An abstract of a patent application describing a high pressure high temperature packer system, improved expansion assembly for a tubular expander tool, and method of tubular expansion. The inventors are J. Eric Lauritzen, Aberdeen (GB); A. Craig MacKay, Aberdeen (GB); Neil A.A. Simpson, Aberdeen (GB); Robert J. Coon, Missouri City, TX (US)

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Abstract
A method and apparatus for creating a seal between two coaxial strings of pipe are provided. The method and apparatus have utility in one embodiment for sealing the annulus between the tubing and the casing within a hydrocarbon wellbore. According to the method of the present invention, an expander tool is positioned at a selected depth within the tubing, and then actuated in order to expand the tubing against the inner wall of the casing wall. Multiple configurations of the expander tool are disclosed. The expander tool is rotated in order to provide a fluid seal in the annulus. In this way, the tubing string becomes its own packer. In one embodiment, a seal ring is provided around the outer surface of the tubing to enhance the fluid seal. Further, a slip ring is provided around the outer surface of the tubing to provide a gripping means between the tubing and the casing.
Fig. 3
Fig. 7
HIGH PRESSURE HIGH TEMPERATURE PACKER SYSTEM, IMPROVED EXPANSION ASSEMBLY FOR A TUBULAR EXPANDER TOOL, AND METHOD OF TUBULAR EXPANSION

RELATED APPLICATIONS

[0001] This application is a continuation-in-part of an earlier application entitled “HIGH PRESSURE HIGH TEMPERATURE PACKER SYSTEM.” That application was filed on Sep. 5, 2001, and has U.S. Ser. No. 09/946,196. The parent application is incorporated herein in its entirety by reference.

[0002] This application is also a continuation-in-part of an earlier application entitled “IMPROVED EXPANSION ASSEMBLY FOR A TUBULAR EXPANDER TOOL, AND METHOD OF TUBULAR EXPANSION.” That application was filed on Apr. 15, 2002, and has U.S. Ser. No. 10/123,035. This second parent application is also incorporated herein in its entirety by reference.

[0003] The parent application entitled “IMPROVED EXPANSION ASSEMBLY FOR A TUBULAR EXPANDER TOOL, AND METHOD OF TUBULAR EXPANSION,” in turn, was a continuation-in-part of an earlier application also entitled “IMPROVED EXPANSION ASSEMBLY FOR A TUBULAR EXPANDER TOOL, AND METHOD OF TUBULAR EXPANSION.” That application was filed on Feb. 4, 2002, and has U.S. Ser. No. 10/066,824. The parent application to the CIP has been abandoned.

BACKGROUND OF THE INVENTION

[0004] 1. Field of the Invention

[0005] The present invention relates to the completion of a wellbore. More particularly, the invention relates to an apparatus and method for sealing a first tubular into a second surrounding tubular by expanding the first tubular into frictional engagement with the second tubular. In addition, the present invention relates to an expander tool for expanding a section of a tubular within a wellbore.

[0006] 2. Description of the Related Art

[0007] Hydrocarbon and other wells are completed by drilling a borehole in the earth, and then lining the borehole with steel pipe or casing to form a wellbore. After a section of wellbore is formed by drilling, a string of casing is lowered into the wellbore and temporarily hung therein from the surface of the well. An annular area is thus defined between the outside of the casing and the surrounding earth formation. Using apparatus known in the art, the casing is cemented into the wellbore by circulating cement into the annular area. In this manner, the casing is permanently set in the wellbore. 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.

[0008] 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, or “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 new string of liner in the wellbore. The second casing string is then cemented. This process is typically repeated with additional casing 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.

[0009] In many wellbore completion operations, a packer is employed. A packer is a downhole tool which places sealing elements within the wellbore to isolate areas of the wellbore fluid or to manage the flow of fluids up the wellbore. Packers are usually constructed of cast iron, aluminum or other alloyed metals, and include slip and sealing means. The slips fix the tool in the wellbore, and typically include slip members and cones to wedgingly attach the tool to the casing wall. In addition, packers typically include an elastomeric sealing element located between upper and lower metallic retaining rings. The sealing element is set when the rings move towards each other and compress the element therebetween, causing the element to expand outwards into an annular area to be sealed against an adjacent tubular.

[0010] Packers are typically used to seal an annular area formed between two coaxially disposed tubulars within a wellbore. For example, packers may seal an annulus formed between production tubing and the surrounding casing string. Alternatively, packers may seal an annulus between the outside of the tubular and an unlined borehole. Routine uses of packers include the isolation of formations or leaks within a wellbore casing or multiple production zones, thereby preventing the migration of fluid between zones. Packers may also be used to hold fluids or treating fluids within the casing annulus.

[0011] One problem associated with conventional sealing and slip systems of conventional downhole tools relates to the relative movement of parts required in order to set the tools in a wellbore. Because the slip and sealing means require parts of the tool to be moved in opposing directions, a run-in tool or other mechanical device must necessarily be placed in the wellbore with the sealing tool. Additionally, the slip means takes up annular space that is limited. Also, the body of a packer necessarily requires wellbore space and reduces the bore size available for production tubing and production fluids therein. Additionally, high temperatures and pressures in a wellbore can corrode and degrade the elastomeric sealing element as well as the moving parts in a conventional slip assembly.

[0012] Therefore, there is a need for a packer for sealing a downhole annular area which employs fewer moving parts. There is further a need for a packer which can be used to seal an annular area at high temperatures and high pressure differentials without experiencing physical degradation.

[0013] To address this need, apparatus and methods that permit tubular bodies to be expanded within a wellbore may be considered. Such apparatus typically include an expander tool that is run into the wellbore on a working string. The expander tool includes radially expandable mem-
bers, or “expansion assemblies,” which are urged radially outward from a body of the expander tool, either in response to mechanical forces, or in response to fluid injected into the working string. The expansion assemblies are expanded into contact with a surrounding tubular body. Outward force applied by the expansion assemblies causes the tubular body to be expanded. Rotation of the expander tool, in turn, creates a radial expansion of the tubular.

[0014] An exemplary embodiment of an expander tool previously known as of the filing of this continuation-in-part application is shown in FIG. 1. FIG. 1 is an exploded view of an exemplary expander tool 100. FIG. 2 presents the same expander tool 100 in cross-section, with the view taken across line 2-2 of FIG. 1.

[0015] The expander tool 100 has a body 102 which is hollow and generally tubular. The central body 102 has a plurality of recesses 114 to hold a respective expansion assembly 110. Each of the recesses 114 has parallel sides and holds a respective piston 120. The pistons 120 are radially slidable, one piston 120 being sealed within each recess 114. The back side of each piston 120 is exposed to the pressure of fluid within a hollow bore 115 of the expander tool 100. In this manner, pressurized fluid provided from the surface of the well can actuate the pistons 120 and cause them to extend outwardly.

[0016] Disposed within each piston 120 is a roller 116. In one embodiment of the expander tool 100, the rollers 116 are near cylindrical and slightly barred. Such a roller 116 is sometimes referred to as a “parallel” roller because it includes a side portion that resides parallel to the surrounding tubular to be expanded. Each of the rollers 116 is supported by a shaft 118 at each end of the respective roller 116 for rotation about a respective axis. The rollers 116 are generally parallel to the longitudinal axis of the tool 100. In the arrangement of FIG. 1, the plurality of rollers 116 are radially offset at mutual 120-degree circumferential separations around the central body 102. In the arrangement shown in FIG. 1, two offset rows of rollers 116 are shown. However, only one row, or more than two rows of roller 116, may be incorporated into the body 102.

[0017] In operation, the expander tool 100 is attached proximate to the lower end of a working string (not shown). The working string is lowered into the wellbore so as to place the attached expander tool 100 at the depth of a tubular to be expanded. The expansion assemblies 110 are then actuated. In some instances, the expansion assemblies 110 are mechanically actuated. In the arrangement shown in FIGS. 1 and 2, the expansion assemblies 110 are actuated by injecting fluid under pressure into the working string, and down into the perforated inner mandrel of the expander tool 100. As sufficient pressure is generated on the piston surface behind the expansion assemblies 110, the tubular being acted upon (not shown) by the expander tool 100 is expanded past its point of elastic deformation. In this manner, the inner and outer diameter of the tubular is increased within the wellbore. By rotating the expander tool 100 in the wellbore and/or moving the expander tool 100 axially in the wellbore with the expansion assemblies 110 actuated, a tubular can be radially expanded into plastic deformation along a predetermined length.

[0018] One disadvantage to known expander tools, such as the hydraulic tool 100 shown in FIGS. 1-2, is the inherently restricted size of the hollow bore 115. In this respect, the dimension of the bore 115 is limited by the size of the expansion assemblies 110 radially disposed around the body 102 of the tool 100. The constricted bore 115 size, in turn, imposes a limitation on the volume of fluid that can be injected through the working string at any given pressure. Further, the dimensions of the bore 115 in known expander tools place a limit on the types of other tools which can be dropped through the expander tool 100. Examples of such tools include balls, darts, retrieving instruments, fishing tools, bridge plugs and other common wellbore completion tools.

[0019] In addition, the tubulars being expanded within a wellbore generally define a thick-walled, high-strength steel body. To effectively expand such tubulars, a large cross-sectional geometry is required for the roller body 116. This further limits the inner bore diameter, thereby preventing adequate flow rates and minimizing the space available to run equipment through the inner bore 115. At the same time, the stresses required to expand the material are very high; hence, reducing the roller body size to accommodate a larger inner bore diameter would mechanically weaken the roller mechanism, thereby compromising the functionality of the expansion assembly. In this respect, where the expander tool 100 is translated within the wellbore, the shaft 118 serves as a thrust bearing.

[0020] Therefore, a need exists for an expander tool which provides for a larger configuration for the hollow bore 115 therein. Further, a need exists for an expander tool which reduces the size of the expansion assemblies 110 around the tool so as to allow for a greater bore 115 size. Further, a need exists for an expander tool having expansion assemblies which do not rely upon rollers 116 rotating about a shaft 118 at a spaced apart distance from the piston member 120.

SUMMARY OF THE INVENTION

[0021] First, a packer is provided. The packer defines an expandable tubular body that is expanded so as to fix and seal the packer against a surrounding second tubular within a wellbore by plastic deformation. In one aspect, the packer is run into the wellbore as part of the production tubing string. An expander tool is then also run into the wellbore within the tubing string, and located at the depth of the packer. The expander tool is actuated so as to expand the packer into frictional engagement with a surrounding string of casing.

[0022] The packer includes at least one elastomeric ring which is affixed to the outer surface of the tubular body. The sealing ring provides a fluid seal between the tubular body and the casing when the packer is expanded. The sealing ring prevents production fluids from passing upwardly between the casing and the tubular. The packer optionally includes at least one slip ring affixed to the outer surface of the tubular body. The slip ring has a plurality of teeth that provide an additional gripping mechanism between the tubular body and the casing. In the preferred embodiment, the elastomeric ring is positioned above the slip ring. Together, the elastomeric ring and the slip ring seal, or “pack off,” a tubing-casing annulus under elevated pressures and temperatures. In this manner, the production string acts as its own high pressure high temperature packer.

[0023] The present invention also provides methods for expanding a first tubular body into frictional engagement
with a surrounding second tubular body. In one aspect, a packer is formed within a wellbore by expanding a first tubular body into sealed engagement with a surrounding casing by using a rotary expander tool. The expander tool is of a generally tubular nature, and employs pressure-actuated rollers which act against the inner surface of the tubular body in order to expand it against the casing. The rollers are disposed on pistons that are movable from a first retracted position within a housing of the expander tool to a second extended position beyond the housing. In order to actuate the pistons, the bottom surfaces of the respective pistons are exposed to an outwardly radial force. In one aspect, the force is a hydraulic force generated by wellbore fluids within the bore of the expander tool. In another aspect, the hydraulic pressure is from a dedicated fluid reservoir in fluid communication with the expander tool downhole. Alternatively, a mechanical force may be employed. The piston is moved radially outward from the body of the expander tool but within the recess in response to the radially outward force, causing the rollers to come into contact with the walls of the tubular body. Simultaneously, the expander tool is rotated within the tubular body. As outward force is increased, the tubular body is expanded until the outer wall of the tubular body is in firm contact with the inner wall of the surrounding casing. In this manner, the elastomer rings are compressed between the tubular body and the casing. The tubular body becomes, in effect, a packer, and eliminates the need for a separate packer device.

[0024] In certain methods of the present invention, novel expansion assemblies are used as part of the expander tool. In one embodiment, the expansion assemblies each employ a roller that rotates about a shaft. The shaft, in turn, is fixed on a piston that slideably moves out from a respective recess within the tool body when the expander tool is actuated. The rollers employs a unique, multi-lobed surface contour that allows the uniform expansion of a tubular while reducing the potential of the expandable tubular to crack.

[0025] In an alternate embodiment, the piston of the expansion assemblies defines an elongated waffer-shaped body which is scalingly disposed within an appropriately configured recess of an expander tool. The piston has a top surface and a bottom surface. The top surface includes a bearing cavity for receiving a roller. In this arrangement, the roller does not rotate about a shaft; rather, the roller is permitted to partially rotate and to partially slide within the bearing cavity of the piston during an expansion operation. Because the roller is held closely to the piston within the bearing cavity, greater space is accommodated for the bore within the expander tool.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] 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 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.

[0027] FIG. 1 is an exploded view of an expander tool previously known as of the time of the filing of this continuation-in-part application. Visible in FIG. 1 is an expansion assembly having a roller which rotates about a shaft.

[0028] FIG. 2 is a cross-sectional view of the expander tool of FIG. 1, taken across line 2-2 of FIG. 1.

[0029] FIG. 3 is a section view of a tubular body within a portion of a string of casing. The tubular body is expandable, so as to form a high temperature high pressure packer within a wellbore.

[0030] FIG. 4 is a perspective view of a novel expander tool as might be used to expand the tubular of FIG. 3 in accordance with the present invention. One of the expansion assemblies is shown in an exploded state away from the body of the expander tool.

[0031] FIG. 5 provides a cross-sectional view of the expander tool of FIG. 4, cut across one row of rollers. The pistons are shown in three different positions in this view for purposes of demonstration. In P1, the piston is shown in its retracted position; in P2, the piston is shown in its expanded state; and in P3, the piston is shown in an exploded view.

[0032] FIG. 6 demonstrates a cross-sectional view of a wellbore having an expander tool therein. The expander tool has been lowered into the wellbore on a working string. The expander tool is cut away to be seen in partial cross-section. It can be seen that the pistons of the expander tool are in their retracted state within the plane of the expander tool body. A tubular body is also seen in the wellbore intermediate the expander tool and a surrounding string of casing.

[0033] FIG. 7 is a cut-away view of the expander tool of FIG. 6, again disposed within an expandable tubular body. The pistons and attached rollers have been actuated into their expanded state. The tubular body has been partially expanded by the expander tool.

[0034] FIG. 8 presents another cross-sectional view of the expander tool of FIG. 6 disposed within an expandable tubular body. In this view, the tubular body has been expanded into frictional and sealed engagement with the surrounding casing so as to form a packer. It can be seen that the pistons and attached rollers have retracted back into the body of the expander tool. The expander tool is now being removed from the wellbore.

[0035] FIG. 9 provides a perspective view of an expander tool having an alternate arrangement for the expansion assemblies. The expansion assemblies are shown exploded away from the body of the expander tool.

[0036] FIG. 10 shows a cross-sectional view of the expander tool of FIG. 9, taken across line 10-10 of FIG. 9.

[0037] FIG. 11 presents the exploded expansion assembly of FIG. 9, in a more enlarged view.

[0038] FIG. 12 shows a side, cross-sectional view of the expansion assembly of FIG. 11, without the top piece.

[0039] FIG. 13 demonstrates the expansion assembly of FIG. 11 from a top view.

[0040] FIG. 14 provides a cross-sectional view of a wellbore. The wellbore includes an upper string of casing, and a lower string of casing having been hung off of the upper string of casing. In this view, the lower string of casing serves as a tubular body to be expanded.

[0041] FIG. 15 presents the wellbore of FIG. 14. In this view, an expander tool which includes expansion assemblies of FIG. 11 is being lowered into the wellbore on a working string.
FIG. 16 presents the wellbore of FIG. 15, with the expander tool being actuated in order to expand the lower string of casing into the upper string of casing, thereby further hanging the liner from the upper string of casing.

FIG. 17 shows the wellbore of FIG. 16, in which the lower string of casing has been expanded into the upper string of casing along a desired length. The expander tool has been removed from the wellbore.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 3 provides a cross-sectional view of a portion of a wellbore 50. The wellbore 50 is formed within a surrounding earth formation 15. The wellbore 50 has been cased with a string of casing 25. The casing 25 has been cemented into the wellbore 50 by a column of cement 20.

A tubular body 10 is seen disposed within the wellbore 50. The tubular body 10 is expandable, so as to form a high temperature high pressure packer within the wellbore 50. It is understood, however, that the tubular body 10 may be any expandable tubular body, meaning that the scope of the present invention is not limited to the formation of packers.

In the arrangement of FIG. 3, the packer 10 defines a tubular body placed in series with a string of production tubing 55. Indeed, in one embodiment, the tubular body 10 is itself simply a joint or portion of a joint of the production tubing 55. However, it is within the scope of this invention to utilize a specially configured tubular body, such as a shorter and more malleable joint of pipe, for expansion into the string of casing 25.

The tubular body 10 is fabricated from a steel or metal alloy material. The material must be strong enough to withstand the high temperatures and pressure differentials prevailing within the downhole environment. However, it must be sufficiently malleable to be plastically deformed by expansion into the casing 25.

In the view of FIG. 3, the tubular body 10 has not been expanded. The tubular body 25 is disposed more or less concentrically within the string of casing 25. For purposes of the present inventions, the term concentrically means that two tubulars have been positioned essentially coaxially, with one residing within the other. The outer surface of the tubular body 10 is separated from the inner surface of the casing 25 by an annulus 45 to permit a clearance between the casing 25 and the tubular body 10 during run-in. The casing 25 is generally formed of steel, iron or a similar material and is typically cemented into the wellbore 50.

Affixed to the outer surface of the tubular body 10 is a plurality of bands 12 and 14. In the preferred embodiment for the apparatus 10, the plurality of bands 12, 14 define at least one sealing ring 12 and at least one slip ring 14. The sealing ring 12 is preferably fabricated from an elastomeric material, and provides a circumferential seal between the tubular body 10 and the casing 25 when the tubular body 10 is expanded against the casing 25. The seal ring 12 prevents production fluids from passing upwardly between the casing 25 and the production tubing 55 after the tubular body 10 has been expanded.

The slip ring 14 has a plurality of teeth 16 formed along its outer surface. The purpose of the slip ring 14 is to provide a gripping means between the tubular body 10 and the casing 25 upon expansion of the tubular body 10. The gripping teeth 16 are designed to grip the inner surface of the casing 25 and to aid in preventing the tubular body 10 from slipping into the wellbore 50. In the preferred embodiment, the slip ring 14 is circumferentially disposed about the outer surface of the tubular body 10, with teeth 16 aiding in creating the desired frictional engagement between the tubular body 10 and the casing 25. However, it is within the scope of this invention to provide slip means of other configurations, such as a plurality of buttons (not shown) having carbide teeth, flame sprayed carbide aggregates, or other carbide-based gripping means. Alternatively, no separate slip ring 14 is employed.

In one aspect, the elastomeric seal ring 12 is spaced apart from the slip ring 14 on the outer surface of the tubular body 10. In embodiment shown in FIG. 3, the seal ring 12 is positioned above the slip ring 14. However, the scope of the present invention is not limited by the relative position of the slip ring 14 and the seal ring 12.

After the tubular body 10 is placed within the wellbore 50, it is expanded so that the seal ring 12 and slip ring 14 are in contact with the casing 25. Expansion is done through use of an expander tool, such as the expander tool 100 of FIG. 4. However, other expander tools, e.g., 100' and 100", are provided herein as preferred alternatives, as will be disclosed below.

First, FIG. 4 presents an expander tool 100 having a novel alternate arrangement for expansion assemblies 110. A perspective view of the tool 100 is provided, with one of the expansion assemblies 110 being seen in an exploded view. As with the expander tool 100 of FIG. 1, the expander tool 100' of FIG. 4 comprises a body 102. In the embodiment shown, the body 102 defines an elongated cylindrical member having a plurality of recesses 114 formed therein. The recesses 114 are formed in two rows, with three recesses 114 per row. The recesses 114 within each row are spaced equidistantly apart from each other, and are generally equiangular to one another in a row. Of course, other configurations of recesses 114 may be utilized for expanding a tubular body, and the present inventions are not limited by the arrangement of the recesses 114.

Each of the recesses 114 is configured to sealingly receive an expansion assembly 110. Each expansion assembly 110 includes a piston 120 which moves from a first recessed position within its respective recess 114 to a second extended position outward from the body 102. The expansion assemblies 110 are shown in these two positions in the cross-sectional view of FIG. 5. FIG. 5 is a cross-sectional view of the expander tool 100 of FIG. 4, cut across one row of expansion assemblies 110. The expansion assemblies 110 are shown in different positions in this view. In P1, the expansion assembly 110 is shown in its recessed position; in P2, the expansion assembly 110 is shown in its expanded state; and in P3, the expansion assembly 110 is shown in an exploded view. Of course, it is understood that in operation, the expansion assemblies 110 would move outwardly together, and would not be staggered as shown in FIG. 5.

As demonstrated in FIGS. 4 and 5, the pistons 120 are coupled to outwardly facing rollers 116. The pistons 120 have a wafer shape with a seal 126 disposed on a back surface and a cup 117 formed on an inner surface. The
pistons 120 are slidingly disposed in the recesses 114 and are retained by a pair of retaining plates 119A and 119B. To prevent the pistons 120 from falling out of the body 102, a pair of flats 144A and 144B are formed in the sides of the pistons 114. The flats 144A, 144B define a pair of flanges. The retaining plates 119A and 119B are fastened to the body 102 by socket head cap screws 121. When fully extended, the flats 144A, 144B abut the plates 119A and 119B. The cup 117 formed within the piston 114 accommodates a portion of the roller 116 that is rotatably affixed by an axle 118 into the cup 117. The axle 118 is disposed through an aperture 140A formed in the piston 120, then passes through a central bore 142 located in the roller 116 before being secured in a second aperture 140B formed in the piston 120.

[0056] Disposed through the center of expander tool 100' runs a central bore 115. The central bore 115 is seen in FIG. 5. The bore 115 carries hydraulic fluid or mud to the pistons 120. The bore 115 feeds hydraulic fluid to perforations, or radial conduits, 124 in order to apply pressure to the back surface 126 of the pistons 120 so as to force them radially outward from the body 102.

[0057] The expander tool 100' also includes an upper connector 125 having an internally threaded bore 122. Threads 126 are placed within the upper connector 125 to facilitate the connection of the expander tool 100' to a run-in string (not shown). The expander tool 100' is configured to include an optional shoulder portion 106. The shoulder 106 is formed to coaxially align and connect the upper connector 125 to the body 102.

[0058] Referring again to the rollers 116, the rollers 116 as seen in FIG. 4 have a contoured shape comprising three elliptical lobes 132, 136 and 138 (respectively top, center and bottom lobes) interspersed by two spacing sections 134A and 134B. In one embodiment, the roller 116 is formed from a single piece of material and has a bore 142 formed along its central axis. The top lobe 132 and the bottom lobe 138 are of similar proportions (diameter and radius), while the intermediate lobe 136 is smaller. Thus, a "bow-tie" profile is presented. The bow-tie shape allows for a narrower point of contact between the roller surface 116 and the surrounding tubular (shown at 25 in FIG. 1) to be expanded. In this respect, less force is required to expand a tubular, e.g., tubular 10, at a single radial point than over an extended surface area. This, in turn, facilitates the transition within the tubular 25 being expanded from elastic deformation to plastic deformation. Thus, a tighter seal can be accomplished.

[0059] While the one embodiment for expansion of the tubular body 202A employs rollers 114 having a bow-tie profile, it is understood that other profiles may be employed for rollers 114. It is within the scope of this invention to utilize alternative roller shapes such as a "barrel" shape, discussed below.

[0060] Operation of the expander tool 100' to expand a tubular body is shown in FIGS. 6-8. First, FIG. 6 presents a cross-sectional view of a wellbore 50 having an expander tool 100' therein. The expander tool 100' has been lowered into the wellbore 50 on a working string 70. The expander tool 100' is seen in partial cross-section. A tubular body 10 is also seen in the wellbore 50 intermediate the expander tool 100' and a surrounding string of casing 25. It can be seen that the pistons 120 of the expander tool 100' are in their recessed state.

[0061] In order to expand the tubular body 10 to form a packer, the expander tool 100' is run into the tubing string 55. The expander tool 100' is located at a depth adjacent the tubular body 10 to be expanded, as demonstrated in FIG. 6. To assist in the location of the expander tool 100', a positioning ring 75 may optionally be run ahead of the tubular body 10. The positioning ring 75 is disposed within the interior of the tubular body 10. The positioning ring 75 is formed having an interior chamfer 78 along its inner diameter. This chamfer 78 serves as a landing profile, and is used to locate the expander tool 100' of FIG. 4 within the tubular body 10. More specifically, a lower end 130 of the expander tool 100' lands on the chamfer 78. The positioning ring 75 may be press-fit, welded or the like affixed to the interior surface of the tubular body 10, and is positioned below the slip ring 14. It is, however, within the scope of this invention to utilize other types of positioning members, or to use an internally profiled locator in lieu of a chamfered positioning member.

[0062] The expander tool 100' is lowered into the wellbore 50 to a depth adjacent the tubular body 10. Use of a positioning ring 75 aids in aligning the rollers 116 of the expander tool 100' with the seal ring 12 and slip ring 14, respectively. The run-in position of the expander tool 100' attached to the lower end of the working string 70 is seen in FIG. 6. The working string 70 is threaded to the upper connector portion 125 of the expander tool 100'.

[0063] After the expander tool 100' has been lowered into the tubular body 10 and aligned with the packer 10, the expander tool 100' is actuated. For the expander tool 100' of FIG. 6, hydraulic fluid or mud is pumped from a fluid source, through the string of pipe 70, and into the bore 115 of the expander tool 100'. FIG. 7 is a cut-away view of the expander tool 100' of FIG. 4, again disposed within an expandable tubular body 10, with the rollers 116 have been actuated into their expanded state. A fluid source is shown schematically at 414. The fluid travels through conduits 124 into the piston recesses 114, forcing the expansion assemblies 110 radially outward. As such, the pistons 120 move radially outward and rollers 116 come in contact with and begin to plastically deform the packer 10. At the same time, the expander tool 100' is rotated from the surface of the well (shown schematically at 412) or by a mud motor (not shown), causing a series of annular rings 402, 404 and 406 to be formed along the interior surface of the tubular body 10. In FIG. 7, it can be seen that the packer 10 has been partially expanded by the expander tool 100'.

[0064] The pumped fluid exits the expander tool 100' through one or more nozzles at the lower portion 130 of the tool 100'. In the embodiment of FIG. 7, a single nozzle 152 serves as a sized orifice, and also as the outlet port for bore 115. As fluid is pumped through the nozzle 152, critical flow is reached. In one embodiment, the pistons 120 are actuated at the point of critical flow. As the hydraulic fluid is pumped through the central aperture 122 and the bore 115, differential pressure created between the hydraulic fluid being pumped into the housing and the hydraulic fluid flowing through the bore 115 creates the radial forcing pressure on the back surface 126 of the pistons 120. As the rollers 116 create the annular rings 402, 404 and 406 within the interior surface of the tubular body 10, the exterior portion of the tubular body 10 is expanded outward toward the casing 25.
The outward expansion of the tubular body 10 continues until seal ring 12 and slip ring 14 are compressed against the interior surface of the casing 25. Sufficient pressure is applied by the rollers 116 to create a contoured seal between the elastomeric ring 12 and the casing 25. Further, the pressure is enough to prevent slip ring 14 from moving within the casing 25. The bow tie profile further allows for two separate points of radial contact, an upper 132 and lower 138 point, thereby doubling the seal contact points 402, 406. The intermediate roller point 136 aids further in the expansion of the tubular 10.

[0065] To provide yet a greater seal between the tubular body 10 and the casing 25, the run-in string 70 may be translated vertically within the wellbore 50. This has the effect of lifting and lowering the expander tool 100 so as to expand an additional length of the tubular body, e.g., packer 10. However, this additional step is considered optional, and is not required when a bow-tie shaped profile is employed for the rollers 116.

[0066] After the tubular body 10 has been expanded and sealed within the casing 25, hydraulic pressure is removed or released. In one embodiment, a pressure differential causes the pistons 120 to be retracted into the body 102 of the expander tool 100", and allows the expander tool 100" to be removed from the tubular body 10. In another embodiment, the pistons 120 are biased inward.

[0067] After the expansion operation, the expander tool 100" is withdrawn from the wellbore 50 by pulling the working tubular 70. FIG. 8 is a cross-sectional view of a wellbore 50 having a production tubing 55 disposed therein, and showing the expander tool 100" being removed from the wellbore 50. The expandable tubular 10 has been expanded against the casing 25 so as to form a high pressure high temperature packer 10. The production tubing 55 now, in essence, functions as both a conduit for production fluids and also as an annular packer.

[0068] As an alternative embodiment for the expansion assemblies 110, 110", a more "tapered" shaped roller may be utilized. FIG. 9 provides a perspective view of an expander tool 100" having an alternate arrangement for an expansion assembly 110". One of the expansion assemblies 110" is shown exploded away from the body 102 of the expander tool 100". An enlarged exploded view of the expansion assembly 110" is shown in FIG. 11.

[0069] Additional views of the expansion assembly 110" are seen in FIGS. 10 and 12. FIG. 10 shows a cross-sectional view of the expander tool 100" of FIG. 9, taken across line 10-10 of FIG. 9. The central bore 115 and perforated conduits 124 of the tool 100" are more clearly seen in FIG. 10. FIG. 12 shows a side, cross-sectional view of the expansion assembly 110". In FIG. 12, a top plate 130 has been removed.

[0070] As with the expansion assembly 110" of FIG. 4, the expansion assembly 110" of FIG. 9 provides an upper connector member 125. The upper connector 125 is typically connected to a working string, as will be shown in a later figure. A lower connector 135 is also shown. The lower connector 135 may be used for connecting the expander tool 100" to other tools further downhole. Alternatively, connector 135 may simply define a deadhead.

[0071] The expansion assembly 110" of FIG. 9 also comprises a piston 120. The piston 120 sealingly resides within a recess 114 of the expander tool body 102. In the arrangement shown in FIG. 9, the piston 120 defines an elongated, wafer-shaped member capable of sliding outwardly from the expander tool body 102 in response to hydraulic pressure within the bore 115 of the tool 100". The novel configuration of the piston 120 is more clearly seen in FIG. 12.

[0072] The piston 120 includes a base 122 that runs the length of the piston 120. An outer lip 123 is formed at either end of the base 122 in order to provide a shoulder within the recess 114 of the expander tool 100". The outer lip 123 may receive an o-ring (not shown) for sealing the radial interface of the respective pistons 120 and the body 102.

[0073] The piston 120 has a top surface 117 and a bottom surface 126. The bottom surface 126 is exposed to hydraulic pressure within the bore 115 of the expander tool 100" when the tool 100" is actuated. The top surface 117 of the piston base 122 defines a bearing cavity. As seen in FIG. 9, the bearing cavity 117 defines an elongated cradle configured to receive the roller 116. In one aspect, the bearing cavity 117 has a polished arcuate surface for closely holding the roller 116. In this way, the coefficient of friction between the bearing cavity 117 and the roller 116 is less than the coefficient of friction between the roller 116 and a surrounding tubular (shown in FIGS. 14-17) to be expanded.

[0074] Positioned over the lower end of the bearing cavity 117 is a shoe 146. The shoe 146 is configured to receive a lower portion 116L of the roller 116. In operation, the lower portion 116L of the roller 116 is gravitationally held within the shoe 146 during operation of the expansion assembly 110L. The shoe 146 further serves to stabilize and support the roller 116 during an expansion operation. The shoe 146 is preferably fabricated from a hardened metal material such as steel so that it can aid in the expansion process.

[0075] An optional feature shown in the expansion assembly 110 of FIG. 9 is a lubrication port 127. The port 127 defines a through-opening through the piston 120, providing a path of fluid communication between the bore 115 of the expander tool 200 and the bearing cavity 117. The port 127 is sized to permit a small flow of fluids onto the surface of the bearing cavity 117 in order to facilitate rotation of the roller 116. In this respect, fluids will further reduce the coefficient of friction between the roller 116 and the bearing cavity surface 117. In addition, the presence of fluid behind the roller 116 as it rotates will serve to cool the roller 116 during the stressful expansion operation, thereby protecting the roller 116 from unnecessary wear.

[0076] It is recognized that the presence of a port 127 within the piston body 120 will reduce pressure behind the piston 126 due to hydraulic forces within the wellbore 10. However, such a pressure reduction is minimal where only a small port 127 is employed. In one aspect, the port 127 is only 0.50 cm in diameter, though other dimensions may be provided.

[0077] Also positioned on the top surface of the base 122 of the piston 120 is a headrest 140. The headrest 140 is configured to receive an upper portion 116U of the roller member 116. In the exemplary arrangement shown best in FIG. 11, the headrest 140 includes a highly polished, arcuate surface 144 configured to closely receive the upper portion 116U of the roller 116. In this way, the headrest 140 also serves as a cradle for the roller 116.
In the view of FIG. 12, it can be seen that the roller 116 does not include an axle or shaft about which rotation is provided; instead, the roller 116 is permitted to rotationally move within the bearing cavity 117 of the piston 120, and upon the headrest 140. More specifically, the roller 116 may partially roll and partially skid on the bearing cavity 117. Removal of the shaft from the expansion assembly (e.g., FIG. 1) reduces the overall thickness of the body 202 of the new expander tool 202 (shown in FIG. 12), thereby saving valuable space within the wellbore.

The roller 116 illustrated in FIGS. 9-12 has a generally frustoconical cross-section. This provides for an elongated tapered section. For this reason, such a roller configuration is sometimes referred to as a “tapered” roller. The elongated tapered surface of the roller 116 more readily accommodates axial movement of the expander tool 100' during an expansion process. In this respect, the tapered surface provides for a more gentle contact angle with the surrounding casing than is present in a parallel roller (seen in FIG. 1) or the bow-die roller (seen in FIG. 4). It is to be appreciated, however, that other roller shapes are possible for the present invention, including a parallel roller. For example, the roller 116 may have a cross-sectional shape that is barrel-shaped, semi-spherical, multifaceted, elliptical or any other cross sectional shape suited to the expansion operation to be conducted within a tubular.

The tapered roller 116 of FIG. 9 is fabricated from a material of appreciable strength and toughness in order to withstand the high hertzian stresses imposed upon the roller 116 during an expansion operation. Preferably, the roller 116 is fabricated from a ceramic or other hardened composite material. Alternatively, a steel or other hard metal alloy may be used. In any arrangement, it is understood that some sacrifice of the material of the roller 116 may occur due to the very high stresses required to expand a surrounding metal tubular.

In one arrangement, the orientation of the tapered roller 116 is skewed relative to the longitudinal center axis of the bore 115 of the expander tool 100'. To accomplish this, the recesses 114 in the expander tool body 102 are tilted so that the longitudinal axis of the rollers 116 are out of parallel with the longitudinal axis of the tool 100'. Preferably, the angle of skew is only approximately 1.5 degrees. The advantage is that simultaneous rotation and translation of the expander tool 100' allows the roller 116 to predominantly roll against the surrounding casing being expanded, without skidding against it. This, in turn, causes the thrust system, i.e., the mechanism for raising or lowering the expander tool 100' within the wellbore 50, to operate more efficiently.

It is understood that “skewing” of the rollers 116 is an optional feature. Further, the degree of tilt of the rollers 116 is a matter of designer’s discretion. In any event, the angle of tilt must be away from the direction of rotation of the tool 100' so as to enable the tool 100' to more freely be translated within the wellbore 50. By employing such an angle, the rollers 116 will tend to pull themselves into the casing 25 as the expandable tubular 10 is expanded (depending on the direction of ‘skew’ and rotation). This, again, reduces the thrust load required to push the rollers 116 into the casing 25 during translation. Tilting the rollers 116 further causes the rollers 116 to gain an increased projected depth to expand the casing 25. This is true for both parallel (FIG. 1) and tapered (FIG. 9) rollers 116.

In one aspect, the expansion assembly 110' of FIGS. 9-12 includes a cap piece 130. An optional cap piece 130 is included in the arrangement of FIGS. 9-12. The cap piece 130 defines an elongated body configured to be connected to the piston 120. In this respect, connector openings 128 within the cap piece 130 are configured to align with connector openings 128 within the piston 120. In the arrangement of FIG. 9, connection of the cap piece 130 is made with the piston 120 by means of threaded screws 150.

The cap piece 130 includes a top surface 132 configured to support and partially enclose the headrest 140 between the cap piece 130 and the piston base 122. Positioning of the top surface 132 over a portion of the headrest 140 is more fully seen in the side cross-sectional view of FIG. 10.

The cap piece 130 also comprises an opening 134. The opening 134 is configured to receive the roller 116. The opening 134 permits the roller 116 to rotate within the bearing cavity 124.

FIG. 13 presents a top view of the expansion assembly of FIG. 9. In this view, the configuration of the roller 116, and the disposition of the roller 116 upon the base 122 of the piston 120 can be more fully seen. The preferred tapered configuration of the roller 116 is also more fully demonstrated.

Referring again to FIG. 10, FIG. 10 presents a cross-sectional view of the expander tool 100' of FIG. 9. As noted, the view in FIG. 10 more clearly shows the bore 115 running through the body 102 of the tool 100'. It is to be observed that the bore 115 of the expander tool 100' is larger than the bore 115 of the previously known expander tool, shown in FIG. 1. This is the advantage of the expansion assembly 110' configuration of FIGS. 9 and 11.

In order to demonstrate the operation of the expander tool 100', FIGS. 14-17 have been provided. FIG. 14 provides a cross-sectional view of a wellbore 50. The wellbore 50 iscased with an upper string of casing 25. The upper string of casing 25 has been cemented into a surrounding formation 15 by a slurry of cement 20, now set. The wellbore 50 also includes a lower string of casing 30, sometimes referred to as a "liner." The lower string of casing 30 has an upper portion 30U which has been positioned in the wellbore 50 at such a depth as to overlap with a lower portion 30L of the upper string of casing 25. It can be seen that the lower string of casing 25 is also cemented into the wellbore 50. A packer 35 is shown schematically in FIG. 14, providing support for the lower string of casing 30 within the upper string of casing 25 before the cement 20 behind the lower string of casing 30 is cured.

FIG. 15 presents the wellbore of FIG. 14, with a working string 70 being lowered into the wellbore 50. Affixed at the bottom of the working string 70 is an expander tool 100'. The expander tool 100' includes alternate improved expansion assemblies 110' of the present invention. In this view, the expansion assemblies 110' have not yet been actuated.

Turning now to FIG. 16, the expander tool 100' has been lowered to a depth within the wellbore 50 adjacent
the overlapping strings of casing 25L, 30U. The expansion assemblies 110° of the expander tool 100° have been actuated. In this manner, the upper portion 30U of the lower string of casing 30 can be expanded into frictional engagement with the surrounding lower portion 25L of the upper string of casing 20. The upper portion of liner 30U becomes the first tubular apparatus 10 being expanded.

[0091] Expansion of the lower casing string 30U in the view of FIG. 16 is from the bottom up. For such an expansion operation, the expansion assemblies 210 are oriented so that the elongated tapered surfaces are facing upward. As noted, the elongated tapered surfaces of the rollers 116 more readily accommodate axial movement of the expander tool 100° during an expansion process. It is, of course, understood that the expander tool 100° may be oriented in the opposite direction, i.e., “turned over,” to facilitate expansion from the top down.

[0092] As with expander tools 100 (FIG. 1) and 100° (FIG. 4), expander tool 100° (FIG. 9) is hydraulically actuated (though the pistons could be configured to be mechanically actuated). In order to actuate the expander tool 100°, fluid is injected under pressure into the working string 70. Fluid then travels downhole through the working string 70 and into the perforated 124 tubular bore 115 of the tool 100°. From there, fluid contacts the bottom surfaces 126 of the various pistons 120. As hydraulic pressure is increased, fluid forces the pistons 120 outwardly from their respective recesses 114. This, in turn, causes the rollers 116 to make contact with the inner surface of the liner 30L. With a predetermined amount of fluid pressure acting on the piston surface 120, the lower string of expandable liner 30L is expanded past its elastic limits. Fluid exits the expander tool 100° through the bottom connector 135 at the base of the tool 100°.

[0093] It will be understood by those of ordinary skill in the art that the working string 70 shown in FIGS. 15 and 16 is highly schematic. It is understood that numerous other tools may and commonly are employed in connection with a well completion operation. For example, the lower string of casing 30 would typically be run into the wellbore 50 on the working string 70 itself. Other tools would be included on the working string 70 and the liner 30, including a cement shoe (not shown) and a wiper plug (also not shown). Numerous other tools to aid in the cementing and expansion operation may also be employed, such as a swivel (not shown) and a collet or dog assembly (not shown) for connecting the working string 70 with the liner 30. Again, it is understood that the depictions in FIGS. 15 and 16 are simply to demonstrate one of numerous uses for an expander tool, e.g., tool 100°, and to demonstrate the operation of the expansion assemblies 110°, 110.

[0094] FIG. 17 presents the lower string of casing 30 having been expanded into frictional engagement with the surrounding upper string of casing 25 along a desired length. In this view, the upper portion 30U of the lower string of casing 30 has utility as a polished bore receptacle. Alternatively, a separate polished bore receptacle can be landed into the upper portion 30U of the lower string of casing 30 with greater sealing capability. Further, a larger diameter of tubing (not shown) may be landed into the liner 30U due to the expanded upper portion 10.

[0095] As described above, the apparatus being expanded 10 may include a pair of bands to aid in the sealing and frictional engagement of the first tubular 10 with a second surrounding tubular 25. In the view of FIG. 17, a sealing ring 12 and a slip ring 14 are shown around the outside of the tubular body 10. The bands 12, 14 are spaced a distance apart. When the tubular body is expanded, the slip ring allows the tubular body to grip the wall of the casing while the sealing ring seals the tubular to the casing.

[0096] As demonstrated by FIGS. 9-17, an improved expansion assembly 110° for an expander tool 100 has been provided. In this respect, the rollers 116 of the expansion apparatus 110° are able to rotate and, at times, skid inside of a bearing cavity 117. In this way, the shaft 118 of the expansion tool 100 has been removed, and a bearing system has been provided in its place. The entire bearing system can be angled to allow the expansion assembly 110° to be rotated and axially translated simultaneously. Because no shaft or thrust bearing apparatus is needed, the expansion assembly components 110° are geometrically reduced, thereby affording a larger inner diameter for the bore 115 of the expander tool 100°.

[0097] The above description is provided in the context of a hydraulic expander tool. Hydraulic pressure may be supplied by the application of wellbore of fluids under pressure against the back surface of the piston, or from another source, such as a dedicated fluid reservoir in fluid communication with the back surface of the piston. It is understood that the present invention includes expander tools in which the pistons are moveable in response to other radially outward forces, such as mechanical forces. 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. A method for sealing the annulus between two concentric tubulars disposed in a wellbore, the first tubular residing within the second tubular, comprising the steps of:
   a. positioning an expander tool at the depth desired for sealing the annulus;
   b. actuating the expander tool so that the expander tool acts against the inner surface of the first tubular;
   c. expanding the first tubular so that an outer surface of the first tubular is in contact with an inner surface of the surrounding second tubular; and
   d. rotating the expander tool so that radial contact is made between the outer surface of the first tubular and the inner surface of the second tubular, thereby creating a fluid seal in the annulus.

2. The method for sealing the annulus between two concentric tubulars or claim 1, further comprising the step of:
   a. translating the expander tool vertically within the wellbore while actuating the expander tool so as to expand the first tubular along a desired portion of its length.

3. The method for sealing the annulus between two concentric tubulars of claim 1, wherein the first tubular is a tubular body in series with a string of tubing, and the second tubular is a string of casing.

4. The method for sealing the annulus between two concentric tubulars of claim 1, wherein the first tubular is an
upper portion of a first string of casing, and the second tubular is a lower portion of a second string of casing.

5. The method for sealing the annulus between two concentric tubulars of claims 3 and 4, wherein the tubular body defines an elongated tubular member comprising:

a top end;

a bottom end; and

at least one seal ring circumferentially fitted along the outer surface of the tubular body intermediate the top and bottom ends.

6. The method for sealing the annulus between two concentric tubulars of claim 5, wherein the tubular body defines an elongated tubular member further comprising:

at least one slip member disposed along the outer surface of the tubular body intermediate the top and bottom ends for gripping between the tubular body and the surrounding casing.

7. The method for sealing the annulus between two concentric tubulars of claim 5, wherein the seal ring is fabricated from an elastomeric material and serves to provide a fluid seal between the tubular body and the casing, thereby sealing the annulus.

8. The method for sealing the annulus between two concentric tubulars of claim 6, wherein the slip member defines a ring circumferentially fitted along the outer surface of the tubular body, and has a plurality of teeth to provide a gripping means between the tubular body and the casing.

9. The method for sealing the annulus between two concentric tubulars of claim 6, wherein the slip member defines a carbide material on the outer surface of the tubular body.

10. The method for sealing the annulus between two concentric tubulars of claim 5, wherein the tubular body further comprises a positioning member for positioning the expander tool at the proper depth within the tubular body.

11. The method for sealing the annulus between two concentric tubulars of claim 10, wherein the positioning member comprises a landing profile having a beveled member internal to said tubular body upon which the expander tool lands during the positioning step.

12. The method for sealing the annulus between two concentric tubulars of claim 3, wherein the tubular body defines a joint of production tubing.

13. The method for sealing the annulus between two concentric tubulars of claim 1, wherein the expander tool comprises:

a body having an upper portion and a lower portion;

a plurality of recesses disposed radially about the circumference of the body intermediate said upper and lower portions;

a piston disposed within each of said recesses; and

a roller coupled to each of said pistons, said roller having a plurality of lobes.

14. The method for sealing the annulus between two concentric tubulars of claim 13, wherein:

said pistons are movable from a first recessed position essentially within said recess, to a second extended position away from said recess by a radial outward force applied from an interior of the body; and

said rollers are profiled to provide a top lobe, a bottom lobe, and an intermediate lobe, said top lobe and said bottom lobe having an essentially equal diameter which is greater than the diameter of said intermediate lobe.

15. The method for sealing the annulus between two concentric tubulars of claim 14, wherein:

said expander tool further comprises a conduit internal to said body for transmitting fluid to said pistons so as to cause said radial outward force against said pistons; and

said body further comprises at least one nozzle through which fluid exits said body.

16. The method for sealing the annulus between two concentric tubulars of claim 14, wherein:

said pistons further comprise at least one row, with at least three pistons per row, where said pistons are disposed substantially equidistantly about the circumference of the body on each row; and

each of said plurality of rollers further comprises an axle about which each of said rollers rotates above said respective pistons.

17. The method for sealing the annulus between two concentric tubulars of claim 14, wherein the expander tool is sized to fit into the inner surface of the tubular body within the wellbore.

18. The method for sealing the annulus between two concentric tubulars of claim 13, wherein:

said pistons are movable from a first recessed position essentially within said recess, to a second extended position away from said recess by a radial outward force applied from an interior of the body; and

said rollers have a tapered profile.

19. The method for sealing the annulus between two concentric tubulars of claim 18, wherein:

said pistons further comprise at least one row, with at least three pistons per row, said pistons being disposed substantially equidistantly about the circumference of the body on each row; and

each of said plurality of rollers is permitted to at least partially rotate on said respective pistons.

20. An expander tool for expanding a tubular body, the expander tool comprising:

a body;

a plurality of recesses disposed radially about the circumference of the body;

a piston disposed within each of said recesses; and

a roller coupled to each of said pistons, said roller having a plurality of lobes.

21. The expander tool of claim 20, wherein:

said pistons are movable from a first recessed position essentially within said recess, to a second extended position away from said recess by a radial outward force applied from an interior of the body; and

said rollers are profiled to provide a top lobe, a bottom lobe, and an intermediate lobe, said top lobe and said bottom lobe having an essentially equal diameter which is greater than the diameter of said intermediate lobe.
22. The expander tool of claim 21, wherein said expander tool further comprises a conduit internal to said body for transmitting fluid to said pistons so as to cause said radial outward force.

23. The expander tool of claim 22, wherein said pistons of said expander tool are movable by a radial force applied from an interior of the housing.

24. The expander tool of claim 23, wherein said body further comprises at least one nozzle through which fluid exits said body.

25. The expander tool of claim 24, wherein each of said nozzles defines an orifice sized so that said pistons are moved from said first recessed position to said second extended position when said fluid reaches critical flow through said nozzles.

26. The expander tool of claim 22, wherein:

said pistons further comprise at least one row of pistons, with a plurality of pistons on each row, and with said pistons being disposed equidistantly about the circumference of the housing on each row; and

said plurality of rollers further comprises an axle coupling each of said rollers to each of said pistons.

27. The expander tool of claim 26, further comprising a set of piston-retaining plates disposed upon the body proximate each recess in order to prevent overt travel of said pistons.

28. The expander tool of claim 22, further comprising a rotational actuator coupled to said body for rotating said expander tool.

29. An expansion assembly for an expander tool for expanding a surrounding tubular body, the expansion assembly being disposed within a recess in the body of the expander tool, and the expander tool having a bore therethrough, the expansion assembly comprising:

a piston disposed within the recess of the expander tool, the piston having a bottom surface and a top surface, the bottom surface being exposed to a radially outward force within the bore of the expander tool, and the piston being outwardly extendable from the body of the expander tool within the recess in response to the radially outward force;

an axle coupled to the top surface of the piston; and

a roller disposed on the piston to permit the roller to rotate about the axle, the roller having a plurality of lobes, and the roller being profiled to have a multi-lobe profile.

30. The expansion assembly of claim 29, wherein the multi-lobe arrangement for the roller defines a top lobe, a bottom lobe, and an intermediate lobe, the top lobe and the bottom lobe having an essentially equal diameter which is greater than the diameter of the intermediate lobe.

31. The expansion assembly of claim 30, wherein the radially outward forces are hydraulic forces from within the bore of the expander tool.

32. The expansion assembly of claim 31, wherein the piston sealingly resides within the recess of the body of the expander.

33. An expansion assembly for an expander tool for expanding a surrounding tubular body, the expansion assembly being disposed within a recess in the body of the expander tool, and the expander tool having a bore therethrough, the expansion assembly comprising:

a piston disposed within the recess of the expander tool, the piston having a bottom surface and a top surface, the bottom surface being exposed to a radially outward force within the bore of the expander tool, and the piston being outwardly extendable from the body of the expander tool within the recess in response to the radially outward force; and

a roller residing on the top surface of the piston, such that the roller is permitted to at least partially rotate upon the top surface of the piston when the piston is extended away from the body of the expander tool and the roller engages a surrounding tubular body.

34. The expansion assembly of claim 33, wherein the top surface defines a bearing cavity for closely receiving the roller.

35. The expansion assembly of claim 34, wherein the top surface bearing cavity defines a polished, bearing cradle for receiving the roller.

36. The expansion assembly of claim 34, wherein the top surface further comprises a shoe for gravitationally receiving the roller at an end.

37. The expansion assembly of claim 36, further comprising a headrest on the top surface of the piston, the headrest configured to receive a portion of the roller at an end opposite the shoe.

38. The expansion assembly of claim 37, wherein the headrest defines a bearing cavity for closely receiving the upper portion of the roller.

39. The expansion assembly of claim 38, wherein the headrest bearing cavity defines a polished, arcuate bearing cradle for receiving the roller.

40. The expansion assembly of claim 38, further comprising a cap piece for covering the top surface of the piston, the cap piece providing structural support for the headrest.

41. The expansion assembly of claim 34, wherein the roller defines a tapered body having an elongated tapered surface.

42. The expansion assembly of claim 41, wherein the orientation of the roller is skewed relative to the longitudinal center axis of the bore of the expander tool.

43. The expansion assembly of claim 41, wherein the radially outward forces are hydraulic forces from within the bore of the expander tool.

44. The expansion assembly of claim 43, wherein the piston sealingly resides within the recess of the body of the expander.

45. The expansion assembly of claim 34, wherein the radially outward forces are hydraulic forces from within the bore of the expander tool.

46. The expansion assembly of claim 45, wherein the piston sealingly resides within the recess of the body of the expander.

47. The expansion assembly of claim 45, further comprising a port within the piston so as to provide a path of fluid communication between the bore of the expander tool and the top surface, thereby providing lubrication between the roller and the top surface during an expansion operation.
48. An expansion assembly for a hydraulic expander tool for expanding a surrounding tubular body, the expansion assembly being sealingly disposed within a recess in the body of the expander tool, and the expander tool having a bore therethrough, the expansion assembly comprising:

a piston residing within the recess of the expander tool, and being outwardly extendable from the body of the expander tool within the recess in response to hydraulic pressure within the bore of the expander tool, the piston comprising a bottom surface exposed to fluid pressure within the expander tool, and a top surface defining a bearing cavity; and

a roller residing on the bearing cavity of the piston, the roller having an outer surface resting on the bearing cavity itself such that engagement of the roller surface to and rotation within the surrounding tubular body causes the roller to at least partially rotate within the bearing cavity.

49. The expansion assembly of claim 48, wherein:

the roller defines a tapered body having an elongated surface oriented to contact the surrounding tubular body at an angle during the expansion process; and

the orientation of the roller is skewed relative to the longitudinal center axis of the bore of the expander tool.

50. The expansion assembly of claim 49, further comprising a shoe disposed upon the top surface of the piston for receiving a lower portion of the roller.

51. The expansion assembly of claim 50, further comprising a headrest disposed upon the top surface of the piston for supporting an upper portion of the roller.

52. The expansion assembly of claim 51, wherein:

the top surface bearing cavity defines an arcuate, polished bearing cradle for closely receiving a first end of the roller; and

the headrest defines an arcuate, polished bearing cradle for closely receiving a second end of the roller.

53. The expansion assembly of claim 52, further comprising a port within the piston so as to provide a path of fluid communication between the bore of the expander tool and the top surface, thereby providing lubrication between the roller and the top surface during an expansion operation.

54. The expansion assembly of claim 53, further comprising a cap piece for covering the top surface of the piston, the cap piece providing structural support for the headrest.

55. A method for expanding a tubular body within a hydrocarbon wellbore, comprising the steps of:

attaching an expander tool to the lower end of a working string, the expander tool having a body and a plurality of recesses within the body, each recess receiving an expansion assembly, each expansion assembly comprising:

a piston residing within the recess of the expander tool, and being outwardly extendable from the body of the expander tool within the recess in response to radially outward forces within the bore of the expander tool, the piston comprising a bottom surface exposed to the radially outward forces within the expander tool, and a top surface defining a bearing cavity; and

a roller residing on the bearing cavity of the piston, the roller having an outer surface resting on the bearing cavity itself such that engagement of the roller surface to and rotation within the surrounding tubular body causes the roller to at least partially rotate within the bearing cavity;

running the working string with the expander tool into a wellbore; and

rotating the working string in order to radially expand a section of the surrounding tubular body within the wellbore.

56. The method for expanding a tubular body within a wellbore of claim 44, wherein the radially outward forces applied against the base of the piston are hydraulic forces; and

wherein the step of actuating the expansion assembly is accomplished by injecting hydraulic fluid under pressure into the working string.

57. The method for expanding a tubular body within a wellbore of claim 45, wherein:

the roller defines a tapered body having an elongated surface oriented to contact the surrounding tubular body at an angle during the expansion process; and

wherein the orientation of the roller is skewed relative to the longitudinal center axis of the bore of the expander tool.

58. The method for expanding a tubular body within a wellbore of claim 46, further comprising a shoe disposed upon the top surface of the piston for receiving an end portion of the roller.

59. The method for expanding a tubular body within a wellbore of claim 47, further comprising a headrest disposed upon the top surface of the piston for supporting a portion of the roller at an end opposite the shoe.

60. The method for expanding a tubular body within a wellbore of claim 48, wherein:

the top surface bearing cavity defines an arcuate, polished bearing cradle for closely receiving a first end of the roller; and

the headrest defines an arcuate, polished bearing cradle for closely receiving a second end of the roller.

61. The method for expanding a tubular body within a wellbore of claim 49, further comprising a cap piece for covering the top surface of the piston, the cap piece providing structural support for the headrest.

62. The method for expanding a tubular body within a wellbore of claim 46, further comprising the step of translating the expander tool axially within the wellbore so as to expand the surrounding tubular body along a desired length.

63. The method for expanding a tubular body within a wellbore of claim 51, further comprising the step of relieving hydraulic pressure from within the expander tool.

64. The method for expanding a tubular body within a wellbore of claim 52, further comprising the step of removing the expander tool from the wellbore.

65. A method for sealing the annulus between a string of production tubing and the casing within a wellbore, comprising the steps of:
positioning an expander tool at a selected depth within the production tubing;

actuating the expander tool so that the expander tool acts against the inner surface of the production tubing;

expanding the production tubing so that the outer surface of the production tubing is in contact with the inner surface of the casing; and

rotating the expander tool so that radial contact is made between the outer surface of the production tubing and the inner surface of the casing, thereby creating a fluid seal in the annulus.

66. The method for sealing the annulus of claim 54, wherein said production tubing comprises therein an expandable portion having:

at least one elastomeric seal ring circumferentially fitted along the outer surface of said expandable portion intermediate top and bottom ends, the seal ring providing a fluid seal between the expandable portion and the casing after the expandable portion of the production tubing has been expanded, thereby sealing the annulus;

at least one slip ring disposed along the outer surface of the expandable portion intermediate the top and bottom ends, and spaced apart from the seal ring, the slip ring having gripping means between the tubular body and the casing; and

a landing profile having a beveled member internal to said expandable portion upon which the expander tool lands during the positioning step.

67. The method for sealing the annulus of claim 55, wherein the expander tool comprises:

a body;

a plurality of recesses disposed radially about the circumference of the body;

a piston disposed within each of said recesses, each of said pistons being movable from a first recessed position essentially within said body to a second extended position away from said body by a radial outward force applied from an interior of the body;

a roller coupled to each of said pistons, each of said rollers being profiled to provide a top lobe, a bottom lobe, and an intermediate lobe, said top lobe and said bottom lobe having an essentially equal diameter which is greater than the diameter of said intermediate lobe; and

a conduit internal to said body for transmitting fluid to said pistons so as to cause said radial outward force.

68. The method for sealing the annulus of claim 56, wherein

said body further comprises at least one nozzle through which fluid exits said body;

said pistons are disposed equidistantly about the circumference of the body; and

said plurality of rollers further comprises an axle coupling each of said rollers to each of said pistons.

69. The method for sealing the annulus of claim 57, further comprising the step of translating the expander tool vertically within the wellbore while expanding the production tubing so as to expand the expandable portion along a desired portion of its length.

70. A method of completing a wellbore comprising the steps of:

providing a tubular;

applying a slip ring around said tubular;

applying a seal ring around said tubular proximate to said slip ring;

positioning the tubular into a casing of the wellbore;

positioning an expander tool in the tubular at a point proximate the slip ring and sealing ring;

applying hydraulic fluid internal to the expander tool; and

expanding, in response to the hydraulic fluid, portions of the tubular corresponding to the depths of the slip ring and sealing ring, whereby the tubular is placed into contact with the inner surface of the surrounding casing.

71. The method of claim 59, wherein the step of positioning an expander tool further comprises the steps of:

providing an expander tool having a plurality of multi-lobed rollers for forming a contoured seal, wherein said roller has a top, a bottom and a center lobe.

72. The method of claim 60, further comprising:

the step of rotating said expander within the tubular until said tubular is sealed to the inner surface of the surrounding casing.