Feb. 4, 1964 C. B. COCHRAN 3,120,272

CUP-SEAL FOR WELL TOOLS

Filed July 5, 1962 3 Sheets-Sheet 1

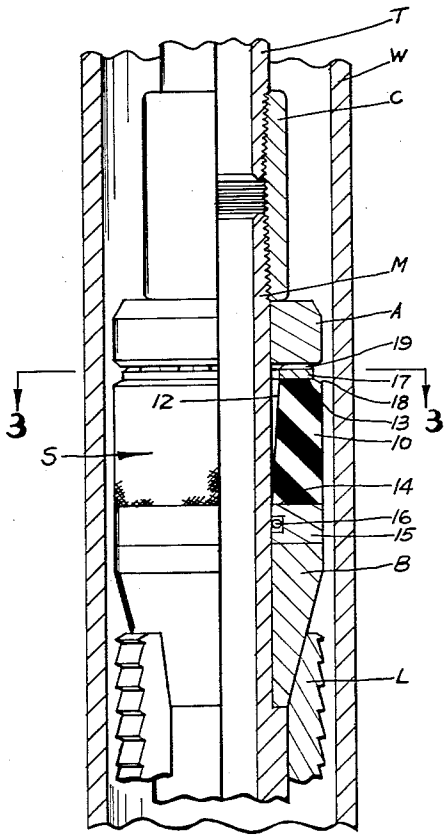


Fig. 1

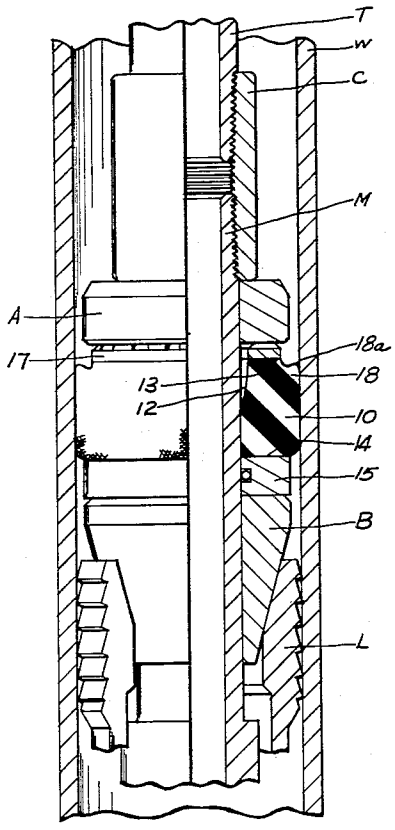


Fig. 2

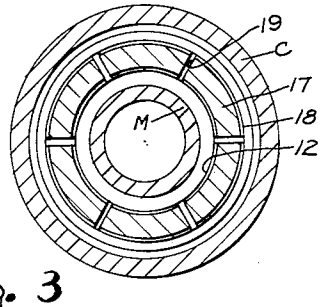


Fig. 3

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CUP-SEAL FOR WELL TOOLS

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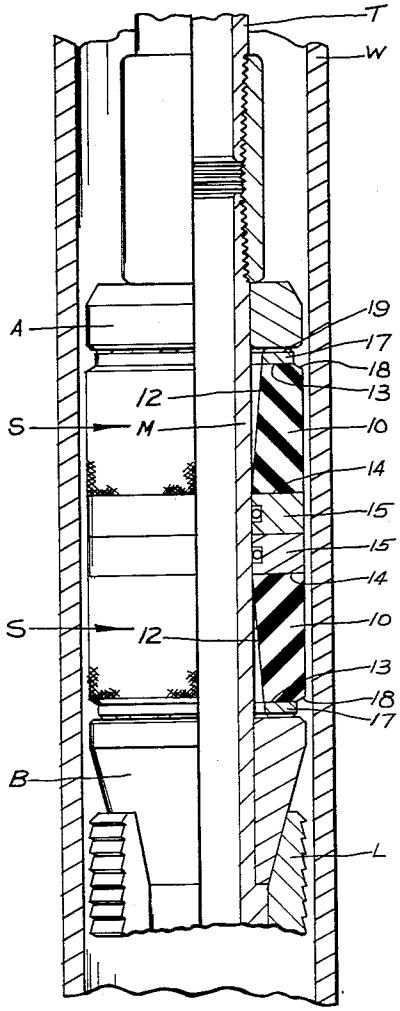


Fig. 4

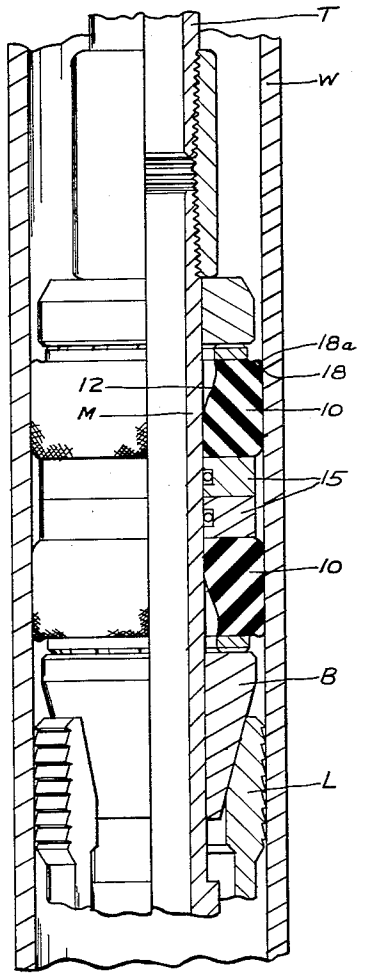


Fig. 5

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CUP-SEAL FOR WELL TOOLS

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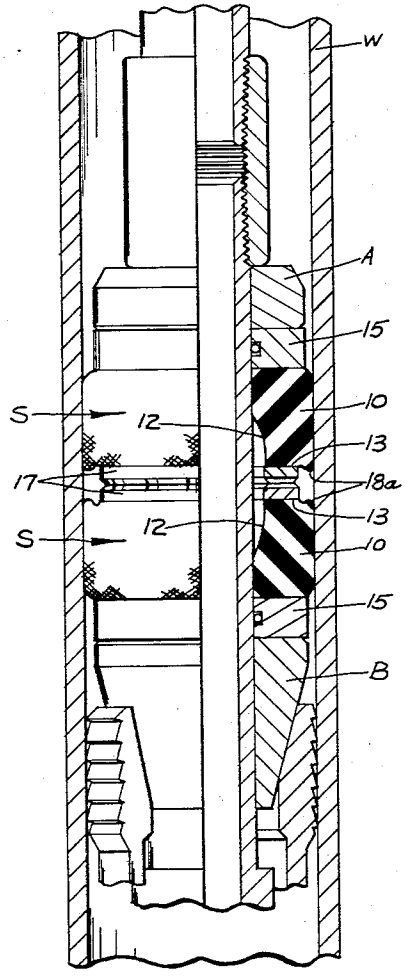


Fig. 6

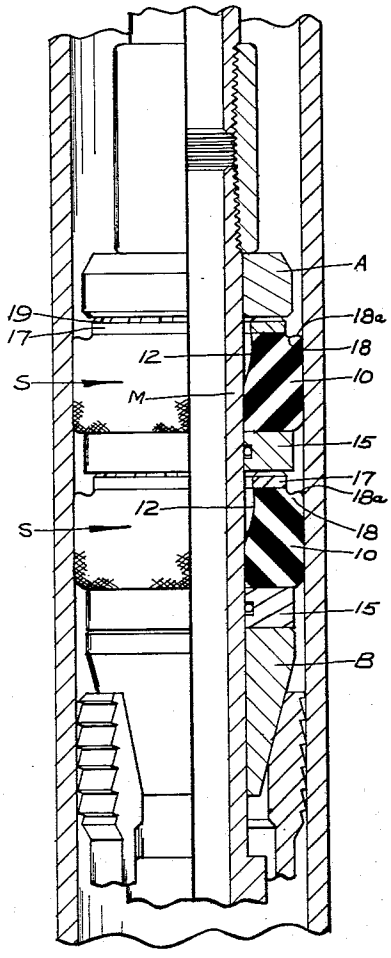


Fig. 7

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3,120,272

# CUP-SEAL FOR WELL TOOLS

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6 Claims. (Cl. 166—202)

This invention relates to cup-type seals for well tools, and particularly to well packers employing cup-type seals.

Conventional cup-type seals employed in well tools for sealing between a tool which is run into the well bore and the wall of the well, particularly the well casing, are every efficient seals but have the serious disadvantage that to be operable the exterior of the cup must be in continuous contact with the wall of the well casing as it is run into the well, and this, therefore, necessarily produces dragging or frictional engagement with the pipe wall which will wear out or seriously damage the flexible composition material commonly comprising the cup seal.

Also, by reason of the continuous sealing contact such cup seals necessitate the employment of some type of fluid by-pass means in the seal support structure to enable the cup seal to be lowered through fluid in the well bore and further mechanism is required for closing the by-pass means when the sealing location is attained in order to make the cup seal effective.

A principal object of this invention, therefore, is to provide an improved form of cup seal which possesses the important advantages of cup-type seals without the disadvantages of more conventional cup-type seals.

A primary object of this invention is to provide a form of cup seal which, in movement or running condition, is retracted relative to the pipe into which it is run, so as to provide substantial clearance between the seal and the wall of the pipe when it is being run, thereby avoiding the wear to which conventional cup seals are subjected and providing adequate by-pass capacity for well fluids encountered during the running of the device.

In accordance with this invention, a cup seal unit is provided which comprises an annular seal body constructed of fexible resilient material having a cylindrical outer surface, the diameter of which, in the normally retracted condition, is substantially less than the inner diameter of the well bore wall with which it is to seal. The body has a bore which tapers inwardly from one end toward the other, thereby providing one end portion having substantially lesser radical thickness than the other. This thinner walled end-portion is herein termed the "lip portion." A metallic back-up ring is molded to the thicker walled end of the seal body and has internal and external diameters which are substantially flush with the inner and outer diameters of the thicker end of the seal body. A metallic lip-support ring is molded to the end face of the lip portion and has an internal diameter substantially flush with the internal diameter of the end of the lip portion and an external diameter somewhat less than the external diameter of the lip portion to thereby provide an annular end section on the lip portion which extends radially outwardly with respect to the external periphery of the lip-support ring and is unsupported thereby. This annular unsupported section of the lip portion is one of the important features of the cup seal in accordance with this invention as will appear subsequently. Radial openings or passages are provided through the lip-support ring for admitting well fluid to the interior of the seal body.

By means of the construction just described, when endwise compression is applied to the ends of the seal body through the metallic rings secured thereto, the seal body will be compressed and radially expanded into sealing engagement with the pipe wall. When this occurs, fluid pressure can enter the bore of the seal body through the openings provided in the lip-support ring and exert internal presusre against the inner wall of the seal body to increase its sealing pressure against the pipe wall.



The seal unit in accordance with this invention will be mounted on a tubular support member, which may be a part of a well packer or the like, and which carries a pair of longitudinally spaced abutments movable longitudinally relative to each other by suitable means by which the forementioned end-wise compression may be applied to the seal body.

Further, in accordance with this invention, a plurality of seal units in accordance with this invention may be mounted on a single support member. Generally two seal units will be mounted in end-abutting relation between the relatively movable abutments, usually with the lip portions facing in opposite directions. In other instances, two or more of the seal units may be mounted between the abutments with their lip portions facing in the same direction.

In still another modification, a pair of seal units may be mounted on the support member between the abutments with the lip portions facing toward each other and in abutting relation.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates several useful embodiments in accordance with this invention.

In the drawing:

FIG. 1 is a longitudinal quarter sectional view showing one of the seal units in accordance with this invention mounted on a well tool for sealing against high pressures from above, the seal unit being shown in retracted or unset position;

FIG. 2 is a view similar to FIG. 1 showing the seal unit in set position;

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a longitudinal quarter sectional view of a modification showing a pair of the seal units mounted with their lip portions facing in opposite directions, the seal units being shown in the unset position;

FIG. 5 is a view similar to FIG. 4, showing the seal units in set position;

FIG. 6 is a view generally similar to FIG. 4, showing a pair of the seal units with their lip portions facing toward each other and in set position; and

FIG. 7 is a view generally similar to FIG. 6, illustrating still another modification wherein two of the seal units are employed with the lip portions facing in the same direction and shown in set position.

Referring to the drawing and to FIGS. 1 to 3, inclusive, a seal unit, designated generally by the letter S, is shown mounted on a tubular support member M, which may be a packer mandrel or body adapted to be secured to a tubing string T by means of a threaded collar C. Seal unit S is mounted between an upper abutment A, which may be a metal ring mounted on mandrel M, and limited against upward movement by the end of collar C. The lower end of unit S is in abutting engagement with a second abutment B, which may be the expander cone of a packer, co-operating with conventional slips L by which the packer is anchored to the wall of a well casing W. Abutments A and B, it will be recognized, are longitudinally movable toward each other. In one instance, abutment A may be fixed and abutment B, the slip cone, may be urged upwardly toward the upper abutment by the upward movement of slips L, which may be effected by a hydraulically actuated cylinder, as in C. C. Brown Patent No. 2,982,538, or by other conventional mechanism by which the lower abutment B may be urged toward abutment A. On the other hand, when lower abutment B has been fixedly positioned, as by engagement of

slips L with the wall of casing W, lower abutment B becomes the stationary abutment and downward movement of tubing T may be applied to upper abutment A to move the latter downwardly toward lower abutment B, whereby upper abutment A becomes the movable abutment.

In either event, it will be evident that longitudinal movement of the abutments with respect to one another will serve to apply end-wise compression to seal unit S, for purposes which will appear hereinafter.

Seal unit S includes an annular seal body 10 constructed of any of the well-known flexible resilient composition materials commonly used for such sealing elements. Seal body 10 has a cylindrical outer surface 11 having a normal or retracted external diameter which is made to be substantially smaller than the internal diameter of casing W, so that when the device is run into the bore of the casing a substantial amount of annular clearance will be provided for by-passing fluid which may be present in the well casing and to prevent drag of the seal body on the casing wall. Seal body 10 has a bore 12 which tapers inwardly toward the axis of the body from the outer end of one end portion 13 to the outer end of the other end portion 14. In the embodiment illustrated in FIG. 1, end portion 13 is the upper end, while end portion 14 is the lower end of the seal body. By reason of the tapered bore, upper end portion 13 will have a radial thickness substantially less than that of lower end portion 14, and end portion 13 is designated herein as the "lip" or "lip portion" of the sealing element. Lower end portion 14, sometimes termed the "base portion," is molded or vulcanized to a metallic back-up ring 15 having internal and external diameters such as to be substantially flush with the internal and external diameters of end portion 14. A packing ring 16 such as a conventional O-ring, is seated in the bore wall of back-up ring 15 and is adapted to form a slidable seal about the exterior of mandrel M. A metallic lip-support ring 17 is molded to the end face of end portion 13. Lip-support ring 17 has an internal diameter substantially equal to the internal diameter of lip portion 13 and is molded thereto so that the inner diameter of lip-support ring 17 will be substantially flush with the inner diameter of end portion 13. The radial thickness of lip-support ring 17 is made less than the radial thickness of the lip portion 13, whereby to provide an annular section 18 on end portion 13 which extends radially outwardly relative to the outer periphery of lip-support ring 17, so as to be unsupported thereby. A plurality of angularly spaced radial slots or grooves 19 is provided in lip-support ring 17 to permit fluid communication between the exterior of the seal body and bore 12 of the seal body.

Operation of the above-described device is as follows: The seal unit will be mounted as shown in FIG. 1 and run into well casing W to the point at which the seal is to be set, thereupon the anchoring elements are actuated in whatever manner may be provided in the structure on which the seal unit is run in order to anchor lower abutment B against further downward movement. Thereupon, downward movement of tubing T will serve to apply weight through collar C and upper abutment A to lip support ring 17 and thence will exert end-wise compression against seal body 10, the lower end of which will be supported by back-up ring 15 and lower abutment B. This end-wise compression will radially expand seal body 10, as shown in FIG. 2, with the result that unsupported annular section 18 will tend to flow upwardly along the wall of casing W and form a narrow sealing lip 18*a* which will extend upwardly along, and in tight sealing engagement with, the wall of casing W. Thereupon, the pressure of any fluid inside well casing W, above the seal unit, will flow through openings 19 into bore 12 and will exert internal pressure against the wall of bore 12, thereby intensifying the sealing pressure exerted by seal body 10 against the wall of casing W and completing an effective pressure-tight seal between tubing string T and casing W. Packing ring 16 assures against escape of fluid pressure between mandrel M and the seal unit. The radial width of unsupported annular section 18 will generally be made in the range of about ⅛ inch to about 3/16 inch for most conventionally sized packers, i.e., 5 inch or 7 inch diameter.

FIG. 4 illustrates another embodiment in which two identical seal units S are mounted between upper and lower abutments A and B, the seal units being disposed with back-up rings 15 in abutting relation and lip portions 13 facing away from each other, as shown. When the packer, in accordance with this embodiment is set, as shown in FIG. 5, the seal bodies 10 will be effective to seal off against fluid pressure from either direction. This is particularly advantageous because in many well operations pressure differentials may reverse direction during the course of such operations and it is of great value to provide a packing arrangement which will be effective in sealing off, irrespective of the direction of the pressure differential.

It will be understood that in the packer construction, as illustrated in FIGS. 4 and 5, when the pressure differential, for instance, is from above, lip 18*a* will prevent the hydraulic pressure or "hydraulic wedge," as it is commonly known, from flowing between the exterior of seal body 10 and the wall of casing W, and as in the case of a conventional cup seal, once the packer has been set, the higher the pressure entering the bore of the seal body, the tighter the resulting seal with the casing wall.

FIG. 6, which illustrates a modification of the packer of FIGS. 4 and 5, shows an arrangement in which two of the seal units are disposed with their lip portions in opposed relation. This type of seal arrangement will be equally effective against pressures from either direction, for although both seal bodies will have been expanded through end-wise compression into engagement with the wall of casing W, fluid pressure from above, for example, will flow past the upper seal unit and will enter the bores of both seal bodies through the passages provided in the respective lip-support rings. However, this pressure will act against the interior of the lower seal body and provide the sealing pressure against the casing wall to seal off against the pressure from above in exactly the same manner as in the case of the embodiment of FIG. 1 and on the upper seal member S of FIG. 4. If the pressure reverses, the upper one of seal units S will be actuated.

In the modification of FIG. 7 wherein the seal units face in the same direction, the lower one, in this illustration where the seal units are positioned to seal off against higher pressure from above, will act as a back-up for the upper one of the seal units, should the latter develop a leak. It will be evident that if the upper one is actuated by the pressure, this flow of pressure cannot reach the lower seal unit until and unless leakage occurs past the upper one of the two units.

In every instance, it will be noted that this invention employs a metal back-up ring which has inner and outer diameters which are substantially flush with the inner and outer diameters of the thicker or base end portion of the seal body, while the lip-support ring has a lesser external diameter than the seal body to provide the unsupported annular section of the lip portion. With this arrangement the larger diameter back-up ring will provide strong support against flow under pressure of the material comprising the base end of the seal body, while some freedom will be permitted for flow of the unsupported material about the periphery of the lip-support ring sufficient to form the tapered wall-sealing lip, as illustrated. Moreover, another important function of lip-support ring 17 is to constrain lip portion 13 from flaring outwardly during running of the device and thereby preventing premature setting of the seal element by fluid by-passing the seal element as the device moves downwardly therethrough.

It will be evident that various other modifications and re-arrangements of the seal units may be made in accordance with this invention within the scope of the appended

claims, but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. A cup-seal for well tools, comprising, an annular seal body constructed of flexible, resilient material, the exterior surface of said body being cylindrical and of a lesser diameter than the bore of a pipe into which it is to be run, the bore of said body tapering inwardly from one end thereof toward the opposite end thereof to thereby define an annular lip portion at said one end having a lesser radial thickness than said opposite end, a metallic back-up ring affixed in abutting relation to said opposite end, the inner and outer peripheries of said back-up ring being substantially flush with the inner and outer peripheries of said opposite end, a metallic lip-support ring affixed to the end face of said lip portion, said lip-support ring having an inner diameter substantially flush with the inner diameter of said lip portion and an outer diameter somewhat less than the external diameter of said lip portion whereby to provide an annular end section of said lip portion which extends radially outwardly with respect to said lip-support ring, said lip-support ring having radial passage means therethrough adapted to provide fluid communication between the exterior of said seal body and the bore thereof.

2. A cup-seal for well tools, comprising, an annular seal body constructed of flexible, resilient material, the exterior surface of said body being cylindrical and of a lesser diameter than the bore of a pipe into which it is to be run, the bore of said body tapering inwardly from one end thereof toward the opposite end thereof to thereby define an annular lip portion at said one end having a lesser wall thickness than said opposite end, a metallic back-up ring affixed in abutting relation to said opposite end, the inner and outer peripheries of said back-up ring being substantially flush with the inner and outer peripheries of said opposite end, a metallic lip-support ring affixed to the end face of said lip portion, said lip-support ring having an inner diameter substantially flush with the inner diameter of said lip portion and an outer diameter somewhat less than the external diameter of said lip portion whereby to provide an annular portion of said lip portion which extends radially outwardly with respect to said lip-support ring, said lip-support ring having radial passage means therethrough adapted to provide fluid communication between the exterior of said seal body and the bore thereof, and an annular seal packing mounted in the bore of said back-up ring for slidable sealing engagement with a tubular body extending therethrough.

3. A cup-seal packer for well tools to be lowered inside a well pipe, comprising, a tubular support member, longitudinally spaced abutments mounted on the support member and movable longitudinally with respect to each other, a cup-seal member mounted about the body between said abutments for end-wise compression therebetween, said cup-seal member comprising an annular seal body constructed of flexible, resilient material, the exterior surface of said body being cylindrical and having a lesser diameter than the bore of said pipe string, the bore of said body being tapered inwardly from one end thereof toward the opposite end thereof to thereby define an annular lip portion at said one end having a lesser wall thickness than said opposite end, a metallic back-up ring slidably disposed about said support member and affixed in abutting relation to said opposite end and to the adjacent one of said abutments, the inner and outer peripheries of said back-up ring being substantially flush with the inner and outer peripheries of said opposite end, a metallic lip-support ring affixed to the end face of said lip portion and in abutting relation to the adjacent abutment, said lip-support ring having an inner diameter substantially flush with the inner diameter of said lip portion, and an outer diameter somewhat less than the external diameter of said lip portion whereby to provide an annular end-section of said lip portion which extends radially outwardly with respect to said lip-support ring, said lip-support ring having radial passage means therethrough adapted to provide fluid communication between the exterior of said seal body and the bore thereof, and packing means mounted in the bore of said back-up ring to slidably seal about said support member.

4. A cup-seal packer according to claim 3 having a pair of said cup-seal members disposed in abutting end-to-end relation to each other between said abutments with said lip portions facing away from each other.

5. A cup-seal packer according to claim 3 having a pair of said cup-seal members disposed in abutting end-to-end relation to each other between said abutments with said lip portions facing toward each other.

6. A cup-seal member according to claim 3 having a plurality of said cup-seal members disposed in abutting end-to-end relation with said lip portions facing in the same direction.

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