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MULTIPLE STRING TUBING HANGER CONSTRUCTIONS

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2 Sheets-Sheet 1

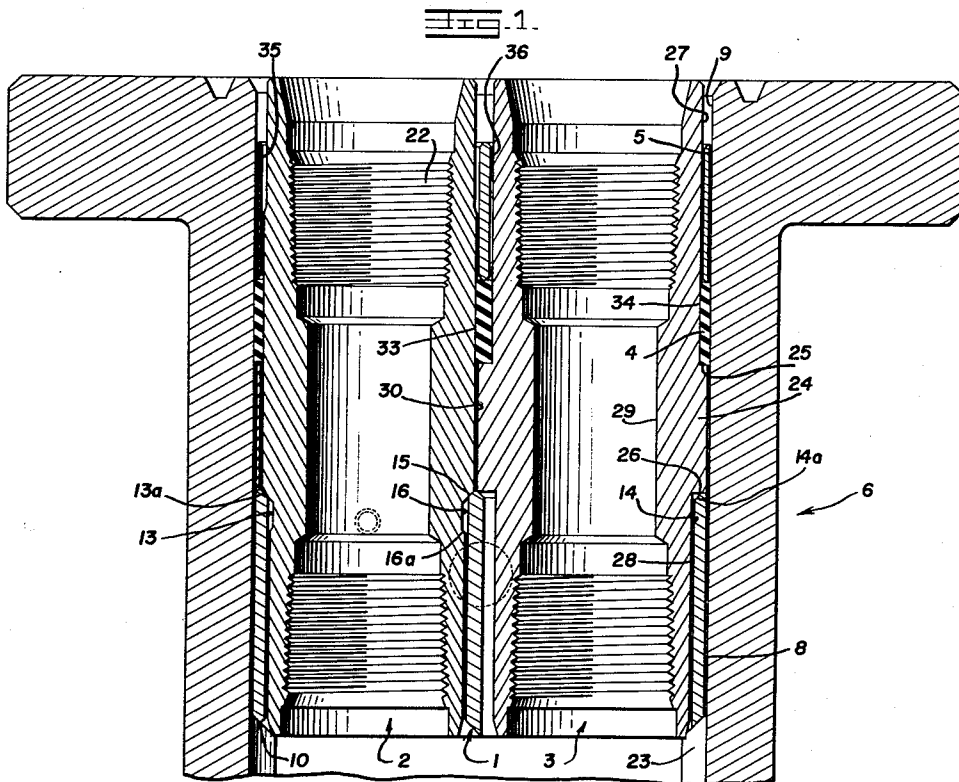
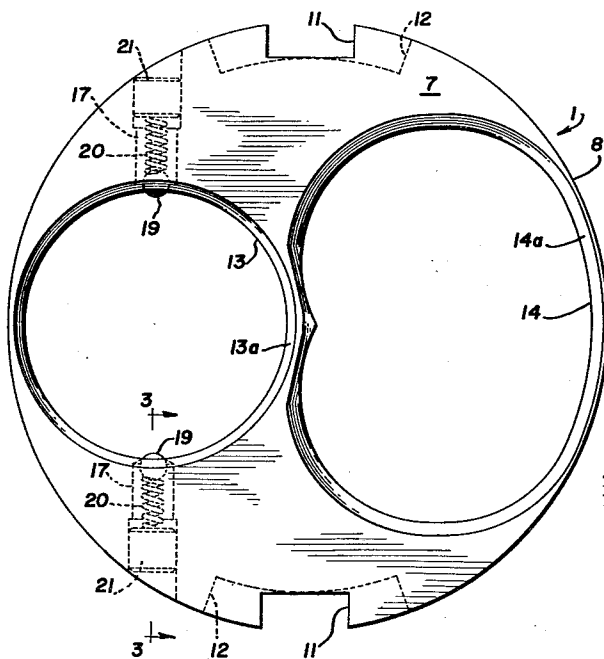
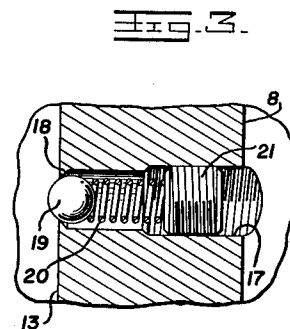


Fig. 4.

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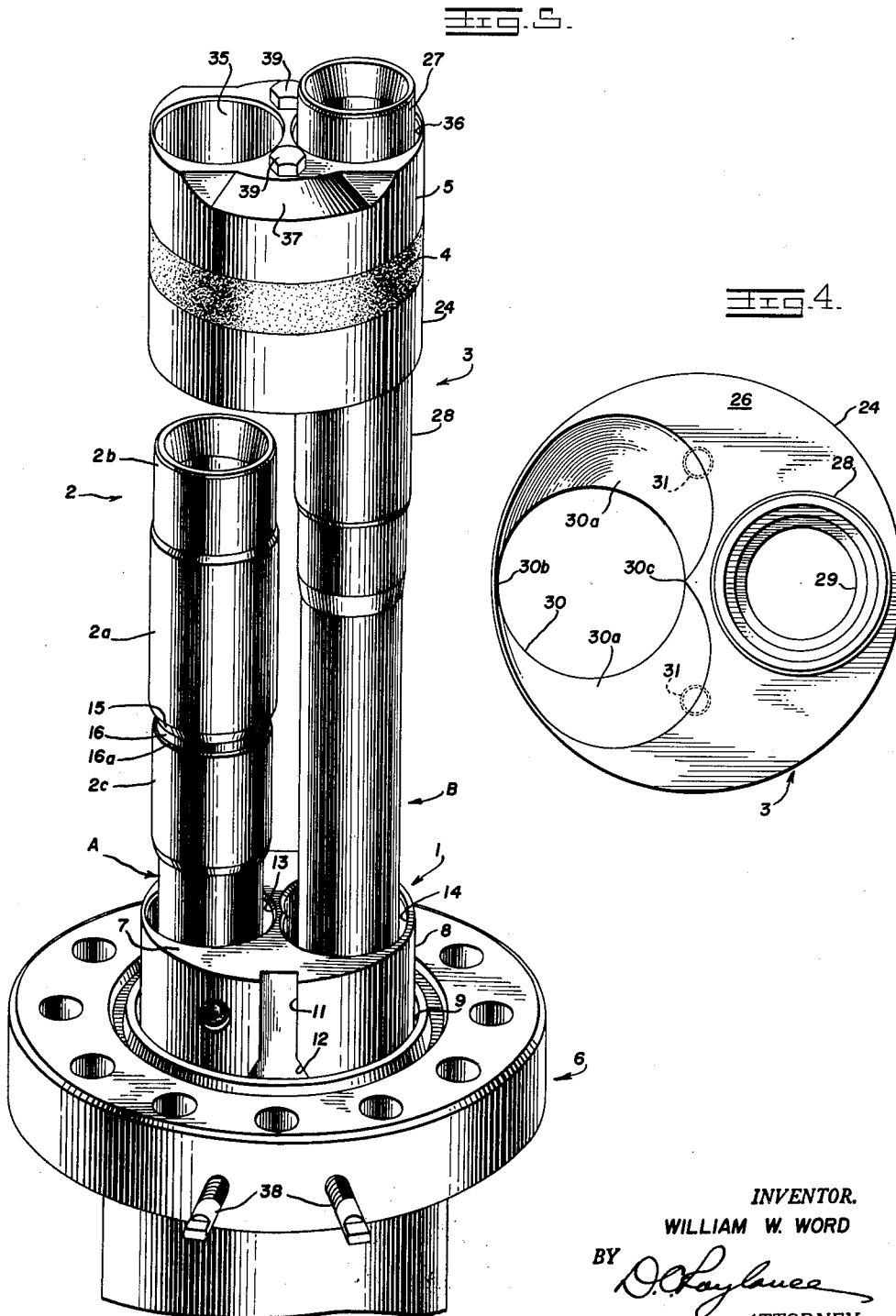
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MULTIPLE STRING TUBING HANGER CONSTRUCTIONS

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2 Sheets-Sheet 2



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MULTIPLE STRING TUBING HANGER
CONSTRUCTIONS

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This invention relates to the art of multiple well completion and particularly to novel and improved multiple string tubing hanger constructions.

It frequently occurs that a well will traverse a plurality of formations each of which is to be produced and for this reason it has become common practice to employ in such wells at least two tubing strings each extending to and in communication with a different one of the formations. Thus, in a typical installation, a first, long tubing string may extend to a lower formation, being "packed off" above the lower formation by a packer and being in communication only with the portion of the well below the packer, and a second, shorter tubing string may extend to and communicate with an upper formation, above the packer for the first tubing string. Such practice necessitates the hanging of both tubing strings by what is now termed a multiple string tubing hanger cooperating with one of the well head members, usually the tubing head. Particular difficulties arise in designing truly satisfactory hanger means because the entire multiple string hanger construction must be disposed within the bore of the tubing head or other head member or members, so that the designer is faced with severe limitations as to size and shape.

Such multiple string tubing hangers have been constructed in various fashions. Thus, in accordance with one prior art proposal, a split hanger is employed, comprising, in the case of a dual string installation, a pair of hanger members of semicylindrical configuration, the hanger members being arranged with their flat faces in contact. While such a split hanger construction offers various advantage, it has the distinct disadvantage that, considering the hanger in its finally assembled condition within the tubing head or the like, neither of the semicylindrical hanger members, and therefore neither of the tubing strings, can be rotated with respect to the other. In this connection, the ability to rotate at least one tubing string relative to the head is highly advantageous in avoiding "fouling" of the tubing string and also in facilitating proper manipulation of one or more of the tubing strings relative to the packer or like downwell equipment employed in connection therewith.

Regardless of the particular type of hanger construction contemplated, additional difficulties arise because of the desirability of using on one or more of the tubing strings various types of down-well equipment, and particularly gas lift valves, which project laterally from the tubing string so that the tubing string cannot be passed through a circular bore of a diameter only slightly larger than the largest diameter of the tubing string.

A general object of the present invention is to provide an improved hanger construction for multiple well completion.

Another object is to provide a multiple tubing string hanger construction for multiple well completion.

Another object is to provide a multiple tubing string hanger construction wherein, after all of the tubing strings are hung from the hanger, at least one of the strings can be rotated with respect to the other string or strings.

Yet another object is to devise such a hanger construction wherein any of the tubing strings can be raised and lowered independently, so as to be capable of being in-

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stalled or removed independently of the other string or strings.

A further object is to devise a multiple string tubing hanger making it possible to rotate at least one of the strings supported from the hanger, with such rotation being accomplished independently of the other string or strings and while the string being rotated is in its final assembled relation with the balance of the hanger components.

A still further object is to devise a multiple string tubing hanger comprising a hanger member to be seated in the bore of a tubing head or the like, and a tubing string supporting element in the nature of a coupling to cooperate with the hanger member, the arrangement being such that the hanger member is releasably attached to the supporting element so that the hanger member can be landed in the head member by manipulating the supporting element, as with a handling joint, and the supporting element can thereafter be released from the hanger member for manipulation relative thereto.

In order that the manner in which these and other objects are attained in accordance with the invention can be understood in detail, reference is had to the accompanying drawings, which form a part of this specification, and wherein:

FIG. 1 is a vertical sectional view illustrating a dual string tubing hanger construction in accordance with one embodiment of the invention;

FIG. 2 is a top plan view of a hanger member forming part of the device of FIG. 1;

FIG. 3 is a fragmentary vertical sectional view taken on line 3-3, FIG. 2;

FIG. 4 is a bottom plan view of a tubing string supporting element forming part of the device of FIG. 1, and

FIG. 5 is an exploded perspective view of the hanger construction of FIG. 1.

Turning now to the drawings in detail, it will be seen that the embodiment of the invention here illustrated, comprises a multiple string tubing hanger including a hanger member 1, a cylindrical tubing string supporting element 2, hereinafter referred to as a hanger coupling, for supporting one tubing string from the hanger member, a tubing string supporting element 3, of special configuration, for supporting a second tubing string from the hanger member, a packing member 4 and a gland 5. The hanger is associated with a well head member 6.

Hanger member 1 has a flat upper face 7 and a cylindrical outer wall 8. The hanger member is adapted to be received within the cylindrical bore 9 of head member 6, the hanger member being provided at its lower end with an annular chamfer to engage the inwardly and downwardly sloping annular shoulder 10 in the wall of the bore of the head member. Hanger member 1 is provided with two diametrically opposed, axially extending, outwardly opening slots 11 one or both of which can cooperate with a suitable radially oriented locator screw, or retractable "dowel," as is now known in the art, to properly orient the hanger member relative to the upper flange bolting of the head member. Slots 11 flare downwardly and outwardly at their lower ends, as seen at 12, FIG. 2, to simplify orientation as the hanger member enters the bore of the head member.

Hanger member 1 is provided with vertical passage means to accommodate a plurality of tubing strings. In this embodiment, the passage means includes a first through bore 13, of circular transverse cross-section, and a second through bore 14, of generally oblong transverse cross-section. Bores 13, 14 lie on opposite sides of the diameter extending through slots 11, and the centers of bores 13, 14 lie on a second diameter extending at right angles to the first. The long dimension of the oblong transverse cross-section of bore 14 extends parallel to the

diameter which passes through slots 11. At top wall 7, outwardly and upwardly flaring annular shoulders 13^a and 14^a are provided for bores 13 and 14, respectively.

Cylindrical bore 13 is of such diameter as to pass the couplings or tubing collars of tubing string A, FIG. 5. Bore 14 is of such transverse dimensions as to pass not only the collars of tubing string B, FIG. 5, but also laterally projecting elements, such as gas lift valves or other similar down-well equipment, carried by that string.

As to outer diameter, the hanger coupling 2 has a larger intermediate portion 2^a, and smaller end portions 2^b and 2^c, FIG. 5. There is provided, at the junction of portions 2^a and 2^c, a circular downwardly and inwardly slanting shoulder 15. The outer diameter of lower end portion 2^c of the coupling 2 is such that this portion fits with slight clearance in cylindrical bore 13 of hanger member 1. Shoulder 15 is, as seen in FIG. 1, adapted to lie in face-to-face engagement with shoulder 13^a.

Immediately adjacent to shoulder 15, coupling 2 is provided with a shallow, transverse, outwardly opening annular groove 16. As will be evident from FIGS. 2 and 3, hanger member 1 is provided with a pair of coaxial detent-receiving bores 17 aligned diametrically across through bore 13. Bores 17 are spaced from top face 7 of member 1 by a distance such that they will open into groove 16 on coupling 2 when shoulders 13^a and 15 are engaged. As seen in FIG. 3, each bore 17 has, at its end at the wall of bore 13, a detent-retaining shoulder 18. A detent ball 19 is located in each bore 17, being urged resiliently against shoulder 18 thereof by a compression spring 20 engaged between the detent ball and a threaded plug 21, FIG. 3.

It is thus apparent that, when the lower end portion of coupling 2 is inserted into bore 13 of hanger member 1, the detent balls 19 are initially forced outwardly, compressing springs 20, and then snap into groove 16, so attaching the hanger member to the coupling. The detent mechanism is so designed that a predetermined upward force on coupling 2 will cause lower wall 16^a of groove 16 to cam the detent balls 19 outwardly, compressing springs 20, so that the attachment between the hanger and coupling is released.

The lower end of coupling 2 is interiorly threaded in the usual fashion for connection to the last joint of tubing string A. The upper end of coupling 2 is interiorly threaded, as at 22, for connection to a handling joint. At its tip, the upper end portion of coupling 2 is provided with a frusto-conical inner surface, forming the lower seat for a sealed coupler (not shown) of the type disclosed in my copending application, Serial Number 791,463, filed February 5, 1959, such coupler providing one fluid connection to the bonnet-master valve-tree assembly or other well head equipment to be mounted on head member 6.

As indicated at 23, the bore 9 of head member 6 is provided with two diametrically opposed grooves, of arcuate transverse cross-section, extending longitudinally downwardly from shoulder 10. Grooves 23 afford free space for the tubing string collars when the collar is disposed partially in the corresponding bore of hanger member 1. Were these grooves not provided, the collars would tend to strike shoulder 10 as the string is lowered through the hanger member. It will be understood that, once the collar clears the hanger member, the tubing string can be shifted inwardly of bore 9, by a distance equal to the difference between the radii of the collar and the tubing, to allow the collar to clear the top of the well casing (not shown).

Supporting element 3 comprises a cylindrical body portion 24, equal in diameter to hanger member 1 and having a flat top face 25 and a flat bottom face 26. A cylindrical portion 27 extends upwardly from the top face of body portion 24, and a cylindrical portion 28 depends from the bottom face thereof. Portions 24, 27 and 28 are integral and a vertical bore 29 extends therethrough,

as seen in FIG. 1. From FIG. 1, it will be observed that the combination of portions 27 and 28, with bore 29, forms a coupling, portion 28 being interiorly threaded for connection to tubing string B and portion 27 being interiorly threaded for connection to a handling joint. As in the case of the upper portion of coupling 2, the tip of portion 27 is provided with a frusto-conical inner surface to form the lower seat for a sealed coupler in accordance with my aforementioned co-pending application Serial Number 791,463.

Lower portion 28 of supporting element 3 is, in this embodiment, of cylindrical shape and the same size as the lower portion of coupling 2. Hence, portion 28 depends freely into bore 14 of hanger member 1 when the circular body portion 24 of element 3 is seated on the top face 7 of the hanger member.

Body portion 24 of supporting element 3 is provided with a second bore 30 to accommodate coupling 2. At top face 25, the bore 30 is of circular transverse cross-section and has a diameter such that the larger, intermediate portion 2^a of the coupling fits snugly therein, as will be clear from FIG. 1. As illustrated in FIG. 4, bore 30 includes a pair of downwardly and outwardly flaring guide portions or locating tapers 30^a. Between portions 30^a, wall portions 30^b and 30^c lie in a cylindrical surface of diameter equal to the top end of the bore. Thus, wall portions 30^b and 30^c are disposed for line contact with intermediate portion 2^a of the coupling, as indicated in FIG. 1. Portions 30^a of bore 30 constitute inverted funnel-like guide surfaces to aid in so aligning the element 3 with respect to hanger member 1 that coupling 2 will properly enter bore 30.

Bores 29 and 30 are centered on one diameter of body portion 24 and lie generally on opposite sides of the center of the body portion, though guide portions 30^a of the bore 30 extend across the diameter which extends at right angles to that on which the centers of bores 29, 30 are located. Supporting element 3 is provided with a plurality of threaded vertically extending bores 31.

Packing member 4 consists of a cylindrical body, of rubber or other suitable compressible packing material, and is provided with two cylindrical through bores 33, 34, bore 33 to accommodate coupling 2 and bore 34 to accommodate upwardly extending portion 27 of supporting element 3. Member 4 is also provided with properly disposed plain cylindrical bores (not shown) to register with bores 31 of element 3.

Gland 5, of metal and generally cylindrical in form, is provided with a bore 35 to accommodate coupling 2, a bore 36 to accommodate portion 27 of element 3, and plain cylindrical bores (not shown) to register with bores 31. The diameters of parts 3, 4 and 5 are of course such, as seen in FIG. 1, that the parts will fit within bore 9 of the head member. At its upper end, gland 5 is provided peripherally extending downwardly and outwardly slanting bevels or cam surfaces 37 to be engaged by one or more of the usual radially disposed anchor screws indicated at 38, FIG. 5. Two such surfaces 37 are provided, opposed across the gland.

Supporting element 3, packing member 4 and gland 5 are assembled before being placed in the head member, as will be clear from FIG. 5. The packing member is simply placed on the top face 25 of body portion 24 of element 3, with portion 27 extending through bore 34 of the packing member. The gland is then placed on top of the packing member, with bore 36 of the gland accommodating portion 27. Cap screws 39, FIG. 5, are then inserted through the aligned plain cylindrical bores of the gland and packing members, which bores are disposed in registry with bores 31 of supporting element 3, and the cap screws are threaded into bores 31.

In employing this embodiment of the invention for multiple completion of a well already equipped with tubing head 6 and the usual blow-out preventer (not shown), the first, longer tubing string A, equipped with

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packer means (not shown) for fastening, supporting and sealing the lower extremity of the string in the bottom of the well bore, is run into the well through the tubing head in the usual fashion. Hanger member 1 is placed on coupling 2, detent balls 19 snapping into groove 16 to attach the hanger member releasably to the coupling. Hanger coupling 2 is then attached to the last joint of the tubing string. A handling joint is connected to the upper end of coupling 2, and the coupling and hanger member then lowered through the blow-out preventer and into the bore of head member 6. As the hanger member moves downwardly in the head member, the flared portions 12 of grooves 11 in the hanger member cooperate with the locator screw or screws (or retractable dowel or dowels) in the head member to properly orient the hanger member relative to the upper flange bolting of the head member. By means of the handling joint, the hanger member is moved downwardly until the chamfered bottom end thereof seats on shoulder 10, as seen in FIG. 1, so that tubing string A is hung by coupling 2 from the hanger member which in turn is supported by the head member. The hanger member thus having been properly landed, the handling joint is disconnected from coupling 2.

It will be noted that, while the tubing string A is fully supported by the hanger construction, the tubing string can be disconnected from the hanger member 1 simply by pulling the string upwardly with sufficient force to compress springs 20 to such an extent that the detents are released.

Second, shorter tubing string B is now run into the well, via bore 14 of hanger member 1, lower coupling portion 28 of supporting element 3 being attached to the last joint of the tubing string. It will be understood that, prior to attachment of element 3 to tubing string B, packing member 4 and gland 5 are installed thereon and secured by cap screws 39. A handling joint is connected to portion 27 of supporting element 3 and the latter is lowered through the blow-out preventer into head member 6 until bottom face 26 of element 3 seats on top face 7 of the hanger member. During such operation, portions 30^a of bore 30 of supporting element 3 coact with the upper end of coupling 2 to properly orient element 3. Anchor screws 38 are now screwed in until their tips, by engagement with cam surfaces 37 of gland 5, force the gland downwardly sufficiently to compress packing member 4 and accomplish a fluid-tight seal between coupling 2, portion 27 of element 3 and the wall of head member 6. The blow-out preventer and handling joint can now be removed and the bonnet-master valve-tree assembly mounted on the top flange of head member 6 to complete the assembly.

It will be noted that, at any time after the hanger member 1 has been landed and before mounting of the bonnet-master valve-tree assembly, tubing string A can be rotated at will in the hanger member. Further, since the detent means provided by balls 19, springs 20 and retainer plugs 21 is releasable, and since coupling 2 is of such shape and dimensions as to pass freely through bore 33 of packing member 3 and bore 35 of gland 5, tubing string A can be raised and lowered even through tubing string B has been hung.

These unique capabilities are of particular advantage in various situations encountered in multiple well completion. For instance, difficulty arises in running long tubing strings separately into parallel installations because the tubing strings often tend to wrap around each other. This is particularly likely to happen when the installation of the first string is such that, due to columnar loading, the string buckles somewhat and assumes a corkscrew-like configuration. To overcome such difficulty, it is desirable to have the first string hanging in tension when the second string is run in. Using the hanger construction of FIGS. 1-5, and assuming that the down well packer (not shown) has been set in the usual

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fashion, hanging of the first string in tension is accomplished by employing coupling 2 to hang the tubing string temporarily in such manner that the lower end thereof is just above the packer, the full weight of the tubing thus being supported from hanger member 1. Second tubing string B is then run in and supporting element 3 attached thereto and positioned in the hanger construction in the manner described earlier. Then, using a handling joint connected to the upper end of coupling 2, the first string A is picked up, an upward force being applied to the coupling sufficient to disengage detent balls 19 from groove 16. Coupling 2 is removed, additional tubing added to the string, the coupling then replaced and the string lowered, the lower end thereof being properly connected to the packer or like equipment and coupling 2 again being seated in hanger element 1 in the position seen in FIG. 1, to permanently hang the tubing string. During this manipulation of the tubing string, it is often necessary to rotate tubing string A to avoid "fouling" of one tubing string by the other and to accomplish proper connection of tubing string A to its down-well packer or like equipment.

With regard to rotation of coupling 2 relative to the hanger member 1, it is to be noted that the detent means comprises a fully annular groove 16 and that relative movement, during such rotation, between the walls of groove 16 and the detent balls 19 is substantially unimpeded.

In the particular dual string hanger embodiment shown and described, the construction is such that the second-installed, shorter tubing string B cannot be rotated relative to the hanger once supporting element 3 has been fully installed in the hanger. When more than one tubing string must be free to rotate, the additional string or strings are supported by couplings, equivalent to coupling 2, disposed in additional bores, equivalent to bore 13, in the hanger member 1.

From FIG. 5, it will be noted that the dimension of the transverse cross-section of bore 14, in the long direction, is markedly greater than the outer diameter of the tubing of string B, so that adequate space is afforded for passage of gas lift valves or like devices projecting laterally from the tubing.

In the present embodiment, the passage means in hanger member 1 which accommodates coupling 2 is a bore with a fully cylindrical wall. In this regard, it is to be understood that such bore need not have a fully cylindrical wall, so long as an adequate seat is provided for shoulder 15 of the coupling. Attention is called to copending application Serial Number 802,104, filed March 26, 1959, by Claude R. Neilon, disclosing and claiming a multiple string tubing hanger construction to which the present invention is applicable and wherein the bore wall of the hanger member surrounding the hanger coupling is less than a full cylindrical surface.

While, in this embodiment, the head member 6 has been described as a tubing head, it will be understood that hanger member 1 can be associated with a head member other than a tubing head.

What is claimed is:

1. In a well head apparatus for multiple completion wells, the combination of
 - a head member adapted for mounting at the top of a well and provided with an upright passage there-through of circular cross section, said passage being provided with a transverse upwardly facing shoulder;
 - a hanger member of generally cylindrical form, said hanger member being dimensioned to be lowered into said passage and having a diameter sufficiently large to substantially fill said passage, said hanger member having a downwardly facing transverse shoulder disposed to come into seating engagement with said shoulder in said passage as said hanger member is lowered into said passage,

said hanger member being provided with a plurality of vertical openings therethrough, at least one of said openings being of circular transverse cross section; a first tubing string supporting element of cylindrical form and of such diameter as to substantially fill the cross-sectional area of said one vertical opening, said first tubing string supporting element being threaded at its lower end for attachment to a tubing string to be suspended therefrom,

said hanger member and said first tubing string supporting element being provided with cooperating shoulder means extending transversely of said first tubing string supporting element whereby said first tubing string supporting element, when received in said one vertical opening, can be supported directly on said hanger member;

releasable attaching means comprising a detent carried by said hanger member, said first tubing string supporting element being provided with a transverse, annular, outwardly opening groove spaced above the lower end of said element by a distance such as to be located within said one opening when said element is received therein and supported on said hanger member, and resilient means engaging said detent to bias the same into said one vertical opening to engage between the side walls of said groove when said first tubing string supporting element is received in said one vertical opening,

engagement of said detent in said groove serving to releasably attach said hanger member to said first tubing string supporting element, whereby said hanger member can be lowered into said passage and seated therein by means of a handling joint attached to said first tubing string supporting element and can be withdrawn upwardly from the passage by the handling joint when not held against upward movement,

said releasable attaching means allowing rotating of said first tubing string supporting element, and the tubing string suspended therefrom, about the vertical axis of said first tubing string supporting element relative to said hanger member when said element is supported on said hanger member, with said detent constantly engaging said first tubing string supporting element during such rotation,

at least one other tubing string supporting element threaded at its lower end for attachment to a tubing string to be suspended therefrom, said other tubing string supporting element being of such transverse dimension and shape that it can be lowered beside said first tubing string supporting element into another of said vertical openings when said first tubing string supporting element is received in said one opening and supported on said hanger member,

said hanger member and said other tubing string supporting element being provided with cooperating shoulder means extending transversely of said other tubing string supporting element whereby said other tubing string supporting element, when received in said other vertical opening, can be supported directly on said hanger member, the transverse dimension and shape of said other tubing string supporting element allowing independent upward withdrawal of said first tubing string supporting element when both of said elements are supported on said hanger member;

said resilient means of said releasable attaching means being effective to allow said attaching means to release under upward strain when said hanger member is seated in said passage and held against upward movement, whereby said first tubing string supporting element can be detached from said hanger member and raised, independently of said other tubing string supporting element,

said vertical openings in said hanger member being of such size as to freely pass the tubing strings to be suspended from said tubing string supporting elements; and

seal means for effecting a fluid-tight seal between said tubing string supporting elements and the wall of said passage, said seal means including packing portions surrounding said tubing string supporting elements and through which said first tubing string supporting element can be withdrawn upwardly without removal of said seal means or said other tubing string supporting element.

2. Well head apparatus in accordance with claim 1 and wherein

said other tubing string supporting element comprises a cylindrical body portion of such diameter as to substantially fill said passage, and a dependent tip portion adapted to be received in said other opening,

said cylindrical body portion having a lower face disposed to seat on the top of said hanger member, the top of said hanger member and said lower face constituting said cooperating shoulder means for direct support of said other tubing string supporting element on said hanger member,

said cylindrical body portion having an upright passage spaced laterally from said dependent tip portion to register with said one opening when said dependent tip portion is received in said other opening,

said upright passage being of such transverse dimension that said first tubing string supporting element can pass freely therethrough.

3. Well head apparatus in accordance with claim 2 and wherein

said upright passage has downwardly and outwardly flaring wall portions to engage the top of said first tubing string supporting element in guiding relation as said other tubing string supporting element is lowered into said passage subsequent to installation of said hanger member and first tubing string supporting element.

4. Well head apparatus in accordance with claim 2 and wherein

said other tubing string supporting element also comprises a cylindrical portion projecting upwardly from said cylindrical body portion in axial alignment with said dependent tip portion, and

said seal means comprises

a cylindrical packing member of compressible material disposed above said cylindrical body portion, and

a gland disposed above said packing member for energizing said packing member,

said packing member having a normal diameter such as to substantially fill said passage and including a first upright bore to accommodate said first tubing string supporting element and a second upright bore spaced laterally from said first bore to accommodate said upwardly projecting cylindrical portion of said other tubing string supporting element,

said first tubing string supporting element being bodily movable axially through said first bore when said packing member is uncompressed.

5. Well head apparatus in accordance with claim 1 and wherein

said first tubing string supporting element includes a plain cylindrical upper portion of a diameter larger than the maximum diameter of said one opening, and a plain cylindrical lower portion of slightly smaller diameter than said one opening,

said upper portion being disposed above said hanger member when said first tubing string supporting element is supported on said hanger member by said cooperating shoulder means.

6. Well head apparatus in accordance with claim 5 and wherein

said transverse groove of said releasable attaching means is located in said lower portion adjacent the juncture between said upper and lower portions,

said upper and lower portions being separated by a transverse annular shoulder which forms the upper side wall of said groove.

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