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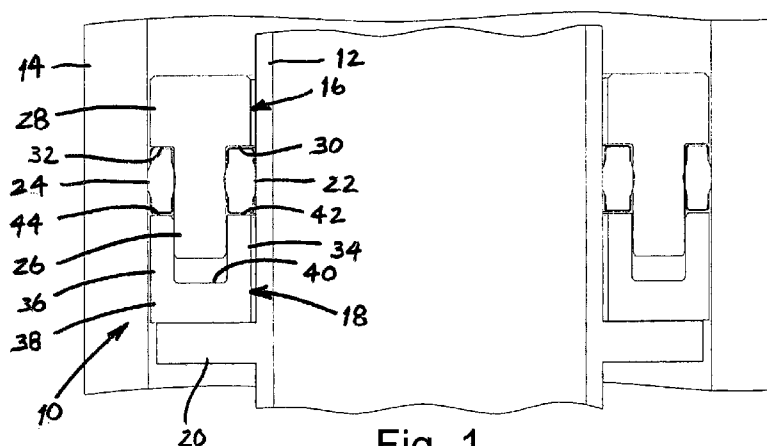


Fig. 1

(57) Abstract: A seal assembly for sealing between an inner tubular member and an outer tubular member includes an annular intensifier ring which comprises a head portion, a generally horizontal, axially inwardly facing first shoulder located adjacent the inner tubular member and a generally horizontal, axially inwardly facing second shoulder located adjacent the outer tubular member. The seal assembly also includes an annular seat ring which comprises a generally horizontal, axially inwardly facing first seat located adjacent the inner tubular member and a generally horizontal, axially inwardly facing second seat located adjacent the outer tubular member. A first metal endcap seal is positioned between the first shoulder and the first seat against the inner tubular member and a second metal endcap seal is positioned between the second shoulder and the second seat against the outer tubular member.



PRESSURE INTENSIFIED METAL ENDCAP SEAL ASSEMBLY

BACKGROUND OF THE INVENTION

The present invention is directed to a sealing assembly for sealing between concentric inner and outer tubular members, such as a wellhead and a casing hanger which is mounted in the wellhead. In particular, the invention is directed to a sealing assembly which comprises a number of metal endcap seals which are positioned between an intensifier ring and a seat ring and which, when the sealing assembly is exposed to an ambient pressure, are subjected to a combination of the ambient pressure and an additional pressure from the intensifier ring.

Hydrocarbon wells typically include a wellhead which is installed at the upper end of a well bore and a casing hanger which is landed in the wellhead and is connected to a casing string that extends into the well bore. Sealing assemblies such as packoffs are commonly used in these applications to seal the annulus between the wellhead and the casing hanger. Prior art packoffs often include one or more seals which are supported on a packoff body that is positioned between the casing hanger and the wellhead. The seals may comprise metal endcap seals, which typically include an elastomeric seal ring which is positioned between a pair of metal endcaps.

Once the packoff is set between the casing hanger and the wellhead, the seals are exposed to ambient pressure, such as the pressure within the annulus or the pressure within the wellhead above the packoff. This ambient pressure is often the only pressure acting on the metal endcap seals. Consequently, the pressure within the elastomeric seal rings is the same as the ambient pressure. As a result, over time ambient gases tend to migrate into the elastomeric seal rings. Accordingly, when the ambient pressure is suddenly removed, the elastomeric seal rings often explosively decompress. This destroys the elastomeric seal and usually results in failure of the metal endcap seal.

SUMMARY OF THE INVENTION

In accordance with the present invention, these and other problems with the prior art are overcome by providing a seal assembly for sealing between an inner tubular member and an outer tubular member, the seal assembly comprising an annular intensifier ring which comprises a head portion, a generally horizontal, axially inwardly facing first shoulder located adjacent the

inner tubular member and a generally horizontal, axially inwardly facing second shoulder located adjacent the outer tubular member; an annular seat ring which comprises a generally horizontal, axially inwardly facing first seat located adjacent the inner tubular member and a generally horizontal, axially inwardly facing second seat located adjacent the outer tubular member; and a pair of first and second metal endcap seals, the first seal being positioned between the first shoulder and the first seat against the inner tubular member and the second seal being positioned between the second shoulder and the second seat against the outer tubular member. The head portion includes an axially outer surface which comprises an effective horizontal area greater than the combined horizontal area of the first and second shoulders. Thus, a first pressure acting on the seal assembly generates an axially inward force on the intensifier ring which causes the intensifier ring to compress the first and second seals against the seat ring and thereby create a corresponding second pressure on the first and second seals. Consequently, the first and second seals are subjected to a combination of the first pressure and the second pressure.

The seat ring may be supported on a seating member which is connected to or formed integrally with one of the inner and outer tubular members.

In accordance with one aspect of the invention, the seat ring may comprise a pair of first and second uprights which extend axially inwardly toward the intensifier ring, and each of the first and second seats may be located on an axially inner end of a corresponding upright. In addition, the intensifier ring may comprise a stem portion which extends axially inwardly from the head portion toward the seat ring.

In accordance with another aspect of the invention, the first shoulder may be located on one side of the stem portion and the second shoulder may be located on the opposite side of the stem portion. In addition, the axially inner end of the stem portion is slidably received within a slot which is formed between the first and second uprights. Furthermore, the intensifier ring may be movably connected to the seat ring.

Each of the first and second seals may comprise an elastomeric seal ring which is positioned between a pair of first and second metal endcaps. The seal ring may comprise a pair of generally rectangular first and second axial end portions which are separated by a convex middle portion. In addition, the first

endcap may be supported on the first end portion and may comprise a generally horizontal first face which engages one of a corresponding shoulder or seat, and the second endcap may be supported on the second end portion and may comprise a generally horizontal second face which engages the other of a corresponding shoulder or seat.

In accordance with another embodiment of the present invention, the seal assembly comprises a packoff which is positioned between a wellhead and a casing hanger. The wellhead comprises a wellhead bore, and the casing hanger is landed in the wellhead bore and is connected to the top of a casing string that extends into a well bore. The packoff is exposed to a bore pressure in a portion of the wellhead bore located above the packoff and an annulus pressure in an annulus located between the casing string and the wellhead below the packoff.

In this embodiment, the packoff includes a packoff body which comprises a head portion, a generally horizontal, downward facing first shoulder located adjacent the casing hanger and a generally horizontal, downward facing second shoulder located adjacent the wellhead; a packoff seat which is positioned below the packoff body and which comprises a generally horizontal, upward facing first seat located adjacent the casing hanger and a generally horizontal, upward facing second seat located adjacent the wellhead; and a pair of first and second metal endcap seals, the first seal being positioned between the first shoulder and the first seat against the casing hanger and the second seal being positioned between the second shoulder and the second seat against the wellhead. The head portion includes an upper surface which comprises an effective horizontal area greater than the combined horizontal area of the first and second shoulders. Thus, the bore pressure generates an axially downward force on the packoff body which causes the packoff body to compress the first and second seals against the packoff seat and thereby create a corresponding first pressure on the first and second seals. Consequently, the first and second seals are subjected to a combination of the bore pressure and the first pressure.

The packoff seat may be supported on one of the wellhead and the casing hanger.

In accordance with one aspect of this embodiment, the packoff seat may comprise a pair of first and second uprights which extend axially upwardly toward the packoff body, and each of the first and second seats may be located on an

upper end of a corresponding upright. In addition, the packoff body may comprise a stem portion which extends axially downwardly from the head portion toward the packoff seat.

In accordance with another aspect of this embodiment, the first shoulder
5 may be located on one side of the stem portion and the second shoulder may be located on the opposite side of the stem portion. In addition, a lower end of the stem portion may be slidably received within a slot which is formed between the first and second uprights. Furthermore, the packoff body may be movably connected to the packoff seat.

10 Each of the first and second seals may comprise an elastomeric seal ring which is positioned between a pair of upper and lower metal endcaps. The seal ring may comprise a pair of generally rectangular upper and lower end portions which are separated by a convex middle portion. In addition, the upper endcap may be supported on the upper end portion and may comprise a generally
15 horizontal upper face which engages a corresponding shoulder, and the lower endcap may be supported on the lower end portion and may comprise a generally horizontal lower face which engages a corresponding seat.

In accordance with yet another embodiment of the present invention, the packoff seat comprises a generally horizontal, downward facing third seat located
20 adjacent the casing hanger and a generally horizontal, downward facing fourth seat located adjacent the wellhead. In addition, the packoff further comprises an intensifier ring which comprises a generally horizontal, upward facing third shoulder located adjacent the casing hanger and a generally horizontal, upward facing fourth shoulder located adjacent the wellhead; and a pair of third and
25 fourth metal endcap seals, the third seal being positioned between the third shoulder and the third seat against the casing hanger and the fourth seal being positioned between the fourth shoulder and the fourth seat against the wellhead. The intensifier ring includes a lower surface which comprises an effective
30 horizontal area greater than the combined horizontal area of the third and fourth shoulders. Thus, the annulus pressure generates an axially upward force on the intensifier ring which causes the intensifier ring to compress the third and fourth seals against the packoff seat and thereby create a corresponding second pressure on the third and fourth seals. Thus, the third and fourth seals are subjected to a combination of the annulus pressure and the second pressure.

In accordance with one aspect of this embodiment, the packoff seat may comprise a pair of first and second legs which extend axially downwardly toward the intensifier ring, and each of the third and fourth seats may be located on a lower end of a corresponding leg. In addition, the intensifier ring may comprise a stem portion which extends axially upwardly toward the packoff seat.

In accordance with another aspect of this embodiment, the third shoulder may be located on one side of the stem portion and the fourth shoulder may be located on the opposite side of the stem portion. In addition, an upper end of the stem portion may be slidably received within a slot which is formed between the first and second legs. Furthermore, the intensifier ring may be movably connected to the packoff seat.

Thus, the sealing assembly of the present invention provides an effective means for sealing between tubular members, such as between wellhead and a casing hanger which is mounted in the wellhead. Since the intensifier ring is configured so that ambient pressure will cause it to exert a resultant force on the metal endcap seals, the metal endcap seals will be subjected to not only the ambient pressure, but also an additional pressure from the intensifier ring. As a result of this increased seal stress, the metal endcap seals will be able to seal more effectively in relatively low temperatures. In addition, since the pressure in the elastomeric seal rings is greater than the ambient pressure, ambient gases will not migrate into the elastomeric material. Consequently, the seal rings will not be subject to explosive decompression if the ambient pressure is abruptly relieved. Furthermore, the generally horizontal interfaces between the shoulders and the metal endcap seals and between the metal endcap seals and the seats will ensure that the metal endcaps and the elastomeric seal rings will deform evenly and predictably when pressure is applied to the seal assembly.

These and other objects and advantages of the present invention will be made apparent from the following detailed description, with reference to the accompanying drawings. In the drawings, the same reference numbers may be used to denote similar components in the various embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic cross sectional view of a first embodiment of the seal assembly of the present invention shown installed between a pair of exemplary inner and outer tubular members;

Figure 2 is a cross sectional view of one possible embodiment of the metal endcap seal component of the seal assembly of the present invention;

Figure 3 is a enlarged cross sectional view of the portion of the seal assembly shown on the left hand side of Figure 1;

5 Figure 4 is a cross sectional view of a representative wellhead with a second embodiment of the seal assembly of the present invention installed therein;

Figure 5 is an enlarged cross sectional view of the seal assembly shown in Figure 4; and

10 Figure 6 is an enlarged cross sectional view of another embodiment of the seal assembly of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 1, the seal assembly of the present invention, which is indicated generally by reference number 10, is shown installed in the annulus
15 between an inner tubular member 12 and an outer tubular member 14. The inner and outer tubular members 12, 14 may comprise, for example, any type of fluid handling pipes or conduits which are used in applications that require the volume above the seal assembly 10 to be sealed off from the annulus below the seal assembly. Further non-limiting examples of certain inner and outer tubular
20 members with which the seal assembly of the present invention may be used will be discussed below.

The seal assembly 10 includes an annular intensifier ring 16, an annular seat ring 18 which is supported on a seating member 20 that is connected to or formed integrally with one of the inner and outer tubular members 12, 14, a first
25 metal endcap seal 22 which is positioned between the intensifier ring and the seat ring adjacent the inner tubular member and a second metal endcap seal 24 which is positioned between the intensifier ring and the seat ring adjacent the outer tubular member. As will be discussed in more detail below, pressure from above will force the intensifier ring 16 downward and compress the first and
30 second seals 22, 24 against the seat ring 18. As a result, the first seal 22 will expand radially against both the intensifier ring 16 and the inner tubular member 12, and the second seal 24 will expand radially against both the intensifier ring and the outer tubular member 14.

In the embodiment of the invention shown in Figure 1, the intensifier ring

16 comprises a generally T-shaped cross section which includes an axial stem portion 26 and a transverse head portion 28. The intersection of the stem portion 26 with the head portion 28 defines a generally horizontal, downward facing first surface or shoulder 30 adjacent the inner tubular member 12 beneath which the first seal 22 is positioned, and a generally horizontal, downward facing second surface or shoulder 32 adjacent the outer tubular member 14 beneath which the second seal 24 is positioned. In the context of the present invention, the term "horizontal" should be construed to mean generally perpendicular to the axes of the first and second tubular members 12, 14.

In this example, the seat ring 18 comprises a generally U-shaped cross section which includes a pair of first and second upright portions 34, 36 that are joined by a transverse base portion 38. The space between the upright portions 34, 36 defines an annular slot 40 within which a lower end of the stem portion 26 of the intensifier ring 16 is slidably received. The top of the first upright portion 34 defines a generally horizontal, upward facing first surface or seat 42 adjacent the inner tubular member 12 on which the first seal 22 is supported, and the top of the second upright portion 36 defines a generally horizontal, upward facing second surface or seat 44 adjacent the outer tubular member 14 on which the second seal 24 is supported.

Referring to Figure 2, each of the first and second metal endcap seals 22, 24 ideally includes an elastomeric seal ring 46 which is positioned between a pair of upper and lower metal end caps 48, 50. The seal ring 46 comprises a pair of generally rectangular upper and lower end portions 52, 54 which are separated by a convex middle portion 56. The upper endcap 48 is supported on the upper end portion 52 and comprises a generally horizontal upper face 58 which engages a corresponding shoulder 30, 32 of the intensifier ring 16. The lower endcap 50 is supported on the lower end portion 54 and comprises a generally horizontal lower face 60 which engages a corresponding seat 42, 44 of the seat ring 18. The upper and lower metal endcaps 48, 50 may be mounted or joined to the seal ring 46 in any conventional fashion.

It should be noted that the intensifier ring 16 is preferably not directly supported by the seat ring 18. Rather, the intensifier ring 16 is ideally supported solely on the first and second metal endcap seals 22, 24, which in turn are supported on the first and second seats 42, 44. Thus, any force acting on the

intensifier ring 16 will be transmitted from the shoulders 30, 32, through the seals 22, 24 and to the upright portions 34, 36 of the seat ring 18. The generally horizontal interfaces between the shoulders 30, 32 and the upper metal endcaps 48 and between the seats 42, 44 and the lower metal endcaps 50 will ensure that the upper and lower metal endcaps and the elastomeric seal ring 46 will deform evenly and predictably when pressure is applied above the seal assembly 10.

In accordance with the present invention, the intensifier ring 16 amplifies the ambient pressure acting on the first and second seals 22, 24. Referring to Figure 3, the ambient pressure P_1 above the seal assembly 10 will act on both the intensifier ring 16 (as indicated by the dashed arrows) and directly on the seals 22, 24. Since the area of the upwardly facing horizontal surface 62 of the head portion 26 is greater than the combined horizontal area of the shoulders 30, 32, the ambient pressure P_1 will create a resultant downward force on the intensifier ring 16. Moreover, since the intensifier ring 16 is ideally supported solely by the seals 22, 24, roughly one-half of this resultant force will be transferred through each shoulder 30, 32 and generate an additional pressure P_2 on each corresponding seal (as indicated by the solid arrows). Thus, each seal 22, 24 will be subjected to a combined pressure P_1 plus P_2 . As a result of this increased seal stress, the seals 22, 24 will be able to seal more effectively in relatively low temperatures. In addition, since the pressure in the elastomeric seal rings 46 is greater than the ambient pressure P_1 , ambient gases will not migrate into the elastomeric material. Consequently, the seal rings 46 will not be subject to explosive decompression if the ambient pressure is abruptly relieved.

Referring now to Figure 4, another embodiment of the seal assembly of the present invention, which is indicated generally by reference number 100, comprises a packoff which is shown by way of example installed between a typical wellhead 102 and a representative casing hanger 104. The wellhead 102 comprises an upper housing 106 which is secured to a lower housing 108 by a number of bolts 110. The upper and lower housings 106, 108 form an axially extending wellhead bore 112 which is sealed from the external environment by an annular gasket 114 that is positioned between the upper and lower housings. The casing hanger 104, which is connected to the upper end of a casing string 116 that extends into the well bore, comprises an integral seat 118 which is supported on an annular shoulder 120 in the lower housing 108. The seat 118

includes a number of longitudinal slots 122 via which the wellhead bore 112 may communicate with a casing annulus 124 located between the wellhead 102 and the casing string 116.

In accordance with this embodiment of the present invention, the packoff 100 is used to seal off the casing annulus 124 from the portion of the wellhead bore 112 located above the casing hanger 104. As shown more clearly in Figure 5, the packoff 100 includes an annular packoff body 126 which comprises an upper head portion 128, a downwardly depending stem portion 130 and an upwardly facing ledge 132 on which an inwardly biased lock ring 134 is supported. A locking mandrel 136 is connected to the head portion 128 by a number of shoulder screws 138, which allow the locking mandrel to move axially relative to the packoff body 126. The locking mandrel 136 includes a downwardly depending nose portion 140 which, in the raised position of the locking mandrel (not shown in Figure 5), is located above the lock ring 134.

Once the packoff 100 is run into the wellhead 102, an appropriate tool (not shown) is used to force the locking mandrel 136 down against the packoff body 126. This action will cause the nose portion 140 to move down between the head portion 128 and the lock ring 134 and push the lock ring into a corresponding locking profile 142 in the upper housing 106. In this position, the lock ring 134 will prevent the packoff body 126 from moving upward relative to the wellhead 102. However, for purposes which will be made apparent below, the packoff body 126 remains free to move slightly downward relative to the wellhead 102 and the casing hanger 104.

The packoff body 126 is sealed to the casing hanger 104 by a first metal endcap seal 144 and to the wellhead 102 by a second metal endcap seal 146, both of which are ideally substantially similar to the metal endcap seals 22, 24 described above. The first seal 144 is positioned beneath a generally horizontal, downward facing first surface or shoulder 148 which extends between the stem portion 130 and the casing hanger 104, and the second seal 146 is positioned beneath a generally horizontal, downward facing second surface or shoulder 150 which extends between the stem portion and the wellhead 102. In the configuration of the invention shown in Figure 5, the shoulders 148, 150 are axially offset to allow the first and second seals 144, 146 to be positioned adjacent the casing hanger 104 and the upper housing 106 of the wellhead 102,

respectively.

The packoff body 126 is positioned above a packoff seat 152 which comprises first and second upright portions 154, 156 that are joined by a transverse base portion 158. The space between the upright portions 154, 156 defines an annular slot 160 within which a lower end of the stem portion 130 of the packoff body 126 is slidably received. The top of the first upright portion 154 defines a generally horizontal, upward facing first surface or seat 162 adjacent the casing hanger 104 on which the first seal 144 is supported, and the top of the second upright portion 156 defines a generally horizontal, upward facing second surface or seat 164 adjacent the wellhead 102 on which the second seal 146 is supported.

The packoff body 126 is connected to the packoff seat 152 in such a manner as to allow these components to move axially relative to each other. As shown in Figure 5, for example, the packoff 100 comprises a retainer strip 166 which is positioned in a circumferential channel formed by a first groove 168 in the second upright portion 156 of the packoff seat 152 and a second, opposing groove 170 in the stem portion 130 of the packoff body 126. While the axial dimension of the first groove 168 is approximately the same as the axial height of the retainer strip 166, the axial dimension of the second groove 170 is larger than the axial height of the retainer strip. Consequently, the packoff body 126 is able to move axially relative to the retainer strip 166 and, thus, the packoff seat 152.

In accordance with the present embodiment, the packoff body 126 and the packoff seat 152 together function similarly to the intensifier ring 16 and the seat ring 18 discussed above. In this regard, it should be noted that the axial lengths of the stem portion 130 and the groove 170 are selected so that the packoff body 126 is supported solely by the first and second metal endcap seals 144, 146, which in turn are supported by first and second seats 162, 164. Thus, any force acting on the packoff body 126 will be transmitted from the first and second shoulders 148, 150, through the seals 144, 146 and to the first and second upright portions 154, 156 of the packoff seat 152. Also, since the effective horizontal area of the upward facing surface of the head portion 128 is greater than the combined area of the shoulders 148, 150, the seals 144, 146 will be subjected not only to the pressure within the wellhead bore 112 above the casing hanger 104, but also to an additional pressure which is generated by the resultant

downward force this pressure creates on the packoff body 126. Thus, the packoff body 126 acts as an intensifier ring to amplify the pressure acting on the first and second metal endcap seals 144, 146.

In accordance with a further aspect of the invention, the packoff 100 may include an additional set of metal endcap seals for sealing the annulus 124 from the portion of the wellhead bore 112 located above the casing hanger 104, and these seals may be pressure intensified in a manner similar to the metal endcap seals 144, 146. Referring still to Figure 5, the packoff 100 may for example include an annular T-ring 172 which is supported on the seat 118, a third metal endcap seal 174 which is positioned between the T-ring and the casing hanger 104, and a fourth metal endcap seal 176 which is positioned between the T-ring and the wellhead 102. The third and fourth seals 174, 176 are ideally substantially similar to the metal endcap seals 22, 24 described above.

The T-ring 172 comprises an axial stem 178 which defines a generally horizontal, upward facing third surface or shoulder 180 on which the third seal 174 is supported and a generally horizontal, upward facing fourth surface or shoulder 182 on which the fourth seal 176 is supported. The packoff seat 152 includes a pair of downwardly directed, first and second legs 184, 186 which define a longitudinal slot 188 in which an upper end of the stem 178 is slidably received. The bottom of the first leg 184 defines a generally horizontal, downward facing third surface or seat 190 beneath which the third seal 174 is positioned, and the bottom of the second leg 186 defines a generally horizontal, downward facing fourth surface or seat 192 beneath which the fourth seal 176 is positioned. As with the packoff body 126 and the packoff seat 152, a retainer strip 194 is used to connect the T-ring 172 to the packoff seat in such a manner as to allow these components to move axially relative to each other.

The T-ring 172 and the packoff seat 152 together function similarly to the intensifier ring 16 and the seat ring 18 discussed above. Accordingly, the T-ring 172 and the packoff seat 152 are designed so that, when exposed to pressure within the annulus 124, the T-ring will be forced upwardly against the third and fourth metal endcap seals 174, 176. This force will be transmitted from the third and fourth shoulders 180, 182, through the seals 174, 176 and to the first and second legs 184, 186 of the packoff seat 152. Since the effective horizontal area of the downwardly facing surface of the T-ring 172 is greater than the combined

area of the shoulders 182, 184, the seals 174, 176 will be subjected not only to the pressure within the annulus 124, but also to an additional pressure which is generated by the resultant upward force this pressure creates on the T-ring 172. Thus, the T-ring 172 acts as an intensifier ring to amplify the pressure acting on the third and fourth metal endcap seals 174, 176.

As shown in Figure 5, the packoff seat 152 may comprise a number of lateral pressure test bores 196 which are in communication with a pressure test port 198 in the wellhead 102. The pressure test bores 196 facilitate the pressure testing of the first and third metal endcap seals 144, 174 during installation of the packoff.

Referring now to Figure 6, another embodiment of the seal assembly of the present invention, which is indicated generally by reference number 200, is shown as a packoff which installed between a wellhead 102 and a casing hanger 104. The packoff 200 is similar in most respects to the packoff 100. However, in this embodiment the packoff seat 152 is movably connected to the T-ring 172 by a number of shoulder screws 202. In addition, the bottom surface of the stem portion 130 of the packoff body 126 is provided with a number of apertures 204 within which the heads of the shoulder screws 202 are received to prevent the shoulder screws from interfering with the axial movement of the packoff body 126 relative to the packoff seat 152.

The operation of the packoff 200 is similar to the operation of the packoff 100 described above. As with the packoff 100, the packoff body 126 acts as an intensifier ring to amplify the pressure acting on the first and second metal endcap seals 144, 146, and the T-ring 172 acts as an intensifier ring to amplify the pressure acting on the third and fourth metal endcap seals 174, 176.

It should be recognized that, while the present invention has been described in relation to the preferred embodiments thereof, those skilled in the art may develop a wide variation of structural and operational details without departing from the principles of the invention. For example, the various elements shown in the different embodiments may be combined in a manner not illustrated above. Therefore, the appended claims are to be construed to cover all equivalents falling within the true scope and spirit of the invention.

We Claim:

1. A seal assembly for sealing between an inner tubular member and an outer tubular member, the seal assembly comprising:

an annular intensifier ring which comprises a head portion, a
5 generally horizontal, axially inwardly facing first shoulder located adjacent the inner tubular member and a generally horizontal, axially inwardly facing second shoulder located adjacent the outer tubular member;

an annular seat ring which comprises a generally horizontal, axially inwardly facing first seat located adjacent the inner tubular member and a
10 generally horizontal, axially inwardly facing second seat located adjacent the outer tubular member;

a pair of first and second metal endcap seals, the first seal being positioned between the first shoulder and the first seat against the inner tubular member and the second seal being positioned between the second shoulder and
15 the second seat against the outer tubular member;

the head portion including an axially outer surface which comprises an effective horizontal area greater than the combined horizontal area of the first and second shoulders;

wherein a first pressure acting on the seal assembly generates an
20 axially inward force on the intensifier ring which causes the intensifier ring to compress the first and second seals against the seat ring and thereby create a corresponding second pressure on the first and second seals;

whereby the first and second seals are subjected to a combination of the first pressure and the second pressure.

2. The seal assembly of claim 1, wherein the seat ring is supported on a seating member which is connected to or formed integrally with one of the inner and outer tubular members.

3. The seal assembly of claim 1, wherein the seat ring comprises a pair of first and second uprights which extend axially inwardly toward the
30 intensifier ring, and wherein each of the first and second seats is located on an axially inner end of a corresponding upright.

4. The seal assembly of claim 3, wherein the intensifier ring comprises a stem portion which extends axially inwardly from the head portion toward the seat ring.

5. The seal assembly of claim 4, wherein the first shoulder is located on one side of the stem portion and the second shoulder is located on the opposite side of the stem portion.

6. The seal assembly of claim 5, wherein an axially inner end of the stem portion is slidably received within a slot which is formed between the first and second uprights.

7. The seal assembly of claim 1, wherein the intensifier ring is movably connected to the seat ring.

8. The seal assembly of claim 1, wherein each of the first and second seals comprises an elastomeric seal ring which is positioned between a pair of first and second metal endcaps.

9. The seal assembly of claim 8, wherein the seal ring comprises a pair of generally rectangular first and second axial end portions which are separated by a convex middle portion.

10. The seal assembly of claim 9, wherein the first endcap is supported on the first end portion and comprises a generally horizontal first face which engages one of a corresponding shoulder or seat, and wherein the second endcap is supported on the second end portion and comprises a generally horizontal second face which engages the other of a corresponding shoulder or seat.

11. A packoff which is positioned between a wellhead which comprises a wellhead bore and a casing hanger which is landed in the wellhead bore and is connected to the top of a casing string that extends into a well bore, the packoff being exposed to a bore pressure in a portion of the wellhead bore located above the packoff and an annulus pressure in an annulus located between the casing string and the wellhead below the packoff, the packoff comprising:

a packoff body which comprises a head portion, a generally horizontal, downward facing first shoulder located adjacent the casing hanger and a generally horizontal, downward facing second shoulder located adjacent the wellhead;

a packoff seat which is positioned below the packoff body and which comprises a generally horizontal, upward facing first seat located adjacent the casing hanger and a generally horizontal, upward facing second seat located adjacent the wellhead;

a pair of first and second metal endcap seals, the first seal being positioned between the first shoulder and the first seat against the casing hanger and the second seal being positioned between the second shoulder and the second seat against the wellhead;

5 the head portion including an upper surface which comprises an effective horizontal area greater than the combined horizontal area of the first and second shoulders;

 wherein the bore pressure generates an axially downward force on the packoff body which causes the packoff body to compress the first and second
10 seals against the packoff seat and thereby create a corresponding first pressure on the first and second seals;

 whereby the first and second seals are subjected to a combination of the bore pressure and the first pressure.

12. The packoff of claim 11 wherein the packoff seat is supported on
15 one of the wellhead and the casing hanger.

13. The packoff of claim 11, wherein the packoff seat comprises a pair of first and second uprights which extend axially upwardly toward the packoff body, and wherein each of the first and second seats is located on an upper end of a corresponding upright.

20 14. The packoff of claim 13, wherein the packoff body comprises a stem portion which extends axially downwardly from the head portion toward the packoff seat.

15. The packoff of claim 14, wherein the first shoulder is located on one side of the stem portion and the second shoulder is located on the opposite side
25 of the stem portion.

16. The packoff of claim 15, wherein a lower end of the stem portion is slidably received within a slot which is formed between the first and second uprights.

17. The packoff of claim 11, wherein the packoff body is movably
30 connected to the packoff seat.

18. The packoff of claim 11, wherein each of the first and second seals comprises an elastomeric seal ring which is positioned between a pair of upper and lower metal endcaps.

19. The packoff of claim 18, wherein the seal ring comprises a pair of

generally rectangular upper and lower end portions which are separated by a convex middle portion.

20. The packoff of claim 19, wherein the upper endcap is supported on the upper end portion and comprises a generally horizontal upper face which
5 engages a corresponding shoulder, and wherein the lower endcap is supported on the lower end portion and comprises a generally horizontal lower face which engages a corresponding seat.

21. The packoff of claim 11, wherein the packoff seat comprises a generally horizontal, downward facing third seat located adjacent the casing
10 hanger and a generally horizontal, downward facing fourth seat located adjacent the wellhead, and wherein the packoff further comprises:

an intensifier ring which comprises a generally horizontal, upward facing third shoulder located adjacent the casing hanger and a generally horizontal, upward facing fourth shoulder located adjacent the wellhead;

15 a pair of third and fourth metal endcap seals, the third seal being positioned between the third shoulder and the third seat against the casing hanger and the fourth seal being positioned between the fourth shoulder and the fourth seat against the wellhead;

20 the intensifier ring including a lower surface which comprises an effective horizontal area greater than the combined horizontal area of the third and fourth shoulders;

wherein the annulus pressure generates an axially upward force on the intensifier ring which causes the intensifier ring to compress the third and fourth seals against the packoff seat and thereby create a corresponding second
25 pressure on the third and fourth seals;

whereby the third and fourth seals are subjected to a combination of the annulus pressure and the second pressure.

22. The packoff of claim 21, wherein the packoff seat comprises a pair of first and second legs which extend axially downwardly toward the intensifier
30 ring, and wherein each of the third and fourth seats is located on a lower end of a corresponding leg.

23. The packoff of claim 22, wherein the intensifier ring comprises a stem portion which extends axially upwardly toward the packoff seat.

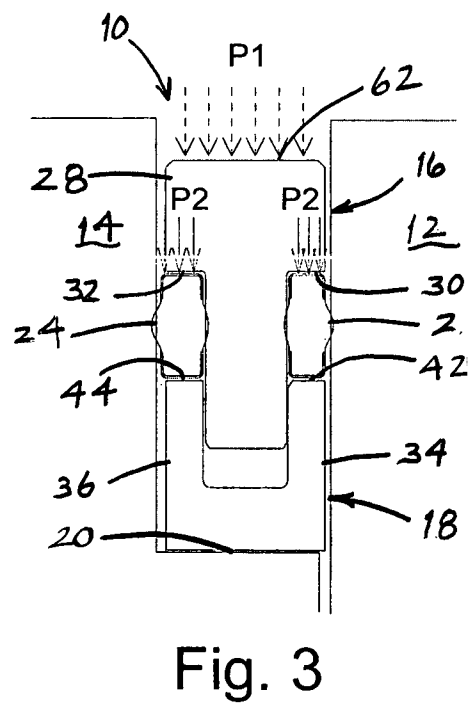
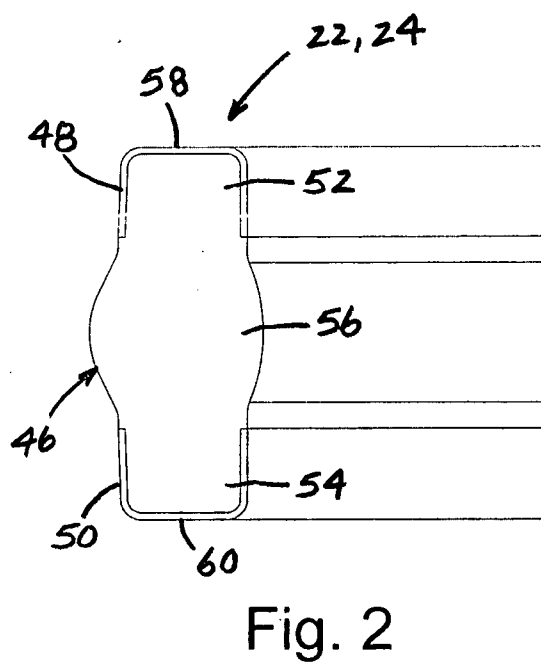
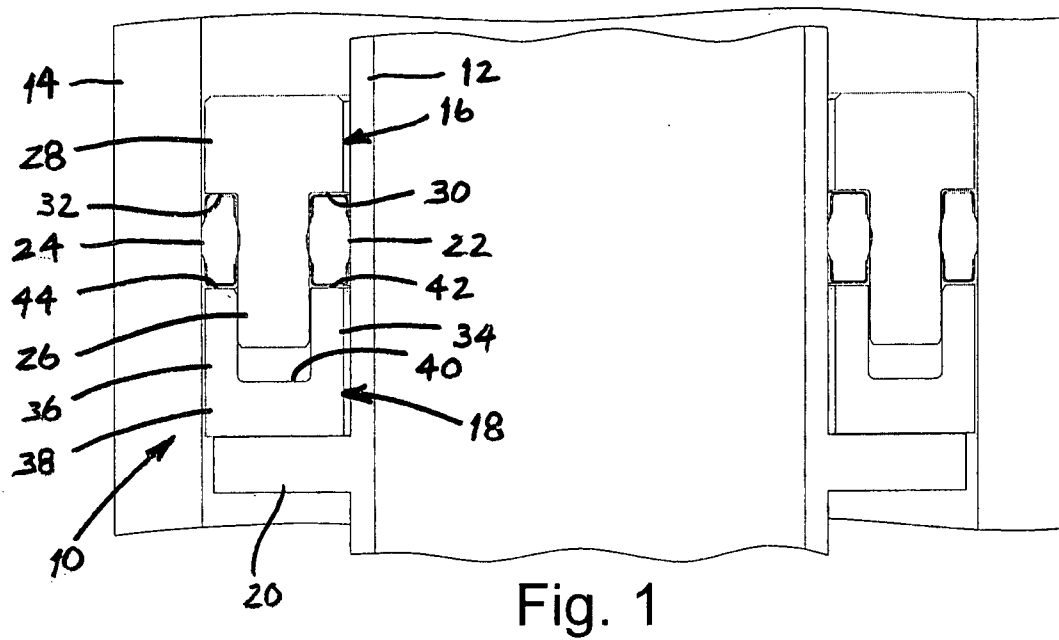
24. The packoff of claim 23, wherein the third shoulder is located on

one side of the stem portion and the fourth shoulder is located on the opposite side of the stem portion.

25. The packoff of claim 24, wherein an upper end of the stem portion is slidably received within a slot which is formed between the first and second

5 legs.

26. The packoff of claim 21, wherein the intensifier ring is movably connected to the packoff seat.



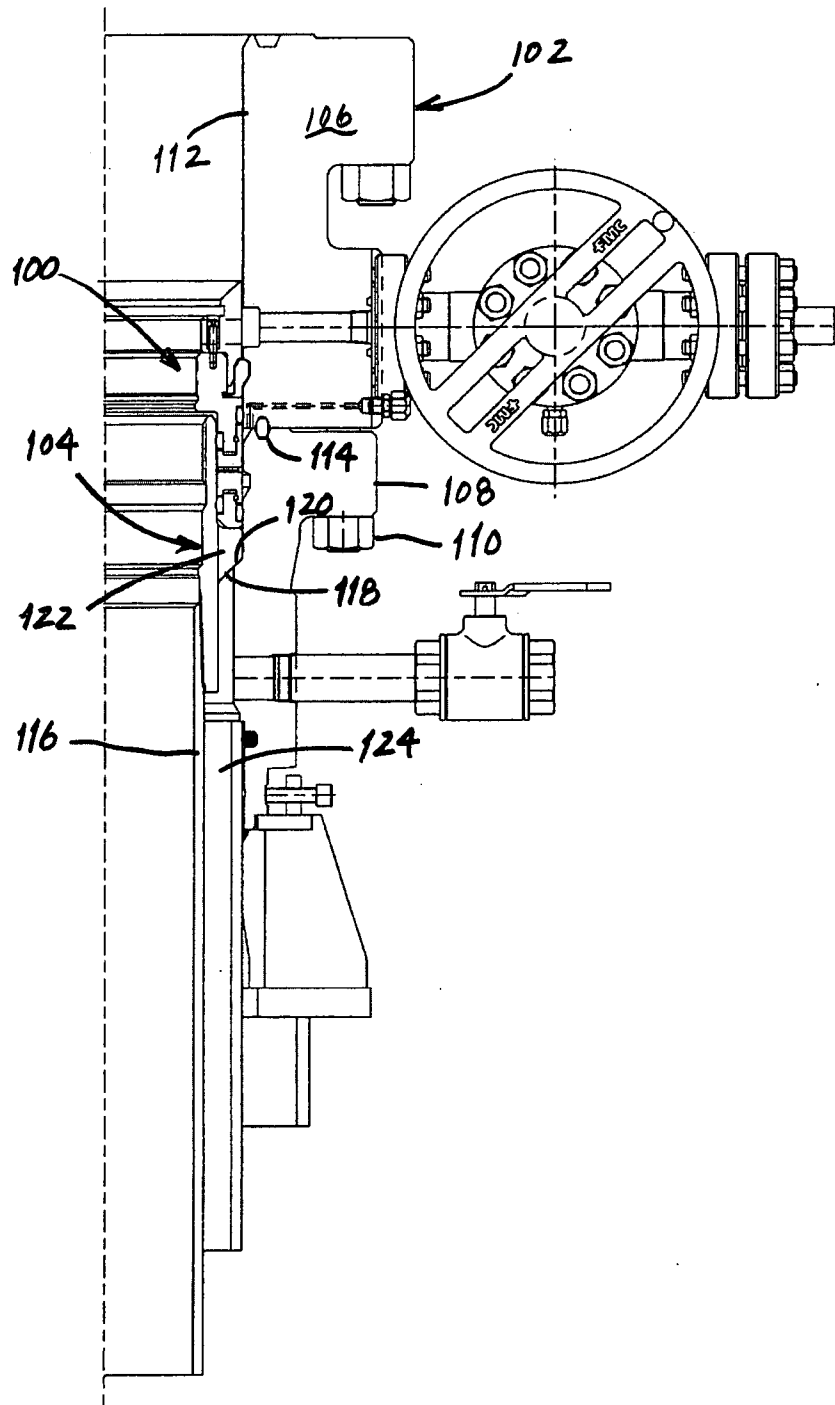


Fig. 4

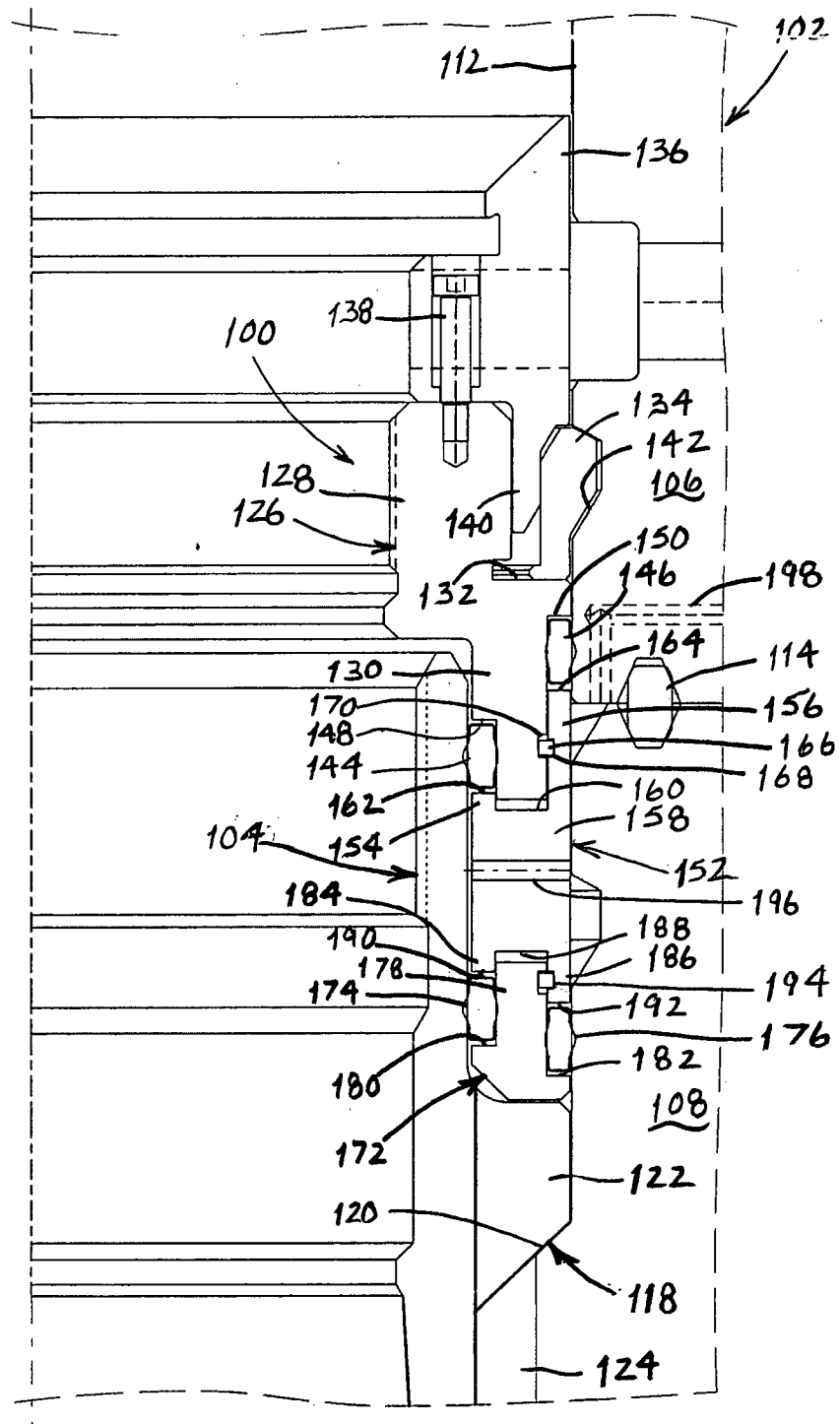


Fig. 5

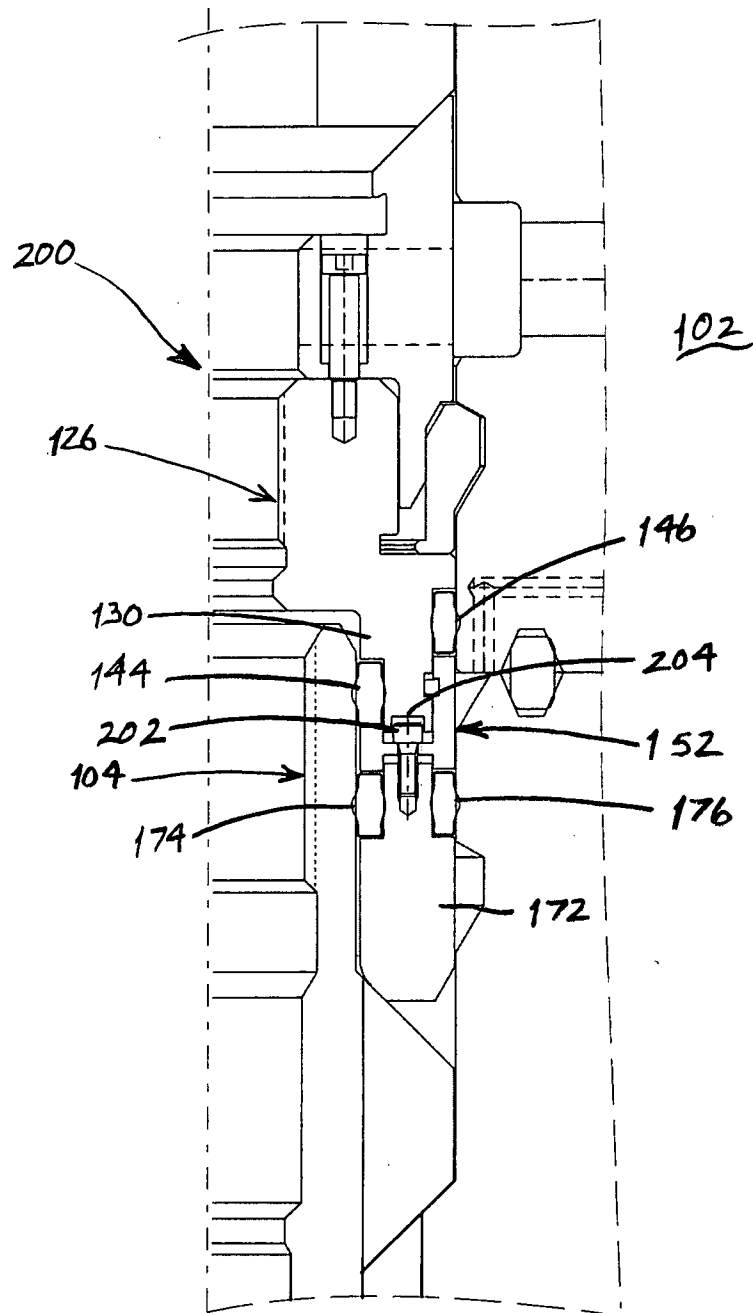


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 08/13283

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E21B 19/00 (2009.01)

USPC - 166/115

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8): E21B 19/00 (2009.01)

USPC: 166/115

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 166/115, 368, 75.11. (see search terms)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPTO - West - DB: PGPB, USPT, EPAB, JPAB

Search terms: seal, seat, ring, tubular, inner, outer, well, pressure, packoff, endcap, shoulder, stem and metal.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,815,770 A (HYNE et al.) 28 March 1989 (28.03.1989), figure 1-5; column 2, line 34 to column 10, line 57	1-26
Y	US 4,496,162 A (MCEVER et al.) 29 January 1985 (29.01.1985), figure 1-4; column 2, line 17 to column 3, line 47.	1-26
Y	US 2008/0265517 A1 (JENNINGS et al) 30 October 2008 (30.10.2008), figure 1-8; paragraph [0018]-[0025].	4-6, 14-16 and 21-25

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

09 January 2009 (09.01.2009)

Date of mailing of the international search report

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