

[54] **TUBING HANGER ORIENTING APPARATUS AND PRESSURE ENERGIZED SEALING DEVICE**

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285/96, 285/137 A  
[51] Int. Cl. ....E21b 33/035  
[58] Field of Search.....166/75, 88, 89, 85, 125, 5,  
166/6; 285/137 A, 93, 89, 24, 25, 27, 28,  
96, 97

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[57] **ABSTRACT**

A tubing hanger for suspending multiple tubing strings is seated in a subsea wellhead or casing hanger, being properly oriented with respect to a running tool by means of which the tubing hanger is lowered from the drilling vessel to seat in the casing hanger. The running tool is properly oriented relative to a guidance system as a reference point which extends from the subsea floor to the drilling vessel, resulting in the multiple string tubing hanger being properly oriented with respect to the guidance system for subsequent appropriate connection with a Christmas tree, or other apparatus, to be lowered down the guidance system, which it also uses as a reference point, thereby properly relating the Christmas tree to the multiplicity of passages in the tubing hanger. The tubing hanger is sealed against the wellhead in which it is seated by hydraulic actuation of the seal and without the necessity for transmitting torque through any parts of the apparatus.

32 Claims, 11 Drawing Figures

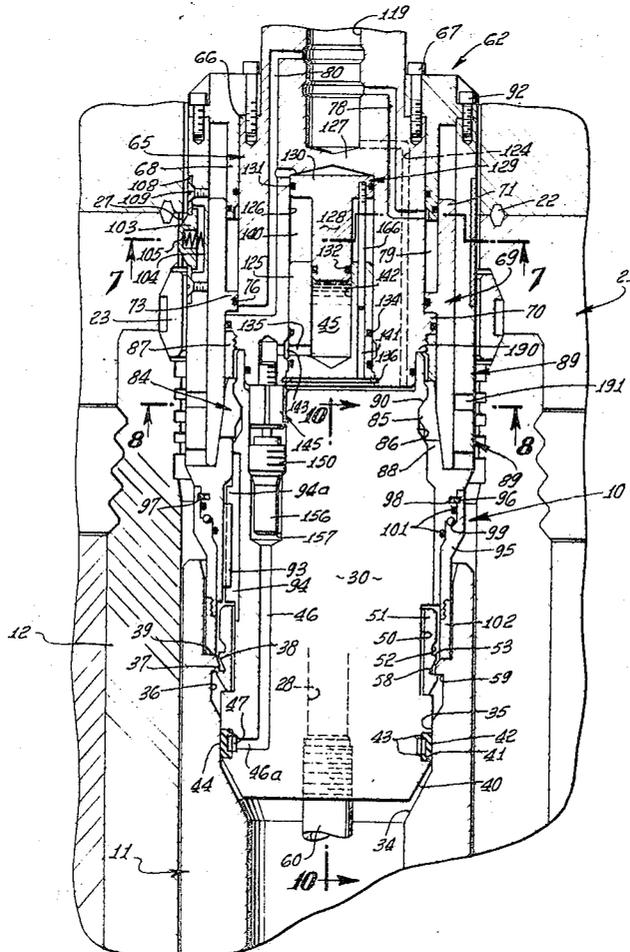


FIG. 1.

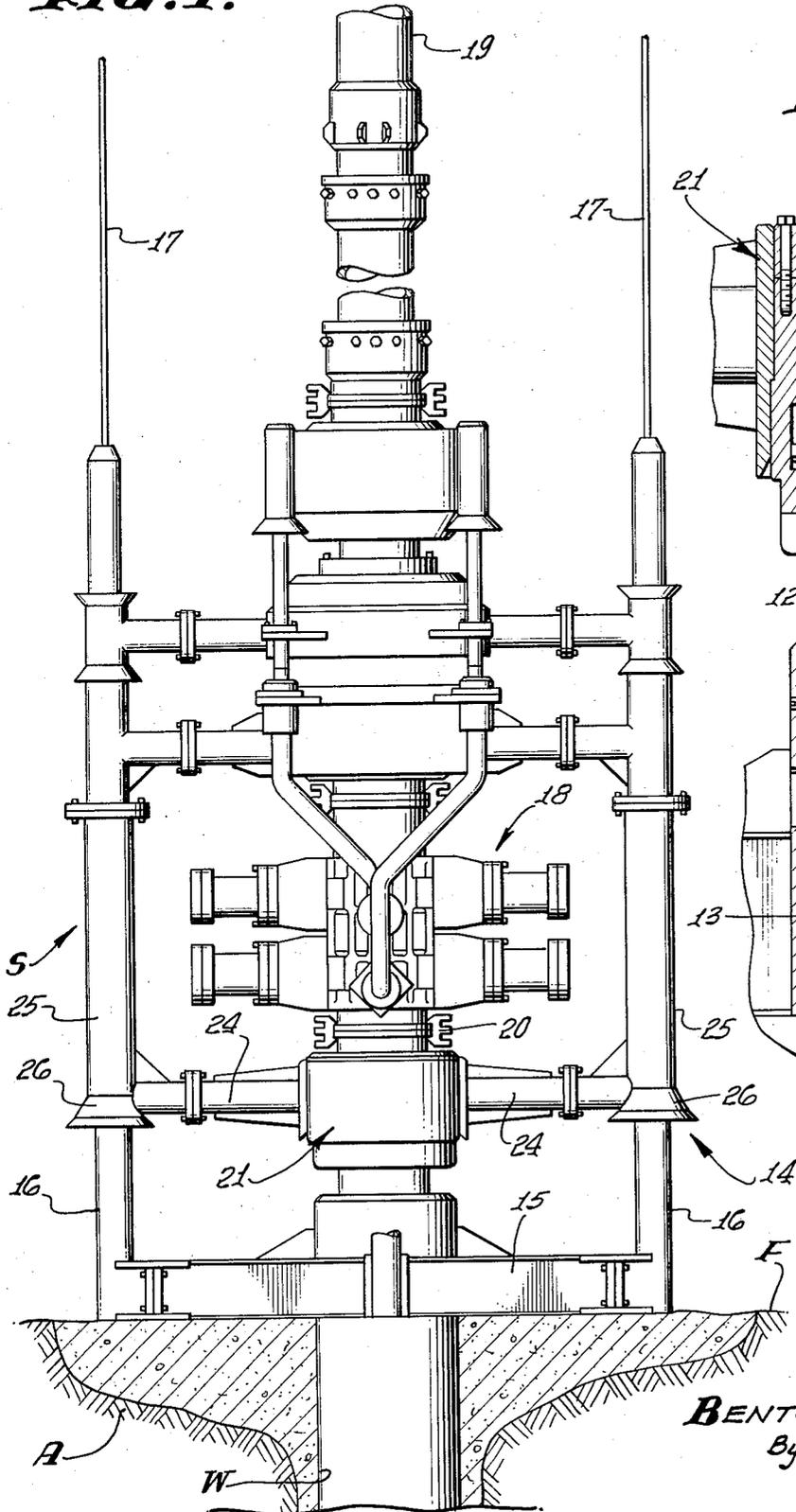
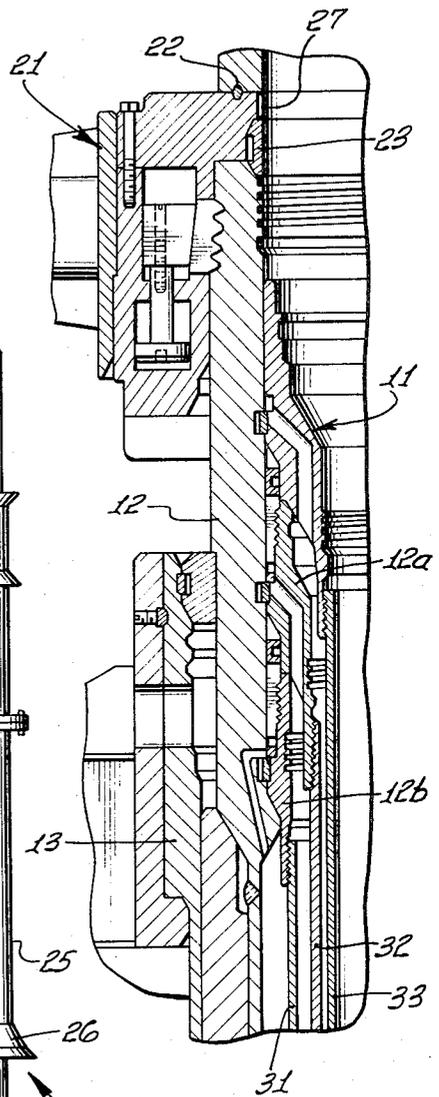
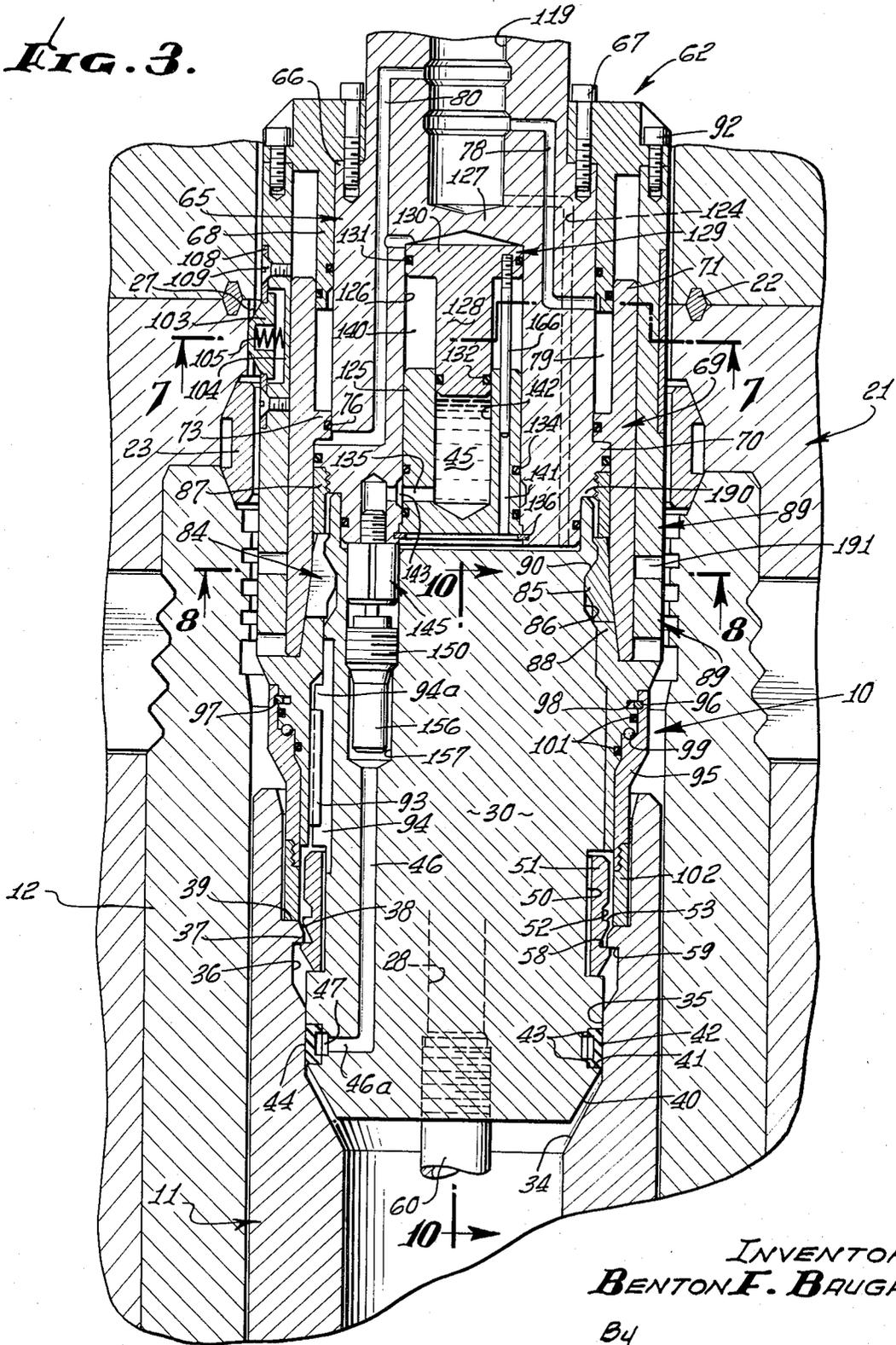


FIG. 2.



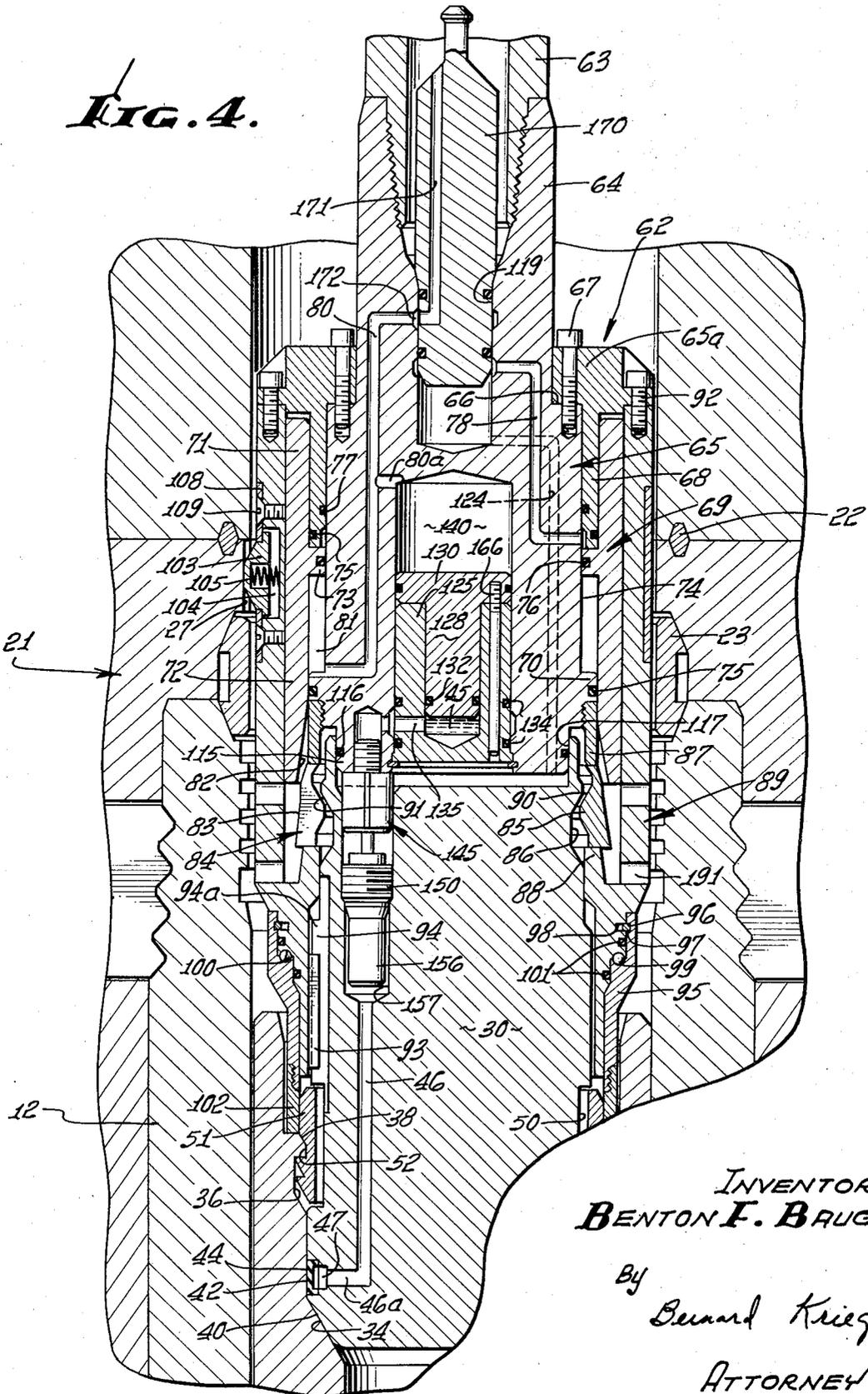
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FIG. 3.



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FIG. 4.



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FIG. 5.

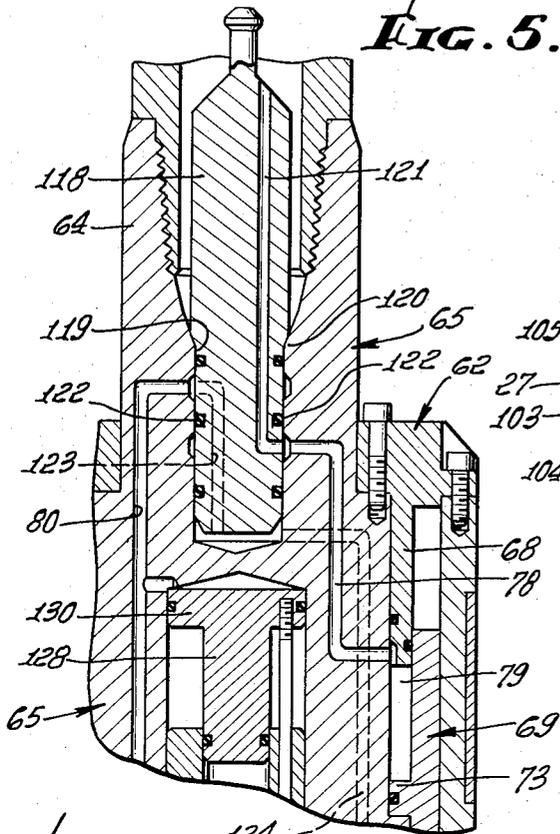


FIG. 7.

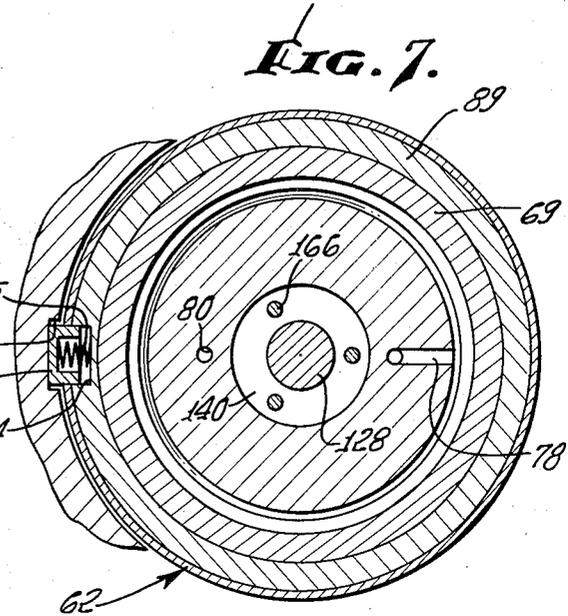


FIG. 6.

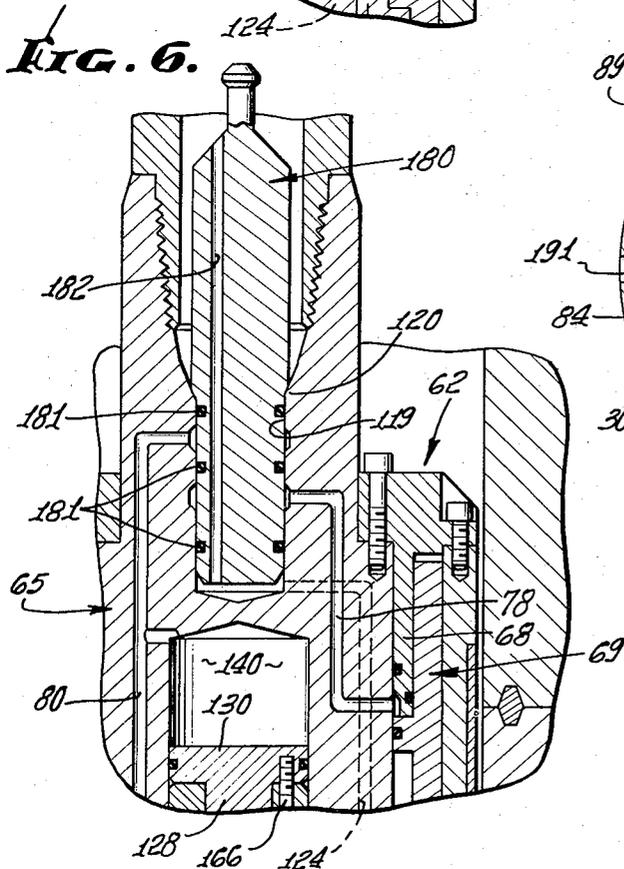
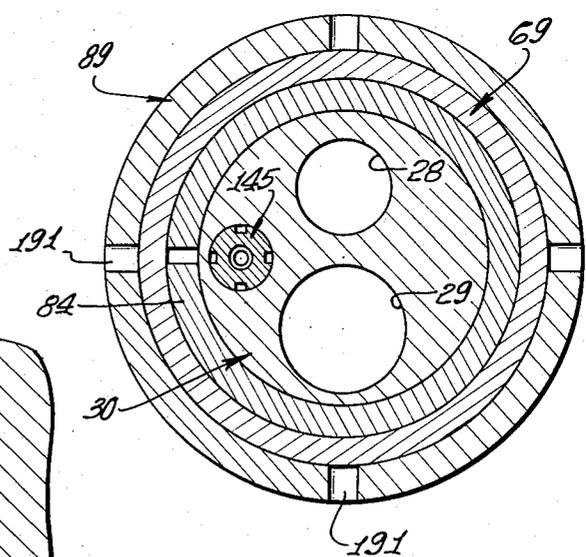


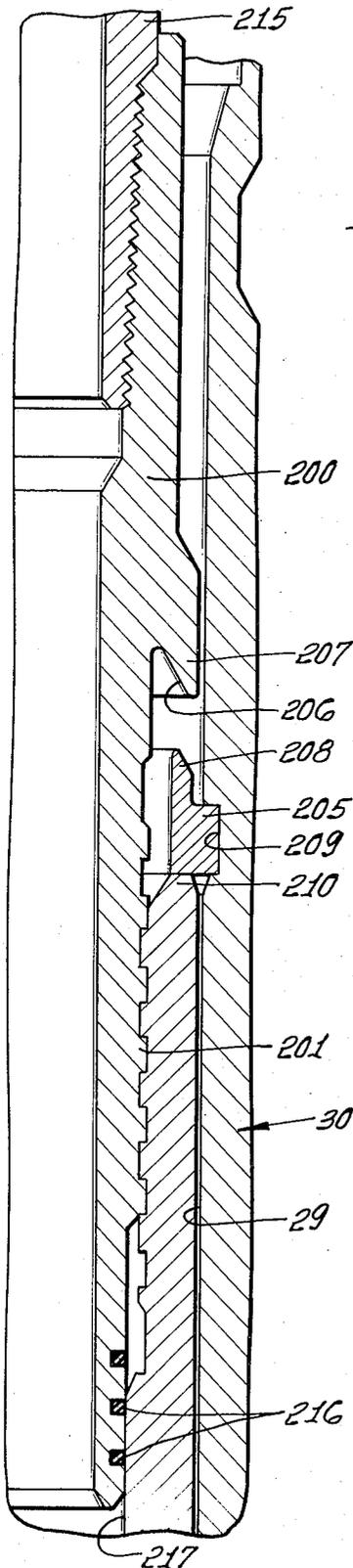
FIG. 8.



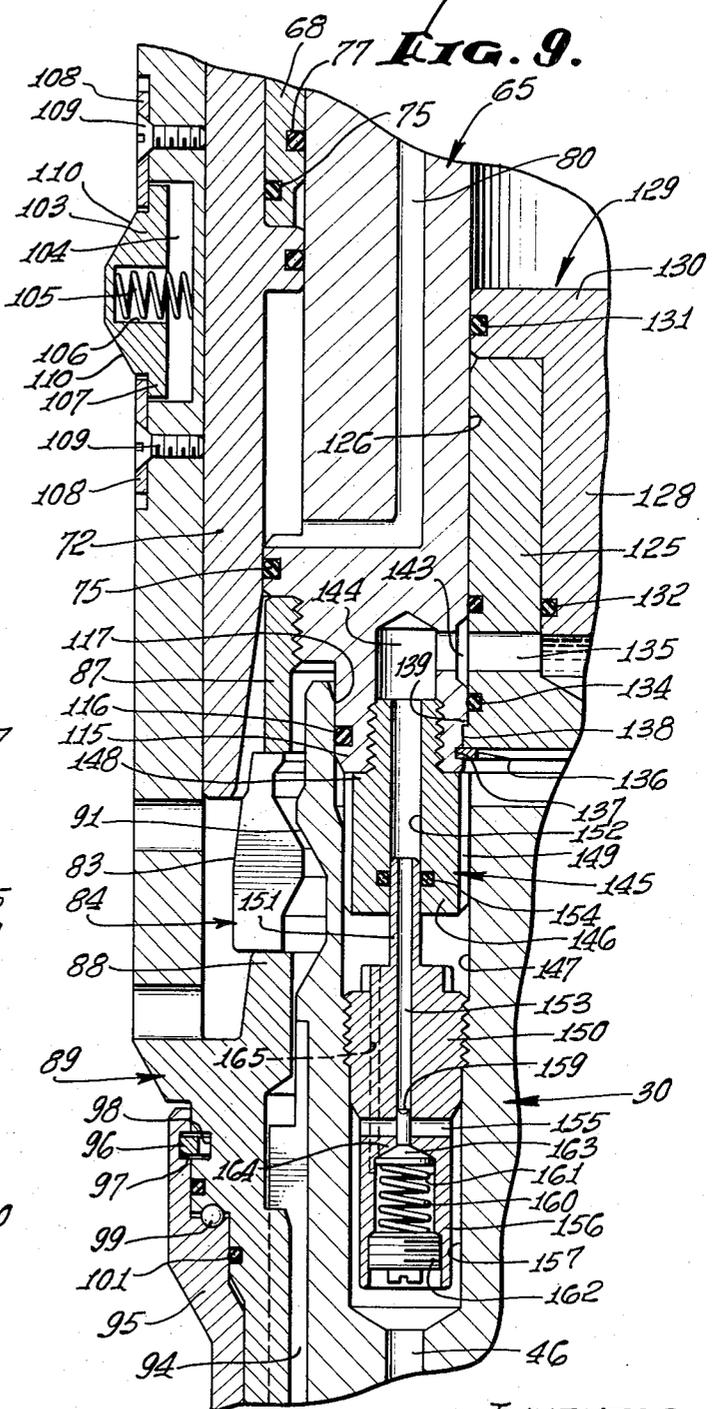
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**FIG. 11.**



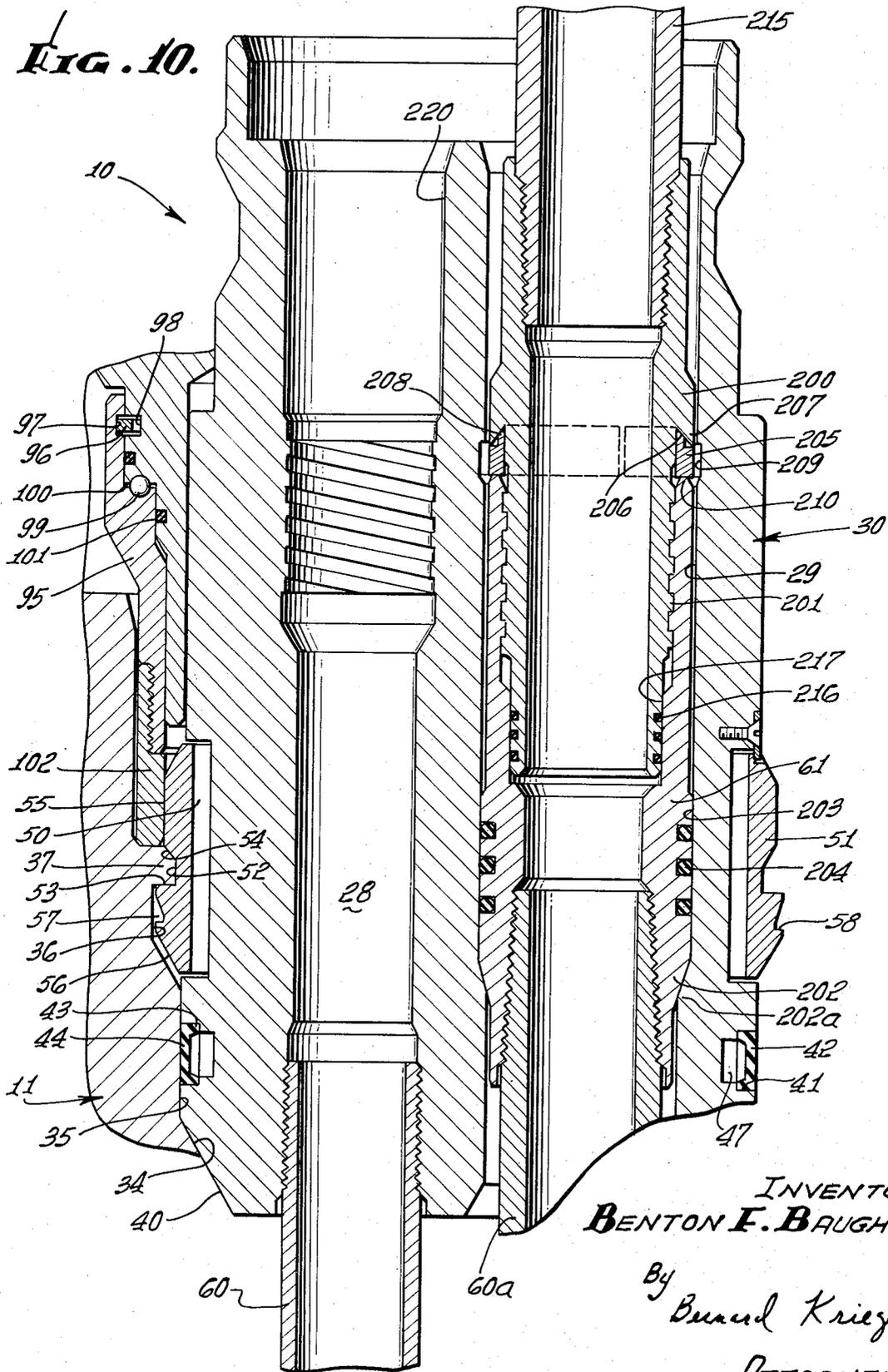
**FIG. 9.**



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FIG. 10.



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## TUBING HANGER ORIENTING APPARATUS AND PRESSURE ENERGIZED SEALING DEVICE

The present invention relates to subaqueous well bore apparatus, and more particularly to apparatus including a multiple string tubing hanger to be set and sealed in a wellhead or casing hanger.

Apparatus has been used for suspending multiple strings of tubing from a tubing hanger seated in a subsea casing hanger or wellhead, the tubing hanger and tubing strings being oriented relative to a reference point, such as the guidance system or structure disposed at the subsea floor, which includes a guide base, guide posts or columns extending upwardly from the base, and cables secured to the post and extending upwardly through the water to the drilling vessel thereabove. The tubing hanger is also sealed against the casing hanger. With prior apparatus, torque is transmitted from the tubular running string, such as a string of drill pipe, extending from the drilling vessel and through a running tool releasably secured to the tubing hanger to set the seal and lock the tubing hanger to the wellhead against upward movement. In addition, to properly orient the tubing hanger with respect to the guidance system, a separate round trip is required between the vessel and subsea floor to run-in and retrieve a special orienting bushing. Moreover, the seal used was set in compression, the seal being of limited volume and, at times, inadequate to effect a leak-proof seal against the casing hanger.

The aforementioned disadvantages are overcome with apparatus embodying the present invention. The multiple string tubing hanger is seated upon and locked down within the casing hanger without the necessity for imposing torque on the running string and running tool connected thereto. Proper orienting of the tubing hanger relative to the guidance system, or other reference point, is secured without the necessity for making additional round trips between the drilling vessel and subsea floor. In fact, only a single trip is required to run-in the tubing hanger, orient it properly relative to a known reference point, and to seal the tubing hanger in its associated casing hanger. Moreover, the seal is actuated in the absence of torque transmitted through the tubular running string. More specifically, the seal is actuated hydraulically into leak-proof sealing relation to the casing hanger, there being a large volume of sealant available to insure the provision of an efficient and effective seal. Such hydraulic actuation enables a relatively simple type of device to be used for locking the tubing hanger in place, such as a split snap ring that automatically expands into a companion lock groove in the casing hanger.

Because of the foregoing features, the multiple string tubing hanger is simpler than corresponding devices, being less costly to manufacture. The performance of all necessary functions with a single round trip in setting and sealing the tubing hanger in an associated casing hanger, in proper oriented relation to a known reference point, effects considerable savings in rig time and expense.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specifi-

cation. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense.

Referring to the drawings:

FIG. 1 is a side elevational view of a subsea system used in connection with the drilling and completion of an underwater well bore;

FIG. 2 is a longitudinal fragmentary section through a portion of the apparatus disclosed in FIG. 1;

FIG. 3 is an enlarged vertical section through apparatus embodying the invention, and which is to be disposed in the wellhead casing hanger apparatus illustrated in FIG. 2, including apparatus for setting a multiple string tubing hanger in a predetermined position;

FIG. 4 is a view similar to FIG. 3, with the tubing hanger locked in a casing hanger and with the running tool released from the tubing hanger;

FIG. 5 is a vertical section through a portion of the apparatus, illustrating the fluid pressure system for securing the running tool to the tubing hanger;

FIG. 6 is a view similar to FIG. 5, illustrating the fluid pressure system for testing the tubing hanger when set in the casing hanger;

FIG. 7 is a cross-section taken along the line 7-7 on FIG. 3;

FIG. 8 is a cross-section taken along the line 8-8 on FIG. 3;

FIG. 9 is a fragmentary longitudinal section, on an enlarged scale, through the injection valve portion of the apparatus illustrated in FIGS. 3 and 4; FIG. 10 is an enlarged vertical section taken along the line 10-10 on FIG. 3;

FIG. 11 is an enlarged fragmentary longitudinal section illustrating the manner of latching a tubing string in the tubing hanger body disclosed in FIG. 10.

As illustrated in the drawings, a multiple tubing string hanger 10 (FIGS. 3, 4, 10) is to be set in sealed relation in a casing hanger 11 disposed within a casing hanger body 12 suitably supported in a housing 13 extending into a well bore W drilled into a formation A underlying the floor F of an ocean, or other body of water. As is known in the art, the housing 13 and the various casing hangers 12, 12a, 12b supported thereby are secured to a guidance structure 14 of a guidance system S, in a known manner, this guidance structure including a base 15 having guide posts 16 extending upwardly from its corner portions and to which are secured cables or lines 17 extending upwardly through the water to a drilling vessel (not shown) floating in the water thereabove. A blowout preventer stack 18 is disposed at the lower end of a marine riser 19 extending upwardly to the drilling vessel, this blowout preventer stack being suitably secured, as by a coupling 20, to a connector 21 suitably attached to the casing hanger body 12, supported in the housing 13 in a known manner. This connector 21 may be of any suitable type, for example, being of the hydraulic type illustrated in U.S. Pat. No. 3,321,217. A suitable seal ring or gasket 22 effects a seal between the upper end of the connector and the lower end of the blowout preventer stack 18, another seal ring 23 effecting a seal between the casing hanger body 12 and the connector.

The connector 21 occupies a known position with respect to the guide structure 14, being moved

downwardly with the blowout preventer stack 18 toward the casing body 12 along the guide lines 17. The connector 21 has a guide frame 24 suitably secured thereto, the outer ends of which are attached to guide sleeves 25, having lower downwardly flaring funnels 26 that are slidable along the guide lines 17 and then over the guide posts 16. The connector has a longitudinal slot or groove 27 disposed therein which has a known orientation with respect to the guide posts 16. It is with respect to this groove 27 that the tubing hanger 10 is to be oriented, so that the longitudinal passages 28, 29 extending through the tubing hanger body 30 (FIGS. 8, 10) will bear a known orientation relative to the groove 27 in the connector and, consequently, with respect to the guide lines 17 and guide posts 16 of the guidance system S, the orientation being accomplished with the structure and in the manner described hereinbelow.

A plurality of concentric casing strings 31, 32, 33 are connected at their upper ends to concentric casing hangers 12b, 12a, 11 disposed in stacked relation and appropriately sealed against the casing hanger body 12. The uppermost casing hanger 11 is the one on which the tubing hanger 10 is to seat and against which it is to be sealed, this casing hanger having a suitable downwardly tapering hanger seat 34 and a cylindrical seal surface 35 thereabove that extends upwardly to an internal circumferential lock groove 36, the upper end of which is defined by a flange 37 having an upper corner 38 tapering downwardly, the upper surface of the flange providing a seat 39. The tubing hanger 10 includes the body 30, which has a tapered seating surface 40 at its lower end conforming to and adapted to seat against the upwardly facing seat or shoulder 34 of the casing hanger 11. Above its seating surface, the tubing hanger body has an external circumferential groove 41 therein in which an elastomer packing ring 42 is disposed provided with upper and lower inwardly directed lip seal portions 43 adapted to seat against the upper and lower sides of the groove 41 and an outer cylindrical surface 44 adapted to seal against the seal surface 35 of the casing hanger 11. As described hereinbelow, a sealant material 45 is forced through a passage 46 in the hanger body 30 and lateral branch 46a into an inner circumferential body groove 47 opening into the groove 41 receiving the packing seal ring 42, to exert a pressure against the seal ring and urge it into firm sealing engagement with the seal surface 35 of the hanger body and with its lips 43 expanded against their companion sides of the hanger body groove 41.

The hanger body 30 has an external circumferential groove 50 therein spaced upwardly a known distance from the seal ring 42, and in which a split inherently expandable latch ring 51 is disposed. This latch ring has an external circumferential groove 52 therein adapted to receive the casing hanger body flange 37, the lower side 53 of the groove being normal to the axis of the tubing hanger body and the upper side 54 of the groove being tapered to conform to the upper tapered surface 38 of the flange. Above its groove 52, the latch ring has an external cylindrical surface 55. Below its groove, it has a lower tapered or frusto-conical surface 56 adapted to engage the flange 37 for the purpose of camming or constricting the split latch ring inwardly of its groove 50, so that its lower portion can ride past the flange and then snap outwardly into the casing hanger internal groove 36.

At first, in running the tubing hanger body 30 into position, only the lower portion of the latch ring might be disposed below the casing hanger body flange 37. Accordingly, a second shallow circumferential groove 57 is provided in the ring below its main locking groove 52, this groove tapering downwardly from the periphery of the ring to a lower groove side 58 which is normal to the axis of the tubing hanger, thereby providing an upwardly facing shoulder adapted to engage the lower side 59 of the flange and preliminarily prevent upward movement of the hanger body 30 from the casing hanger 11, as described hereinbelow.

The hanger body 30 has a plurality, such as a pair, of parallel longitudinal bores 28, 29 extending vertically therethrough. The hanger body supports a first string of tubing 60 threadedly secured thereto, which is in communication with a first bore 28, the second bore 29 being adapted to receive a tubing hanger 61 and a tubing string 60a depending therefrom, as described hereinbelow. The passages or bores 28, 29 through the tubing hanger body 30 are to be oriented relative to the orienting groove 27 in the connector.

The hanger body 30, with the first tubing string 60 threadedly secured thereto, is lowered from the drilling vessel through the marine conductor pipe 19 and blowout preventer stack 18 into the well bore W and the casing hanger 11 on a running and actuating tool 62 secured to the lower end of a tubular running string 63, such as a string of drill pipe (FIGS. 3, 4). As disclosed, the lower end of the drill pipe string is threadedly secured to the upper threaded box 64 of an inner body member 65 that has an annular piston head 65a surrounding it and suitably secured against an upwardly facing body shoulder 66 by a plurality of longitudinally extending cap screws 67. An annular piston skirt 68 is integral with and depends from the piston head 65a, an annular cylinder 69 surrounding the piston skirt and extending downwardly along a lower external piston flange 70 spaced downwardly from the lower end of the piston skirt 68. The annular cylinder includes an upper cylinder sleeve portion 71 slidable along the upper piston skirt 68, a lower cylinder sleeve portion 72 slidable along the lower piston flange 70, and an inwardly directed annular cylinder head 73 disposed between the piston skirt 68 and piston flange 70 and slidable along the cylindrical periphery 74 of the inner body 65 therebetween. External seal rings 75 are mounted in the piston skirt and piston flange for slidable sealing against the inner peripheries of the cylinder sleeves 71, 72, the cylinder head 73 having an internal seal ring 76 mounted therein for slidable sealing against the periphery 74 of the inner body. The piston skirt 68 also carries a piston ring 77 which seals against the periphery 74 of the inner body.

Fluid under pressure can be directed through a passage 78 in the body 65 into an annular space 79 between the cylinder head 73 and piston skirt 68, for the purpose of forcing the annular cylinder 69 downwardly along the body 65. Fluid under pressure can also be directed through a different passage 80 into the annular space 81 between the cylinder head 73 and lower piston flange 70 to shift the annular cylinder in an upward direction along the body. Such upward and downward shifting of the annular cylinder is provided for the purpose of causing a lower internal cam or ring contracting surface 82, diverging in a downward

direction, to engage a companion external tapered or inclined surface 83 on a split coupling ring 84 for the purpose of shifting such ring inwardly and place an internal lock rib or flange 85 of the ring into a companion peripheral lock groove 86 in the upper portion of the tubing hanger body 30. As shown, the lock ring 84 is disposed in a longitudinal space provided between an upper body collar 87 threadedly secured to the inner body 65 of the running tool and an upwardly facing shoulder 88 provided on an outer locating body 89 surrounding the upper portion of the tubing string body 30 and the annular cylinder 69. The lower end of the body collar 87 and the upwardly facing shoulder 88 form guide surfaces for the upper and lower sides of the coupling ring 84, downward shifting of the annular cylinder 69 along the inner body and with the outer locating body 89 causing its cam surface 82 to engage the tapered surface 83 on the coupling ring and shift it inwardly within the tubular hanger body groove 86, an upper downwardly tapering surface 90 on the lock rib or flange 85 engaging a companion tapered surface face 91 defining the upper side of the groove 86 and initially holding the tubing hanger body 30 in a slightly raised position within the outer locating body 89.

The outer locating body 89 is secured to the piston head 65a, and, therefore, to the inner body 65 by a plurality of longitudinal cap screws 92. The lower portion of the locating body has an inwardly directed longitudinal key 93 disposed within a companion longitudinal groove or keyway 94 in the tubing hanger body 30, the lower portion of the locating body being swivelly connected to a lower housing 95 that encompasses the key portion of the locating body, and which is secured to the latter by a split snap ring 96 in an internal groove 97 of the housing fitting within a companion external groove 98 in the locating body. Ball bearing elements 99 are disposed in opposed axial raceways 100 in the locating body and housing to permit rotation of the locating body 89 relative to the housing 95. Foreign material is prevented from entering the bearing by the provision of upper and lower seal rings 101 on the body bearing against companion seal surfaces of the housing 95. The housing 95 has a running collar 102 threadedly secured thereto which encompasses the upper portion of the latch ring 51 to limit the extent of outward expansion of the latter within its groove 50 and insure its retention in the groove during lowering of the apparatus from the drilling vessel through the water to the casing hanger 11.

The outer locating body 89 carries a locating lug or key 103 in a longitudinal groove 104 within the body, this key being disposed in a known circumferential position on the body with respect to the lower body key 93. The locating lug or key is urged outwardly by a helical compression spring 105 bearing against the base of the groove 104 and against the base of a socket 106 in the lug in which the spring is received, the extent of outward movement of the locating lug being limited by engagement of its upper and lower terminals 107 with upper and lower stop plates 108 overlying such terminals and secured to the locating body by screws 109. The key 103 is projected outwardly of the body by the spring 105 and is adapted to be received within the orienting groove 27 in the connector 21. The key has upper and lower tapered portions 110 so as to be shift-

able inwardly against the force of the spring when engaging other members, such as the blowout preventer stack 18 and the connector 21. The key 103 is disposed in a horizontal plane including the groove 27 when the running collar 102 engages the flange 37 of the casing hanger 11, the running string 63 and body structure 65, 65a, 89 then being turned so that the key slides around the inner circumferential surface of the connector 21 until it reaches the groove 27, whereupon it snaps thereinto, arcuately positioning the locating body 89 with respect to the connector, and, consequently, the tubing hanger body 30 with respect to the connector, the connector 21, as noted above, bearing a known arcuate position relative to the guidance system S.

The tubing hanger 10 with the tubing string 60 depending therefrom is inserted into the locating body 89 with its groove 94 receiving the locating key 93. The hanger body 30 has a flaring mouth 94a at the upper end of the groove to facilitate insertion of the key into the groove. With the key fully disposed within the groove 94, the upper end of the hanger body 30 receives a downward pilot portion 115 of the inner body, which carries an external seal ring 116 sealing against a companion internal surface 117 of the hanger body. A locking dart 118 (FIG. 5) is inserted in the upper bore 119 of the inner body 65, coming to rest on a body shoulder 120, this dart having a longitudinal passage 121 extending from its upper end and communicating with the longitudinal passage 78 opening into the annular cylinder space 79 between the cylinder head 73 and piston skirt 68. The dart carries side seal rings 122 on opposite sides of its passage 121 that seal against the inner wall of the body bore. The introduction of fluid under pressure into the running string will cause the annular cylinder 69 to be shifted downwardly and contract the coupling ring 84 into the tubular hanger body groove 86, any fluid in the annular space 81 below the cylinder head 73 being exhausted through the body passage 80 which communicates with a dart passage 123 extending to the lower end of dart 118 and communicating with a vent passage 124 in the inner body 65.

With the tubular hanger body 30 coupled to the running tool 62, its longitudinal passage 46 is in a position to receive the fluent sealing material 45 disposed within a lower cylinder member 125 extending into a larger cylinder 126 in the lower portion of the inner body 65, the upper end of this cylinder being closed by a cylinder head portion 127 of the body. A smaller diameter piston portion 128 of a pressure boosting piston 129 extends into the lower cylinder 125, this piston portion being integral with an upper larger diameter piston portion 130 slidable along the wall of the enlarged diameter cylinder 126. The large diameter piston portion 130 carries a suitable seal ring 131 adapted to slidably and sealingly engage the wall of the large diameter cylinder 126, the piston 128 carrying a seal ring 132 sealing against the inner wall of the smaller cylinder 125. The exterior of the lower cylinder 125 is sealed against the large diameter cylinder surface 126 by side seal ring 134 on the lower cylinder sealingly engaged thereagainst on opposite sides of one or more discharge ports 135. One or a plurality of split snap retainer rings 136 are disposed in an inner body groove 137 and overlies the lower end of the lower

cylinder 125, retaining an external flange 138 thereon upwardly against a downwardly facing body shoulder 139. The annular cylinder space 140 between the small diameter piston 128 and the large diameter cylinder 126 below the large diameter piston section 130 communicates through a longitudinal indicator passage 141 in the lower cylinder member 125 with the exterior of the tool.

Initially, the pressure boosting piston 129 is in its upper position, the smaller diameter cylinder space 142 being filled with the plastic packing 45, which is fluent, but preferably of a relatively stiff consistency. The lower end of the inner cylinder 142 communicates through the circumferentially spaced lateral ports 135 with a circumferential groove 143 in the inner body, this groove opening into a cavity 144 in the lower portion of the inner body. An injection body member 145 is threaded in the body within this cavity, having a lower larger diameter portion 146 fitting within an upper enlarged bore 147 in the upper portion of the tubing hanger body 30, a shoulder 148 on the injection body member engaging the lower end of the running tool inner body 65, the injection body member having a plurality of longitudinal external grooves 149 therein establishing communication between the bore 147 therebelow and the exterior of the tubing hanger body 30. A valve body 150 is threadedly secured in this bore, having an upper tubular stem 151 piloted within a central passage 152 through the injection body member 145, which establishes communication between the cavity 144 and the valve body passage 153. A suitable side seal ring 154 in the injection body member sealingly engages the periphery of the stem 151. The valve body passage 153 communicates at its lower end with radial ports 155 opening to the exterior of the lower reduced diameter portion 156 of the valve body within a lower portion 157 of the bore 147 of the tubing hanger body, this bore communicating with the longitudinal passage 46 in the tubing hanger body that communicates through the lateral port 46a with the packing seal ring 42.

The sealant material 45 can only flow from the valve body passage 153 and through its ports 155 when the valve is in an open condition. The valve includes a cylindrical valve head 159 slidable in the passage 153 and across the ports 155, the valve head being held in such position by a helical compression spring 160 in a spring chamber 161 in the valve body that bears against a spring seat 162 threaded into the valve body and against an enlarged lower portion 163 of the head, forcing such enlarged portion against a valve body shoulder 164. When the fluid pressure in the passage 153 exceeds the force of the spring 160, the head 159 is shifted downwardly to a position opening the ports 155, whereupon fluid can flow from the passage through the ports and around the lower portion 156 of the valve body into the tubing hanger body passage 46, from where it will pass through the lateral port 46a into the circumferential groove 47 behind the packing seal ring 42. Fluid is permitted to flow into and from the spring chamber 161 through a longitudinal bleeder passage 165 in the valve body opening into the tubing hanger body externally of the valve body 150, its lower end opening into the spring chamber, such fluid, in turn, being movable through the longitudinal grooves 149 of the injector body member 145.

The fact that the chamber 142 is filled with the fluent plastic material 45 is indicated by a longitudinal rod 166 secured to the large diameter piston portion 130 and slidable in the longitudinal indicator passage 141 extending through the cylinder 125.

When the pressure boosting piston 129 is to be forced downwardly to force the plastic sealant 45 out of the cylinder and through the passages 135, 152, 153, to open the check valve 159 and flow through the tubular hanger body passage 46 into the seal ring 42 to expand the latter outwardly against its companion sealing surface 35 in the casing hanger body 11, an unlocking and packing dart 170 (FIG. 4) is lowered into the bore 119 of the inner body 65 coming to rest upon the shoulder 120. This dart has a longitudinal passage 171 extending downwardly from its upper end and opening through the periphery of the dart, this port communicating with an internal groove 172 in the inner body, which, in turn, communicates with the longitudinal body passage 80. A branch passage 80a extends from the longitudinal passage to the upper end of the large diameter cylinder 126 above the piston 129. The application of pressure to the fluid in the running string 63 will now be exerted on the large diameter piston section 130, and also on the fluid in the cylinder space 81 and upon the annular cylinder head 73, shifting the cylinder 69 upwardly and allowing the coupling ring 84 to expand from the tubing hanger body groove 86, thereby releasing the running tool 62 from the tubing hanger body 30. The fluid pressure acts on the large diameter piston section 130, forcing the booster piston 129 downwardly, its smaller diameter piston portion 128 bearing against the plastic sealant material 45 and forcing it from the cylinder at a much higher pressure than the fluid pressure acting on the large diameter piston portion 130, in view of the relative diameters between the piston portions. The plastic material is ejected through the ports 135 into the annular groove 143 and through the cavity 144 and passages 152, 153, forcing the valve head 159 downwardly to a position opening the ports 155, and continuing down through the passage 46, 46a into the hanger body groove 47 behind the seal ring 42, expanding the latter outwardly and its lips 43 upwardly and downwardly against the companion upper and lower sides of the seal ring groove 41. In this manner, a large volume of plastic sealant material 45 can be forced from the cylinder into the passages to offer assurance that the elastomeric seal ring 42 effects a positive and leakproof seal between the tubing hanger body 30 and the casing hanger 11.

As assurance that a leakproof seal has been provided, the unlocking and pack-off dart 170 can be retrieved and a running and testing dart 180 (FIG. 6) lowered down the string of drill pipe 63 for seating in the bore 119 of the inner body 65. This dart has side seal rings 181 straddling the passages 78, 80, closing them off. It has a longitudinal passage 182 extending from its upper to its lower ends and communicating through the vent passage 124 with the annular space between the tubing hanger body 30 and the casing hanger 11. Fluid pressure can be imposed on the liquid in the drill pipe string 63 and in the apparatus, which will be imposed on the fluid in the annulus above the seal 42. If the seal is pressure tight, the dart may be removed and the running string 63 elevated to remove the running tool 62 from the tubing hanger body 30.

In the operation of the apparatus, the tubing hanger body 30 is piloted within the lower portion of the locating body 89, the locating keyway 94 receiving the locating key 93, and the upper end of the tubing hanger body receiving the lower portion 115 of the inner running tool body 65. The cylinder 69 is shifted downwardly hydraulically along the inner body 65 to force the coupling ring 84 into the groove 86, the tapered sides 90, 91 elevating the tubing hanger body 30 slightly until its upper end engages a downwardly facing shoulder 190 of the inner body (FIG. 3). Any fluid in the locating body 89 can escape through the side bleeder ports 191 in the locating body during downward shifting of the annular cylinder 69 therewithin. The pressure boosting piston 129 will be in its upper position and the cylinder 125 therebelow will be filled with the plastic sealant material 45. The tubing hanger body 30, with the first tubing string 60 secured thereto, is then lowered from the drilling vessel on the string of drill pipe 63 until the running collar 102 engages the flange 37, the latch ring 51 being shifted inwardly by the flange 37, but in view of the fact that the hanger body 30 occupies a slightly elevated position along the running tool body 65, only the lower end of the latch ring can expand slightly outwardly so that its latch surface 58 engages the downwardly facing corner of the flange 37, preliminarily preventing the tubing hanger body 30 from moving upwardly (FIG. 3). The drill pipe string 63 is now turned to turn the inner body 65, outer locating body 89 and tubing hanger body 30 until the locating lug or key 103 snaps into the groove 27 in the connector 21, which insures the proper orientation of the passages 28, 29 extending through the tubing hanger body with respect to the guidance system S, and, therefore, subsequently with respect to a Christmas tree (not shown), or other apparatus, that is to be placed subsequently in a known relationship with respect to such passages. As is well known, the Christmas tree assembly is lowered along the same guidance cables 17 with its frame sleeve sliding onto the guide posts 16.

The unlocking and packing dart 170 (FIG. 4) is then lowered down the drill pipe string and into the inner body 65, and pressure is applied to the fluid in the drill pipe string, which passes to the large cylinder 126 above the pressure boosting piston 129, and also into the unlocking cylinder space 81, shifting the annular cylinder 69 upwardly to allow the coupling ring 84 to expand from the groove 86, and shifting the pressure boosting piston 129 downwardly to force the sealant material 45 from the cylinder 142, and through the passages 152, 153, past the check valve 159 into the tubing hanger body passage 46 for expanding action against the elastomer seal ring 42, sealing the latter firmly against the casing hanger 11 and against the top and bottom sides of the groove 47 of the tubing hanger body. The pressure imposed on the plastic sealant material is very high because of the differences in diameters between the large piston portion 130 and smaller piston portion 128 of the pressure boosting piston. Thus, a very large sealing force is imposed on the plastic sealant material 45, which will expand the elastomer ring 42 outwardly, such sealant material being retained in position by the closing of the check valve 159 upon relieving of the pressure of the fluid in the drill pipe string.

The unlocking and packing energizing dart 170 can now be removed and the testing dart (FIG. 6) inserted in place to test the efficacy of the seal, after which the running and testing dart can be removed and the running string 63 elevated to remove the running tool 62 from the tubing hanger body 30.

When the coupling ring 84 has been removed from the groove 86, and during the injection of the sealant material 45 behind the elastomer ring 42, the weight of the tubing 60 hanging from the tubing hanger body 30 will shift the latter downwardly to a slight extent, at which the latch ring groove 52 becomes aligned with the flange 37 of the casing hanger 11, the latch ring 51 snapping outwardly to its fullest extent and securing the hanger body 30 in its downward position and resting upon the hanger seat 34 (FIG. 4). After full seating and latching down of the tubing hanger body 30, and following full injection of the plastic material behind the packing seal ring 42, the latter remains sealed against the tubing hanger body 11.

The drill pipe string 63 and running tool 62 are now elevated through the blowout preventer stack 18 and marine conductor pipe 19 to the drilling vessel, leaving the tubing hanger body 30 latched in packed off condition in the casing hanger, and with the first tubing string 60 depending from the hanger body 30. A second string of tubing 60a can now be lowered from the drilling vessel and disposed in the well bore, hanging from the tubing hanger 10. A tubing hanging mandrel 61 is connected to a running tool 200 by a left-hand thread 201, the second string of tubing 60a being threadedly connected to the lower end of the mandrel. The mandrel has a downwardly tapering surface or shoulder 202 engageable with an upwardly facing shoulder provided in the tubing hanger body 30 around the bore 29, so that the mandrel supports the second tubing string in the body. Engageable in the cylindrical section 203 of the bore 29 are suitable seal rings 204 carried by the cylindrical body section of the mandrel.

An inherently expansible split lock ring 205 is held in contracted relation about the running tool 200 by a downwardly and outwardly inclined internal surface 206 on a flange 207 of the running tool, the flange providing a space for reception of an upstanding skirt 208 on the ring. The body 30 is provided with an internal groove 209 adapted to receive the outer portion of the hold down ring 205 when the latter is allowed to expand, so that the ring will engage in the groove 209 and with the upper end 210 of the mandrel 61 to effectively hold the mandrel against upward movement.

The second string of tubing 60a is threadedly secured to the hanger body 61, which, in turn, is threadedly secured to the running tool 200 attached to the lower end of an upper string of tubing 215 by means of which the apparatus is lowered from the drilling vessel to the tubing hanger 10. The lock down ring 205 is retained in its inward position at this time, there being side seal rings 216 on the running tool engaging the cylindrical wall 217 of the mandrel below its threaded portion 201. The tubing string 215, with the second string of tubing 60a depending from the mandrel 61 and running tool 200, is lowered until the mandrel shoulder 202 engages the seat 202a in the tubing hanger body 30, at which time the side seal rings 204 on the mandrel sealingly engage against the cylindrical wall 203 of the bore 29 through the tubing hanger. The running string of tubing

215 connected to the running tool 200 is then rotated in a right-hand direction, which effects upward threading and movement of the running tool relative to the tubing hanger mandrel 61, elevating the flange 207 from the split ring 205 and allowing the latter to expand inherently into the opposed groove 209 in the tubing hanger body 30 surrounding the second bore 29 therethrough. The running tool 200 is not threaded completely from the mandrel 61, but is elevated sufficiently to free the lock ring 205 for expansion into its companion groove, at which time at least one of the seal rings 216 on the running tool engages the inner cylindrical wall 217 of the mandrel, which permits a pressure test to be performed, after which the tool 200 is rotated to a further extent to the right by the tubing string 215 to fully unthread the running tool from the mandrel 61, permitting retrieval of the tubing string 215 and the running tool.

The manner in which the second tubing string 60a is latched in position within the tubing hanger body forms no part of the present invention. It is both disclosed and claimed in the application of Bobby H. Nelson and Benton F. Baugh, Ser. No. 868,319, filed Oct. 22, 1969, for "Tubing Hanging Method and Apparatus."

Appropriate completion of the well can now be undertaken, which will include the lowering of another string of tubing (not shown) from the drilling vessel and its positioning within an upper counterbore 220 in the tubing hanger body 30 and in appropriate sealed relation thereto. At the appropriate time, the marine conductor pipe 19 and the blowout preventer stack 18 can be removed by uncoupling the connector 21 from the casing head 12. A Christmas tree (not shown), or other production device, is lowered along the guidance structure S and is coupled to the casing head 12, in a known manner. The Christmas tree is properly oriented by the guidance system, and when coupled to the casing head will be properly oriented with respect to the passages 28, 29 in the tubing hanger 10.

It is, accordingly, apparent that an apparatus has been provided in which the multiple passage tubing hanger is run in and latched in place, appropriately oriented with respect to a fixed reference point, such as the guidance system S, without the imposition of any torque on any of the parts, except for the comparatively low effort required to rotate the apparatus and locate the key 103 within the orienting groove 27 in the connector 21. Moreover, it is unnecessary to impose any torque on the apparatus for the purpose of insuring an effective seal between the tubing hanger body 30 and the casing hanger 11, a large volume of fluent material 45 being available which is capable of being forced hydraulically and under very high pressure, if desired, behind the seal ring 42 to insure its full and effective sealing engagement with the casing hanger 11. The sealant material 45 is of a known type available on the commercial market. Any suitable fluent material can be used for the purpose of forcing the elastomer seal ring 42 under high pressure into intimate sealing contact with the casing hanger.

I claim:

1. In apparatus to be disposed in a hanger located above a well bore and to be oriented in a predetermined angular position relative to a reference member above the well bore: hanger body means adapted to be

seated in the hanger; a running tool adapted to be secured to a running string, said running tool having an orienting member engageable with the reference member to place said running tool in a predetermined angular position relative to the reference member; means securing said running tool to said hanger body means for lowering said tool into the hanger; and means interconnecting said hanger body means and running tool for retaining said hanger body means in a predetermined angular position relative to said running tool, whereby to locate said hanger body means in a predetermined angular position relative to the reference member when said orienting member is engaged therewith.

2. In apparatus as defined in claim 1; and means providing a seal between said hanger body means and hanger when said hanger body means is engaged in the hanger.

3. In apparatus as defined in claim 1; said securing means releasably connecting said running tool to said hanger body means; and means for releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger.

4. In apparatus as defined in claim 1; interengaging latch means on said hanger body means and hanger for preventing upward removal of said body means from said hanger.

5. In apparatus as defined in claim 1; said hanger body means having a plurality of parallel passages therethrough; and means on said body means for supporting tubular strings depending from said body means into the well bore and in alignment with said passages.

6. In apparatus as defined in claim 1; said interconnecting means comprising a keyway and key received therein, one of said keyway and key being on said running tool and the other of said keyway and key being on said hanger body means.

7. In apparatus as defined in claim 1; said securing means releasably connecting said running tool to said hanger body means; and means for releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger; said interconnecting means comprising a keyway and key received therein, one of said keyway and key being on said running tool and the other of said keyway and key being on said hanger body means.

8. In apparatus as defined in claim 1; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said key.

9. In apparatus as defined in claim 1; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said key; said interconnecting means comprising a keyway and second key received therein, one of said keyway and second key being on said running tool and the other of said keyway and second key being on said hanger body means; said securing means releasably connecting said running tool to said hanger body means; and means for releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger.

10. In apparatus as defined in claim 1; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said key; said interconnecting means comprising a keyway and second key received therein, one of said keyway and second key being on said running tool and the other of said keyway and second key being on said hanger body means; said securing means releasably connecting said running tool to said hanger body means; and means for releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger; and means providing a seal between said hanger body means and hanger with said body means seated in the hanger.

11. In apparatus as defined in claim 1; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said key; said interconnecting means comprising a keyway and second key received therein, one of said keyway and second key being on said running tool and the other of said keyway and second key being on said hanger body means; said securing means releasably connecting said running tool to said hanger body means; and means for releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger; said hanger body means having a plurality of parallel passages therein; and means on said body means for supporting tubular strings depending from said body means into the well bore and in alignment with said passages.

12. In apparatus as defined in claim 1; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said key; said interconnecting means comprising a keyway and second key received therein, one of said keyway and second key being on said running tool and the other of said keyway and second key being on said hanger body means; said securing means releasably connecting said running tool to said hanger body means; and means for releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger; said hanger body means having a plurality of parallel passages therein; and means on said body means for supporting tubular strings depending from said body means into the well bore and in alignment with said passages; and means providing a seal between said hanger body means and hanger with said body means seated in the hanger.

13. In apparatus as defined in claim 1; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said key; said interconnecting means comprising a keyway and second key received therein, one of said keyway and second key being on said running tool and the other of said keyway and second key being on said hanger body means; said securing means releasably connecting said running tool to said hanger body means; and means for releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger; and means providing a seal between said hanger body means and hanger with said body means seated in the

hanger; and interengaging latch means on said hanger body means and hanger for preventing upward removal of said body means from said hanger.

14. In apparatus as defined in claim 1; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said key; said interconnecting means comprising a keyway and second key received therein, one of said keyway and second key being on said running tool and the other of said keyway and second key being on said hanger body means; said securing means releasably connecting said running tool to said hanger body means; and means for releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger; said hanger body means having a plurality of parallel passages therein; and means on said body means for supporting tubular strings depending from said body means into the well bore and in alignment with said passages; and means providing a seal between said hanger body means and hanger with said body means seated in the hanger; and interengaging latch means on said hanger body means and hanger for preventing upward removal of said body means from said hanger.

15. In apparatus as defined in claim 1; and means providing a seal between said hanger body means and hanger when said hanger body means is engaged in the hanger; and means for forcing a fluent material into said seal to force said seal against the hanger.

16. In apparatus as defined in claim 1; and means providing a seal between said hanger body means and hanger when said hanger body means is engaged in the hanger; and means for forcing a fluent material into said seal to force said seal against the hanger; said hanger body means having check valve means through which the fluent material is forced and which closes to prevent return flow of the fluent material.

17. In apparatus as defined in claim 1; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said key; said interconnecting means comprising a keyway and second key received therein, one of said keyway and second key being on said running tool and the other of said keyway and second key being on said hanger body means; said securing means releasably connecting said running tool to said hanger body means; and means for releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger; and means providing a seal between said hanger body means and hanger with said body means seated in the hanger; means for forcing a fluent material into said seal to force said seal against the hanger; said hanger body means having check valve means through which the fluent material is forced and which closes to prevent return flow of the fluent material.

18. In apparatus as defined in claim 1; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said key; said interconnecting means comprising a keyway and second key received therein, one of said keyway and second key being on said running tool and the other of said keyway and second key being on said hanger body means; said securing means releasably connecting said running tool to said hanger body means; and means for

releasing said securing means to permit withdrawal of said running tool from said hanger body means after said hanger body means has been seated in the hanger; said hanger body means having a plurality of parallel passages therein; and means on said body means for supporting tubular strings depending from said body means into the well bore and in alignment with said passages; and means providing a seal between said hanger body means and hanger with said body means seated in the hanger; and interengaging latch means on said hanger body means and hanger for preventing upward removal of said body means from said hanger; means for forcing a fluent material into said seal to force said seal against the hanger; said hanger body means having check valve means through which the fluent material is forced and which closes to prevent return flow of the fluent material.

19. In apparatus to be disposed in a hanger located above a well bore and to be oriented in a predetermined angular position relative to a reference member above the well bore: a hanger body adapted to be seated in the hanger; a running tool body structure adapted to be secured to a tubular running string; an orienting member on said body structure engageable with the reference member to place said body structure in a predetermined angular position relative to the reference member; said hanger body having a coupling groove; a coupling ring on said body structure shiftable laterally into and from said groove to connect and disconnect said body structure to and from said hanger body; cam means shiftable longitudinally along said body structure into engagement with said coupling ring to shift said ring into said groove and from engagement with said ring to permit its removal from said groove; first fluid actuated means responsive to fluid pressure in the tubular running string for shifting said cam means longitudinally along said body structure; a keyway and key received therein interconnecting said body structure and hanger body for retaining said hanger body in a predetermined angular position relative to said body structure; one of said keyway and key being on said body structure and the other of said keyway and key being on said hanger body.

20. In apparatus as defined in claim 19; and interengaging latch means on said hanger body and hanger for preventing upward removal of said hanger body from the hanger when seated therein.

21. In apparatus as defined in claim 19; and seal means on said hanger body engageable with the hanger with said hanger body seated in the hanger.

22. In apparatus as defined in claim 19; and interengaging latch means on said hanger body and hanger for preventing upward removal of said hanger body from the hanger when seated therein; and seal means on said hanger body below said latch means and engageable with the hanger and with said hanger body seated in the hanger.

23. In apparatus as defined in claim 19; and seal means on said hanger body engageable with the hanger with said hanger body seated in the hanger; said body structure having a chamber containing a fluent material; said body structure and hanger body having interconnecting passages extending from said chamber to said seal means; second fluid actuated means responsive to fluid pressure in the running string for forcing

said fluent material from said chamber and through said passages to said seal means to force said seal means against the hanger.

24. In apparatus as defined in claim 19; and seal means on said hanger body engageable with the hanger with said hanger body seated in the hanger; said body structure having a chamber containing a fluent material; said body structure and hanger body having interconnecting passages extending from said chamber to said seal means; second fluid actuated means responsive to fluid pressure in the running string for forcing said fluent material from said chamber and through said passages to said seal means to force said seal means against the hanger; said hanger body having a check valve permitting flow of fluent material through said hanger body passage to said seal means, but preventing reverse flow of fluent material through said hanger body passage.

25. In apparatus as defined in claim 19; and seal means on said hanger body engageable with the hanger with said hanger body seated in the hanger; said body structure having a chamber containing a fluent material; said body structure and hanger body having interconnecting passages extending from said chamber to said seal means; second fluid actuated means responsive to fluid pressure in the running string for forcing said fluent material from said chamber and through said passages to said seal means to force said seal means against the hanger; said second fluid actuated means comprising a first piston shiftable in said body structure and responsive to the fluid pressure in the running string, and a second piston smaller in diameter than said first piston and shiftable in said chamber to apply a greater unit pressure to the fluent material in said chamber than the unit fluid pressure in the running string.

26. In apparatus as defined in claim 19; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said spring pressed key.

27. In apparatus as defined in claim 19; and interengaging latch means on said hanger body and hanger for preventing upward removal of said hanger body from the hanger when seated therein; and seal means on said hanger body below said latch means and engageable with the hanger and with said hanger body seated in the hanger; said orienting member comprising a spring pressed key; the reference member having a groove adapted to receive said spring pressed key.

28. In apparatus as defined in claim 19; and seal means on said hanger body engageable with the hanger with said hanger body seated in the hanger; said body structure having a chamber containing a fluent material; said body structure and hanger body having interconnecting passages extending from said chamber to said seal means; second fluid actuated means responsive to fluid pressure in the running string for forcing said fluent material from said chamber and through said passages to said seal means to force said seal means against the hanger; said second fluid actuated means comprising a first piston shiftable in said body structure and responsive to the fluid pressure in the running string, and a second piston smaller in diameter than said first piston and shiftable in said chamber to apply a greater unit pressure to the fluent material in

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said chamber than the unit fluid pressure in the running string; said hanger body having a check valve permitting flow of fluent material through said hanger body passage to said seal means, but preventing reverse flow of fluent material through said hanger body passage; interengaging latch means on said hanger body and hanger for preventing upward removal of said hanger body from the hanger when seated therein; said orienting means comprising a spring pressed key; the reference member having a groove adapted to receive said spring pressed key.

28. In apparatus to be disposed in a hanger located above a well bore: a hanger body adapted to be seated in the hanger; seal means on said hanger body engageable with the hanger when said hanger body is sealed in the hanger; means providing a chamber containing a fluent material and passage means extending from said chamber to said seal means; and means for applying pressure to the fluent material in said chamber to force the fluent material through said passage means to said seal means to force said seal means against the hanger.

30. In apparatus as defined in claim 29; said hanger body having a check valve permitting flow of the fluent

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material through said passage means to said seal means, but preventing reverse flow of fluent material from said seal means through said passage means.

31. In apparatus as defined in claim 29; said pressure applying means comprising a first piston responsive to a source of fluid pressure and a second piston smaller in diameter than said first piston and shiftable in said chamber to apply a greater unit pressure to the fluent material in said chamber than the unit pressure of the fluid applied to said first piston.

32. In apparatus as defined in claim 29; said pressure applying means comprising a first piston responsive to a source of fluid pressure and a second piston smaller in diameter than said first piston and shiftable in said chamber to apply a greater unit pressure to the fluent material in said chamber than the unit pressure of the fluid applied to said first piston; said hanger body having a check valve permitting flow of the fluent material through said passage means to said seal means, but preventing reverse flow of fluent material from said seal means through said passage means.

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