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DRAWINGS ATTACHED

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(54) IMPROVEMENTS RELATING TO WELL BLOWOUT PREVENTERS

(71) We, CAMERON IRON WORKS INC., a corporation organised and existing under the laws of the State of Texas, United States of America, of P.O. Box 1212, Houston, Texas, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to well blowout preventers and, more particularly, to improvements in annular blowout preventers.

As well known in the art, a blowout preventer controls the pressure within an oil or gas well during drilling and completion of the well. It comprises a housing adapted to be connected above the head of the well with its bore aligned with the well bore, and one or more packing elements carried within a recess in the bore. The packing element or elements are adapted to be moved inwardly for closing about a pipe or other member in the bore or for closing the entire bore when it is empty.

An annular blowout preventer has a single packer comprising an annulus of deformable material such as rubber whose bore is adapted to be radially constricted. In one such annular blowout preventer which is shown and described in United States Patent No. 2,609,836, the packer comprises a massive annulus of rubber having rigid inserts molded into it for containing it during constriction. These inserts extend from one end to the other of the annulus and comprise longitudinally extending ribs having flanges at their opposite ends which move radially inwardly as the bore is constricted.

The outer side of the annulus is conically shaped for seating upon a similarly shaped upper surface of an annular piston which is vertically reciprocable within the housing. As the piston is moved upwardly, its face slides over the outer side of the annulus to seal thereabout and move it inwardly in order to constrict the packer. This construction requires a large housing, and in particular, one high enough to permit the required vertical stroke of the piston, despite the fact that headroom is often at a premium in the environment in which blowout preventers are used. Also, since the piston must slide over a substantial portion of the outer side of the annulus, it requires considerable operating force, which adds to the size and cost of the preventer. Still further, the strain induced in the annulus as it is urged inwardly breaks its bond to the rigid inserts, and, as a result, the packer may fail.

The object of this invention is to provide an improved packer for an annular blowout preventer.

The packer in accordance with this invention comprises an annulus of deformable material, and a substantially circular series of rigid, circumferentially relatively movable insents extending through the annulus from one end to the other, each said insert including a rib and there being flanges on the ends of the ribs on at least one end of the annulus, said annulus having an annular surface at said one end which is substantially coplanar with the end surfaces of said flanges for sealing against an oppositely facing end surface of the housing recess. This sealing surface preferably is adjacent the outer side of the annulus and protrudes beyond the end surfaces of the flanges. It is also advantageous for such a sealing surface to be provided at both ends of the annulus so that the packer may be installed with either end up.

The present invention also provides an annular blowout preventer comprising a housing having a bore extending therethrough, an annular recess extending outwardly from the bore through the housing, and a packer as defined above disposed within the annular recess with the bore of

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the packer being substantially axially aligned with the bore through the housing.

In the preferred embodiment of the blowout preventer of this invention, there are parts within the annular recess in the housing and about the outer side of the packer which are movable radially inwardly against the outer side of the packer to constrict the packer bore and urge the annular surface or surfaces thereof into tight sealing engagement with the end or ends of the annular recess. Inasmuch as the packer constricting parts move radially, they require no more height within the housing than does the packer itself. Furthermore, these constricting parts are reciprocated by pistons which have short strokes, so that the housing need not be particularly large in diameter. Consequently, the housing of this blowout preventer may be smaller than that described in the above-mentioned U.S. patent. Still further, since they move in the same direction, the only sliding which takes place between the annulus and the constricting parts is that due to the small relative circumferential displacement between them.

In the illustrated embodiment of the the blowout preventer of the invention, the cylinders receiving the pistons extend radially into the housing from its outer side, and a ring is disposable over the outer side of the housing to form a common cover over the outer ends of all of the cylinders. Thus, hydraulic fluid may be introduced through a common line into the space between the outer ends of the pistons and the inner side of the ring for moving the pistons inwardly. Also, since the ring is assembled by merely sliding it over the outer side of the housing, it is easily secured and released to obtain access to the pistons.

The invention will now be described further with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of an annular blowout preventer having a packer constructed in accordance with the present invention, as seen from the top and side thereof, and with a portion removed to show a pipe within the bore of the packer in its unconstricted position;

Fig. 2 is a vertical sectional view through the blowout preventer of Fig. 1, as seen along broken line 2--2 of Fig. 1;

Fig. 3 is a partial top plan view of the packer of the preventer of Figs. 1 and 2, in its unconstricted position, and showing in broken lines the ribs of its rigid inserts;

Fig. 4 is a vertical sectional view through the packer as seen along broken line 4--4 of Fig. 3;

Figs 4A and 4B are partial vertical sections illustrating modified forms of packer in accordance with this invention;

Fig. 5 is a cross-sectional view, on an enlarged scale and as seen along broken line 5--5 of Fig. 2, of a connection between adjacent packer constricting parts which synchronizes their radial movement;

Fig. 6 is a partial vertical sectional view of the preventer, similar to Fig. 2, but showing the packer upon constriction inwardly to seal about the pipe in the bore of the housing;

Fig. 7 is another partial sectional view similar to Fig. 6, but showing the packer in a further constricted position to close an open hole in the bore of the preventer housing;

Fig. 8 is a perspective view of a rigid insert;

Fig. 9 is a horizontal sectional view of the insert, as seen along broken line 9--9 of Fig. 8; and

Fig. 10 is a diagrammatic illustration of the manner in which the orientation of the rib of the rigid insert within the packer may be determined in order to arrange its opposite sides generally in planes of least strain.

With reference now to the details of the above described drawings, the preventer, which is designated in its entirety by reference character 20, includes a housing 21 which is annular in shape and has a cylindrical bore 22 extending axially through it. Threaded holes 23 and ring grooves 24 are provided at both ends of the housing for coaxial connection and sealing to other wellhead members (not shown).

With the preventer 20 thus connected as a part of the wellhead, a drill pipe P forming part of the drill string may extend through its bore 22 and into the well bore. Alternatively, a Kelly or other out-of-round member may extend through the bore 22 of the blowout preventer. Still further, the bore may be empty so as to form an "open hole" therethrough. As known in this art, there may be occasion for the preventer to be used in sealing about the member in the hole, such as the pipe P or the Kelly, so as to close off the annular space between such member and the bore 22, or alternatively to seal off with itself so as to close an open hole.

Housing 21 is made up of a body 25 which is generally L-shaped in vertical, half cross section to provide an upwardly opening shelf about its interior, and a cap 26 disposable over the upper end of the body 25 to form an annular recess 27 about bore 22. Cap 26 has a bore 22a therethrough which forms a continuation of a bore 22b through the housing. Body 25 includes a bridging ring 40 (to be described below), and the cap 26 and the top surface of the ring form the upper and lower ends 27a and 27b, respectively, of the recess. The outer wall of recess 27 is concentric with bore 22 of the housing, and the ends 27a and 27b of the recess are perpendicular to its axis.

Cap 26 is secured to the upper end of the body 25 by a series of cap screws 28 extend-

ing through holes in the cap for connection with threaded holes 29 in the body 25. Threaded holes 30 in cap 26 may receive eyes for lifting it into and out of place. An O-ring 31 about a reduced lower end portion of the cap seals with respect to an inner annular wall 32 of the body 25 above the recess 27.

A packer 33 is disposed within the recess 27 of the preventer housing 21 for movement between an unconstricted position in which its bore 35 is substantially axially aligned with the housing bore 22, as best shown in Figs. 1 and 2, and a constricted position in which its bore 35 is moved radially inwardly into the housing bore for sealing about the pipe P, as best shown in Fig. 6, or for sealing upon itself when the bore is empty, as best shown in Fig. 7. As will be described below, the packer is so moved by means of constricting parts including laterally extending segments 36 disposed about the outer side of the packer within recess 27 and adapted to be moved radially inwardly and outwardly by means of the hydraulically operated pistons.

Packer 33 is cylindrical in shape, with its outer side and bore 35 concentric, and its ends 37 and 38 perpendicular to the axis of the bore 35. It fits closely within the upper and lower ends 27a and 27b of the recess and, as best shown in Fig. 2, when the packer is unconstricted, segments 36 are disposed with their inner arcuate faces adjacent its outer side and their outer arcuate faces adjacent the outer side of the recess 27. Bore 22b of the housing is connected to the radially outer portion of the recess 27 behind the outer side of the packer by a series of slots 39 formed in the bridging ring 40 to permit well pressure to act over the outer side of the packer.

The constricting segments 36 are circumferentially spaced to permit them to move radially inwardly to constrict the packer. As will be apparent from Fig. 5, they are caused to move in unison by means of pins 60 connecting the opposite ends of adjacent segments. Thus, one end of each pin is threadedly received in a socket 61 in one segment, while its other end is slidably received in a socket 62 in an adjacent segment. Each segment is so moved by means of a piston 63 having a seal ring 69 slidable within a cylinder 64 extending inwardly from the outer side of body 25 of housing 21. Each piston is connected to a segment 36 by a rod 66 having a stud 65 threadedly connected between a socket on the inner end of the rod and a central hole in the segment. Each rod 66 extends through a seal such as an O-ring 67 carried within an opening 68 through the housing 25 between the recess 27 and a cylinder 64.

Upon removal of the cap 26 from the body 25 of the housing, the packer 33 may be lifted from or lowered into the recess 27. With the packer removed from the recess, access may be had to the segments 36 for replacing or repairing them. Thus, the threaded connection of each stud 65 to the piston rod enables the rod to be disconnected from the stud, so that the segment may be withdrawn and removed from its operating position within the recess 27.

The outer ends of cylinders 64 are closed by means of a ring 70 which surrounds body 25 and is seated on a shoulder 71. This ring is normally prevented from moving inwardly by a pin 70a removably connected to cap 26. However, when the pin is removed, the ring may be lifted from and lowered into position for closing the cylinders 64. When lifted, the ring 70 permits access to any one or all of the pistons 63 for replacing or repairing them. Due to the threaded connection of the piston rod 66 to the stud 65, the piston may be rotated so as to release it from the stud 65 and permit it to be withdrawn from its cylinder 64.

Seal rings 72 and 73 about body 25 above and below cylinders 64 seal with respect to ring 70 to form an annular space about pistons 63 into which pressure fluid may be introduced through a conduit 74 connecting with a passageway 75 leading thereto. This pressure fluid urges the pistons inwardly and thus the packer to a constricted position.

Alternatively, pressure fluid may be introduced into cylinders 64 on the inner side of pistons 63 to urge them outwardly and permit the packer to expand. This fluid is introduced through a conduit 75a connecting with an annular passageway 76 which is formed from the lower side of the body 25 and then covered by a ring 77 welded to the body. Individual passageways 78 then connect passageway 76 with the inner end of each cylinder 64.

Packer 33 includes a massive annulus 34 of rubber-like material having its bore 35 formed therethrough and a circular series of rigid inserts 41 which extend through the annulus from one end to the other. Each such insert is bonded to the annulus and includes a rib 42 having a flange 43 at each end which overhangs the rib on all sides, as best shown in Figs. 8 and 9. The ribs are disposed generally midway between the bore 35 and the outer side of the annulus, while the flanges are disposed with their innermost edges 43a flush with the bore when the annulus is unconstricted.

The outermost edges 43b of the flanges 43 of the ribs of the packer illustrated in all but Figs. 4A and 4B are disposed inwardly of the outer side of the annulus to leave an annular portion at each end of the annulus surrounding the flanges. Each annular portion is substantially coplanar with the end surfaces of the flanges 43 but protrudes slightly

at 44 beyond the adjacent end surfaces of the flange 43 for engaging the opposite end surface of recess 27. Inward movement of the segments 36 constricts the packer, urging the top protuberance upwardly against the upper end of the recess to supplement the action of well pressure on the lower end of the packer.

In the packer modification illustrated in Fig. 4A, an annular surface 44a protrudes from an annular portion of the packer annulus intermediate the inner and outer edges of the flanges. Thus, this annular portion is received within grooves 44b across the outer sides of the flanges 43. In the other packer modification illustrated in Fig. 4B, an annular surface 44c protrudes from an annular portion of the annulus and is received within grooves 44d formed in the rear outer corners of the flanges 43. As in the case of the surface 44, each of the protruding surfaces 44a and 44c on the upper end of the packer is substantially coplanar with the end surfaces of the flanges 43 and is urged upwardly against the upper end of the recess 27 as the packer is constricted.

Although the protruding surfaces on the lower end of the annulus may also form a seal against the lower end 27b of the recess, the lower portion 22b of the bore is nevertheless connected through slots 39 to the recess behind the annulus. Thus, well pressure will still have access to the recess 27 behind the outer wall of the annulus. Since the protruding surface on the upper end of the annulus seals with respect to the upper end 27a of the recess, the differential between this well pressure and atmospheric pressure in the upper portion 22a of the bore is effective over a substantial portion of the height of the packer to supplement the force of the actuators of the segments 36 in maintaining the annulus in its constricted position.

Inasmuch as the packer is symmetrical end-for-end, it may be disposed in the recess 27 of the housing with either end up. Thus, if an upper protruding surface is damaged, the packer may be inverted to dispose the effective lip at its upper end.

As the packer is constricted, the rigid inserts 41 are also caused to move inwardly, although to a lesser extent than the annulus itself. That is, as will be appreciated from a comparison of Figs. 1 and 2 with Figs. 6 and 7, upon constriction of the packer, the vertically mid-portion of its bore 35 will move radially inwardly past the innermost edges 43a of the flanges 43 of the inserts. As the rigid inserts move inwardly, these innermost edges of the flanges move into the bore 22 of the housing to overhang a substantial portion of the annulus which has moved into the bore 22, thereby reducing the likelihood of extrusion of the annulus past the flanges.

Flanges 43 of the inserts are arranged radially with respect to the axis of the annulus so that each flange has outwardly diverging sides and is bisected by a radius of the annulus. As seen in Figs. 3 and 4 the opposite sides of adjacent flanges 43 are spaced apart with little rubber between them in the unconstricted position of the packer to permit the sides of the flanges to move circumferentially toward one another as the flanges move radially inwardly. The small amount of rubber which is shown in Fig. 3 between the opposite sides of adjacent flanges 43 results from the molding process used to make the annulus, and for the sake of clarity has been ignored in the preparation of the other Figures.

The opposite sides of the rib 42 of each insert are parellel to one another and disposed angularly with respect to radii of the annulus intersecting such sides, and thus angularly with respect to the radial vertical plane bisecting the flanges. More particularly, and in accordance with the invention of the parent Application the opposite sides of rib 42 are disposed approximately within planes of least strain of the rubber of the annulus during movement of the annulus from unconstricted to constricted positions, so as to reduce the likelihood of breaking the bond between the ribs and the annulus, with consequent reduction of its effective life.

An approximation of the angles which such planes make with a radius of the annulus may be easily determined for particular cases by those skilled in the art, and Fig. 10 illustrates a method for doing so. Thus, since constriction of the annulus causes the innermost portions thereof to move inwardly a greater distance than the outermost portions thereof, the intermediate area of the annulus surrounding each rib 42 is caused to change shape during constriction. For example, as shown in Fig. 10, a circular area A of the annulus, having a diameter equal to the length of rib 42 in its unconstricted position, is changed to a somewhat egg-shaped area B when constricted.

Although the shape of this area has changed, there are nevertheless two diameters of area A which remain constant in length during transformation to area B. Either of these diameters defines an approximate vertical plane of least strain.

Obviously, the location of these planes of least strain and thus the arrangement of the ribs will be dependent upon the extent to which the annulus is to be constricted in use. However, in practice, it is possible to design for planes of least strain in the predominant use of the preventer, which may for example be for sealing about a drill pipe of given size. It has been found that excellent results are obtained by disposing the sides of the rib at an angle of about 45° to the radius bisecting

such sides.

The reader's attention is directed to our co-pending Application No. 39895/69, Serial No. 1266556 from which the presciut Application has been divided, and which describes and claims a packer for use in an annular blowout preventer, comprising an annulus of deformable material, and a substantially circular series of rigid inserts bonded to the annulus, each insert including a rib having opposite sides which lie generally within planes of least strain in said material as the annulus is radially constricted.

WHAT WE CLAIM IS:—

1. A packer for disposal within a recess in the bore of the housing of an annular blowout preventer, comprising an annulus of deformable material, and a substantially circular series of rigid, circumferentially relatively movable inserts extending through the annulus from one end to the other, each said insert including a rib and there being flanges on the ends of the ribs on at least one end of the annulus, said annulus having an annular surface at said one end which is substantially coplanar with the end surfaces of said flanges for sealing against an oppositely facing end surface of the housing recess.

2. A packer according to claim 1, wherein said sealing surface is adjacent the outer side of said annulus.

3. A packer according to claim 1 or claim 2, wherein said annular sealing surface protrudes beyond the end surfaces of the flanges at said one end of the annulus.

4. A packer according to any preceding claim wherein there are flanges on both ends of each rib, and there is a sealing surface on each end of the annulus, so that the packer may be disposed with either end for sealing against said end surface of the housing recess.

5. A packer according to any preceding claim, wherein the outer side of the annulus is constricted simultaneously with constriction of its bore.

6. An annular blowout preventer comprising a housing having a bore extending therethrough, an annular recess extending outwardly from the bore through the housing, and a packer according to any preceding claim disposed within said annular recess with the bore of the packer being substantially axially aligned with the bore through said housing.

7. A blowout preventer according to claim 6, including means within the recess and about the outer side of the annulus for constricting the annulus and urging said annular surface or surfaces into tight sealing engagement with the end or ends of said recess.

8. A blowout preventer according to claim 7, wherein said annulus constricting means comprises circumferentially separated, laterally extending segments having inner arcuate surfaces for substantially surrounding the outer side of the annulus within the recess, and pistons reciprocable within the housing for moving the segments inwardly and outwardly.

9. A blowout preventer according to claim 8, wherein a series of cylinders extend into the housing from its outer side, a piston is sealably slidable within each cylinder, rods extend sealably within the housing to connect each packer constricting segment with a piston, there is a fluid connection with each cylinder on the inner side of the piston, a ring is disposable about the outer side of the housing to sealably cover the outer ends of the cylinders, and there is a fluid connection to the space between the outer side of each piston and the inner side of the ring.

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9. A blowout preventer according to claim 8, wherein a series of cylinders extend into the housing from its outer side, a piston is sealably slidable within each cylinder, rods extend sealably within the housing to connect each packer constricting segment with a piston, there is a fluid connection with each cylinder on the inner side of the piston, a ring is disposable about the outer side of the housing to sealably cover the outer ends of the cylinders, and there is a fluid connection to the space between the outer side of each piston and the inner side of the ring.

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