PATENT SPECIFICATION (11) 1 266 557

DRAWINGS ATTACHED

(21) Application No. 39896/69 (22) Filed 8 Aug. 1969
(31) Convention Application No. 765 061 (32) Filed 4 Oct. 1968 in
(33) United States of America (US)
(45) Complete Specification published 15 March 1972
(51) International Classification E 21 b 33/06
(52) Index at acceptance
E1F 44

(72) Inventors MARVIN RICHARD JONES
BENTON FREDERICK BAUGH

1 266 557

(54) IMPROVEMENTS RELATING TO WELL BLOWOUT PREVENTERS AND PACKERS THEREFOR

(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 annular blowout preventers and packers therefor.

As well known in the art, a blow out 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 rubber whose bore is adapted to be radially constricted. In one such annular blowout preventer, 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 construction. 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 constructed.

The flanges are arranged radially of the annulus and the sides of adjacent flanges are spaced apart so that they may move inwardly as the annulus is constricted. The radially innermost ends of the flanges are disposed substantially adjacent the bore of the annulus in the unconstricted position of the annulus, so that as the annulus is constricted, these ends will move into the bore of the preventer housing. Thus, even though the bore of the annulus moves inwardly beyond the inner ends of the flanges, the latter overhang a sufficient portion of the annulus to prevent its being blown out by well pressure.

Obviously, however, as the packer is used to close off on itself, or even on small objects in the bore of the preventer housing, a greater amount of overhang may be required. With the preventer shown in the aforementioned patent, this could be accomplished only by reducing the diameter of the housing bore or by extending the inner ends of the flanges into the housing bore, which would reduce the effective or useful diameter therethrough when the packer is unconstricted. The operating conditions for which the preventer is designed do not normally permit this.

Also, since there are spaces between the sides of the flanges, the portions of the annulus beneath these spaces must be recessed. Otherwise, the annulus would be extruded into the spaces and thereby either cause the extruded rubber to be pinched off or prevent full and uniform inward movement of the inserts.

With a view to avoiding at least to some degree disadvantages of the prior construction above referred to, the invention provides a packer for use in an annular well blowout preventer, comprising an annulus of deformable material having a bore therethrough, and a substantially circular series of rigid elements on at least one end of the annulus, the radially innermost ends of the elements being substantially adjacent the bore, when the annulus is unconstricted, and the elements having end surfaces arranged generally perpen-

dicular to the bore and being responsive to movement of said material so as to swing from skewed to more radially disposed positions with respect to said bore as the annulus is constricted.

Preferably said rigid elements are plates, and the sides of the plates are wedge-shaped in plan and adjacent one another to confine the annulus against extrusion between them and to cause them to move in unison as the annulus is constricted. In the illustrated embodiment of the invention, the plates are arranged at both ends of the annulus so that the packer may be arranged in the preventer housing with either end up. Preferably, ribs extend through the annulus in circularly spaced apart relation, and each is connected to a plate at each end which overhangs the rib to form a flange. This controls to some extent the flow of the resilient annulus material and minimizes the tendency for the overhanging ends of the plates to bend under pressure.

One embodiment of the invention will now be described by way of example only with reference to the accompanying drawings, in which:—

Fig. 1 is a perspective view of an annular blowout preventer embodying 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. 2A is a partial top plan view of the packer of the preventer of Figs. 1 and 2, as seen along line 2A--2A of Fig. 2, with the packer in its unconstricted position and showing in broken lines the ribs of its rigid inserts;

Fig. 3 is a vertical sectional view through a portion of the packer, upon an enlarged scale and as seen along broken line 3--3 of Fig. 2A;

Fig. 4 is a cross-sectional view, on an enlarged scale and as seen along broken line 4--4 of Fig. 2, of a connection between adjacent packer constricting parts which synchronize their radial movement;

Fig. 5 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. 5A is a top plan view of the packer, as seen along line 5A--5A of Fig. 5 and similar to Fig. 2A, but with the packer in the constricted position of Fig. 5;

Fig. 6 is another partial sectional view similar to Fig. 5, but showing the packer in a further constricted position to close an open hole in the bore of the preventer housing;

Fig. 6A is a top plan view of the packer, as seen along line 6A--6A of Fig. 6, and similar to Fig. 2A but with the packer in the constricted position of Fig. 6;

Fig. 7 is a perspective view of a rigid insert; and

Fig. 8 is a horizontal sectional view of the insert, as seen along broken line 8--8 of Fig. 7.

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 lower end of body 25, the two bores thus forming the bore 22 through the housing. Body 25 includes a bridging ring 40 (to be described below), and 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 extending 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 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 move-

ment 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. 5, or for sealing upon itself when the bore is empty, as best shown in Fig. 6. As will be described in detail below, the packer is 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 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 series of slots 39 formed in a 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. 4, 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 cylinder 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 upwardly 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 cylinder 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. 7 and 8. The ribs are disposed generally midway between the bore 35 and the outer side of the annulus, while the flanges are disposed with their radially innermost ends 43a flush with the bore when the annulus is unconstricted.

The radially outermost ends 43b of the flanges 43 are disposed inwardly of the outer side of the annulus to leave an annular portion at each end of the annulus surrounding the flanges. As best shown in Fig. 3, each annular portion is substantially coplanar with the end surfaces of the flanges 43 but protrudes slightly at 44 beyond the adjacent end surface 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.

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. 5 and 6, upon constriction of the packer, the vertically mid-portion of its bore 35 will move radially inwardly past the innermost end 43a of the flanges 43 of the inserts. As the rigid inserts move inwardly, these innermost ends move into the bore 22 of the housing to overhang a portion of the annulus which has moved into the bore 22, thereby reducing the likelihood of extrusion of the annulus past the flanges.

As shown in Fig. 2A, when the packer is unconstricted, the flanges 43 are skewed with respect to the bore of the packer. Thus, the axis of each flange—i.e., a plane bisecting the flange from end to end—extends at an acute angle with respect to a radius of the packer which passes through the centroid of the flange. Since constriction of the annulus causes its inner portions to move radially inwardly at a greater rate than the outer portions thereof, and the rigid inserts 41 are bonded to the annulus, the flanges will swing to a more radial orientation with respect to the packer bore. Thus, as can be seen from the drawings, the flanges swing from the skewed positions of Fig. 2A, when the packer is unconstricted, to a more radial position when the packer is constricted to seal about a pipe, as shown in Fig. 5A, and to a still more radial position when the packer is constricted to seal upon itself, as shown in Fig. 6A.

Thus, the effective radial extent of each flange—i.e., the radial distance between the radially innermost and outermost ends 43a and 43b thereof—increases during constriction of the packer. This is in contrast to the behaviour of initially radially disposed flanges, as in the packers of the above mentioned patent, which have the same effective radial extent at all degrees of constriction of the packer. As a result, the rigid inserts of the packer of the present invention occupy less initial space for a given amount of subsequent overhang.

As in the packer of the previously mentioned patent, the rubber forming the annulus is free to flow between the circularly spaced apart ribs 42 as the packer is constricted. However, as distinguished from the prior packer, the sides of the flanges 43 of adjacent inserts 41 engage one another in both the unconstricted and constricted positions of the annulus. Thus, as previously described, the rubber at opposite ends of the annulus is confined against extrusion between the flanges. Also, no one flange at an end of the annulus is free to move without movement of the remainder, so that in fact all the flanges and thus the inserts move in unison.

The opposite sides of the rib 42 of each insert are parallel to one another and arranged with the vertical plane bisecting each rib disposed at an acute angle to the radius of the annulus passing through the centroid of the rib. More particularly, as described and claimed in our copending Application No. 39895/69 (Serial No. 1 266 556), 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.

These planes of least strain may extend at acute angles on either side of the radius. However, in the case of the inserts 41, which swing as a whole toward more radial positions during constriction of the annulus, it is preferred that the sides of the rib be so disposed as to also be swung to more radial positions as the annulus is constricted. In this way, the ribs do not detract from the tendency of the inserts 41 to twist as a whole toward their more radial positions.

WHAT IS CLAIMED IS:—

1. A packer for use in an annular well blowout preventer, comprising an annulus of deformable material having a bore therethrough, and a substantially circular series of rigid elements on at least one end of the annulus, the radially innermost ends of the elements being substantially adjacent the bore, when the annulus is unconstricted, and the elements having end surfaces arranged generally perpendicular to the bore and being responsive to movement of said material so as to swing from skewed to

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more radially disposed positions with respect to said bore as the annulus is constricted.

2. A packer as claimed in Claim 1, wherein the rigid elements are arranged on each end of the annulus and ribs extend through the annulus each to connect a pair of elements.

3. A packer as claimed in Claim 1 or Claim 2, wherein the sides of the rigid elements converge toward their innermost ends.

4. A packer as claimed in Claim 3 wherein the sides of adjacent rigid elements lie against one another to confine the annulus and cause said elements to swing in unison.

5. A packer as claimed in any of Claims 1 to 4 wherein said rigid elements are plates of uniform thickness.

6. For a well blowout preventer, a packer substantially as hereinbefore described with reference to the accompanying drawings.

7. A well blowout preventer having a housing defining a bore with an annular recess and a packer as claimed in any one of the preceding claims, within the recess, the bore of the packer being substantially aligned with the bore of the housing.

8. A blowout preventer as claimed in Claim 7, wherein the packer annulus has an annular surface on at least one end which is substantially coplanar with the end surfaces of the plates for sealing against an oppositely facing end surface of the recess in the blowout preventer housing.

TREGEAR, THIEMANN & BLEACH,
Chartered Patent Agents,
Melbourne House,
Aldwych,
London, W.C.2.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1972.
Published at the Patent Office, 25 Southampton Buildings, London WC2A 1AY from which copies may be obtained.

