May 16, 1967 C. C. BROWN 3,319,726

EXTENSIBLE COUPLING FOR WELL PIPES

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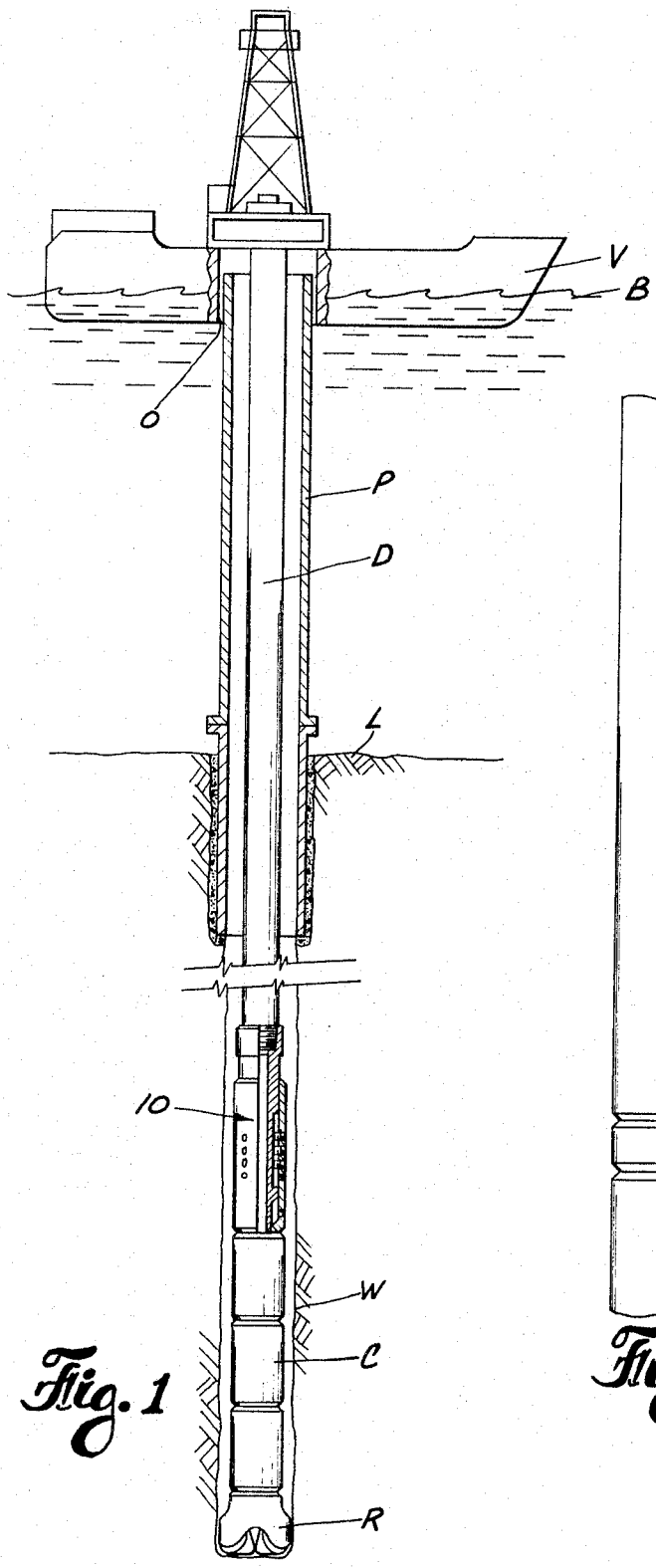


Fig. 1

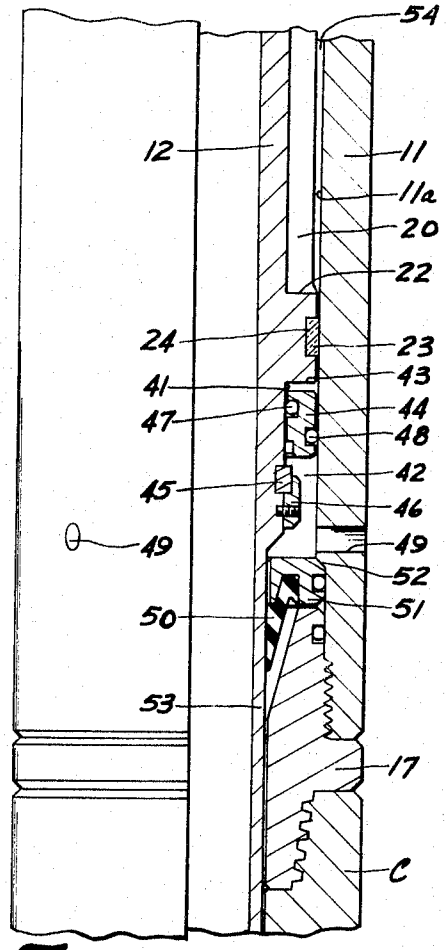


Fig. 6

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Fig. 2

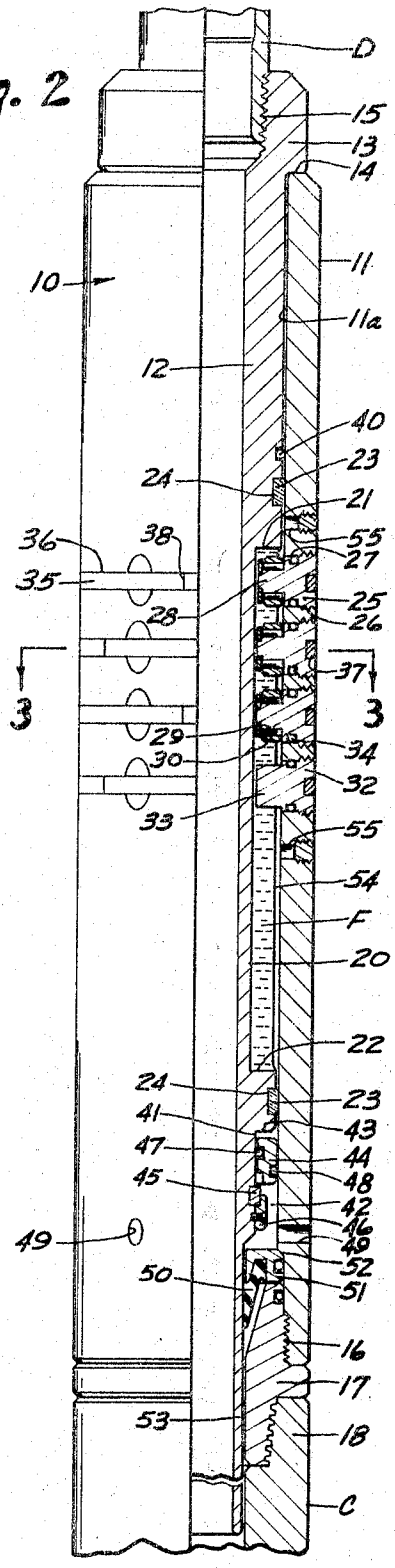


Fig. 3

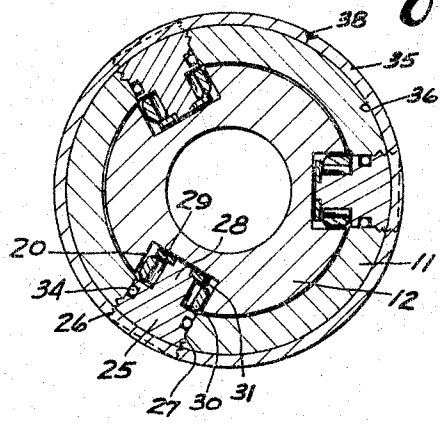


Fig. 4

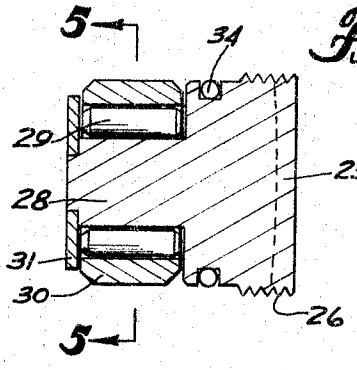
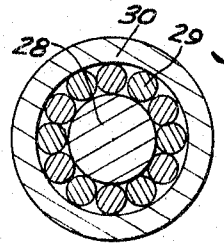


Fig. 5



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EXTENSIBLE COUPLINGS FOR WELL PIPES

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13 Claims. (Cl. 175—5)

This invention relates to extensible couplings for pipe strings, and more particularly to a form of extensible coupling, commonly referred to as "slack joint," installed in a drill pipe string being operated from afloat-type drilling platforms during drilling of wells in submerged lands.

In drilling wells by the conventional rotary method from a floating drilling platform, the platform will be subjected to vertical movements in response to the passage of waves over the surface of the water body on which it is afloat. This necessarily produces a corresponding up and down movement of the drill pipe string, which is a serious hinderance to maintenance of the drilling operation, since upward movements tend to pull the bit and drill collars off bottom while downward movement may tend to apply undue downward pressure on the drill string and the bit.

Various types of "slack joints" have heretofore been employed to overcome this difficulty by providing an extensible coupling in the drill pipe string which will allow for the vertical movements of the floating platform, while maintaining rotative movement throughout the drill string necessary to turn the drill bit. Such conventional joints employ various forms of splined connections between telescoping members of the coupling to accommodate the longitudinal movement which occurs. However, such conventional couplings are subject to very severe wear and to unbalanced pressure forces such that they must be replaced frequently and may, in some instances, become broken by reason of the extensive wear thereon.

Accordingly, it is a primary object of the present invention to provide an improved form of extensible coupling which overcomes the deficiencies of more conventional couplings.

An important object is to provide a coupling in which the internal and external pressure forces are balanced to permit free relative movement of the coupling members under all conditions.

A further object is to provide a coupling in which the spline connection is enclosed within a body of hydraulic fluid which serves as a lubricant for the spline members and as a pressure transfer medium in connection with the balancing of the pressures across the coupling.

Yet another object is to provide in a coupling of the character described, a spline connection in which the male spline member comprises a plurality of longitudinally aligned cylindrical pins, each of which is enclosed by an anti-friction bearing which engages the walls of the female spline grooves to assure substantially free relative movement of the members.

Still another object of this invention is the provision of a hydraulic fluid-containing chamber enclosing the spline connection, the chamber being defined by upper and lower seal elements arranged between the coupling

members above and below the spline connection, one of the seal elements being in the form of an annular piston slidably disposed between the coupling members and exposed to fluid pressure externally of the coupling, whereby to maintain a balancing pressure on the confined hydraulic fluid corresponding to the external fluid pressure.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description which illustrates a useful embodiment in accordance with this invention.

In the drawing:

FIG. 1 is a generally diagrammatic view of a marine drilling operation illustrating an extensible coupling in accordance with this invention, installed in a drill pipe string being operated in a well;

FIG. 2 is a longitudinal quarter sectional view of an extensible coupling in accordance with this invention;

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

FIG. 4 is a longitudinal cross-sectional view of one of the pin members forming the male spline member of the coupling;

FIG. 5 is a cross-sectional view taken along line 5—5 of FIG. 4; and

FIG. 6 is a fragmentary, quarter sectional view on a larger scale of a portion of the coupling shown in FIG. 2.

Referring first to FIG. 1, there is shown a marine drilling operation in which drilling of a well W is being conducted in a sub-natant land body L from a drilling vessel V, which is afloat on the surface of the over-lying water body B. Vessel V has a vertical opening O therethrough, from which a conductor pipe P extends into land body L and through which drilling operations are conducted from the vessel, the latter being free to move up and down relative to the upper end of pipe P in response to wave action. A conventional drill pipe string D is shown extending from the vessel through conductor pipe P, into well W and is fitted at its lower end with a drill bit R above which are positioned a plurality of conventional drill collars C. The upper end of the drill pipe string will normally be secured to or suspended from the vessel so as to be subject to the vertical movements of the latter. Interposed in the drilling string immediately above drill collars C, is an extensible coupling or slack joint in accordance with this invention, designated generally by the numeral **10**.

As best seen in FIGS. 2 to 6, inclusive, extensible coupling **10** comprises a tubular outer member **11** and a tubular inner member **12** telescopically received in the bore **11***a* of the outer member. The upper or outer end of inner member **12** is enlarged somewhat in external diameter to form a socket portion **13** defining downwardly facing annular shoulder **14** engageable by the upper end of outer member **11** to limit relative longitudinal movement of the members toward each other. Socket portion **14** is internally threaded at **15** to receive the lower end of the next adjacent section of drill pipe P. The lower end of outer member **11** is internally threaded at **16** to receive a double-ended externally threaded bushing **17** by which the outer coupling member is connected to the box portion **18** of the subadjacent drill collar C.

The exterior of inner member **12** is provided with a plurality of angularly spaced elongate grooves **20** which extend longitudinally of the coupling member for a length sufficient to accommodate to the designed "stroke," or relative longitudinal movement of the coupling members. In the illustrative embodiment three grooves **20**, which constitute the female spline elements, are shown spaced on 120° centers. It will be understood, however, that a greater or lesser number of such spline grooves may be provided. At least one obviously must be used, but the larger number is employed to better balance the forces to which the coupling will be subjected. Ordinarily the length of grooves **20** will be made to correspond substantially to the anticipated extent of the rise and fall of the vessel due to wave action to which it will be subjected. Each of the grooves **20** is generally rectangular in cross-section and terminates in upper and lower end walls **21** and **22**, respectively, which, as will appear, form stops for limiting longitudinal travel between the coupling members. In most cases, however, shoulder **14** will serve as the upper stop for limiting relative inward travel of the members. Bronze or other type wear rings **23—23** are disposed in the exterior of inner member **12** immediately above and below end walls **21**, **22**, being mounted in corresponding grooves **24—24** to project slightly therefrom in order to slidably engage the wall of bore **11***a* of the outer member.

Each of the male spline members which cooperate with the corresponding female spline grooves **20**, comprises a plurality of closely spaced longitudinally aligned pins **25**, each having an externally threaded head **26** adapted to be screwed into suitable tapped radial openings **27** provided through the wall of outer member **11**. Each of the pins **25** includes a cylindrical shank **28**, smaller in cross-sectional diameter than head **26**, which projects from outer member **11** into the related groove **20**. The exterior of shank **28** forms the inner race for an anti-friction bearing, such as the roller bearing **29**, which is, in turn, enclosed by a collar **30** defining the outer race for the bearing. A retainer ring **31** is suitably mounted over the end of shank **28** to retain the bearing in place on the shank. The outer diameter of collar **30** is dimensioned to provide a snug rolling fit between pins **25** and the side walls of grooves **20**, so as to permit relatively friction-free movement of one coupling member with respect to the other. It will be evident that pins **25** cooperate with grooves **20** to constrain movement between the coupling members to relative longitudinal movement but preventing relative rotation between the coupling members.

The lowermost one of the series of pins forming the male spline member is designated by the numeral **32** and is provided with a shank **33** having a larger cross-section than shanks **28**, the external diameter of shank **33** being substantially equal to the external diameter of bearing collars **30**, so as to have a moderately close sliding fit in groove **20**.

With the arrangement of pins **25** and **32**, as described above, it will be seen that the "stroke" or longitudinal travel between the coupling members will be limited at one end by engagement of pin **32** with lower end wall **22** and at the other end by engagement of the uppermost pin **25** with upper end wall **21** or, as noted previously, by engagement of the upper end of outer member **11** with shoulder **14**. The number of pins **25** and **32** forming the male spline members may, of course, be varied, depending upon the loads likely to be encountered in a particular case, the number illustrated being exemplary only. Each of the pins **25** and **32** is provided with an annular packing **34**, such as an O-ring, to seal between the pin and the opening **27** in which it is installed.

By reason of their threaded connection into outer coupling member **10**, pins **25** may be readily replaced when worn or broken. To prevent their becoming loosened or unscrewed due to vibration and the like to which the coupling is subjected during use, the pins are held in place by a series of metal bands **35** which are flush-seated in annular grooves **36** of suitable depth cut in the outer surface of outer member **11** and in kerfs **37** provided in the outer ends of pins **25**. The ends of each band are welded together at **38**. When necessary to replace pins **25**, the weld is cut or broken and band **35** removed.

A packing **40**, such as a conventional O-ring, is suitably mounted between the coupling members at a point above the upper ends of grooves **20**, preferably above upper wear ring **23**, to form an upper fluid-tight seal between the coupling members. The external diameter of inner coupling member **12** has a reduced diameter portion **41** extending downwardly from a point just below lower wear ring **23** to form a somewhat widened annular space **42** between the coupling members and defining a downwardly facing annular shoulder **43** at the upper end of space **41**. A small annular piston **44** is slidably disposed about reduced diameter portion **41** in space **42** and has limited longitudinal travel therein, shoulder **43** forming an upper stop therefor and a snap ring **45** mounted to project from the exterior of reduced diameter portion **41** at a point a short distance below shoulder **43** forming a lower stop for piston **44**. Snap ring **45** is held against downward dislodgment by means of a locking collar **46** which is pinned to portion **41**. Piston **44** carries an internal seal packing **47** to slidably seal with the exterior of reduced diameter portion **41** and an external seal packing **48** to slidably seal with the wall of bore **11***a* of the outer coupling member. Piston **44** with its internal and external seal packings thus forms a lower seal between the inner and outer coupling members below the lower ends of grooves **20**, and preferably, as shown, below lower wear ring **23**. Piston **44** thus forms a slidable seal between the coupling members having limited longitudinal travel for purposes to be described hereinafter.

A plurality of ports **49** are provided through the wall of outer coupling member **11** providing fluid pressure communication between the exterior of outer coupling member and space **42** below piston **44**. A lip-type annular seal **50** is mounted between the inner and outer coupling members at a point below ports **49**, to seal off the annular space between the coupling members below ports **49**. As illustrated seal **50** is secured to a metal support ring **51** which is clamped between the upper end of bushing **17** and a shoulder **52** formed in the bore wall of the outer coupling member. The free end of lip seal **50** fits tightly about the exterior of a reduced diameter extension **53** of inner coupling member **12**. Extension **53** is free to move upwardly and downwardly through the bore of lip seal **50** while the latter maintains fluid-tight sealing engagement therearound.

The portion of the annular space between the inner and outer coupling members and extending between upper seal **40** and piston seal **44** defines a chamber **54** adapted to contain a body of hydraulic fluid F, such as conventional lubricating oil or grease, which will be confined between the upper and lower seals. Spaced filler openings **55—55** are provided through the wall of outer coupling member **11** to permit introduction of fluid F into chamber **54**. Screw plugs **56—56** serve to close openings **55—55** after chamber **54** has been filled with fluid F. The latter has a dual function. It serves as a lubricant to reduce wear of the spline connection between the coupling members and as a pressure balancing medium to equalize the pressure between that exteriorly of the coupling and that on the interior of chamber **54** between the coupling members. As the exterior of the coupling will be subjected to the hydrostatic heads of fluid through which it is operated, the resultant external pressures may be as much as several thousand pounds per square inch, depending upon the depth of operation. By providing the sliding seal formed by piston **44**, the external pressures and the variation therein will be continuously transmitted to the body of fluid F, thereby equalizing the pressure between the interior of chamber **54** and that exteriorly thereof. This prevents any excessive pressure differen-

tials which could be damaging to the tool and would interfere with the free movement of the coupling members.

In operation of the device, coupling **10** will be installed in the drill string, as illustrated in FIG. 1, and will form a part thereof for all purposes. The vertical movements of the floating vessel occasioned by the passage of waves thereunder will produce corresponding extension and retraction of the coupling members.

When lowering the pipe string into the well, the weight of the bit and drill collars will extend the coupling, bringing the cylindrical shanks **33** of pins **32** into engagement with lower end walls **22** of grooves **20**. Since this load will be carried by shanks **33** of pins **32**, the provision of the enlarged diameter for shanks **33** will provide the necessary strength to support the load of this portion of the drill string. The same situation will, of course, occur when the drill string is pulled from the well, the load of the drill collars and bit hanging on end walls **22** by engagement therewith of shanks **33**.

In addition to the pressure equalizing function of ports **46** and piston **44** acting on the body of hydraulic fluid F, it will be evident that both the interior and outer coupling members will have pressure-effective areas at their opposite ends which are substantially equal, thereby providing for a fully pressure-balanced structure both internally and externally and permitting free movement between the coupling members in response to the vertical movements of the vessel to which the drill pipe string is secured.

It will be understood that various changes and modifications may be made in the details of the illustrative embodiment within the scope of the appended claims but without departing from the spirit of the invention.

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

1. In marine drilling from a floating vessel,

(a) a rotary drill pipe string having its upper end connected to the vessel,

(b) a drill bit carried by the lower end of said drill pipe string for drilling in subnatant land, and

(c) an extensible coupling mounted between sections of said pipe string to accommodate vertical movements of the vessel relative to the land while maintaining said drilling bit in rotary drilling contact with said land, said coupling comprising:

(d) telescopically engaged inner and outer tubular members,

(e) spline means forming a non-rotating longitudinally slidable connection between said members, and including means limiting relative longitudinal movement of the members,

(f) longitudinally spaced seal means arranged between said members on opposite sides of said spline means to define a fluid-confining chamber therebetween,

(g) a body of hydraulic fluid confined within said chamber,

(h) one of said seal means comprising an annular piston longitudinally slidably disposed between said members,

(i) an additional seal means arranged between said members in spaced relation to said piston, and

(j) port means in said outer member providing fluid communication between the exterior thereof and the interior thereof between said piston and said additional seal means.

2. An extensible coupling for pipe strings according to claim **1** wherein said spline means comprises,

(a) longitudinally extending groove means in the exterior of said inner coupling member, and

(b) pin means mounted on said outer coupling member and having a portion projecting radially into said groove means.

3. An extensible coupling for pipe strings according to claim **2** wherein said projecting portion of the pin means carries anti-friction bearing elements.

4. An extensible coupling according to claim **2** wherein said limiting means comprises walls defining the opposite ends of said groove means.

5. An extensible coupling for pipe strings, comprising,

(a) telescopically engaged inner and outer tubular members,

(b) means carried by the outer ends of the members for connecting them to adjacent sections of a pipe string,

(c) spline means on the members forming a non-rotating longitudinally slidable connection between said members and including means limiting relative longitudinal movement of the members,

(d) longitudinally spaced annular seal means arranged between said members on opposite sides of said spline means to define a fluid-confining chamber therebetween,

(e) a body of hydraulic fluid confined within said chamber,

(f) one of said seal means comprising an annular piston longitudinally slidably disposed between said members,

(g) an additional seal means arranged between said members in spaced relation to said piston, and

(h) port means in said outer member providing pressure fluid communication between the exterior thereof and the interior thereof between said piston and said additional seal means.

6. An extensible coupling for pipe strings, comprising,

(a) telescopically engaged inner and outer tubular members,

(b) means carried by the outer ends of the members for connecting the members to adjacent sections of a pipe string,

(c) a plurality of equiangularly spaced elongate longitudinally extending grooves generally rectangular in cross-section in the exterior of said inner member,

(d) said grooves terminating in opposite end walls forming longitudinally spaced stops in said grooves,

(e) a plurality of longitudinally aligned pins extending from said outer member and having cylindrical end portions projecting into said grooves to constrain movement between said members to relative longitudinal movement limited by said stops,

(f) upper and lower seal means arranged between said members above and below the ends of said groove means to form fluid-tight seals between said members and defining a fluid-confining chamber therebetween,

(g) a body of hydraulic fluid confined within said chamber,

(h) said lower seal means comprising an annular piston longitudinally slidably disposed between said members,

(i) port means in said outer member providing fluid communication between the exterior thereof and the interior thereof below said piston, and

(j) an additional seal means arranged between said members below said port means.

7. An extensible coupling according to claim **6** wherein said pin means carry roller bearing elements engageable with the side walls of said groove means.

8. An extensible coupling for pipe strings according to claim **6** having wear rings arranged between said members above and below the ends of said grooves.

9. An extensible coupling for pipe strings according to claim **6** wherein said additional seal means comprises a lip-type seal having a flexible annular lip having slidable sealing engagement with said inner member.

10. An extensible coupling for pipe strings according to claim **6** wherein said hydraulic fluid is a lubricant.

11. An extensible coupling for pipe strings according to claim **6** wherein said inner member carries an external shoulder means adjacent its upper end abuttable by

the upper end of said outer member to limit longitudinal travel of the members toward each other.

12. An extensible coupling for pipe strings according to claim **6** wherein each of said pins except the lowermost one carries roller bearings about their respective cylindrical portions engageable with the side walls of the grooves.

13. An extensible coupling for pipe strings according to claim **12** wherein the cross-sectional area of the cylindrical portion of said lowermost one of said pins is greater than that of the others of said pins.

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