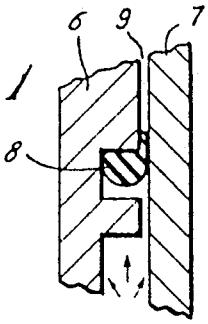
Feb. 7, 1967 J. W. KISLING III 3,302,736

WELL TOOL SEAL

Filed Sept. 12, 1963

Fig. 1



PRIOR ART

Fig. 2

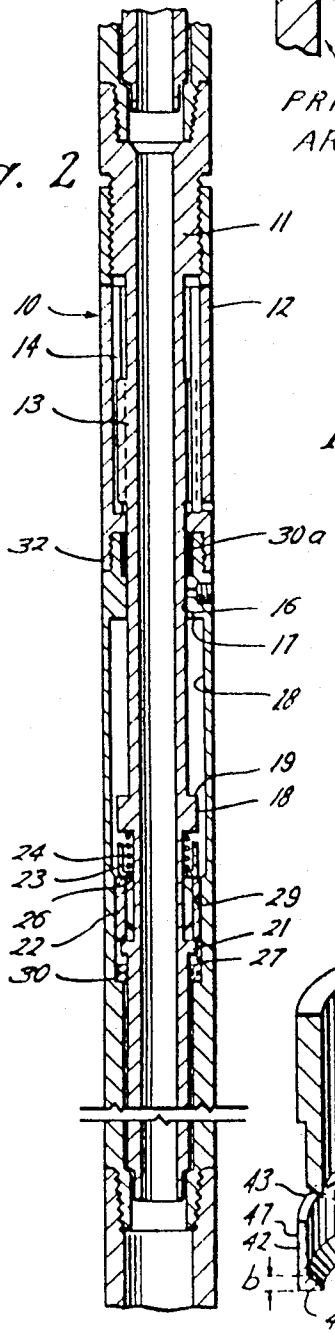


Fig. 3

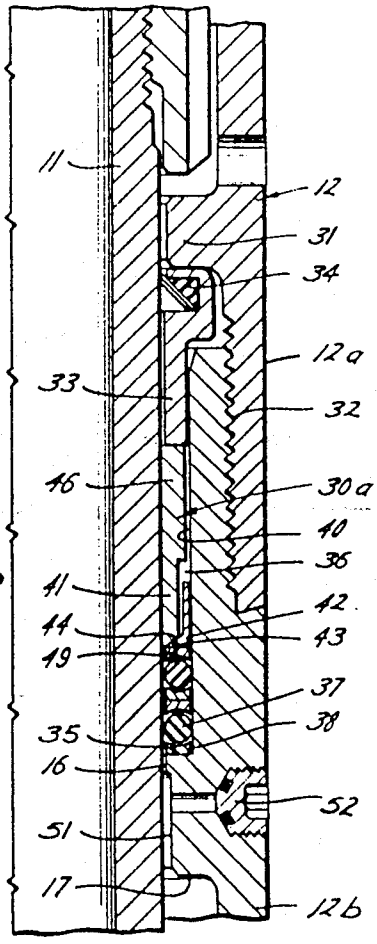
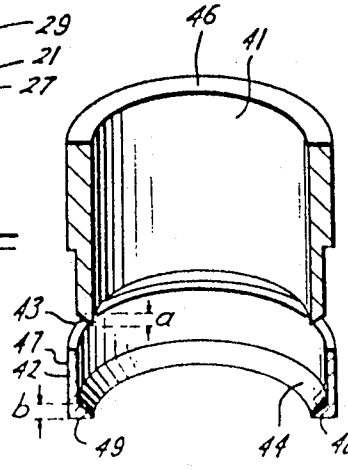


Fig. 4



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WELL TOOL SEAL

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7 Claims. (Cl. 175—297)

This invention relates to a well tool, and more particularly, to a device providing a high pressure seal in a well tool such as a jar.

In a well it is often desirable to test a formation traversed by the well bore. In order to do this, various tools are suspended from a string of drill pipe or an armored electrical cable and used within the well bore. Particularly in open well bores containing mud or other control fluid, the drill pipe or well tool sometimes becomes lodged or stuck in the well bore. To assist in the recovery of a stuck tool, a hydraulic jar device is sometimes included in the string of tools. Hydraulic jar devices operate on the principle of a hydraulically delaying longitudinally moving hammer coupled to the drill pipe, the hammer thereafter being released to strike an anvil attached to the parts stuck in the well. To provide the longitudinal movement and resulting impact force, tension is applied to the drill pipe and the drill pipe is then locked in the drill stand. The initial relative longitudinal movement in the jar is retarded by a hydraulic mechanism to permit the tension to be applied and the drill pipe locked in the drilling stand.

A typical hydraulic mechanism to provide a time delay in a jar is a piston moving in a compression bore to compress a hydraulic fluid in a chamber, the delayed rate of movement of the piston being controlled by a fluid metering orifice bypassing the piston. The jar is provided with a release bore of larger diameter than the diameter of the compression bore which provides a relatively large fluid bypass and release of the piston in the chamber. The compression of the hydraulic fluid produces large magnitude forces within the jar. Thus, the tension which can be applied to a jar is limited by structural limitations of the jar to withstand the hydraulic forces produced therein. These forces sometimes develop a pressure of 40,000 pounds per square inch. In conventional sealing devices used to seal the chambers and telescopically mounted members of the jar, the extreme forces which developed in the jar tend to cause the conventional sealing members made of resilient material to flow into the spaces between the telescopically mounted members or fluids to leak by the sealing device.

Accordingly, it is an object of the present invention to provide a new and improved well tool with a seal which will contain extreme hydraulic pressures.

Another object of the present invention is to provide a new and improved well tool with a non-flowable hydraulic seal which will expand and contract within the chamber to be sealed and permit sliding movement between members of a well tool.

Still another object of the present invention is to provide a new and improved well tool with an expandable primary sealing device and an ordinary sealing means as a secondary sealing device.

Yet another object of the present invention is to provide a new and improved well tool having a seal therein which is formed by beveled rings sliding one upon the other to prevent high pressures from being transferred between chambers formed in telescoping members of the tool.

Still another object of the present invention is to provide telescoping well tool members with a seal which will expand and contract without flowing when subjected to corresponding increases and decreases in pressures developed within the tool and at the same time permit sliding movement between members of the tool.

With these and other objects in view, the present invention contemplates a well tool comprised of telescoping members and a seal device for preventing the transfer of high pressure fluids between two telescoping members. More particularly, the apparatus includes a pair of rings having opposed inclined surfaces formed on the rings. The rings are positioned in a slot communicating with a space between the two telescoping members of the tool. As fluid pressures communicating from the space to the slot change, the rings slide along their inclined surfaces to expand or contract and thereby maintain at all times sealing engagement with the opposed walls of the telescoping members to provide a high pressure seal.

A complete understanding of this invention may be had by reference to the following detailed description when read in conjunction with the accompanying drawings illustrating an embodiment thereof, wherein:

FIG. 1 shows a prior art conventional resilient seal positioned between two telescoping members wherein the seal has been deformed to flow between the members;

FIG. 2 is a vertical section of a hydraulic well jar;

FIG. 3 is a detailed vertical section of a portion of the well jar incorporating the sealing members and embodying the invention; and

FIG. 4 is a detailed sectional view of the sealing rings.

Referring first to FIG. 1, a conventional O-ring seal **8** is shown in between partial sections of a tubular mandrel **6** and housing **7**. The resilient O-ring sealing member **8** normally maintains a fluid tight seal by its diametrical squeeze pressure. However, where fluid pressures (as shown by the arrows) between the tubular members are large in magnitude, the mandrel will tend to contract and the housing will tend to expand so that the O-ring will deform and actually flow into the space **9** between the mandrel and housing. This is particularly true in oil well operations when the members are subjected to high temperatures. If the pressures are sufficiently great, the O-ring can be completely blown out and even when not blown out, relative movement between the mandrel and housing can cut or otherwise destroy the effectiveness of an O-ring which is distorted.

Referring now to FIG. 2, a well jar **10** in accordance with the preferred embodiment of the present invention includes a telescopically mounted mandrel **11** and housing **12**. The mandrel **11** at its upper end has external splines **13** received within internal longitudinally extending splines **14** on the housing co-rotatively securing the mandrel and housing to one another to permit rotation of the drill string through the jar and at the same time permit longitudinal non-rotative movement between the housing and mandrel.

Intermediate the length of the housing is an internal downwardly facing shoulder **17** formed between bore portions **16**, **28** of different diameter, the shoulder **17** being the jar anvil. The mandrel **11** is provided with an upwardly facing shoulder **19** forming a hammer. Valved piston means are provided on the mandrel **11** below the hammer **19** in the form of an enlarged flange **21** on the mandrel **11** on which a tubular metal sleeve **22** sets, the abutment of the sleeve **22** with the flange **21** forming a metal-to-metal fluid tight seal. The sleeve **22** is normally urged toward the enlarged flange by an annular ring **23** slidably received on the mandrel **11** and a spring **24** extending between the ring **23** and lower portion of the mandrel hammer **18**. The lower base portion of the slidably mounted annular ring **23** has circumferentially spaced bypass ports **26**. The tubular sleeve **22** is slidably received within a compression bore **27** in the housing which adjoins the enlarged bore **28**, the compression bore

27 being smaller in diameter than bore 28. Sleeve 22 is slidably mounted on an enlarged longitudinally splined portion of the mandrel. The fit between the outer surface of the tubular sleeve 22 and compression bore 27 is such that a restricted annular space 29 is provided to meter fluid past the sleeve. Below flange 21 an annular floating piston 30 is slidably and sealingly received between the mandrel and housing.

The diameter of bore 16 is identical in diameter to the bore of floating piston 30 and the fluid chamber found therebetween is filled with a relatively non-compressible fluid. Piston 30 has O-ring or other suitable pressure seals at the lower or low pressure end of the chamber while a high presure seal 30*a* is disposed between the mandrel and the housing at the upper or high pressure end of the chamber.

Operation of the apparatus described thus far is briefly as follows: The housing and mandrel of the jar are coupled in a drill string to permit usual operations to be conducted in a well bore. If part of the drill string below the jar becomes stuck, the operator determines the tension to be applied, pulls the tension on the drill string, and locks the drill string at the desired tension in the drill stand. In the jar, the housing 12 is attached to the stuck portion while the mandrel 11 has tension applied thereto and the jar is in the position shown in FIG. 2. The mandrel first moves slowly upward relative to the housing because the sleeve 22 is seated on flanged 21 closing the valve piston means to compress the fluid contained in the fluid chamber between sealing means 30*a* and the piston means. The rate of movement of the mandrel is controlled by the rate at which the compressed fluid bypasses the piston through the restricted space 29 and compression bore 27. Slow movement of the piston means continues until the tubular sleeve 22 exits from the compression bore 27 into the enlarged bore 28 and the jar is then tripped because fluid may be very rapidly bypassed between the housing 12 and sleeve 22 permitting a rapid relative movement between the mandrel 11 and the housing 12. The rapid relative movement terminates when the hammer 19 impacts the anvil 17. If the part is still stuck, the operator repeats the operation. To reset the jar, the mandrel 11 is moved downwardly and the tubular sleeve 22 will move upwardly so that fluid may bypass between the sleeve 22 and mandrel 11 and permit a quick resetting of the valve piston means to its initial position in the compression bore 27.

From the preceding discussion, it will be appreciated that the amount of force which may be applied to the stuck drill string, is primarily limited by the structural design of the jar and amount of hydraulic compressive forces which can be contained within the jar. The weakest members of the jar in relation to hydraulic compressive forces developed are the sealing members. In particular the upper seal means 30*a* between the jar mandrel and the housing in the bore 16 receives the full force of pressures generated in the fluid chamber.

Referring now to FIG. 3, details of a high pressure sealing means 30*a* are shown. The housing 12 at the point where the sealing means 30*a* is located is separated into two parts 12*a* and 12*b* which are threadedly coupled to one another. The inner threaded end of housing part 12*b* and an inwardly extending flange on housing part 12*a* form a recess which receives a wiper holder 33. The wiper holder is loosely received on the mandrel 11 and has a wiper element 34 in sliding contact with the outer wall of the jar mandrel 11. The wiper element 34 is constructed with annular, frusto-conically shaped metal rings which effectively wipe the mandrel as it is moved downwardly relative to the housing.

Bore 16 is recessed to form an annular space 36 between the wiper holder 33 and an upwardly facing shoulder 35 above the compression chamber of the jar. The bore 16 is also recessed at 51 to the anvil 17 to permit filing of the chamber with fluid through an access means 52. Two

conventional sealing elements 37 such as O-rings are disposed between annular back-up rings 38 in the lower portion of the annular space 36. The back-up rings 38 are sized with the usual tolerances to fit between the mandrel and housing and have facing curved surfaces somewhat complementary to the curvature of the O-rings. Between the sealing elements 37 and wiper holder 33 are concentrically arranged inner and outer expandable and contractable sealing rings 41, 42. Rings 41, 42 are preferably made of any metal with good bearing and strength qualities along with a low modulus of elasticity relative to the materials used in the housing and mandrel. Materials which have been found satisfactory in the construction of these rings are aluminum bronze, manganese bronze and ductile cast iron.

Ring 41 is tubular with an outwardly extending flanged base portion 46 arranged to abut the wiper holder 33. Ring 42 is similarly tubular with a base portion 49 arranged to abut a back-up ring 38. In cross-section each ring has a generally L shaped configuration. The tubular portion of the outer ring 42 is sized to be loosely received over the tubular portion of the inner ring 41, the bore of the inner ring 41 slidably receiving the mandrel and a bore 40 of the space 36 slidably receiving the outer ring 42. The contacting surfaces 43, 44 of the rings 41, 42, are complementarily beveled along a plan which is at an acute angle relative to horizontal or a perpendicular to the longitudinal axis of the mandrel. This angle preferably is in the range of 15°–45°.

As shown in FIG. 3, base 49 of ring 42 extends across the width of the space 36 and the tubular portion of ring 42 is about one-half the thickness of the tubular portion of ring 41. The tubular portion of ring 42 also terminates short of the base portion 46 of ring 41 permitting longitudinal movement therebetween.

In the operation of the sealing means 30*a*, as hydraulic pressures are developed in the compression chamber of the jar before the piston means leaves the compression bore 29, the pressure of the fluid is transmitted to the back-up rings 38 and sealing elements 37 positioned in the annular recess 36 through the clearance between the mandrel and bore 16 which may be in the order of a few thousandths of an inch. The pressure applied to the back-up rings 38 and sealing elements 37 is, in turn, transferred from the uppermost back-up ring to the base 49 of the outer expanding ring 42 to move the inclined surface 44 of the outer ring 42 relative to the inclined surface 43 of the inner ring 41. This occurs since the base 46 of the inner ring 41 abuts against the wiper holder 33 which, in turn, abuts against the housing shoulder or flange 31. As presure is transmitted to the ring members 41, 42 they are forced to move longitudinally relative to one another and radially relative to one another because of the cooperating inclined surfaces 43, 44. This movement, depending upon the pressure applied, causes the outer ring 42 to expand and the inner ring 41 to contract so that the rings 41, 42 thereby engage the walls of the housing and mandrel. The seal provided by the expanding and contracting rings 42, 41 prevents the sealing elements 37 from flowing into recesses between the housing and mandrel.

The sealing elements, back-up rings, and inner and outer sealing rings are assembled into the housing by uncoupling the upper and lower housing at the threaded joint 32, and inserting the sealing members in the annular recess 36. The wiper holder and wiper elements are next placed on top of the sealing rings and the housing sections 12*a* and 12*b* recoupled.

It has been found from tests using the above described seal arrangement that the portion of the ring members which bears the greatest load of the sealing members under pressure is that portion (designated *a* and *b* in FIG. 4) of the rings which is opposite the inclined surfaces and which bears against the walls of the housing and mandrel. Therefore, it may be seen that as the angle of the inclined

surfaces is increased vertically to make the inclined surfaces longer, the amount of surface which generally bears against the housing and the mandrel is increased, thus rendering the sealing members more sensitive in response to pressures applied to the sealing members but at the same time offering more frictional drag between movement of the mandrel with respect to the housing. It may also be appreciated that the sealing rings **41**, **42** would, in themselves, maintain a seal and could be used without additional sealing elements. Dimensional tolerances of the rings permitting a tighter fit and quicker response would be required if the rings were used by themselves as a sealing means. The rings themselves are made of a low modulus material, say in the range of 20,000,000 to 10,000,000 p.s.i., so as not to be distorted or fractured upon contraction and expansion and yet present a material which is radially contractable and expandable.

Although the sealing device which has been described herein has been applied specifically to use in a hydraulic jar in the foregoing description, it may be readily realized that such a sealing device would be readily adaptable to other types of well tools. It will be appreciated that the jar can be for wireline or tubing use and can use other types of hydraulic delay mechanisms than that described herein. Therefore, while particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. A well jar for use in a well bore including:

a telescopically arranged mandrel and housing movable longitudinally relative to one another between extended and collapsed positions;

said housing and mandrel having an anvil and hammer positioned therein in a spaced-apart relationship in one of said positions and arranged for impact contact in the other of said positions;

said mandrel and housing having a chamber formed therebetween containing a fluid and hydraulic time delay means for compressing said fluid for at least the initial part of the longitudinal relative movement;

said chamber having a high pressure sealing device for containing fluid therein including packing means and concentrically arranged ring members, said ring members having contacting cooperating inclined portions and constructed of a material permitting radial contraction and expansion of said rings in response to changes in pressure in said chamber.

2. A well jar for use in a well bore including:

a telescopically arranged mandrel and housing movable longitudinally relative to one another between extended and collapsed positions;

said housing and mandrel having an anvil and hammer positioned therein in a spaced-apart relationship in one of said positions and arranged for impact contact in the other of said positions;

said mandrel and housing having a chamber formed therebetween containing a fluid and hydraulic time delay means for compressing said fluid for at least the initial part of the longitudinal relative movement;

said chamber having a high pressure sealing device including a packing element between said mandrel and housing providing a fluid tight seal and means for retaining said packing element in position between said mandrel and housing by providing an expandable and contractable end wall surface between the mandrel and housing, said retaining means including inner and outer annular concentrically arranged rings having contacting portions inclined relative to one another and cooperating with one another and said packing element upon changes in pressure to radially contract and expand maintaining an end wall surface across the space between the mandrel and housing.

3. A well jar for use in a well bore including:

a telescopically arranged mandrel and housing movable longitudinally relative to one another between extended and collapsed positions;

said housing and mandrel having an anvil and hammer positioned therein in a spaced-apart relationship in one of said positions and arranged for impact contact in the other of said positions;

said mandrel and housing having a chamber formed therebetween containing a fluid and hydraulic time delay means for compressing said fluid for at least the initial part of the longitudinal relative movement;

sealing means for said high pressure chamber including a packing element between said mandrel and housing providing a fluid tight seal;

means for retaining said packing element in position between said mandrel and housing including cooperative radially contractable and expandable, concentrically arranged elements forming a horizontal end wall between said mandrel and housing adjacent said packing element, said elements being responsive to changes in pressure transmitted to said packing element for maintaining said end wall surface across the space between said mandrel and housing.

4. A well tool sized for passage through a well bore and having telescoping members with portions thereof defining an annular recess;

a first ring member in said recess;

said first ring member being slidably received on one of said members and having an inclined surface;

a second ring member in said recess;

said second ring member being slidably received on said other telescoping member and having an inclined surface cooperating with the inclined surface of the first ring member upon motion of said ring members relative to one another for radially expanding and contracting said ring members to maintain said members in a close fitting but sliding relationship to said telescoping members;

said recess having means for holding one of said ring members against longitudinal movement in one direction and means for providing a high pressure fluid communication path to said other ring member and recess.

5. A well tool device including a tubular housing member, a tubular mandrel member disposed within the housing, with an annular space therebetween subject to high pressures, and sealing means, said sealing means including

a pair of annular sealing rings concentrically arranged within the annular space and each of said rings having complementary inclined surfaces cooperating with one another;

means on one side of said rings for limiting movement of one of said rings relative to one of said members;

a seal member; and

a spacer member positioned on the other side of said rings for engaging the other of said rings, said space member having one side complementary to the surface of said other annular ring for transmitting motion from the seal member to said annular rings for filling the cross-section of said annular space and preventing flowing of the seal member under high pressure conditions;

said rings being constructed of a metal material having a modulus of elasticity substantially lower than the modulus of elasticity of steel and said inclined surfaces having an angle relative to a perpendicular to their column between the range of 15 to 5 degrees.

6. A well tool sized for passage through a well bore and having body members, a fluid pressure chamber formed within said body members, an annular recess in

said body members at one end of said fluid pressure chamber, a first metallic annular ring member in said recess, said first ring member having an inclined surface, and a second metallic annular ring member in said recess, said second ring member having an inclined surface slidably engaging the inclined surface of the first ring member, said recess having means for holding one of said ring members against longitudinal movement in one direction while permitting longitudinal movement of said other ring member, said ring members having surface means radially expandable upon relative longitudinal movement of said ring members for sealingly engaging said body members, and means for providing a high pressure fluid communication path between said fluid pressure chamber and said other ring member.

7. The apparatus of claim 6 wherein said ring members have concentrically arranged longitudinally overlapping portions, and at least one end of said overlapping portion

on one of said ring members being longitudinally spaced from said other ring member to permit longitudinal movement of said ring members relative to one another.

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