor the relative acidity of the wound area while the thermometer **603** can monitor temperature in regions of tissue adjacent to the thermometer **603**.

FIG. **6**B is a diagram illustrating an increased magnification of the cross-sectional view of the dressing system **600**A of FIG. **6**A according to one exemplary embodiment of the invention. The triangular prismatic shaped beam second sponge **618** is more readily apparent in this exemplary Figure.

FIG. **6**C is a diagram illustrating another cross-sectional view of the dressing system **600**A in which tension forces are applied to the dressing system **300**A according to one exemplary embodiment of the invention. In this exemplary embodiment, the end tensioning mechanism **605**A is pulled in a direction as indicated by arrow C. Further, the central longitudinal member **625** has been removed from this view so that the movement of the tensioning device **610**, and particularly its tensioning members **610**A, **610**B is readily seen. Meanwhile, the central longitudinal member **625** is present in a working embodiment, though not illustrated in this Figure.

Section **610**C of the endoskeleton **610** may comprise two members which are positioned together because of the tension force exerted on the end tensioning mechanism **605**A. Meanwhile, FIG. **6**C only illustrates section **610**C to comprise a single member when in fact two members may form the section. The two members of section **610**C may comprise portions of the first tension member **610**A and the second tension member **610**B.

The movement of section **610**C causes the first tension member **610**A to move in a direction as indicated by arrow A. The movement of section **610**C also causes the second tension member **610**B to move in a direction as indicated by arrow B.

The first tension member **610**A and the second tension member **610**B are secured to portions of the sponge **315** as well as to skin sections **10**A, **10**B. The first and second tension members **610**A, **610**B may be attached to skin sections **10**A, **10**B by one or more fastening mechanisms **615**A, B. The fastening mechanisms **615**A, B may comprise staples, suture threads, metal rings, and other like fastening devices. According to one preferred and exemplary embodiment, the fastening mechanisms **615**A, B may comprise staples.

With the fastening mechanisms **615**A, B, the tension members **610**A,B will pull skin sections **10**A, B towards each other when tensile forces such as indicated by arrows A, B are applied to these tension members **610**A, B. This action also causes sections of the first sponge **315** coupled to the tension members **610**A, B to compress. Meanwhile, the second sponge **618** because it has a higher rigidity or stiffness relative to the first sponge **315**, does not undergo any compression or very little or minute amounts of compression with respect to its volume relative to the volume of the first sponge **315**. This provides a stable housing for NIRS, suction, pH monitoring, etc.

The application of these tensile forces to the two tension members **610**A, B in a gradual manner over time allows the wound **6** to heal more rapidly and consistently without the use of skin grafts and other types of ancillary surgical procedures. The compressive nature of the sponge **315** allows the dressing system **600**A to adjust its relative size while the size of the wound **6** is being reduced due to healing and movement of the skin sections **10**A, **10**B.

FIG. **6**D is a diagram illustrating an elevation view of the dressing system **600**A of FIG. **6**A according to one exemplary embodiment of the invention. The dressing system **600**A illustrated in FIG. **6**D shares several elements which are similar to those of the dressing system **300** in FIG. **3**. Therefore, only the differences between these two figures will be discussed and described in further detail below.

The endoskeleton **610** may comprise a plurality of ribs as seen from this view that are made of respective pairs of tensioning members **610**A, **610**B. In the exemplary embodiment illustrated in FIG. **6**D, there are five pairs of tensioning members that include a first pair **610**A**1**, **610**B**1**; a second pair **610**A**1**, **610**B**2**; a third pair **610**A**3**, **610**B**3**; a fourth pair **610**A**4**, **610**B**4**; and a fifth pair **610**A**5**, **610**B**5**. Each tensioning member **610** may be coupled to a central longitudinal member **625** that intersects each tensioning member **610** at an approximately **90** degree angle.

The sponge **315** generally has an area that is approximately the same size as the wound **6** in the tissue **10**. In the exemplary embodiment illustrated in FIG. **6**D, there are two ends **635**A, **635**B of the wound **6**, which are not covered by the sponge **315** because of the shape of the wound **6**.

The central longitudinal member **625** may be referred to as a spine relative to the tensioning members **610** which can be referred to as ribs. At each end of the central longitudinal member **625** can comprise a bearing **620** or other type of holding mechanism that allows for the central longitudinal member **625** to rotate as indicated by directional arrows A illustrated in FIG. **6**D.

Each tensioning member **610** may comprise a substantially planar material, like a solid tape analogous to a how a conventional, flexible tape measure may be constructed, which is both stiff and flexible. See FIG. **19** which is described more fully below and which further explains this flexible tape measure-like structure. As illustrated in FIG. **6**D, each tensioning member **610** has a first end which is coupled to an edge of tissue **10** by two fastening mechanisms, such as staples **615**. One of ordinary skill the art will appreciate that fewer or additional fastening mechanisms can be used without departing from the scope of the invention. Each tensioning member **610**, as discussed above, also has a second end which is attached to the central longitudinal member **625**.

As mentioned previously, the central longitudinal member **625** or spine may be permitted to rotate through the use of a pair of bearings **620**A, **620**B or other similar holy mechanisms. Because each tensioning number **610** is attached to the central longitudinal member **625**, each tensioning member **610** "rolls up" and wraps around the central longitudinal member **625** as it is rotated. This rotation of the central longitudinal member **625** in combination with the "rolling up" of the tensioning members **610** causes the first ends of the tensioning member **610** attached to the tissue **10** by fasteners **615** two contract and move towards each other as illustrated in FIG. **6**E.

FIG. **6**E is a diagram illustrating an elevation view of the dressing system **600**A of FIG. **6**A in which tension forces have been exerted by the tensioning device **610** according to one exemplary embodiment of the invention. The dressing system **600**A illustrated in FIG. **6**E shares several elements which are similar to those of the dressing system **600**A in FIG. **6**D. Therefore, only the differences between these two figures will be discussed and described in further detail below.

As mentioned above, the central longitudinal member **625** or spine of the dressing system **600**A is permitted to rotate so that each tensioning member **610** "rolls up" and wraps around the central longitudinal member **625** as it is rotated. The portions of the tensioning member **610** that are collected or rolled up on the central longitudinal member **625** form spools of material **610**C1-C5 that are wrapped around the central longitudinal member **625** as illustrated in FIG. **6**E.

FIG. **6**D illustrates how the tensioning members **610** can further close the wound **6** as the tensing members **610** are reeled or rolled up on the central longitudinal member **625**. Compared to FIG. **6**D, the two ends **635**A, **635**B of the wound **6** are no longer present in FIG. **6**E because the width across the wound **6** has been reduced due to healing and due to the tension forces exerted by the tensioning member **610** on the tissue **10**. Specifically, the tensioning member **610** in combination with the staples **615** have pulled the edges of the tissue **10** closer together relative to each other. The suction may reduce edema so that the edges of the wound **6** can be more closely approximated while the tension draws the edges in as well. FIG. **6**D also illustrates how the sponge **315**B, having an oval shape, which houses the NIRS device is stationary and does not compress or retract with tension of the tensioning members **610**. The sponge **315**B may comprise a less compliant or flexible material relative to the compressive sponge **315** in order to reduce or prevent compression but which still allows for transmission of the negative pressure to the wound **6**. Also the sponge **315**B housing the NIRS device may also have other shapes as needed, such as, but not limited to, rectangular, square, circular, and other similar geometrical shapes.

FIG. **6**E also illustrates how the suction tubing **325** may be contracted when the tensioning member **610** are reeled or wound up on the central longitudinal member **625**. The suction tubing **325** may be pulled up or moved up towards the pump **340** as the central longitudinal member **625** is rotated so that any excess suction tubing is positioned appropriately within the sponge **315** as it is contracted by the tensioning members **610**. The tubing will usually be stable enough that they do not collapse and prevent transmission of the suction during tensioning.

FIG. **6**F is a diagram illustrating an elevation view of a dressing system **600**B with the tensioning device **610** of FIGS. **6**A-**6**C without a NIRS device according to one exemplary embodiment of the invention. The dressing system **600**B illustrated in FIG. **6**F shares several elements which are similar to those of the dressing system **600**A in FIGS. **6**D-**6**E . Therefore, only the differences between these figures will be discussed and described in further detail below.

The tensioning device **610** comprises the end tension mechanism **605**A which is positioned on the central longitudinal member **625**. As noted previously, end the tension mechanism **605**A can comprise an end section of the tension device **610** and it may be coupled to a first tension member **610**A and a second tension member **610**B. According to this exemplary embodiment, the dressing system **600**B does not comprise a NIRS sensor **310**. Further, while fastening mechanisms such as staples **615** have not been illustrated, they are likely used with this embodiment for connecting to the tissue **10** to the tension members or ribs **610**, **610**B.

According to this exemplary embodiment, the end tensioning mechanism **605**A can comprise a longitudinal prismatic beam member that has a rectangular cross section. However, one of ordinary skill the art will appreciate that other shapes for the cross section, such as circular, elliptical, or other polygonal shapes are included within the scope of the invention.

FIG. **6**G is a diagram illustrating a cross-sectional view of the dressing system **600**B of FIG. **6**F without any tensile forces applied to the dressing system **600**B according to one exemplary embodiment of the invention. As noted previously, the tensioning members **610**A, **610**B may be coupled to the tissue **10** with fastening mechanisms, such as staples **615**.

In this view of FIG. **6**G, the coupling between the end tension mechanism **605**A in the tensioning members **610**A,B is illustrated. As discussed above in connection with FIG. **6**F, the tensioning members **610**A,B flow or moved through apertures within the central longitudinal member **625** when the end tension mechanism **605**A is moved apart and away from the central longitudinal member **625**.

FIG. **6**H is a diagram illustrating a cross-sectional view of the dressing system **600**B of FIG. **6**F with tensile forces applied to the dressing system **600**B according to one exemplary embodiment of the invention. According to this exemplary embodiment, the end tensioning mechanism **605**A has been displaced or moved away from the central longitudinal member **625**, causing the central section **610**C to be displaced from the central longitudinal member. The movement of the tensioning mechanism **605**A and the central section **610**C causes the tensioning members **610**A,B to move in a direction towards the central longitudinal member **625** and therefore, pulling ends of the tissue **10**A,B towards each other while contracting the sponge **315**.

A locking mechanism **655** is further illustrated in which it is positioned between the end tensioning mechanism **605**A and the central longitudinal member **625**. The locking mechanism **655** can comprise a device which pinches or grasps the tensioning members **610**A, **610**B as they are pulled through the central longitudinal member **625**.

FIG. **6**I is a diagram illustrating a cross-sectional view of the dressing system **600**B of FIG. **6**H with additional tensile forces applied to the dressing system **600**B according to one exemplary embodiment of the invention. According to this view, relative to FIG. **6**H, the tensioning members **610**A,B have been further contracted and pulled through the central longitudinal member **625** causing the sponge **315** to be compressed further while the ends of the tissue **10**A,B have been drawn closer together.

FIG. **6**H and FIG. **6**I illustrate how tensile forces can be applied to a wound **6** over time, and specifically to the ends of the healthy tissue **10**A, **10**B that surround the wound **6**. By applying these tensile forces over time, the size of the wound **6** can be decreased over time and can promote natural healing of the wound **6** without any additional surgical procedures, such as skin grafts, that are often used to help heal large, open wounds **6**.

FIG. **6**J is a diagram illustrating a cross-sectional view of another dressing system **600**C having another type of end tensioning mechanism **605**B in the tensioning device **610** according to one exemplary embodiment of the invention. In this dressing system **600**C, the end tensioning mechanism **605**B can comprise a spool that operates similar to the central longitudinal member **625** of FIG. **6**D. In this exemplary embodiment, a central longitudinal member **625** is not present.

While not illustrated in this figure, the tensioning members **610**A, B can be coupled to ends of the tissue **10** with staples

615. This exemplary embodiment has a simpler design relative to FIG. 6D because it has fewer parts. In other words, this exemplary embodiment does not have a central longitudinal member 625 and NIRS sensors 310 like those of FIG. 6D.

FIG. 6K is a diagram illustrating the dressing system 600C of the FIG. 6J with tensile forces applied to the dressing system 600C according to one exemplary embodiment of the invention. In this exemplary embodiment, the tensioning members 610A, B have been reeled up or further wound onto the spool 605B causing the sponge 315 to further contract or compress.

FIG. 6N is a diagram illustrating an elevation view of a dressing system 600E with the tensioning device 610 of FIGS. 6D-E according to one exemplary embodiment of the invention. The dressing system 600E illustrated in FIG. 6N shares several elements which are similar to those of the dressing system 600A in FIGS. 6D-6E . Therefore, only the differences between these figures will be discussed and described in further detail below.

In this exemplary embodiment, the dressing system 600E does not have a NIRS sensor 310 or a vacuum system with a pump 340. The tensioning members 610A,B of this exemplary embodiment can be reeled or wound up on the central longitudinal member 625.

FIG. 6O is a diagram illustrating an elevation view of the dressing system 600E of FIG. 6N after further tensile forces have been applied according to one exemplary embodiment of the invention. In this exemplary embodiment, as the tensioning members or ribs 610A, B are wound around the central longitudinal member 625, this causes the sponge 315 two contract while shrinking the size of the wound 6.

FIG. 6P is a diagram illustrating a cross-sectional view of the dressing system 600E of FIG. 6N according to one exemplary embodiment of the invention. In this exemplary embodiment, a housing 603 comprising a tubular member may enclose or encompass the central longitudinal member 625 on which the tensioning members or ribs 610A,B may be wound. In this view, the tensioning members 610A,B have not been wound.

FIG. 6Q is a diagram illustrating a cross-sectional view of the dressing system 600E of FIG. 6O according to one exemplary embodiment of the invention. In this exemplary embodiment, the tensioning members 610A,B have been wound around the central longitudinal member 625. As noted previously, the central longitudinal member 625 is encased by a housing 603 which can contain and protect the tensioning members 610A,B as they are wound around the central longitudinal member 625. The movement of the tensioning members 610A,B as indicated by the arrows causes the sponge 315 to contract and/or compress.

FIG. 6R is a diagram illustrating a cross-sectional view of a dressing system 600F with another type of locking mechanism 655A for the end tensioning mechanism 605 according to one exemplary embodiment of the invention. Specifically, this diagram depicts a safety mechanism that will allow for a controlled/measured failure mechanism for the tensioning system in order to prevent too much tension to be applied to the skin edges.

According to this exemplary embodiment, the locking mechanism 655A may comprise a housing 662, springs 660, and force applicators 665. The housing 662, springs 660, and force applicators 665 can comprise a material such as plastic or metal. The springs 660 are made of metal in preferred exemplary embodiments. While the springs 660 have been illustrated as compression springs, other types of springs such as tension or torsional springs are within the scope of the invention as recognized by one of ordinary skill in art.

The springs 660 can be coupled to the housing 662 and may exert forces against the force applicators 665. Each force applicator 665 can press against a tension member 610A,B. The opposing compression forces of the two springs 665 illustrated in FIG. 6R can lock or can prevent movement of the tensioning members 610A,B through the locking mechanism 655A.

The forces of the two springs 665 may have a magnitude that prevents movement of the tensioning members 610A,B through the locking mechanism 655A when no tensile forces are applied to the tensioning members 610A,B. However, the forces of the two springs 665 may have a magnitude which also permits movement of the tensioning members 610A,B through the locking mechanism 655A when tensile forces are applied to the end tensioning mechanism 605A.

This embodiment also serves as a safety feature. This force of the locking mechanism 655A can be set so that too much tension cannot be applied by medical personnel. This mechanism would prevent medical personnel from pulling the tensioning system too tight and locking it down. The release mechanism would not catastrophically fail but simply release the excess tension but not completely release all tension. Once the tension is released to an acceptable level the lock would maintain the appropriate tension. This aspect will prevent tissue ischemia from over tensioning.

FIG. 6S is a diagram illustrating a cross-sectional view of a dressing system 600G with another type of locking mechanism 655B according to one exemplary embodiment of the invention. According to this exemplary embodiment, the locking mechanism 655B comprises a ratcheting system that includes a ratchet gear 670 and a pawl 675 that engages the teeth of the gear 670. The locking mechanism 655B allows the tension member 610A, B to be wound upon the central longitudinal member 625 such that the tensioning members 610A, B are held in place and locked as they are wound around the central longitudinal member 625. This diagram depicts a safety mechanism for a locking mechanism 655B that will allow for a "controlled/measured failure mechanism" for the tensioning system in order to prevent too much tension to be applied to the skin edges. The controlled failure mechanism relieves tension if medical personnel attempt to apply to great of a tension. The latches in FIG. 6S will release and reset at a lower tension or as in FIG. 6T, described below, the tensioning cords will slide back until a safe tension is reached & maintained by the two compression applicators depicted.

The pawl 675 may have a certain predetermined stiffness to accommodate a predetermined level of tension. If medical personnel cranks the tensioning device too far, the locking mechanism 655B will slip back until an appropriate tension is obtained. Once reached, the mechanism 655B would reengage preventing complete loss of tension on the skin edges. This aspect may prevent tissue ischemia from over tensioning.

FIG. 6T is a diagram illustrating a cross-sectional view of a dressing system 600I with a spring-biased end tensioning mechanism 605A according to one exemplary embodiment of the invention. This illustration depicts a safety mechanism for preventing excessive tension by applying a constant tension provided by a spring 688 which does not allow medical personnel to alter the tension. Additionally, this tension system 600I does not require medical personnel to serially increase the tension as the other embodiments may require. The system 600I may constantly apply tension through the spring 688. According to this exemplary embodiment, the end tensioning mechanism 605A, which is similar to the ones described above in connection with FIGS. 6A-6C, has a spring **688** which provides a bias or expansion force against the end tensioning mechanism **605**A. The spring **688** can be coupled to the longitudinal block **625** and the end tensioning mechanism **605**A.

The spring **688** may be held in a compressed state by some sort of locking mechanism (not illustrated). Exemplary locking mechanisms may include, but are not limited to, hooks, wires, and the like. The dressing would arrive in a package locked without tension. Once the dressing is attached to the skin edges the tensioning mechanism may then be unlocked to allow the application of tension.

One benefit of this embodiment is that tension may be constantly applied at a known level of tension provided by the spring. There would usually be no times where there was no tension placed on the wound because medical personnel did not manually tension the device on a sequential basis. Additionally, there would be limited concern for over tensioning by medical personnel since the tension would be supplied at a constant and controlled level. This exemplary embodiment provides both safety feature as well as a measure of safety measure for tension. A spring controlled mechanism could be applied to the crank mechanism in a similar fashion.

FIG. **6**U is a diagram illustrating a cross-sectional view of the dressing system of FIG. **6**T after further tensile forces have been applied according to one exemplary embodiment of the invention. In this exemplary embodiment, the spring **688** is allowed to expand so that its expansion forces can press upon the end tensioning mechanism **605**A so that the end tensioning mechanism **605**A is displaced or moves away from the longitudinal member **625**.

This action causes section **610**C of the tension device **610** to move upward and through the longitudinal member **625**. This also causes the tensioning members **610**A,B to contract and move upward through the longitudinal member **625**. This also causes the sponge **315** to compress and/or contract.

FIG. **6**V is a diagram illustrating a cross-sectional view of a dressing system **600**J with another type of locking mechanism **655**C for the longitudinal member **625** according to one exemplary embodiment of the invention. According to this exemplary embodiment, the housing **690** of the locking mechanism **655**C which contains the longitudinal member **625** on which the tensioning members **610**A,B are wound may comprise a rectilinear, prismatic shape. Longitudinal member may roll backwards until a safe tension is applied and may be reset at that point. The tension may be preset by the medical pesonnel.

Specifically, the housing **690** may comprise a square or rectangular shape. However, one of ordinary skill in the art recognizes that other cross-sectional shapes for the housing **690** as well as for the longitudinal member **625** are within the scope of the invention. The portions of the locking mechanism **655**C which hold the longitudinal member **625** in place after the longitudinal member **625** has been rotated are not depicted in this illustration. The portions of the locking mechanism **655**C which holds the longitudinal member **625** in place may comprise the ratchet of FIG. **6**S.

FIG. **6**W is a diagram illustrating a cross-sectional view of the dressing system **600**J of FIG. **6**T after further tensile forces have been applied according to one exemplary embodiment of the invention. In this exemplary embodiment, the tensioning members **610**A, B have been reeled up or further wound around the central longitudinal member **625**. Section **610**C of the tensioning device **610** may form a spool comprising the reeled in tensioning members **610**A, **610**B, which are protected and contained by the housing **690**.

FIG. **6**X is a diagram illustrating a cross-sectional view of a dressing system **600**K with another type of locking mechanism **655**D for the longitudinal member **625** according to one exemplary embodiment of the invention. This exemplary embodiment employs two separate longitudinal members or cranks **625**A, **625**B versus one to allow for different tensions to be applied to different edges. As noted, the locking mechanism **655**D of this exemplary embodiment may comprise two separate longitudinal members **625**A, B that are moved by a motor. This means that one side of tensioning members **610**A,B can be wound up or reeled upon a respective separate rotating longitudinal member **625** in which each member **625** is rotated by a motor. Each side could be wound independently of each other in order to allow for maximum tensioning for each side.

In other words, the first set of tensing members **610**A present in one half of a sponge **315** can be reeled up and stored on a first central, longitudinal member **625**A. Similarly, a second set of tensioning members **610**B occupying the second half of sponge **315** can be reeled up in stored on the second central, longitudinal member **625**B.

The portions of the locking mechanism **655**D which hold the two longitudinal members **625**A,B in place after the longitudinal members **625**A,B have been rotated are not depicted in this illustration. The portions of the locking mechanism **655**C which holds the longitudinal member **625** in place may comprise the ratchet of FIG. **6**S. Exemplary motors may include, but are not limited to, electric motors like an AC motor that includes a synchronous motor, an induction motor, DC motors such as a brushed DC electric motor or a brushless DC motor, an electrostatic motor, a servo motor, and a pneumatic motor.

FIG. **6**Y is a diagram illustrating a cross-sectional view of the dressing system **600**K of FIG. **6**T after further tensile forces have been applied according to one exemplary embodiment of the invention. According to this exemplary embodiment, the two longitudinal members **625**A, B have been further rotated by a motor relative to FIG. **6**X, causing the tension members **610**A,B to contract and compress or contract the sponge **315** while moving into the housing **695** around the respective rotating central longitudinal members **625**A, B.

FIG. **7**A is a diagram illustrating an expandable splint **700**A designed for an extremity of an animal, such as for a leg of a human, according to one exemplary embodiment of the invention. The expandable splint **700**A may comprise two sections: a first inner section **715** and a second outer section **720**. The inner section **715** may comprise an envelope dressing similar to the one discussed above in connection with FIG. **1**A. The inner section **715** has a first end **705** and a second end **710**.

According to the exemplary embodiment illustrated in FIG. **7**A, the first end **705** of the inner section **715** may be smaller and its cross-sectional area relative to the second end **710**. The first end **705** may be designed to receive a foot of the human body while the second end **710** is designed to receive the leg of a human body. However, one of ordinary skill in the art recognizes that the inner section **715** and outer section **720** can be sized appropriately depending upon the extremity that is injured and which requires stability from the expandable splint **700**A. Other exemplary extremities include, but are not limited to, face, head, chest, abdomen, pelvis, torso, hands, forearms, and the shoulder, feet, foot to knee, and foot to groin, etc. The expandable splint **700**A may replace other conventional splints such as the (arm) sugar tong, volar slab, coaptation (humerus fxs), posterior splint, cadillac, posterior splint, and knee immobilizer.

The outer section **720** may comprise an expandable bladder made from a synthetic material like plastic or rubber. The expandable splint **700**A, and specifically, the outer section **720**, may be inflated with a fluid such as air or with a fluid that hardens over time such as to a hardening plastic material or an epoxy. Fluids that may harden over time may be prepackaged and stored in the outer section **720**.

To start the hardening process for prepackaged fluids contained within the outer section **720**, a chemical reaction can be initiated by a user. In other words, the outer section **720** may store or house two fluids that are separated by a thin membrane material (not illustrated) that can be broken in order to initiate a chemical reaction to cause hardening of the fluids contained within the outer section **720**. This chemical could also be injected or added in some way to begin the reaction.

Prior to any chemical reaction between the two or more fluids (not illustrated) housed in the outer section **720**, the outer section **720** may be very soft and flexible for easy storage and for not providing any structural support. Alternatively, when structural support or hardening of the outer section **720** is desired, it can be filled with a fluid from an external source such as air from a pneumatic pump. The outer section **720** may be used to provide structural support and for stabilizing broken bones.

FIG. **7**B is a diagram illustrating a cross-sectional view of the expandable splint **700**A illustrated in FIG. **7**A according to one exemplary embodiment of the invention. According to this exemplary embodiment, the outer section **720** has been expanded with a fluid such as air or fluids that may harden over time such as in a chemical reaction described above. Meanwhile, the inner section **715** comprising the envelope addressing may completely encompass or surround the extremity being treated.

In the exemplary embodiment illustrated in FIG. **7**B, the extremity being treated comprises a human leg having the tibia **735** and fibula **730** bones being immobilized with the expandable splint **700**A. The outer section **720** comprises a valve **725** through which the fluid is introduced into the inflatable outer section **720**. The valve **725** may comprise a one-way valve said that any fluid introduced into the inflatable outer section **720** cannot exit through the valve **725**.

FIG. **7**C is a diagram illustrating a cross-sectional view of an expandable splint **700**B for another kind of extremity, such as an arm for human having the ulna **745** and radius **740** bones immbolized, according to one exemplary embodiment of the invention. The expandable splint **700**B illustrated in FIG. **7**C shares several elements which are similar to those of the expandable splint **700**A in FIGS. **7**A-**7**B. Therefore, only the differences between these figures will be discussed and described in further detail below.

In the exemplary embodiment illustrated in FIG. **7**C, two expandable outer section **720**s along with two separate valve **725**A, B are illustrated. The first outer section **720**A can be positioned on one side of the extremity while the second outer section **720**B can be positioned on an opposing side of the extremity. Both outer sections **720** can be inflated at the same time or they can be inflated in a sequential manner depending upon the conditions of the extremity being treated and immobilized.

FIG. **8**A is a diagram illustrating an irrigation and/or suction system **800** for a dressing system **600**L according to one exemplary embodiment of the invention. The dressing system **600**L illustrated in FIG. **8**A shares several elements which are similar to those of the dressing system **600**B of FIGS. **6**F-**6**G. Therefore, only the differences between these two figures will be discussed and described in further detail below.

The tensioning members **610** of FIG. **8**A are very similar to those illustrated in FIGS. **6**F-**6**G except that the tensioning number **610** of the exemplary embodiment illustrated in FIG. **8**A are generally hollow instead of being solid. Further, each tensioning member **610** may have a plurality of holes **805** for propagating a fluid. The fluid can be propagated into the sponge **315** or fluid can be removed from the sponge **315** or both depending upon the cycling of the pump **340** (see FIGS. **8**B-**8**C).

Each tensioning member **610** can be hollow and made from a materials such as plastic. Each tensioning member **610** should be made from a material that is soft enough that will allow for trimming through the use of scissors in an operating room but that is also strong enough to support any negative pressure or vacuum without collapsing in order to remove fluid from the sponge **315** when used as a suction system.

In other words, each tensioning member **610** and the central longitudinal member **625** of the endoskeleton can support the propagation of fluid towards the sponge **315** or it may support a vacuum in which fluid can be removed from the sponge **315**. Further details of the holes **805** present in each tensioning member **610** are further illustrated in FIGS. **8**B-**8**C.

When used for irrigation, the irrigation system **800** can supply a fluid such as, but not limited to, antibiotics, enzymes, growth factors, pain medicine, anesthetics, and the like. The antibiotics can be used to treat or prevent infections for a wound covered by the sponge **315**. When used for fluid removal, the suction system **800** can support a vacuum for removing exudate from the wound covered by the sponge **315** and for preventing any hematomas adjacent to the wound.

FIG. **8**B is a diagram illustrating a cross-sectional view of a suction system **800**A for a dressing system **600**L according to one exemplary embodiment of the invention. According to this exemplary embodiment, the pump **340** creates a vacuum which is supported by the tubing **325**. The tubing **325** is coupled to the hollowed tension members **610** which also have apertures or holes **805**. The apertures or holes **805** can be randomly positioned over the entire surface of each hollow tension member **610**.

Alternatively, the apertures or holes **805** can be uniformly distributed across each tension member **610**. The holes can have diameters that range between approximately one millimeter to five millimeters. However, one of ordinary skill in the art recognizes that other ranges above or below this range are included within the scope of the invention. When a vacuum is created in the suction system **800**A by the pump **340**, any fluid present in the sponge **315** is sucked into the apertures or holes **805** present within each tension member **610**. From each tension member **610**, the fluid flows towards the pump **340** through the tubing **325**.

FIG. **8**C is a diagram illustrating a cross-sectional view of an irrigation system **800**B for a dressing system **600**L according to one exemplary embodiment of the invention. The dressing system **600**L illustrated in FIG. **8**B shares several elements which are similar to those of the dressing system **600**L of FIGS. **8**B. Therefore, only the differences between these two figures will be discussed and described in further detail below.

According to this exemplary embodiment, the pump **340** pushes a fluid through the tubing **325** and through the tension members **610** and out through the apertures or holes **805** and into the sponge **315**. As noted previously, the pumped fluid may include, but is not limited to, antibiotics, enzymes, growth factors, pain medicine, anesthetics, and the like.

The tubing **325** in this exemplary embodiment could be filled with a porous material (filler material **817**) such as but not limited to a sponge, microspheres, or a screen at the interface of the hole and tissue. The purpose of filling the tube **325** with filler material **817** would be to prevent or limit the ability of the soft tissue to in-grow. Additionally, if there is any sponge or micro-sphere residue, it would be significantly reduced or limited. The "filler" material would allow suction transmission or fluid injection but prevent or limit clogging and in-growth of soft tissue.

FIG. **9**A is a diagram illustrating a cross-sectional view of a pressure monitor **902**A to evaluate the pressure placed on tissue by the external dressing system **900**A according to one exemplary embodiment of the invention. The dressing system **900**A of this exemplary embodiment may comprise an envelope dressing **715**, a pressure transducer **910**, tubing **330**, a pressure monitor **905**, and an alarm **225**. The envelope dressing **715** may be similar or identical to the inner section **715** of the expandable splint **700**A of FIG. **7**A. The pressure transducer **910** can be positioned between the envelope dressing **715** and tissue **10**A. The tissue **10**A may comprise an arm having a radius **740** and ulna **745** bone structures.

The pressure transducer **910** may be coupled to a computer monitor **905** through tubing **330** or wiring depending upon the type of pressure transducer **910** being employed. The pressure transducer **910** can monitor the pressure in which the external envelope dressing **715** is placing on the tissue **10**A, such as an arm of a human body. The alarm **225** can be activated by the computer monitor **905** is the pressure transducer **910** measures pressure within a predetermined range. For example, if the pressure transducer **910** measures pressure of approximately 40 mmHg of diastolic pressure, the computer monitor **905** may activate the alarm **225**.

An exemplary embodiment of this design would comprise a main computer that would allow for input of external devices such as an ICU monitor or sphygmomanometer, etc. This application would allow the blood pressure information to be incorporated to insure adequate perfusion pressures and blood flow.

FIG. **9**B is a diagram illustrating another cross-sectional view of the pressure monitor **902**A of FIG. **9**A according to one exemplary embodiment of the invention. In this exemplary embodiment, the tissue **10**B has become swollen and has started pressing against the envelope dressing **715** as indicated by the directional arrows adjacent to the analog dressing **715**. The tissue **10**B has expanded and pushed the pressure transducer **910** against the envelope dressing **715**. If the pressure measured by the pressure transducer **910** reaches a predetermined value, such as 40 mm Hg of mercury, then the computer monitor **905** can activate the alarm **225** to alert medical personnel of the condition being measured.

FIG. **9**C is a diagram illustrating another pressure monitor **902** for dressing systems **900**B1, **900**B2 according to one exemplary embodiment of the invention. The dressing systems **900**B1 and **900**B2 illustrated in FIGS. **9**C share several elements which are similar to those of the dressing system **900**A-B of FIGS. **9**A-**9**B. Therefore, only the differences between these two figures will be discussed and described in further detail below.

According to this exemplary embodiment, the pressure monitor **902**B can comprise a conventional computer **345**, an alarm **225**, tubing **330**, and a plurality of pressure transducers **910** at different site locations **915**. The first dressing system **900**B1 comprises an envelope dressing **715** shaped for treating an extremity such as the human arm or the torso **10**C. Pressure transducers **910** can be placed at various site locations **915** throughout the envelope dressing **715** and preferably between the envelope dressing **715** and the body **10**C, similar to FIG. **9**A.

The second dressing system **900**B2 comprises an envelope dressing **715** shaped for treating an extremity such as the human leg **10**D. Pressure transducers **910** can be placed at various site locations **915** throughout the envelope dressing **715** and preferably between the envelope dressing **715** and the body **10**C, similar to FIG. **9**A.

FIG. **9**D is a diagram illustrating the environment for an exemplary pressure transducer **910**A according to one exemplary embodiment of the invention. The pressure gauge or transducer **910**A can comprise anyone of a number of electronic pressure sensors. The pressure monitor **902**C may detect movement or strain from the tissue **10** expanding against the gauge into the dressing **715**.

Exemplary pressure transducers **910**A may include, but are not limited to, piezoresistive strain types (using the piezoresistive effect of bonded or formed strain gauges to detect strain due to applied pressure), capacitive types (using a diaphragm and pressure cavity to create a variable capacitor to detect strain due to applied pressure), magnetic types (measures the displacement of a diaphragm by means of changes in inductance-reluctance, LVDT, Hall Effect, or by eddy current principal), and piezoelectric types (using the piezoelectric effect in certain materials such as quartz to measure the strain upon the sensing mechanism due to pressure).

FIG. **9**E is a diagram illustrating a pressure transducer **910**B for a pressure monitoring system according to one exemplary body of the invention. The pressure transducer **910**A may comprise a movable member **930**, a spring **925**, and a stationary housing **920**. The movable member **930** can be moved into the housing **920** which causes the movable member to press against the spring **925**.

The spring **925** can be monitored for its displacement or change in electrical properties such as inductance when the movable member **930** compresses the spring **925** against the stationary housing **920**. One of ordinary skill in the art recognizes that other types of transducers **910** besides the one illustrated in FIG. **9**E are within the scope of the invention.

FIG. **9**F is a diagram illustrating another pressure transducer **910**C for a pressure monitoring system according to one exemplary embodiment of the invention. The pressure transducer **910**C may comprise a movable button **930**, a housing **935**, tubing **325**, and a manometer **905**. The button **930** may be pushed by swollen tissue **10** into the housing **935**.

The housing **935** may comprise a bladder filled with a liquid in which can be compressed by the button **930**. The liquid from the bladder can flow out of the tubing **325** and into the manometer **905**. Changes in the liquid levels present in the manometer **905** can indicate changes in pressure.

FIG. **9**G is a diagram illustrating another pressure transducer **910**D for a pressure monitoring system according to one exemplary embodiment of the invention. The pressure transducer hundred **2**F may comprise a flat pad/sensor pressure gauge **940** that is coupled by wires **332** a digital monitor, such as a computer **345** as illustrated in FIG. **9**C. Such flat pad/sensor pressure gauges **940** are sold under the trade name ConTacts™ by Pressure Profile Systems, Inc., of 5757 Century Boulevard, Suite 600, Los Angeles, Calif. 90045 USA.

FIG. **10**A is a diagram illustrating an irrigation and/or suction system **800** with pressure gauges or transducers **910** to monitor the negative pressure being supplied by the dressing system **1000** and which are embedded within the sponge **315** of the dressing system **1000** according to one exemplary embodiment of the invention. The dressing system **1000** illustrated in FIG. **10**A shares several elements which are similar to those of the dressing system **600**L of FIGS. **8**A-**8**C. Therefore, only the differences between these figures will be discussed and described in further detail below.

According to this exemplary embodiment, pressure transducers **910** are coupled to the tension members **610** which extend from the central longitudinal member **625**. The pressure transducers **910** can comprise any of the ones discussed and described above in connection with FIGS. **9**D-**9**G. While the pressure transducers **910** have been illustrated as positioned adjacent to the ends of each tension member **610**, one of ordinary skill the art will appreciate that other positions on each tension member **610** are well within the scope of the invention. Further, a plurality of pressure transducers **910** may be provided on each tension member **610** depending upon the sensitivity desired for a particular application.

The pressure transducers **910** can monitor the dressing system **1000** to insure there is adequate negative pressure within the system **1000**. If a leak occurs within the airtight system **1000** in which negative pressure is lost, the pressure transducers **910** can activate an alarm **225** as described in further detail below in connection with FIGS. **10**B-**10**C.

Each pressure transducer **910** may be assigned an alphanumeric identifier that can be presented on a display (not illustrated) that may be part of the monitor **905**. In this way, the monitor **905** can indicate a specific region of the dressing system **1000** that may be experiencing a leak so that medical personnel can patch a specific area of the dressing system **1000** without removing the entire dressing system **1002** to repair a leak. This embodiment will allow for isolated and targeted reinforcement of the dressings and assist medical personnel in quick management of leaks.

FIG. **10**B is a diagram illustrating a cross-sectional view of a suction system **800** with pressure gauges **910** for a dressing system **1000** in a non-alarm or inactive state according to one exemplary embodiment of the invention. The dressing system **1000** may further comprise a negative pressure/vacuum generator **1010**, the pressure transducer **910**, a monitor **905**, an alarm **225**, and an airtight cover **1020**. The airtight cover **1020** can comprise materials similar to those described above in connection with the cover **305** of FIG. **3**A.

The alarm **225** can comprise an audio one and/or visual one, similar to the one described above in connection with FIG. **2**B. The monitor **905** may comprise a computer, a central processing unit, a hardwired circuit, and/or firmware, software, and the like. The monitor **905** can measure the negative pressure/vacuum that is created by the negative pressure/vacuum generator **1010**. The negative pressure/vacuum generator **1010** may comprise a pump, similar to pump **340** of FIGS. **8**A-**8**B. When there is no air pressure within the enclosure formed by the cover **1020**, the monitor **905** will keep the alarm **225** in an inactive state.

FIG. **10**C is a diagram illustrating a cross-sectional view of a suction system **800** with pressure gauges **910** for a dressing system **1000** in an alarm state or active state according to one exemplary embodiment of the invention. In this exemplary embodiment, the monitor **905** has detected a decrease or change in the negative pressure/vacuum that is flowing within the tension member **610**.

This decrease or change in the negative pressure/vacuum may be caused by a break **1030** in the airtight seal formed by the cover **1020**. This break **1030** may permit air to flow through the break within the airtight seal of the cover **1020**. Upon detecting a change in the negative pressure/vacuum, the monitor **905** may activate the alarm **225** which may comprise an audio or visual indicator (or both) in order to alert medical personnel of this change in the condition of the dressing system **1000**.

FIG. **11**A is a diagram illustrating a cross-sectional view of another dressing system **1100**A comprising a wound-vacuum **800** combined with an environmental sensor **1105** and a tensioning device **610** according to one exemplary embodiment of the invention. The dressing system **1100** illustrated in FIG. **11**A shares several elements which are similar to those of the dressing system **600**A of FIGS. **6**D-**6**E. Therefore, only the differences between these figures will be discussed and described in further detail below.

In this exemplary embodiment, the environmental sensor **1105** can be positioned within the central longitudinal member **625** of the tension device **610**. The environmental sensor **1105** may comprise at least one of, but is not limited to, a pH sensor, a temperature probe/thermometer, an exudates sampling device, and/or a combination thereof.

The pH sensor may comprise an electronic instrument used to measure the pH (acidity or alkalinity) of a liquid. A typical pH sensor or meter may include a special measuring probe (a glass electrode) connected to an electronic meter that measures and displays the pH reading. The pH sensor could also comprise a NIRS device that could be used to monitor pH levels. Wireless pH sensors that are commercially available include those produced by the manufacturer of met Tronic, Inc., of Minneapolis Minn.

The thermometer may comprise an infrared thermometer, a recording thermometer, a thermistor, a thermocouple, a pill thermometer, a liquid crystal thermometer, a resistance thermometer, silicon bandgap temperature sensor, and other similar thermometers.

As illustrated in FIG. **11**A, the environmental sensor **1105** may be contained within the central longitudinal member **625** while also protruding beyond the member **625** and against the tissue **10** within the wound **6**. The environmental sensors **1105** may be prepackaged and positioned within predetermined locations on the tensioning device **610**. Alternatively, the environmental sensors **1105** may be added individually by the clinician after or prior to application of the dressing system **1000** on a wound **6**.

A monitored change in the environmental condition of tissue **10** within a wound **6**, such as a change in a pH level or a change in temperature, or a combination thereof, may indicate a need for changing a dressing. One of ordinary skill in the art recognizes that clinical infections/abscesses typically change the environment of any surrounding tissue **10**, such as pH levels and sometimes temperature. One of ordinary skill the art also recognizes that abscesses typically have or thrive in an acidic environment which can be monitored with a pH sensor.

FIG. **11**B is a diagram illustrating a cross-sectional view of another dressing system **1100**B comprising a wound-vacuum **800** and combined with an environmental sensor **1105** spaced apart from a tensioning device **610** according to one exemplary embodiment of the invention. In this exemplary embodiment, the environmental sensor **1105** is positioned away and spaced apart from the tension device **610**. The environmental sensor **1105** can monitor the fluid/exudate as it is removed from the wound under any form of negative pressure combined with the hollow tension members **610**.

FIG. **11**C is a diagram illustrating an elevation view of the dressing system **1100** comprising a wound-vacuum **800** combined with a environmental sensor **1105** and a tensioning device according to one exemplary embodiment of the invention. In this exemplary embodiment, the environmental sensor **1105** can be positioned within the central longitudinal member **625**.

Alternatively, the environmental conditions within the dressing system **1100**A may be monitored by taking samples from two different collection units **1105**A,B in which the first collection unit **1105**B1 may be positioned closer to a pump **340** relative to the dressing system **1100**. Alternatively, the second potential collection unit **1105**B2 may be monitored by taking samples in which the second unit **1105**B2 is positioned closer to the dressing system **1000** relative to the pump **340** and the dressing system **1000**. The monitor **905** may also detect other conditions other than pH levels, such as, but not limited to, bacteria, fungi, body chemicals, cytokines, growth factors, proteins, peptides, sugars, and etc.

The monitor **905** coupled to the first and second possible collection units **1105**B1, **1105**B2 may comprise a computer, a central processing unit, a hardwired circuit, and/or firmware, software, and the like. The pump **340** may comprise the types discussed above in connection with FIGS. **8**B-**8**C.

In addition to or as an alternative exemplary function, the wound-vacuum system **800** may be able to distribute warm or cold water through the dressing system **1100** to promote healing of the wound **6**. This means that the wound-vacuum system **800** can pump warm or cold water through the hollow central longitudinal member **625** and hollow tension members **610** and into the sponge **315**. After distributing this warm or cold water, the wound-vacuum system **800** can pump and reverse in order to remove the water as well as any exudates, or any other fluid or particulate matter, that may be present within the wound and absorbed by the sponge **315**.

FIG. **12**A is a diagram of a side view of a wound **6** that has a wound edge **635** which is part of the tissue **10** that may comprise a human leg according to an exemplary embodiment of the invention. Within the wound **6**, there could be exposed muscle tissue. The wound **6** may be formed as a result of a fasciotomy or an injury.

FIG. **12**B is a diagram illustrating a Roman sandal or shoelace technique for closing wounds **6** according to an exemplary embodiment of the invention. The shoelace **1215** may comprise a single cord and that is attached to skin edges by fastening mechanisms **615**. The fastening mechanisms **615** may include, but are not limited to, staples, suture threads, or a combination thereof.

The shoelace **1215** may be crisscrossed over wound **6**. The shoelace **1215** may be sequentially pulled to draw the skin edges **635** into a geometric central region relative to the wound **6**. Fastening mechanisms **615** on opposite sides of the wound **6** are pulled closer to one another as the shoelace is tightened across the wound **6**. The single chord of the shoelace **1215** may comprise materials such as, but not limited to, rubber, or plastic.

FIG. **12**C is a diagram illustrating a Roman sandal or shoelace technique that has further closed the wound **6** illustrated in FIG. **12**B according to one exemplary embodiment of the invention. As illustrated in this exemplary embodiment, the shoelace **1215** has been drawn tighter relative to FIG. **12**B.

By pulling the shoelace **1215** tighter, this action has moved opposing sides were wound edges **635** closer toward another since the fastening mechanisms **615** attached to the wound edges **635** are connected to the shoelace **1215**. In this figure, the additional or excess shoelace **1215** that has been pulled through the fastening mechanisms **615** has been denoted with reference numeral **1225**. The excess shoelace material **1225** that no longer has tension forces applied to it can be wrapped up or it can be removed by cutting from medical personnel.

FIG. **12**D is a diagram illustrating further details of the fastening mechanisms **615** for the Roman sandal or shoelace technique of FIG. **12**C according to one exemplary embodiment of the invention. As illustrated in this exemplary embodiment, the fastening mechanisms **615** may comprise staples. The staples may comprise materials such as, but not limited to, metal, hard plastic, and the like. For example, the staples may be made from titanium or stainless steel. Titanium usually produces less reaction with the immune system and, being non-ferrous, does not interfere significantly with MRI scanners, although some imaging artifacts may result. The staples may also comprise synthetic absorbable (bioabsorbable) materials, based on polyglycolic acid. The fastening mechanisms **615** can have one section that engages a wound edge **635** while another section engages a portion of the shoelace **1215**.

FIG. **13**A is a side view of a sequential compression dressing system **1300** according to one exemplary embodiment of the invention. The sequential compression dressing system **1300** may comprise a pump **340**, tubing **325**, an inflatable bladder **1305**, and an envelope dressing **715**. The system may also incorporate the wound monitoring and suction/irrigation systems, such as the system **300**A of FIG. **3**B that comprises a computer **345**. The system **300**A via computer **245** may monitor conditions such as, but not limited to, pH, NIRS values, temperature, exudate sampling, and other similar conditions. The envelope dressing **715** may comprise materials similar to those as discussed above in connection with the inner section **715** of FIG. **7** and the envelope dressing **12** of FIG. **1**.

The inflatable bladder **1305** may comprise an elastic material such as rubber, plastic, vinyl, a combination thereof, and other like materials. The materials of the bladder **1305** may be sterilized or made from sterile materials in exemplary embodiments in which the bladder **1305** directly contacts tissue **10**. The inflatable bladder **1305** may be filled with a fluid, such as air, or a liquid, such as water or inert fluids. The inflating and deflating of the bladder **1305** may comprise or act as a sequential compression of the tissue **10** which may promote blood flow in general, and possibly the return of blood flow towards the heart of an animal, such as a human.

This periodic inflating and deflating of the bladder **1305** may be automated by coupling a controller, such as a computer (not illustrated), to the pump **340**. The sequential compression of the extremity or tissue **10** may be varied by time, rate, and magnitude of the pressure applied by the bladder **1305**.

The periodic inflating and deflating of the bladder **1305** may also reduce the risk of creating any possible perfusion complications within the extremity that is in contact with the bladder **1305**. This action may also prevent blood pooling and possibly prevent a blood clot forming within the extremity that is in contact with the bladder **1305**. The sequential compression action may also prevent or reduce the risk of an edema forming in the compartment of the extremity or tissue **10** which is in contact with the bladder **1305**.

FIG. **13**B is a cross-sectional view of the sequential compression dressing system **1300** of FIG. **13**A in a deflated state according to one exemplary embodiment of the invention. According to this exemplary embodiment, two bladders **1305**A, **1305**B are illustrated and are in a deflated state. The bladders **1305** may come in direct contact with the tissue **10** that may comprise a human leg that has a tibia bone **735** and a fibula bone **730**. Alternatively, the bladders **1305** may be positioned or enclosed by the envelope dressing **715** so that they are not in direct contact with the tissue **10** so that only the envelope dressing **715** comes in direct contact with the tissue **10**.

FIG. **13**C is a cross-sectional view of the sequential compression dressing system **1300** of FIG. **13**B in an inflated state according to one exemplary embodiment of the invention. According to this exemplary embodiment, each of the two bladders **1305**A, **1305**B has been inflated with a fluid such as air or another inert fluid. Each bladder **1305** may press against the tissue **10** such that the tissue **10** may move and/or deform in response to the compressive force produced by the surface of each bladder **1305**.

FIG. **14**A is a diagram illustrating a cross-sectional view of a first anchoring mechanism **1405** for a tension member **610**A of a tensioning device **1400**A according to one exemplary embodiment of the invention. The tensioning device **1400**A illustrated in FIG. **14**A shares several elements which are similar to those of the tensioning device **610** of FIGS. **6**A-**6**E. Therefore, only the differences between these figures will be discussed and described in further detail below.

The tensioning device **1400**A may comprise a tension member **610**A and an anchoring mechanism **1405**. The anchoring mechanism **1405** may comprise a section of the tension member **610**A that is positioned in an approximately perpendicular manner relative to a main portion of the tension member **610**A. This anchoring mechanism **1405** may comprise a material that is similar to the material of the tension member **610**A and it may be uniform with or made in conjunction with the tension member **610**A. In other words, the first anchoring mechanism **1405** may be formed integrally with the tension member **610**A.

The anchoring mechanism **1405** may increase the surface area that the tension member **610**A has in contact with the sponge **315** such that the anchoring mechanism **1405** may pull the sponge **315** when the tension member **610**A is contracted as discussed above in connection with FIG. **6**. While only a single anchoring mechanism **1405** is illustrated, one of ordinary skill the art recognizes that a plurality of anchoring mechanism **1405** can be disposed upon a length of the tension member **610**A and such an exemplary embodiment would be included within the scope of the invention.

FIG. **14**B is a diagram illustrating a cross-sectional view of a second anchoring mechanism **1410** for a tension member **610**B of a tensioning device **1400**B according to one exemplary embodiment of the invention. The tensioning device **1400**B illustrated in FIG. **14**B shares several elements which are similar to those of the tensioning device **610** of FIGS. **6**A-**6**E. Therefore, only the differences between these figures will be discussed and described in further detail below.

According to this exemplary embodiment, the second anchoring mechanism **1410** may comprise a lattice of linear members that are coupled to an end of a tension member **610**B. The lattice of linear members may comprise elements made of similar materials relative to the tension member **610**B but which may have a substantially smaller diameter relative to a diameter of the tension member **610**B. The anchoring mechanism **1410** may be attached to the tension member **610**B by a fastening mechanism such as a plastic weld. Alternatively, the second anchoring mechanism **1405** may be formed integrally with the tension member **610**B.

The anchoring mechanism **1410** may provide a secure attachment to the tension member **610**B as well as to the sponge **315**. While the second anchoring mechanism **1410** may be strong enough to withhold and to move in conjunction with the tension forces applied by the tension member **610**B, the respective diameters of the members forming the second anchoring mechanism **1410** may be small enough so that they can be easily trimmed or cut by medical personnel in order to properly size and/or shape the sponge for a wound **6** having a specific or particular shape/geometry.

FIG. **14**C is a diagram illustrating a cross-sectional view of a third anchoring mechanism **1415** for a tension member **610**C of a tensioning device **1400**C according to one exemplary embodiment of the invention. The tensioning device **1400**C illustrated in FIG. **14**C shares several elements which are similar to those of the tensioning device **610** of FIGS. **6**A-**6**E. Therefore, only the differences between these figures will be discussed and described in further detail below.

According to this exemplary embodiment illustrated in FIG. **14**C, the third anchoring mechanism **1415** may comprise a plurality of barbs or bulged portions having increased and variable sized cross-sectional areas along the length of the tension member **610**C. The anchoring mechanism **1415** may increase an amount of surface area of the tension member **610**C that is in contact with the sponge **315** so that the tension member **610**C may contract the sponge **315** when tension forces are applied to the tension member **610**C. The third anchoring mechanism **1415** may be formed integrally with the tension member **610**C.

FIG. **14**D is a diagram illustrating a cross-sectional view of a fourth anchoring mechanism **1420** for a tension member **610**D of a tensioning device **1400**D according to one exemplary embodiment of the invention. The tensioning device **1400**D illustrated in FIG. **14**D shares several elements which are similar to those of the tensioning device **610** of FIGS. **6**A-**6**E. Therefore, only the differences between these figures will be discussed and described in further detail below.

According to this exemplary embodiment illustrated in FIG. **14**D, the fourth anchoring mechanism **1420** may comprise a plurality of angled within barbs or spikes that grasp of the sponge **315**. The fourth anchoring mechanism **1420** may be formed integrally with the tension member **610**D. The invention is not limited to the angles for the barbs or spikes illustrated in FIG. **14**D. One of ordinary skill the art recognizes that other angles for the barbs or spikes along the tension member **610**D are within the scope of the invention.

FIG. **15**A is a diagram illustrating an elevation view of a dressing system **600**M with the tensioning device **610** according to one exemplary embodiment of the invention. The dressing system **600**M illustrated in FIG. **15**A shares several elements which are similar to those of the dressing system **600**B in FIGS. **6**F-**6**I. Therefore, only the differences between these figures will be discussed and described in further detail below.

According to this exemplary embodiment illustrated in FIG. **15**A, the sponge **315** may comprise a circular or elliptical shape. To appropriately grasp and compress the circularly shaped sponge **315**, the tension members **610** may extend in a radial manner relative to a geometric center of the circularly shaped sponge **315**.

In this exemplary embodiment, the end tensioning device **605**A in addition to the central member **625** may both comprise a circular or annular shape which corresponds with the circular shape of the sponge **315**.

FIG. **15**B is a diagram illustrating cross-sectional view of the dressing system with the tensioning device of FIG. **15**A according to one exemplary embodiment of the invention. As noted previously, the central member **625** of the tensioning device **610** may comprise a circular shape. Similarly, the end tensioning device **605**A may also comprise a circular shape to correspond with the circular shaped sponge **315**. The tensioning device **610** may comprise radial tension members **610**A and **610**B.

FIG. **15**C is a diagram illustrating an elevation view of a dressing system **600**N with the tensioning device **610** according to one exemplary embodiment of the invention. The dressing system **600**N illustrated in FIG. **15**C shares several elements which are similar to those of the dressing system **600**B in FIGS. **6**L-**6**M . Therefore, only the differences between these figures will be discussed and described in further detail below.

According to this exemplary embodiment illustrated in FIG. **15**C, the radial extended tension members **610** can be coupled to the edge of a wound through fastening mechanisms **615**. As noted previously, the fastening mechanisms **615** may comprise elements such as staples or suture threads or any combination thereof.

FIG. **15**D is a diagram illustrating an elevation view of the dressing system **600**N of FIG. **15**C with the end tensioning device **605**A in an extended position according to one exemplary embodiment of the invention. In this exemplary embodiment, the end tensioning device **605**A has been displaced or moved relative to the stationary central member **625**.

This causes the tension members **610** to be moved through the central member **625** and in a direction that corresponds with the end tensioning device **605**A. This action and movement of the radial tension members **610** through the circularly shaped central member **625** causes the sponge **315** to compress as illustrated in FIG. **15**E discussed below.

FIG. **15**E is a diagram illustrating cross-sectional view of the dressing systems **600**M, N of FIGS. **15**A and **15**C in a compressed state according to one exemplary embodiment of the invention. In this exemplary embodiment, the radial tension members **610** have been retracted and pulled through the central member **625**. The radial tension member **610** are coupled to the end tensioning device **605**A which has been moved or displaced relative to the stationary circular central member **625**. This movement and action of the radial tension members **610** causes the sponge **315** to compress or contract.

FIGS. **16**A-C are diagrams illustrating the sequence of steps that may be employed to secure fastening mechanisms **615**A to tissue **10** and a combination of a tension member **610** and a sponge **315** according to one exemplary embodiment of the invention. FIG. **16**A illustrates a fastening mechanism **615**A comprising a staple positioned above tissue **10** and a sponge **315** that includes a tension member **610**.

The attachment of the fastening mechanism **615**A to the tissue **10** and sponge **315** will usually be performed by medical personnel and preferably in a sterile environment, such as in a surgical operating room. Each fastening mechanism **615**A comprising a staple may be made of a material such as, but not limited to, metal, plastic, or a biodegradable material similar to the material used in suture threads.

FIG. **16**B is a diagram illustrating the fastening mechanism **615**A comprising a staple that is penetrating both the tissue **10** in the sponge **315** as well as the tensioning member **610**. FIG. **16**C is a diagram illustrating the fastening mechanism **615**A comprising of a staple that has penetrated the tissue **10**, sponge **315**, and tensioning member **610** and which has been bent slightly under these elements to provide a fuller connection between the fastening mechanism **615**A and these elements. In this way, when the tensioning member **610** is retracted or contracted, it will pool the tissue **10** in close contact with the sponge **315** as the sponge **315** contracts with the tensioning member **610**.

FIGS. **17**A-C are diagrams illustrating the sequence of steps that may be employed to secure alternate fastening mechanisms **615**B to tissue **10** and a combination of a tension member **610** and a sponge **315** according to one exemplary embodiment of the invention. According to this exemplary embodiment, the fastening mechanisms **615** may comprise suture thread.

The suture thread may be made from numerous materials, such as from biological materials. The suture threads may comprise synthetic materials, including absorbables like polyglycolic acid, polylactic acid, and polydioxanone as well as the non-absorbables nylon and polypropylene, and caprolactone. The suture threads may be coated with antimicrobial substances to reduce the chances of wound infection. The suture threads may have standard sizes and may be either absorbable (naturally biodegradable in the body) or non-absorbable. The suture threads usually must be strong enough to hold tissue securely but flexible enough to be knotted. They generally under most circumstances must be hypoallergenic and avoid any "wick effects" that may allow fluids and thus infection to penetrate the body along the suture thread tract.

FIG. **17**A is a diagram illustrating the fastening mechanism **615**B comprising suture thread to penetrate through tissue **10** and both the sponge **315** and the tension member **610**. A needle (not illustrated) may be used to push and pull the suture thread through the tissue **10**, the sponge **315**, and the tension member **610**.

FIG. **17**B is a diagram illustrating the fastening mechanism comprising suture thread that is knotted onto itself. Preferred, yet exemplary knots, for the suture thread may comprise a figure eight stitch and a horizontal mattress stitch. However, one of ordinary skill the art recognizes that other stitches not particularly identified are included within the scope of the invention. Meanwhile, an ordinary simple not has been illustrated in each of the figures.

FIG. **17**C is a diagram illustrating the fastening mechanism **615**B in a fully knotted state and for receiving any tension forces that could be exerted by the tensioning member **610**. The suture thread should have enough tensile strength to withstand any tensile forces applied by the dancing member **610** in order to slowly pool besides of a wound together in order to promote healing as discussed and described above.

FIG. **18**A is a diagram illustrating an elevation view of a dressing system **1800** with the tensioning device of FIGS. **6**A-**6**C and anchoring system **1805** according to one exemplary embodiment of the invention. The dressing system **1800** illustrated in FIG. **18**A shares several elements which are similar to those of the dressing system **600**B in FIGS. **6**F-**6**I and the anchoring system **1405** of FIG. **14**B. Therefore, only the differences between these figures will be discussed and described in further detail below.

In FIG. **18**A, the sponge **315** has an oval or a elliptical shape and has a corresponding tensioning device **610** with tensioning members **610**A,B and a central longitudinal member **625** along with an end tensioning device **605**A. At an outer edge or circumference of the sponge **315**, an anchoring mechanism **1805** may be provided. This anchoring system **1805** may comprise a lattice structure that is similar to the anchoring system **1405** of FIG. **14**B. One advantage of the anchoring mechanism **1805** comprising the lattice structure is that it allows medical personnel to trim and customize a shape of the sponge **315** and corresponding tension member **610**. Additionally, a perimeter of reinforced anchoring system would allow for anchoring to the skin in any area versus having to anchor the skin to the rib areas only.

FIG. **18**B is a diagram illustrating cross-sectional view of the dressing system of FIG. **18**A according to one exemplary embodiment of the invention. The anchoring system **1805** may attach to the sponge **315** as well as the tensioning members **610**. The anchoring system **1805** may be made of materials strong enough to withstand the tensile forces applied by the tensioning member **610** while also being pliable or malleable to be cut by medical personnel so that the sponge **315** and its corresponding tension member **610** can be customized with respect to shape.

FIG. **19** is a diagram illustrating a perspective view of a tensioning device **610** of a dressing system **1900** comprising two tensioning members **610**A, **610**B which may be wound around a central longitudinal member **625** according to one exemplary embodiment of the invention. Each tensioning member **610** may comprise a planar-like structure in which the length dimension L may be substantially greater than the width dimension W. Similarly, the width dimension W may be substantially greater than the thickness dimension T. Each tensioning member **610** may comprise a material which is both strong yet flexible to permit the tensioning member **610** to wind around the central longitudinal member **625**.

According to the exemplary embodiment illustrated in FIG. **19**, both the first and second tension members **610**A,B may be wound around the central longitudinal member **625** in a counterclockwise direction when tensile forces are desired to be applied to a corresponding sponge **315** (not illustrated). The central longitudinal member **625** may be biased by a spring **688** such that the central longitudinal member **625** constantly applies a tensile force to each tensioning member **610** by winding or rotating the central longitudinal member **625**. A continual tensioning device would prevent the need for clinicians to sequentially tension the device while also eliminating the chance that the clinician over tensions the system causing perfusion problems.

FIG. **20**A is a diagram illustrating an elevation view of a system **2000** for attaching multiple dressings together according to one exemplary embodiment of the invention. The dressings in FIG. **20**A share several elements which are similar to those of the dressing systems **600**B in FIGS. **6**F-**6**I. Therefore, only the differences between these figures will be discussed and described in further detail below.

The system **2000** provides at least two different coupling mechanisms **2005**, **2010** for linking or connecting several different dressings to one another. In the exemplary embodiment illustrated in FIG. **20**A, four separate substantially rectangular dressings that include four separate sponges **315** have been coupled together using the coupling mechanisms **2005**, **2010**.

The system **2000** may be ideal for those situations in which a wound **6** is significantly large and which may far exceed the average or standard sized dressing system that has a tensioning device. Further details of the exemplary coupling mechanisms **2005**, **2010** are illustrated in FIG. **20**B and FIG. **20**C and are described in further detail below. By placing the dressings in series, the tensioning mechanism will continue to pull one side towards the other. The tensioning arms can be connected through similar means as the skin using staples or suture or a specific fastening/linking device.

FIG. **20**B is a diagram illustrating a cross-sectional view of a first dressing-to-dressing coupling mechanism according to one exemplary embodiment of the invention. In this exemplary embodiment, the first coupling mechanism **2005** may comprise one of the fastening mechanisms **615** described above. Specifically, the fastening mechanism **615** may comprise a staple or a suture thread as discussed above. This first coupling mechanism **2005** may be employed for connecting lateral sides of sponges **315** together in which the lateral sides are parallel to the central longitudinal member **625**. The fastening mechanisms **615** can be used to couple one tensioning member **610** of a first dressing to a second tensioning member of a second dressing.

FIG. **20**C is a diagram illustrating a cross-sectional view of a second dressing-to-dressing coupling mechanism **2010** according to one exemplary embodiment of the invention. According to this exemplary embodiment, the second coupling mechanism **2010** may comprise a hook system between respective central longitudinal members **625** of at least two different dressings. A first dressing may have a central longitudinal member **625** with a first hook **2015**A while a second dressing may have a central longitudinal member **625** with a second hook **2015**B.

Each hook **2015** may have a geometrical shape that is opposite to another respective hook **2015** of another dressing. In other words, a single dressing may be provided with a central longitudinal member **625** having mirrored opposite geometrical shapes for its two hooks at the end of the central longitudinal member **625** so that respective dressings may be aligned so that their respective hooks **2015** can be mated with one another. These linking devices can be made pre-installed or come in the package to be attached only if needed.

While hooks **625** have been illustrated as one exemplary coupling mechanism **2010**, other types of coupling mechanisms **2010** not particularly described are included within the scope of the invention. For example, other coupling mechanisms **2010** may include, but are not limited to, clasps that have members which open and close, buttons, zippers, wedge anchors, and other like coupling mechanisms.

FIG. **21** is a diagram illustrating a cross-sectional view of a shell system **2100** for covering and protecting a dressing system and allow for an airtight seal according to one exemplary embodiment of the invention. The shell system **2100** may comprise a dressing with a tensioning device **610** and a sponge **315**, a shell **320**, and an adhesive **305**. The materials and parts of the system **2100** may be similar to those illustrated in FIG. **3**A and FIGS. **6**V-**6**W. Therefore, only the differences between these figures will be described below.

According to this exemplary embodiment of FIG. **21**, the shell **320** may form an air-tight seal over the dressing that comprises the tensioning device **610** and sponge **315**. The adhesive **305** may hold the shell **320** over the dressing. The shell **320** can comprise a solid material such as plastic or rubber, or even metal as noted previously. All of the elements of the dressing may be encompassed or encased within the shell **320**, such as any wires **330** or tubing **325** (not illustrated in this Figure) and which may be part of a wound-vacuum system **800** that is also part of the dressing. By covering the internal mechanisms by an external shell, the device can be made to be airtight to prevent any air leaks.

FIG. **22**A is a diagram illustrating a cross-sectional view of a suction device **2200** that may be used without a sponge for a wound **6** according to one exemplary embodiment of the invention. In this exemplary embodiment, the suction device **2200** may comprise tubing **325** that has an outer diameter **2220** and an inner diameter **2225**. A plurality of the holes or apertures **2205** may be present in the outer diameter **2225**. These holes **2205** may be part of channels **2215** that lead to the inner diameter **2205** of the main tube.

The tubing **325** in this embodiment could be filled (filler material **817**) with a porous material such as but not limited to a sponge, microspheres, or a screen at the interface of the hole and tissue. The purpose of filling the tube **325** with filler material **817** would be to prevent or limit the ability of the soft tissue to in-grow. Additionally, if there is any sponge or micro-sphere residue, it would be significantly reduced or limited. The "filler" material would allow suction transmission or fluid injection but prevent or limit clogging and in-growth of soft tissue.

The tubing **325** can be designed such that a section that does not face a wound **6** also does not have any apertures **2205** or channels **2215**. Conversely, any section which does face a wound **6** will have holes **2205** and channels **2215**. In this way, an air-tight seal may be formed over a wound **6** when a cover **2207** such as a bandage is placed over the tubing **325**.

As noted previously, tubing **325** can be made from a range of polymers, and may include, but is not limited to silicone rubber latex and thermoplastic elastomers. Silicone may be one of the most common choices because it is inert and unreactive to body fluids and a range of medical fluids with which it might come into contact. Other materials may include, but are not limited to, plastic and hard rubbers, or a combination thereof.

FIG. **22**B is a diagram illustrating a cross-sectional view of the suction device **2200** of FIG. **22**A without the wound environment according to one exemplary embodiment of the invention. In this exemplary embodiment, the inner diameter **2225** of the main channel that couples with the smaller channels **2215** that extend to the outer diameter **2220** can easily be seen.

FIG. **23** is a diagram illustrating a side view of the suction device **2200** of FIG. **22** according to one exemplary embodiment of the invention. According to this exemplary embodiment, the suction device **2200** comprises a long cylindrical tube having a plurality of holes or apertures **2205** that form entrances to channels **2215** that lead to the main channel having the inner diameter **2225**.

FIGS. **24**A-**24**E are diagrams illustrating a tubing system **2400** going from an expanded state to a compressed state according to exemplary embodiments of the invention. The materials and parts of the tubing system **2400** may be similar to those illustrated in FIG. **23**. Therefore, only the differences between these figures will be described below.

While the individual holes or apertures **2205** and each tube **325** have not been illustrated, these holes **2205** are present but have not been illustrated for the sake of a simple description and illustration. In this exemplary embodiment, the tubing **325** may extend in a radial fashion so that the tubing **325** extends in a substantially linear manner. Further, in this exemplary embodiment, the tubing system **2400** may further comprise a central, planar disc **2405** that is attached to a top surface of each one of the tubes **325**. The central disc **2405** may be attached to each one of the two through **25** by a fastening mechanism such as an adhesive or a plastic weld.

Next, in FIG. **24**B, the tubing **325** has been illustrated with curves because the tubing system **2400** has been rotated about a central geometrical axis in order to contract the tubing **325** towards the central geometrical axis. Specifically, the disc **2405** has been rotated in a counter clockwise fashion so that the tubes **325** are drawn closer relative to the disc **2405**. This can be accomplished through a crank mechanism (not illustrated).

FIGS. **24**C and **24**D illustrate further rotation of the central disc **2405** so that the tubes **325** are drawn closer towards the central disc **2405**. The tubes **325** may be attached to tissue **10** surrounding a wound **6**, so that the tubes **225** can grasp the tissue **10** and draw it closer to the central disc **2405** as the central disc **2405** is rotated. Additionally, the dressing is drawn into the middle allowing the skin to granulate in from the periphery. The dressing does not prevent peripheral secondary healing by retracting.

FIG. **24**E illustrates further contraction of the tubing **325** relative to the central disc **2405** after the central disc **2405** has been rotated. The central disc **2405** may be rotated over a predetermined time schedule, such as on the order of days, such that the tissue **10** surrounding a wound **6** (not illustrated in FIG. **24**) may be pulled in closer while the tubing **325** is contracted towards the central disk **2405** over time.

FIGS. **25**A-**25**B are diagrams illustrating a tubing system **2500** with a tension device **2505** according to one exemplary embodiments of the invention. The materials and parts of the tubing system **2500** may be similar to those of the tubing system **2400** illustrated in FIG. **24**. Therefore, only the differences between these figures will be described below.

According to this exemplary embodiment, the tubing system **2400** may comprise an integral central housing **2510** that receives each of the tubes **325**. The central housing **2510** may direct each of the tubes **325** to a central channel **2515** that is coupled to a feeding or exit tube **2520**. The feeding or exit tube **2520** may have a diameter that is larger than the diameters of the tubes **325**. Each of the tubes **325** may comprise apertures or holes **2205** but are not illustrated in this figure. A film **2517** may be provided between the tubes **325** to allow for an airtight seal. The film may be made from made from a range of polymers, like the tubes **325**, and may include, but is not limited to silicone rubber latex and thermoplastic elastomers. Other materials may include, but are not limited to, plastic and hard rubbers, or a combination thereof.

Positioned on one side of the central housing **2510** can be a tensioning device **2505**. The tensioning device **2505** may comprise a knob or gear that can be rotated in order to rotate the central housing **2510**. As discussed above in connection with FIG. **24**, rotation of the central housing **2510** and the corresponding tubing **325** causes the corresponding tubing to contract and move towards the central housing **2510**. Any tissue **10** (not illustrated) coupled to the ends of the tubing **325** may be pulled towards the central housing **2510** so that a wound **6** (not illustrated) may be closed or covered more by the tissue **10**.

FIG. **26** is a diagram illustrating a web-like tubing system **2600** according to one exemplary embodiment of the invention. The materials and parts of the tubing system **2600** may be similar to those of the tubing systems **2400** and **2500** illustrated in FIGS. **24**-**25**. Therefore, only the differences between these figures will be described below.

According to this exemplary embodiment, the web-like tubing system **2600** may further comprise a planar material **2605** that is positioned between each of the first tubes **325**A that extend from the central disc **2405** in a radial manner. This planar material **2605** may comprise materials similar to those from which the tubes **325** are made. The planar material **2605** may have a thickness which is typically less than a diameter of the tubes **325**. The planar material **2605** may be designed to form an air-tight seal over a wound **6** (not illustrated) when the web-like tubing system **2600** is positioned on top of the wound **6**. This film would be significantly pliable and thin to allow the system to collapse on itself and allow for wound contraction.

Also in this exemplary embodiment, each of the first tubes **325**A extending from the central disc **2405** in a radial manner may have second tubes **325**B that extend in circumferential direction relative to the central disc **2405** and which connect each first tube **325**A to a corresponding neighboring first tube **325**A. Each of the tubes **325**, including the first and second tubes **325**A, B, may comprise apertures or holes **2205** but are not illustrated in this figure for simplicity. The web-like tubing system **2600** may be trimmed with scissors to an appropriate size depending upon a particular size of a wound **6** (not illustrated).

FIG. **27** is a diagram illustrating another web-like tubing system **2700** according to one exemplary embodiment of the invention. The materials and parts of the tubing system **2700** may be similar to those of the tubing system **2600** illustrated in FIG. **26**. Therefore, only the differences between these figures will be described below.

According to this exemplary embodiment, the web-like tubing system **2700** may comprise planar materials **2705** that have an adhesive so that the planar material **2705** will adhere to wounded tissue **10**. The planar material **2705** having the adhesive may be positioned around a perimeter of the web-like tubing system **2700** in order to form an air-tight seal over a wound **6** (not illustrated). The adhesive could be on either the side of the skin/wound as well as on the side opposite the skin/wound. The adhesive on the skin side would assist in forming an airtight seal on the skin and assist in tensioning. The adhesive on the reverse side would assist in adhesion of a thin plastic film for creation of an airtight seal.

Similar to the other exemplary embodiments described above, each of the first and second tubes **325**A, **325**B may be attached to edges of tissue **10** that surround a wound **6** with fastening mechanisms **615** (not illustrated) that may comprise staples were suture threads. Each of the tubes **325**, including the first and second tubes **325**A, B, may comprise apertures or holes **2205** but are not illustrated in this figure for simplicity. The web-like tubing system **2700** may be trimmed with scissors to an appropriate size depending upon a particular size of a wound **6** (not illustrated).

FIGS. **28**A-**28**B are diagrams illustrating applications of a web-like tubing system **2800** with an adhesive perimeter to facilitate an airtight seal on the skin and prevent the need to put an airtight seal over the entire dressing (only a peripheral boarder is required) according to exemplary embodiments of the invention. The materials and parts of the tubing system **2800** may be similar to those of the tubing system **2700** illustrated in FIG. **27**. Therefore, only the differences between these figures will be described below.

Similar to the other exemplary embodiments described above, each of the first and second tubes **325**A, **325**B may be attached to edges of tissue **10** that surround a wound **6** with fastening mechanisms **615** (not illustrated) that may comprise staples or suture threads. Each of the tubes **325**, including the first and second tubes **325**A, B, may comprise apertures or holes **2205** but are not illustrated in this figure for simplicity. The web-like tubing system **2800** may be trimmed with scissors to an appropriate size depending upon a particular size of a wound **6** (not illustrated).

According to the exemplary embodiment illustrated in FIG. **28**A, the second tubes **325**B of the system **2800** may be attached to tissue **10** with fastening mechanisms **615** that may comprise staples. In the exemplary embodiment illustrated in FIG. **28**A, the wound **6** may have a conical shape and the tubing system **2800** may be shaped appropriately so that it mirrors the shape of the wound **6**.

According to the exemplary embodiment illustrated in FIG. **28**A, the web-like tubing system **2800** may comprise planar adhesive materials **2705**. A separate planar sheet **2805** of another adhesive may be used in combination with the planar adhesive material **2705** in order to fasten or secure the web-like tubing system **2000** to the wound **6** and surrounding tissue **10**. Similar to FIG. **28**A, the wound **6** of FIG. **28**B comprises a conical shape that has depth.

In each of the tubing systems **2400**, **2500**, **2600**, **2700**, and **2800**, the geometric central region of the tubing systems can be rotated in order to contract the first tubes **325** extending in the radial directions. This contraction of the first tubes **325**A may further close a wound **6** when the tubes **325**A, **325**B are attached to tissue **10** surrounding the wound **6**.

In FIG. **28**B, the illustration depicts a peripheral strip of adhesive film **2805** is placed only on the periphery of the dressing as appose to the entire dressing. The application of the adhesive film **2805** will create an airtight system despite not covering the entire dressing since the dressing will be airtight by design. This design may limit air leaks and loss of negative pressure since the only location of leaks can occur at the skin-dressing margin. Additionally, adhesive around the periphery of the dressing will facilitate the adhesion between the adhesive film and the dressing itself.

FIGS. **29**A-**29**F are diagrams illustrating a tissue filler system **2900** and its relative movement according to exemplary embodiments of the invention. According to the exemplary embodiment illustrated in FIG. **29**A, the tissue filler system **2900** may comprise a first small tube ring **325**A**2** and a second larger tube ring **325**A**1**. The first small tube ring **325**A**2** may be coupled to an exit or distribution tube **325**A**3**. The exit or distribution tube **325**A**3** may be coupled to a pump **340** (not illustrated) which may create a vacuum or which may distribute fluid. The first small tube ring **325**A**2** and second large ring tube **325**A**2** may have diameters of approximately 3 mm or less. However, one of ordinary skill the art recognizes that other diameters are included within the scope of the invention.

Since wounds can often be coupled with soft tissue loss as well as skin, the tissue filler system **2900** may be positioned in voids or defects in soft tissue **10**. The tissue filler system **2900** may be used for deep wounds **6** requiring deep wound care. The tissue filler system **2900** comprises a three-dimensional vacuum structure that can assist with reducing or eliminating infection in deep wounds **6** by removing fluids from the wounds **6**. One treatment goal for deep wounds or sinuses is to allow the wound to heal from the deep to superficial level by preventing the wound from closing at the superficial area first creating a closed space for abscess development.

In a fluid distribution context, fluid would enter the distribution tube **325**A**3** and then the fluid would proceed to the second smaller ring tube **325**A**2**. From the second smaller ring tube **325**A**2**, the fluid would be disbursed among the longitudinal tubes **325**. The fluid then would flow through each of the longitudinal tubes **325** and an exit through the apertures **2205** present in each longitudinal tube **325**. According to one exemplary embodiment, the longitudinal tubes **325** may be coupled together by transverse tubes **325**B**1** which may have holes or apertures similar to the longitudinal tubes **325**. The transverse tubes **325**B**1** may be made from the same materials as the longitudinal tubes **325** oriented at approximately ninety degrees relative to the transverse tubes **325**B**1**.

In the vacuum context, the flow of the fluid described above would be in reverse in which fluid would enter each of the apertures **2205** and then flow towards the exit tube **325**A**3**. The longitudinal tubes **325** may have diameters of approximately 1 mm or less. However, one of ordinary skill the art recognizes that other diameters are included within the scope of the invention.

A plurality of longitudinal tubes **325** are connected between the first small ring tube **325**A**2** and the larger ring tube **325**A**1**. Each of the longitudinal tubes **325** may further comprise apertures **2205** and channels **2215** (not illustrated), similar to the embodiment described above in connection with FIG. **22**A. In the exemplary embodiment illustrated in FIG. **29**A, the tissue filler system **2900** is any mid-or halfway expandable state as dictated by the position of the second larger ring tube **325**A**1**.

As noted previously, tubing **325** can be made from a range of polymers, and may include, but is not limited to silicone rubber latex and thermoplastic elastomers. Silicone may be one of the most common choices because it is inert and unreactive to body fluids and a range of medical fluids with which it might come into contact. Other materials may include, but are not limited to, plastic and hard rubbers, or a combination thereof.

In the exemplary embodiment illustrated in FIG. **29**B, the tissue filler system **2900** is illustrated with an increased magnification view to show more detail of the system **2900**. The longitudinal tubes **325** may be coupled to the first small ring tube **325**A**2** and second large ring tube **325**A**1** using adhesives or plastic welds. Between the longitudinal tubes **325**, transverse tubes **325**B**1** may be provided. The first small ring tube **325**A**2** and second large ring tube **325**A**1** in addition to the longitudinal tubes **325** may be formed by a single mold in order to form an integral structure without any discontinuities or separations that require coupling mechanisms.

In the exemplary embodiment illustrated in FIG. **29**C, the second larger ring tube **325**A**1** has been positioned closer to the first small ring tube **325**A**2** which causes the longitudinal tubes **325** to expand in a radial fashion relative to the ring tubes **325A1**, **325A2**. Further, the transverse tubes **325B1** illustrated in FIGS. **29**A-B have been removed. The transverse tubes **325B1** have been removed from this FIG. **29**C as well as the remaining FIGS. **29**D-F. However, the transverse tubes **325B1** may be added to these embodiments without departing from the invention.

As illustrated in FIG. **29**D, the second larger ring tube **325A1** has been displaced or moved apart relative to the first ring tube **325A2**. This relative movement of the first and second ring tubes **325A1**, A2 as illustrated in FIGS. **29**C-D causes the longitudinal tubes **325** to contract relative to their previous position as illustrated in FIG. **29**C. This second larger ring tube **325A1** can be incrementally moved relative to these first small ring tube **325A2** so that the displacement or contraction of the longitudinal tubes **325** is relatively small over the course of time which would allow for the closing of healthy tissue **10** surrounding a wound **6**.

A pliable and airtight material **2923** (that may be transparent in some exemplary embodiments) may be draped between the two rings **325A1** and **325A2**. By allowing this material **2923** to be pliable it will allow for the tensioning or retraction of the loops while maintaining an airtight system. Additionally, as described above an airtight seal between the peripheral skin edge and the dressing (the larger ring) would be obtained through thin adhesive strips.

In the exemplary embodiment of the tissue filler system **2900** of FIG. **29**E, a coupling mechanism **2920** positioned on the second larger ring tube **325A1** is illustrated. The coupling mechanism **2920** may comprise a valve that mates with a cylindrical end of one of the longitudinal tubes **325**.

If a tubular void or sinus is present near a wound **6**, then one or more of the longitudinal tubes **325** may be cut away from the second larger ring tube **325A1** such as illustrated in FIG. **29**E. In the exemplary embodiment illustrated in FIG. **29**E the longitudinal tube **325A4** has been cut so that it is removed from the second larger ring tube **325A1**. In the exemplary embodiment illustrated in FIG. **29**F, the cut longitudinal tube **325A4** can be moved into tubular voids or a sinus that may be present adjacent to a wound **6**. Additionally, other common drains (such as, but not limited to, a JACKSON PRATT™ brand drain) that are available in the market today could be attached to the suction mechanism in order to allow for sinus management or multiple wounds.

For the dressing systems described above which may include a tensioning device **610**, locking mechanisms may be employed to prevent loss of traction on the edges of tissue **10**. According to some of the exemplary embodiments, traction or tensile forces may be applied to the central longitudinal member **625** allowing for the edges of tissue **10**, such as skin, to be brought closer together and to compress a sponge **315**. After 3 to 5 days, the sponge **315** may be removed and the edges of the tissue **10**, such as skin, may be directly repaired without the need for skin grafts. With the exemplary embodiments described above, closure of wounds **6** may occur over a period of days to weeks while tensile forces are applied to a tensioning device **610**. Alternatively, wound management that allows for partial wound closure but not complete closure will reduce the needs for large amounts of skin grafting or even free flaps.

According to one alternate exemplary embodiment (not illustrated), the Roman sandal chord **1215** may be embedded into a dressing system such as in a sponge **315**. With such a system, the sponge **315** usually would not be trimmed or cut in order to prevent accidental cutting or damage to the Roman sandal cord **1215**.

Certain steps in the processes or process flows described in this specification listed below and mentioned above naturally precede others for the invention to function as described. However, the invention is not limited to the order of the steps described if such order or sequence does not alter the functionality of the invention. That is, it is recognized that some steps may performed before, after, or parallel (substantially simultaneously with) other steps without departing from the scope and spirit of the invention. In some instances, certain steps may be omitted or not performed without departing from the invention. Further, words such as "thereafter", "then", "next", etc. are not intended to limit the order of the steps. These words are simply used to guide the reader through the description of the exemplary method.

Referring now to FIG. **30**, this figure is a flowchart illustrating a method **3000** for promoting the healing of injured tissue. Step **3002** is the first step of the method **3000** in which a dressing system may be provided with an absorbent material that may expand or contract for promoting healing of the injured tissue. The dressing system may comprise anyone of those illustrated in FIGS. **1**-**29** of this disclosure. The absorbent material may comprise a sponge, such as sponge **315** described above.

Next, in step **3005**, the dressing system may be provided with an environmental sensor. The environmental sensor may comprise at least one of and/or a combination of a near infrared spectroscopy (NIRS), pH, temperature sensor, or any other similar sensors. As discussed above, a NIRS sensor may detect oxygenation levels adjacent to injured tissue. A pH sensor may detect acid levels near injured tissue while a temperature sensor may provide temperature readings adjacent to injured tissue. One or more computers may be coupled to these environmental sensors.

Subsequently, in step **3010**, the dressing system may be provided with a tensioning system such as illustrated in FIGS. **2**A-**2**B and FIG. **6**. The tensioning system may apply tensile forces to the dressing system in order to close or move the injured tissue while it heals.

Next, in step **3015**, the dressing system may be provided with a suction and/or irrigation system such as illustrated in FIGS. **3**-**5**, **8**, and **10**-**11**. This means that the dressing system may be provided with a suction system that removes fluid from the injured tissue. Alternatively, or in combination with the suction system, the dressing system may be provided with a separate irrigation system that applies fluids, such as those containing antibiotics and other health promoting substances, to the injured tissue.

In step **3020**, the dressing system may be sized and/or shaped and applied to the injured tissue. In this step, materials that form part of the dressing system, such as a sponge **315**, may be cut or manufactured to an appropriate geometrical shape that matches the injured tissue. Alternatively, in this step, when the dressing system is being manufactured, it may be provided with a particular geometric shape to match a specific section of the human anatomy such as an arm, leg, or torso region, such as illustrated in FIG. **1**.

In step **3025**, one or more environmental conditions of the injured tissue adjacent to the dressing system may be monitored. For example, if a NIRS sensor is provided with the dressing system, then the oxygenation levels adjacent to the injured tissue may be monitored and recorded. Similarly, if a pH sensor or a temperature sensor is provided with the dressing system, then acid levels as well as temperature of the injured tissue may be monitored and recorded. In this step, computer implemented algorithms and software may be provided for operating and monitoring the environmental sensors for the automatic detection of change in various environmental conditions relative to the injured tissue.

In step **3030**, tension may be applied to the dressing system as appropriate. This tension may be applied by a medical personnel as well as by a machine such as a motor that is under the control of a computer. In step **3035**, over tensioning of the tensioning system may be prevented through mechanical devices and/or various sensors. These sensors may be coupled to a computer. The computer may provide feedback to a medical personnel when tension is applied by the medical personnel or by a machine, or a combination thereof. The computer may sound one or more various alarms if over tensioning is detected by the one or more tension sensors.

In step **3040**, fluids adjacent to the dressing system and the injured tissue may be removed with a suction system. The suction system may comprise a vacuum producing device which produces negative pressure that draws fluid produced by injured tissue through one or more various tubes coupled to the dressing system. In step **3040**, health promoting substances in the form of fluids may also be applied with an irrigation system coupled to the dressing system which provides liquid delivery of substances such as drugs, antibiotics, and other similar substances. The process then may return and continue with anyone of the aforementioned steps described above.

For any software described in the flow chart discussed above and in the computer-implemented embodiments illustrated in the various Figures of this disclosure, one of ordinary skill in programming is able to write computer code or identify appropriate hardware and/or circuits to implement the disclosed invention without difficulty based on the flow charts and associated description in this specification. Therefore, disclosure of a particular set of program code instructions or detailed hardware devices is not considered necessary for an adequate understanding of how to make and use the invention. The inventive functionality of the claimed computer implemented processes is explained in more detail in the above description and in conjunction with the Figures which may illustrate various process flows.

With respect to computer based systems described in connection with the dressing system described above, in one or more exemplary aspects, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted as one or more instructions or code on a computer-readable medium. Computer-readable media include both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage media may be any available media that may be accessed by a computer. By way of example, and not limitation, such computer-readable media may comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that may be used to carry or store desired program code in the form of instructions or data structures and that may be accessed by a computer.

Although selected aspects have been illustrated and described in detail, it will be understood that various substitutions and alterations may be made therein without departing from the spirit and scope of the present invention, as defined by the following claims.

What is claimed is:

1. A dressing system comprising:

a sponge;

a near infrared spectroscopy (NIRS) sensor positioned adjacent to the sponge for monitoring oxygenation levels of open tissue adjacent to the sponge;

a tube coupled to the sponge for removing fluid from the sponge; and

a central longitudinal member coupled to the sponge and for providing an adjustable tension force to at least one tensioning member having a length, the at least one tensioning member being coupled to the central longitudinal member, the central longitudinal member receiving a portion of the length of the at least one tensioning member when tension is applied to the at least one tensioning member by the central longitudinal member.

2. The dressing system of claim **1**, wherein the tube is coupled to a pump that creates negative pressure relative to the sponge.

3. The dressing system of claim **1**, wherein the NIRS sensor comprises at least one light source and at least one light detector.

4. The dressing system of claim **1**, wherein the NIRS sensor is coupled to a computer.

5. The dressing system of claim **1**, wherein the NIRS sensor is coupled to an alarm.

6. The dressing system of claim **5**, wherein the alarm comprises at least one of an audible indicator and a visual indicator.

7. The dressing system of claim **1**, wherein the at least one tensioning member applies tensile forces to the sponge for retracting the sponge.

8. The dressing system of claim **7**, further comprising a plurality of tensioning members coupled to the central longitudinal member, the tensioning members and central longitudinal member forming a tensioning system.

9. The dressing system of claim **8**, wherein the tensioning system is coupled to tissue with one or more fastening mechanisms.

10. The dressing system of claim **9**, wherein the fastening mechanisms comprise one of staples and suture threads.

11. A dressing system comprising:

a sponge;

a tensioning system coupled to the sponge, the tensioning system further comprising:

a central longitudinal member coupled to the sponge and for providing an adjustable tension force to at least one tensioning member having a length, the at least one tensioning member being coupled to the central longitudinal member, the central longitudinal member receiving a portion of the length of the at least one tensioning member when tension is applied to the at least one tensioning member by the central longitudinal member.

12. The dressing system of claim **11**, wherein the tensioning system further comprises an end tensioning mechanism for applying tensile forces to the at least one tensioning member which causes the sponge to contract.

13. The dressing system of claim **11**, wherein the at least one tensioning member comprises a flexible tape-like material.

14. The dressing system of claim **11**, further comprising a tube for removing fluid from the sponge and a vacuum system coupled to the tube.

15. The dressing system of claim **11**, further comprising a tube for sending fluids to the sponge.

16. A method for promoting healing of injured tissue with a dressing system, the method comprising:

providing the dressing system with a flexible, absorbent material comprising a sponge;

providing the dressing system with an environmental sensor;

providing a tensioning system coupled to the dressing system;

applying the dressing system to the injured tissue;

monitor one or more environmental conditions relative to the injured tissue with the environmental sensor; and

applying tension to the dressing system with the tensioning system, the tensioning system comprising a central longitudinal member coupled to the sponge and for providing an adjustable tension force to at least one tensioning member having a length, the at least one tensioning member being coupled to the central longitudinal member, the central longitudinal member receiving a portion of the length of the at least one tensioning member when tension is applied to the at least one tensioning member by the central longitudinal member.

17. The method of claim **16**, wherein the environmental sensor comprises at least one of an oxygenation sensor, a pH level sensor, and a temperature sensor.

18. The method of claim **16**, wherein applying tension to the dressing system further comprises applying tensile forces to the dressing system with a plurality of tensioning members coupled to the central longitudinal member.

19. The method of claim **16**, further comprising providing the dressing system with a suction system for removing fluid from the injured tissue adjacent to the dressing system.

20. The method of claim **16**, further comprising coupling the at least one tensioning member to tissue and the sponge with one or more fastening mechanisms.

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专利名称(译)	用于促进受损组织愈合的方法和敷料系统		
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摘要(译)

公开了一种敷料系统，其具有海绵和邻近海绵定位的近红外光谱传感器，用于监测与海绵相邻的组织的氧合水平。敷料系统还可包括连接到海绵的管，用于从海绵中移除流体。敷料系统包括：海绵;和连接到海绵的张紧系统。张紧系统还包括连接到海绵的中央纵向构件;至少一个张紧构件连接到中央纵向构件。顺序压缩系统包括：包络套管敷料;以及既可伸缩又可伸缩的膀胱。还描述了一种组织填充系统，其包括多个管;其中，所述多个管中的每个管还包括孔;泵和一个泵连接到至少一个管上，这样就不需要任何海绵或卷绕屏。