March 31, 1964 V. J. ORUND 3,127,198

COMBINATION SLIP AND PACKING APPARATUS FOR OIL FIELD USE

Filed Oct. 2, 1959 2 Sheets-Sheet 1

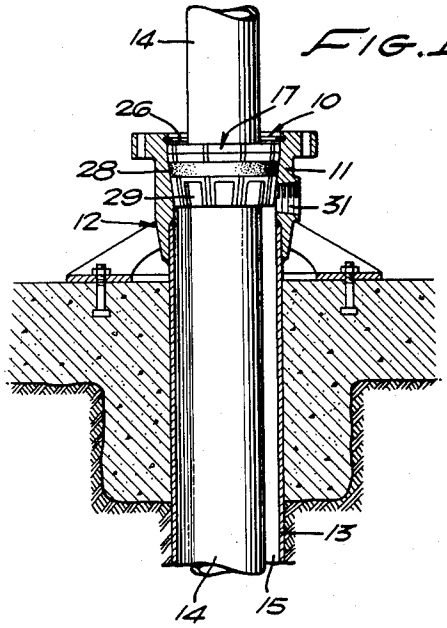

FIG. 1.

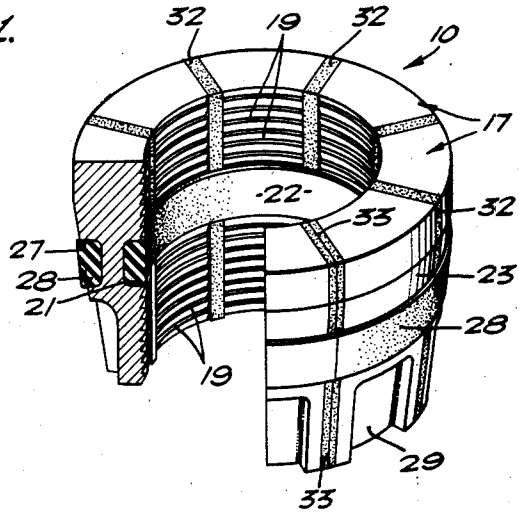

FIG. 2.

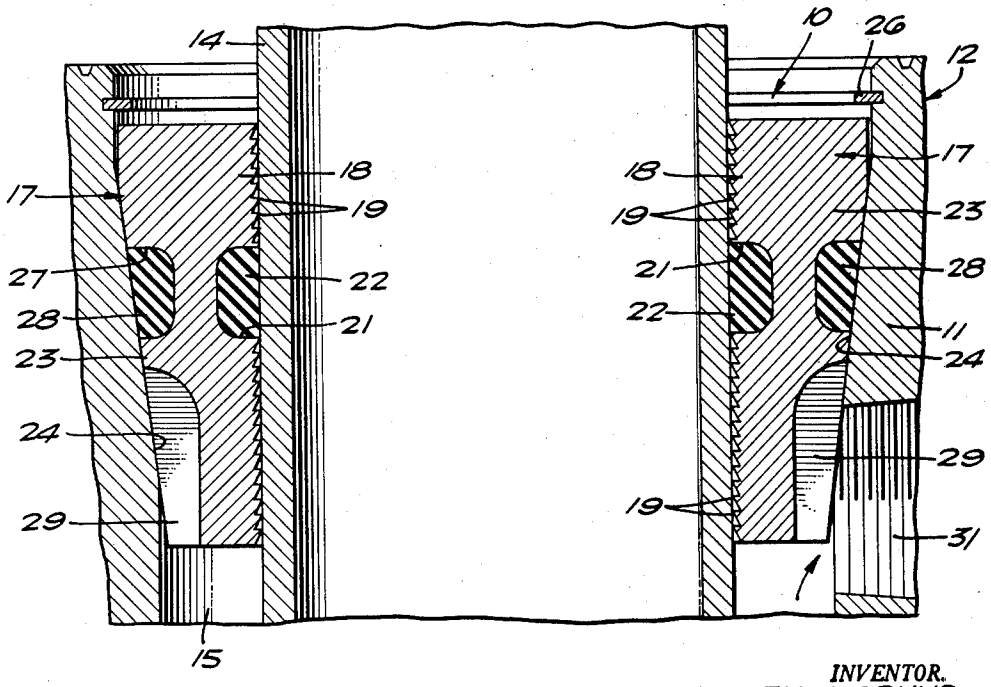

FIG. 3.

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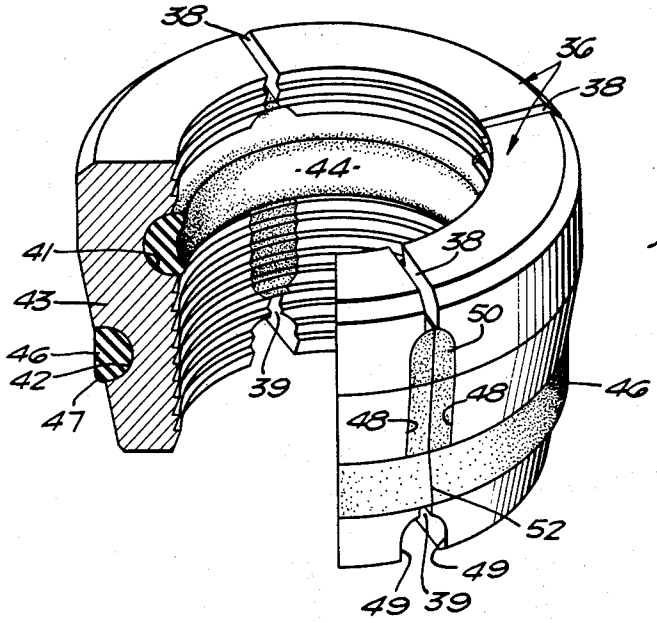

FIG. 4.

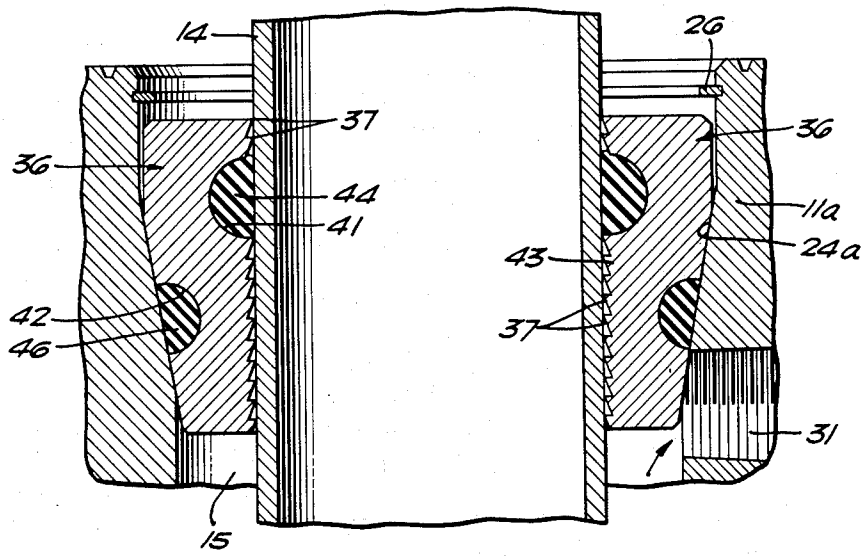

FIG. 5.

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COMBINATION SLIP AND PACKING APPARATUS FOR OIL FIELD USE

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1 Claim. (Cl. 285—146)

This invention relates to a slip and packing apparatus adapted to be mounted around a string of casing to support the same and to seal off the annulus between two concentric casing strings.

An object of the present invention is to provide a combination slip and packing apparatus which is completely automatic in its sealing operation, and which is adapted to seal off an annulus even after being subjected to prolonged and maximum fluid pressures such as would extrude and eventually deplete conventional packing assemblies.

A further object of the invention is to provide a combination slip and packing assembly incorporating reservoirs adapted automatically to supply energized rubber to the sealing areas.

An additional object of the invention is to provide a combination slip and packer apparatus wherein means are provided to effect supply of additional sealing material to the sealing areas in response to the pressure of the gas in the annulus, whereby the seal is maintained despite reduction in the weight supported by the slip assembly and despite years of use under high fluid pressures.

Another object of the present invention is to provide a combination slip and packing apparatus capable of effectively supporting long and heavy strings of casing, and adapted automatically to seal off the annulus between two concentric casing strings without the necessity of employing auxiliary clamps, bolts or seals.

A further object of the invention is to provide a slip and packing assembly incorporating large and strong unitary slip segments formed of metal, said segments having relatively long ridges or wickers which are in metal-to-metal contact with the external surface of the string of casing being supported.

A further object is to provide a slip and packing assembly adapted to create an effective seal yet which may be opened up and wrapped around a section of casing without the requirement for disassembly and reassembly of fastener means or the like.

These and other objects and advantages of the invention will be more fully set forth in the following specification and claims, considered in connection with the attached drawings to which they relate.

In the drawings:

FIGURE 1 is a view, partly in vertical section and partly in elevation, illustrating a combination slip and seal apparatus as disposed in the tapered-bowl portion of a base head;

FIGURE 2 is a perspective view of the slip and seal apparatus, a portion of the apparatus being broken away and illustrated in section;

FIGURE 3 is an enlarged vertical sectional view illustrating the slip and seal apparatus as seated in the tapered bowl around a section of casing;

FIGURE 4 is a view corresponding generally to FIGURE 2 but illustrating a second embodiment of the invention; and

FIGURE 5 is a view, corresponding generally to FIGURE 3, illustrating the operation of the embodiment of FIGURE 4 in supporting a string of casing and sealing the annulus between concentric casing strings.

Referring first to the embodiment shown in FIGURES 1–3 of the drawings, the combination slip and packer

assembly is indicated generally at 10 and is illustrated as seated in the tapered bowl portion 11 of the base head 12 which is anchored at the wellhead of an oil well. Base head 12 is shown as being welded or otherwise suitably secured to the outer casing string 13, whereas the assembly 10 is illustrated as disposed around a second and smaller-diameter casing string 14 disposed concentrically within string 13. The purpose of the assembly 10 is to support the casing string 14 and to seal off the annulus 15 between the concentric strings.

Although the slip and seal assembly 10 is illustrated as related to the base head 12, it is to be understood that corresponding assemblies may be employed with relation to other landing heads of various types. For example, a smaller-diameter assembly 10 may be employed around a third string of casing, or a string of tubing, disposed concentrically within string 14.

Referring particularly to FIGURE 2, the combination slip and seal assembly is illustrated to comprise a substantial number of metal slip segments 17 having vertical side faces disposed generally in radial planes containing the axis of the assembly. Adjacent (opposed) side faces are parallel to each other, and are separated by distances much smaller than the width (circumferentially of the assembly) of each segment. Thus, for example, in a situation where each segment occupies 50 degrees of the circle, the space between opposed parallel surfaces of adjacent segments may be 10 degrees. Such spaces form reservoirs for elastomeric material, as will be set forth subsequently.

The inner portion 18 of each slip segment 17 is shaped generally as a section of a cylinder having a diameter corresponding to that of the casing, such as 14, with which the assembly is to be employed in supporting relationship. Such inner portion 18 is formed with a substantial number of wickers, ridges or teeth 19 which lie in horizontal planes. The wickers extend horizontally and continuously along the inner portion 18 of each slip segment, and face upwardly or in a direction to effect support of the casing 14. Stated otherwise, the upper surface of each wicker or ridge 19 may lie in a horizontal plane, whereas the lower surface of each wicker or ridge may lie on the surface of an upwardly-convergent cone the apex of which is disposed at the axis of the assembly.

A groove 21, having a large cross-sectional area, is formed at the mid-portion of each slip segment 17 concentrically with the axis of the apparatus, being filled by an annular elastomeric member 22 to be described subsequently. As will be stated hereinafter, the elastomeric member 22 performs a packing or sealing function relative to the exterior surface of casing string 14, and additionally performs important connecting and hinge functions relative to the slip segments 17.

The exterior or outer portion 23 of each slip segment 17 lies on the surface of a cone the apex of which is disposed at the axis of the assembly a substantial distance below the apparatus 10. The inner wall of tapered bowl 11 also lies on the surface of such cone, and is indicated at 24. Accordingly, downward shifting of the slip segment 17 along tapered wall 24 causes the slip segments to be wedged together and force the wickers 19 into casing 14.

The extreme upper part of each segment portion 23 may lie on the surface of a cylinder, adjacent a corresponding cylindrical upper portion of bowl 11. A snap ring 26 is mounted in such cylindrical bowl portion, above the horizontal upper surface of each slip segment.

The outer portion 23 of each slip segment has formed therein, in a horizontal plane and radially outwardly of groove 21, a groove 27 adapted to receive a second annular elastomeric member 28 which is coaxial with the first member 22 but has a substantially larger diameter. The

groove 27, similarly to groove 21, has a relatively large cross-sectional area. The elastomeric member 28 therein has an even larger cross-sectional area when in undeformed condition. It thus completely fills the groove 27 and protrudes substantially therefrom as illustrated at the left portion of FIGURE 2.

In addition to the groove 27, the outer portion of each slip segment has formed therein at its lower end a recess 29 adapted to register, at least partially, with a vent opening 31 (FIGURE 3) in the tapered bowl 11. The recesses 29 serve the purpose of insuring that gas may escape from annulus 15 through vent opening 31 under control of suitable valve means, not shown.

The assembly further comprises a plurality of vertical block-like elastomeric members 32 which are connected to annular members 22 and 28 in free communication therewith. Members 32 fill the reservoir spaces between the opposed vertical side faces of the slip segments. The outer edges of such members 32 are preferably flush with the outer surfaces of the segments. The inner edges of the members 32 may be generally flush with the apex portions of the wickers or ridges 19.

The inner portion of the first-mentioned annular elastomeric member 22 should extend inwardly until it is at least flush with the apex portions of the wickers, so that it will be in sealing engagement with the cylindrical surface of casing 14 when the wickers have dug into the casing. Also, the inner surface of the annular member 22 may protrude somewhat above the apex portions of the wickers but not sufficiently far to impede the wickers from biting into the casing and thereby supporting the same. The outer surface of the larger-diameter elastomeric ring 28 protrudes above the adjacent surface of each slip segment, as stated above, to thereby cause compression of member 28 for sealing engagement with frusto-conical wall 24 when the weight of the casing is impressed upon the slip segments.

Referring to FIGURE 2, it is pointed out that the assembly 10 is split at one point around its circumference, through both of the annular elastomeric members 22 and 28 and through or adjacent one of the vertical elastomeric members 32. The assembly may therefore be spread open by separating the portions thereof adjacent the split, which is indicated at 33, to permit mounting thereof around the casing 14 and thereby eliminate the necessity of threading the assembly over the casing.

It is pointed out that when the assembly is spread apart at split 33, as indicated above, the diametrically-opposite portions of annular members 22 and 28 perform the functions of hinges or joints. It is also pointed out that such annular members 22 and 28, together with members 32, perform the function of maintaining the slip segments 17 in assembled relationship prior to mounting of the slip and seal apparatus in tapered bowl 11.

To summarize the operation of the apparatus shown in FIGURES 1–3, let it be assumed that the casing string 14 is ready for landing and that a stretch has been impressed thereon to effect elongation thereof. It is then merely necessary to spread the assembly 10 apart at split 33, mount the assembly around the string 14 above tapered bowl 11, and drop the assembly into the bowl. The stretch on the casing string 14 is then released to effect lowering of the portion of string 14 adjacent the assembly 10. The wickers 19 then bite into the exterior cylindrical surface of the string 14, and the slip segments 17 wedge into the tapered bowl. Such wedging action operates, as stated above, to effect positive sealing engagement between the annular elastomeric members 22 and 28 and the opposed casing and bowl surfaces. Leakage of gas from annulus 15 is thereby effectively prevented by the members 22 and 28, as well as by the vertical elastomeric members 32 which are compressed between the wedged segments to insure against a seal at the split 33. The members 32 perform an important reservoir function to be set forth subsequently.

Embodiment of Figures 4 and 5

Referring to the embodiment of FIGURES 4 and 5, four metal slip segments 36 are illustrated as having wickers 37 which correspond to the wickers or ridges 19 previously described. The slip segments 36 each occupy substantially less than 90 degrees, for example about 85 degrees, so that gaps of approximately 5 degrees are formed at 38 and 39 between the opposed parallel faces of adjacent sections.

An annular groove 41 having a relatively large cross-sectional area is provided in the inner portions of the corresponding slip segments relatively adjacent the upper ends thereof. Such inner groove 41 corresponds generally to groove 21 of the previous embodiment except that it is disposed at a higher elevation. An outer annular groove 42 is formed in the outer portions of the corresponding segments 36, such portions being frusto-conical and downwardly-convergent for seating against the tapered wall 24*a* of bowl 11*a* (FIGURE 5). The outer groove 42 is disposed a substantial distance beneath the inner groove 41, so that a relatively thick and strong section 43 of metal is provided between the grooves 41 and 42.

Disposed in inner annular groove 41 is an inner elastomeric member 44. As in the case of member 22 described with relation to the previous embodiment, member 44 extends inwardly sufficiently far to provide an effective seal relative to casing string 14, but not sufficiently far to prevent the wickers 37 from binding with the casing to support the same. An outer elastomeric member 46 is disposed in outer groove 42 and has an outwardly-extending portion 47 (FIGURE 4) at its lower edge.

The opposed vertical faces of adjacent segments 36, between gaps 38 and 39 and also beneath gaps 39, are cut back or recessed a substantial distance as indicated at 48 and 49 in FIGURE 4. The relatively large recesses or areas thus formed between gaps 38 and 39 form reservoirs for elastomeric material, and are filled completely with such material as indicated at 50. The reservoirs communicate freely with both of the annular grooves 41 and 42. The annular elastomeric members 44 and 46 are integral with the material 50 in the reservoirs.

It is to be understood that the elastomeric material 50 (and annular members 44 and 46) between one set of upper and lower gaps 38 and 39 are vertically split as indicated at 52, correspondingly to the split 33 illustrated in FIGURE 2 with relation to the previous embodiment. This permits the assembly to be opened up for mounting around the casing string 14 as described heretofore. Except as will be noted subsequently, the operation of the apparatus illustrated in FIGURES 4 and 5 corresponds to the operation described with relation to the embodiment of FIGURES 1–3.

Description of Certain Important Features Relative to Both Embodiments

It is an important feature of both embodiments that the elastomeric material 32 and 50 in the large reservoir gaps between adjacent slip segments operate as sources of supply for the material in the inner and outer annular grooves. The reservoirs operate to maintain the sealing regions sufficiently full of sealing material to provide effective seals, despite the occurrence of certain conditions to be discussed below.

It is pointed out that as the slip segments settle in the tapered bowl, the elastomeric material in the annular grooves and in the reservoirs between the segments is placed under very great pressure. The material is thus caused to flow to regions where it is needed, for example, to regions which have been depleted of elastomeric material due to extrusion thereof. A continued adequate seal with the tapered bowl and with the casing string is thus assured.

After the casing string 14 has been landed, well conditions frequently change due to such factors as lapse

of time, cementing of the lower portion of the casing string, thermal expansion, etc. The casing weight supported by the slip assembly may then be much less than originally, so that the sealing pressures caused by the casing string may be greatly reduced. It is therefore important that the above-mentioned reservoir action be continued despite reduction in those internal stresses in the elastomeric material which are the result of mechanical loading. It is a feature of the invention that the well pressure in annulus 15 operates to cause the elastomeric material to flow to sealing regions in the inner and outer annular grooves, and thus continue the reservoir action.

With reference to the embodiment of FIGURES 4 and 5, it is pointed out that the metal on both sides of each upper gap 38 tends to prevent upward extrusion of the sealing material 50 in the reservoirs, so that upward pressure in annulus 15 causes the material to flow from the reservoirs into the annular grooves 44 and 46 instead of upwardly through the gaps 38. It is pointed out that the above-described reservoir principle means that a substantial number of slip segments should be employed, preferably at least four. If only two slip segments were employed, there would only be two reservoirs and it would be necessary for the sealing material to flow through undesirably large circular paths. It is also pointed out that it is highly important that the annular grooves 21–27 and 41–42 be large in cross-sectional area and communicate freely with the reservoirs.

The term "elastomeric material" is intended to include natural and synthetic rubbers, as well as certain plastics having similar properties. A preferred elastomeric material is Buna N synthetic rubber.

The term "horizontal plane," as employed in the specification and claims relative to wickers 37, should be construed to cover constructions in which the wickers are cut with a threading tool, and thus are helical.

Various embodiments of the present invention, in addition to what has been illustrated and described in detail, may be employed without departing from the scope of the accompanying claims.

I claim:

A combination slip and packer apparatus for use at the wellhead of an oil well, comprising a substantial number of metal slip segments each having wickers at their inner portions and tapered surfaces at their outer portions, said segments when disposed adjacent each other and occupying substantially less than 360 degrees whereby substantial reservoir spaces are formed between opposed surfaces of adjacent segments, first large-area groove means formed in said inner portions of said segments at a first elevation, second large-area groove means formed in said outer portions of said segments at a second elevation substantially different from said first elevation, first and second annular elements formed of elastomeric material and respectively disposed in said first and second groove means to at least fill the same, and masses of elastomeric material provided in said reservoir spaces between opposed surfaces of said segments, said reservoir spaces communicating freely with said groove means for flow of elastomeric material thereto, said opposed surfaces of adjacent segments at said reservoirs being cutback substantially, whereby gaps are formed above said reservoirs, the opposed surfaces of said segments at said gaps being spaced apart a sufficient distance to permit substantial compression of the elastomeric material in said reservoirs.

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