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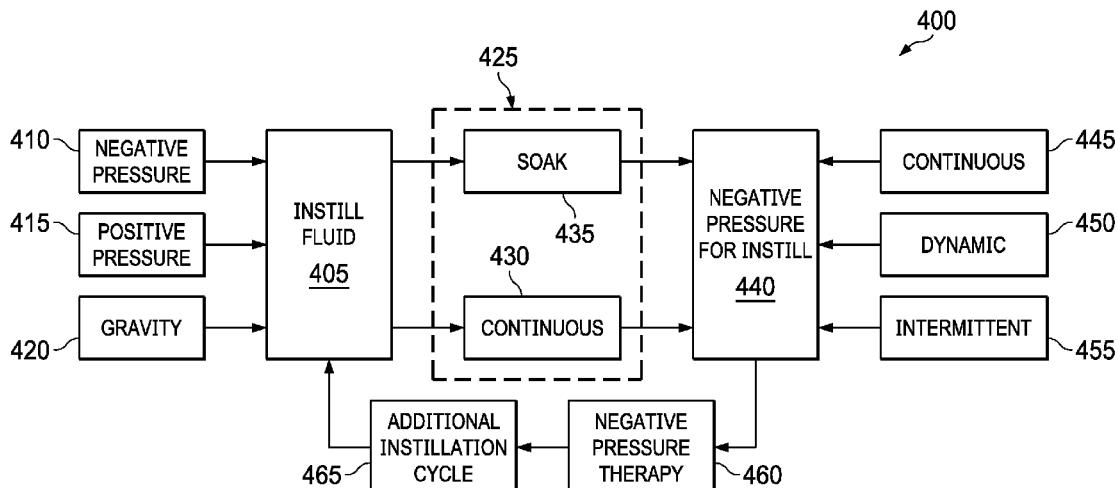


FIG. 4

(57) Abstract: An apparatus for treating a tissue site comprising a negative-pressure source configured to be fluidly coupled to the tissue site; an instillation source configured to be fluidly coupled to the tissue site; and a controller operatively coupled to the negative-pressure source and to the instillation source. The controller can be configured to operate the negative-pressure source and the instillation source to intermittently deliver negative pressure to the tissue site for a negative-pressure interval and deliver instillation fluid to the tissue site for an instillation interval. A purge volume of instillation fluid may be delivered to the tissue site at a purge frequency. In some examples, the purge volume may be delivered through the second fluid conductor and removed through the first fluid conductor during a negative-pressure interval.

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SYSTEMS AND METHODS FOR INSTILLATION PURGING

RELATED APPLICATION

[0001] The present invention claims the benefit of the filing of U.S. Provisional Patent Application No. 62/797,035, filed January 25, 2019, which is incorporated herein by reference for all purposes.

TECHNICAL FIELD

[0002] The invention set forth in the appended claims relates generally to tissue treatment systems and more particularly, but without limitation, to treating tissue with negative-pressure and instillation therapy.

BACKGROUND

[0003] Clinical studies and practice have shown that reducing pressure in proximity to a tissue site can augment and accelerate growth of new tissue at the tissue site. The applications of this phenomenon are numerous, but it has proven particularly advantageous for treating wounds. Regardless of the etiology of a wound, whether trauma, surgery, or another cause, proper care of the wound is important to the outcome. Treatment of wounds or other tissue with reduced pressure may be commonly referred to as "negative-pressure therapy," but is also known by other names, including "negative-pressure wound therapy," "reduced-pressure therapy," "vacuum therapy," "vacuum-assisted closure," and "topical negative-pressure," for example. Negative-pressure therapy may provide a number of benefits, including migration of epithelial and subcutaneous tissues, improved blood flow, and micro-deformation of tissue at a wound site. Together, these benefits can increase development of granulation tissue and reduce healing times.

[0004] There is also widespread acceptance that cleansing a tissue site can be highly beneficial for new tissue growth. For example, a wound or a cavity can be washed out with a liquid solution for therapeutic purposes. These practices are commonly referred to as "irrigation" and "lavage". "Instillation" is another practice that generally refers to a process of slowly introducing fluid to a tissue site and leaving the fluid for a prescribed period of time before removing the fluid. For example, instillation of topical treatment solutions over a

wound bed can be combined with negative-pressure therapy to further promote wound healing by loosening soluble contaminants in a wound bed and removing infectious material. As a result, soluble bacterial burden can be decreased, contaminants removed, and the wound cleansed.

[0005] While the clinical benefits of negative-pressure therapy and/or instillation therapy are widely known, improvements to therapy systems, components, and processes may benefit healthcare providers and patients.

[0006] Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

BRIEF SUMMARY

[0007] According to one aspect of the present invention, there is provided an apparatus for treating a tissue site, the apparatus comprising: a negative-pressure source configured to be fluidly coupled to the tissue site; an instillation source configured to be fluidly coupled to the tissue site; and a controller operatively coupled to the negative-pressure source and to the instillation source, the controller configured to: operate the negative-pressure source and the instillation source to intermittently deliver negative pressure to the tissue site for a negative-pressure interval and deliver a fill volume of instillation fluid to the tissue site for an instillation interval, and deliver a purge volume of instillation fluid to the tissue site at a purge frequency; and deliver the purge volume during the negative-pressure interval.

[0008] According to another aspect of the present invention, there is provided a method of treating a tissue site with negative-pressure and therapeutic solution, the method comprising: delivering the negative pressure to the tissue site for a first interval; delivering a fill volume of the therapeutic solution to the tissue site for a second interval; and delivering a purge volume of the therapeutic solution to the tissue site; the purge volume being delivered during the first interval.

[0009] According to another aspect of the present invention, there is provided an apparatus for treating a tissue site, the apparatus comprising: a dressing; a first fluid conductor coupled to the dressing; a negative-pressure source coupled to the first fluid conductor; an instillation source coupled to the second fluid conductor; and a controller operatively coupled to the negative-pressure source and to the instillation source, the

controller configured to: deliver negative pressure to the dressing through the first fluid conductor for a negative-pressure interval, deliver a fill volume of instillation fluid to the dressing through the second fluid conductor for an instillation interval, and deliver a purge volume of instillation fluid to the dressing through the second fluid conductor at a purge frequency; wherein the purge volume is delivered during the negative-pressure interval.

[0010] New and useful systems, apparatuses, and methods for treating tissue with negative pressure, instillation of therapeutic solutions, or both, are set forth in the appended claims. Illustrative embodiments are also provided to enable a person skilled in the art to make and use the claimed subject matter.

[0011] For example, in some embodiments, a therapy apparatus may be capable of intermittently delivering various instillation solutions to a wound bed. Solution instillation can occur during a pause in negative pressure, allowing the solution to soak and solubilize wound debris for a set time. The solution and solubilized debris can be removed during a subsequent cycle of negative pressure. The therapy apparatus may additionally have a controller configured to provide intermittent purge cycles of vacuum tubing during a negative-pressure phase to minimize wound fluid build-up and potential blockage. Additionally or alternatively, the controller may be configured to provide intermittent purge cycles of instillation tubing using a relatively small volume of instillation solution to minimize the deposition of material at the interface between a dressing and tubing. Software controls may provide a user interface for setting various levels of instillation purge. For example, the level may depend on the type of instillation solution and other factors associated with the wound etiology, which can impact viscosity and other exudate characteristics.

[0012] More generally, an apparatus for treating a tissue site may comprise a negative-pressure source configured to be fluidly coupled to the tissue site; an instillation source configured to be fluidly coupled to the tissue site; and a controller operatively coupled to the negative-pressure source and to the instillation source. In some examples, the negative-pressure source may be coupled to a first fluid conductor configured to be coupled to a dressing, and the instillation source may be coupled to a second fluid conductor configured to be coupled to the dressing. The controller can be configured to operate the negative-pressure source and the instillation source to intermittently deliver negative pressure to the tissue site for a negative-pressure interval and deliver instillation fluid to the tissue site for an instillation interval. A purge volume of instillation fluid may be delivered to the tissue site at a purge frequency. In some examples, the purge volume may be delivered through the

second fluid conductor and removed through the first fluid conductor during a negative-pressure interval.

[0013] A method of treating a tissue site with negative-pressure and therapeutic solution can comprise delivering the negative pressure to the tissue site for a first interval; delivering the therapeutic solution to the tissue site for a second interval; and delivering a purge volume of the therapeutic solution to the tissue site during the first interval. Alternatively, the purge volume may be delivered before the first interval. The purge volume may be removed by negative pressure during the first interval.

[0014] Unless the context clearly requires otherwise, throughout the description and the claims, the words “comprise”, “comprising”, and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of “including, but not limited to”.

[0015] Objectives, advantages, and a preferred mode of making and using the claimed subject matter may be understood best by reference to the accompanying drawings in conjunction with the following detailed description of illustrative embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Figure 1 is a functional block diagram of an example embodiment of a therapy system that can provide negative-pressure treatment and instillation treatment in accordance with this specification;

[0017] Figure 2 is a graph illustrating additional details of example pressure control modes that may be associated with some embodiments of the therapy system of Figure 1;

[0018] Figure 3 is a graph illustrating additional details that may be associated with another example pressure control mode in some embodiments of the therapy system of Figure 1;

[0019] Figure 4 is a chart illustrating details that may be associated with an example method of operating the therapy system of Figure 1; and

[0020] Figure 5 is a graph illustrating additional details of another example control mode that may be associated with some embodiments of the therapy system of Figure 1.

DESCRIPTION OF EXAMPLE EMBODIMENTS

[0021] The following description of example embodiments provides information that enables a person skilled in the art to make and use the subject matter set forth in the appended claims, but it may omit certain details already well known in the art. The following detailed description is, therefore, to be taken as illustrative and not limiting.

[0022] The example embodiments may also be described herein with reference to spatial relationships between various elements or to the spatial orientation of various elements depicted in the attached drawings. In general, such relationships or orientation assume a frame of reference consistent with or relative to a patient in a position to receive treatment. However, as should be recognized by those skilled in the art, this frame of reference is merely a descriptive expedient rather than a strict prescription.

[0023] Therapy System

[0024] Figure 1 is a simplified functional block diagram of an example embodiment of a therapy system 100 that can provide negative-pressure therapy with instillation of topical treatment solutions to a tissue site in accordance with this specification.

[0025] The term “tissue site” in this context broadly refers to a wound, defect, or other treatment target located on or within tissue, including, but not limited to, bone tissue, adipose tissue, muscle tissue, neural tissue, dermal tissue, vascular tissue, connective tissue, cartilage, tendons, or ligaments. A wound may include chronic, acute, traumatic, subacute, and dehisced wounds, partial-thickness burns, ulcers (such as diabetic, pressure, or venous insufficiency ulcers), flaps, and grafts, for example. The term “tissue site” may also refer to areas of any tissue that are not necessarily wounded or defective, but are instead areas in which it may be desirable to add or promote the growth of additional tissue. For example, negative pressure may be applied to a tissue site to grow additional tissue that may be harvested and transplanted.

[0026] The therapy system 100 may include a source or supply of negative pressure, such as a negative-pressure source 105, and one or more distribution components. A distribution component is preferably detachable and may be disposable, reusable, or recyclable. A dressing, such as a dressing 110, and a fluid container, such as a container 115, are examples of distribution components that may be associated with some examples of the therapy system 100. As illustrated in the example of Figure 1, the dressing 110 may comprise or consist essentially of a tissue interface 120, a cover 125, or both in some embodiments.

[0027] A fluid conductor is another illustrative example of a distribution component. A “fluid conductor,” in this context, broadly includes a tube, pipe, hose, conduit, or other

structure with one or more lumina or open pathways adapted to convey a fluid between two ends. Typically, a tube is an elongated, cylindrical structure with some flexibility, but the geometry and rigidity may vary. Moreover, some fluid conductors may be molded into or otherwise integrally combined with other components. Distribution components may also include or comprise interfaces or fluid ports to facilitate coupling and de-coupling other components. In some embodiments, for example, a dressing interface may facilitate coupling a fluid conductor to the dressing 110. For example, such a dressing interface may be a SENSAT.R.A.C.TM Pad, available from Kinetic Concepts, Inc. of San Antonio, Texas.

[0028] The therapy system 100 may also include a regulator or controller, such as a controller 130. Additionally, the therapy system 100 may include sensors to measure operating parameters and provide feedback signals to the controller 130 indicative of the operating parameters. As illustrated in Figure 1, for example, the therapy system 100 may include a first sensor 135 and a second sensor 140 coupled to the controller 130.

[0029] The therapy system 100 may also include a source of instillation solution. In some examples, an instillation source may comprise a solution source operatively coupled to a positive-pressure source. For example, a solution source 145 may be fluidly coupled to the dressing 110, as illustrated in the example embodiment of Figure 1. The solution source 145 may be fluidly coupled to a pump or other positive-pressure source, such as a positive-pressure source 150, a negative-pressure source, such as the negative-pressure source 105, or both, in some embodiments. A regulator, such as an instillation regulator 155, may also be fluidly coupled to the solution source 145 and the dressing 110 to ensure proper dosage of instillation solution (e.g. saline) to a tissue site. For example, the instillation regulator 155 may comprise a piston that can be pneumatically actuated by the negative-pressure source 105 to draw instillation solution from the solution source during a negative-pressure interval and to instill the solution to a dressing during a venting interval. Additionally or alternatively, the controller 130 may be coupled to the negative-pressure source 105, the positive-pressure source 150, or both, to control dosage of instillation solution to a tissue site. In some embodiments, the instillation regulator 155 may also be fluidly coupled to the negative-pressure source 105 through the dressing 110, as illustrated in the example of Figure 1.

[0030] Some components of the therapy system 100 may be housed within or used in conjunction with other components, such as sensors, processing units, alarm indicators, memory, databases, software, display devices, or user interfaces that further facilitate therapy.

For example, in some embodiments, the negative-pressure source 105 may be combined with the controller 130, the solution source 145, and other components into a therapy unit.

[0031] In general, components of the therapy system 100 may be coupled directly or indirectly. For example, the negative-pressure source 105 may be directly coupled to the container 115 and may be indirectly coupled to the dressing 110 through the container 115. Coupling may include fluid, mechanical, thermal, electrical, or chemical coupling (such as a chemical bond), or some combination of coupling in some contexts. For example, the negative-pressure source 105 may be electrically coupled to the controller 130 and may be fluidly coupled to one or more distribution components to provide a fluid path to a tissue site. In some embodiments, components may also be coupled by virtue of physical proximity, being integral to a single structure, or being formed from the same piece of material.

[0032] A negative-pressure supply, such as the negative-pressure source 105, may be a reservoir of air at a negative pressure or may be a manual or electrically-powered device, such as a vacuum pump, a suction pump, a wall suction port available at many healthcare facilities, or a micro-pump, for example. “Negative pressure” generally refers to a pressure less than a local ambient pressure, such as the ambient pressure in a local environment external to a sealed therapeutic environment. In many cases, the local ambient pressure may also be the atmospheric pressure at which a tissue site is located. Alternatively, the pressure may be less than a hydrostatic pressure associated with tissue at the tissue site. Unless otherwise indicated, values of pressure stated herein are gauge pressures. References to increases in negative pressure typically refer to a decrease in absolute pressure, while decreases in negative pressure typically refer to an increase in absolute pressure. While the amount and nature of negative pressure provided by the negative-pressure source 105 may vary according to therapeutic requirements, the pressure is generally a low vacuum, also commonly referred to as a rough vacuum, between -5 mm Hg (-667 Pa) and -500 mm Hg (-66.7 kPa). Common therapeutic ranges are between -50 mm Hg (-6.7 kPa) and -300 mm Hg (-39.9 kPa).

[0033] The container 115 is representative of a container, canister, pouch, or other storage component, which can be used to manage exudates and other fluids withdrawn from a tissue site. In many environments, a rigid container may be preferred or required for collecting, storing, and disposing of fluids. In other environments, fluids may be properly disposed of without rigid container storage, and a re-usable container could reduce waste and costs associated with negative-pressure therapy.

[0034] A controller, such as the controller 130, may be a microprocessor or computer programmed to operate one or more components of the therapy system 100, such as the negative-pressure source 105. In some embodiments, for example, the controller 130 may be a microcontroller, which generally comprises an integrated circuit containing a processor core and a memory programmed to directly or indirectly control one or more operating parameters of the therapy system 100. Operating parameters may include the power applied to the negative-pressure source 105, the pressure generated by the negative-pressure source 105, or the pressure distributed to the tissue interface 120, for example. The controller 130 is also preferably configured to receive one or more input signals, such as a feedback signal, and programmed to modify one or more operating parameters based on the input signals.

[0035] Sensors, such as the first sensor 135 and the second sensor 140, are generally known in the art as any apparatus operable to detect or measure a physical phenomenon or property, and generally provide a signal indicative of the phenomenon or property that is detected or measured. For example, the first sensor 135 and the second sensor 140 may be configured to measure one or more operating parameters of the therapy system 100. In some embodiments, the first sensor 135 may be a transducer configured to measure pressure in a pneumatic pathway and convert the measurement to a signal indicative of the pressure measured. In some embodiments, for example, the first sensor 135 may be a piezo-resistive strain gauge. The second sensor 140 may optionally measure operating parameters of the negative-pressure source 105, such as a voltage or current, in some embodiments. Preferably, the signals from the first sensor 135 and the second sensor 140 are suitable as an input signal to the controller 130, but some signal conditioning may be appropriate in some embodiments. For example, the signal may need to be filtered or amplified before it can be processed by the controller 130. Typically, the signal is an electrical signal, but may be represented in other forms, such as an optical signal.

[0036] The tissue interface 120 can be generally adapted to partially or fully contact a tissue site. The tissue interface 120 may take many forms, and may have many sizes, shapes, or thicknesses, depending on a variety of factors, such as the type of treatment being implemented or the nature and size of a tissue site. For example, the size and shape of the tissue interface 120 may be adapted to the contours of deep and irregular shaped tissue sites. Any or all of the surfaces of the tissue interface 120 may have an uneven, coarse, or jagged profile.

[0037] In some embodiments, the tissue interface 120 may comprise or consist essentially of a manifold. A manifold in this context may comprise or consist essentially of a

means for collecting or distributing fluid across the tissue interface 120 under pressure. For example, a manifold may be adapted to receive negative pressure from a source and distribute negative pressure through multiple apertures across the tissue interface 120, which may have the effect of collecting fluid from across a tissue site and drawing the fluid toward the source. In some embodiments, the fluid path may be reversed or a secondary fluid path may be provided to facilitate delivering fluid, such as fluid from a source of instillation solution, across a tissue site.

[0038] In some illustrative embodiments, a manifold may comprise a plurality of pathways, which can be interconnected to improve distribution or collection of fluids. In some illustrative embodiments, a manifold may comprise or consist essentially of a porous material having interconnected fluid pathways. Examples of suitable porous material that can be adapted to form interconnected fluid pathways (e.g., channels) may include cellular foam, including open-cell foam such as reticulated foam; porous tissue collections; and other porous material such as gauze or felted mat that generally include pores, edges, and/or walls. Liquids, gels, and other foams may also include or be cured to include apertures and fluid pathways. In some embodiments, a manifold may additionally or alternatively comprise projections that form interconnected fluid pathways. For example, a manifold may be molded to provide surface projections that define interconnected fluid pathways.

[0039] In some embodiments, the tissue interface 120 may comprise or consist essentially of reticulated foam having pore sizes and free volume that may vary according to needs of a prescribed therapy. For example, reticulated foam having a free volume of at least 90% may be suitable for many therapy applications, and foam having an average pore size in a range of 400-600 microns (40-50 pores per inch) may be particularly suitable for some types of therapy. The tensile strength of the tissue interface 120 may also vary according to needs of a prescribed therapy. For example, the tensile strength of foam may be increased for instillation of topical treatment solutions. The 25% compression load deflection of the tissue interface 120 may be at least 0.35 pounds per square inch, and the 65% compression load deflection may be at least 0.43 pounds per square inch. In some embodiments, the tensile strength of the tissue interface 120 may be at least 10 pounds per square inch. The tissue interface 120 may have a tear strength of at least 2.5 pounds per inch. In some embodiments, the tissue interface may be foam comprised of polyols, such as polyester or polyether, isocyanate, such as toluene diisocyanate, and polymerization modifiers, such as amines and tin compounds. In some examples, the tissue interface 120 may be reticulated polyurethane

foam such as found in GRANUFOAM™ dressing or V.A.C. VERAFL™ dressing, both available from Kinetic Concepts, Inc. of San Antonio, Texas.

[0040] The thickness of the tissue interface 120 may also vary according to needs of a prescribed therapy. For example, the thickness of the tissue interface may be decreased to reduce tension on peripheral tissue. The thickness of the tissue interface 120 can also affect the conformability of the tissue interface 120. In some embodiments, a thickness in a range of about 5 millimeters to 10 millimeters may be suitable.

[0041] The tissue interface 120 may be either hydrophobic or hydrophilic. In an example in which the tissue interface 120 may be hydrophilic, the tissue interface 120 may also wick fluid away from a tissue site, while continuing to distribute negative pressure to the tissue site. The wicking properties of the tissue interface 120 may draw fluid away from a tissue site by capillary flow or other wicking mechanisms. An example of a hydrophilic material that may be suitable is a polyvinyl alcohol, open-cell foam such as V.A.C. WHITEFOAM™ dressing available from Kinetic Concepts, Inc. of San Antonio, Texas. Other hydrophilic foams may include those made from polyether. Other foams that may exhibit hydrophilic characteristics include hydrophobic foams that have been treated or coated to provide hydrophilicity.

[0042] In some embodiments, the tissue interface 120 may be constructed from bioresorbable materials. Suitable bioresorbable materials may include, without limitation, a polymeric blend of polylactic acid (PLA) and polyglycolic acid (PGA). The polymeric blend may also include, without limitation, polycarbonates, polyfumarates, and capralactones. The tissue interface 120 may further serve as a scaffold for new cell-growth, or a scaffold material may be used in conjunction with the tissue interface 120 to promote cell growth. A scaffold is generally a substance or structure used to enhance or promote the growth of cells or formation of tissue, such as a three-dimensional porous structure that provides a template for cell growth. Illustrative examples of scaffold materials include calcium phosphate, collagen, PLA/PGA, coral hydroxy apatites, carbonates, or processed allograft materials.

[0043] In some embodiments, the cover 125 may provide a bacterial barrier and protection from physical trauma. The cover 125 may also be constructed from a material that can reduce evaporative losses and provide a fluid seal between two components or two environments, such as between a therapeutic environment and a local external environment. The cover 125 may comprise or consist of, for example, an elastomeric film or membrane that can provide a seal adequate to maintain a negative pressure at a tissue site for a given negative-pressure source. The cover 125 may have a high moisture-vapor transmission rate

(MVTR) in some applications. For example, the MVTR may be at least 250 grams per square meter per twenty-four hours ($\text{g}/\text{m}^2/24 \text{ hours}$) in some embodiments, measured using an upright cup technique according to ASTM E96/E96M Upright Cup Method at 38°C and 10% relative humidity (RH). In some embodiments, an MVTR up to 5,000 $\text{g}/\text{m}^2/24 \text{ hours}$ may provide effective breathability and mechanical properties.

[0044] In some example embodiments, the cover 125 may be a polymer drape, such as a polyurethane film, that is permeable to water vapor but impermeable to liquid. Such drapes typically have a thickness in the range of 25-50 microns. For permeable materials, the permeability generally should be low enough that a desired negative pressure may be maintained. The cover 125 may comprise, for example, one or more of the following materials: polyurethane (PU), such as hydrophilic polyurethane; cellulosics; hydrophilic polyamides; polyvinyl alcohol; polyvinyl pyrrolidone; hydrophilic acrylics; silicones, such as hydrophilic silicone elastomers; natural rubbers; polyisoprene; styrene butadiene rubber; chloroprene rubber; polybutadiene; nitrile rubber; butyl rubber; ethylene propylene rubber; ethylene propylene diene monomer; chlorosulfonated polyethylene; polysulfide rubber; ethylene vinyl acetate (EVA); co-polyester; and polyether block polyimide copolymers. Such materials are commercially available as, for example, Tegaderm® drape, commercially available from 3M Company, Minneapolis, Minnesota; polyurethane (PU) drape, commercially available from Avery Dennison Corporation, Pasadena, California; polyether block polyamide copolymer (PEBAX), for example, from Arkema S.A., Colombes, France; and Inspire 2301 and Inspire 2327 polyurethane films, commercially available from Expopack Advanced Coatings, Wrexham, United Kingdom. In some embodiments, the cover 125 may comprise INSPIRE 2301 having an MVTR (upright cup technique) of 2600 $\text{g}/\text{m}^2/24 \text{ hours}$ and a thickness of about 30 microns.

[0045] An attachment device may be used to attach the cover 125 to an attachment surface, such as undamaged epidermis, a gasket, or another cover. The attachment device may take many forms. For example, an attachment device may be a medically-acceptable, pressure-sensitive adhesive configured to bond the cover 125 to epidermis around a tissue site. In some embodiments, for example, some or all of the cover 125 may be coated with an adhesive, such as an acrylic adhesive, which may have a coating weight of about 25-65 grams per square meter (g.s.m.). Thicker adhesives, or combinations of adhesives, may be applied in some embodiments to improve the seal and reduce leaks. Other example embodiments of an attachment device may include a double-sided tape, paste, hydrocolloid, hydrogel, silicone gel, or organogel.

[0046] The solution source 145 may also be representative of a container, canister, pouch, bag, or other storage component, which can provide a solution for instillation therapy. Compositions of solutions may vary according to a prescribed therapy, but examples of solutions that may be suitable for some prescriptions include hypochlorite-based solutions, silver nitrate (0.5%), sulfur-based solutions, biguanides, cationic solutions, and isotonic solutions.

[0047] Therapy Modes

[0048] In operation, the tissue interface 120 may be placed within, over, on, or otherwise proximate to a tissue site. If the tissue site is a wound, for example, the tissue interface 120 may partially or completely fill the wound, or it may be placed over the wound. The cover 125 may be placed over the tissue interface 120 and sealed to an attachment surface near a tissue site. For example, the cover 125 may be sealed to undamaged epidermis peripheral to a tissue site. Thus, the dressing 110 can provide a sealed therapeutic environment proximate to a tissue site, substantially isolated from the external environment. The negative-pressure source 105 and the solution source 145 can be fluidly coupled to the tissue interface through one or more fluid conductors. The negative-pressure source 105 can reduce pressure in the sealed therapeutic environment, and fluid from the solution source 145 can be instilled to the sealed therapeutic environment.

[0049] The fluid mechanics of using a negative-pressure source to reduce pressure in another component or location, such as within a sealed therapeutic environment, can be mathematically complex. However, the basic principles of fluid mechanics applicable to negative-pressure therapy and instillation are generally well-known to those skilled in the art, and the process of reducing pressure may be described illustratively herein as “delivering,” “distributing,” or “generating” negative pressure, for example.

[0050] In general, exudate and other fluid flow toward lower pressure along a fluid path. Thus, the term “downstream” typically implies something in a fluid path relatively closer to a source of negative pressure or further away from a source of positive pressure. Conversely, the term “upstream” implies something relatively further away from a source of negative pressure or closer to a source of positive pressure. Similarly, it may be convenient to describe certain features in terms of fluid “inlet” or “outlet” in such a frame of reference. This orientation is generally presumed for purposes of describing various features and components herein. However, the fluid path may also be reversed in some applications, such as by substituting a positive-pressure source for a negative-pressure source, and this descriptive convention should not be construed as a limiting convention.

[0051] Negative pressure applied across the tissue site through the tissue interface 120 in the sealed therapeutic environment can induce macro-strain and micro-strain in the tissue site. Negative pressure can also remove exudate and other fluid from a tissue site, which can be collected in container 115.

[0052] In some embodiments, the controller 130 may receive and process data from one or more sensors, such as the first sensor 135. The controller 130 may also control the operation of one or more components of the therapy system 100 to manage the pressure delivered to the tissue interface 120. In some embodiments, controller 130 may include an input for receiving a desired target pressure and may be programmed for processing data relating to the setting and inputting of the target pressure to be applied to the tissue interface 120. In some example embodiments, the target pressure may be a fixed pressure value set by an operator as the target negative pressure desired for therapy at a tissue site and then provided as input to the controller 130. The target pressure may vary from tissue site to tissue site based on the type of tissue forming a tissue site, the type of injury or wound (if any), the medical condition of the patient, and the preference of the attending physician. After selecting a desired target pressure, the controller 130 can operate the negative-pressure source 105 in one or more control modes based on the target pressure and may receive feedback from one or more sensors to maintain the target pressure at the tissue interface 120.

[0053] Figure 2 is a graph illustrating additional details of an example control mode that may be associated with some embodiments of the controller 130. In some embodiments, the controller 130 may have a continuous pressure mode, in which the negative-pressure source 105 is operated to provide a constant target negative pressure, as indicated by line 205 and line 210, for the duration of treatment or until manually deactivated. Additionally or alternatively, the controller may have an intermittent pressure mode, as illustrated in the example of Figure 2. In Figure 2, the x-axis represents time and the y-axis represents negative pressure generated by the negative-pressure source 105 over time. In the example of Figure 2, the controller 130 can operate the negative-pressure source 105 to cycle between a target pressure and atmospheric pressure. For example, the target pressure may be set at a value of -125 mmHg, as indicated by line 205, for a specified period of time (e.g., 5 min), followed by a specified period of time (e.g., 2 min) of deactivation, as indicated by the gap between the solid lines 215 and 220. The cycle can be repeated by activating the negative-pressure source 105, as indicated by line 220, which can form a square wave pattern between the target pressure and atmospheric pressure.

[0054] In some example embodiments, the increase in negative pressure from ambient pressure to the target pressure may not be instantaneous. For example, the negative-pressure source 105 and the dressing 110 may have an initial rise time, as indicated by the dashed line 225. The initial rise time may vary depending on the type of dressing and therapy equipment being used. For example, the initial rise time for one therapy system may be in a range of about 20-30 mmHg/second and in a range of about 5-10 mmHg/second for another therapy system. If the therapy system 100 is operating in an intermittent mode, the repeating rise time, as indicated by the solid line 220, may be a value substantially equal to the initial rise time as indicated by the dashed line 225.

[0055] Figure 3 is a graph illustrating additional details that may be associated with another example pressure control mode in some embodiments of the therapy system 100. In Figure 3, the x-axis represents time and the y-axis represents negative pressure generated by the negative-pressure source 105. The target pressure in the example of Figure 3 can vary with time in a dynamic pressure mode. For example, the target pressure may vary in the form of a triangular waveform, varying between a negative pressure of 50 and 135 mmHg with a rise time 305 set at a rate of +25 mmHg/min. and a descent time 310 set at -25 mmHg/min. In other embodiments of the therapy system 100, the triangular waveform may vary between negative pressure of 25 and 135 mmHg with a rise time 305 set at a rate of +30 mmHg/min and a descent time 310 set at -30 mmHg/min.

[0056] In some embodiments, the controller 130 may control or determine a variable target pressure in a dynamic pressure mode, and the variable target pressure may vary between a maximum and minimum pressure value that may be set as an input prescribed by an operator as the range of desired negative pressure. The variable target pressure may also be processed and controlled by the controller 130, which can vary the target pressure according to a predetermined waveform, such as a triangular waveform, a sine waveform, or a saw-tooth waveform. In some embodiments, the waveform may be set by an operator as the predetermined or time-varying negative pressure desired for therapy.

[0057] Figure 4 is a chart illustrating details that may be associated with an example method 400 of operating the therapy system 100 to provide negative-pressure treatment and instillation treatment to the tissue interface 120. In some embodiments, the controller 130 may receive and process data, such as data related to instillation solution provided to the tissue interface 120. Such data may include the type of instillation solution prescribed by a clinician, the volume of fluid or solution to be instilled to a tissue site (“fill volume”), and the amount of time prescribed for leaving solution at a tissue site (“dwell time”) before applying

a negative pressure to the tissue site. The fill volume may be, for example, between 10 and 500 mL, and the dwell time may be between one second to 30 minutes. The controller 130 may also control the operation of one or more components of the therapy system 100 to instill solution, as indicated at 405. For example, the controller 130 may manage fluid distributed from the solution source 145 to the tissue interface 120. In some embodiments, fluid may be instilled to a tissue site by applying a negative pressure from the negative-pressure source 105 to reduce the pressure at the tissue site, drawing solution into the tissue interface 120, as indicated at 410. In some embodiments, solution may be instilled to a tissue site by applying a positive pressure from the positive-pressure source 150 to move solution from the solution source 145 to the tissue interface 120, as indicated at 415. Additionally or alternatively, the solution source 145 may be elevated to a height sufficient to allow gravity to move solution into the tissue interface 120, as indicated at 420.

[0058] The controller 130 may also control the fluid dynamics of instillation at 425 by providing a continuous flow of solution at 430 or an intermittent flow of solution at 435. Negative pressure may be applied to provide either continuous flow or intermittent flow of solution at 440. The application of negative pressure may be implemented to provide a continuous pressure mode of operation at 445 to achieve a continuous flow rate of instillation solution through the tissue interface 120, or it may be implemented to provide a dynamic pressure mode of operation at 450 to vary the flow rate of instillation solution through the tissue interface 120. Alternatively, the application of negative pressure may be implemented to provide an intermittent mode of operation at 455 to allow instillation solution to dwell at the tissue interface 120. In an intermittent mode, a specific fill volume and dwell time may be provided depending, for example, on the type of tissue site being treated and the type of dressing being utilized. After or during instillation of solution, negative-pressure treatment may be applied at 460. The controller 130 may be utilized to select a mode of operation and the duration of the negative pressure treatment before commencing another instillation cycle at 465 by instilling more solution at 405.

[0059] Figure 5 is a graph illustrating additional details of another example control mode that may be associated with some embodiments of the controller 130 to provide negative-pressure treatment and instillation treatment to the tissue interface 120. In the example of Figure 5, the controller 130 is configured to provide discrete intervals of negative pressure and instillation. The controller 130 can operate the negative-pressure source 105 in an intermittent-pressure mode to maintain a target negative pressure 205 during negative-pressure intervals. During an instillation interval 505, the controller 130 can deactivate the

negative-pressure source 105 and operate the positive-pressure source 150 to instill a prescribed volume of fluid from the solution source 145 to a tissue site. The target negative pressure, the prescribed volume, or both, may be preset by the controller 130, or may be set by an operator at run-time in some examples. The controller 130 may also provide a dwell interval 510, during which neither the negative-pressure source 105 nor the positive-pressure source 150 is active. In some examples, the cycle can be repeated. In the example of Figure 5, the controller 130 re-activates the negative-pressure source 105 after the dwell interval 510.

[0060] Figure 5 further illustrates an example of the controller 130 configured to provide intermittent purge cycles. In Figure 5, the controller 130 periodically activates a first purge cycle 515 and a second purge cycle 520. For example, the negative-pressure source 105 may be coupled to the dressing 110 through a first fluid conductor, and the controller 130 may activate the first purge cycle 515 by opening a valve to expose the first fluid conductor to ambient pressure or positive pressure. The pressure increase can force exudate out of the first fluid conductor, reducing exudate build-up that can block the first fluid conductor. Similarly, the solution source 145 may be coupled to the dressing 110 through a second fluid conductor, and the second purge cycle 520 may comprise instilling a relatively small volume of fluid from the solution source 145 through the second fluid conductor. For example, a suitable purge volume may be in a range of about 0.1 milliliters to about 1 milliliter. The purge frequency may also vary. In some embodiments, the frequency may be in a range of about 5 to 20 minutes. In some embodiments, a purge volume of about 0.2 milliliters and a frequency of about 10 minutes may be suitable for reducing material deposits in the second fluid conductor near the dressing 110. The second purge cycle 520 can be activated during a negative-pressure interval, as in the example of Figure 5, or between negative-pressure intervals. The purge volume of solution may be removed by negative pressure through the first fluid conductor in some configurations. In some examples, the first purge cycle 515 and the second purge cycle 520 can be activated concurrently.

[0061] The systems, apparatuses, and methods described herein may provide significant advantages. For example, interaction between instillation solutions and proteins and lipids from exudate can produce sticky deposits that can collect at a dressing interface. Instillation purge cycles can substantially reduce or eliminate these deposits which can occlude fluid conductors and other distribution components.

[0062] While shown in a few illustrative embodiments, a person having ordinary skill in the art will recognize that the systems, apparatuses, and methods described herein are

susceptible to various changes and modifications that fall within the scope of the appended claims. Moreover, descriptions of various alternatives using terms such as "or" do not require mutual exclusivity unless clearly required by the context, and the indefinite articles "a" or "an" do not limit the subject to a single instance unless clearly required by the context. Components may be also be combined or eliminated in various configurations for purposes of sale, manufacture, assembly, or use. For example, in some configurations the dressing 110, the container 115, or both may be eliminated or separated from other components for manufacture or sale. In other example configurations, the controller 130 may also be manufactured, configured, assembled, or sold independently of other components.

[0063] The appended claims set forth novel and inventive aspects of the subject matter described above, but the claims may also encompass additional subject matter not specifically recited in detail. For example, certain features, elements, or aspects may be omitted from the claims if not necessary to distinguish the novel and inventive features from what is already known to a person having ordinary skill in the art. Features, elements, and aspects described in the context of some embodiments may also be omitted, combined, or replaced by alternative features serving the same, equivalent, or similar purpose without departing from the scope of the invention defined by the appended claims.

CLAIMS

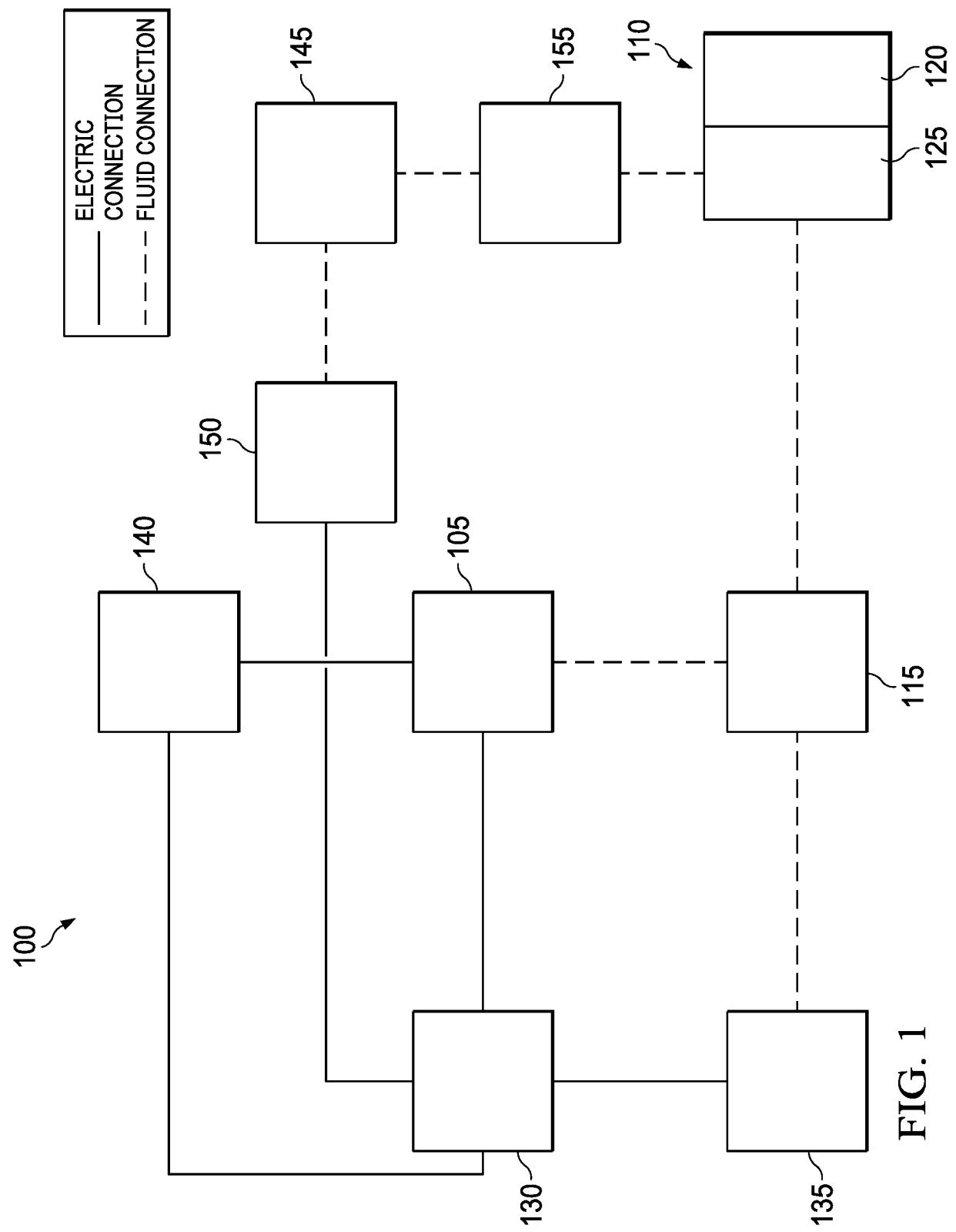
1. An apparatus for treating a tissue site, the apparatus comprising:
 - a negative-pressure source configured to be fluidly coupled to the tissue site;
 - an instillation source configured to be fluidly coupled to the tissue site; and
 - a controller operatively coupled to the negative-pressure source and to the instillation source, the controller configured to:
 - operate the negative-pressure source and the instillation source to intermittently deliver negative pressure to the tissue site for a negative-pressure interval and deliver a fill volume of instillation fluid to the tissue site for an instillation interval, and deliver a purge volume of instillation fluid to the tissue site at a purge frequency; and
 - deliver the purge volume during the negative-pressure interval.
2. The apparatus of claim 1, wherein the fill volume is at least 10 times the purge volume.
3. The apparatus of claim 1, wherein a ratio of the fill volume to the purge volume is in a range of about 10:1 to about 5000:1.
4. The apparatus of claim 1, wherein the fill volume is in a range of about 10 milliliters to about 500 milliliters, and the purge volume is in a range of about 0.1 milliliters to about 1 milliliter.
5. The apparatus of claim 1, wherein the purge frequency is in a range of about 5 minutes to about 20 minutes.
6. The apparatus of claim 1, wherein:
 - the fill volume is in a range of about 10 milliliters to about 500 milliliters;
 - the purge volume is in a range of about 0.1 milliliters to about 1 milliliter; and
 - the purge frequency is in a range of about 5 minutes to about 20 minutes.
7. The apparatus of claim 1, further comprising a fluid conductor fluidly coupled to the instillation source, and wherein the controller is configured to deliver the purge volume of instillation fluid through the fluid conductor.

8. The apparatus of claim 1, further comprising a first fluid conductor fluidly coupled to the negative-pressure source, a second fluid conductor fluidly coupled to the instillation source, and wherein the controller is configured to deliver the purge volume of instillation fluid through the second fluid conductor and to remove the purge volume of instillation fluid through the first fluid conductor.
9. The apparatus of claim 1, further comprising a user interface coupled to the controller and operable to receive input to configure at least one of the purge volume and the purge frequency.
10. A method of treating a tissue site with negative-pressure and therapeutic solution, the method comprising:
 - delivering the negative pressure to the tissue site for a first interval;
 - delivering a fill volume of the therapeutic solution to the tissue site for a second interval; and
 - delivering a purge volume of the therapeutic solution to the tissue site;the purge volume being delivered during the first interval.
11. The method of claim 10, wherein the fill volume is at least 10 times the purge volume.
12. The method of claim 10, wherein a ratio of the fill volume to the purge volume is in a range of about 10:1 to about 5000:1.
13. The method of claim 10, wherein the purge volume is in a range of about 0.1 milliliters to about 1 milliliter.
14. The method of claim 10, wherein the purge volume is delivered at a frequency of no greater than 20 minutes.
15. The method of claim 10, wherein the purge volume is delivered at a frequency of not less than 5 minutes.
16. The method of claim 10, wherein the purge volume is delivered at a frequency between about 5 minutes and about 20 minutes.
17. An apparatus for treating a tissue site, the apparatus comprising:
 - a dressing;

a first fluid conductor coupled to the dressing;
a second fluid conductor coupled to the dressing;
a negative-pressure source coupled to the first fluid conductor;
an instillation source coupled to the second fluid conductor; and
a controller operatively coupled to the negative-pressure source and to the
instillation source, the controller configured to:
deliver negative pressure to the dressing through the first fluid conductor for a
negative-pressure interval,
deliver a fill volume of instillation fluid to the dressing through the second
fluid conductor for an instillation interval, and
deliver a purge volume of instillation fluid to the dressing through the second
fluid conductor at a purge frequency;
wherein the purge volume is delivered during the negative-pressure interval.

18. The apparatus of claim 17, wherein the fill volume is at least 10 times the purge volume.
19. The apparatus of claim 17, wherein a ratio of the fill volume to the purge volume is in a range of about 10:1 to about 5000:1.
20. The apparatus of claim 17, wherein the purge volume is in a range of about 0.1 milliliters to about 1 milliliter.
21. The apparatus of claim 17, wherein the purge volume is delivered at a frequency of no greater than 20 minutes.
22. The apparatus of claim 17, wherein the purge volume is delivered at a frequency of not less than 5 minutes.
23. The apparatus of claim 17, wherein the purge volume is delivered at a frequency between about 5 minutes and about 20 minutes.

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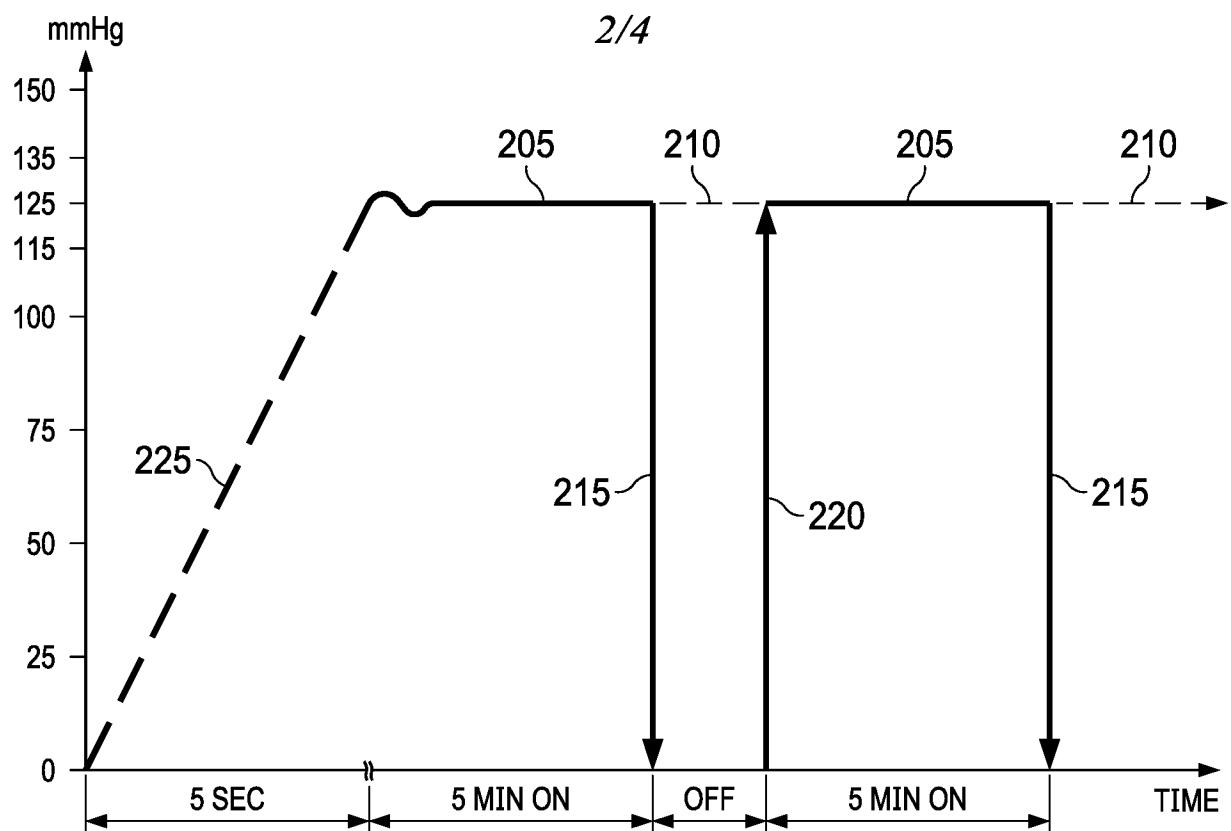


FIG. 2

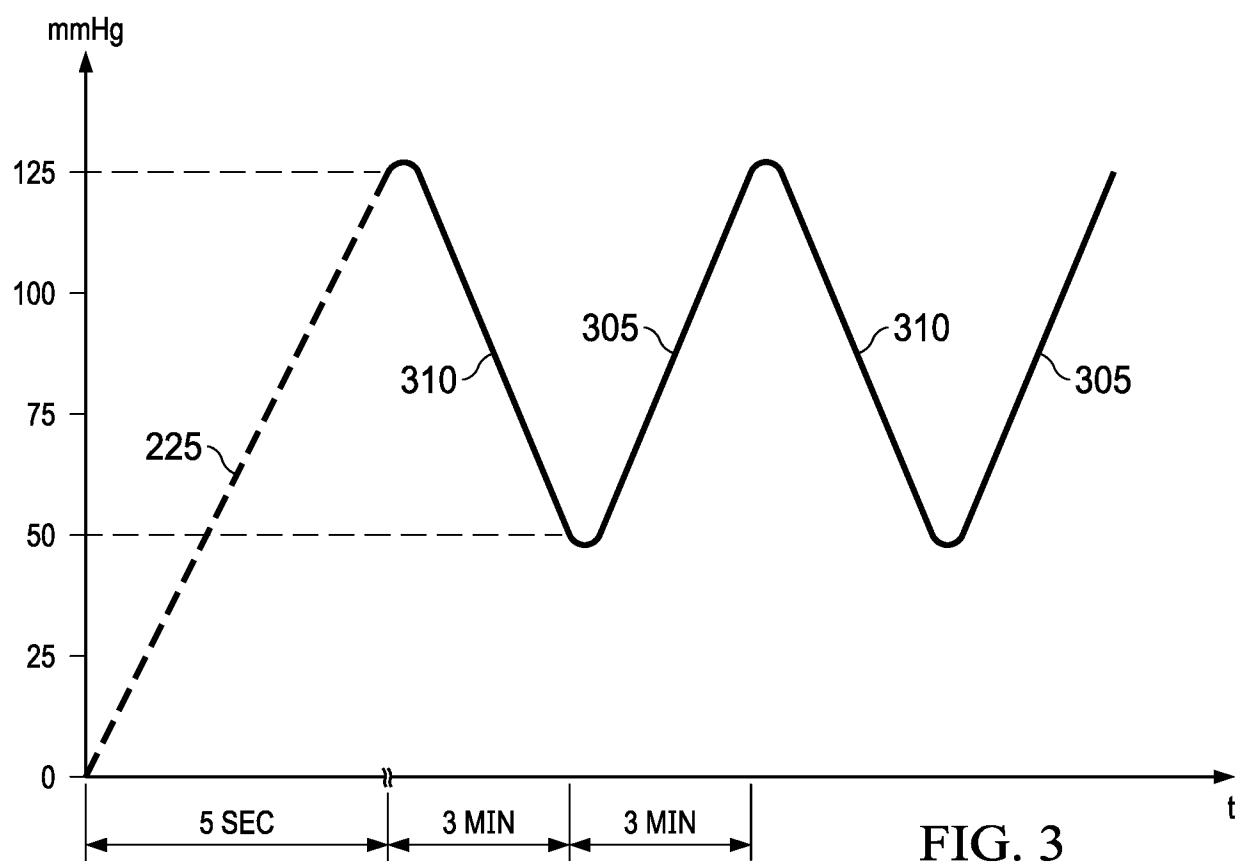


FIG. 3

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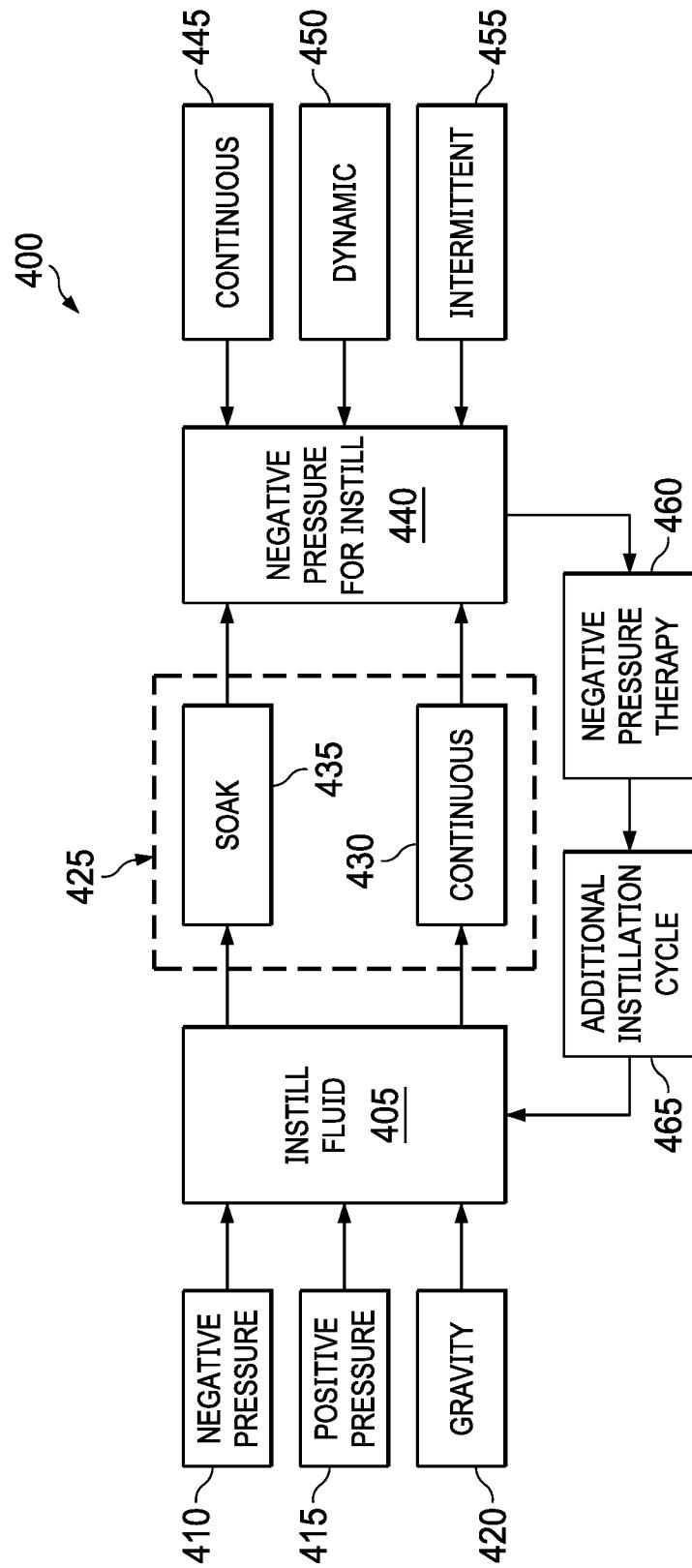


FIG. 4

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FIG. 5

