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(54) **EXPANDABLE AND DEGRADABLE DOWNHOLE HYDRAULIC REGULATING ASSEMBLY**

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(60) Provisional application No. 60/771,627, filed on Feb. 9, 2006, provisional application No. 60/746,097, filed on May 1, 2006.

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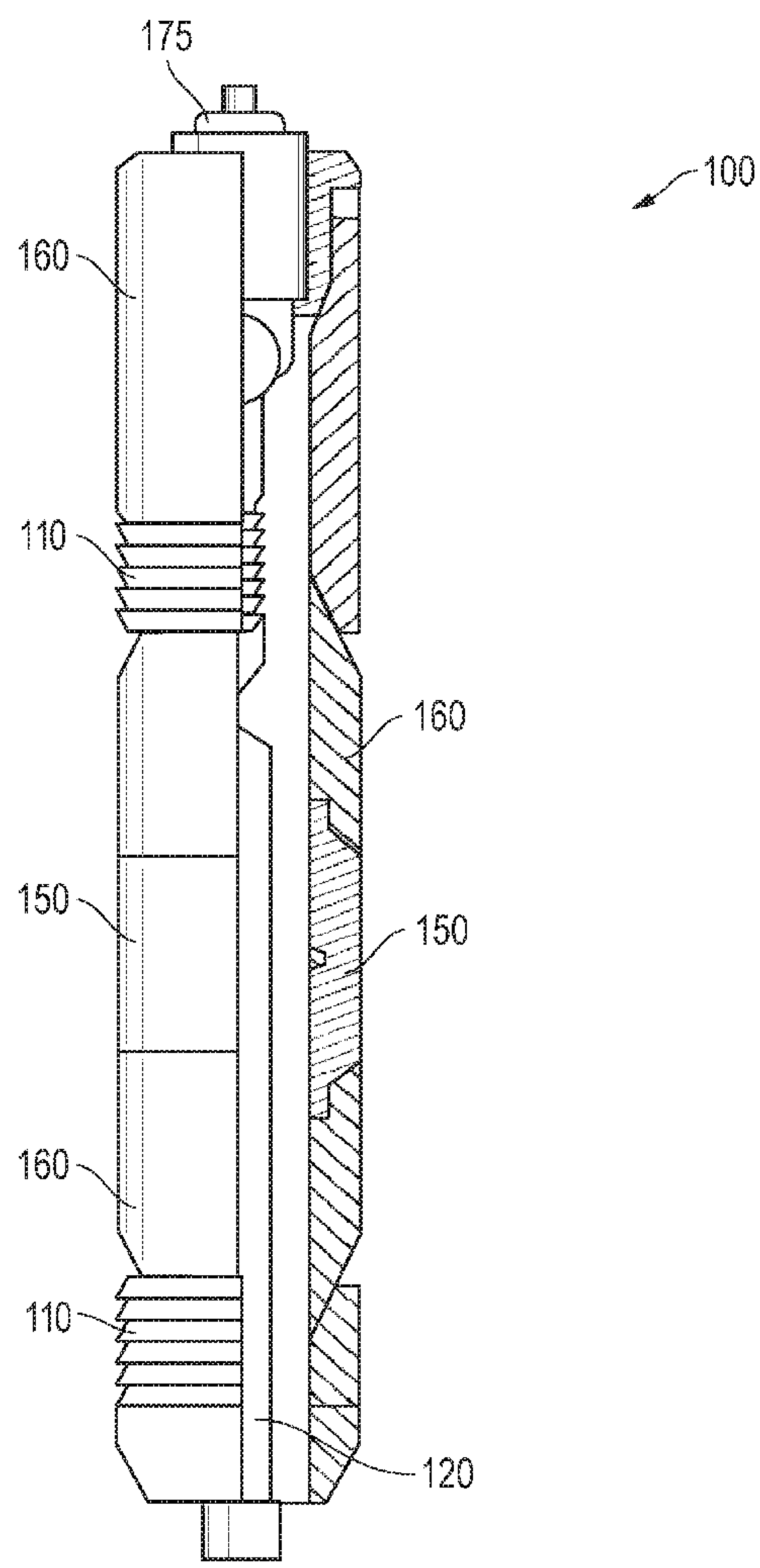
(57) **ABSTRACT**

A hydraulic regulating mechanism for disposal in a well. The mechanism includes a degradable metal based element and a swellable component for hydraulic regulation. The mechanism is configured for ease of setting and removal by allowing degrading of the metal based element upon exposure of certain downhole conditions to trigger shrinking of the swellable component. Further, the swellable component may be initially set by exposure to downhole conditions as well. Ultimately, a mechanism is provided which may effectively regulate high pressure applications downhole and yet, as a practical matter, be removed via a displacement or drill out that may take less than 15 to 30 minutes to achieve.



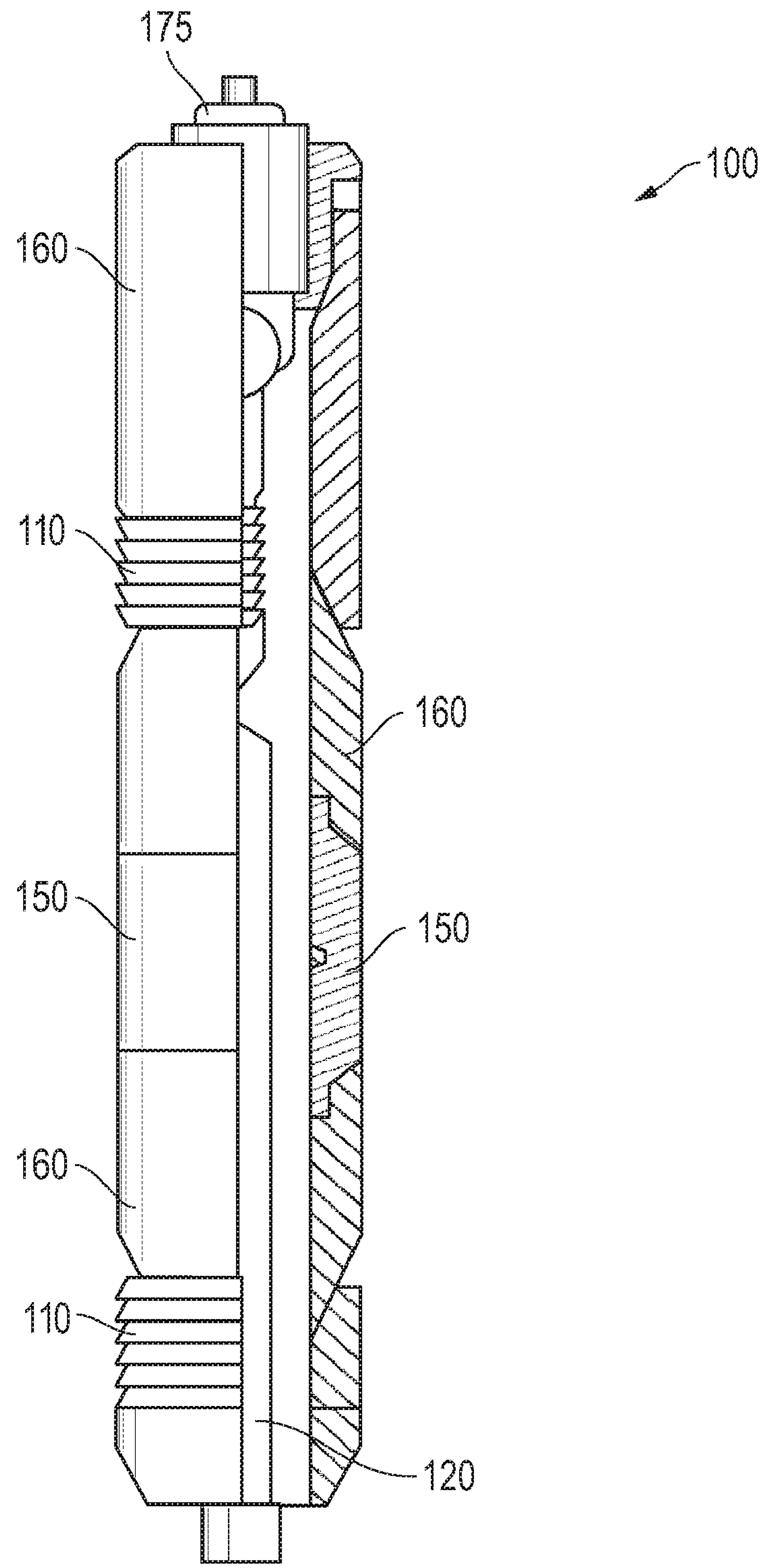
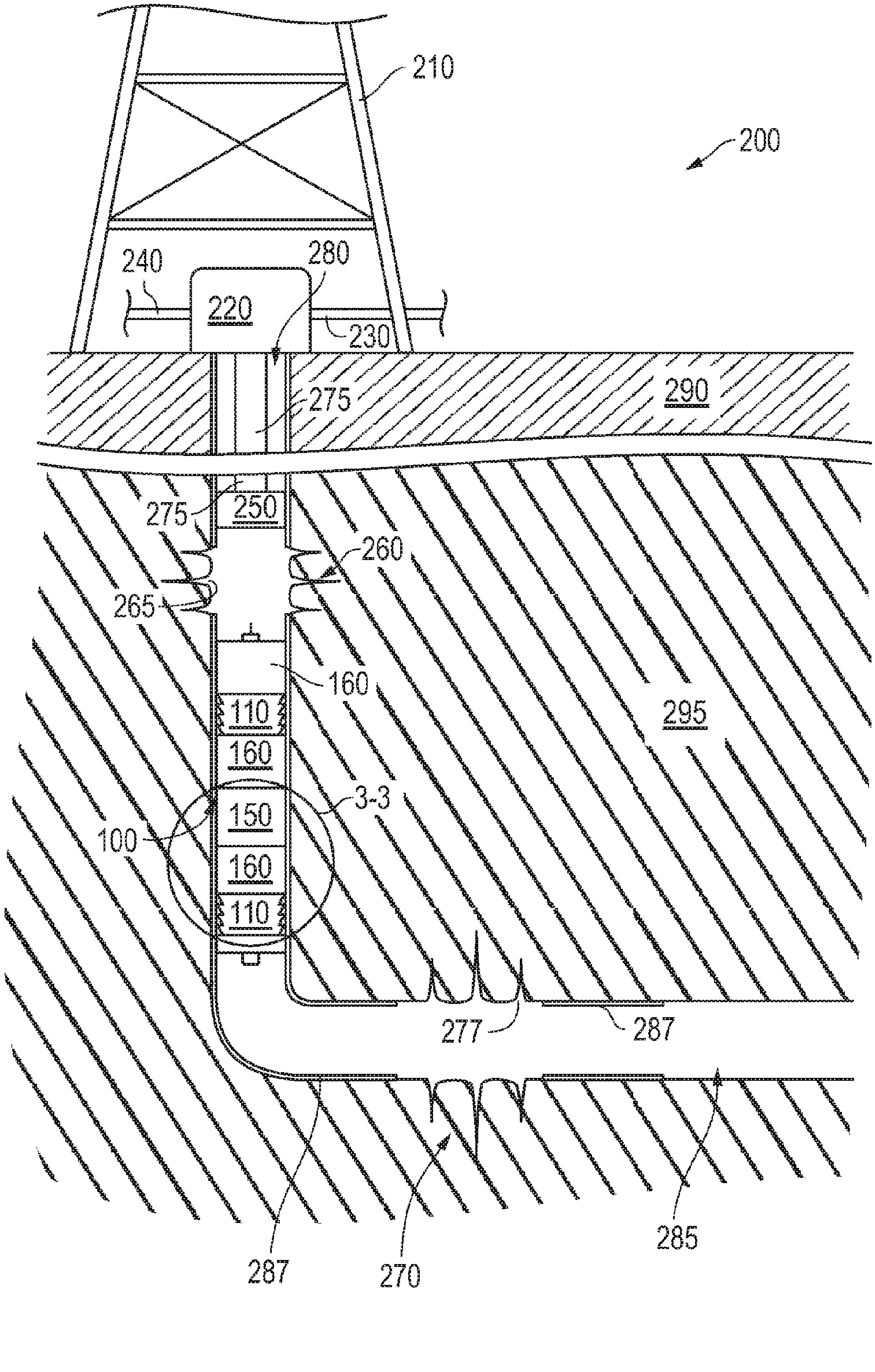


FIG. 1



210
200
240
280
220
230
290
275
275
250
260
265
160
110
160
295
3-3
150
100
160
110
277
287
287
270
285

FIG. 2

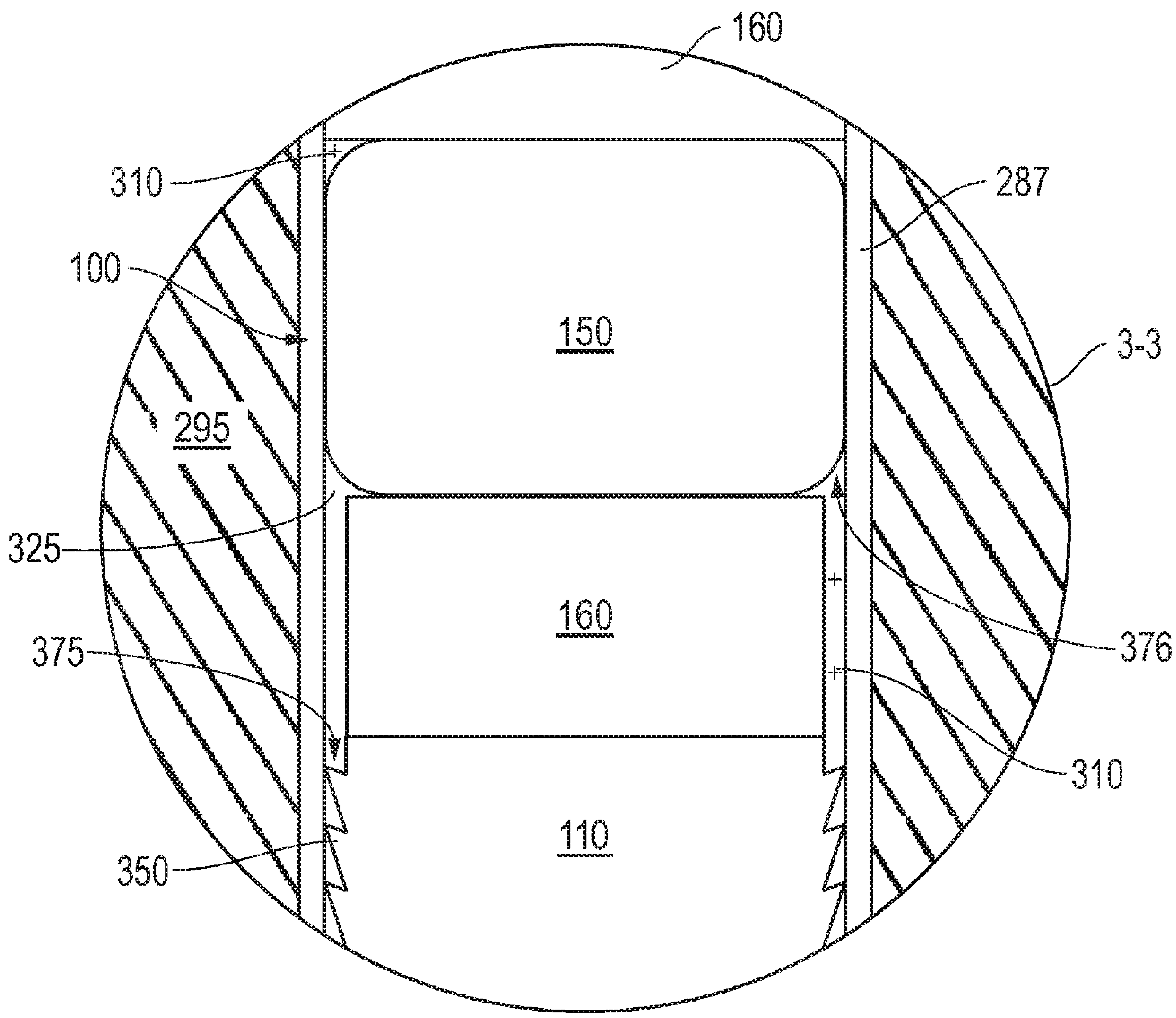


FIG. 3

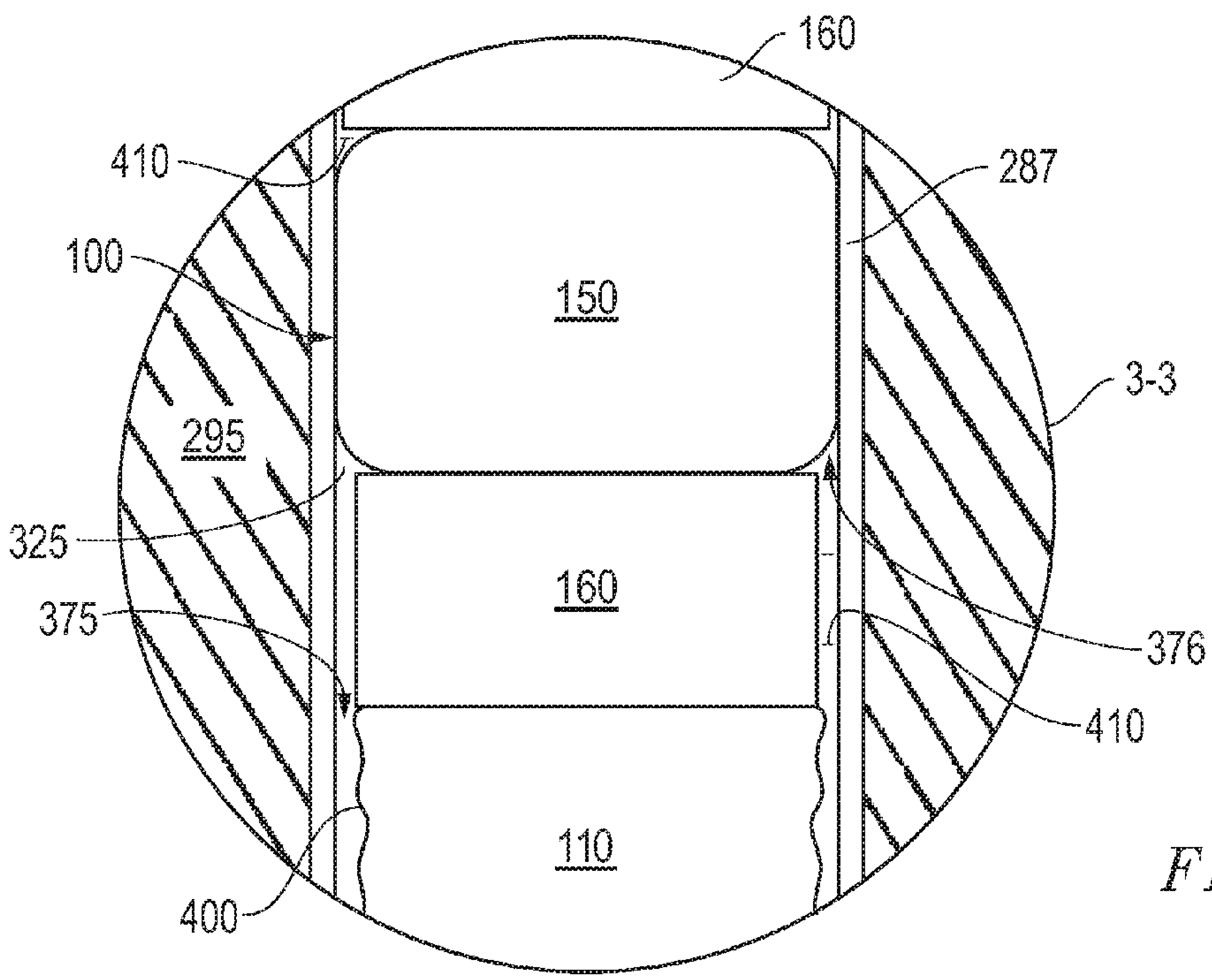

160
410
287
100
150
3-3
295
325
160
375
376
410
110
400

FIG. 4A

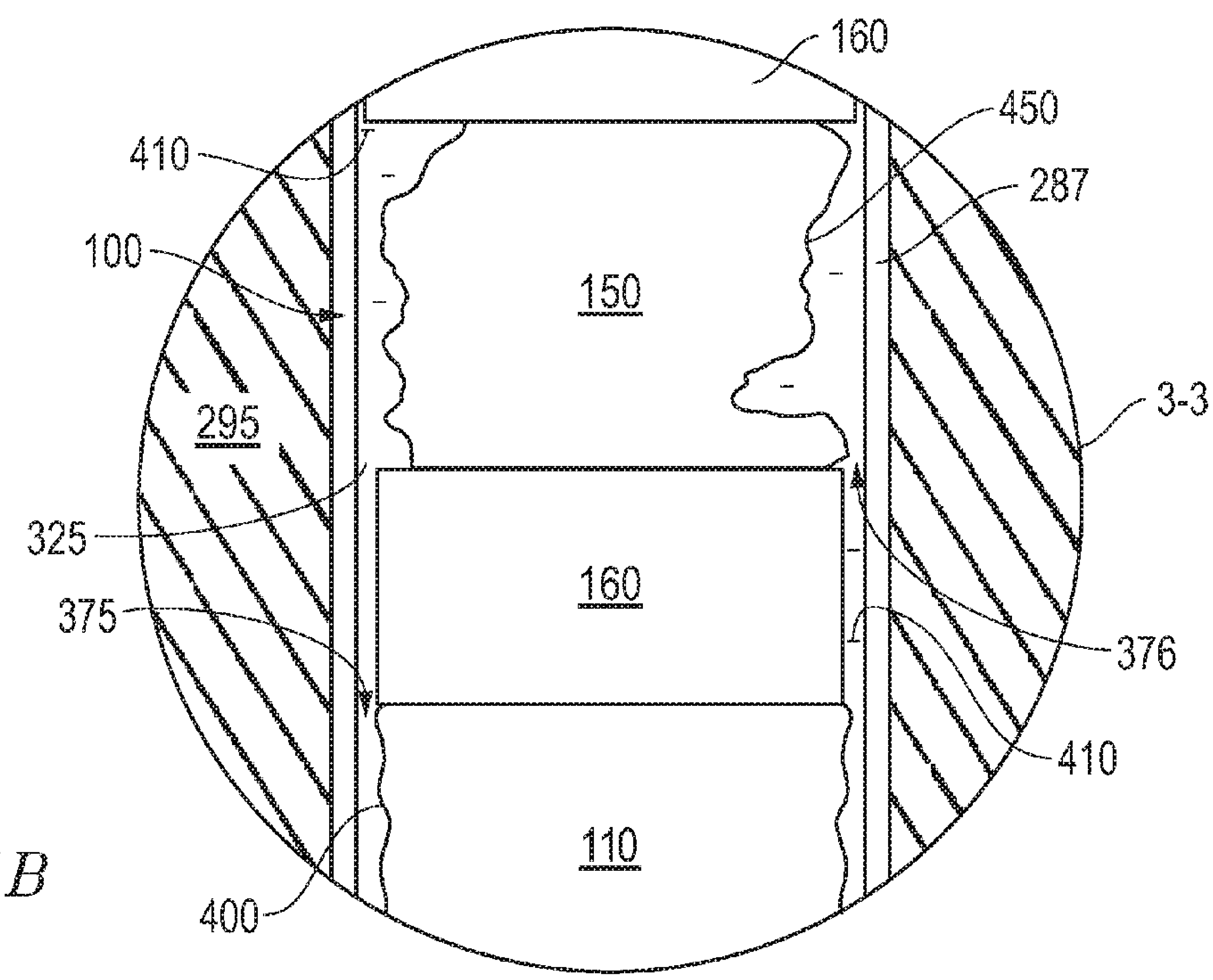
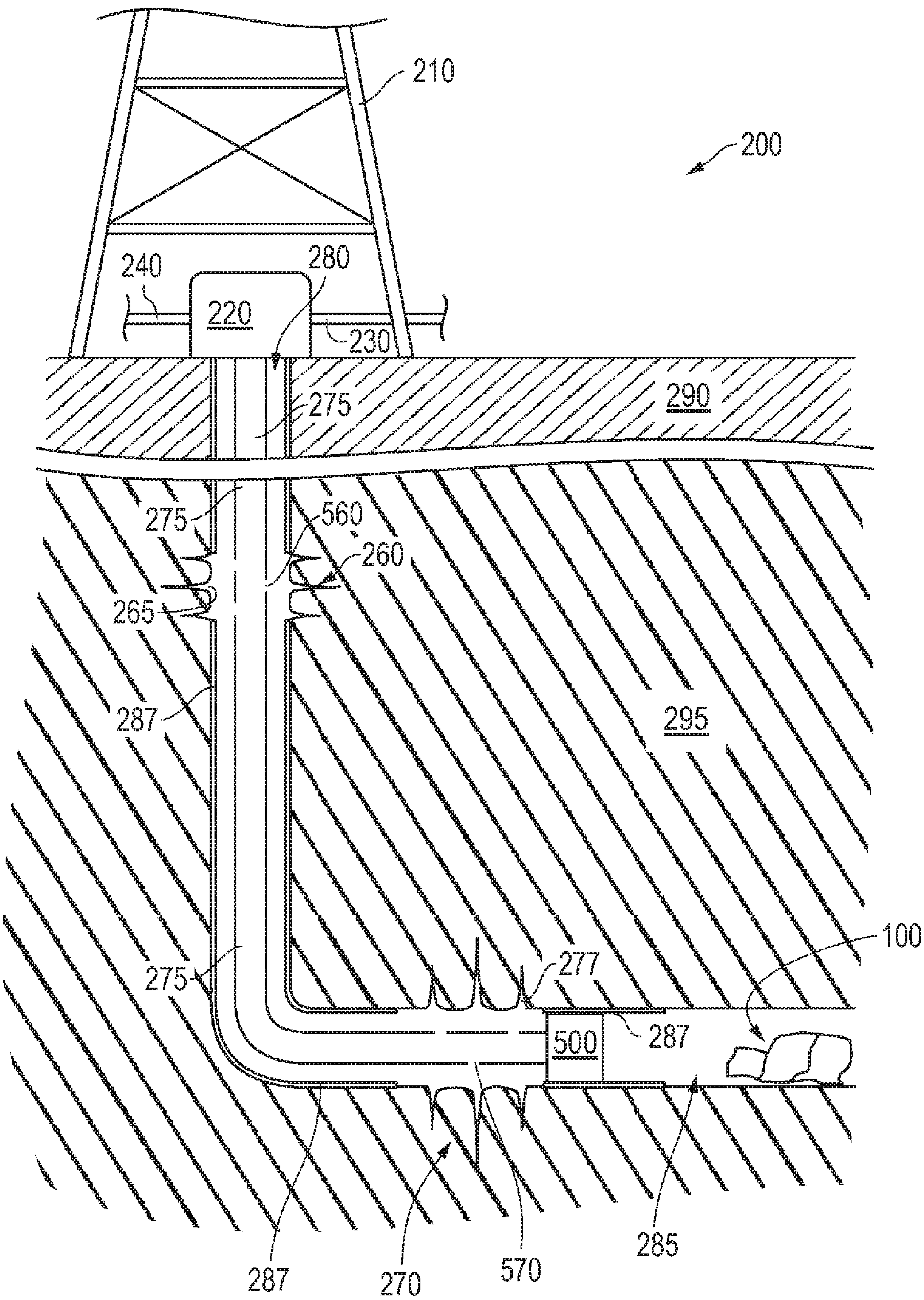

160
450
410
287
100
150
3-3
295
325
160
375
376
410
110
400

FIG. 4B



210
200
240
280
220
230
275
290
275
560
260
265
287
295
100
277
275
500
287
287
270
570
285

FIG. 5

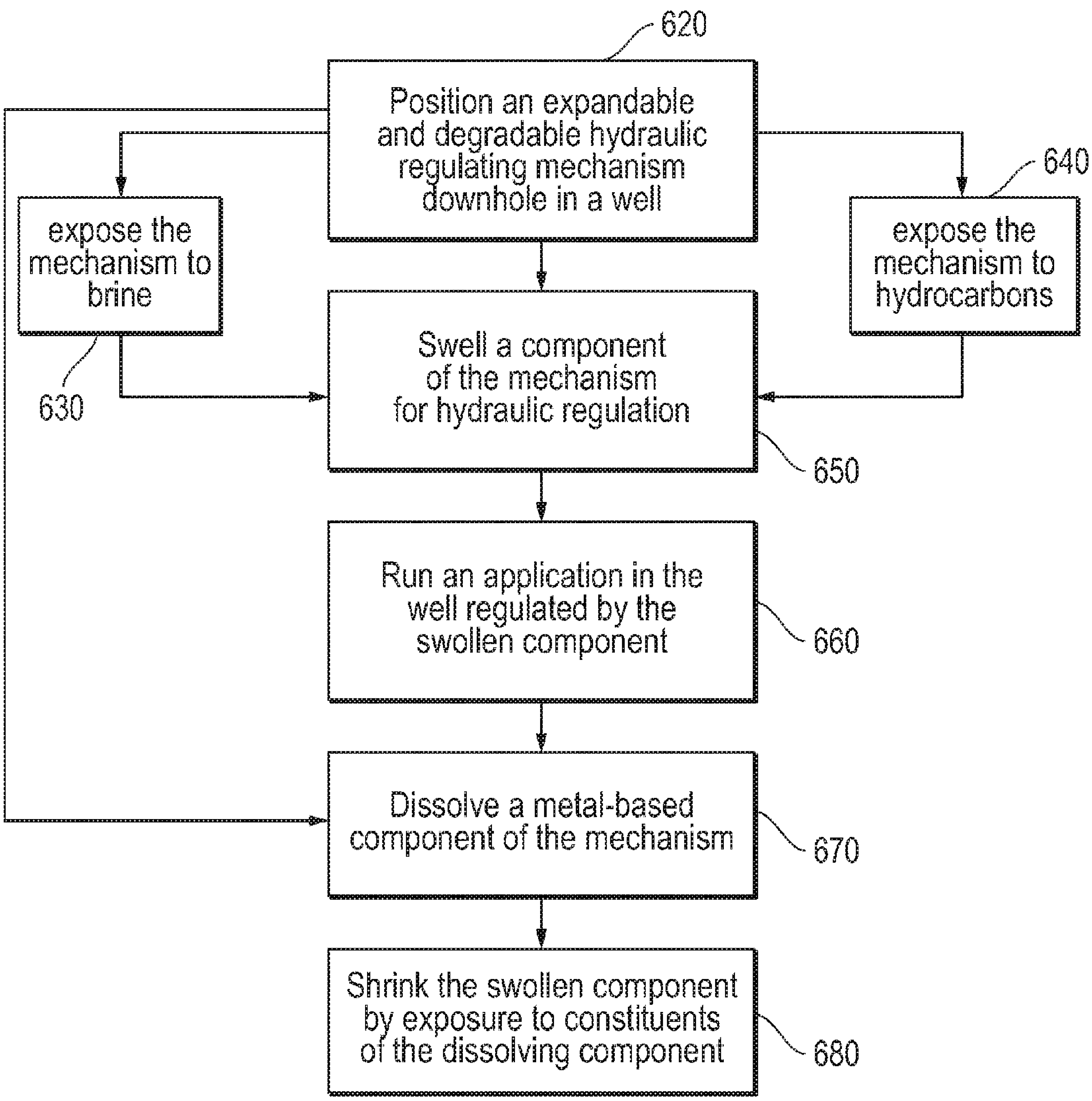

620
Position an expandable and degradable hydraulic regulating mechanism downhole in a well
expose the mechanism to brine
630
expose the mechanism to hydrocarbons
640
Swell a component of the mechanism for hydraulic regulation
650
Run an application in the well regulated by the swollen component
660
Dissolve a metal-based component of the mechanism
670
Shrink the swollen component by exposure to constituents of the dissolving component
680

FIG. 6

EXPANDABLE AND DEGRADABLE DOWNHOLE HYDRAULIC REGULATING ASSEMBLY

PRIORITY CLAIM/CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present document is a Continuation in Part claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 12/855,503 filed on Aug. 12, 2010, and entitled “Dissolvable Bridge Plug” which is in turn a Continuation in Part of U.S. patent application Ser. No. 11/427,233, filed on Jun. 28, 2006, and entitled, “Degradable Compositions, Apparatus Comprising Same, and Method of Use”. This ’233 Application also in turn claims priority under 35 U.S.C. §119(e) to U.S. Provisional Patent Application Ser. Nos. 60/771,627 and 60/746,097, filed on Feb. 9, 2006, and May 1, 2006, respectively. The disclosures of each of these Applications are incorporated herein by reference in their entireties. Further, the present document is also a Continuation in Part claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 12/763,280, filed on Apr. 20, 2010, and entitled, “Swellable Downhole Device of Substantially Constant Profile”.

FIELD

[0002] Embodiments described relate to deliverable downhole device assemblies for affecting fluid flow in a well. More specifically, assemblies which are configured to swell in order to divert, restrict, or isolate are detailed. Further, these assemblies are also tailored to degrade in the well over a given period, upon exposure to certain downhole conditions, or both.

BACKGROUND

[0003] Exploring, drilling and completing hydrocarbon and other wells are generally complicated, time consuming and ultimately very expensive endeavors. In recognition of these expenses, added emphasis has been placed on efficiencies associated with well completions and maintenance over the life of the well. Over the years, ever increasing well depths and sophisticated architecture have made reductions in time and effort spent in completions and maintenance operations of even greater focus.

[0004] Completions and maintenance operations often involve the utilization of isolation mechanisms such as packers, plugs, and other downhole devices. Such devices may be used to sealably isolate one downhole section of the well from another as an application is run in one of the sections. Indeed, a considerable amount of time and effort may be spent achieving such isolations in advance of running the application, as well as in removing the isolation mechanism following the application. For example, isolations for perforating and fracturing applications may involve a significant amount of time and effort, particularly as increases in well depths and sophisticated architecture are encountered. These applications involve the positioning of an isolation mechanism in the form of a bridge plug. More specifically, the bridge plug is located downhole of a well section to be perforated and fractured. Positioning of the bridge plug may be aided by pumping a driving fluid through the well. This may be particularly helpful where the plug is being advanced through a horizontal section of the well.

[0005] Once in place, equipment at the oilfield surface may communicate with the plug over conventional wireline so as to direct setting thereof. In the circumstance of a cased well, such setting may include expanding slips of the plug for interfacing a casing wall of the well and thereby anchoring of the plug in place. A seal of the plug may also be expanded into sealing engagement with the casing. Thus, structural and hydraulic isolation may be achieved.

[0006] Once anchored and hydraulically isolated, a perforation application may take place above the plug so as to provide perforations through the casing in the corresponding well section. Similarly, a fracturing application directing fracture fluid through the casing perforations and into the adjacent formation may follow. This process may be repeated, generally starting from the terminal end of the well and moving uphole section by section, until the casing and formation have been configured and treated as desired.

[0007] The presence of the set bridge plug as indicated above keeps the high pressure perforating and fracturing applications from affecting well sections below the plug. Indeed, even though the noted applications are likely to generate well over 5,000 psi, the well section below the plug is kept isolated from the section thereabove. This degree of isolation is achieved largely due to the use of durable metal features of the plug, including the above noted slips, as well as a central mandrel.

[0008] Unfortunately, unlike setting of the bridge plug, wireline communication is unavailable for releasing the plug. Rather, due to the high pressure nature of the applications and the degree of anchoring and sealing required of the plug, it is generally configured for near permanent placement once set. As a result, removal of a bridge plug may be quite challenging, particularly where the plug is set in a horizontal section of the well as detailed further below.

[0009] In many circumstances, a packer or seal such as that of the plug may be of a swellable configuration. That is, rather than employing a more challenging isolation technique, the seal may be of a material configured to swell upon exposure to certain downhole conditions. Generally, the material is configured to expand or ‘swell’ upon exposure to brine. As used herein, the term brine is meant to refer to any water-based fluid containing a measureable concentration of a salt such as sodium chloride. A brine swellable material may be well suited for construction of a seal that is to be exposed to a commonly encountered horizontal terminal end of a well. This is because such locations are often partially open-hole and prone to brine production. However, as alluded to above, due to the likely continued presence of brine in the horizontal section, the seal may be set for long term placement.

[0010] As also alluded to above, the slips of the plug may be anchored in a near permanent manner as well. Thus, ultimately a labor and time intensive drill-out of the plug may be required. Indeed, each drill-out of a plug in a horizontal well section may require hours of dedicated manpower and drilling equipment. All in all, this may add up to several days and several hundred thousand dollars in added manpower and equipment expenses, solely dedicated to bridge plug drill-out. Unfortunately, even with such expenses incurred, the most terminal or downhole horizontal plugs are often left in place, with the drill-out application unable to achieve complete plug removal, thus cutting off access to the last several hundred feet of the well. Furthermore, a host of other isolation mechanisms make use of metal based anchoring and support features as well as swellable elastomer based sealing elements, both of which display far greater setting than releasing characteristics.

SUMMARY

[0011] A downhole isolation mechanism is disclosed for use in a well. The mechanism includes a metal based component configured for degrading in the well. A seal is also provided that is coupled to the metal based component and configured to swell upon exposure to a downhole condition. Further, the seal is also configured to shrink upon the degrading.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a side, partially-sectional view of an embodiment of an expandable and degradable downhole hydraulic regulating assembly in the form of a bridge plug.

[0013] FIG. **2** is an overview of an oilfield accommodating a well with the hydraulic regulating bridge plug of FIG. **1** employed therein.

[0014] FIG. **3** is an enlarged view of a downhole area taken from **3-3** of FIG. **2** and revealing seal and slip interfaces of the bridge plug with a casing of the well.

[0015] FIG. **4**A is the enlarged view of FIG. **3** now revealing the degradable nature of the slip and the changing slip interface as a result.

[0016] FIG. **4**B is the enlarged view of FIG. **4**A now revealing the degradable nature of the seal due to the degrading slip and the changing seal interface as a result.

[0017] Referring now to FIG. **5**, the overview of FIG. **2** is depicted with the bridge plug of FIG. **1** degraded and displaced eliminating its hydraulic regulating effects.

[0018] FIG. **6** is a flow-chart summarizing an embodiment of employing an expandable and degradable hydraulic regulating assembly such as the noted plug.

DETAILED DESCRIPTION

[0019] Embodiments are described with reference to certain downhole operations employing an expandable and degradable downhole hydraulic regulating assembly. For example, embodiments herein focus on such an assembly in the form of a bridge plug to aid in perforating and fracturing applications. However, a variety of alternate embodiments of expandable and degradable downhole hydraulic regulating assemblies are possible. For example, any number of devices for more temporary isolations, profilers, diverters, and/or constrictors, may take advantage of expandable and degradable characteristics of embodiments described below. Regardless, embodiments described herein include a downhole assembly of some type that is both expandable for hydraulic regulation and degradable to aid in removal or displacement.

[0020] Referring now to FIG. **1**, a side, partially-sectional view of an embodiment of an expandable and degradable hydraulic regulating assembly is depicted in the form of a bridge plug **100**. The bridge plug **100** is referred to as degradable or dissolvable in the sense that certain features thereof may be configured for passive degradation or dissolution upon exposure to downhole well conditions as detailed further below. As used herein, the term passive degradation is meant to refer to degradation upon exposure to downhole conditions, whether or not such conditions are pre-existing or induced.

[0021] In the embodiment of FIG. **1**, the plug **100** includes metal based elements of slips **110** and a mandrel **120** which, while ultimately degradable, are initially of substantially high strength and hardness (e.g. L80, P110). Thus, maintaining isolation and anchoring to a casing **380** during a high pressure application may be ensured (see FIG. **3**A). In one embodiment, the slips **110** and mandrel **120** are configured to withstand a pressure differential of more than about 8,000 psi to ensure structural integrity of the plug **100**. Thus, a standard perforating or fracturing application which induces a pressure differential of about 5,000 psi is not of significant concern.

[0022] In spite of the high strength and hardness characteristics of the slips **110** and mandrel **120**, their degradable or dissolvable nature allows for subsequent displacement, drill-out or other plug removal techniques to be carried out in an efficient and time-saving manner (see FIG. **5**). Incorporating a degradable or dissolvable character into the slips **110** and mandrel **120** may be achieved by use of reactive metal in construction. Namely, as detailed to a greater degree below, the slips **110** and mandrel **120** may be made up of a reactive metal such as aluminum with an alloying element incorporated thereinto. For example, as detailed in U.S. application Ser. Nos. 12/855,503 and 11/427,233, incorporated herein, the alloying element may be elements such as lithium, gallium, indium, zinc and/or bismuth. Thus, over time, particularly in the face of exposure to water, fracturing fluid, high temperatures, and other downhole well conditions, the material of the slips **110** and mandrel **120** may begin to degrade or dissolve.

[0023] Continuing with reference to FIG. **1**, with added reference to FIG. **2**, the plug **100** may also include a seal **150** for isolation upon deployment in a well **280**. The seal **150** is swellable. For example, in one embodiment, the seal **150** is of a brine swellable polymeric construction, perhaps of styrenic isoprene block copolymers, polyvinyl alcohol, polylatic acid, or sulfonated polyarylether ketone. Thus, it may be well suited for placement as shown in FIG. **2**, where it is exposed to an open hole portion of a lateral leg **285** of the well **280**, perhaps prone to brine production. Furthermore, water or brine may be introduced by a well operator to aid in swelling of the seal **150**. Thus, the brine swellable construction may help to ensure adequate hydraulic sealing with the well casing **287** at the location of the plug **100**.

[0024] In one embodiment the seal **150** is constructed of swellable elastomers that are less affected by fluctuations in brine concentration. Thus, its long-term effectiveness may be enhanced. More specifically, polymer particles may be drawn from a betaine group prepared by inverse emulsion polymerization. Additional fillers and vulcanizing agents and other substances may be incorporated into elastomer. Ultimately, the elastomer backbone of the brine swellable material may be tailored with particular concentrations of cations and/or anions grafted thereto so as to reduce the sensitivity thereof to brine concentration. As a result, the seal **150** may be constructed that is swellable in the presence of brine but with a resultant swell profile that is of a reduced sensitivity the actual concentration of brine in the well **180**.

[0025] The elastomer base material for the seal **150** may also include non-elastomeric polymers and be constructed in a variety of configurations. For example, different non-elastomer and elastomer layers may be individually provided of varying thicknesses. Such layers may be stacked or of interpenetrating networks. Further, the elastomer composition itself may include fillers, plasticizers, accelerants and various fibers. Additionally, non-elastomeric polymer choices may include thermoplastic polymers, such as polyolefins, polyamides, polyesters, thermoplastic polyurethanes and polyurea urethanes, copolymers and blends thereof and/or thermoset polymers such as phenolic and epoxy resins.

[0026] Continuing with reference to FIG. **1**, the plug **100** is configured for wireline deployment and equipped with a coupling **175** for securing to the wireline. The plug **100** also includes other body portions **160** which may house underlying components and/or serve as structural interfaces between the slips **110**, seal **150**, head **175** and other plug features. Unlike the slips **110** and mandrel **120**, however, none of the body portions **160**, the seal **150**, or the head **175** is responsible for anchoring or maintaining structural integrity of the plug **100** during a perforating, fracturing or other high pressure applications in the well **280**. Thus, at the very outset material choices for these features **150**, **160**, **175** may be selected based on other operational parameters. For example, the body portions **160** of the plug **100** may be a conventional polymer or fiberglass composite that is selected based on its ease of displacement or drill-out removal following a high pressure application (see FIG. **5**).

[0027] Referring now to FIG. **2**, an overview of an oilfield **200** is depicted which accommodates a well **280** with the bridge plug **100** of FIG. **1** employed therein. More specifically, the bridge plug **100** is employed for isolation above a terminal lateral leg **285** of the well **280**. As detailed below, this isolation allows for effective perforating and fracturing applications so as to form a vertical production region **260** of perforations **265** above the plug **100**. Nevertheless, follow-on displacement or drill-out of the plug **100** may be efficiently achieved so as to provide access to a lateral production region **270** and perforations **277** located in the lateral leg **285**.

[0028] In the embodiment shown, a rig **210** is provided at the oilfield surface over a well head **220** with various lines **230**, **240** coupled thereto for hydraulic access to the well **280**. More specifically, a high pressure line **230** is depicted along with a production line **240**. The production line **240** may be provided for recovery of hydrocarbons following completion of the well **280**. However, more immediately, this line **240** may be utilized in recovering fracturing fluids. That is, the high pressure line **230** may be coupled to large scale surface equipment including fracturing pumps for generating at least about 5,000 psi for a fracturing application. Thus, fracturing fluid, primarily water, may be driven downhole for stimulation of a production region **260**.

[0029] In the embodiment of FIG. **2**, the well **280**, along with production tubing **275**, is shown traversing various formation layers **290**, **295** and potentially thousands of feet before reaching the noted production region **260**. Perforations **265** penetrating the formation **295** may be pre-formed via a conventional fracturing application. Additionally, the production tubing **275** may be secured in place uphole of the region **260** by way of a conventional packer **250**. Thus, a high pressure fracturing application as directed through the production tubing **275** may be effectively directed at the region **260**.

[0030] As to deployment and setting of the bridge plug **100**, a variety of techniques may be utilized. For example, as noted above, wireline coupled to the head **175** may be used to drop the plug **100** down the vertical portion of the well **280** (see FIG. **1**). The plug **100** may be located at the depicted position, just below the intended location of the vertical production region **260**. However, in an alternate embodiment where the region **260** is for locating closer to, or within the lateral leg **285**, hydraulic pressure may be employed for directing the plug **100** around the elbow between the vertical and lateral **285** well portions and into position. Regardless, once in place, the slips **110** may be wireline actuated for anchoring as described below. Similarly, the seal **150** may be compressibly actuated for sealing in addition to allowing for swelling as noted above. In other embodiments slickline, jointed pipe, or coiled tubing may be used in deployment of the plug **100**. In such embodiments, setting may be actuated hydraulically or though the use of a separate setting tool which acts compressibly upon the plug **100** for radial expansion of the slips **110**.

[0031] Continuing with reference to FIG. **2**, the bridge plug **100** may be deployed as indicated so as to isolate more downhole, portions of the well **280**, including the lateral leg **285** and uncased portions thereof. With the bridge plug **100** in place as shown, the fracturing application may be focused at the area of the well **280** between the plug **100** and the packer **250**. Thus, high pressure targeting of the perforations **265** of the production region **260** may be achieved. As noted above, subsequent recovery of fracturing fluid may follow through the production tubing **275** and line **240**.

[0032] Referring now to FIG. **3**, an enlarged view of a downhole area taken from **3-3** of FIG. **2** is depicted. In this view, slip **375** and seal **376** interfaces with the casing **287** are readily visible. Indeed, in spite of the anchoring provided by teeth **350** of the slip **110** at the slip interface **375**, the seal **150** may be exposed to brine constituents **310** such as sodium chloride (represented by the indicated + symbols). Of course, as detailed above, the makeup of the seal **150** is such that this exposure leads to swelling thereof, thereby enhancing the hydraulic sealing engagement provided by the seal interface **376**.

[0033] The seal **150** may be of conventional swellable materials. However, as indicated above, in one embodiment, variability in the degree of swell of the seal **150** may be reduced. That is, the seal **150** may be configured to remain of a substantially constant profile. More specifically, upon exposure to brine, the seal **150** may configured to swell to a given degree of between about 50% and 250% over and above its pre-swollen size, limited only by the surrounding structural restriction of the depicted casing **287**. In this embodiment, the seal **150** is constructed of materials such that the achieved profile, or given degree to which the seal **150** is swollen, varies by no more than about 30% so long as the brine concentration remains less than about 10%.

[0034] In an alternate embodiment, where exposure to water or brine is less likely, the seal **150** may be configured to swell upon exposure to hydrocarbons. For example, in one embodiment, the seal **150** may be of a polyarylether ketone of tailored sulfonation to enhance swell upon hydrocarbon exposure. As such, sealing engagement of the seal **150** and casing **187** at the interface **376** may be adequately ensured. Nevertheless, as with brine swellable embodiments, the seal **150** may still be configured for dissolution upon degradation of other metal based components of the plug **100** as described further below.

[0035] Continuing with reference to FIG. **3**, with added reference to FIG. **2**, the well **280** is defined by conventional casing **287** as noted. In this view, the slip interface **375** reveals the indicated teeth **350** of the slip **110** which dig into the casing **287**, thereby anchoring the plug **100** in place. Indeed, in spite of differential pressure potentially exceeding about 5,000 psi during the noted fracturing application, or during the preceding perforating, the slips **110** help keep the plug **100** immobilized as shown. Similarly, with added reference to FIG. **1**, the internal mandrel **120** helps to ensure structural integrity of the plug **100** in the face of such high pressures. As noted above, the mandrel **120** may be rated for maintaining structural integrity in the face of an 8,000-10,000 psi or greater pressure differential.

[0036] Referring now to FIG. **4**A, the enlarged view of FIG. **3** is depicted, now revealing the degradable nature of the slip **110** and the changing slip interface **375** as a result. More specifically, the plug **100** of FIG. **4**A is depicted following a degrade period in the well **280**. Noticeably, the visible slip **110** has undergone a degree of degradation or dissolve over the degrade period. Indeed, the underlying support structure for the teeth **350** of the slip **110** as shown in FIG. **3** has eroded away. Thus, the teeth **350** are no longer supported at the casing **380**. This leaves only an eroded surface **400** at the interface **375**. As a result, the plug **100** is no longer anchored by the slips **110** as described above. The internal support structure of the mandrel **120** of FIG. **1** is similarly degraded over the degrade period. As a result, a follow-on displacement or drill-out application may take place over the course of less than about 30 minutes, preferably less than about 15 minutes (see FIG. **5**).

[0037] The degrade rate of the plug **100** may be tailored by the particular material choices selected for the reactive metals and alloying elements described above. That is, material choices selected in constructing the slips **110** and mandrel **120** of FIG. **1** may be based on the downhole conditions which determine the degrade rate. For example, when employing reactive metals and alloying element combinations as disclosed herein and in the '233 Application, incorporated herein by reference as detailed above, the higher the downhole temperature and/or water concentration, the faster the degrade rate.

[0038] Continuing with reference to FIG. **4**A, with added reference to FIG. **1**, downhole conditions which affect the degrade rate may be inherent or pre-existing in the well **280**. However, such conditions may also be affected or induced by applications run in the well **280** such as the above noted fracturing application. That is, a large amount of fracture fluid, primarily water, is driven into the well **280** at high pressure during the fracturing operation. Thus, while the plug **100** may be exposed to an open-hole portion of the well **280** and a certain degree of brine, a greater degree of exposure to water is now guaranteed.

[0039] In circumstances where the well **280** is otherwise relatively water-free or not of particularly high temperature, the duration of the fracturing application may constitute the bulk of downhole conditions which trigger the degrade. Alternatively, the well **280** may already be significantly water producing or of relatively high temperature (e.g. exceeding about 75° C.). In total, the slips **110** and mandrel **120** are constructed of materials selected based on the desired degrade rate in light of downhole conditions whether inherent or induced as in the case of fracturing operations. Further, where the conditions are induced, the expected duration of the induced condition (e.g. fracturing application) may also be accounted for in tailoring the material choices for the slips **110** and mandrel **120**.

[0040] While material choices may be selected based on induced downhole conditions such as fracturing operations, such operations may also be modulated based on the characteristics of the materials selected. So, for example, where the duration of the fracturing application is to be extended, effective isolation through the plug **100** may similarly be extended through the use of low temperature fracturing fluid (e.g. below about 25° C. upon entry into the well head **220** of FIG. **2**). Alternatively, where the fracture and dissolution periods are to be kept at a minimum, a high temperature fracturing fluid may be employed.

[0041] Compositions or material choices for the slips **110** and mandrel **120** are detailed at great length in the noted '233 Application. As described, these may include a reactive metal, which itself may be an alloy with structure of crystalline, amorphous or both. The metal may also be of powder-metallurgy like structure or even a hybrid structure of one or more reactive metals in a woven matrix. Generally, the reactive metal is selected from elements in columns I and II of the Periodic Table and combined with an alloying element. Thus, a high-strength structure may be formed that is nevertheless degradable.

[0042] In most cases, the reactive metal is one of calcium, magnesium and aluminum, preferably aluminum. Further, the alloying element is generally one of lithium, gallium, indium, zinc, or bismuth. Also, calcium, magnesium and/or aluminum may serve as the alloying element if not already selected as the reactive metal. For example, a reactive metal of aluminum may be effectively combined with an alloying element of magnesium in forming a slip **110** or mandrel **120**.

[0043] In other embodiments, the materials selected for construction of the slips **110** and mandrel **120** may be reinforced with ceramic particulates or fibers which may have affect on the rate of degradation. Alternatively, the slips **110** and mandrel **120** may be coated with a variety of compositions which may be metallic, ceramic, or polymeric in nature. Such coatings may be selected so as to affect or delay the onset of degrade. For example, in one embodiment, a coating is selected that is itself configured to degrade only upon the introduction of a high temperature fracturing fluid. Thus, the degrade period for the underlying structure of the slips **110** and mandrel **120** is delayed until fracturing has actually begun.

[0044] The particular combinations of reactive metal and alloying elements which may be employed based on the desired degrade rate and downhole conditions are again detailed at great length in the noted '233 Application. Factors such as melting points of the materials, corrosion potential and/or the degradability in the presence of water, brine or hydrogen may all be accounted for in determining the makeup of the slips **110** and mandrel **120**.

[0045] In one embodiment, the degrade apparent in FIG. **4**A may take place over the course of between about 5 and 10 hours. During such time, a perforating application may be run whereby the perforations **265** are formed. Further, a fracturing application to stimulate recovery from the formation **295** through the perforations **265** may also be run as detailed above. Additionally, to ensure that the plug **100** maintains isolation throughout the fracturing application, the degrade rate may be intentionally tailored such that the effective life of the plug **100** extends substantially beyond the fracturing application. Thus, in one embodiment where hydrocarbon recovery is possible downhole of the plug **100**, the plug **100** may be actuated via conventional means to allow flow therethrough. This may typically be the case where the plug **100** is employed in a vertical section of the well **280** as depicted in FIG. **2**.

[0046] Continuing with reference to FIG. 4A, the degradation of metal based components such as the slip 110, also has the effect of releasing seal shrinking constituents 410. For example, the above described dissolution of the slip 110 is likely to dramatically affect the pH of the vicinity of the plug 100. More specifically, a typical downhole pH may be a bit acidic, say in the 5-6 range. However, dissolution of, for example, an aluminum based slip 110 and other components releases constituents 410 that are likely to drive the local pH up to a level of between about 9 and 11. As described below, such a pH range is likely to shrink the seal 150.

[0047] Referring now to FIG. 4B, the enlarged view of FIG. 4A is depicted now revealing the shrinking nature of the seal 150 due to the degrading slip 110. In this view, the changing seal interface 376 with the casing 287 is quite apparent. Indeed, the shrinking of the seal 150 appears to be in the form of an actual degradation of the seal 150 as a result of exposure to the noted seal shrinking constituents 410.

[0048] In addition to exposure to the noted constituents 410 other readily available measures may utilized in shrinking/degrading the seal 150. For example, use of hotter fluids, above about 35° C. or so, during the perforating and/or fracturing applications, may increase the rate of dissolution of both the slip 110 and the seal 150. So to, would use of higher pH fluids, say above 7, during such applications. Of course, depending on the nature and duration of such applications, lower pH and temperature fluids may be employed where maintenance of the interfaces 375, 376 is sought for longer durations. In this manner, both the makeup of the seal 150 and slip 110 as well as the protocol of the applications may be tailored to support the duration of the interfaces 375, 376 sought.

[0049] Referring now to FIG. 5, the overview of FIG. 2 is depicted with the bridge plug 100 of FIG. 1 now degraded and displaced eliminating its hydraulic regulating effects. That is, once the above interfaces 375, 376 are rendered substantially ineffective for anchoring and sealing as depicted in FIG. 4B, the plug 100 may be displaced, for example, by pushing off to the non-productive terminal end of the well 280 as shown in FIG. 5. This may be achieved through a conventional coiled tubing or perhaps tractor driven application. Alternatively, where a non-productive terminal end of the well 280 is unavailable, a conventional drill-out application may be employed to effect substantial disintegration of the entire bridge plug 100. Regardless, the dissolution of the metal based components such as the slips 110 as well as the seal 150 of FIG. 1 allow for such displacement or drill-out application to take place in a matter of minutes. This, in spite of the once durable structural characteristics of the slips 110 and swollen nature of the seal 150 (see FIGS. 1 and 2).

[0050] As depicted in FIG. 5, with the plug 100 out of the way, the production tubing 275 may be extended to traverse both production regions 260, 270. In the embodiment shown, the tubing 275 is terminated at a packer 500 and includes openings 560, 570 adjacent each respective production region 260, 270. Of course additional packers for stabilization as well as a host of other architectural features may be provided to the downhole completion. Whatever the case, features of the hydraulic regulating bridge plug 100 ensure that its displacement or removal contributes a substantially minimal amount to the overall time spent attaining the completion.

[0051] Referring now to FIG. 6, a flow-chart summarizing an embodiment of employing an expandable and degradable hydraulic regulating mechanism or assembly such as the noted plug is shown. As indicated at 620, the mechanism is positioned downhole for hydraulic regulation where it may be exposed to brine or hydrocarbons 630, 640. Through such exposure or other means, a component of the mechanism may be swollen as noted at 650. Thus, a hydraulically regulated application may be run as indicated at 660.

[0052] Perhaps most notably, is the manner by which the mechanism may be dissolved or degraded for eventual displacement or removal. Namely, as indicated at 670 a metal-based component of the mechanism may be degraded. This may be upon exposure to the application noted at 660, positioning in the downhole environment as noted at 620, or both. Regardless, as indicated at 680, the swollen component may be shrunk by exposure to constituents of the degrading metal-based component.

[0053] Embodiments described hereinabove provide an expandable and degradable mechanism for downhole hydraulic regulation. The mechanism, may be used to manage hydraulic flow downhole, as in the case of a bridge plug. The mechanism may include swellable features such as that of a packer or seal as well as durable anchoring and structural features such as slips and mandrels. Nevertheless, long term placement of the mechanism may be avoided without requiring labor and time intensive drill-outs or other substantially expensive measures be taken.

[0054] The preceding description has been presented with reference to presently preferred embodiments. Persons skilled in the art and technology to which these embodiments pertain will appreciate that alterations and changes in the described structures and methods of operation may be practiced without meaningfully departing from the principle, and scope of these embodiments. Furthermore, the foregoing description should not be read as pertaining only to the precise structures described and shown in the accompanying drawings, but rather should be read as consistent with and as support for the following claims, which are to have their fullest and fairest scope.

We claim:

1. A hydraulic regulating mechanism for disposal in a well, the mechanism comprising:
   - a metal based element configured for degrading in the well; and
   - a swellable component coupled to said element, said swellable component configured for swelling upon exposure to a downhole condition and for shrinking upon the degrading.

2. The hydraulic regulating mechanism of claim 1 wherein the metal based element is of constituents for releasing during the degrading to initiate the shrinking.

3. The hydraulic regulating mechanism of claim 1 wherein the metal based element is configured for degrading in the well upon exposure to a downhole condition.

4. The hydraulic regulating mechanism of claim 3 wherein the downhole condition for one of the degrading and the swelling is one of a water based condition, a hydrocarbon based condition and a temperature based condition.

5. The hydraulic regulating mechanism of claim 1 wherein the mechanism includes one of a bridge plug, temporary isolation device, profiler, diverter, and a constrictor.

6. The hydraulic regulating mechanism of claim 5 wherein the mechanism is the bridge plug, the metal based element comprising one of a slip and a mandrel thereof, and the swellable component a seal thereof.

7. The hydraulic regulating mechanism of claim **6** wherein the downhole condition is a presence of brine.

8. The hydraulic regulating mechanism of claim **7** wherein the seal is of a material selected from a group consisting of styrenic isoprene block copolymer, polyvinyl alcohol, polylactic acid, and sulfonated polyarylether ketone.

9. The hydraulic regulating mechanism of claim **4** wherein the downhole condition is the presence of hydrocarbons.

10. The hydraulic regulating mechanism of claim **9** wherein the seal is of a polyarylether ketone of tailored sulfonation for swelling in the presence of hydrocarbons.

11. The hydraulic regulating mechanism of claim **1** wherein the metal based element comprises:

a reactive metal selected from a group consisting of aluminum, calcium, and magnesium; and

an alloying element.

12. The hydraulic regulating mechanism of claim **11** wherein said alloying element is one of lithium, gallium, indium, zinc, bismuth, aluminum where aluminum is not said reactive metal, calcium where calcium is not said reactive metal, and magnesium where magnesium is not said reactive metal.

13. A hydraulic regulating assembly for disposal in a well, the assembly comprising:

a component for exposure to a downhole condition arising from an open hole portion of a well, the exposure to induce swelling of the component; and

a metal based element for exposure to a downhole condition to induce degrading thereof, the degrading to induce shrinking of said component.

14. The hydraulic regulating assembly of claim **13** wherein the assembly is a bridge plug for disposal uphole of a first production region to support one of perforating and fracturing of a second production region uphole of the assembly.

15. A method of hydraulic regulation in a well, the method comprising:

positioning a hydraulic regulating mechanism in a well;

swelling a swellable component of the mechanism into sealing engagement with a wall of the well;

degrading a metal based element of the mechanism; and

shrinking the swellable component by exposing to constituents of the degrading component.

16. The method of claim **15** wherein said swelling comprises exposing the swellable component to one of brine and hydrocarbons.

17. The method of claim **15** further comprising running an application in the well uphole of the mechanism after said swelling.

18. The method of claim **17** wherein the application is one of a perforating application and a fracturing application.

19. The method of claim **16** wherein said shrinking comprises driving up pH at a location of the mechanism in the well by the exposing.

20. The method of claim **19** wherein the driving up is to a pH of greater than about 9.

21. The method of claim **15** wherein said shrinking comprises driving up a temperature at a location of the mechanism in the well.

22. The method of claim **21** further comprising introducing heated fluid to the location to increase the temperature thereat.

23. The method of claim **15** further comprising removing the mechanism from productive portions of the well after said shrinking.

24. The method of claim **23** wherein said removing comprises one of displacing and drilling out of the mechanism.

25. The method of claim **23** wherein said removing is achieved over the course of less than about 15 minutes.

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