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(54) **EXPANSION APPARATUS HAVING RESISTIVE MEDIUM**

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(57) **ABSTRACT**

An apparatus for expanding a portion of a tubular within a wellbore. The expansion assembly first comprises an expander tool. The expander tool is preferably a rotary expander tool which is lowered into the wellbore at the lower end of a working string. In one aspect, the rotary expander tool defines a tubular body having recesses, with each recess containing a compliant roller. The expansion assembly further comprises a chamber having a resistive medium therein. In one arrangement, the medium is a clean oil loaded into the chamber before being run into the wellbore. The fluid chamber is sized and configured to sealingly receive an elongated lower portion of the body of the expander tool. As the body of the expander tool travels into the fluid chamber, it encounters resistance from the fluid loaded therein. The fluid serves as a resistant force to the downward movement of the drill string and the expander tool during the expansion process, thereby preventing any rapid springing of the pipe string above it.

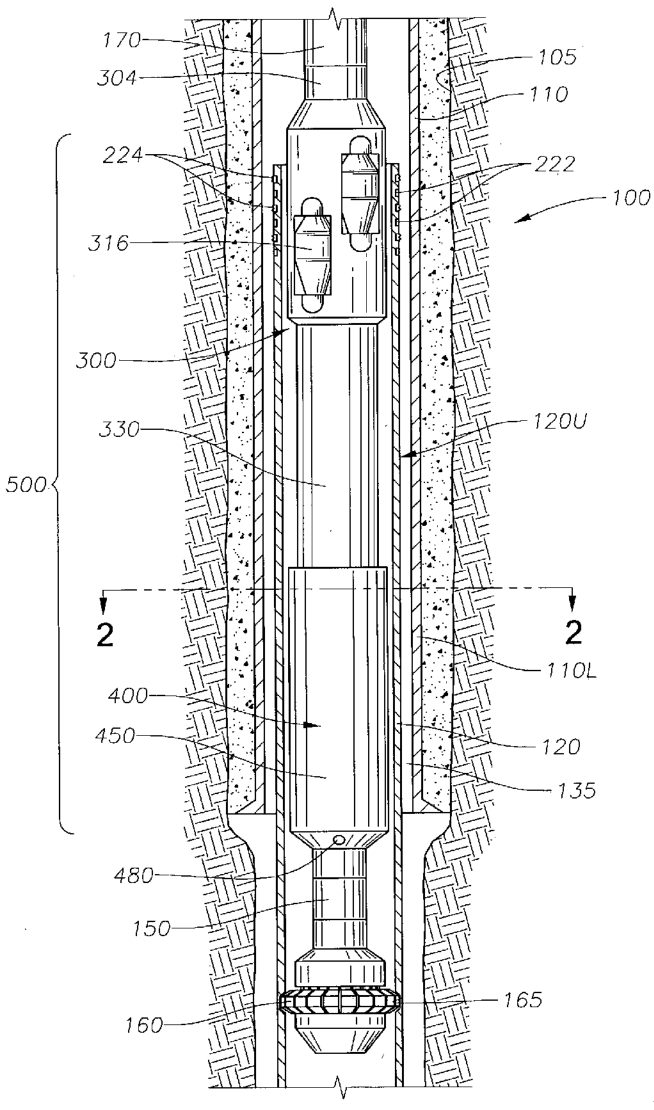

Fig. 1

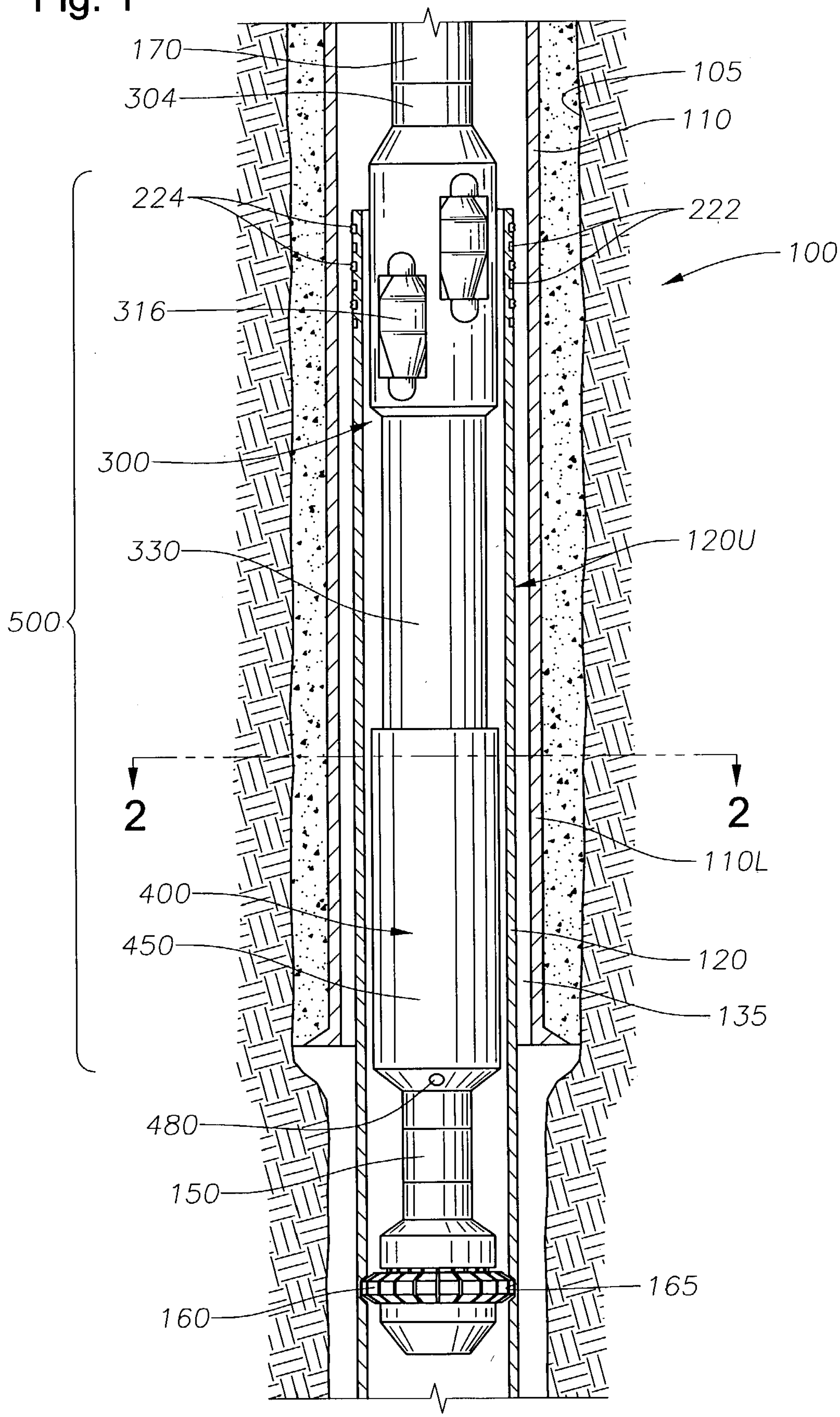
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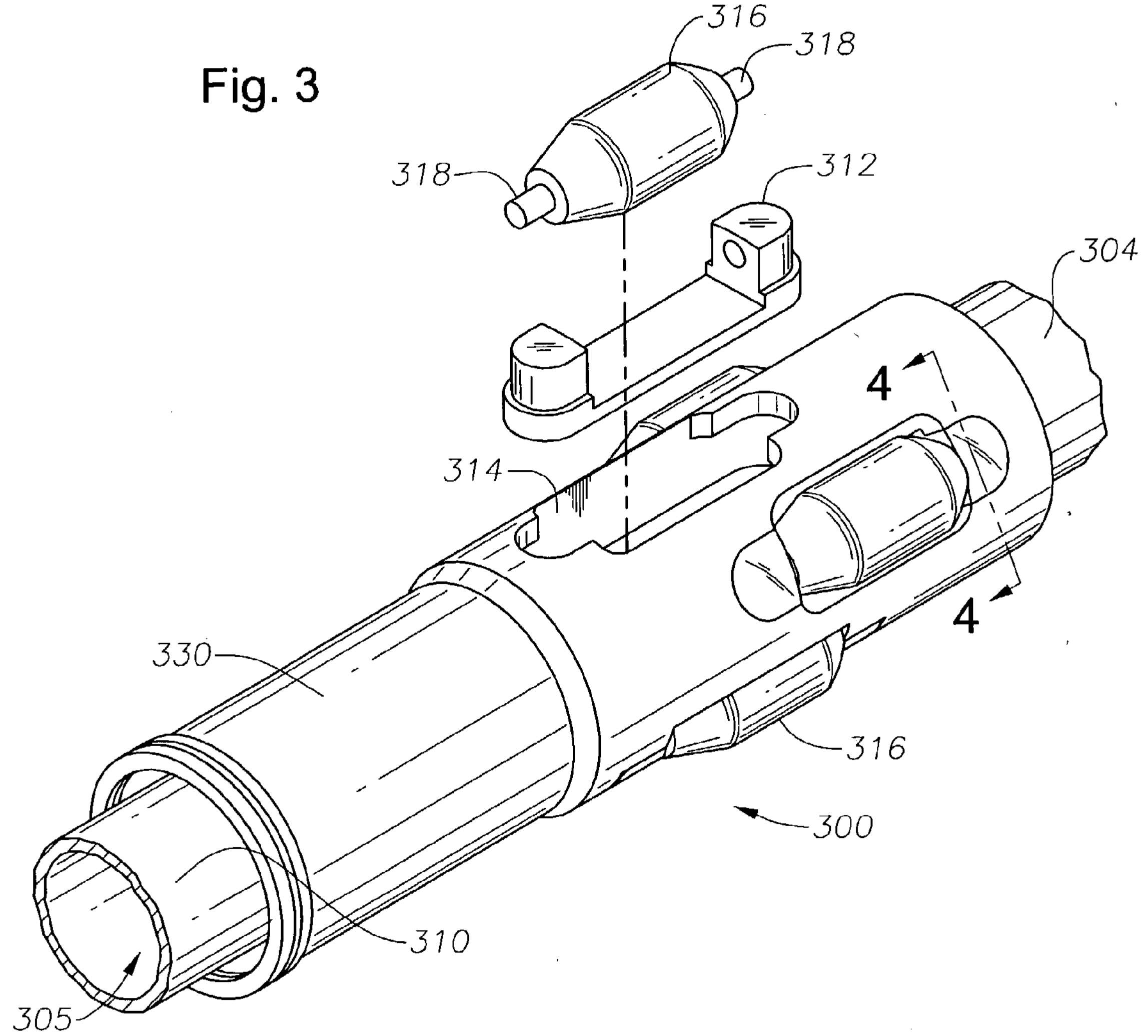
Fig. 3



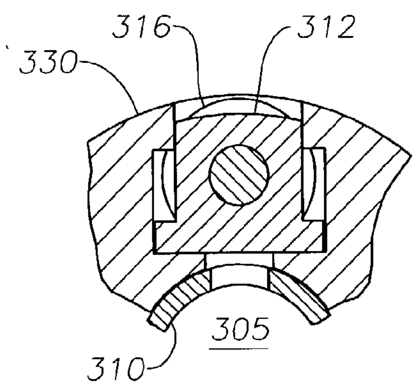


Fig. 4

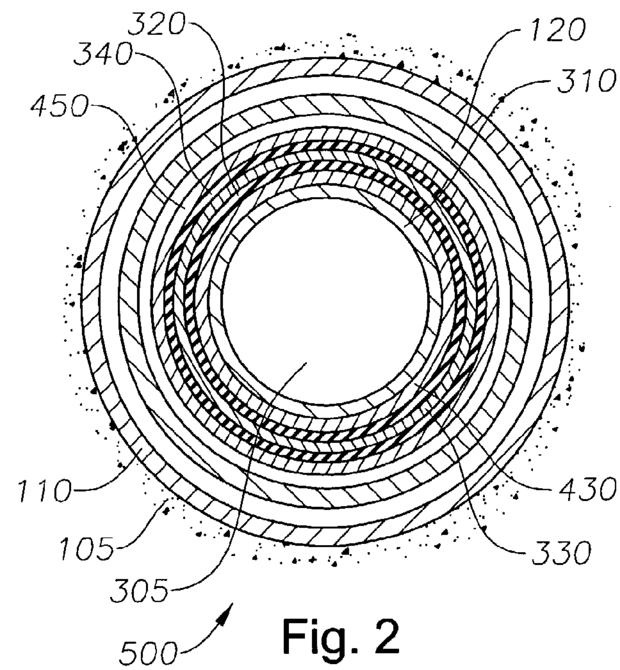
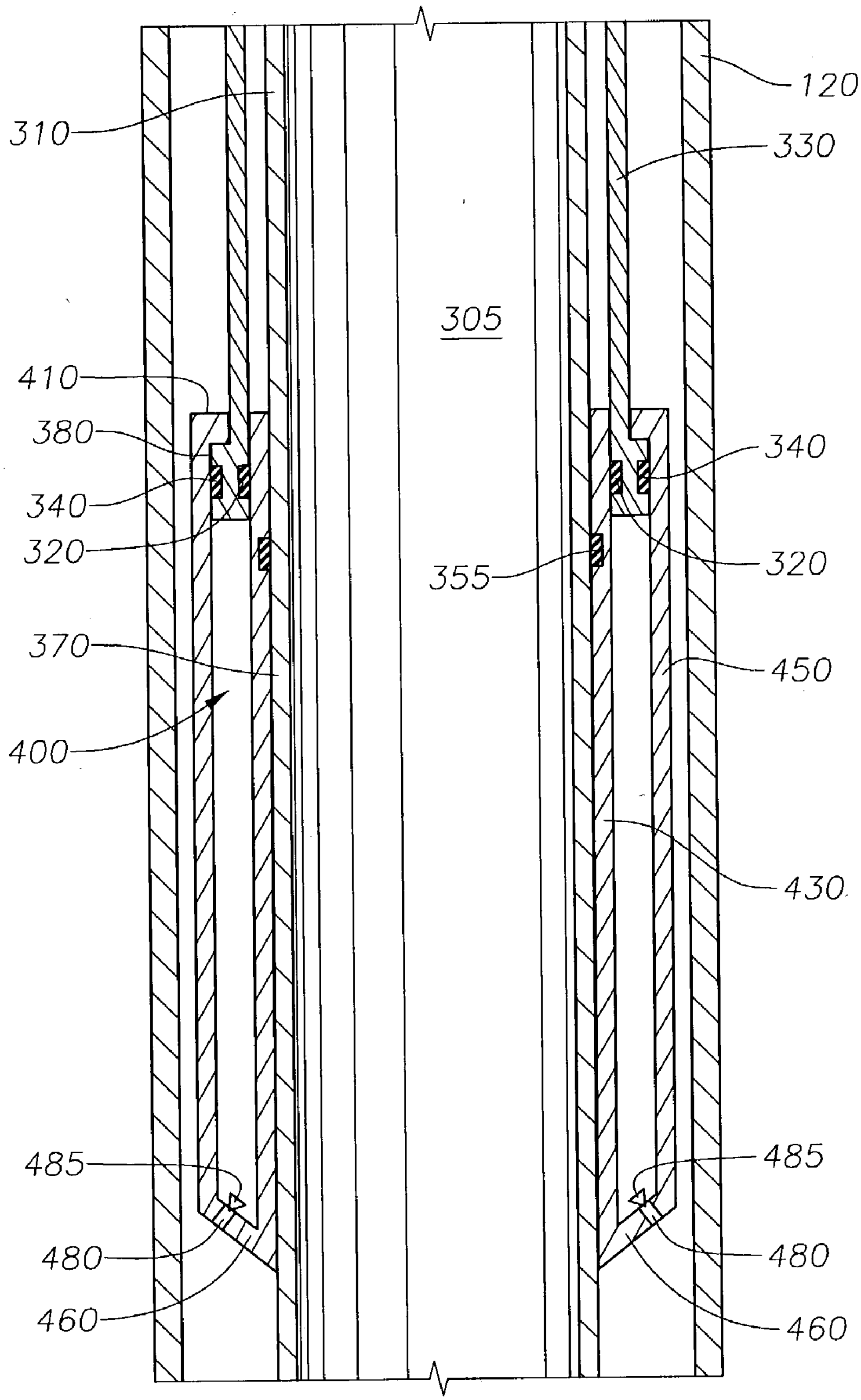


Fig. 2


310
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460

Fig. 5

Fig. 6

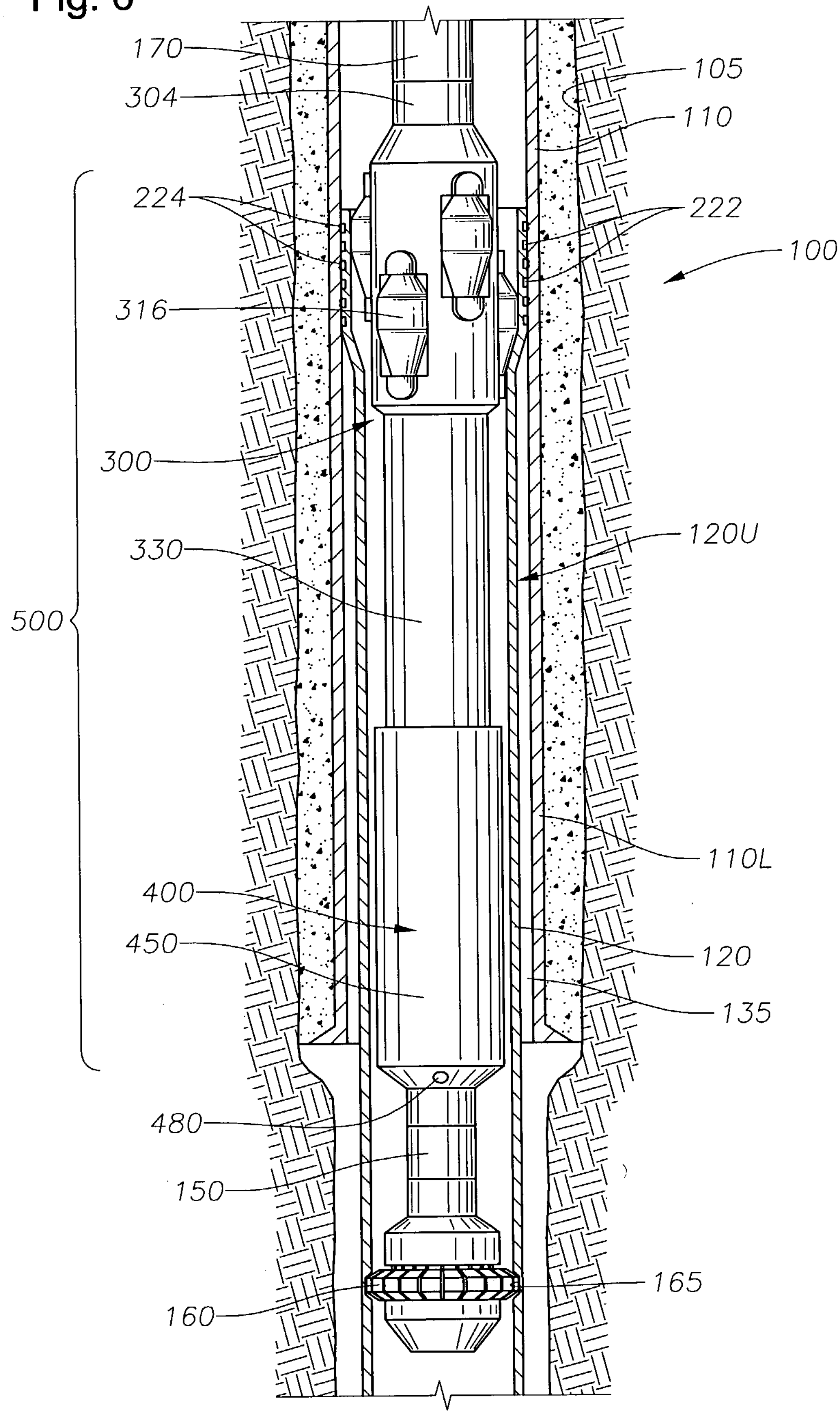
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Fig. 7

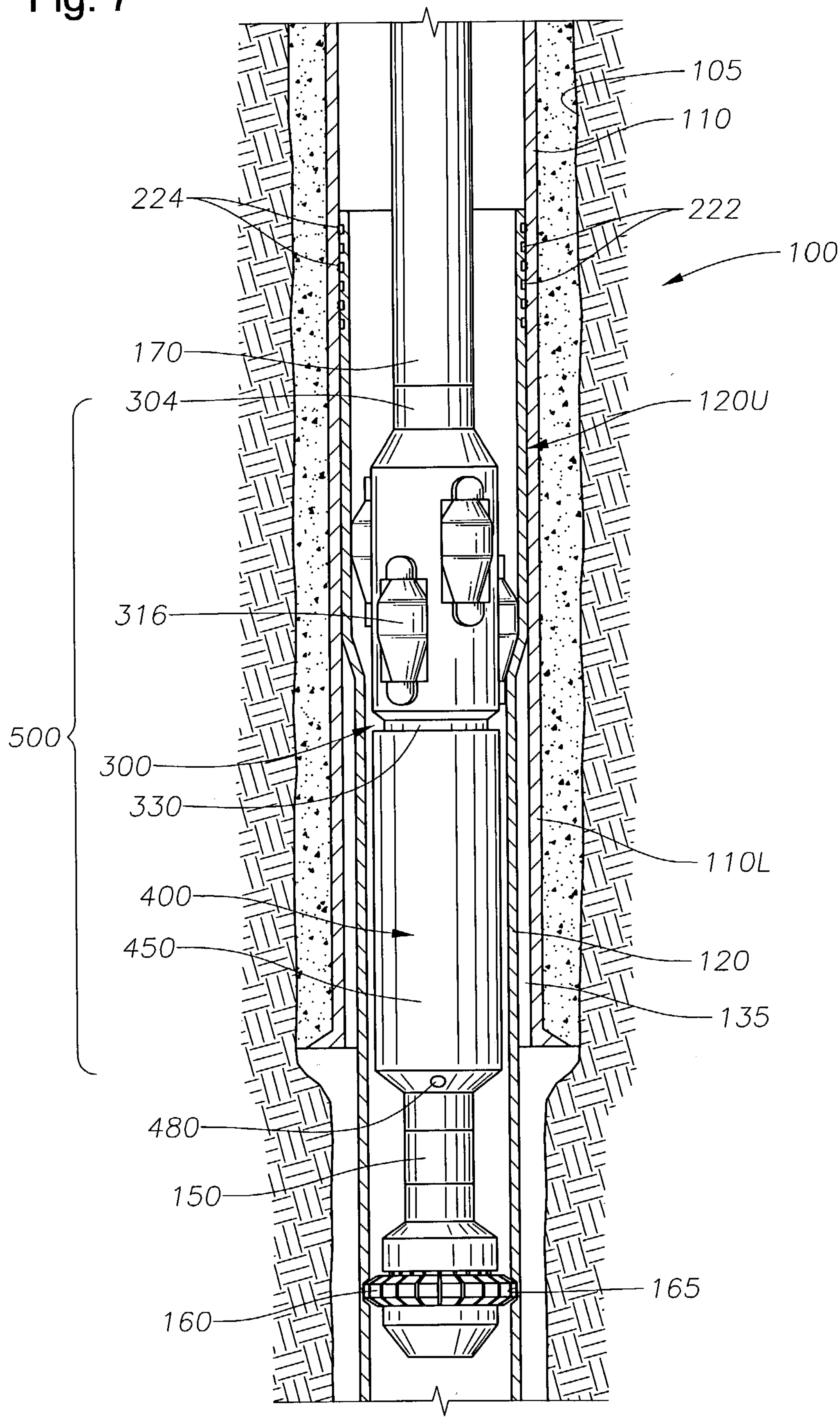
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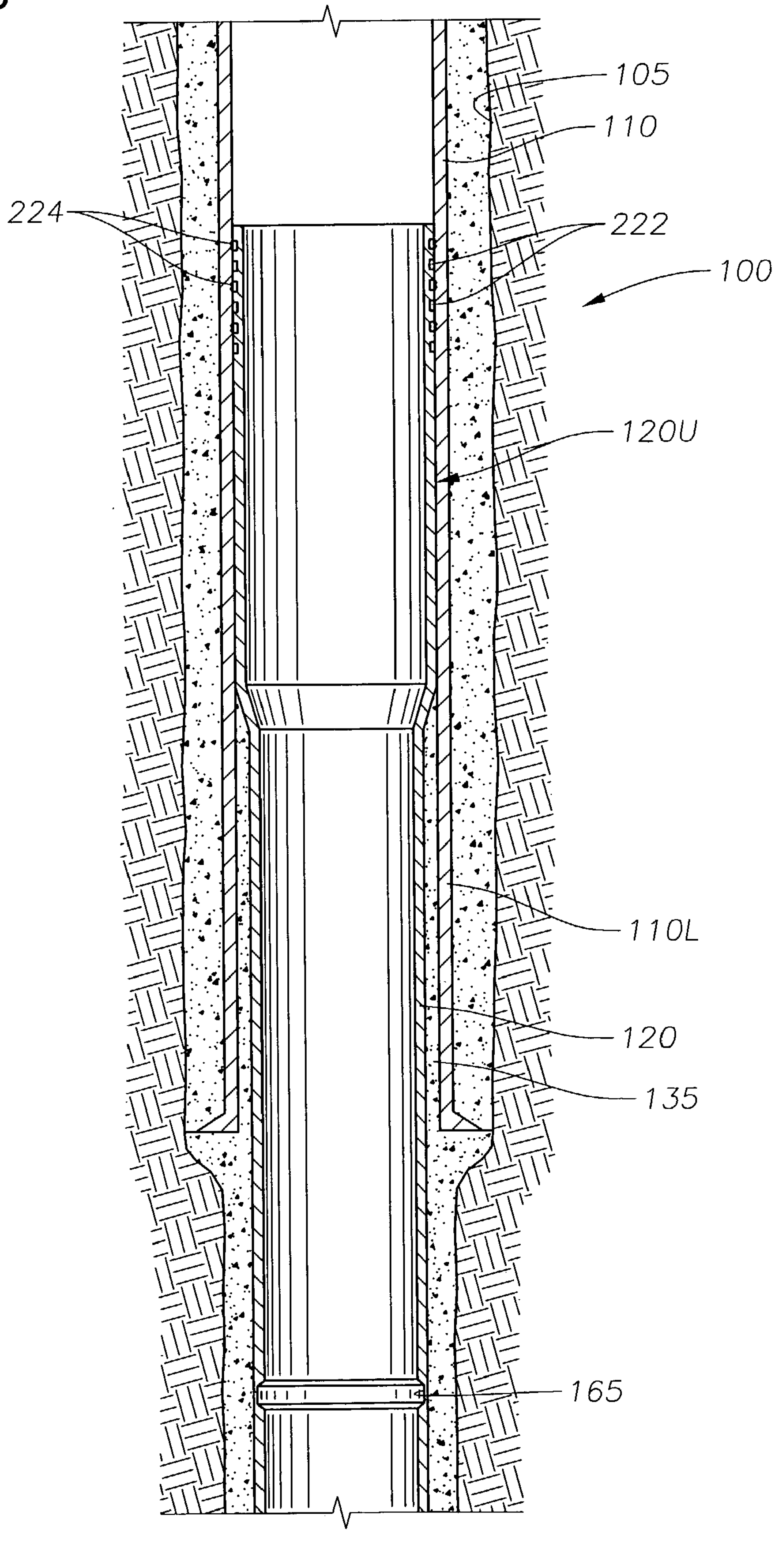
Fig. 8



EXPANSION APPARATUS HAVING RESISTIVE MEDIUM

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to methods for wellbore completion. More particularly, the invention relates to an apparatus for expanding a tubular in a wellbore.

[0003] 2. Description of the Related Art

[0004] Hydrocarbon and other wells are completed by forming a borehole in the earth and then lining the borehole with steel pipe to form a wellbore. After a section of wellbore is formed by drilling, joints of pipe are lowered into the wellbore and temporarily hung therein from the surface of the well. Using apparatus known in the art, the joints of pipe, or "casing," are cemented into the wellbore by circulating cement into the annular area defined between the outer wall of the casing and the borehole. The combination of cement and casing strengthens the wellbore and facilitates the isolation of certain areas of the formation behind the casing for the production of hydrocarbons.

[0005] It is common to employ more than one string of casing in a wellbore. In this respect, a first string of casing is set in the wellbore when the well is drilled to a first designated depth. The first string of casing is hung from the surface, and then cement is circulated into the annulus behind the casing. The well is then drilled to a second designated depth, and a second string of casing, sometimes referred to as a "liner," is run into the well. The second string is set at a depth such that the upper portion of the second string of casing overlaps the lower portion of the first string of casing. The second liner string is then fixed or "hung" off of the existing casing by the use of slips which utilize slip members and cones to wedgingly fix the second pipe string in the wellbore. The second pipe string, or liner, is then cemented. This process is typically repeated with additional liner strings until the well has been drilled to total depth. In this manner, wells are typically formed with two or more strings of casing of an ever decreasing diameter.

[0006] Apparatus and methods are emerging that permit tubulars to be expanded in situ. The apparatus typically includes expander tools which are run into the wellbore on a working string. The expander tools include radially expandable members which are urged outward radially from the body of the expander tool and into contact with a tubular therearound. The expander tools may be actuated either mechanically, or they may be fluid powered. In the case of a hydraulic system, fluid pressure is applied to a piston surface located at the back of the expansion members. As sufficient pressure is generated on the respective piston surfaces, the expansion members move radially outward from the expander tool body and against the inner surface of a surrounding tubular. The tubular being acted upon by the expansion tool is then expanded past its point of elastic deformation. In this manner, the inner and outer diameter of the surrounding tubular is increased in the wellbore. By rotating the actuated expander tool in the wellbore and moving the expander tool axially, a tubular can be radially expanded into plastic deformation along a predetermined length in a wellbore.

[0007] Multiple uses for expandable tubulars are being discovered. For example, an intermediate string of casing can be hung off of a string of surface casing by expanding an upper portion of the intermediate string into frictional contact with the lower portion of surface casing therearound. This allows for the hanging of a string of casing without the need for a separate slip assembly as described above. Additional applications for the expansion of downhole tubulars exist, such as the use of an expandable sand screen.

[0008] There are problems associated with the expansion of tubulars. One problem particularly associated with the use of rotary expander tools is the likelihood of obtaining an uneven expansion of a tubular. In this respect, the inner diameter of the tubular that is expanded tends to initially assume the shape of the compliant rollers of the expander tool, including imperfections in the rollers. Moreover, as the working string is rotated from the surface, the expander tool may temporarily stick during expansion of a tubular, then turn quickly, and then stop again. This spring-type action in the working string further creates imperfections in the expansion job.

[0009] Another obstacle to smooth expansion relates to the phenomenon of pipe stretch. Those of ordinary skill in the art will understand that raising a working string a selected distance at the surface does not necessarily translate in the raising of a tool at the lower end of a working string by that same selected distance. The potential for pipe stretch is great during the process of expanding a tubular. Once the expander tool is actuated at a selected depth, an expanded profile is created within the expanded tubular. This profile creates an immediate obstacle to the raising or lowering of the expander tool. Merely raising the working string a few feet from the surface will not, in many instances, result in the raising of the expander tool; rather, it will only result in stretching of the working string. Applying further tensile force in order to unstick the expander tool may cause a sudden recoil, causing the expander tool to move uphole too quickly, leaving gaps in the tubular to be expanded.

[0010] The same problem exists in the context of pipe compression. In this respect, the lowering of the working string from the surface does not typically result in a reciprocal lowering of the expander tool at the bottom of the hole. This problem is exacerbated by rotational sticking, as discussed above. The overall result of these sticking problems is that the inner diameter of the expanded tubular may not have a uniform circumference.

[0011] There is a need, therefore, for an improved apparatus for expanding a portion of casing or other tubular within a wellbore. Further, there is a need for an apparatus which will aid in the expansion of a tubular downhole and which avoids the potential of pipe-stretch/pipe-compression by the working string. Correspondingly, there is a need for an expansion apparatus which will enable a rotary expander tool to be axially translated downhole without substantial risk of uneven tubular expansion caused by pipe-compression.

[0012] There is yet a further need for an apparatus which employs at least one valve and at least one sized orifice for controlling the rate of translation of an expander tool during a tubular expansion operation.

SUMMARY OF THE INVENTION

[0013] The present invention provides an apparatus for expanding a tubular within a wellbore. According to the present invention, an expansion assembly is introduced into a wellbore. The expansion assembly is lowered downhole on a working string, such as a string of drill pipe. At the same time, the expansion assembly may be releasably connected to the lower string of casing or other tubular to be expanded. In this way, the expandable tubular is optionally lowered into the wellbore by the working string as well.

[0014] The expansion assembly first comprises an expander tool. The expander tool is preferably a rotary expander tool which is lowered into the wellbore at the lower end of a working string. The rotary expander tool defines a tubular body having recesses, with each recess containing a compliant roller. The rollers are expandable outwardly against the inner surface of a tubular to be expanded upon actuation. In one aspect, the expander tool is hydraulically actuated. In this respect, the application of fluid pressure from the surface, through the working string, and into a perforated inner bore of the expander tool generates pressure behind the rollers so as to expand them outwardly. The rollers are then placed into contact with the inner surface of the surrounding tubular to be expanded.

[0015] The expansion assembly of the present invention further comprises a fluid chamber. The fluid chamber is loaded with an amount of clean fluid, such as oil, before being run into the wellbore. The fluid chamber is sized to receive the body of the expander tool. In one arrangement, the fluid chamber is disposed below the body of the expander tool and receives a lower elongated portion of the expander tool body. In this arrangement, the fluid chamber defines an outer wall, an inner wall, and a bottom wall, and receives the lower body portion of the expander tool. Seals are provided within the fluid chamber and/or circumferentially around the elongated body portion of the expander tool to enable the body of the expander tool to be sealingly received within the inner and outer walls of the fluid chamber.

[0016] In operation, the expansion assembly of the present invention is lowered into the wellbore along with the tubular to be expanded. The expander tool is actuated by the injection of fluid under pressure into the drill string. As the rollers are forced outwardly against the tubular to be expanded, the drill string is rotated. This, in turn, rotates the rotary expander tool and provides for initial radial expansion of the surrounding tubular. Thereafter, the drill string is slowly lowered further into the wellbore, causing the body of the expander tool to be further inserted into the fluid chamber. As the body of the expander tool travels into the fluid chamber, it encounters resistance from the fluid loaded therein. The fluid serves as a resistant force to sudden downward movement of the drill string, thereby preventing any rapid springing of the pipe string above it.

[0017] One or more valves is placed in the outer wall of the fluid chamber. Each of the valves defines a sized orifice which serves as a through-opening in the outer wall. The valves include a pressure-sensitive diaphragm. As additional downward force is applied against the fluid in the fluid chamber, the diaphragms rupture, allowing fluid to exit the fluid chamber. At the same time, resistive pressure is maintained within the fluid chamber due to the constricted configuration of the valves. Thus, fluid is permitted to only slowly bleed from the fluid chamber as the expander tool is lowered downhole. In this manner, rapid springing of the pipe string caused by pipe-compression is further resisted.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] So that the manner in which the above recited features of the present invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0019] **FIG. 1** is a cross-sectional view of a wellbore having an upper string of casing, and a lower string of casing being lowered into the upper string of casing. In this view, the lower string of casing serves as the expandable tubular. Also depicted in **FIG. 1** is an expansion apparatus of the present invention for translating an expander tool.

[0020] **FIG. 2** is a cross-sectional view of the expansion apparatus of the present invention, taken across line **2-2** of **FIG. 1**.

[0021] **FIG. 3** presents an exploded view of an expander tool as might be translated by a slow-bleed expansion apparatus of the present invention.

[0022] **FIG. 4** presents a portion of the expander tool of **FIG. 3** in cross-section, with the view taken across line **4-4** of **FIG. 3**.

[0023] **FIG. 5** is an enlarged sectional view of a fluid chamber for an expansion apparatus of the present invention. In this view, the surrounding upper string of casing and formation are not shown.

[0024] **FIG. 6** depicts the wellbore of **FIG. 1**. In this view, the expander tool has been actuated so as to begin expanding the lower string of casing.

[0025] **FIG. 7** depicts the wellbore of **FIG. 6**. Here, the expander tool has been lowered further so as to expand the upper portion of the lower string of casing along a desired length.

[0026] **FIG. 8** is a partial section view of the wellbore of **FIG. 7**, with the slow-bleed expansion apparatus of the present invention having been removed. In this view, the lower string of casing has been expanded into frictional and sealing engagement with the surrounding upper string of casing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0027] **FIG. 1** presents a cross-sectional view of a wellbore **100** having an upper string of casing **110** and a lower string of casing **120**. The lower string of casing **120**, or liner, is being lowered into the wellbore **100** co-axially with the upper string of casing **110**. The lower string of casing **120** is positioned such that an upper portion **120U** of the lower string of casing **120** overlaps with a lower portion **110L** of the upper string of casing **110**.

[0028] In the example of **FIG. 1**, the lower string of casing **120** serves as an expandable tubular. The lower string of casing **120** will be hung off of the upper string of casing **110** by expanding the upper portion **120U** of the lower string of casing **120** into the lower portion **110L** of the upper string of casing **110**. However, it is understood that the apparatus and method of the present invention may be utilized to expand downhole tubulars other than strings of casing.

[**0029**] A sealing member **222** is preferably disposed on the outer surface of the lower string of casing **120**. Preferably, the sealing member **222** defines a matrix formed in grooves (not shown) on the outer surface of the lower string of casing **120**U. However, other configurations are permissible, including one or more simple rings formed circumferentially around the lower string of casing **120**.

[**0030**] The sealing member **222** is fabricated from a suitable material based upon the service environment that exists within the wellbore **100**. Factors to be considered when selecting a suitable sealing member **222** include the chemicals likely to contact the sealing member, the prolonged impact of hydrocarbon contact on the sealing member, the presence and concentration of corrosive compounds such as hydrogen sulfide or chlorine, and the pressure and temperature at which the sealing member must operate. In a preferred embodiment, the sealing member **222** is fabricated from an elastomeric material. However, non-elastomeric materials or polymers may be employed as well, so long as they substantially prevent production fluids from passing upwardly between the outer surface of the lower string of casing **120** and the inner surface of the upper string of casing **110** after the expandable section **120**U of the casing **120** has been expanded.

[**0031**] Also positioned on the outer surface of the lower string of casing **120** is at least one slip member **224**. The slip member **224** is used to provide an improved grip between the expandable tubular **120**U and the upper string of casing **110** when the lower string of casing **120** is expanded. In this example, the slip member **224** defines a plurality of carbide buttons interspersed within the matrix of the sealing member **222**. However, any suitable placement of a hardened material which provides a gripping means for the lower string of casing **120** into the upper string of casing **110** may be used. For example, a simple pair of rings having grip surfaces (not shown) formed thereon for engaging the inner surface of the upper string of casing **110** when the lower string of casing **120** is expanded would be suitable. The size, shape and hardness of the slips **224** are selected depending upon factors well known in the art such as the hardness of the inner wall of casing **110**, the weight of the casing string **120** being hung, and the arrangement of slips **224** used.

[**0032**] In order to expand the lower string of casing **120** seen in **FIG. 1**, the present invention provides an expansion assembly **500**. The expansion assembly **500** of the present invention defines two primary components—(1) an expander tool **300**; and (2) a chamber **400** which receives the expander tool **300**. The two components **300** and **400** are shown together within the wellbore **100** of **FIG. 1**, defining an expansion assembly **500**. **FIG. 2** is also provided, which shows the expansion assembly **500** of **FIG. 1** in cross-section, with the view being taken across line **2-2** of **FIG. 1**.

[**0033**] In **FIG. 1**, the expander tool **300** is shown positioned above the chamber **400**. In this respect, the working string **170** will be lowered, causing the expander tool **300** to be received in the chamber **400**. However, it is to be understood that the scope of the present invention permits the expander tool portion **300** to be positioned below the fluid chamber portion **400**. In such an arrangement, the working string **170** is axially translated towards the surface of the well, causing the expander tool **300** to be raised or otherwise pulled into the fluid chamber **400**.

[**0034**] As noted, the expansion assembly of the present invention **500** first comprises an expander tool **300**. An exploded view of the expander tool **300** of **FIG. 1** is seen in **FIG. 3**. This presents an exemplary hydraulic expander tool **300**. In this embodiment, the expander tool **300** first has a body **330**. The body **330** is preferably an elongated tubular member defining a bore **305** there through. As will be discussed further below, the body **330** is elongated in order to be sealingly received within a chamber **400** there below. A connector **304** is provided at an upper end of the body **330** for connection to the working string **170**. The connector **304** is typically of a reduced diameter (compared to the outside diameter of the body **330** of the tool **300**).

[**0035**] The expander tool **300** next provides an inner mandrel **310**. The inner mandrel **310** runs longitudinally through the body **330**. Where the expander tool **300** is a hydraulically actuated, the inner mandrel **310** is perforated. The perforations permit fluid to fill an annular region defined between the inner mandrel **310** and the outer body **330**, or to otherwise act on a plurality of roller members **316**. **FIG. 4** presents a portion of the expander tool **300** of **FIG. 3** in cross-section, with the view taken across line **4-4**. A portion of the perforated tubular mandrel **310** is more closely seen.

[**0036**] The central body **330** has a plurality of recesses **314** for holding the respective rollers **316**. In one arrangement, each of the recesses **314** has parallel sides and holds a roller **316** capable of extending radially from the perforated tubular core **305** of the tool **300**. The rollers **316** illustrated in **FIG. 3** have generally cylindrical or barrel-shaped cross sections; however, it is to be appreciated that other roller shapes are possible. For example, a roller **316** may have a cross sectional shape that is conical, truncated conical, semi-spherical, multifaceted, elliptical or any other cross sectional shape suited to the expansion operation to be conducted within the tubular **120**. It is understood that any cross-sectional shape suitable for engaging the surrounding tubular may be employed.

[**0037**] In the arrangement for an expander tool **300** shown in **FIG. 3**, each of the rollers **316** is supported by a shaft **318** at each end of the respective roller **316**. The shaft **318**, in turn, is supported by a piston **312**. In this manner, the rollers **316** may rotate above the respective pistons **312** about a defined rotational axis. However, the present invention is not limited to the manner in which the roller members **316** are mounted. Alternatively, the roller members **316** may define solid bodies that reside directly on the outer piston surface. In such an arrangement, the roller members **316** may define non-rotating members that are integral to the piston, or they may define roller bodies that partially roll and partially skid on the piston **312**. And still alternatively, the roller members **316** may define one or more bearings that reside in one or more respective races above the piston **312**.

[**0038**] The rollers **316** are generally parallel to the longitudinal axis of the tool **300**. It is permissible, however, to skew the orientation of the roller members **316** at a one or two degree offset in order to aid in the axial movement of the expander tool **300**. The plurality of rollers **316** are radially offset at mutual circumferential separations around the central body **330**. In the arrangement shown in **FIG. 3**, two rows of three rollers **316** are employed. However, additional rows may be incorporated into the body **330**, or only one may be utilized. Various numbers of roller members **316** may be employed.

[**0039**] As shown in **FIG. 3**, the pistons **312** are radially slidable, one piston **312** being slidably sealed within each radially provided recess **314**. The back side of each piston **312** is exposed to the pressure of fluid within the hollow bore **305** of the inner mandrel **310**. In this manner, pressurized fluid provided from the surface of the well can actuate the pistons **312** and cause them to extend outwardly whereby the rollers **316** contact the inner surface of the surrounding tubular to be expanded, e.g., tubular **120U**.

[**0040**] The expander tool **300** is preferably designed for use at or near the end of a working string **170**. In order to actuate the expander tool **300** shown in **FIG. 3**, fluid is injected into the working string **170**. Fluid under pressure then travels downhole through the working string and into the perforated tubular bore **305** of the tool **300**. From there, fluid contacts the backs of the pistons **312**. As hydraulic pressure is increased, fluid forces the pistons **312** from their respective recesses **314**. This, in turn, causes the rollers **316** to make contact with the inner surface of the liner **120U**. Fluid finally exits the expander tool **300** at the base of the mandrel **310**. The circulation of fluids to and within the expander tool **300** is preferably regulated so that the contact between and the force applied to the inner wall of liner **120U** is controlled. In this respect, fluid passing from the mandrel **310** encounters a sized orifice (not shown) at the base of or below the tool **500**. The pressurized fluid causes the piston assembly **312** to extend radially outward so as to place the rollers **316** into contact with the inner surface of the lower string of casing **120U**. With a predetermined amount of fluid pressure acting on the piston surface **312**, the lower string of casing **120U** is expanded past its elastic limits.

[**0041**] Below the expander tool **300** is a chamber **400**. The chamber of **FIG. 1** is seen more fully in the enlarged cross-sectional view of **FIG. 5**. As can be seen, the chamber **400** is comprised of an outer wall **450** and an inner wall **430**. A connecting surface **460** is also shown. The outer wall **450**, the inner wall **430**, and the connecting surface **460** define a chamber **400** for containing a resistive medium. Preferably, the resistive medium is a viscous fluid such as a clean oil, but may be any liquid material. The oil is loaded into the chamber **400** before the chamber **400** is run into the wellbore **100**. In this arrangement, the chamber **400** defines a fluid chamber.

[**0042**] The fluid chamber **400** is sized and configured to receive the elongated tubular body **330** of the expander tool **300**. A portion of the body **330** can be seen in **FIG. 5**. In this view, the body **330** remains only partially inserted into the chamber **400**, as the expander tool **300** has not yet been fully lowered into fluid chamber **400**. Two seal rings **320** and **340** are disposed around the body **330**. Seal ring **320** defines an inner seal ring, and is disposed circumferentially internal to the body **330**, while seal ring **340** defines an outer seal ring, and is disposed circumferentially external to the body **330**. The seal rings **320** and **340** enable the body **330** to be sealingly received within the fluid chamber **400** as the expander tool **300** is lowered during expansion operations.

[**0043**] An additional seal **355** is optionally provided between the mandrel **310** and the inner wall **430**. In one aspect, the seal **355** is attached circumferentially to the inner surface of the inner wall **430**. The optional seal **355** is also seen in **FIG. 5**.

[**0044**] In operation, the expansion apparatus **500** of the present invention is run into the wellbore **100** on the lower end of a working string **170**. In order to accomplish the expansion operation in a single trip, the working string **170** also is temporarily connected to the lower string of casing **120**. In this manner, the lower string of casing **120** can be introduced into the wellbore **100** at the same time as the expander tool **300**. In **FIG. 1, a** collet **160** is presented as the releasable connection. The collet **160** is shown near the end of the working string **170**. The collet **160** is landed into a radial profile **165** within the lower string of casing **120** so as to support the lower string of casing **120**. The collet **160** is mechanically or pneumatically actuated as is known in the art, and supports the lower string of casing **120** until such time as the lower string of casing **120** has been expandably set by actuation of the expander tool **300**.

[**0045**] When expansion of the surrounding tubular **120U** is desired, the rollers **316** of the expander tool **300** are actuated as disclosed above. At about the same time, the rotary expander tool **300** is rotated within the expandable tubular **120**. It is contemplated in **FIG. 1** that rotation of the expander tool **300** is accomplished by rotating the working string, i.e., drill pipe **170**, from the surface. However, rotation may also be achieved by activation of a downhole hydraulic or electric rotary motor, such as a mud motor (not shown).

[**0046**] Once the initial section of expandable tubular **120U** is expanded, the expander tool **300** is translated. In the arrangement depicted in **FIG. 1**, the expander tool **300** is moved downwardly by slacking off the weight of the drill string **170** from the surface. This has the effect of lowering the expander tool **300** within the wellbore **100** so as to expand a desired length of tubular **120U**. As the expander tool **300** is lowered, the body **330** of the tool **300** is received within the fluid chamber **400**. The resistant medium within the chamber **400** resists entry of the body **330** into the chamber **400**. However, as additional weight is slacked off of the drill string **170** by the operator, the body **330** is urged further downward.

[**0047**] In accordance with the present invention, at least one valve member **480** is disposed proximate to the bottom connecting surface **460** of the inner and outer walls **430, 450**. In the enlarged view of **FIG. 5, a** pair of valves **480** is depicted in the connecting surface **460** of the outer wall **450**. The valves **480** define through-openings having pressure-sensitive diaphragms **485** designed to be penetrated at a given elevated pressure within the fluid chamber **400**. Preferably, the valves **480** include a one-way internal member (not shown) for permitting fluid to flow from the fluid chamber **400** at a designated elevated pressure, but prohibiting wellbore fluid from flowing into the chamber **400**. Thus, when pressure reaches a certain anticipated level caused by the advancement of the expander tool body **330** into the fluid chamber **400**, the valves **480** open, permitting fluid to be released.

[**0048**] As a further feature of the present invention, the valves **480** are specially sized to restrict the rapid release of fluid from the fluid chamber **400**. In this respect, the valves **480** are sized so that oil is released slowly, thereby prohibiting a rapid drop of the expander tool body **330** into the fluid chamber **400**. This, in turn, protects against any downward pipe spring caused by pipe compression and release. Thus, a "slow-bleed" expansion apparatus is provided.

[**0049**] As the body **330** of the expander tool **300** continues to advance into the chamber **400**, fluid will continue to be pushed through the at least one valve **480**. The operator may discontinue axial translation of the expander tool **300** before the body **330** of the expander tool **300** reaches the connecting surface **460**. Alternatively, the operator may push (or pull) the body **330** to the end of the chamber **400**. In this approach, the length of the chamber **400** defines the length of the surrounding tubular **120** that gets expanded.

[**0050**] It should be noted that the slow-bleed expansion apparatus **500** of the present invention permits of other arrangements and embodiments. For example, other media besides oil may be utilized, although it is preferred that the media be viscous. The medium may even be in a gaseous phase rather than a liquid phase. Further, a plurality of valves designed to be opened at ever-increasing pressures may be employed. In this arrangement, a first valve would open at a first designated pressure, while a second valve would later open at a second higher designated pressure. Further, the size of the through-opening attendant to the second valve may be smaller or larger than the size of the first through-opening, subject to design consideration. Yet an alternate arrangement for a slow-bleed apparatus employs a subsea downhole motion compensator system. Such a system is currently used to eliminate the effect of rig heave during offshore operations, such as from a floating vessel. For example, the subsea downhole motion compensator allows the operator to control weight-on-bit during sensitive milling operations. Finally, the fluid chamber may define a single, cylindrical receptacle for entirely receiving the body of the expander tool. The cylindrical receptacle would have the resistive medium therein.

[**0051**] It is also understood that other arrangements which do not employ a fluid medium may be used. For example, the resistive medium can be a powerful spring (not shown). In this arrangement, the spring is disposed within the chamber **400** for providing resistance against the downward-moving expander tool body **330**. In such an arrangement, the use of valves is not needed.

[**0052**] **FIG. 6** depicts the wellbore of **FIG. 1**. In this view, the expander tool **300** has been actuated so as to begin expanding the lower string of casing **120U**. Expansion is accomplished radially by rotating the actuated expander tool **300**, such as by rotating the working string **170**. In such an arrangement, a swivel **150** is placed in the working string **170** below the expansion apparatus **500**. The swivel **150** permits the expander tool **300** to rotate without rotating other tools downhole, including the collet **160**. The swivel **150** is shown schematically in **FIG. 1** as a separate downhole tool. However, it is preferred that the swivel **150** simply be incorporated into the lower end of the fluid chamber **400** using a bearing-type connection (not shown).

[**0053**] **FIG. 7** depicts the wellbore of **FIG. 6**. Here, the expander tool **300** has been lowered further into the fluid chamber **400** so as to expand the upper portion of the lower string of casing **120U** along a desired length. As explained above, actuation of the expander tool **300** is by injection of fluid under pressure into the working string **170**. Fluid travels from the surface, down the working string **170**, through the bore **305** of the mandrel **310**, and through the perforations behind the pistons **312** of the expander tool **300**.

[**0054**] Following expansion operations, hydraulic pressure from the surface is relieved, allowing the pistons **312** to return to the recesses **314** within the body **330** of the tool **300**. The releasable connection **160** with the liner **120** is also released. The expander tool **300** and the fluid chamber **400** can then be withdrawn from the wellbore **100** by pulling the run-in tubular **170**. **FIG. 8** is a partial section view of the wellbore of **FIG. 7**, with the slow-bleed expansion apparatus **500** of the present invention having been removed. In this view, the lower string of casing **120** has been expanded into frictional and sealing engagement with the upper string of casing **110**. This, in turn, results in an effective hanging and sealing of the lower string of casing **120** upon the upper string of casing **110** within the wellbore **100**. Thus, the apparatus **500** enables a lower string of casing **120** to be hung onto an upper string of casing **110** by expanding the lower string **120** into the upper string **110** while avoiding the problem of pipe-spring discussed above.

[**0055**] It can be seen in **FIG. 8** that the seal member **222** and the slip member **224** are engaged with the inner surface of the upper string of casing **110**. Further, the annulus **135** between the lower string of casing **120** and the upper string of casing **110** has been filled with cement, excepting that portion of the annulus which has been removed by expansion of the lower string of casing **120U**. This is part of an effective well completion enabled by the apparatus **500** of the present invention.

[**0056**] As a further aid in the expansion of the lower casing string **120**, a torque anchor may optionally be utilized. Those of ordinary skill in the art may perceive that the radially outward force applied by the rollers **316**, when combined with rotation of the expander tool **300**, might cause some unwanted rotation of the casing **120**. The torque anchor (not shown) serves to prevent rotation of the lower string of casing **120** during the expansion process.

[**0057**] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

1. An apparatus for expanding a tubular in a wellbore, the apparatus being disposed on a working string, the apparatus comprising:

an expander tool, the expander tool having an elongated tubular body;

a chamber for receiving a portion of the elongated tubular body when the expander tool is lowered during expansion operations; and

a resistive medium within the chamber for providing resistance against the body of the expander tool as the body enters the chamber.

2. The apparatus of claim 1, wherein

the chamber comprises an outer wall having a side surface; and

the resistive medium is disposed within the outer wall.

3. The apparatus of claim 2, wherein:

said chamber further comprises an inner wall;

said inner wall and said outer wall are connected by a connecting surface portion of said outer wall; and

said resistive medium is disposed between the inner wall and the outer wall.

4. The apparatus of claim 3, wherein said resistive medium is a fluid.

5. The apparatus of claim 4, wherein said resistive medium is oil.

6. The apparatus of claim 2, wherein said resistive medium is a powerful spring.

7. The apparatus of claim 4, wherein said chamber further comprises:

at least one valve disposed proximate to the connecting surface, each valve being designed to prevent fluid from entering the chamber, but to open so as to permit fluid to exit the chamber once pressure within the chamber reaches a designated level.

8. The apparatus of claim 7, wherein the at least one valve is sized to permit the resistive fluid medium to slowly bleed from the chamber after the valve has been opened and as the body of the expander tool advances into the chamber.

9. The apparatus of claim 8, wherein the at least one valve includes a diaphragm.

10. The apparatus of claim 8, wherein the at least one valve defines a one-way valve.

11. An apparatus for expanding a tubular in a wellbore, the apparatus being disposed on a working string, the apparatus comprising:

an expander tool, the expander tool having an elongated tubular body;

a chamber for receiving a portion of the elongated tubular body when said expander tool is lowered during expansion operations, the chamber comprising an inner wall and an outer wall; and

a resistive medium disposed between the inner wall and the outer wall of the chamber for providing resistance against the body of the expander tool as the body enters the chamber.

12. The apparatus of claim 11, wherein said resistive medium is a fluid.

13. The apparatus of claim 12, wherein said resistive medium is oil.

14. The apparatus of claim 11, wherein said resistive medium is a powerful spring.

15. The apparatus of claim 13, wherein said chamber further comprises:

a connecting surface connecting the inner wall and the outer wall; and

at least one valve disposed proximate to the connecting surface each valve being designed to prevent fluid from entering the chamber, but to open so as to permit fluid to exit the chamber once pressure within the chamber reaches a designated level.

16. The apparatus of claim 15, wherein the at least one valve comprises an opening that is sized to permit the resistive fluid medium to slowly bleed from the chamber after the valve has been opened and as the body of the expander tool advances into the chamber.

17. The apparatus of claim 16, wherein the at least one valve defines at least two valves, the at least two valves being opened in response to different pressure levels in order to incrementally throttle advancement of the body into the chamber.

18. The apparatus of claim 16, wherein the at least one valve includes a pressure-sensitive diaphragm.

19. The apparatus of claim 11, wherein the length of the chamber defines and controls the length of tubular that gets expanded.

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