US 20140041880A1

(19) United States

(12) Patent Application Publication

Noel et al.

(10) Pub. No.: US 2014/0041880 A1

(43) Pub. Date: Feb. 13, 2014

(54) HYBRID EXPANSION CONE

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(21) Appl. No.: **13/960,364**

(22) Filed: **Aug. 6, 2013**

**Related U.S. Application Data**

(60) Provisional application No. 61/680,487, filed on Aug. 7, 2012.

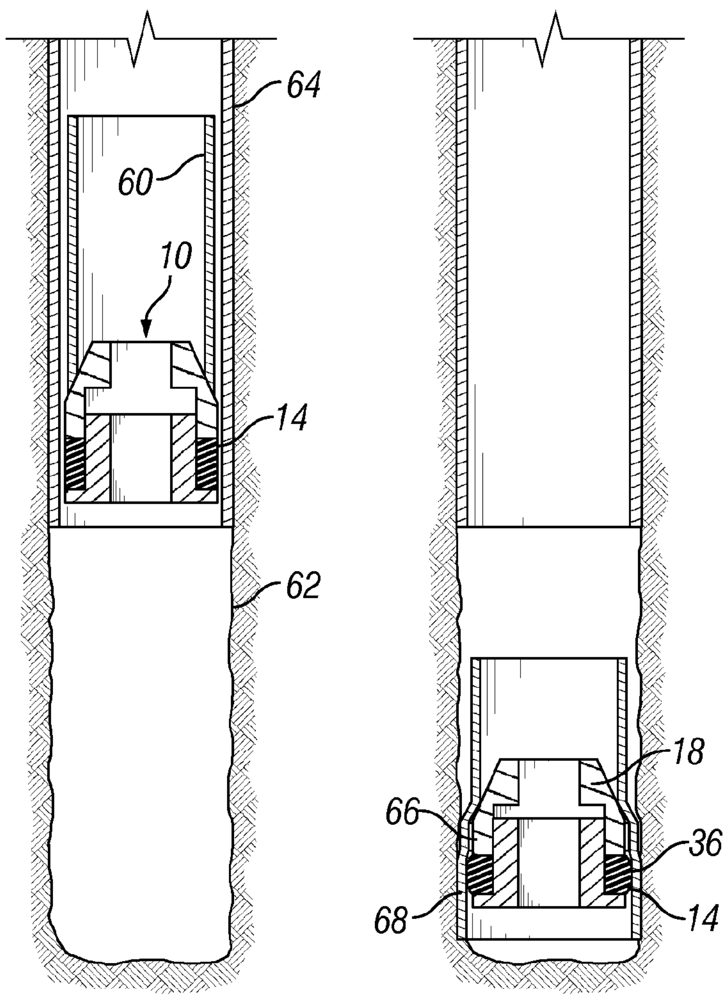
**Publication Classification**

(51) **Int. Cl.**
*E21B 43/10* (2006.01)

(52) **U.S. Cl.**
CPC .................................... ***E21B 43/105*** (2013.01)
USPC .......................................... **166/380**; 166/217

(57) **ABSTRACT**

An expansion cone comprising a cone body having a first expansion surface with a diameter that increases from a leading edge to a first expansion diameter. A resilient sleeve disposed on an actuation mandrel that is coupled to the cone body. Movement of the actuation mandrel relative to the cone body moves an outer surface of the resilient sleeve to a second expansion diameter that is greater than the first expansion diameter.



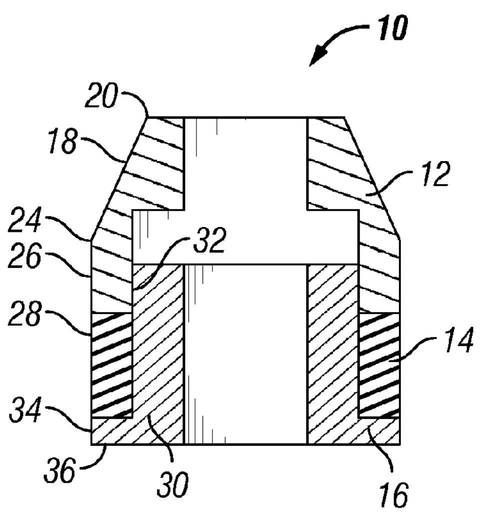



FIG. 1

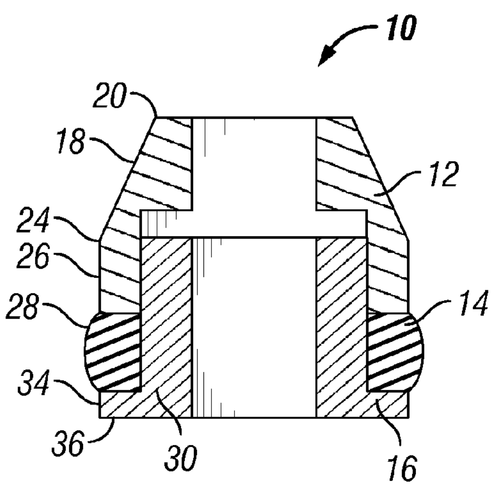



FIG. 2

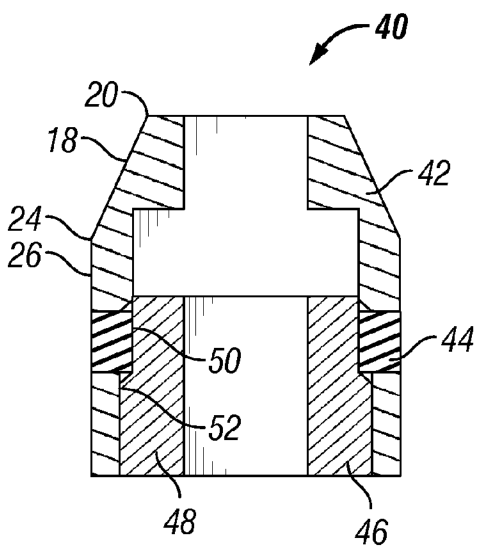



FIG. 3

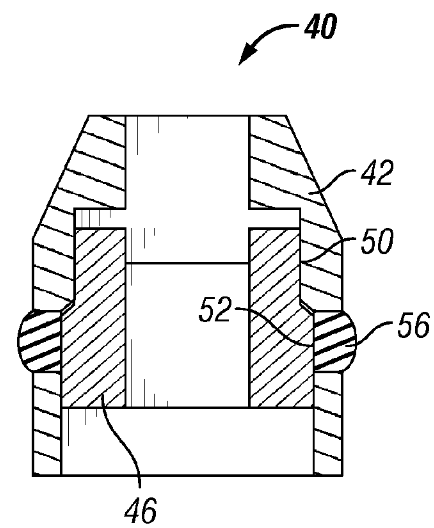



FIG. 4

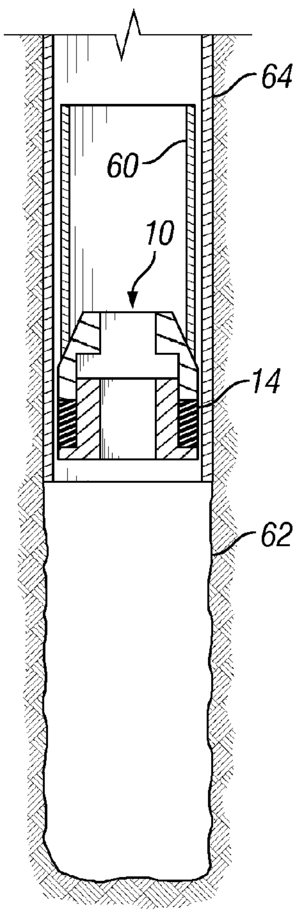



FIG. 5A

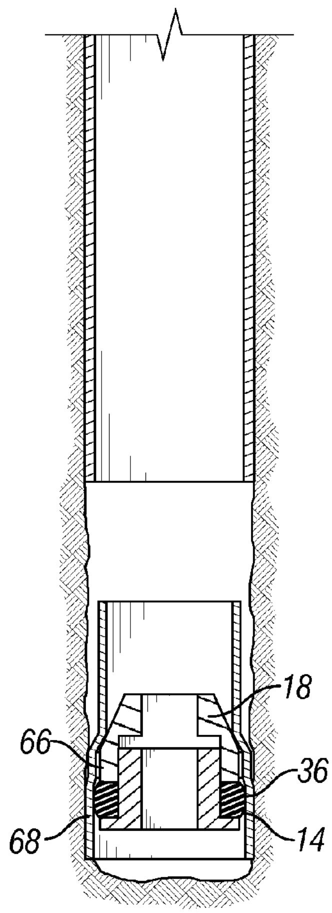



FIG. 5B

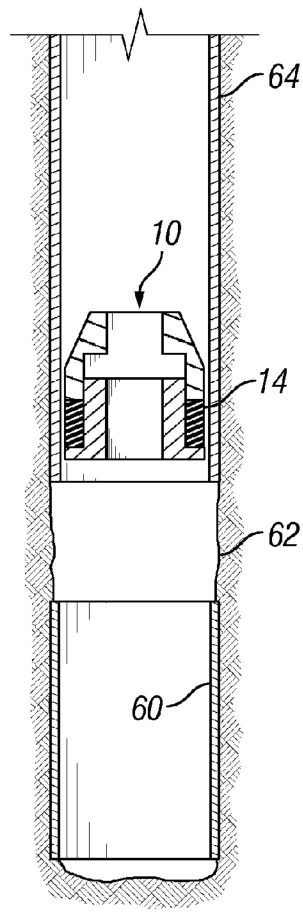



FIG. 5C

# HYBRID EXPANSION CONE

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims priority to U.S. Patent Application Ser. No. 61/680,487, titled Hybrid Expansion Cone, which was filed Aug. 7, 2012. This priority application is hereby incorporated by reference in its entirety into the present application, to the extent that it is not inconsistent with the present application.

## BACKGROUND

**[0002]** This disclosure relates generally to methods and apparatus for expanding a tubular member in a wellbore. More specifically, this disclosure relates to expanding a tubular member using an adjustable expansion cone.

**[0003]** Wellbore tubular members, such as casings or liners, can be expanded in the wellbore using a variety of known processes. These processes often utilize expansion cones that are shaped to radially expand the tubular as the cone moved axially through the tubular. Many conventional expansion cones have a fixed outer diameter that is larger than the outer diameter of tubular member before expansion. The size of the fixed diameter expansion cone necessitates that, before expansion begins, the cone is contained within an enlarged section of the tubular, known as a launcher, or disposed outside of the tubular being expanded.

**[0004]** The launcher, or the expansion cone itself, is thus the component of the tool string having the largest outer diameter and is therefore a major factor in determining the operating envelope of the system. For example, if an expandable tubular is needed at a location in the wellbore below a restriction, the size of the launcher or cone will limit the systems that can be used. Fixed diameter cones are also susceptible to getting stuck in the unexpanded tubular should the expansion process fail or an unexpected restriction be encountered.

**[0005]** Adjustable expansion cones have been used to overcome some of the limitations of fixed diameter cones by providing a mechanism for varying the outer diameter of the cone. Adjustable expansion cones generally include a plurality of segments that are "assembled" downhole into a cone capable of expanding a tubular member. Adjustable cones are available in a variety of styles and configurations but, like conventional fixed diameter cones, suffer from certain performance limitations and are generally more mechanically complex than fixed diameter cones.

**[0006]** Thus, there is a continuing need in the art for methods and apparatus for adjustable expansion cones that overcome these and other limitations of the prior art.

## BRIEF SUMMARY OF THE DISCLOSURE

**[0007]** An expansion cone comprising a cone body having a first expansion surface with a diameter that increases from a leading edge to a first expansion diameter. A resilient sleeve disposed on an actuation mandrel that is coupled to the cone body. Movement of the actuation mandrel relative to the cone body moves an outer surface of the resilient sleeve to a second expansion diameter that is greater than the first expansion diameter.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** For a more detailed description of the embodiments of the present disclosure, reference will now be made to the accompanying drawings, wherein:

**[0009]** FIG. **1** illustrates a hybrid expansion cone in a retracted position.

**[0010]** FIG. **2** illustrates the hybrid expansion cone of FIG. **1** in an expanded position.

**[0011]** FIG. **3** illustrates an alternative hybrid expansion cone in a retracted position.

**[0012]** FIG. **4** illustrates the hybrid expansion cone of FIG. **3** in an expanded position.

**[0013]** FIGS. **5**A-**5**C illustrate the expansion of a tubular member using a hybrid expansion cone.

## DETAILED DESCRIPTION

**[0014]** It is to be understood that the following disclosure describes several exemplary embodiments for implementing different features, structures, or functions of the invention. Exemplary embodiments of components, arrangements, and configurations are described below to simplify the present disclosure; however, these exemplary embodiments are provided merely as examples and are not intended to limit the scope of the invention. Additionally, the present disclosure may repeat reference numerals and/or letters in the various exemplary embodiments and across the Figures provided herein. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various exemplary embodiments and/or configurations discussed in the various figures. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact. Finally, the exemplary embodiments presented below may be combined in any combination of ways, i.e., any element from one exemplary embodiment may be used in any other exemplary embodiment, without departing from the scope of the disclosure.

**[0015]** Additionally, certain terms are used throughout the following description and claims to refer to particular components. As one skilled in the art will appreciate, various entities may refer to the same component by different names, and as such, the naming convention for the elements described herein is not intended to limit the scope of the invention, unless otherwise specifically defined herein. Further, the naming convention used herein is not intended to distinguish between components that differ in name but not function. Additionally, in the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to." All numerical values in this disclosure may be exact or approximate values unless otherwise specifically stated. Accordingly, various embodiments of the disclosure may deviate from the numbers, values, and ranges disclosed herein without departing from the intended scope. Furthermore, as it is used in the claims or specification, the term "or" is intended to encompass both exclusive and inclusive cases, i.e., "A or B" is intended to be synonymous with "at least one of A and B," unless otherwise expressly specified herein.

**[0016]** Referring initially to FIG. **1**, a hybrid expansion cone **10** includes a solid cone body **12**, a resilient sleeve **14**, and an actuation mandrel **16**. The solid cone body **12** includes an expansion surface **18** with a first end **20** having a leading edge diameter and a second end **24** having a first expansion diameter. The expansion surface **18** has a diameter that increases from the leading edge diameter to the first expansion diameter in a linear or non-linear manner from the first end **20** to the second end **24**. The solid cone body **12** also includes a constant diameter portion **26** that extends from the second end **24** of the expansion surface and terminates in a shoulder **28**.

**[0017]** Actuation mandrel **16** includes a main body **30** having a first end **32** that is slidably engaged with the solid cone body **12**. An annular flange **34** projects radially outward from a second end **36** of the main body **30**. The resilient sleeve **14** is disposed about the main body **30** of the actuation mandrel **16** between the annular flange **34** and the shoulder **28** of solid cone body **12** in a first position. The resilient sleeve **14** may be constructed from any desirable resilient material including, but not limited to, polyurethane, rubber, polymers, and other materials.

**[0018]** Referring now to FIG. **2**, during expansion operations, the actuation mandrel **16** is moved axially relative to the solid cone body **12** so that the annular flange **34** moves closer to the shoulder **28**. As the annular flange **34** moves closer to the shoulder **28**, the resilient sleeve **14** is axially compressed, which causes the outer surface of the resilient sleeve **14** to move radially outward to a second position where the resilient sleeve forms a second expansion surface.

**[0019]** The actuation mandrel **16** may be moved relative to the solid cone body **12** by a variety of mechanisms. In certain embodiments, the actuation mandrel **16** may be coupled to a work string, or other component, that is operable to apply tension to pull the actuation mandrel **16** relative to the solid cone body **12**. In other embodiments, hydraulic pressure applied to the actuation mandrel **16** may generate the force needed to move the actuation mandrel **16** relative to the solid cone body **12**. In either embodiment described above, the force used to move the actuation mandrel **16** relative to the solid cone body **12** may also be used to move the hybrid expansion cone **10** through a tubular member.

**[0020]** Referring now to FIG. **3**, an alternative hybrid expansion cone **40** includes a solid cone body **42**, a resilient sleeve **44**, and an actuation mandrel **46** that directly radially expands the resilient sleeve **44**. The solid cone body **42** includes a first expansion surface **18** defined by a first end **20** and a second end **24**. The first expansion surface **18** has a diameter that increases from a leading edge diameter at the first end **20** to a first expansion diameter at the second end **24** in a linear or non-linear fashion.

**[0021]** The resilient sleeve **44** may be coupled to the solid cone body **42** at a location that is substantially adjacent to the second end **24** or may be spaced from the second end **24** by a constant diameter portion **26**. The resilient sleeve **44** may be constructed from any desirable resilient material including, but not limited to, polyurethane, rubber, polymers, and other materials. Actuation mandrel **46** includes a main body **48** having a substantially cylindrical portion **50** and an expansion portion **52**. In the unexpanded first position shown in FIG. **3**, the cylindrical portion **50** of the actuation mandrel is disposed under the resilient sleeve **44**.

**[0022]** Referring now to FIG. **4**, during expansion operations, the actuation mandrel **46** is moved axially relative to the solid cone body **42** so that the expansion portion **52** of the actuation mandrel **46** moves under and radially expands the resilient sleeve **44** to a second position. This radially outward movement of the resilient sleeve **44** creates a second expansion surface **56**.

**[0023]** The actuation mandrel **46** may be moved relative to the solid cone body **42** by a variety of mechanisms. In certain embodiments, the actuation mandrel **46** may be coupled to a work string, or other component, that is operable to apply tension to pull the actuation mandrel **16** relative to the solid cone body **42**. In other embodiments, hydraulic pressure applied to the actuation mandrel **46** may generate the force needed to move the actuation mandrel **46** relative to the solid cone body **42**. In either embodiment described above, the force used to move the actuation mandrel **46** relative to the solid cone body **42** may also be used to move the hybrid expansion cone **40** through a tubular member.

**[0024]** FIGS. **5A-5C** illustrate the expansion of a tubular member **60** using a hybrid expansion cone **10**. Referring to FIG. **5A**, a hybrid expansion cone **10** is coupled to an expansion system (not shown) and run into a wellbore **62** with a tubular member **60**. The resilient sleeve **14** is retracted so that the outside diameter of the hybrid expansion cone **10** is substantially the same as, or slightly larger than, the unexpanded outer diameter of the tubular member **60**. This allows the hybrid expansion cone **10** and the tubular member **60** to be run through a wellbore restriction, such as a string of installed casing **64**.

**[0025]** Once the tubular member **60** is positioned at a desired location in the wellbore **62**, the hybrid expansion cone **10** is actuated and the resilient sleeve **14** moved to an expanded position. The hybrid expansion cone **10** is then moved axially through the tubular member **60**. As the hybrid expansion cone **10** moves through the tubular member **60**, the solid cone body **12** expands the tubular member **60** to a first expanded inner diameter **66** and the resilient sleeve **14** expands the tubular member **60** to a second expanded inner diameter **68**.

**[0026]** As shown in FIG. **5C**, after the hybrid expansion cone **10** has fully expanded the entire length of the tubular member **60**, the hybrid expansion cone **10** is returned to its retracted state with the resilient sleeve **14** refracted. Once the resilient sleeve **14** is retracted, the hybrid expansion cone **10** can pass freely through the installed casing **64**.

**[0027]** The tubular member **60** is illustrated as being used in an open-hole clad application but is it understood that the methods illustrated and described herein are can also be used in other expandable applications. For example, a hybrid expansion cone could be used in a conventional casing expansion in its expanded state and the resilient sleeve only be refracted if the expansion cone should become stuck or need to otherwise pass through a restriction in the wellbore. A hybrid expansion cone could also be used in a pipe-in-pipe application where the resilient sleeve provides a slight over-expansion of the inner pipe to ensure close contact with the base pipe.

**[0028]** In other applications, a hybrid expansion cone could be used in an application where the resilient sleeve was only actuated to over-expand limited sections of the tubular, such as seal or anchor hanger sections, and the solid portion of the hybrid cone used for the substantial part of the expansion process. A hybrid expansion cone could also be used to expand a tubular into a well containing a tapered string or other casing strings where the inner diameter of the base casing may vary over the length of the casing. A hybrid expansion cone could also be used to create a larger inner diameter of the expanded casing at the upper end for use as a tie-back receptacle.

**[0029]** While the disclosure is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and description. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the disclosure to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present disclosure.

What is claimed is:

**1**. An expansion cone comprising:

a cone body having a first expansion surface with a diameter that increases from a leading edge to a first expansion diameter;

an actuation mandrel coupled to the cone body; and

a resilient sleeve disposed on the actuation mandrel, wherein movement of the actuation mandrel relative to the cone body moves an outer surface of the resilient sleeve to a second expansion diameter that is greater than the first expansion diameter.

**2**. The expansion cone of claim **1**, wherein the actuation mandrel further comprises:

a main body having a first end that is slidably engaged with the cone body; and

an annular flange that projects radially outward from a second end of the main body, wherein the resilient sleeve is disposed about the main body between the annular flange and the cone body.

**3**. The expansion cone of claim **1**, wherein the actuation mandrel further comprises a main body having a cylindrical portion and an expansion portion, wherein the expansion portion of the main body is disposed under the resilient sleeve when the outer surface of the resilient sleeve is moved to the second expansion diameter.

**4**. The expansion cone of claim **1**, wherein the diameter of the first expansion surface increases in a non-linear manner.

**5**. The expansion cone of claim **1**, wherein the diameter of the first expansion surface increases in a linear manner.

**6**. The expansion cone of claim **1**, wherein the actuation mandrel is moved by hydraulic force.

**7**. The expansion cone of claim **1**, wherein the actuation mandrel is moved by applying tension to the actuation mandrel.

**8**. An expansion cone comprising:

a first expansion surface formed by a solid cone body, wherein the first expansion surface has as diameter that increases from a leading edge to a first expansion diameter; and

a second expansion surface formed by a resilient sleeve that is selectively moveable between a first position where the resilient sleeve has an outer diameter that is not greater than the first expansion diameter and a second position where the resilient sleeve has an outer diameter that is greater than the first expansion diameter.

**9**. The expansion cone of claim **8**, further comprising

an actuation mandrel having a main body with a first end that is slidably engaged with the solid cone body; and

an annular flange that projects radially outward from a second end of the main body, wherein the resilient sleeve is disposed about the main body between the annular flange and the solid cone body.

**10**. The expansion cone of claim **8**, further comprising:

an actuation mandrel disposed as least partially within the solid cone body, the actuation mandrel having a main body with a cylindrical portion and an expansion portion, wherein in the second position, the expansion portion of the main body is disposed under the resilient sleeve.

**11**. The expansion cone of claim **8**, wherein the diameter of the first expansion surface increases in a non-linear manner.

**12**. The expansion cone of claim **8**, wherein the diameter of the first expansion surface increases in a linear manner.

**13**. The expansion cone of claim **8**, wherein the resilient sleeve is moved from the first position to the second position by hydraulic force.

**14**. The expansion cone of claim **8**, wherein the resilient sleeve is moved from the first position to the second position by applying tension to the expansion cone.

**15**. A method of expanding a tubular member comprising:

expanding the tubular member to a first expanded inner diameter by axially translating a solid cone body having a first expansion surface through the tubular member, wherein the first expansion surface has as diameter that increases from a leading edge to a first expansion diameter that is equal to the first expanded inner diameter; and

expanding the tubular member to a second expanded inner diameter by translating a resilient sleeve having a second expansion surface through the tubular member, wherein the second expansion surface is selectively moveable between a first position where the second expansion surface is not greater than the first expansion diameter and a second position where the second expansion surface is greater than the first expansion diameter.

**16**. The method of claim **15**, wherein the second expansion surface is moved to the second position by translating an actuation mandrel relative to the resilient sleeve.

**17**. The method of claim **16**, wherein the actuation mandrel has a main body with a first end that is slidably engaged with the solid cone body; and

an annular flange that projects radially outward from a second end of the main body, wherein the resilient sleeve is disposed about the main body between the annular flange and the solid cone body and is moved to the second position by moving the annular flange closer to the solid cone body.

**18**. The method of claim **16**, wherein the actuation mandrel is disposed as least partially within the solid cone body and has a main body with a cylindrical portion and an expansion portion, wherein the resilient sleeve is moved to the second position by disposing the expansion portion of the main body is disposed under the resilient sleeve.

**19**. The method of claim **15**, wherein the resilient sleeve is moved from the first position to the second position by hydraulic force.

**20**. The method of claim **15**, wherein the resilient sleeve is moved from the first position to the second position by applying tension to the expansion cone.

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