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(54) **SYSTEMS AND METHODS FOR MONITORING A PARAMETER OF A SUBTERRANEAN FORMATION USING SWELLABLE MATERIALS**

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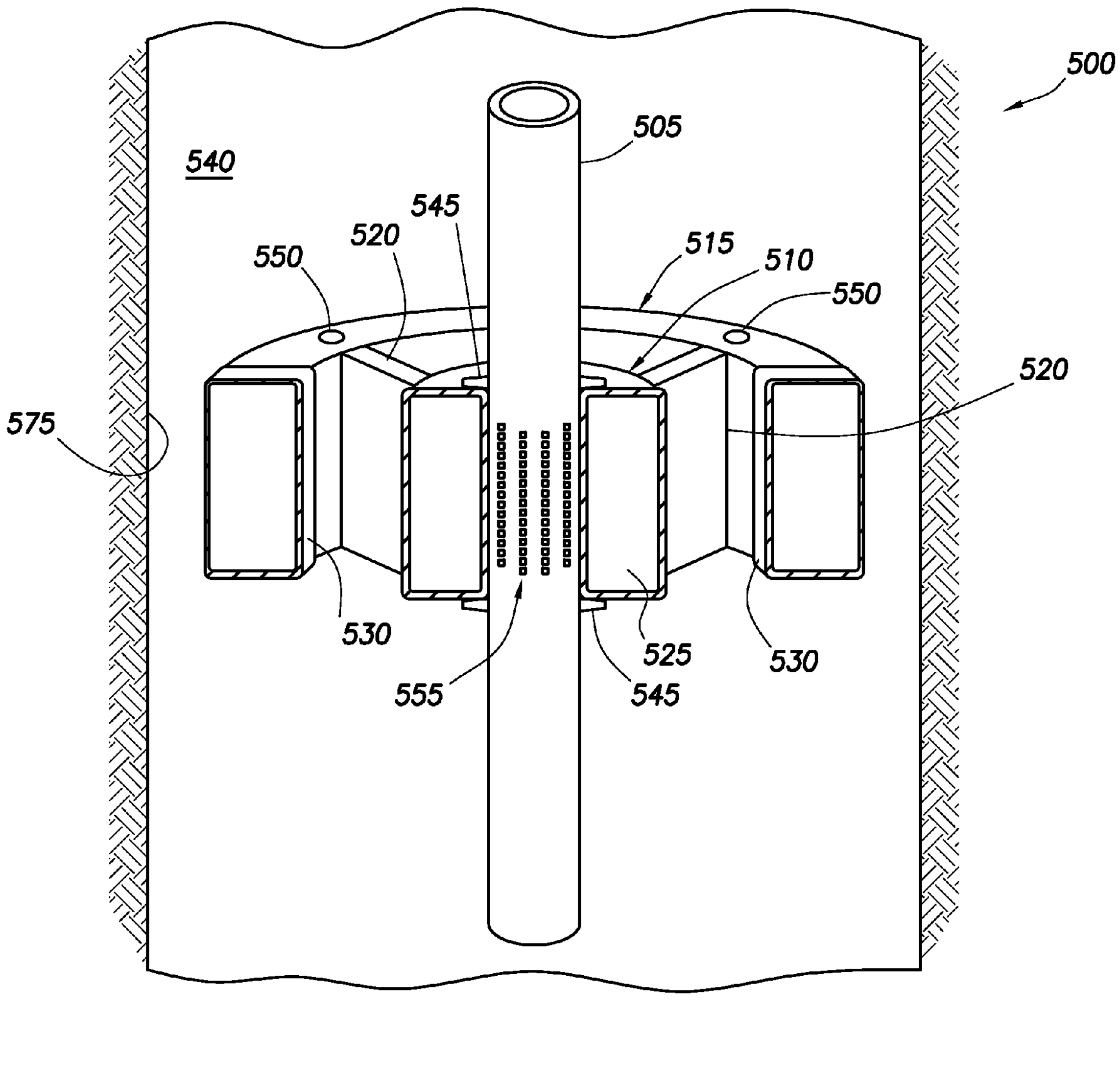
(57) **ABSTRACT**

A system for monitoring a parameter of a subterranean formation using swellable materials is disclosed. The system may include a sensor device configured to detect a parameter of a subterranean formation. The system may also include a swellable material configured to position the sensor device toward a surface of the subterranean formation by swelling of the swellable material. The system may further include a telescoping section coupled to the sensor device and emplaced in the swellable material. The telescoping section may be configured to extend with the positioning of the sensor device.



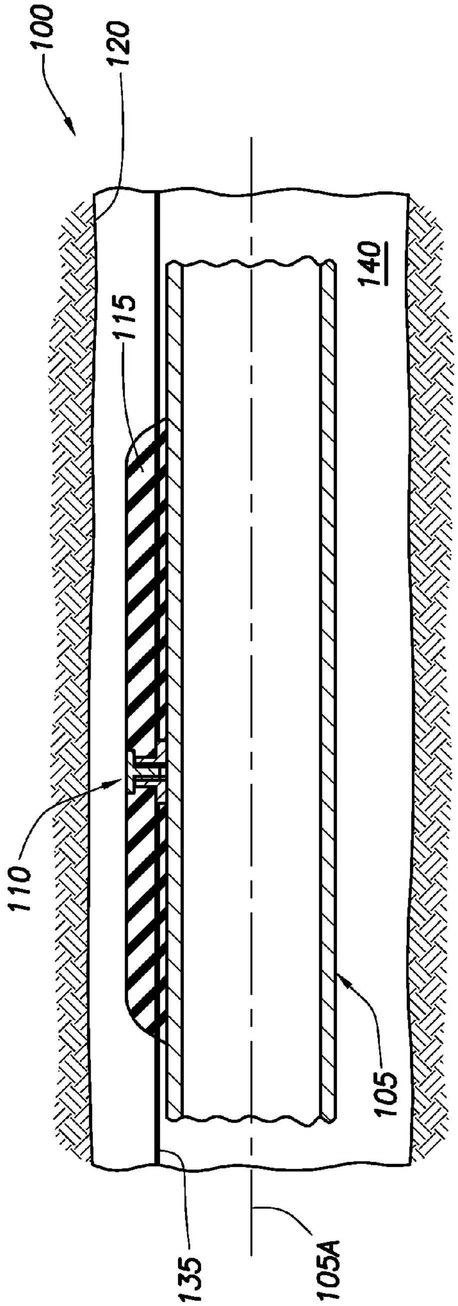


FIG. 1A

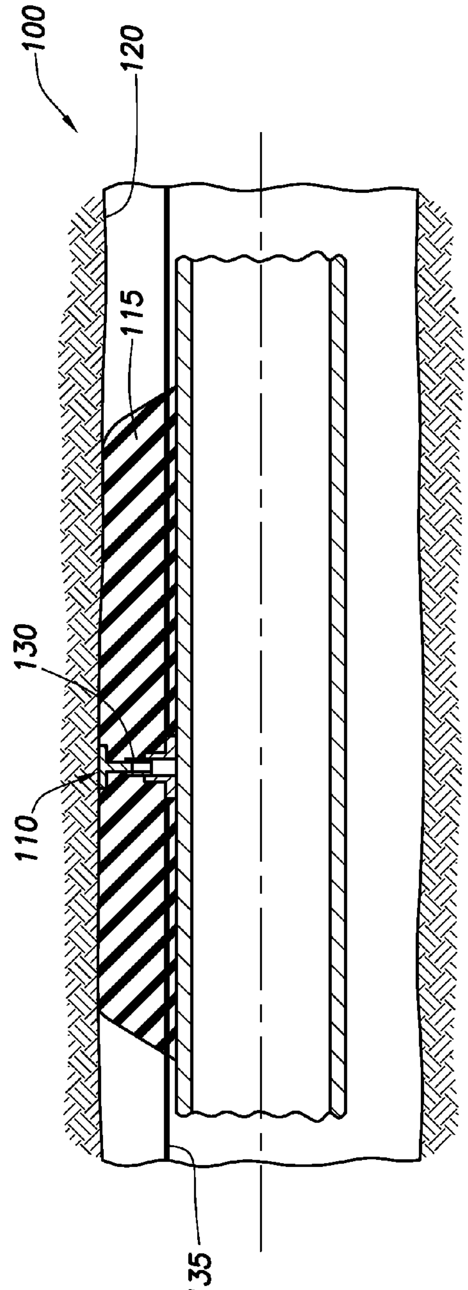


FIG. 1B

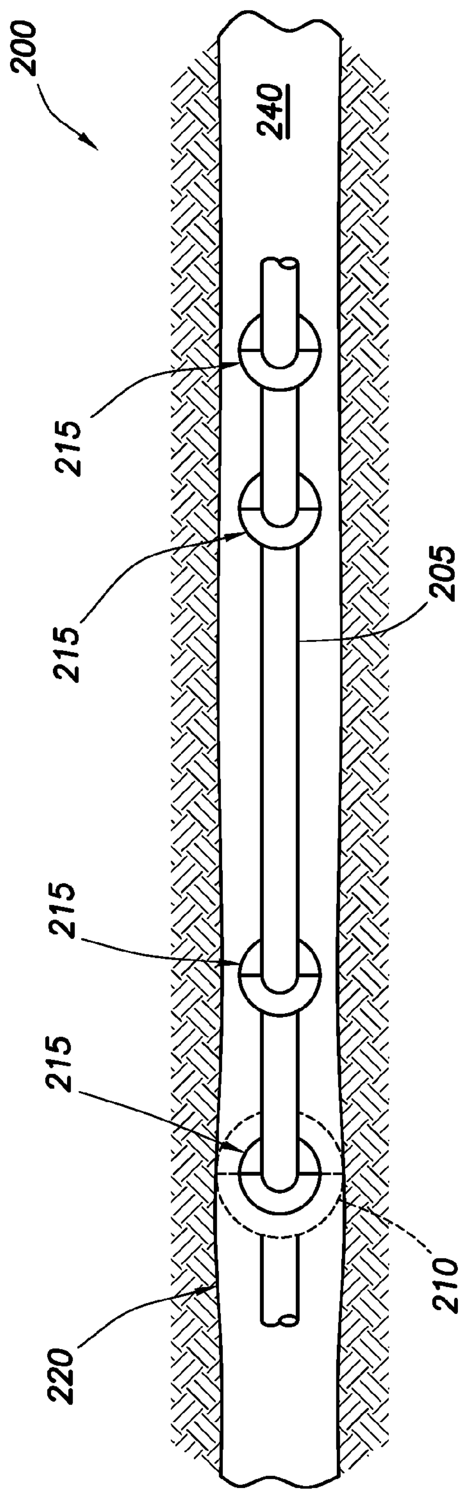

200
240
215
215
205
215
215
220
210

FIG.2

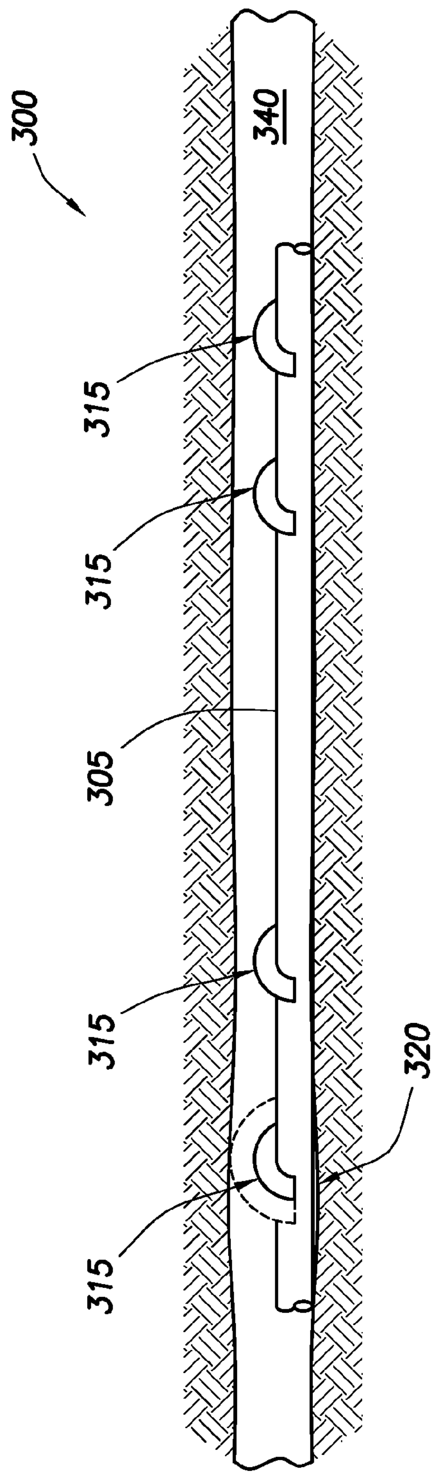

300
340
315
315
305
315
320
315

FIG.3

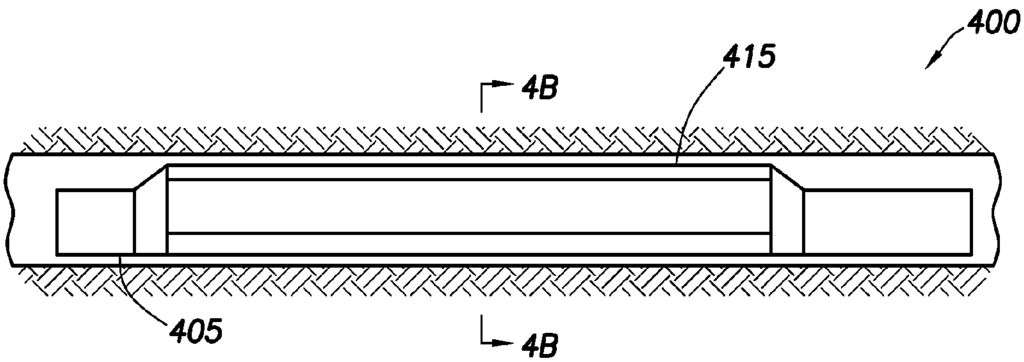
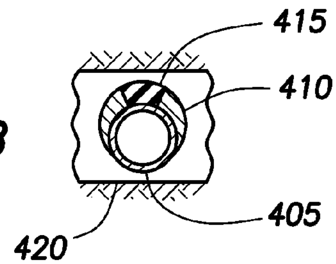


FIG.4A

FIG.4B



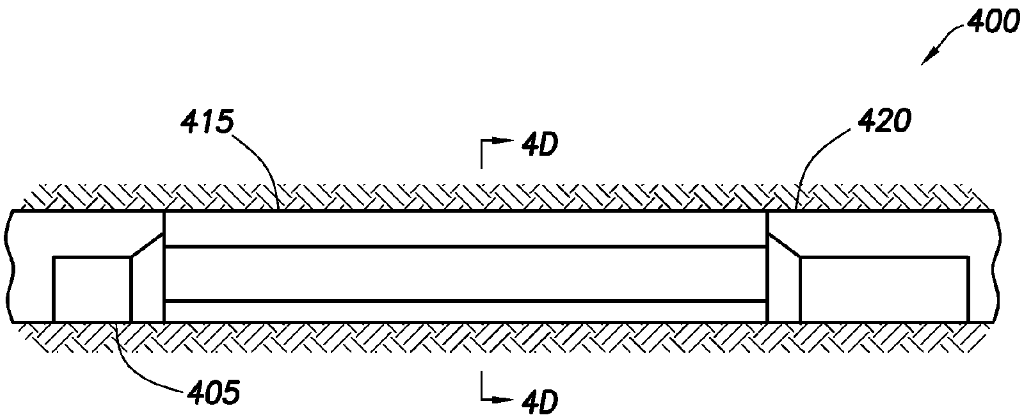
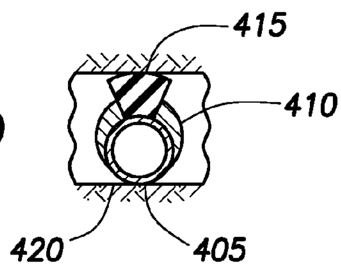


FIG.4C

FIG.4D



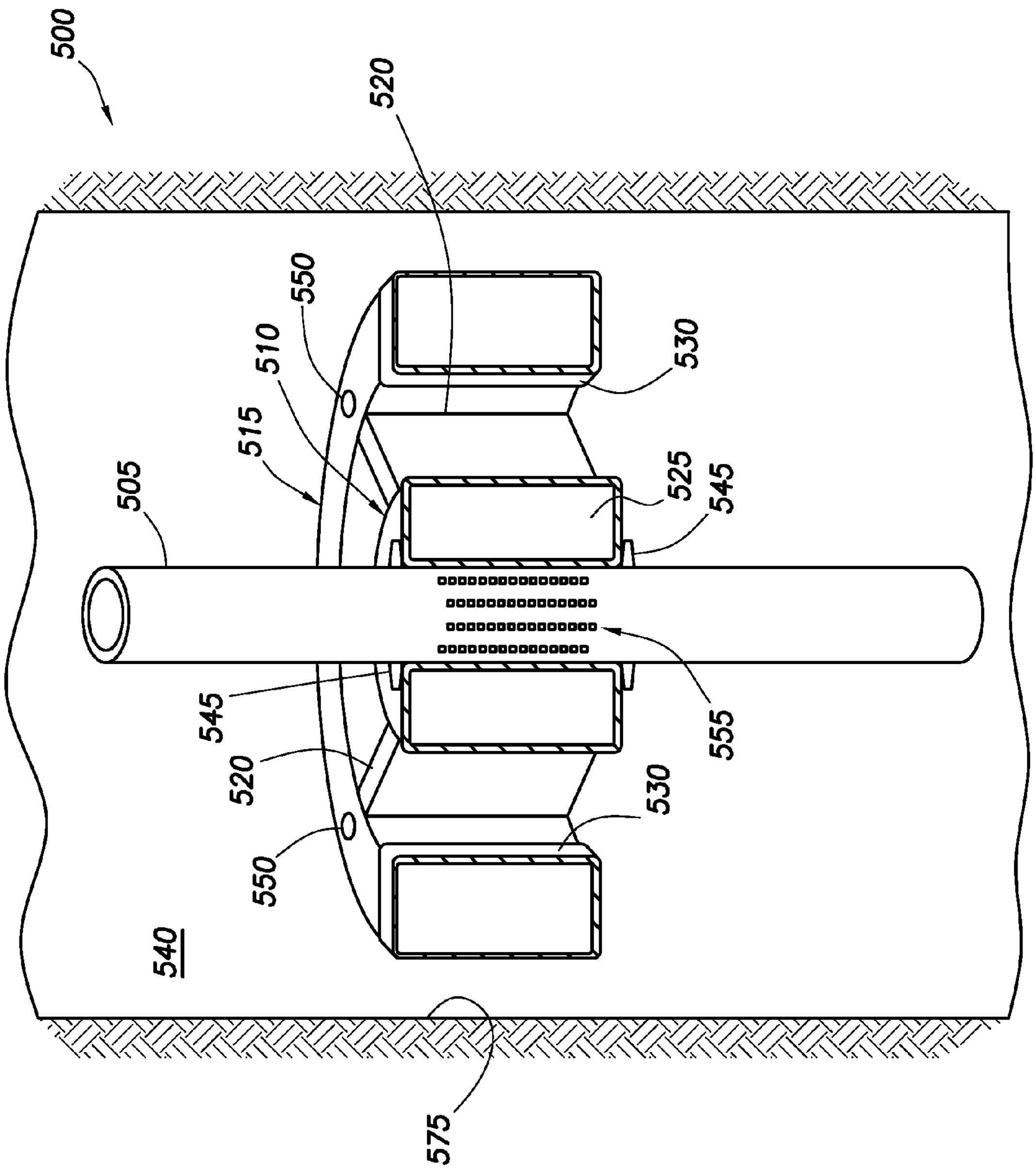


FIG.5A

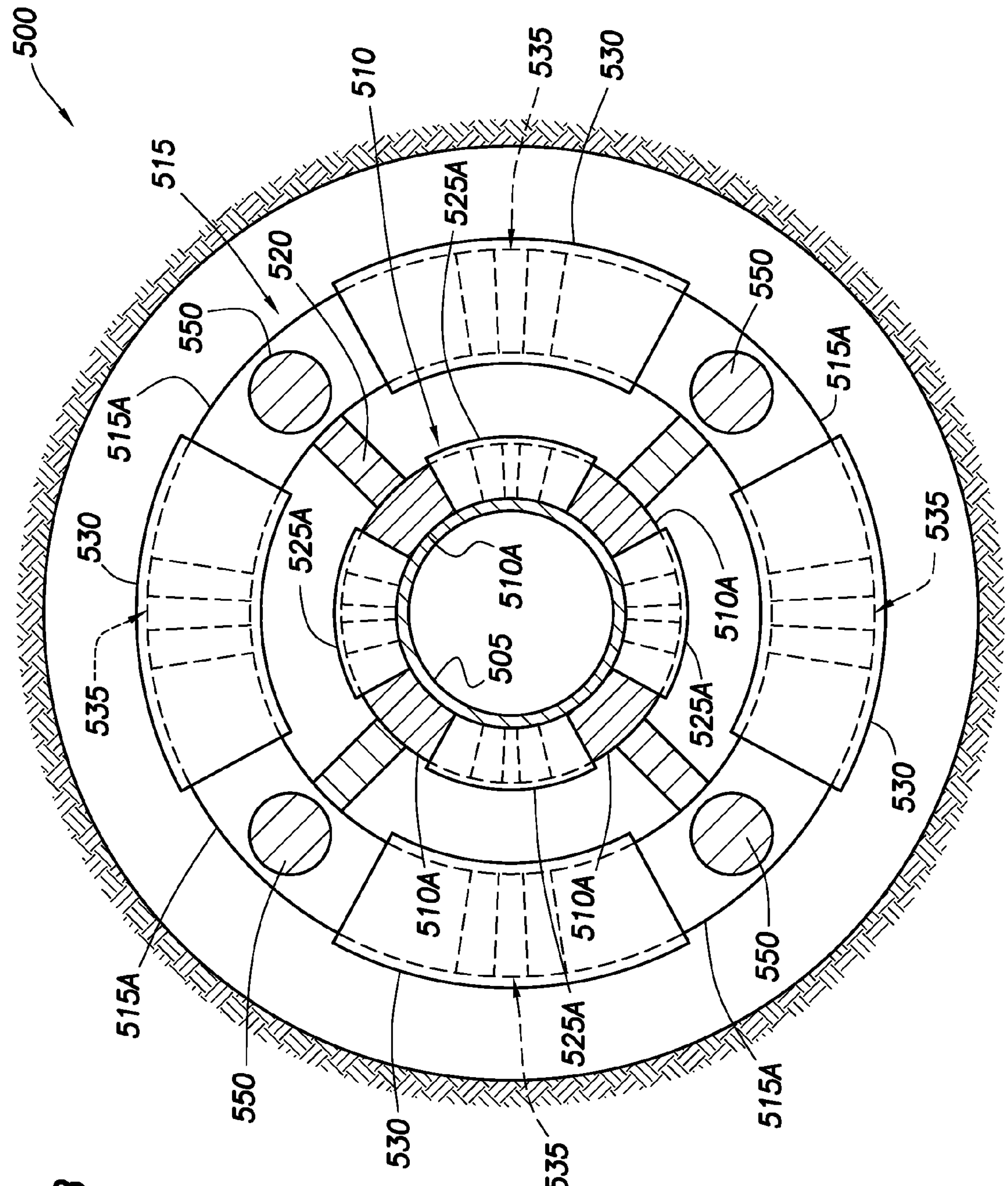


FIG.5B

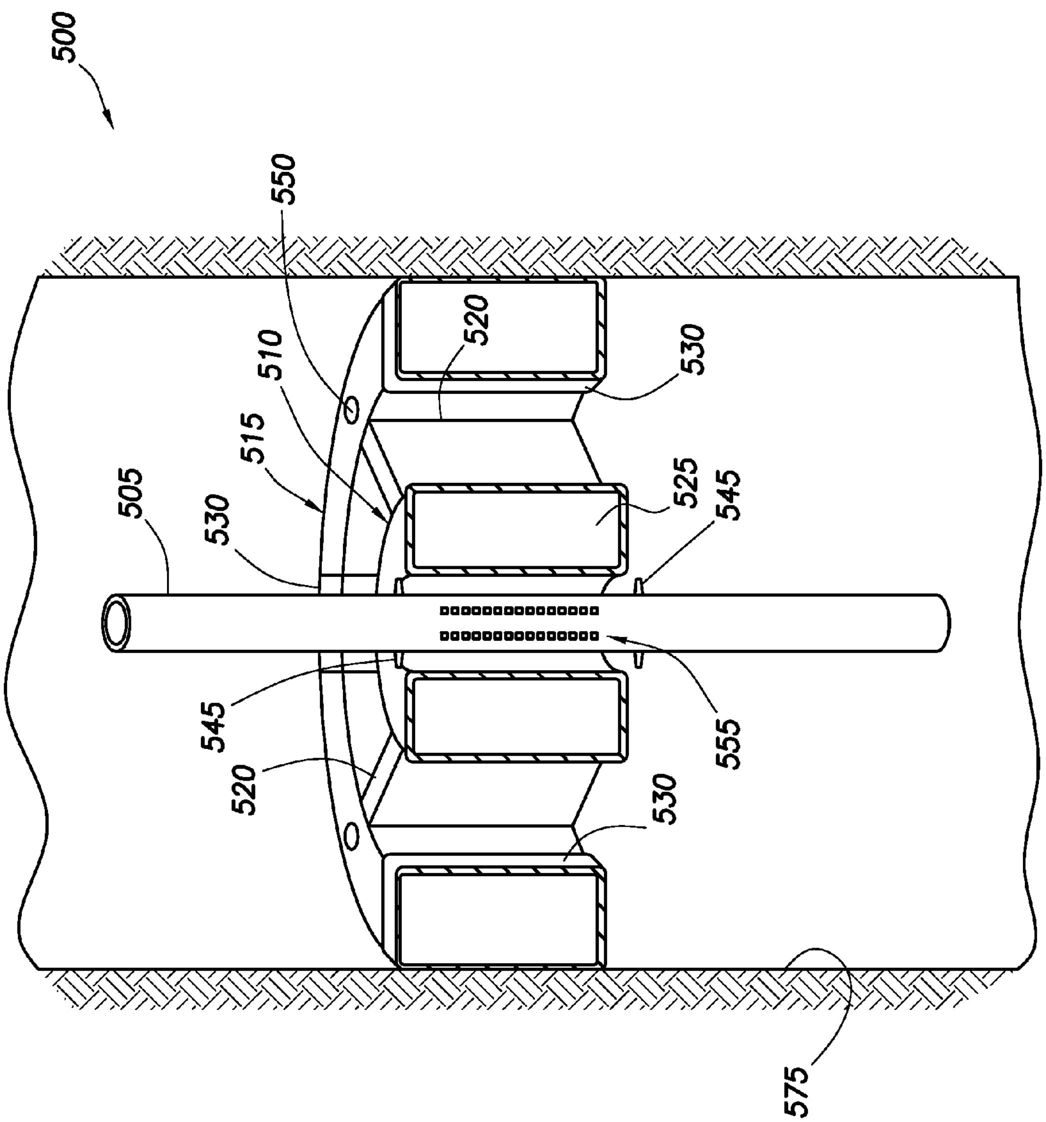


FIG.5C

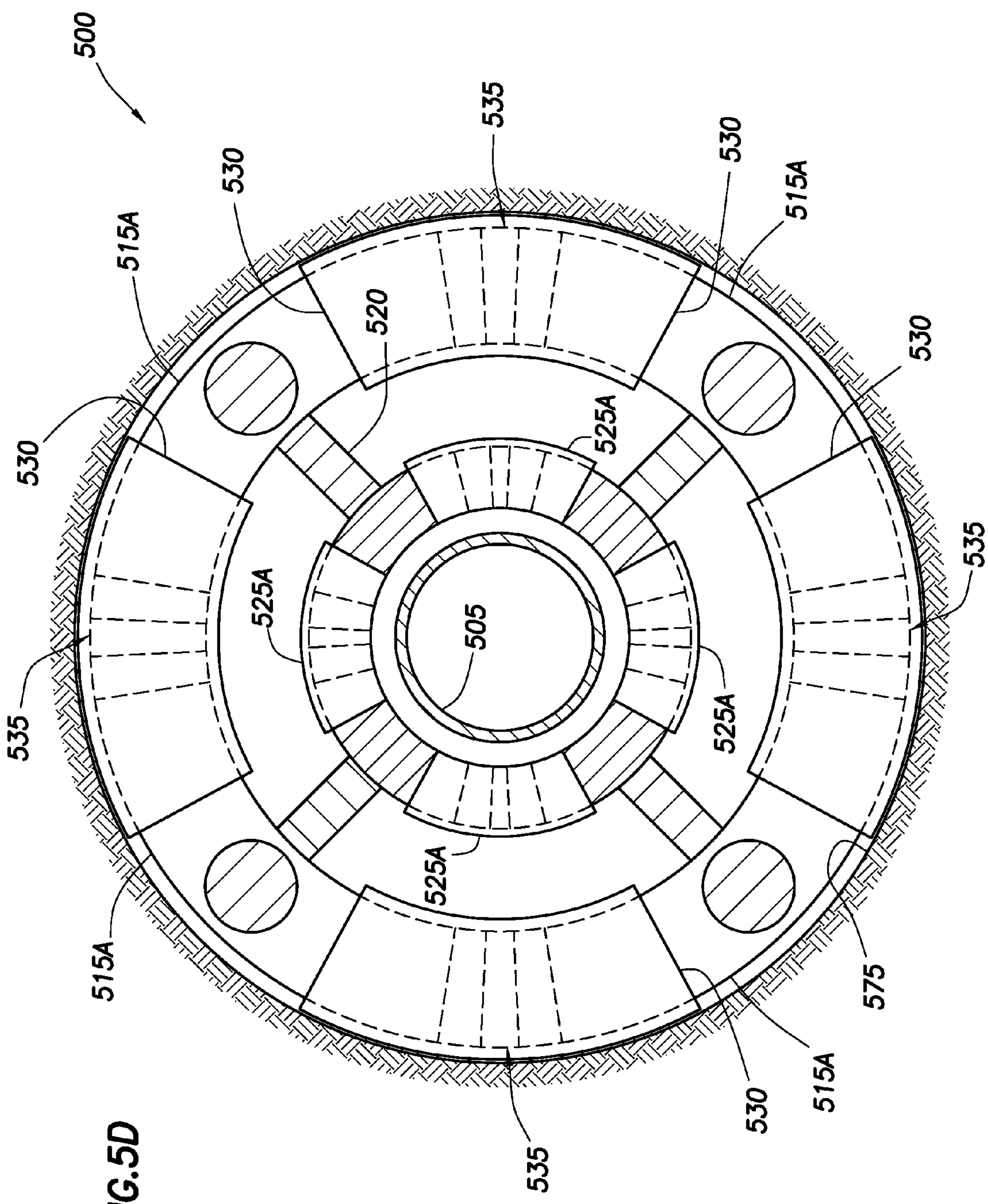

500
535
530
515A
530
515A
520
530
530
525A
535
525A
505
535
525A
525A
515A
575
530
515A
535

FIG.5D

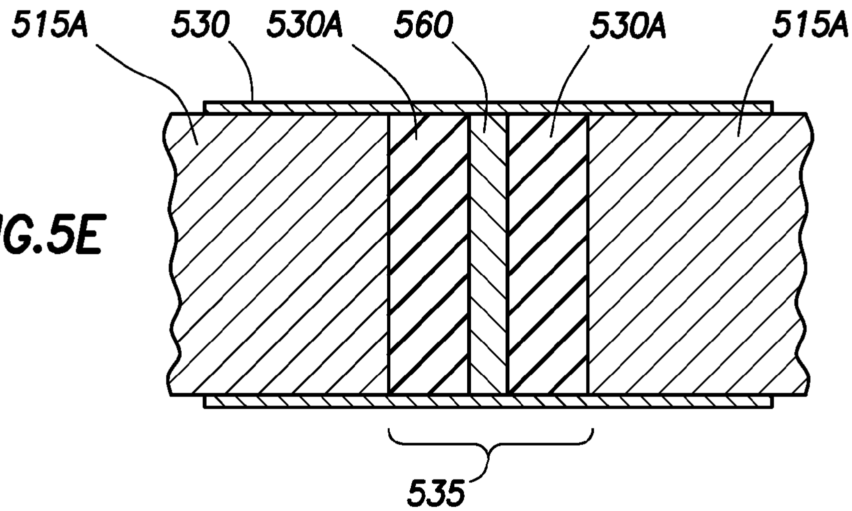


FIG.5E

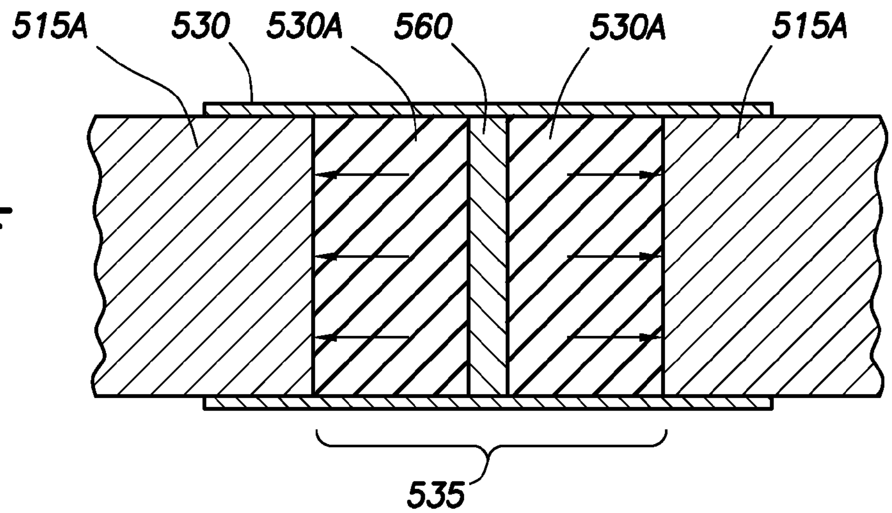


FIG.5F

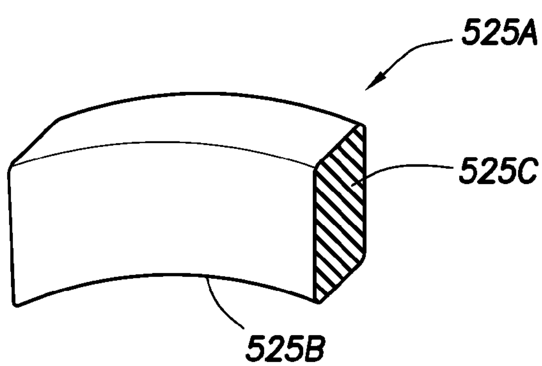


FIG.5J

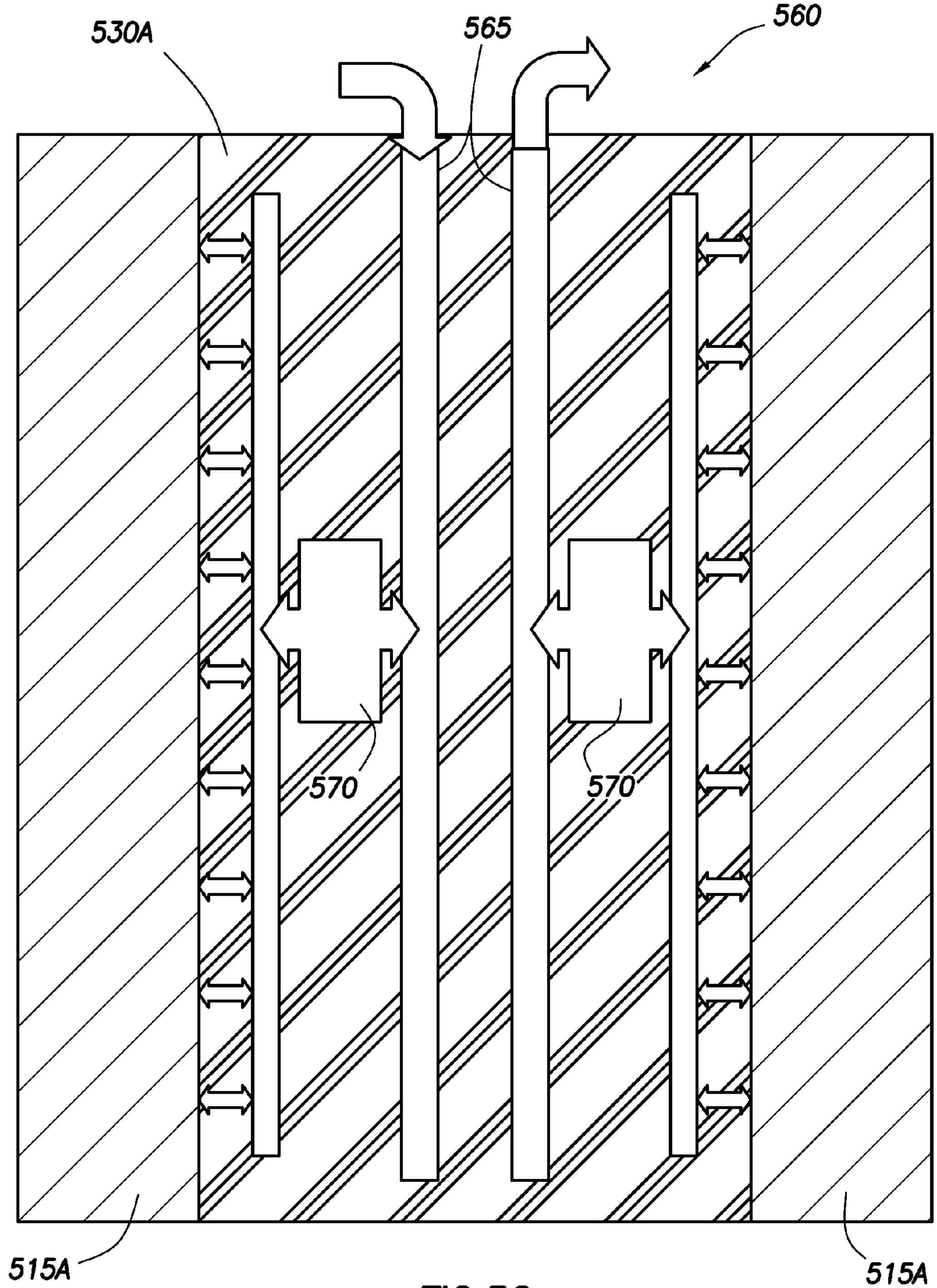


FIG.5G

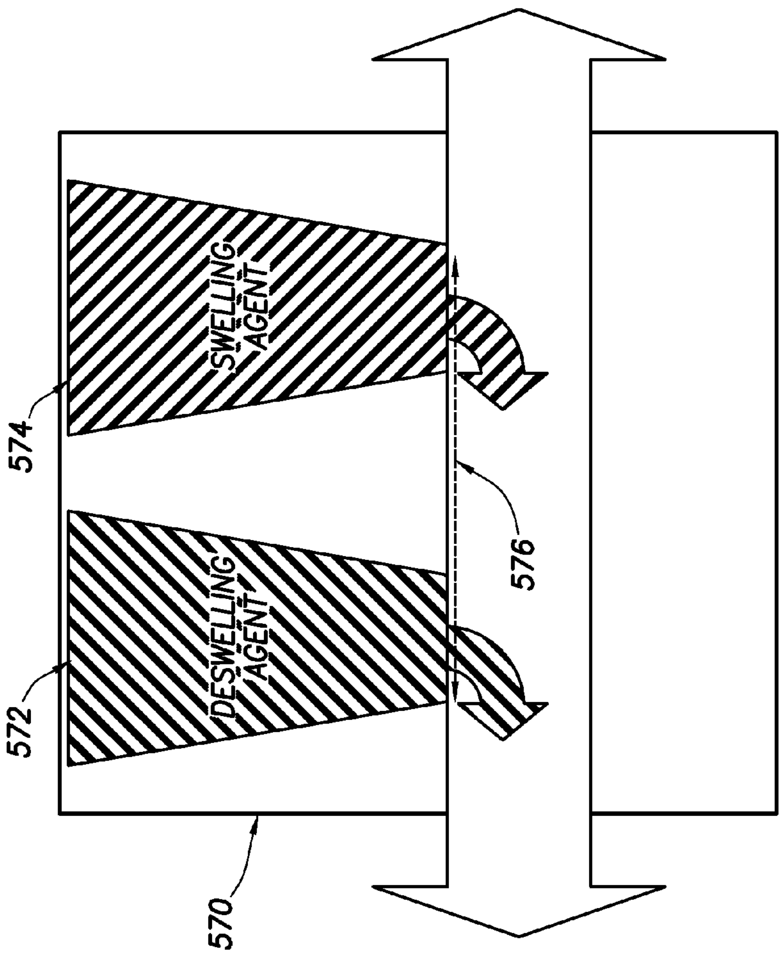

SWELLING AGENT
DESWELLING AGENT
574
572
576
570

FIG.5H

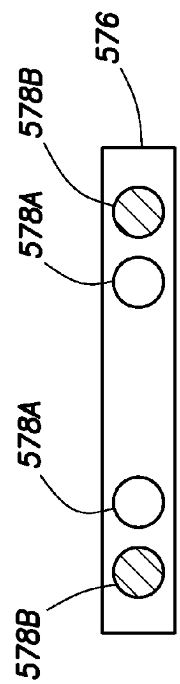

576
578B
578A
578A
578B

FIG.5I

SYSTEMS AND METHODS FOR MONITORING A PARAMETER OF A SUBTERRANEAN FORMATION USING SWELLABLE MATERIALS

BACKGROUND

[0001] The present invention relates to monitoring subterranean formations and more particularly, systems and methods for monitoring a parameter of a subterranean formation using swellable materials.

[0002] Monitoring of reservoir behavior due to injection and production processes is an important element in optimizing the performance and economics of completion and production operations. Examples of these processes may include hydraulic fracturing, water flooding, steam flooding, miscible flooding, wellbore workover operations, remedial treatments and many other hydrocarbon production activities, as well as drill cutting injection, CO_2 sequestration, produced water disposal, and various activities associated with hazardous waste injection. Because the changes in the reservoir may be difficult to resolve with surface monitoring technology, it may be desirable to emplace sensor instruments downhole at or near the reservoir depth in either special monitor wells or within the injection and production wells.

[0003] Challenges with downhole measurements may include securely coupling sensor packages to the rock mass, isolating the packages as much as possible from noise in the wellbore, and providing cabling paths (if necessary) for transmitting data to the surface. Sensors may be deployed permanently or retrievably. Retrievable sensors packages are often deployed on wirelines, but also on coiled tubing or production tubing. Wireline deployed arrays may use clamp arms, magnets, or bow springs for coupling to the wellbore, whereas coiled tubing or tubing deployed arrays may have decentralizers and may be locked into the wellbore through friction and bending stresses. However, these types of deployment may be susceptible to coupling problems if the clamp arms do not fully extend, if magnets are placed over scale or other wellbore irregularities, or if the coiled tubing is not wedged against the casing wall.

[0004] Permanent sensors may be cemented in place, but this can be a difficult and costly process for sizable sensor arrays. Successful deployments of large sensor arrays may have inserted the sensors coupled to tubing inside cemented casing with the tubing then cemented inside the casing. Attempts to directly place sensor arrays on the outside of casing have often been unsuccessful due to damage to the array during emplacement. A successful deployment of cemented sensors may remain susceptible to noise transferred either up or down the tubulars because of the affixation to the tubing or casing.

FIGURES

[0005] Some specific exemplary embodiments of the disclosure may be understood by referring, in part, to the following description and the accompanying drawings.

[0006] FIGS. **1**A and **1**B are partial schematic cross-sectional views of a monitoring system using swellable materials in accordance with an exemplary embodiment of the present invention.

[0007] FIG. **2** is schematic perspective view of a monitoring system using swellable materials in accordance with an exemplary embodiment of the present invention.

[0008] FIG. **3** is schematic perspective view of a monitoring system using swellable materials in accordance with an exemplary embodiment of the present invention.

[0009] FIGS. **4**A, **4**B, **4**C and **4**D are schematic cross-sectional views of a monitoring system using swellable materials in accordance with an exemplary embodiment of the present invention.

[0010] FIGS. **5**A, **5**B, **5**C, **5**D, **5**E, **5**F, **5**G, **5**H, **5**I and **5**J are schematic partial cross-sectional views of a monitoring system using swellable materials in accordance with an exemplary embodiment of the present invention.

[0011] While embodiments of this disclosure have been depicted and described and are defined by reference to exemplary embodiments of the disclosure, such references do not imply a limitation on the disclosure, and no such limitation is to be inferred. The subject matter disclosed is capable of considerable modification, alteration, and equivalents in form and function, as will occur to those skilled in the pertinent art and having the benefit of this disclosure. The depicted and described embodiments of this disclosure are examples only, and not exhaustive of the scope of the disclosure.

SUMMARY

[0012] The present invention relates monitoring subterranean formations and more particularly, systems and methods for monitoring a parameter of a subterranean formation using swellable materials.

[0013] In one aspect, a system for monitoring a parameter of a subterranean formation using swellable materials is disclosed. The system may include a sensor device configured to detect a parameter of a subterranean formation. The system may also include a swellable material configured to position the sensor device toward a surface of the subterranean formation by swelling of the swellable material. The system may further include a telescoping section coupled to the sensor device and emplaced in the swellable material. The telescoping section may be configured to extend with the positioning of the sensor device.

[0014] In another aspect, a system for monitoring a parameter of a subterranean formation using swellable materials is disclosed. The system may include a sensing tool configured to detect a parameter of a subterranean formation. The sensing tool may include a generally tubular body. The system may also include a swellable material on an exterior surface of the generally tubular body. The swellable material may be configured to anchor the sensing tool in a position corresponding to a surface of the subterranean formation by swelling of the swellable material.

[0015] In yet another aspect, a method for monitoring a parameter of a subterranean formation is disclosed. The method may include introducing a sensing tool to a wellbore. The sensing tool may include a generally tubular body and is configured to detect a parameter of a subterranean formation. The method may also include positioning the sensing tool in a position corresponding to a surface of the wellbore by swelling a swellable material. The swellable material may be disposed on an exterior surface of the generally tubular body. The method may also include detecting a parameter of a subterranean formation with the sensing device.

[0016] Certain embodiments of the present disclosed provide for a retractable sensor device and/or tool that may reenter a retracted state. Certain embodiments provide for swell controls that may be adapted for swelling and/or deswelling swellable materials.

[0017] The features and advantages of the present invention will be apparent to those skilled in the art. While numerous changes may be made by those skilled in the art, such changes are within the spirit of the invention.

DETAILED DESCRIPTION

[0018] The present invention relates monitoring subterranean formations and more particularly, systems and methods for monitoring a parameter of a subterranean formation using swellable materials.

[0019] The systems, apparatuses and methods of the present disclosure may allow for the deployment of sensors in permanent, semi-permanent, and/or retrievable applications with minimal effect on the wellbore, superior coupling to the rock mass, minimal vibrational degrees of freedom, and significant isolation from the wellbore noise for those cases where monitoring of the reservoir is desirable. In certain embodiments, sensors may be at least partially emplaced within swell packers for direct coupling to tubulars with maximum isolation from the rock mass for cases where it is desirable to monitor the tubing deformation and/or flow noise/activity within the tubing. Such swell packers may be constructed of elastomers that swell when exposed to either hydrocarbons or water, depending upon the application, in order to seal off and isolate zones within the wellbore. The swell packers may provide coupling by swelling and forcing a sensor package against either a formation, a wellbore, or any rigid contact point. In certain embodiments, swellable materials may be implemented to centralize or decentralize sensors and/or sensor tools within a wellbore, depending on the desirability of placing the sensors and/or sensor tools in a central or decentralized position.

[0020] Illustrative embodiments of the present invention are described in detail herein. In the interest of clarity, not all features of an actual implementation may be described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the specific implementation goals, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of the present disclosure.

[0021] To facilitate a better understanding of the present invention, the following examples of certain embodiments are given. In no way should the following examples be read to limit, or define, the scope of the invention. Embodiments of the present disclosure may be applicable to horizontal, vertical, deviated, or otherwise nonlinear wellbores in any type of subterranean formation. Embodiments may be applicable to injection wells as well as production wells, including hydrocarbon wells. In addition well bore and well casing implementations, embodiments may be applicable for securely planting surface instruments in soft, crumbly ground.

[0022] FIG. **1**A illustrates a system **100** where a tubular body **105** having an axis **105**A is shown disposed in a wellbore **140** and adjacent to the wall **120**. As depicted, the tubular body **105** may be disposed in an uncased section of wellbore **140**, but the tubular body **105** may be disposed in a cased section or in near-surface ground in other embodiments. The tubular body **105** may provide a conduit for formation fluids to travel therethrough. The system **100** may include a sensor package **110** fully or partially encased in a swellable element **115**. The sensor package **110** may be disposed at or near an outer boundary of the swellable element **115**.

[0023] It should be clearly understood that the principles of this disclosure are not limited to use with a particular sensor, sensor package, sensing device or tool. Instead, the principles of this disclosure are applicable to wide variety of devices, tools and methods. Two common sensors for reservoir monitoring are seismic and deformation sensors. The sensor package **110** may include, for example, a sonde, a geophone, an accelerometer, a hydrophone, or another device that detects ground motion due to either source shots (e.g., vertical seismic profiling or crosswell surveys) or passive behavior such as microseismicity and/or noise in both the wellbore and the reservoir. Also, for example, the sensor package **110** may include a sensor for measuring deformation in the downhole environment, such as a tiltmeter that measures the gradient of displacement, or any instrument that measures differential displacement in the reservoir.

[0024] A line **135** may be coupled to the sensor package **110**. The line **135** may be any one, or a combination, of a multi-conductor cable, a single conductor cable, a fiber optic cable, a fiber optic bundle, and a conduit or umbilical that contains cables, fiber optics and control lines to provide a hydraulic connection down hole. In certain embodiments, the line **135** may be a wireline. In certain embodiments, the line **135** may be a means of placing the sensor package **110** in the wellbore **140**. In the alternative, the sensor package **110** and the swellable material may be coupled to the tubular body **105** and introduced into the wellbore **140** together. The line **135** may also be a means of communicating electrical signals, such as indications of a parameter associated with the subterranean formation, between the sensor package **110** and a data collection system and/or control system at remote location, such as the earth's surface or a subsea location. In certain embodiments, the line **135** may be a means of communicating with another well tool at another location in the wellbore **140** or another wellbore. As depicted, a portion of the line **135** may be encased in the swellable element **115**. In alternative embodiments, the sensor package **110** may communicate via any type of telemetry, such as acoustic, pressure pulse, electromagnetic telemetry or any wireless means.

[0025] Referring next to FIG. **1**B, therein is depicted the system **100** of FIG. **1**A with the swellable element **115** in an expanded configuration. When the swellable element **115** comes in contact with an activating agent, the swellable element **115** expands radially outwardly. As illustrated in FIG. **1**B, the swellable element **115** may come in contact with the wellbore wall **120** due to swelling. The sensor package **110** may include a telescoping section **130** configured to extend outwardly toward the wall **120** along with the expansion of the swellable element **115** such that the swellable element **115** in effect pulls the sensor package **110** toward the wall **120**. In certain embodiments, the swellable element **115** may force the sensor package **110** to come into contact with the wall **120** and/or to partially or completely protrude into the wall **120**. The telescoping section **130** may include any means by which the sensor package **110** may be displaced while maintaining connection with the portion of the line **135** encased in the swellable element **115**. For example, the telescoping member **130** may include an extensible arm or an expandable cavity within the swellable element **115** that houses a length of the line **135** with sufficient slack corresponding to the displacement of the sensor package **110**.

[0026] Certain embodiments may employ a single swellable element **115** as depicted in FIGS. **1**A and **1**B. Other embodiments may employ multiple swellable elements. Though not shown in FIGS. **1**A and **1**B, one or more additional swellable elements may be placed about the tubing **105**.

[0027] It is recognized that the swellable element **115** may be made of different materials, shapes, and sizes. For example, the swellable element **115** may be deployed on tubing with a symmetrical ring configuration. The swellable element **115** may take an annular form surrounding or partially surrounding the tubing **105**, and may be any elastomeric sleeve, ring, or band suitable for expanding within a space between tubing **105** and an outer tubing, casing, or wellbore.

[0028] The term "swell" and similar terms (such as "swellable") are used herein to indicate an increase in volume of a material. Typically, this increase in volume is due to incorporation of molecular components of a fluid into the swellable material itself, but other swelling mechanisms or techniques may be used, if desired. The swellable element **115** may include one or more swellable materials that swell when contacted by an activating agent, such as an inorganic or organic fluid. In one embodiment, a swellable material may be a material that swells upon contact with and/or absorption of a hydrocarbon, such as oil. In another embodiment, a swellable material may be a material that swells upon contact with and/or absorption of an aqueous fluid. The hydrocarbon is absorbed into the swellable material such that the volume of the swellable material increases creating a radial expansion of the swellable material when positioned around a base pipe which creates a radially outward directed force that may operate to radially extend telescoping members as described above. The swellable material may expand until its outer surface contacts the formation face in an open hole completion or the casing wall in a cased wellbore. The swellable material accordingly may provide the force to extend the telescoping member **130** of the sensor package **110** to the surface of the formation such as wellbore wall **120**.

[0029] Suitable swellable elements include, but are not limited, to the swellable packers disclosed in U.S. Pat. Nos. 3,385,367; 7,059,415; and 7,143,832; the entire disclosures of which are incorporated by reference. In certain embodiments, the swellable element **115** may be individually designed for the conditions anticipated for a particular case, taking into account the expected temperatures and pressures for example. Some exemplary swellable materials may include elastic polymers, such as EPDM rubber, styrene butadiene, natural rubber, ethylene propylene monomer rubber, ethylene-propylene-copolymer rubber, ethylene propylene diene monomer rubber, ethylene-propylene-diene terpolymer rubber, ethylene vinyl acetate rubber, hydrogenized acrylonitrile butadiene rubber, acrylonitrile butadiene rubber, isoprene rubber, butyl rubber, halogenated butyl rubber, brominated butyl rubber, chlorinated butyl rubber, chlorinated polyethylene, chloroprene rubber and polynorborene.

[0030] As discussed above, these and other swellable materials may swell in contact with and by absorption of hydrocarbons so that the swellable material expands. In one embodiment, the rubber of the swellable materials may also have other materials dissolved in or in mechanical mixture therewith, such as fibers of cellulose. Additional options may be rubber in mechanical mixture with polyvinyl chloride, methyl methacrylate, acrylonitrile, ethylacetate or other polymers that expand in contact with oil. Other swellable materials that behave in a similar fashion with respect to hydrocarbon fluids or aqueous fluids also may be suitable. Those of ordinary skill in the art, with the benefit of this disclosure, will be able to select an appropriate swellable material for use in the present invention based on a variety of factors, including the desired swelling characteristics of the swellable material and the environmental conditions in which it is to be deployed.

[0031] In some embodiments, the swellable materials may be permeable to certain fluids but prevent particulate movement therethrough due to the porosity within the swellable materials. For example, the swellable material may have a pore size that is sufficiently small to prevent the passage of the sand therethrough but sufficiently large to allow hydrocarbon fluid production therethrough. For example, the swellable material may have a pore size of less than 1 mm.

[0032] As discussed above, the activating fluid/agent may comprise a hydrocarbon fluid or an aqueous fluid. In addition, an activating fluid may comprise additional additives such as weighting agents, acids, acid-generating compounds, and the like, or any other additive that does not adversely affect the activating fluid or swellable material with which it may come into contact. For instance, it may be desirable to include an acid and/or an acid-generating compound to at least partially degrade any filter cake that may be present within a wellbore. One of ordinary skill in the art, with the benefit of this disclosure, will recognize that the compatibility of any given additive should be tested to ensure that it does not adversely affect the performance of the activating fluid or the swellable material.

[0033] The activation agent may be introduced to the swellable material in a variety of ways. The activation agent may be injected into the wellbore or casing from a source at the surface. In other embodiments, the activation agent may be placed in the wellbore or casing and released on demand. In yet other embodiments, swelling of the swellable material may be delayed, if desired. For example, a membrane or coating may be on any or all surfaces of the material to thereby delay swelling of the material. The membrane or coating could have a slower rate of swelling, or a slower rate of diffusion of fluid through the membrane or coating, in order to delay swelling of the material. The membrane or coating could have reduced permeability or could break down in response to exposure to certain amounts of time and/or certain temperatures. Suitable techniques and arrangements for delaying swelling of a swellable material are described in U.S. Pat. Nos. 7,143,832 and 7,562,704, the entire disclosures of which are incorporated herein by reference.

[0034] The swellable materials of certain embodiments may be shrinkable or may be distintegratable. A deactivating fluid/agent, for example, may comprise a salt compound that would cause the swelled materials to contract by way of osmosis. A disintegrating fluid/agent, for example, may comprise any chemical adapted to chemically destroy the swellable material. In either case, the shrinking or disintegrating of the swellable material allows for the unanchoring of the sensor device or tool.

[0035] In alternative embodiments, the system **100** may comprise a sampling package (not shown) in lieu of or in addition to the sensor package **110**. The sampling package may comprise an extendable straw or functional equivalent. When the swellable element **115** comes in contact with an activating agent, the swellable element **115** expands radially outwardly and may seal about an area of the wellbore wall **120**. The sampling package, coming into contact with the formation, may facilitate fluid flowing from the formation such that the fluid may be monitored by the sensors. Alternatively or additionally, the fluid from the formation at that spot may be used as a fluid power source. Alternatively or additionally, the sampling package, coming into contact with the formation, may obtain a sample from the location. Then, by way of the de-swelling processes disclosed herein, the system **100** may be retracted from the wellbore **120** and the sample may be recovered from the sampling package.

[0036] FIG. **2** illustrates a system **200** where a swellable element **215** provides for symmetric instrument tool clamping within a borehole or casing. A tool **205** may be or include a sensor device, a microseismic array tool, or any other tool for which vibrations degrade its fidelity. As depicted, the tool **205** may comprise a tubular body and may be disposed in an uncased section of the wellbore **240**. Alternatively, the tool **205** may be disposed in a cased wellbore. Certain embodiments may include umbilical lines, wirelines, or tubes to the surface that could be incorporated to provide for positioning and/or monitoring the tool **205** and downhole sensors, for electrically activated controls of subsurface equipment, for injecting chemicals, or any combination thereof. In alternative embodiments, communication with the tool **205** may be achieved via any type of telemetry, such as acoustic, pressure pulse or electromagnetic telemetry.

[0037] One or more swellable elements **215** may be coupled to the tool **205** and may be configured to expand to anchor symmetrically, or substantially symmetrically, the tool **205** against a wall **220** of the wellbore or casing. For example, the swellable elements **215** may be configured to swell, due to contact with an activation agent, to a position **210**. As illustrated by the position **210**, the swellable elements **215** may come in contact with the wall **220** upon expansion.

[0038] The swellable elements **215** may be any elastomeric sleeve, band, ring, or other annular form surrounding or partially surrounding the tubing **205** and suitable for expanding between the tool **205** and wall **220**, as long as the swellable elements **215** anchor the tool **205** in a symmetrical or substantially symmetrical manner. For example, when a configuration of the swellable elements **215** fully ring the tool **205**, the tool **205** may become well-centered in the wellbore or casing so that microseismic energy may reach the tool **205** substantially equally well from all sides. In certain embodiments, a symmetric, or substantially symmetric, system similar to system **200** may surround a geophone planted in a shallow surface borehole to suppress decoupled oscillations of the instrument.

[0039] The areal contact of the swellable elements **215** with the tool **205** provides stiffening and allows shifting of modal vibrations to higher frequencies above the range of the microseisms or other sources that are being monitored. Because they expand into available space, the swelling elements themselves are very well suited for use in irregular boreholes as tool contact is necessarily hit-or-miss along the length of the tool in such settings. Similar swelling elements applied to surface-based acquisition sensors (e.g., shallow borehole geophones or tiltmeters) allow firm emplacement that, in contrast to permanent cementation, allows subsequent retrieval and reuse. In certain embodiments, the swellable elements **215** may form seals in the wellbore **240** by swelling. The swellable elements **215** accordingly may prevent fluid from flowing outside of an interval along the body of the tool **205**. In certain embodiments, the swellable elements **215** may be configured to effectively isolate the entire, or nearly the entire, body of the tool **205**, as desired.

[0040] FIG. **3** illustrates a system **300** where a swellable element **315** provides for asymmetric instrument tool clamping within a wellbore **340**. One or more swellable elements **315** may be coupled to the tool **305** in an asymmetric manner so that the swellable elements **315** anchor the tool **305** in an asymmetrical manner. In such a configuration, the tool **305** may be pushed up against a side **320** of the wellbore or casing, where the tool **305** may receive microseismic energy via direct contact. The swellable elements **315** may push the tool against the borehole wall more uniformly and firmly along its length, as compared to conventional approaches.

[0041] It should be understood, in light of this disclosure, that a number of combinations of tubing and/or wireline run with encased, ring, or partial ring deployment may have advantages that can be exploited for a given monitoring situation, as for example to shield against noise, temperature, or wellbore chemistry and to appropriately couple for what is actually being monitored.

[0042] FIGS. **4**A-**4**D illustrate a system **400** run on wireline using an eccentric swell packer for clamping a tool **405**. A swellable element **415** may run along a length of the tool **405** to provide for asymmetric instrument tool clamping within a wellbore or casing. The swellable element **415** may fit along a holder **410**. FIGS. **4**A and **4**B depict the swellable element **415** prior to activation. FIGS. **4**C and **4**D depict the swellable element **415** in an expanded position after contact with an activation agent. The expansion may cause the swellable element **415** and the tool **405** to contact the wall **420** of the wellbore or casing.

[0043] FIGS. **5**A-**5**H illustrate a system **500** where a tubular body **505** is shown disposed in a wellbore or casing **540** and adjacent to the wall **575**. FIGS. **5**A and **5**B respectively illustrate partial side and perspectives views of the system **500** in a retracted state. FIGS. **5**C and **5**D respectively illustrate partial side and perspectives views of the system **500** in an expanded state. The tubular body **505** may be encircled by an inner arrangement **510** and an outer arrangement **515**. The tubular body **505** may be provided with ribbing **555** or other means configured to prevent rotation of the inner arrangement **510** about the tubular body **505**. The tubular body **505** may be provided with one or more flanges **545** proximate to the inner arrangement **510** and configured to anchor the inner arrangement **510** so as to prevent axial movement with respect to the tubular body **505**.

[0044] The inner arrangement **510** and the outer arrangement **515** may respectively include components **510**A and **515**A, disposed in a generally circular, annular and/or cylindrical arrangement. For example, as depicted in the cross-sectional representations in FIGS. **5**B and **5**D, one or more components **510**A, **515**A generally form partial sectors or arcs. The components **510**A, **515**A may be solid or hollow pieces and may be made of metal, composite or another type of suitable material.

[0045] One or more sensor packages **550** may be coupled to the outer arrangement **515**. Each sensor package **550** may have at least a portion extending into a component **515**A. In certain embodiments, one or more sensor packages may be coupled to the inner arrangement **505**. In certain embodiments, one or more sensor packages may be coupled to both the inner arrangement **505** and the outer arrangement **515**. In the latter embodiment, the sensor packages may be configured for noise-canceling in order to attenuate tubular-borne noise.

[0046] As depicted, the inner arrangement **510** and the outer arrangement **515** may be coupled by way of one or more struts **520**. The struts **520** may be configured to have a degree of freedom and, for example, may be swivably attached to one or both of the inner arrangement **510** and the outer arrangement **515**. It may be preferable that a swivel attachment be associated with either one or the other of the inner arrangement **510** and the outer arrangement **515**, so that both may maintain a stable configuration during insertion into or retrieval from the borehole. In one exemplary embodiment, the swivel attachment may be of a hinge type and may have a vertical length around an axis of rotation. In certain embodiments, the swivel attachment may include paths for electrical signal lines.

[0047] Adjacent components **510**A, **515**A may be coupled to each other. For example without limitation, each component **510**A, **515**A may be coupled to an adjacent component **510**A, **515**A via a mandrel and/or an expansion sleeve. As depicted, adjacent components **510**A of the inner arrangement **510** are coupled via expansion sleeves **525**. Adjacent components **515**A of the outer arrangement **515** are coupled via expansion sleeves **530**. The expansion sleeves **525** and **530** may partially encase, surround or otherwise wrap around portions of adjacent circular components **510**A and **515**A, thereby aiding the generally circular alignment of the components **510**A and **515**A. The expansion sleeves **525** and **530** may be made of metal, composite or another type of suitable material.

[0048] FIGS. **5**E-**5**J illustrate one example of an expansion sleeve **530** about adjacent circular components **515**A. FIG. **5**E illustrates an unexpanded state, while FIG. **5**F illustrates an expanded state. The adjacent components **510**A may be configured to allow a region **535** between them when not flush. Swellable elements may be disposed in the region **535**. In one example, elastomer **530**A may be disposed in the region **535** with swell controls **560**. Though not depicted, an expansion sleeve **525** and adjacent circular components **510**A may be similarly configured. The swellable elements may be configured to expand generally tangentially to the inner arrangement **510** so that the inner arrangement **510** expands generally tangentially, as opposed to radially. Thus, the swellable elements, in conjunction with other elements of system **500**, provide a mechanism for the system **500** to detach from the tubular body.

[0049] As depicted in FIG. **5**G, the swell controls **560** may include fluid and/or electrical lines **565** that may be configured to convey activation agent and/or activate valves **570**. The valve **570** may include one or more reservoirs and may be operable to disperse the activation agent to the swellable materials **515**A. By this or similar means, the swell controls **560** may be adapted for swelling the swellable materials **515**A so that the system **500** may detach from the tubular body.

[0050] In addition to detachment, the swellable elements may similarly provide a mechanism for reattachment. For example, it may be preferable for the swellable elements to be water-swellable. A deswelling agent may include salt to extract water from a water-swellable material by osmosis. The electrical lines may later be used to expose the swellable elements to a deswelling agent in order to shrink the swellable material, thereby transitioning the tool to a retracted state that would allow for tool retrieval. Thus, the swell controls **560** may be adapted for de-swelling the swellable materials **515**A.

[0051] FIGS. **5**H and **5**I show diagrams of one exemplary embodiment of a valve **570**. By way of example without limitation, the valve **570** may include a deswelling agent reservoir **572** and/or a swelling agent reservoir **574**. A slide **576** may include ports that may be selectively aligned with a deswelling agent reservoir **572** and/or a swelling agent reservoir **574**. For example, FIG. **5**I depicts a view of the slide where ports **578**A are shown in an open state and in aligned with a reservoir port. Ports **578**B are shown in a closed state and not aligned with a reservoir port. The valve **570** may be configured with the slide **576** to allow for the controlled feed of an agent to the swellable material. The slide **576** may be activated by hydraulics or an electrical device such as an electromagnet on either end. In alternative embodiments, one or both of the valve **570** and the slide **576** may be adapted so the ports of the slide may be selectively aligned with the ports of a reservoir by rotation, rather than lateral motion of the slide **576** indicated in FIG. **5**H. For example, the slide **576** may have a disk form with ports that may be rotated about a center.

[0052] FIG. **5**J illustrates a mandrel **525**A that may be used in the alternative or in addition to expansion sleeves to couple two or more adjacent circular components **510**A and **515**A. The mandrel **525**A may be used as a one- or two-ended piston to prevent or minimize lateral expansion such that expansion is directed along an axis of the mandrel. In certain embodiments, secondary mandrels in the outer arrangement **515** may be preferred in order to shift the centerpoint of the inner arrangement **510** as the tubular body **505** may not always be well-centered in the borehole **540**.

[0053] Swellable elements may be included with the mandrels **525**A. As depicted in FIG. **5**J, a mandrel **525**A may include an outer body **525**B that at least partially surrounds an elastomer material **525**C. The elastomer material **525**C is shown in an at least partially expanded state. The outer body **525**B may comprise metal, a composite, or any other suitable material. Although the mandrel **525**A is depicted as having a particular shape, it should be understood that the shape and implementation of the mandrel **525**A may be subject to considerable modification, as would be understood by one of ordinary skill in the art having the benefit of this disclosure.

[0054] Thus, in the expanded state, the system **500** allows sensor packages to be deployed in a state that has no direct physical contact or intermediate structural contact with the tubular body. Having the tool placed against the side of the borehole with no direct solid-to-solid contact with the tubular body, the sensor packages are afforded a degree of acoustic isolation from acoustics that may otherwise be transferred via the tubular body. Further, the system **500** provides a safety margin such that the tool may be spared from sharp, high-force, or uncontrolled movements that could endanger tubing, wiring, the borehole wall, or the tool. The generally circular outer arrangement **515** provides a perimeter that may allow for positioning while maintaining tolerance for irregularities that may be encountered in the surface of the borehole. Although system **500** is depicted with four circular components and four sensor packages in the outer arrangement **515**, and four circular components in the inner arrangement **510**, it should be understood that other embodiments may include a different number and combination of circular components and sensor packages.

[0055] In another embodiment, the inner arrangement **510** may be coupled to spring- powered extensions released to point inwards to the tubular body **505** in order to "measure" the radial distance between the inner arrangement **510** and the tubular body **505** at three or more points. As the spring-powered extensions increasingly extend, they may restrict the flow of swelling agent into their respective components **510**A, thereby allowing those swellable sections nearest the tubular to be expanded outwards more rapidly than those farther away, and thereby centering the inner arrangement **510** at a uniform distance from the tubular body **505**. Once deployed, the extensions may be refracted into the inner arrangement **510**.

[0056] Certain embodiments of the present disclosure may provide a simpler, cheaper, and easier means of coupling sensors to a formation or tubing/casing that are likely to provide much surer coupling. Most previous sensor deployments have used cement coupling (generally for permanent deployments), mechanical coupling such as clamp arms and bow springs (for both permanent and retrievable applications), magnetic coupling (retrievable applications), or even uncoupled deployments (e.g., sensors attached to tubing run inside of casing) that rely on friction and bending stresses. Methods and systems of the present disclosure may eliminate the need for mechanical clamp arms (which may have leak issues with seals and high temperature), bow springs (which may have poor high frequency response and resonances), magnets (which may have limited coupling and resonances), or cementing. Methods and systems of the present disclosure may also improve omnidirectional array fidelity, even for retrievable operations and settings where the swelling elements may be subsequently de-swelled, detached or torn off to facilitate tool retrieval or repositioning.

[0057] Certain embodiments of the present disclosure may allow for long-term emplacement in difficult open-hole environments without permanently cementing an instrument in place. This may simplify operations and may allow for retrievable sensor devices if difficulties occur during emplacement. This may avoid the situation in open-hole environments where mechanical arms or bowsprings can sink into soft materials in the hole and cause poor tool coupling. Such a situation can occur in shales and many shallow boreholes where sensors would otherwise have to be cemented in permanently to obtain good coupling.

[0058] Certain embodiments may allow for improved signal fidelity for microseismic monitoring of hydraulic fractures by ensuring better coupling compared to clamp arms, bow spring, magnets, or other emplacement methods, thus attenuating or eliminating longitudinal tool vibrations that degrade the recording fidelity of elastic body wave motion parallel to a tool axis. In certain embodiments, swelling elements may effectively dampen acoustic noise generated by flow in production tubulars as well as noise received via the tubulars. The swelling elements may even yield sensor isolation from the tubulars even though swellable elements are in contact with both. Additionally, certain embodiments may allow for securely planting surface instruments in soft, crumbly ground.

[0059] Certain embodiments may remove directional bias of recorded signals by emplacing sensors in the center of a borehole with equal response from all directions, as opposed to a likely higher fidelity on the side of the borehole on which it is deployed when clamped or cemented. Certain embodiments may eliminate the need for a nearby vertical observation well by allowing for installation of tools in the injection/production well with good coupling and a degree of noise suppression from tubing activities.

[0060] Certain embodiments may be used for time-lapse seismic monitoring and/or time-lapse deformation monitoring throughout the life of the reservoir for more permanent installations. The time-lapse seismic application requires a source on either the surface or in a nearby well; time-lapse deformation only requires continuous measurements of tilt or other deformation parameters. For emplacement of tiltmeters, geophones, or other sensors in shallow boreholes, certain embodiments provide a fast, easy method to deploy sensors, potentially allowing them to stabilize much faster—which translates to a shorter lead time for monitoring.

[0061] Even though the figures depict embodiments of the present disclosure in a horizontal section of a wellbore, it should be understood by those skilled in the art that embodiments of the present disclosure are well suited for use in deviated or vertical wellbores or casings. Accordingly, it should be understood by those skilled in the art that the use of directional terms such as above, below, upper, lower, upward, downward and the like are used in relation to the illustrative embodiments as they are depicted in the figures, the upward direction being toward the top of the corresponding figure and the downward direction being toward the bottom of the corresponding figure. Additionally, as discussed above, embodiments of the present disclosure may be implemented in cased or uncased wellbores, even though only uncased wellbores are depicted in the figures.

[0062] Therefore, the present invention is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present invention. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. The indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the element that it introduces.

What is claimed is:

1. A system for monitoring a parameter of a subterranean formation using swellable materials, the system comprising:
- a sensor device configured to detect a parameter of a subterranean formation;
- a swellable material configured to position the sensor device toward a surface of the subterranean formation by swelling of the swellable material; and
- a telescoping section coupled to the sensor device and emplaced in the swellable material, wherein the telescoping section is configured to extend with the positioning of the sensor device.

2. The system of claim **1**, wherein the sensor device is emplaced at least partially in the swellable material.

3. The system of claim **1**, wherein the swellable material is further configured to position the sensor device against the surface of the subterranean formation by swelling.

4. The system of claim **1**, wherein the sensor device is operative to communicate a signal related to the parameter of the subterranean formation.

5. The system of claim **4**, wherein the telescoping section is configured to allow the positioning of the sensor device while the sensor device is operative to communicate a signal related to the parameter of the subterranean formation.

6. The system of claim **1**, wherein the swellable material is on an exterior surface of a tubular body and is configured to position the sensor device away from the pipe by swelling.

7. The system of claim **6**, wherein the swellable material is further configured to reduce an effect on the sensor device of acoustic noise traveling along the tubular body.

8. A system for monitoring a parameter of a subterranean formation using swellable materials, the system comprising:

a sensing tool configured to detect a parameter of a subterranean formation, wherein the sensing tool comprises a generally tubular body; and

a swellable material on an exterior surface of the generally tubular body, wherein the swellable material is configured to anchor the sensing tool in a position corresponding to a surface of the subterranean formation by swelling of the swellable material.

9. The system of claim **8**, wherein the swellable material is further configured to substantially center the sensing tool between at least two opposing points on the surface of the subterranean formation.

10. The system of claim **9**, wherein the swellable material comprises a plurality of swellable members disposed along the generally tubular body.

11. The system of claim **9**, wherein the swellable material at least substantially surrounds a length the generally tubular body.

12. The system of claim **8**, wherein the swellable material is configured to anchor the sensing tool against the surface of the subterranean formation.

13. The system of claim **12**, the swellable material comprises a plurality of swellable members disposed along the generally tubular body, wherein each swellable member partially surrounds a corresponding length of the generally tubular body.

14. The system of claim **12**, wherein the swellable material longitudinally extends along a length of the generally tubular body.

15. A method for monitoring a parameter of a subterranean formation, the method comprising:

introducing a sensing tool to a wellbore, wherein the sensing tool comprises a generally tubular body and is configured to detect a parameter of a subterranean formation;

positioning the sensing tool in a position corresponding to a surface of the wellbore by swelling a swellable material, wherein the swellable material is disposed on an exterior surface of the generally tubular body; and

detecting a parameter of a subterranean formation with the sensing device.

16. The method of claim **15**, wherein the positioning step comprises substantially centering the sensing tool between at least two opposing points on the surface of the wellbore.

17. The method of claim **16**, wherein the swellable material comprises a plurality of swellable members disposed along the generally tubular body.

18. The method of claim **16**, wherein the swellable material at least substantially surrounds a length the generally tubular body.

19. The method of claim **15**, wherein the positioning step comprises anchoring the sensing tool against the surface of the wellbore.

20. The method of claim **19**, wherein the swellable material longitudinally extends along a length of the generally tubular body.

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