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ENERGY ACCUMULATOR AND SHOCK ABSORBING DEVICE FOR WELL PIPE STRINGS

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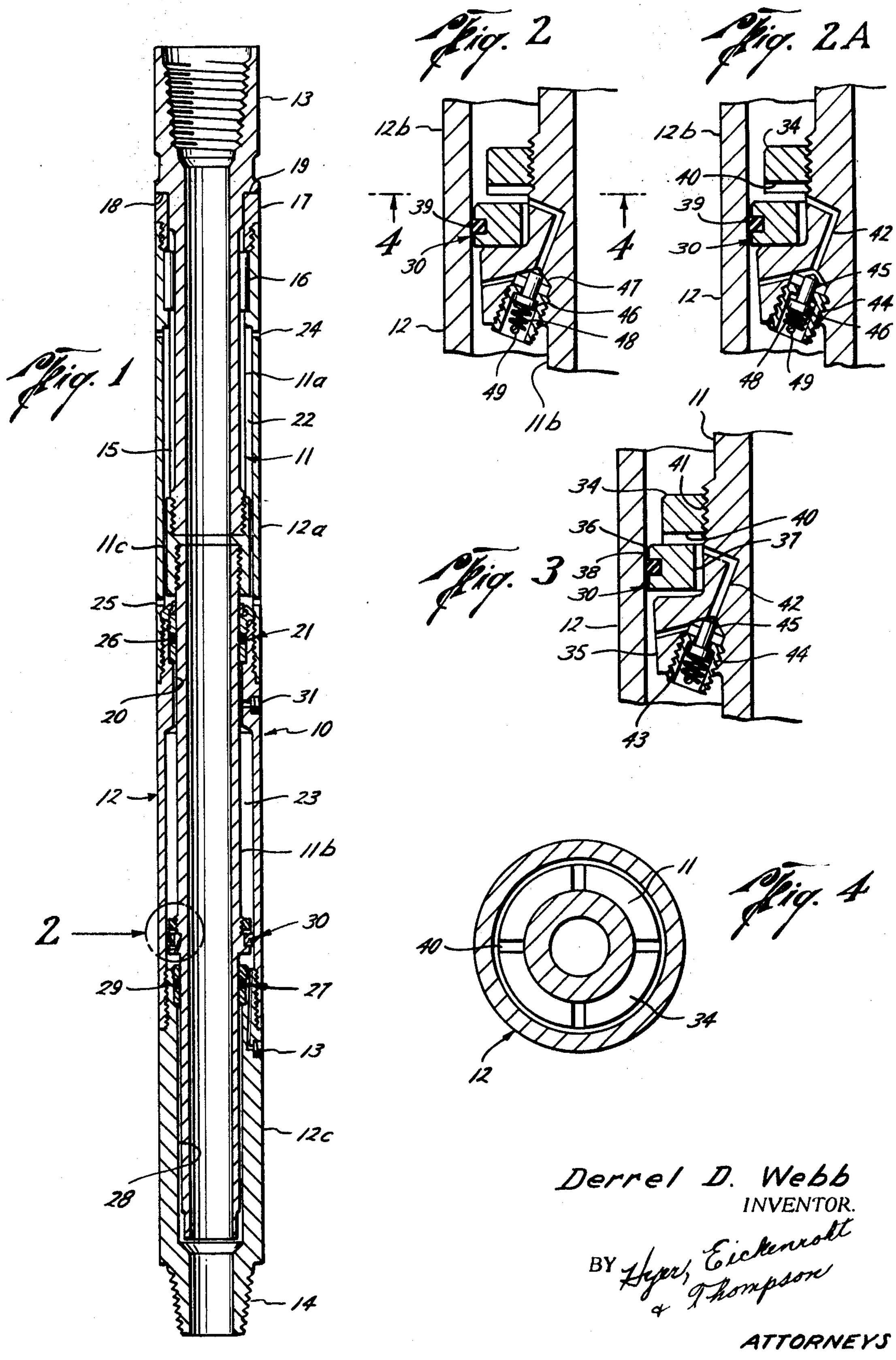

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ENERGY ACCUMULATOR AND SHOCK ABSORBING DEVICE FOR WELL PIPE STRINGS

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ABSTRACT OF THE DISCLOSURE

A well tool comprising telescopically arranged tubular members connectable in a well string for relative longitudinal movement between extended and contracted positions. A piston on the inner tubular member is sealably slidable within a closed chamber formed in the annular space between the tubular members. The piston has a check valve which permits flow past the piston upon movement in the chamber in one direction. A means is also provided for relieving excessive pressure in the chamber upon movement of the piston in the opposite direction within the chamber.

This invention relates to improvements in tools comprising telescopically arranged and relatively axially movable tubular parts adapted for connection as part of a well string disposed in a well bore and forming a closed chamber in which fluid is compressed by a piston on one such member, so as to accumulate energy therein, during the working stroke of the piston upon extension or contraction of the members in response to manipulation of the well string.

One such tool, which is shown and described in my prior Pat. No. 2,953,352, is adapted to be connected above an hydraulic jar in the string, so that, in response to an upward strain on the well string, energy is accumulated for supplementing the effect of the jar on the portion of the well string beneath such tool and then cushioning the effect of such jar on the portion of the well string above the tool. It has been found, however, that fluid compressed in chambers formed between relatively thin tubular members of tools of this type tends to leak past the piston in the chamber, especially when compressed to very high pressures. Eventually, the accumulation of fluid which thereby enters the chamber on the opposite side of the piston interferes with the return stroke of the piston. Although this fluid might eventually leak past the piston back to the chamber on the one side of the piston, this takes time and prevents full use of the tool on a frequent basis. Also, of course, there is a risk of damaging the tool by exceeding maximum allowable pressures during compression of fluid in the chamber.

It is therefore an object of this invention to provide a tool of this type in which there is little likelihood of leakage past the piston, but in which fluid which does leak past the piston may quickly return to the working side of the piston, whereby the tool will be ready for frequent use, and further in which pressures above the maximum allowed will be relieved during the working stroke of the tool.

These and other objects are accomplished, in accordance with the illustrated embodiment of the present invention, by a tool in which the piston on one of the telescopically arranged tubular members includes check valve means which permits flow past the piston during the return stroke of the one member. Thus, in a tool of the type shown in my prior Pat. No. 2,953,352, wherein energy is accumulated as the tubular members are moved toward extended position in response to an upward strain on the well string connected to the upper end of the one

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member, the check valve means is operable to permit such flow, upon movement of the members toward contracted position, whereby they are quickly returned to such position and thus ready for repeated use.

More particularly, in the preferred embodiment of the invention, the piston is carried on the inner of the tubular members and includes axially spaced-apart flanges disposed thereabout and a valve ring for shifting axially between seated positions on the oppositely facing sides of such flanges. The inner diameter of this valve ring is spaced from the outer diameter of the inner member, and the side of the flange on which the valve ring is seated during the return stroke of the first member is slotted so as to permit the aforementioned flow past the valve ring through the slots and the annular space between the valve ring and the inner tubular member.

The outer diameter of the valve ring is close to the chamber wall formed by the inner diameter of the outer tubular member, and a seal ring is carried in a groove in the outer diameter of the valve ring. This seal ring is maintained in sealing engagement against the chamber wall, even as the chamber expands under pressure, because fluid in the chamber on the working side of the piston acts over the side and inner diameter of the valve ring to stress it outwardly with a force which increases as its pressure increases. Even if some leakage occurs, the check valve means permits the fluid to return to the working side of the piston upon the reutrn stroke of the inner member, as above described.

This tool also includes means for relieving excessive pressures in the chamber on the working side of the piston, which may occur due to overloading of the tool in the field. In the preferred embodiment of the invention, this means comprises conduit means in the inner member connecting with its exterior above and below the side of the flange on which the valve ring is seated during the working stroke of the tool, and relief valve means in the conduit for permitting flow from the working side of the piston to the other side thereof in response to a predetermined pressure in the chamber on the working side thereof.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a longitudinal sectional view of a tool constructed in accordance with the present invention, and with the tubular members thereof in contracted position relative to one another;

FIG. 2 is an enlarged detail view of the part of the piston on the inner member of the tool indicated by the encircled portion of FIG. 1, during the working stroke thereof;

FIG. 2A is a view similar to FIG. 2, but upon opening of the relief valve means;

FIG. 3 is also a view similar to FIG. 2, but during the return stroke of the tool; and

FIG. 4 is a cross-sectional view of the tool, on a scale intermediate that of FIGS. 1, 2 and 3, as seen along broken lines 4—4 of FIG. 2.

With reference now to a detailed description of the above-described drawings, the over-all tool shown in FIG. 1, and indicated in its entirety by reference character **10**, includes an inner tubular member **11** telescopically received within an outer tubular member **12** to provide an annular space between them. A box **13** on the upper end of the inner tubular member **11** provides a means for connecting it to an upper portion of a well string (not shown), and a pin **14** on the lower end of the outer tubular member **12** provides a means for connection to a lower portion of the well string. When the members are sealed with respect to one another, as will be described to follow, they provide a flow conduit forming a continuation of the well string flow conduit above and below.

The tubular members are longitudinally reciprocable with respect to one another between the contracted position of FIG. 1 and an extended position (not shown) in response to manipulation of the well string above the tool. As previously described, and as will be explained in more detail to follow, a tool of this type is normally connected in the well string above an hydraulic jar adapted to deliver a jar in an upward direction when an upward strain is taken on the string to extend the members **11** and **12**.

The inner tubular member **11** is made up of an upper portion **11***a* which extends downwardly beneath the box **13**, and a lower portion **11***b* connected to the lower end of the upper portion **11***a* by means of a coupling **11***c*. The outer tubular member **12** includes an upper portion **12***a* connected to the upper end of an intermediate portion **12***b*, which in turn is threadedly connected to the upper end of a lower portion **12***c*.

The upper portion of the inner tubular member **11** has longitudinal splines **15** thereabout which receive longitudinally extending pins **16** carried on the upper portion of the inner diameter of the upper end of the outer tubular member **12**, so as to cause the inner and outer tubular members to rotate with one another and thus transmit torque from the upper portion of the well string to the lower portion thereof. More particularly, the pins **16** are received within slots formed in the upper end of upper tubular member portion **12***a* and are supported on abutments at the lower ends of such slots. The upper end of portion **12***a* includes a nut **17** which is removable to permit the pins **16** to be moved into and out of position within the slots.

The upper end of upper tubular member portion **11***a* beneath the head **13** is reduced to provide a downwardly shoulder **18** adapted to seat on the upper end of nut **17** in the contracted position of the tubular members. As above described, the tubular members are adapted to assume the contracted position when the tool is not being used to accumulate energy. Thus, the upper end of the nut **17** supports the inner tubular member in the well string thereabove in this inactive position of the tool.

The upper end of intermediate portion **12***b* of the outer tubular member **12** has a reduced inner diameter **20** which fits relatively closely about the outer diameter of lower portion **11***b* of the inner tubular member **11** to support seal means **21** in position to form a sliding seal with the outer diameter of the inner tubular member. This seal means thus divides the annular space between the inner and outer tubular members into an upper spline chamber **22** and a lower compression chamber **23**. For purposes of assembly, the coupling **11***c* is disposed within the spline chamber **22**, and to prevent pressure build up within the spline chamber, ports **24** and **25** are formed in the upper portion **12***a* of the outer tubular member.

As will be understood from FIG. 1, the seal assembly **21** is of conventional construction and includes a seal ring **26** carried between a seat ring on its lower end and a gland nut on its upper end threadedly connected to the upper portion **12***a* of the tubular member.

The lower end of the pressure chamber **23** is closed by a seal assembly **27** carried on the reduced inner diameter **28** of the upper end of lower portion **12***c* of the outer tubular member for sealing about lower portion **11***b* of the inner tubular member. As shown in FIG. 1, this assembly includes a seal ring **29** and is of substantially the same conventional construction as the seal assembly **21**. As will also be apparent from FIG. 1, the lower portion **11***b* of the inner tubular member is of such length that it will remain sealably slidable within the seal assembly **27** upon extension of the tubular members, and thus during operation of the tool to accumulate energy therein.

As also shown in FIG. 1, a piston **30** is carried on the lower portion **11***b* of the inner tubular member **11** for sealably sliding within the wall of the pressure chamber **23** formed by the inner diameter of the intermediate portion **12***b* of the outer tubular member **12**. More particularly, the piston **30** is located along an intermediate portion of the lower portion **11***b* so as to be disposed in the lower end of the chamber **23** when the tubular members are contracted, whereby it has a maximum permissible stroke upon extension of the tubular members.

As also shown in FIG. 1, plugs **31** and **32** fill ports providing access to the pressure chamber **23** from the exterior of the tool. Thus, upon removal of the plugs, of course, a suitable fluid, such as an inert gas or a compressible liquid of some type, may be injected into the chamber.

The piston **30** includes a pair of spaced-apart upper and lower flanges **34** and **35**, respectively, about the outer diameter of the tubular member **11**, and a valve ring **36** axially movable between seated positions on the oppositely facing sides of the flanges. The inner diameter **37** of the valve ring is spaced radially outwardly from the outer diameter of the tubular member **11**, and the outer diameter **38** of such ring is disposed close to the wall of the chamber formed by the inner diameter of outer tubular member **12**. A seal ring **39** of suitable resilient material is carried in a groove in the outer diameter **38** of the valve ring to provide a sliding seal with the chamber wall.

The lower side of the valve ring and top side of flange **35** are parallel and provide continuous annular seating surfaces when the valve ring is in its lower position, as shown in FIG. 2. The top side of the valve ring and the bottom side of the flange **34** are aslo parallel to one another for seating engagement therebetween when the valve ring is in its upper position, as shown in FIG. 3. However, a plurality of radial grooves **40** are formed in the bottom side of the flange **34** so as to communicate the chamber above the valve ring with the space between the the inner diameter **37** thereof and the outer diameter of the inner tubular member **11**, and thus with the chamber **23** on the lower side of the valve ring, when such ring is in its upper position, as shown in FIG. 3. Thus, the valve ring **36** and the oppositely facing sides of the flange against which it seats provide a one-way check valve means which prevents flow past the piston when the seat is in the lower position of FIG. 2, and the tubular members are being moved to extended positions, and permits flow past the piston from the upper portion of the pressure chamber to the lower portion thereof when the valve ring is in the upper position of FIG. 3, and the tubular members are being moved toward contracted position.

Consequently, when an upward strain is taken on the inner tubular member so as to raise the piston **30** within the pressure chamber, fluid on the upper portion thereof is compressed so as to accumulate energy therein. On the other hand, upon downward movement of the inner member **11**, and thus during the return stroke of the piston, flow is permitted from the portion of the pressure chamber beneath the piston to the portion thereabove. This flow not only serves the purpose of accelerating the return stroke of the piston, and thus the return of the tool to a position for a further working stroke, but also permits fluid which may have bypassed the piston during its working stroke to return from the lower portion of the pressure chamber, into which it leaked, back up into the upper portion of the pressure chamber.

As will also be understood from FIGS. 2 and 3, with the valve ring seated on the upper side of flange **35**, the high pressure fluid in the upper portion of the chamber **23** will act downwardly over the top side of the valve ring, as well as radially outwardly against the inner diameter **37** thereof. Consequently, the pressure fluid urges the outer diameter **38** of the valve ring toward the chamber wall with a force which increases as the piston moves upwardly in its working stroke. As a result, the outer diameter of the ring will be maintained close to the chamber wall inasmuch as the outward expansion of the outer diameter of the valve ring will compensate for expansion of the chamber wall due to the increased pressure.

As will also be apparent from FIGS. 2 and 3, the spacing of the inner diameter **37** of the valve ring outwardly from the outer diameter of the inner tubular member also facilitates assembly of the valve ring about the inner tubular member **11**. Thus, as shown in FIGS. 2 and 3, the flange **34** comprises a separate ring connected to threads **41** about the outer diameter of the inner tubular member **11** which are of a smaller diameter than the inner diameter **37** of the valve ring, whereby the valve ring may be moved over the threads **41** during assembly and disassembly. The flange **35** may be integral with the inner tubular member, as shown.

The means for relieving excessive pressure in the upper portion of the chamber **23** during the working stroke of the piston comprise a conduit **42** within the inner tubular member **11** connecting at its upper end with the outer diameter thereon in the annular space between the flanges **34** and **35**, and at its lower end with the exterior of the tubular member **11** below the top side of the flange **35**. Preferably, the lower end of the conduit **42** extends outwardly so as to intersect with the outer side of the flange **35** generally intermediate its upper and lower ends, and an enlarged opening **43** connects an intermediate portion of the conduit **42** with the bottom side of the flange **35**. A sleeve **44** is threadedly received in the opening **43** to mount a closure element **45** for movement therein between positions opening and closing the conduit **42**.

Thus, as shown in FIGS. 2 and 3, the closure element **45** includes an enlarged head **46** guidably slidable within the sleeve **43** and a reduced stem extending upwardly from the end of the sleeve **44** and having a conical point for seating against a conical intersection of the opening **43** with the conduit **42** in the closed position (FIG. 2). A spring **48** is held within the sleeve by means of a pin **49** extending across the inner diameter of the sleeve for urging the closure member **45** to its closed position. However, the closure member is adapted to be urged away from seated position to open the conduit **42** (FIG. 2A) when the pressure in the upper portion of the chamber **23** reaches a predetermined level. When the conduit **42** is thus opened, excessive pressure in the chamber **23** is relieved through the slots **40**, the annular space inside the valve ring, and the conduit **42** into the lower portion of the pressure chamber beneath the piston **30**.

In the aforementioned use of the tool **10**, it is connected in a well string above an hydraulic jar, which may be of the construction shown in U.S. Pat. No. 2,802,703. In the event the string becomes stuck in the well bore beneath the jar, the operator lifts the string to take an upward strain on it. This raises the piston **30** of the tool **10** as well as a piston on the inner tubular member of the jar and, due to resistance of each piston to lifting, stretches the string as pressure builds up in the chamber of each tool above its piston.

When the piston of the jar moves into an enlarged portion of its chamber, the stretch in the string causes the inner member to move rapidly upwardly, at which time a shoulder thereon engages with considerable force a shoulder on the outer tubular member, which is connected to the struck portion of the string. The energy accumulated in the tool **10** supplements that stored in the well string to add to the force of impact. It also cushions the downward reaction on the inner tubular member of the jar to absorb shock therefrom which might otherwise be transmitted to the string above the tool.

Obviously, more than one such jarring operation may be required to release the struck string. The construction of the tool **10** is particularly useful in permitting it to quickly return to its fully retracted position for this purpose.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. A tool adapted for connection as part of a string of pipe to be disposed in a well bore, comprising first and second tubular members telescopically arranged with respect to one another to provide an annular space therebetween and being movable longitudinally relatively to one another between extended and contracted positions, means on one end of each member for connecting the opposite ends of said tool in said well string, means on said members forming sliding seals with one another to provide a closed annular chamber within said annular space, said first member having a piston within the chamber for compressing fluid within the chamber on one side of the piston as the members move in one longitudinal direction relative to one another, said piston including axially spaced-apart flanges about the first member, a valve ring disposed about said first member for shifting axially between seated positions on each of said flanges, the inner diameter of said valve ring being spaced from the outer diameter of said first member and the outer diameter of said rigid ring being close to the chamber wall, a seal ring carried in a groove in the outer diameter of the valve ring for sealing against the second member, said valve ring being stressed outwardly by compressed fluid in said chamber to normally maintain the outer diameter thereof close to said chamber wall despite outward expansion of said chamber, and one of one side of the ring and the flange on which said one side seats being slotted to permit flow therethrough when said one side is seated thereon upon relative longitudinal movement of said members in the opposite direction, and pressure relief valve means permitting flow from said one side of the piston to the said other side thereof in response to a predetermined pressure of fluid in said chamber on said one side upon relative movement of said members in said one direction.

2. A well tool of the character defined in claim **1**, wherein said pressure relief valve means includes conduit means in said first member connecting with the exterior thereof above and below the seal ring as said members are extended, and valve means in said conduit permitting said flow from said one side to said other side of the piston.

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