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(54) Sealing method and apparatus for wellheads
Verfahren und Vorrichtung zum Abdichten von Bohrlochköpfen
Procédé et dispositif pour étancher des têtes de puits

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Description

The invention relates to a sealing method and apparatus for sealing an annulus between an outer surface of an oil and/or gas well tubing or casing hanger and an inner surface of a wellhead housing.

Oil and/or gas wells typically include one or more pipe strings extending downwardly into the earth from its surface. The strings are included one within the other and serve various purposes, such as maintaining the structural integrity of the well and for controlling fluid flow and fluid pressures within the well. A "string" is referred to as casing if there is at least one string within that string, and the innermost string is referred to as tubing.

At the wellhead, various types of wellhead members are connected and sealed to the casing and tubing and perform various functions, among which are: to support the casing and tubing from the surface; to provide means for connecting fluid conduits to the tubing as well as to the annulus defined by the tubing and the various casing strings surrounding it; and for maintaining control of the fluid pressures experienced within the wellhead. To maintain control of the often very high fluid pressures, it is necessary to provide seals between the various wellhead members and the tubing and casing. Elastomeric seals have been provided in such devices which provide a seal against the tubing and casing when the seal is pressed inwardly thereagainst. This is achieved in various devices by exerting pressure vertically against the seal causing it to expand inwardly against the tubing or casing therefore to seal it off. The elastomeric seal may be urged inwardly also by pressure exerted upon its outer circumferential surface. For example, such seals have been in use for many years wherein fluid pressure is exerted in an annulus surrounding the outer diameter of the elastomeric seal thus to urge it inwardly. The annulus is connected to the exterior of the device by means of a check valve through which fluid under pressure is introduced. In some types of sealing methods, a liquid plastic under pressure is injected through the check valve for forming the seals, and thereafter the plastic hardens so that the seal is permanently maintained.

Many well operators believe that elastomeric seals may be unreliable under extremes of temperature and high pressures, which may cause them to breakdown, leading to an undesirable failure of the seal. Accordingly, metal-to-metal type seals have been adopted for use in order to overcome the foregoing temperature sensitivity problems of elastomeric materials. Various types of metal-to-metal seals have been proposed; however, they suffer from many disadvantages. Examples of such disadvantages include high setting force loads are required in order to force the seal into engagement. In many instances, complex hydraulically-operated systems are required to energize the seal, and typically include additional tools to lock the seal in the desired sealing engagement. Many metal-to-metal type seals utilize a solid wedge to force the seal into engagement with the desired surface; however, temperature changes experienced by the wellhead and casing or tubing strings, and differential expansion and/or contraction of the various metal parts associated with such temperature changes, can cause the desired sealing to be lost. Some prior art seals permit movement of some components with respect to each other after achieving the desired sealing, whereby it is possible that undesired movement of some components can cause the seal to fail.

Some types of metal-to-metal seals seal against a tapered surface disposed on the wellhead housing and/or tubing or casing hanger. If there is longitudinal movement of either the seal or the adjacent tapered surface, which can be caused by differential expansion or contraction caused by temperature changes or changing tensile force loads on the casing or tubing, the seal may move off the tapered surface and thus destroy the desired sealing. Another disadvantage associated with many types of metal-to-metal seals is that the seals may not be subjected to an external pressure test, nor can the well operator visually determine if the desired sealing has been accomplished. Another disadvantage is that some types of metal-to-metal seals do not provide for a stored energy preload force which takes advantage of the resilience and the elastic/plastic properties of the metal used to make the seal, so as to constantly urge the seal into the desired sealing engagement with its adjacent surfaces. A further disadvantage with many metal-to-metal seals, which utilize multiple seals, is that the multiple seals are set at the same time, rather than independently of one another. It may be difficult to determine whether or not all of the multiple seals have been properly set into sealing engagement.

EP-A-0289107 discloses a seal assembly for sealing an annulus between concentric spaced apart inner and outer generally cylindrical surfaces, each surface having an upper and a lower portion, the seal assembly comprising upper and lower ring shaped seal members each formed of a metallic material and arranged to be disposed adjacent to the upper and lower portions, respectively, of the surfaces, the seal members each having, in axially sectional form, generally U-shaped configuration with radially inner and radially outer axially extending leg members, with an inner seal disposed on each inner leg member and an outer seal disposed on each outer leg member; energising means for energising the upper and lower seal members by spreading apart the leg members of the seal members upon relative axial movement between the energising means and the seal members to complete the engagement of the inner and outer seals against the surfaces; means for causing the relative axial movement between the energising means and the seal members; and staging means for initially restraining movement of the energising means relatively to the upper seal member until the lower seal member has been fully energised and, according to the present invention, such an assembly is characterised in that the
leg members of the upper seal member extend downwardly, the leg members of the lower seal member extend upwardly, in that the energising means comprises an energising ring the upper end of which is arranged to be relatively advanced between the two leg members of the upper seal member and the lower end of which is arranged to be relatively advanced between the leg members of the lower seal member; in that the restraining means is arranged to prevent downward movement of the upper seal member relatively to the energising ring before the lower seal member has been fully energised; in that the two inner seals are interference type seals, which are arranged to be engaged, in use, by riding onto a respective reduced diameter portion of the inner surface upon relative axial movement therebetween; and in that the inner seals are wedge type seals, which are arranged to be brought into sealing engagement with the outer surface by wedging action of the energising ring, upon relative axial movement therebetween.

The staging means may be provided by a shear means for preventing downward axial movement of the upper seal member relatively to the energising ring prior to application of a predetermined axial force.

A second shear means may be provided between the energising ring and the lower seal member to prevent downward movement of the energising ring relatively to the lower seal member until, in use, the lower seal member has bottomed out with the outer seal thereof fully engaged.

In the accompanying drawings:

FIG. 1 is a partial cross-sectional view of a wellhead housing provided with the seal assembly of the present invention, a portion of the seal assembly being encircled by dotted lines;

FIG. 2 is a cross-sectional view along the longitudinal axis of a seal assembly of the present invention;

FIG. 3 is a cross-sectional view of a lower seal member of the seal assembly of the present invention, taken along line 3-3 of FIG. 4;

FIG. 4 is a partial cross-sectional view of the lower seal member of FIG. 3; and,

FIGS. 5-9 are partial cross-sectional views of the seal assembly of the present invention illustrating the successive stages of energising the seal assembly of the present invention to seal an annulus disposed between a wellhead housing and a tubing hanger.

In FIG. 1, a seal assembly 20 in accordance with the present invention is shown disposed in an annulus 21 between concentric spaced apart inner and outer generally cylindrical surfaces 22, 23 with each surface, having an upper portion 24, 25, and a lower portion 26, 27. As illustrated in FIG. 1, inner surface 22 of the annulus 21 is the outer surface 26 of a tubing hanger 29, and outer surface 23 of the annulus 21 is the inner surface 30 of a wellhead housing 31. Seal assembly 20 may be utilized to seal the annulus 21 between a wellhead housing 31 and tubing hanger 29, or as is conventional in the art, between a casing hanger (not shown) and wellhead housing 31. Wellhead housing 31 may be of conventional construction, but is typically part of a "multibowl" wellhead system, wherein seal assembly, or assemblies, 20 are installed through a blowout preventer stack (not shown).

With reference to FIGS. 1 and 2, seal assembly 20 is shown to generally comprise: an upper seal member 35 formed of a metallic material and adapted to be disposed adjacent the upper portions 24, 25 of the inner and outer surfaces 22, 23; a lower seal member 36 formed of a metallic material and adapted to be disposed adjacent the lower portions 26, 27 of inner and outer surfaces 22, 23; an energizing ring member 37, disposed between the upper and lower seal members 35, 36, for energising the upper and lower seal members 35, 36 to engage, and seal against, adjacent surfaces 24-27; a means for causing relative motion 38 between the energising ring 37 and the upper and lower seal members 35, 36, or an actuation sleeve member 39; and a first means for staging the energising 40 of the upper and lower seal members 35, 36 to cause the lower seal member 36 to engage, and seal against, the upper portions 26, 27 of the surfaces 22, 23 before the upper seal member 35 engages, and seals against, the upper portions 24, 25 of the inner and outer surfaces 22, 23. Upper and lower seal members 35, 36, as well as energizing ring member 37 and actuation sleeve member 39, may be made of any suitable metallic material having the required strength characteristics for use in an oil and/or gas well wellhead system, which can be subject to high pressure and temperature conditions, as is known in the industry.

With reference to FIGS. 2-4, lower seal member 36 is a ring-shaped member 41 having a generally U-shaped configuration with inner and outer upwardly extending leg members 42, 43 with an inner seal 44 disposed on the inner leg member 42 and an outer seal 45 disposed on the outer leg member 43. Upper seal member 35 is of a generally similar construction, and comprises a ring-shaped member 51 having a generally U-shaped configuration with inner and outer downwardly extending leg members 52, 53 with an inner seal 54 disposed on the inner leg member 52 and an outer seal 55 disposed on the outer leg member 53. Energizing ring member 37 is disposed between upper and lower seal members 35, 36, and has upper and lower wedges 61, 62 formed integral with centrally disposed ring member 63, the operation of upper and lower wedges to be hereinafter described in greater detail.

Still with reference to FIGS. 2-4, actuation sleeve member 39 is a ring member 70 disposed on top of upper seal member 35, and as will be hereinafter described in greater detail, is rotatably mounted with respect to upper seal member 35. The internal surface 71
of actuation sleeve member 39 is provided with a set of threads which are adapted for threaded engagement with a set of threads 73 (FIGS. 1 and 5) on the upper portion 24 of inner surface 22, or outer surface 28 of tubing hanger 29. Lower seal member 36 and upper seal member 35 are each provided with an annular groove 75 which receives a plurality of balls 76, which balls 76 are also received within an annular groove 77 disposed on the interior surface 78 of energizing ring member 37, whereby upper and lower seal members 35, 36 are releasably connected to energizing ring member 37, and may be moved upwardly and downwardly with respect to energizing ring member 37 along their common longitudinal axis 79, as balls 76 roll within cooperating grooves 75, 77. Suitable openings 80 are provided in energizing ring member 37, to permit balls 76 to pass through energizing ring member 37 and be disposed within cooperating grooves 75, 77. Similarly, actuation sleeve member 39 is rotatably mounted within upper seal member 35, as by a plurality of balls 81 disposed in annular groove 82 formed in the outer surface 83 of actuation sleeve member 39, the balls 81 being passed through an opening 84 in upper seal member 35, whereby actuation sleeve member 39 can be rotated with respect to upper seal member 35.

With reference to FIGS. 2-5, inner seals 54, 44 of upper and lower seal members 35, 36 are preferably interference type seals, which may take the form of an internally disposed annular projection, or rib 90, disposed on the inner leg members 52, 42 of upper and lower seal members 35, 36. As will be hereininafter described in greater detail in connection with FIGS. 5-9, sealing between the inner seals 44, 54 and inner surface 22, or outer surface 28 of tubing hanger 29, is accomplished by an interference fit of the inner seal 44, 54 with their adjacent inner surfaces 26, 24, in that the inner diameter of the projecting rib 90 is slightly smaller than the outer diameter of the surfaces 24, 26, against which inwardly projecting annular ribs 90 are sealed against. Outer seals 55, 45, of upper and lower seal members 35, 36 are preferably wedge type seals, which are preferably formed as an outwardly extending annular projection, or rib, 91 disposed on outer leg 53, 43 of upper and lower seal members 35, 36. Outer seals 55, 45, are placed in sealing engagement with upper and lower outer surfaces 25, 27, or the interior surface 30 of wellhead housing 31, by wedging, or forcing, outer seals 55, 45 into sealing engagement with the adjacent outer surfaces 25, 27. Preferably outer seals 55, 45 are wedged, as will be hereininafter described in greater detail, by upper and lower wedges 61, 62, moving into contact with the interior surfaces 92, 93 of lower outer leg member 43 and upper outer leg member 53, as will be hereininafter described in greater detail.

With reference to FIGS. 2-5, first staging means 40 includes a means for initially restraining movement 100 of the upper seal member 35 with respect to the energizing ring member 37. As will be hereininafter described in greater detail, after a predetermined amount of force is applied and exceeded between the upper seal member 35 and energizing ring member 37, movement of the upper seal member 35 with respect to energizing ring member 37 will then be permitted. Preferably, the means for initially restraining movement 100 of the upper seal member 35 is a first shear ring 101 which engages both the upper seal member 35 and the energizing ring member 37. Preferably, a portion 102 of the downwardly extending inner leg member 52 of upper seal member 35 is provided with a shoulder 103 upon which is seated on first shear ring 101. First shear ring 101 has an outer flange portion 104 which is received within a groove 105 disposed within energizing ring member 37. Until a predetermined amount of force is applied downwardly in the direction of longitudinal axis 79, upper seal member 35 will be secured to energizing ring member 37 by first shear ring 101. After the predetermined amount of force is applied and exceeded in the direction of longitudinal axis 79, first shear ring 101 will be sheared, whereby outer flange 104 will remain in groove 105, as upper seal member 35 moves downwardly with respect to energizing ring member 37, at which time, ball 76 will move downwardly within groove 77, as will hereininafter be described in greater detail. Alternatively, at least one shear pin could be utilized in lieu of first shear ring 101 to releasably connect upper seal member 35 to energizing ring member 37 and for initially restraining movement of the upper seal member 35 with respect to the energizing ring member 37, until a predetermined amount of force has been applied and exceeded, as previously described.

Still with reference to FIGS. 2-5, an upper portion 105 of inner leg member 42 of lower seal member 36 is also preferably provided with a shoulder 106 upon which is mounted a second shear ring 111, and outer flange 107 of shear ring 111 is similarly received within groove 108 of energizing ring member 37. Second shear ring 111, as will be hereininafter described in greater detail, serves as a second means for staging 115 the energizing of the inner and outer seals 44, 45, to cause one of the seals 44, 45 of the lower seal member 36 to engage, and seal against, one of the lower portions 26, 27 of one of the surfaces 22, 23, before the other seal 44, 45 of the lower seal member 36 engages, and seals against, the other portion 26, 27 of the other surface 22, 23. Second shear ring 111 serves as a means for initially restraining movement 116 of the lower seal member 36 with respect to the energizing ring member 37, until a predetermined amount of force is applied between the lower seal member 36 and the energizing ring member 37, as will be hereininafter described in greater detail. Similarly, as previously described, at least one shear pin (not shown) may be utilized in lieu of second shear ring 111 to serve as the means for initially restraining movement 116 of the lower seal member 36 with respect to the energizing ring member 37.

With reference to FIGS. 5-9, a method of the
present invention for sealing an annulus 21 between a tubing hanger 29 and a wellhead housing 31 will be described. After seal assembly 20 has been assembled as illustrated in Fig. 2, and after the casing or tubing hang- er 29 has been landed in wellhead housing 31, as illus- trated in Fig. 1, the seal assembly 20 is run through the blowout preventer stack while attached to a installation tool (not shown). The installation tool may be of conven- tional construction and have a plurality of projections (not shown) for engagement with a plurality of mating openings 120 disposed along the periphery of actuation sleeve member 39, so as to permit actuation sleeve member 39 to be rotated as will be hereinafter de- scribed. Seal assembly 20 may be preferably passed through the blowout preventer stack on one or more joints of drill pipe (not shown). As seal assembly 20 reaches tubing hanger 29, seal assembly 20 slides over the top of the tubing hanger 29 until threads 72 on actua- tion sleeve member 39 contact the threads 73 at the top of the outer surface 28 of tubing hanger 29. A torque force is applied to actuation sleeve member 39 to rotate actuation sleeve member 39 with respect to upper seal member 35. An axial force along the longitudinal axis 79 of seal assembly 20 is generated by the torque ap- plied to the actuation sleeve member threads 72.

With reference to Fig. 5, outer surface 28 of tubing hanger 29 is provided with a first tapered surface 120 adjacent the inner leg member 52 of upper seal member 35. The first tapered surface 120 tapers downwardly and outwardly toward the upper seal member 35 to provide the tubing hanger 29 with a first enlarged diameter D1 adjacent the inner leg member 52 of upper seal member 35. The outer surface 28 of tubing hanger 29 is further provided with a second tapered surface 122 adjacent the inner leg member 42 of the lower seal member 36, and the second tapered surface 122 tapers downwardly and outwardly toward the lower seal member 36 to pro- vide the tubing hanger 29 with a second enlarged diam- eter D2 adjacent the inner leg member 42 of lower seal member 35. (Preferably, the second enlarged diameter D2 is greater than the first enlarged diameter D1).

Still with reference to Fig. 5, as the axial force upon seal assembly 20 is generated by the torque force ap- plied to the actuation sleeve member 39, the seal as- sembly 20 moves downwardly within annulus 21. The inner seal 44, or inwardly projecting annular rib 90, on inner leg member 42 of lower seal member 36 moves downwardly along second tapered surface 122 on tub- ing hanger 29 and downwardly onto straight portion 123 of tubing hanger 29 which has the second enlarged di- ameter. Because the inner diameter of inner seal 44, or inwardly projecting annular rib 90, is slightly smaller than second enlarged diameter D2, inner seal 44 is forced into an interference fit with straight portion 123 of the outer surface 28 of tubing hanger 29 which is disposed below second tapered surface 122. The wall surface portion 123 is preferably straight, or disposed substan- tially parallel with the longitudinal axis 79 of seal assem- bly 20.

Further rotation of actuation sleeve member 39 causes seal assembly 20 to continue to move downwardly within annulus 21, until the bottom 124 of lower seal member 36 bottoms out on a shoulder 125 disposed on tubing hanger 29, as illustrated in Fig. 6. While seal assembly 20 is moving downwardly within annulus 21, the axial force being applied by the torque force used to rotate actuation sleeve member 39, is insufficient to shear the first shear ring 101 of the means for initially restraining movement 100 of the upper seal member 35 with respect to the energizing ring member 37 of first staging means 40. The axial force generated, while seal assembly 20 moves downwardly from the position illustrated in Fig. 5 is to that illustrated in Fig. 6, is also insufficient to shear the second shear ring 111 of the means for initially restraining movement 116 of the lower seal member 36 with respect to the energizing ring member 37 of the second staging means 115. Thus, as seal as- sembly moves downwardly within annulus 21 from the position illustrated in Fig. 5 to that illustrated in Fig. 6, inner seal 44 remains in an interference fit with the straight portion 123 of the tubing hanger 29. During this downward movement, outer seal 45 of outer leg mem- ber 43 of lower seal member 36 is in engagement with the inner surface 30 of wellhead 31, however, outer seal 45 has not sealed against inner surface 30 of wellhead 31 so as to prevent fluids from passing between outer seal 45 and the inner surface 30 of wellhead housing 31.

While seal assembly is moving downwardly into the configuration shown in Fig. 6, the second means for ini- tially restraining movement 116 of the lower seal mem- ber 36 with respect the energizing ring member 39, or second shear ring 111 of the second staging means 115, in addition to transferring the axial force to the lower seal member 36, also prevents premature energizing of the outer seal 45 of lower seal member 36. When seal as- sembly is in the configuration illustrated in Fig. 6, it should be noted that neither of the seals 54, 55 of the upper seal member 35 are sealed against either the outer surface 28 of tubing hanger 29, or the inner surface 30 of wellhead housing 31. The only seal in sealing en- gagement, when seal assembly 20 is in the configura- tion illustrated in Fig. 6, is the inner seal 44 of lower seal member 36.

With reference to Fig. 7, upon an additional and in- creased torque force being applied to actuation sleeve member 39, which force is converted by mating threads 72 and 73 into a downward axial force along longitudinal axis 79 of seal assembly 20, a sufficient axial force is generated to shear second shear ring 111, whereby the central portion of second shear ring 111 remains on the shoulder 106 at the top of lower seal member 36, and the outer flange portion 107 remains in groove 108 dis- posed in energizing ring member 37. After second shear ring 111 has been sheared, upper seal member 35 and energizing ring member 37 continue to move down- wardly within annulus 21, during which time the lower
wedge 62 of energizing ring member 37 contacts the tapered inner surface 92 of outer leg member 43 of lower seal member 36 and exerts an outwardly extending force upon outer leg member 43 and outer seal 45 of lower seal member 36. The continued downward movement of upper seal member 35 and energizing ring member 37 causes lower wedge 62 to wedge, or force, the outer seal 45 of lower seal member 36 into sealing engagement with the lower portion 27 of outer surface 23 or inner surface 30 of wellhead housing 31. As lower wedge 62 forces outer leg member 43 and outer seal 45 of lower seal member 36 outwardly to engage, and seal against, inner surface 30 of wellhead housing 31, the lower wedge is deflected inwardly toward the inner leg member 42 of lower seal member 36.

As seen in FIG. 7, the deflected portion of energizing ring member 37, or lower wedge 62, is spaced from the inner leg member 42 as seen at annular cavity 130. Because of the resilience and the elastic/plastic properties of the metal of which energizing ring member 37 is made, energy is stored in the deflected lower wedge 62, so that it can constantly apply an outwardly extending force to the outer seal 45 of the lower seal member 36 to maintain the outer seal 45 in sealing engagement with the inner surface 30 of the wellhead housing 31. Accordingly, if the tubing hanger 29 and wellhead housing 31, and lower seal member 36 are subjected to differential expansion and contraction caused by temperature changes, the interference type inner seal 44 remains in sealing engagement, as does the outer seal 45 of lower seal member. For example, if tubing hanger 29 were to expand due to exposure to an increased temperature and cause the width of annulus 21 to decrease, outer seal 45 would remain in sealing engagement, while lower wedge 62 would be deflected further inwardly to accommodate the expansion of tubing hanger 29. Upon cooling of tubing hanger 29, and its attendant contraction, which could cause the width of annulus 21 to increase, the energy stored in deflected lower wedge 62 would still be constantly applying an outwardly extending force against outer leg member 43 of lower seal member 36, so as to cause outer seal 45 to remain in sealing engagement with inner surface 30 of wellhead housing 31.

While outer seal 45 of lower seal member 36 is being set into the desired sealing engagement with the inner surface 30 of wellhead housing 31, upper seal member 35 and energizing ring member 37 continue to move downwardly until inner shoulder 146 of energizing ring member 137 abuts the top of second shear ring 111 as illustrated in FIG. 7. During this downward movement, the movement of upper seal member 35 with respect to energizing ring member 37 is restrained by the first staging means 40, or first shear ring 101 remaining engaged in both the upper seal member 35 and the energizing ring member 39.

With reference to FIG. 8, after the inner and outer seals 44, 45 of lower seal member have been energized into sealing engagement, as previously described in connection with FIG. 7, an additional torque force is applied to actuation sleeve member 39. This force results in a downwardly extending axial force along longitudinal axis 79 of seal assembly 20, to cause upper seal member 35 to be further compressed downwardly against energizing ring member 37. When the axial force exceeds the force necessary to shear the first shear ring 101, as illustrated in FIG. 8, the central portion of first shear ring 101 remains on shoulder 103 on the inner leg member 52 of the upper seal member 35, and the outer flange 104 of first shear ring 101 remains within groove 105. As upper seal member 35 moves downwardly, the inner seal 45, or inwardly projecting annular rib 90 on the inner leg member 52 of upper seal member 35 passes over first tapered surface 120 and engages, and seals against, the portion of outer surface 28 of tubing hanger 29, disposed below first tapered surface 120, which has the first enlarged diameter D1. Because of the shearing of first shear ring 101, some of the axial load being applied to the lower seal member 36 may be reduced, whereby it is desirable to prevent energizing ring member 37 from moving upwardly, so as to prevent any loss of the energy being stored in deflected lower wedge 62. Preferably, seal assembly 20 is provided with a means for locking 135 the lower seal member 36 to the energizing ring member 37, after the inner and outer seal 44, 45 of the lower seal member 36 have engaged, and sealed against, their adjacent surfaces 26, 27. Preferably, the locking means 135 comprises mating surfaces 136, 137, disposed upon the upper end of inner leg member 42, and upon energizing ring member 37, which surfaces are designed to create a press fit there between upon energizing ring member 37 moving downwardly from the position illustrated in FIG. 6, into the position illustrated in FIGS. 7.

As upper seal member 35 moves downwardly from the position illustrated in FIG. 7, to that illustrated in FIG. 8, upper wedge 61 contacts the tapered inner surface 93 of the outer leg 53 of upper seal member 35 and wedges, or forces, outer seal 55 of outer leg member 53 of upper seal member 35, into sealing engagement with the inner surface 30 of wellhead housing 31, in the same manner as previously described in connection with the energizing of the outer seal 45 of lower seal member 36. Upper wedge 61 is deflected inwardly toward inner leg 52 of upper seal member 36 and is spaced from inner leg member 52, as by cavity 140. The deflected wedge 61 can then store energy to apply the desired outwardly extending force to the outer leg member 53 of upper seal member 35, to maintain outer seal 55 in the desired sealing engagement with inner surface 30 of wellhead housing 31.

With reference to FIGS. 5-9, it should be noted that the first staging means 40, or first shear ring 101, has an additional function other than staging the energizing of the upper and lower seal members 35, 36 to cause the lower seal member 36 to engage, and seal against,
the wellhead housing 31 and tubing hanger 29 before the upper seal member 35 engages, and seals against, the wellhead housing 31 and tubing hanger 29. The first shear ring 101 also serves as a third means for staging the energizing of the inner and outer seals 54, 55 of the upper seal member 35, to cause the inner seal 54 to engage, and seal against, the tubing hanger 29, before the outer seal 55 engages, and seals against, the wellhead housing 31.

With reference to FIG. 9, actuation sleeve member 39 has been rotated until the first and second shear rings 101, 111 are in an abutting relationship with inner shoulders 145, 146 of energizing ring member 137, at which time no further movement of upper and lower seal members 35, 36, energizing ring member 137, and actuation sleeve member 39 is possible. Seal assembly 20 is thus locked into a relatively solid unit, whereby the seals 44, 45, 54, 55, of upper and lower seal members 35, 36 cannot become disengaged. The pressure integrity of the upper and lower seal members 35, 36 may be tested by applying a pressure force, such as high pressure fluid, from an external source 148 through a test port 149 formed in wellhead housing 31 (FIG. 1) which leads to a cavity 150 (FIG. 9) between the upper and lower seal members 35, 36. The lower seal member 35 is adapted to hold pressure coming from the top of the seal assembly 20, and the pressure force acting on the inner and outer legs 42, 43 of the lower seal member 36 will enhance the contact stresses between the inner and outer seals 44, 45 against the tubing hanger 29 and wellhead housing 31. The upper seal member 35 is likewise adapted to hold pressure forces from below seal assembly 20 in the same manner.

It should be noted that it is possible for a well operator to visually determine whether or not the various seals of seal assembly 20 have been set, as by viewing the instrumentation associated with applying the torque force to the actuation sleeve member 39. For example, the torque readings will remain steady as the seal assembly moves downwardly in annulus 21. When the inner seal 44 of the lower seal member 36 first encounters the first tapered surface 122, as illustrated in FIG. 5, the torque reading will begin to increase, indicating the setting of seal 44. Similarly, the torque reading will increase until the second shear ring is sheared, at which time the torque readings will decrease, thus indicating the shearing of the second shear ring 111 and the subsequent setting of the outer seal 45 of the lower seal member. Similarly, the torque reading will increase as the inner seal 52 of the upper seal member 35 passes downwardly over the first tapered surface 120, indicating the setting of the inner seal 52. The torque reading will also momentarily decrease after the first shear ring 101 has been sheared, indicating the subsequent setting of the outer seal 55 of the upper seal member. Continued increases in the torque reading, when actuation sleeve member can no longer be rotated, will indicate that all the seals of the upper and lower seal members 35, 36 have been secured in place.

In connection with seal assembly 20 of FIGS. 1-9, it should be noted that the configuration of the upper and lower seal members 35, 36 could be reversed. The inner seals 44, 54 could be wedge type seals, and the outer seals 45, 55 could be interference type seals.

Claims

1. A seal assembly for sealing an annulus (21) between concentric spaced apart inner and outer generally cylindrical surfaces (22,23), each surface having an upper (24,25) and a lower (26,27) portion, the seal assembly comprising upper and lower ring shaped seal members (35,36) each formed of a metallic material and arranged to be disposed adjacent to the upper and lower portions, respectively, of the surfaces, the seal members each having, in axial section, a generally U-shaped configuration with radially inner and radially outer axially extending leg members (52,53,42,43), with an inner seal (54,55) disposed on each inner leg member and an outer seal disposed on each outer leg member, energising means (37) for energising the upper and lower seal members by spreading apart the leg members of the seal members upon relative axial movement between the energising means and the seal members to complete the engagement of the inner and outer seals against the surfaces; means (38) for causing the relative axial movement between the energising means and the seal members; and staging means (101) for initially restraining movement of the energising means relatively to the upper seal member until the lower seal member has been fully energised; characterised in that the leg members (52,53) of the upper seal member (35) extend downwardly, the leg members (42,43) of the lower seal member (36) extend upwardly, in that the energising means comprises an energising ring (37) the upper end (61) of which is arranged to be relatively advanced between the two leg members of the upper seal member and the lower end (62) of which is arranged to be relatively advanced between the leg members of the lower seal member, in that the restraining means (101) is arranged to prevent downward movement of the upper seal member (35) relatively to the energising ring before the lower seal member (36) has been fully energised; in that the two inner seals (44,54) are interference type seals, which are arranged to be engaged, in use, by riding onto a respective reduced diameter portion (D1,D2) of the inner surface upon relative axial movement therebetween; and in that the inner seals (45,55) are wedge type seals, which are arranged to be brought into sealing engagement with the outer surface by wedging action of the energising ring, upon relative axial movement.
thirebetween.

2. An assembly according to claim 1, in which the staggering means is provided by a shear means (101) for preventing downward axial movement of the upper seal member (35) relatively to the energising ring (37) prior to application of a predetermined axial force.

3. An assembly according to claim 1 or claim 2, wherein a second shear means (111) is provided between the energising ring (37) and the lower seal member (36) to prevent downward movement of the energising ring relatively to the lower seal member until, in use, the lower seal member has bottomed out with the outer seal thereof fully engaged.

4. An assembly according to any one of the preceding claims, in which the relative axial movement means comprises an actuation sleeve (39) for engaging the upper seal member (35) to push the assembly downwards, in use, into the annulus.

5. Wellhead apparatus comprising a wellhead housing (31) in which a hanger (29) is landed to which the hanger is sealed by a seal assembly (20) according to any one of the preceding claims.

Patentansprüche

1. Abdichtanordnung zum Abdichten eines Rings (21) zwischen konzentrisch voneinander beabstandeten inneren und äußeren, im wesentlichen zylindrischen Oberflächen (22, 23), wobei jede Oberfläche einen oberen (24, 25) und einen unteren (26, 27) Bereich besitzt, wobei die Abdichtanordnung ein oberes und ein unteres ringförmiges geformtes Abdichtteil (35, 36) aufweist, von denen jedes aus einem metallischen Material gebildet und so angeordnet ist, daß es angrenzend an den oberen und den unteren Bereich der Oberflächen jeweils angeordnet ist, wobei die Abdichtteile jeweils, im axialen Schnitt, eine im wesentlichen U-förmige Konfiguration mit radial inneren und radial äußeren, sich axial erstreckenden Schenkeltülen (52, 53, 42, 43) besitzt, wobei eine innere Abdichtung (54, 55) auf jedem inneren Schenkeltiel angeordnet ist und eine äußere Abdichtung auf jedem äußeren Schenkeltiel angeordnet ist; eine Energiebeaufschlagungseinrichtung (37) zum Beaufschlagen von Energie auf das obere und das untere Abdichtteil durch Auswechseln der Schenkeltüle der Abdichtteile unter einer relativen, axialen Bewegung zwischen der Energiebeaufschlagungseinrichtung und den Abdichtteilen, um den Eingriff der inneren und äußeren Abdichtung gegen die Oberflächen zu verhindern; Einrichtungen (38) zum Bewirken der relativen axialen Bewegung zwischen der Energiebeaufschlagungseinrichtung und den Abdichtteilen; und eine Abstufungseinrichtung (101) zum anfänglichen Einschränken einer Bewegung der Energiebeaufschlagungseinrichtung relativ zu dem oberen Abdichtteil, bis das untere Abdichtteil vollständig mit Energie beaufschlagt worden ist; dadurch gekennzeichnet, daß sich die Schenkeltüle (52, 53) des oberen Abdichtteils (35) nach unten erstrecken, sich die Schenkeltüle (42, 43) des unteren Abdichtteils (36) nach oben erstrecken; daß die Energiebeaufschlagungseinrichtung einen Energiebeaufschlagungring (37) aufweist, wobei das obere Ende (61) davon so angeordnet ist, daß es relativ zwischen die beiden Schenkeltüle des oberen Abdichtteils vorgeschoben wird, und das untere Ende (62) davon so angeordnet ist, daß es relativ zwischen die beiden Schenkeltüle des unteren Abdichtteils vorgeschoben wird; daß die Einschränkungseinrichtung (101) so angeordnet ist, um eine nach unten gerichtete Bewegung des oberen Abdichtteils (35) relativ zu dem Energiebeaufschlagungsringteil zu verhindern; bevor das untere Abdichtteil (36) vollständig mit Energie beaufschlagt ist; daß die zwei inneren Abdichtungen (44, 54) Dichtungen vom Interferenz-Typ sind, die so angeordnet sind, daß sie, unter Verwendung, durch Laufen auf einem jeweiligen Bereich mit reduziertem Durchmesser (D1, D2) der inneren Oberfläche, unter relativ, axialer Bewegung dazwischen, in Eingriff gebracht werden; und daß die inneren Abdichtungen (45, 55), Dichtungen von Keil-Typ sind, die so angeordnet sind, daß sie in dichtendem Eingriff mit der äußeren Oberfläche durch eine verkleidende Wirkung des Energiebeaufschlagungsringes, unter relativ, axialer Bewegung dazwischen, gebracht werden.

2. Anordnung nach Anspruch 1, wobei die Abstufungseinrichtungen durch eine Schereinrichtung (101) zum Verhindern einer nach unten gerichteten, axialen Bewegung des oberen Abdichtteils (35) relativ zu dem Energiebeaufschlagungring (37) vor einer Aufbringung einer vorbestimmten, axialen Kraft versehen sind.

3. Anordnung nach Anspruch 1 oder Anspruch 2, wobei eine zweite Schereinrichtung (111) zwischen dem Energiebeaufschlagungssring (37) und dem unteren Abdichtteil (36) vorgesehen ist, um eine nach unten gerichtete Bewegung des Energiebeaufschlagungsrings relativ zu dem unteren Abdichtteil zu verhindern, bis, unter Verwendung, sich das untere Abdichtteil herausgehoben hat, und zwar mit der äußeren Abdichtung davon vollständig in Eingriff gebracht.

4. Anordnung nach einem der vorhergehenden Ansprüche, wobei die relative, axiale Bewegungsein-
richtung eine Betätigungsebene (39) zum Eingreifen in das obere Abdichtteil (35) aufweist, um die Anordnung, unter Verwendung, nach unten in den Ring zu drücken.

5. Bohrochokopfgerät, das ein Bohrochokopfgehäuse (31) aufweist, in dem eine Aufhängungseinrichtung (29) angebracht ist und an der die Aufhängungseinrichtung durch eine Abdichtanordnung (20) gemäß einem der vorhergehenden Ansprüche abgedichtet ist.

Revendications

1. Ensemble formant joint pour assurer l'étanchéité d'un espace annulaire (21) entre des surfaces globalement cylindriques, concentriques, espacées, intérieure et extérieure (22, 23), chaque surface ayant une partie supérieure (24, 25) et une partie inférieure (26, 27), l'ensemble formant joint comprenant des éléments supérieur et inférieur de joint en forme d'anneau (35, 36), chacun étant formé en matériau métallique et agencé pour être respectivement disposé adjacent aux parties supérieure et inférieure des surfaces, les éléments de joint ayant chacun, en coupe axiale, une configuration globalement en forme de U avec des éléments formant jambe, s'étendant axialement, radialement intérieur et radialement extérieur (52, 53, 42, 43), un joint intérieur (54, 55) étant disposé sur chaque élément inférieur formant jambe et un joint extérieur étant disposé sur chaque élément extérieur formant jambe ; des moyens d'activation (37) pour activer les éléments de joint supérieur et inférieur en déployant à distance les éléments formant jambe des éléments de joint lors d'un déplacement axial relatif entre les moyens d'activation et les éléments de joint pour achever la mise en contact des joints intérieur et extérieur contre les surfaces ; des moyens (38) pour provoquer le déplacement axial relatif entre les moyens d'activation et les éléments de joint ; et des moyens d'étagement (101) pour limiter initialement le déplacement des moyens d'activation par rapport à l'élément de joint supérieur jusqu'à ce que l'élément de joint inférieur ait été totalement activé ; caractérisé en ce que les éléments formant jambe (52, 53) de l'élément de joint supérieur (35) s'étendent vers le bas, les éléments formant jambe (42, 43) de l'élément de joint inférieur (36) s'étendent vers le haut ; en ce que les moyens d'activation comprennent un anneau d'activation (37) dont l'extrémité supérieure (61) est agencée pour être relativement avancée entre les deux éléments formant jambe de l'élément de joint supérieur et dont l'extrémité inférieure (62) est agencée pour être relativement en avant entre les éléments formant jambe de l'élément de joint inférieur ; en ce que les moyens de limitation (101) sont agencés pour empêcher un déplacement vers le bas de l'élément de joint supérieur (35) par rapport à l'anneau d'activation avant que l'élément de joint inférieur (36) ait été totalement activé ; en ce que les deux joints intérieurs (44, 54) sont des joints du type à interférence, qui sont agencés pour être en contact, en utilisation, en passant sur une partie respective de diamètre réduit (D1, D2) de la surface inférieure lors d'un déplacement axial relatif entre eux ; et en ce que les joints intérieurs (45, 55) sont des joints toriques trapézoïdaux, qui sont agencés pour être amenés en contact étanche avec la surface extérieure par une action de coinçement de l'anneau d'activation, lors du déplacement axial relatif entre eux.

2. Ensemble selon la revendication 1, dans lequel les moyens d'étagement sont réalisés par des moyens de cisaillement (101) pour empêcher un déplacement axial vers le bas de l'élément de joint supérieur (35) par rapport à l'anneau d'activation (37) avant l'application d'une force axiale prédéterminée.

3. Ensemble selon la revendication 1 ou la revendication 2, dans lequel des secondes moyens de cisaillement (111) sont prévus entre l'anneau d'activation (37) et l'élément de joint inférieur (36) pour empêcher un déplacement vers le bas de l'anneau d'activation par rapport à l'élément de joint inférieur jusqu'à ce que, en utilisation, l'élément de joint inférieur ait atteint son niveau le plus bas, le joint extérieur de ce dernier étant totalement engagé.

4. Ensemble selon l'une quelconque des revendications précédentes, dans lequel les moyens de déplacement axial relatif comprennent un manchon d'actionnement (39) pour contacter l'élément de joint supérieur (35) pour pousser l'ensemble vers le bas, en utilisation, dans l'espace annulaire.

5. Appareil de tête de puits comprennant un logement de tête de puits (31) dans lequel un dispositif de suspension (29) est arrière et auquel le dispositif de suspension est scellé par un ensemble formant joint (20) selon l'une quelconque des revendications précédentes.