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WELL CASING AND TUBING SUSPENSION ASSEMBLY

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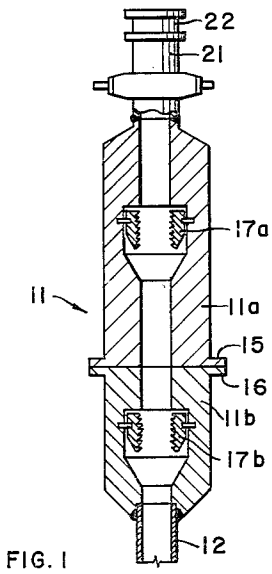


FIG. 1

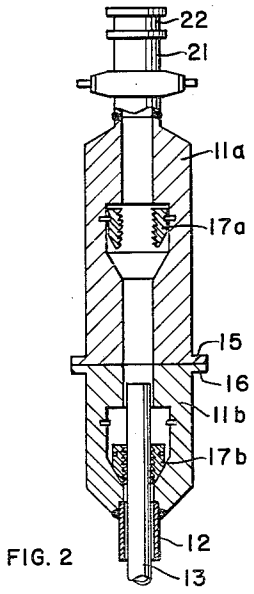


FIG. 2

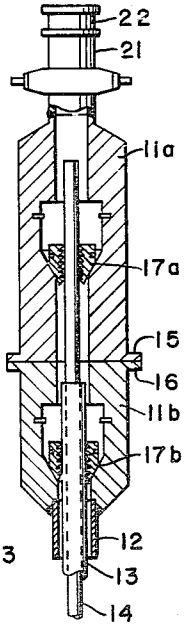


FIG. 3

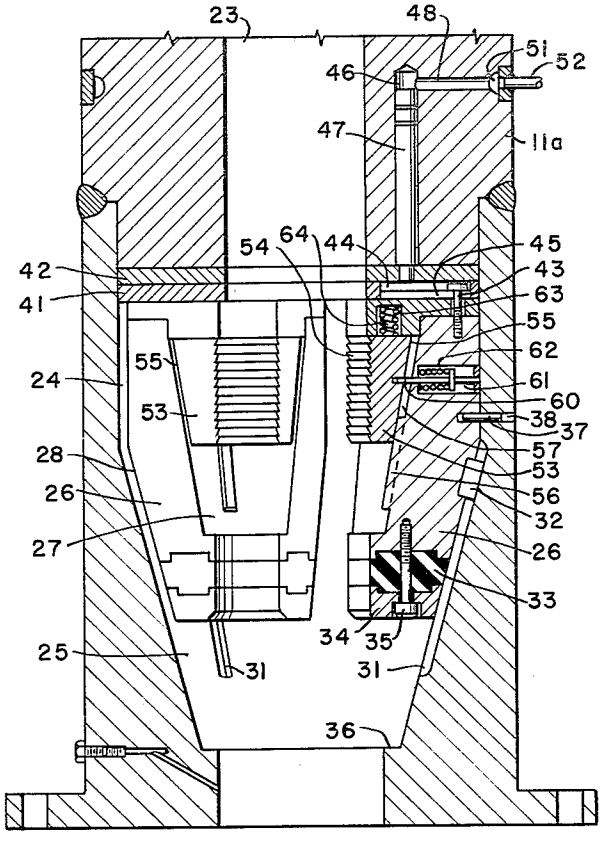


FIG. 4

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WELL CASING AND TUBING SUSPENSION ASSEMBLY

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This invention relates to the completion of oil and gas wells and pertains more particularly to a method and apparatus for suspending long strings of pipe such as well casing and tubing in a well.

In the field of well drilling operations it is well known that it is necessary to support in a borehole multiple strings of pipe such as well casing and well tubing. It is general practice to effect a seal between the various strings of pipe at the point of support so that the fluid pressures between the various strings of pipe can be controlled independently of one another. The suspension of the various strings of pipe and the installation of seals between the individual strings is accomplished at the wellhead where each successively smaller string of pipe is provided at the top thereof with a pipe hanger by which it is suspended in its individual spool piece which constitutes part of the wellhead assembly. Since all work is done at the surface of the earth, it is quite easy for workmen to assemble this equipment for suspending the pipes by the use of hand tools.

However, to date there has been no system whereby a plurality of strings of pipe, such as well casing and tubing, can be successfully suspended in a well drilled at an offshore location where the wellhead is positioned on the bottom of the ocean in, say, 50 to 1500 feet of water.

It is therefore a primary object of the present invention to provide a method and apparatus by which an operator, positioned at a remote location, may suspend and seal various strings of pipe in a well where the wellhead is positioned on an ocean floor.

A further object of this invention is to provide a power-operated apparatus adapted to be positioned in a wellhead to clamp various strings of pipe which may be individually or simultaneously installed therein.

A further object of the present invention is to provide an apparatus whereby casing may be set above an intended set point in the well in case the casing sticks before the total length is run.

These and other objects of this invention will be understood from the following description of the invention taken with reference to the drawing, wherein:

FIGURE 1 is a schematic drawing showing a wellhead assembly in longitudinal cross-section;

FIGURE 2 is a view taken in longitudinal cross-section of the wellhead assembly of FIGURE 1 with a first string of pipe being suspended therefrom;

FIGURE 3 is a diagrammatic view taken in longitudinal cross-section of the equipment of FIGURE 2 with a second string of pipe suspended from the well assembly; and

FIGURE 4 is a view taken in longitudinal cross-section of either of the slip assemblies diagrammatically illustrated in FIGURE 1.

Referring to the drawing, the well casing and tubing suspension assembly of the present invention will be called a pipe suspension assembly **11** which may comprise one or more sections, the number of sections depending upon the number of strings of pipe that are to be suspended from the assembly. In FIGURES 1–3 the pipe suspension assembly **11** is shown as having upper and lower sections **11***a* and **11***b*, respectively, since it is desired to suspend three strings of pipe **12**, **13** and **14**, as shown in

FIGURE 3. The outermost pipe string **12** will be known as the surface casing of the well for purposes of description, pipe string **13** will be described as the intermediate string casing, and pipe string **14** as the oil string casing. The number of strings of casing to be employed depends mainly upon the depth to which the well is drilled, the number of times the size of the drill bit was reduced, the formations, lost circulation, abnormal pressures, etc. Although no surface conductor string is shown it is realized that the entire apparatus of FIGURE 3 could, if desired, be positioned upon a conductor string which would have been previously cemented into the ground. Additionally, when producing the well, a well tubing string may be suspended within the oil string casing **14**.

The pipe suspension assembly **11** is essentially a thick-walled tubular housing, the sections **11***a* and **11***b* thereof being fixedly secured together in any suitable manner such as, for example, by bolting flanges **15** and **16** together. The upper and lower sections **11***a* and **11***b* of the suspension assembly are provided with individual slip assemblies **17***a* and **17***b*, respectively, as shown in FIGURE 3. Each slip assembly is capable of suspending a string of pipe therefrom with the third string of pipe **12** being suspended from the bottom of the lower section **11***b* of the suspension assembly in any suitable manner such, as by welding. During drilling operations a hydraulic ram type tubing head **21** may be connected to the top of the suspension assembly **11** with a connector head **22** being provided thereabove for connecting other equipment, as desired.

As shown in FIGURE 4 of the drawing, each section of the pipe suspension assembly, for example section **11***a*, is provided with a large bore passing coaxially therethrough, through which strings of pipe may pass or be positioned during the drilling and completion of the well. Wherever a slip assembly is to be located, the thick wall of the suspension assembly is machined or otherwise formed so that a substantial recess **24** is provided, the lower portion of said recess sloping inwardly to form the tapered face of a slip bowl **25**. A plurality of slips **26**, preferably three in number, are mounted within the slip bowl **25**, in sliding contact therewith, for both axial and radial movement. Both the inner and outer faces, **27** and **28**, respectively, of the slips **26** are smooth with the outer face **28** having the same slope as that of the slip bowl **25** while the inner face **27** slopes in the same direction, although not necessarily at the same angle.

A number of grooves, equal in number to the number of segments or slips **26**, are preferably cut in the sloping face of the slip bowl **25**, forming keyways **31** in which slip keys **32** may slide, the slip keys **32** being fixedly attached to the outer face of the slips **26**. By the use of the keys **32** and keyways **31**, the slip segments **26** remain positively aligned with respect to each other within the slip bowl **25** thus preventing movement of the segments of the slips around the inner face of the bowl.

Mounted in each of the slip segments **26** is a segment of an annular sealing element or packer **33** which is held in place by a segment of a packer retaining ring **34** which may be secured as by one or more bolts **35** to the body of the slip **26**. When the sealing element **33** is in its operative position, that is, when the slip **26** and the packer retaining segment **34** has been forced against the seat **36** formed at the bottom of the bowl **25**, the sealing element will be expanded so that its outer face seals against the slip bowl **26** while its inner face seals against the string of pipe centrally located between the slip segments **26**. At the same time the sides of each of the sealing element segments **33** expand to seal against each other to form a complete sealing ring. Normally each slip segment **26** is releasably retained in its inoperative or retracted position by positioning means, such as a shear pin **37** which may be inserted through a hole **38** in the wall of

the suspension assembly. The shear pin holes are sealed in a fluidtight manner to prevent escape of annulus pressure.

Positioned above the slip segments **26** are a slip segment positioning ring **41** and a drive ring **42**. Each slip segment **26** is connected to the slip segment positioning ring **41** by a bolt **43** having a large head which is positioned in a recess **44** above a radial slot **45** therein. Thus, by having the head of the bolt **43** lower than the depth of recess **44**, and the shank of the bolt **43** smaller than the width of the slot **45**, the bolt **43** together with the attached slip segment **26** is allowed to move radially within the slot **45** below the drive plate **42**.

Mounted in a pressure chamber **46** formed within the wall of the section of suspension assembly **11** is a drive piston **47** which is preferably fixedly secured at its lower end to the drive ring **42**. Each of the pressure chambers **46** of the assembly is in communication, through a radial conduit **48**, with a circumferential conduit **51** by which a hydraulic fluid may be applied through port **52**. If desired, the drive pistons **47** could be connected directly to the top of the slip segments **26**, but the use of a drive ring **42** is preferred to assure that equal force is applied to each of the slip segments **26** when they are being set against a pipe. Likewise, in some cases the slip segment positioning ring with its slots **44** and the bolts **43** movable therein may be omitted in installations where the use of keys **32** and keyways **31** are sufficient to keep the slip segments **26** aligned.

Slidably mounted for axial movement along the sloping inner face **27** of each of the slip segments **26** is an auxiliary slip segment or slip means **53** having a vertical serrated or toothed inner surface **54** and a sloping outer surface **55** which has the same angle as that of the inner surface of the slip segment **26**. The wedge-shaped auxiliary slip segment or slip means **53** is of a thickness so that when it is in its retracted or inoperative position, as illustrated in FIGURE 4, it does not extend inwardly toward the center of the suspension assembly bore **23** a distance greater than the inner surface of the top of the slip segment **26**. Likewise, the slip segments **26** are of a size and thickness such that no portion of the slip segments **26**, while in their retracted or inoperative position, as illustrated, extends into the bore **23** of the pipe suspension assembly **11***a*. Thus, the teeth on the inner face of the auxiliary slip segments **53** are not subject to wear by tools passing through or rotating within the bore **23** of the suspension assembly section **11***a*.

The auxiliary slip segments **53** are prevented from moving circumferentially by a key **56** formed on the inner face of slip segment **26** which mates with a keyway **57** cut or formed in the outer face of the auxiliary slip segment **53**. The auxiliary slip segments **53** are normally held in the retracted or inoperative position by means of a releasable slip positioning or retaining pin **60** which is slidably mounted within a recess **61** within the slip segment **26**, and spring loaded by means of a compression spring **62**, in a manner such that either end of pin **60** may slide from the recess **61**. However, its normal position is that shown in FIGURE 4, with the inner end of the pin **60** extending into the auxiliary slip means **53** and the outer end of the pin **60** bearing against the inner wall forming recess **24**.

Mounted in a recess **63** in the overhanging top of the slip segment **26** is a compression spring **64** which bears on the upper face of the auxiliary slip segment **53**. The spring is so selected and designed that it applies a predetermined force against the top of the slip segment **53** to force it downwardly along the sloping inner face of the slip segment **26** while simultaneously urging the inner serrated face **54** against a pipe casing that is positioned within the bore **23** of the suspension assembly.

In operation of the apparatus of the present invention, the equipment illustrated in FIGURE 1 of the drawing is set into a well and the surface casing **12** is cemented therein. Drilling operations can then be continued with the drill pipe extending through the pipe suspension assembly **11**, surface casing **12**, and blow-out preventer **21**. When the desired amount of additional hole has been drilled, the drill string and bit (not shown) are withdrawn from the well and an intermediate string of casing **13** is run into the pipe suspension assembly **11** to the lower section **11***b* thereof where the lower slips **17***b* are set, as shown in FIGURE 2.

In setting the slips a pressure fluid is applied through port **52** (FIGURE 4), conduit **48**, and into pressure chamber **46** where the drive piston **47** is forced downwardly. This action causes drive ring **42** and adjacent components of slip segments **26** to move downwardly, shearing pin **37**, thus allowing the slip segments **26** to move both downwardly and inwardly. During this time the keys **32** in the keyways **31** as well as bolts **43** in slots **45** maintain the relative position of the several slip segments **26** with regard to each other.

As the slip segments **26** move downwardly along the tapered slip bowl **25**, the vertical outer surfaces of the slip segments **26** move away from the inner wall of the suspension assembly section **11***a*, thus allowing compression spring **62** to slowly withdraw the pin **61** from the auxiliary slip segment or slip means **53** and force the pin out of the other side of the slip segment **26**. When the pin **60** has been entirely withdrawn from the auxiliary slip segment **53**, the compression spring **64** exerts a downward force against the top of the auxiliary slip segment **53** causing it to move down along the sloping inner face **27** of the slip segment **26** which in turn causes it also to move inwardly against the intermediate casing string **13** to lock the casing **13** into position, as shown in FIGURE 2. Just prior to the serrated auxiliary slips **53** biting into the outer walls of the casing **13**, the packer retaining ring at the bottom of the slip segment **26** contacts the seat **36** formed in the suspension assembly section, thus causing the sealing elements **33** to be expanded radially both inwardly against the casing **13** and outwardly against the slip bowl **25** to effectively form a fluidtight seal therein. At the same time the sealing elements expand circumferentially against each other at their ends to form a sealing ring. After being securely anchored, the casing may be cut off at any desired level above the slips.

With the intermediate string of casing set in a manner shown in FIGURE 2, drilling operations can then proceed in a conventional manner with a smaller size drill bit and the drill string extending through the pipe suspension assembly and through the intermediate string of casing. After the well has been drilled to its desired depth, the drill string and bit are withdrawn and the oil string casing **14** is inserted, suspended and sealed in the casing suspension assembly as shown in FIGURE 3 and in the same manner as described with regard to the suspending of the intermediate casing **13**.

We claim as our invention:

1. Apparatus for suspending a string of pipe within a well, said apparatus comprising a suspension body having an axial throughbore, a sloping-faced slip bowl being formed in said suspension body around a portion of the throughbore, a plurality of slip segments carried in circumferentially spaced relationship in said slip bowl in a normally retracted inoperative position and mounted for sliding movement along the sloping face thereof, the outer face of said slip segments sloping at the same angle as said slip bowl, the inner faces of said slip segments sloping in substantially the same direction, positioning means normally releasably connecting said slip segments to said suspension body in a retracted position out of the throughbore thereof, auxiliary slip means carried on the inner faces of said slip segments in circumferentially spaced relationship with each other, the inner faces of said slip means being vertical and serrated horizontally, second positioning means releasably connecting said slip segments and said slip means to hold said slip means in

a retracted position, moving means carried within said suspension body in contact with said slip means for normally urging said slip means to an extended position, and slip segment actuating means carried by said suspension body and in contact with said slip segments for normally urging said slip segments downwardly along said slip bowl to release said first positioning means and subsequently to release said second positioning means on radial inward movement of said slip segments.

2. Apparatus for suspending and sealing a string of pipe within a well, said apparatus comprising a suspension body having an axial throughbore, a sloping-faced slip bowl being formed in said suspension body around a portion of the throughbore, a slip segment seat formed at the bottom of said bowl, a plurality of slip segments carried in circumferentially spaced relationship in said slip bowl in a normally retracted inoperative position and mounted for sliding movement along the sloping face thereof, the outer face of said slip segments sloping at the same angle as said slip bowl, the inner faces of said slip segments sloping in substantially the same direction, positioning means normally releasably connecting said slip segments to said suspension body in a retracted position out of the throughbore thereof, auxiliary slip means carried on the inner faces of said slip segments in circumferentially spaced relationship with other, the inner faces of said slip means being vertical and serrated horizontally, second positioning means releasably connecting said slip segments and said slip means to hold said slip means in a retracted position, moving means carried within said suspension body in contact with said slip means for normally urging said slip means to an extended position, slip segment actuating means carried by said suspension body and in contact with said slip segments for normally urging said slip segments downwardly along said slip bowl to release said first positioning means and subsequently to release said second positioning means on radial inward movement of said slip segments, and sealing means carried within said suspension body for sealing around a pipe positioned in the bore thereof upon seating of said slip segments.

3. Apparataus for suspendng and sealing a string of pipe within a well, said apparatus comprising a suspension body having an axial throughbore, a sloping-faced slip bowl being formed in said suspension body around a portion of the throughbore, a plurality of slip segments carried in circumferentially spaced relationship in said slip bowl in a normally retracted inoperative position and mounted for sliding movement along the sloping face thereof, the outer face of said slip segments sloping at the same angle as said slip bowl, the inner faces of said slip segments sloping in substantially the same direction, positioning means normally releasably connecting said slip segments to said suspension body in a retracted position out of the throughbore thereof, auxiliary slip means carried on the inner faces of said slip segments in circumferentially spaced relationship with each other, the inner faces of said slip means being vertical and serrated horizontally, second positioning means releasably connecting said slip segments and said slip means to hold said slip means in a retracted position, spring means bearing against said slip means for normally urging said slip means to an extended position, pressure-fluid-operated slip segment actuating means carried by said suspension body and in contact with said slip segments for normally urging said slip segments downwardly along said slip bowl to release said first positioning means and subsequently to release said second positioning means on radial inward movement of said slip segments, and sealing means carried within said suspension body around the bore thereof.

4. Apparatus for suspending a string of pipe within a well, said apparatus comprising a suspension body having an axial throughbore, a sloping-face slip bowl being formed in said suspension body around a portion of the throughbore, a plurality of slip segments carried in circumferentially spaced relationship in said slip bowl and mounted for sliding movement along the sloping face thereof, the outer face of said slip segments sloping at the same angle as said slip bowl, the inner faces of said slip segments sloping in substantially the same direction, shear pin means normally releasably connecting said slip segments to said suspension body in a retracted position out of the throughbore thereof, auxiliary slip means carried on the inner faces of said slip segments in circumferentially spaced relationship with each other, the inner faces of said slip means being vertical and serrated horizontally, spring-loaded pin means releasably connecting said slip segments and said slip means to hold said slip means in a retracted position, spring means carried within said suspension body in contact with said slip means for normally urging said slip means to an extended position, and pressure-fluid-operated slip segment actuating means carried by said suspension body and in contact with said slip segments for normally urging said slip segments downwardly along said slip bowl to release said first positioning means and subsequently to release said second positioning means on radial inward movement of said slip segments.

5. Apparatus for suspending a plurality of strings of pipe within a well, said apparatus comprising a plurality of suspension bodies fixedly connected together coaxially and having an axial throughbore, a sloping-faced slip bowl being formed in each suspension body around a position of the throughbore, a plurality of slip segments carried in circumferentially spaced relationship in said slip bowl in a normally retracted inoperative position and mounted for sliding movement along the sloping faces thereof, the outer face of said slip segments sloping at the same angle as said slip bowl, the inner faces of said slip segments sloping in substantially the same direction, positioning means normally releasably connecting said slip segments to said suspension body in a retracted position out of the throughbore thereof, auxiliary slip means carried on the inner faces of said slip segments in circumferentially spaced relationship with each other, the inner faces of said slip means being vertical and serrated horizontally, second positioning means releasably connecting said slip segments and said slip means to hold said slip means in a retracted position, moving means carried within said suspension body in contact with said slip means for normally urging said slip means to an extended position, slip segment actuating means carried by said suspension body and in contact with said slip segments for normally urging said slip segments downwardly along said slip bowl to release said first positioning means and subsequently to release said second positioning means on radial inward movement of said slip segments, and a string of pipe of an inner diameter greater than the bore of said suspension body, the upper end of said pipe being fixedly secured coaxially to the lower end of the lowermost suspension body.

6. Apparatus for suspending a string of pipe within a well, said apparatus comprising a suspension body having an axial throughbore, a portion of the throughbore having a diameter greater than the portions above and below it and forming an annular recess, the body portion at the lower part of said recess being formed to slope inwardly forming a sloping-faced slip bowl, a plurality of slip segments carried in circumferentially spaced relationship in said slip bowl in a normally retracted inoperative position and mounted for sliding movement along the sloping face thereof, the outer face of said slip segments sloping at the same angle as said slip bowl, the inner faces of said slip segments sloping in the same direction, shear pin means normally connecting said slip segments to said suspension body in a retracted position, auxiliary slip means carried on the inner faces of said

slip segments in circumferentially spaced relationship with each other, the inner faces of said slip means being vertical and serrated horizontally, spring-loaded pin means in said slip segments and contacting said slip means to hold said slip means in a retracted position, spring means carried within said suspension body in contact with said slip means for normally urging said slip means to an extended position, piston means carried by said suspension body and in contact with said slip segments for normally urging said slip segments downwardly along said slip bowl to release said first positioning means and subsequently to release said second positioning means on radial inward movement of said slip segments, and conduit means in said suspension body in communication with said piston means for applying a pressure fluid thereto.

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