April 26, 1966 W. P. KNIGHT 3,248,130

SYSTEM AND METHOD FOR RUNNING AND HANGING TUBING IN A WELL

Filed April 2, 1965 2 Sheets-Sheet 1

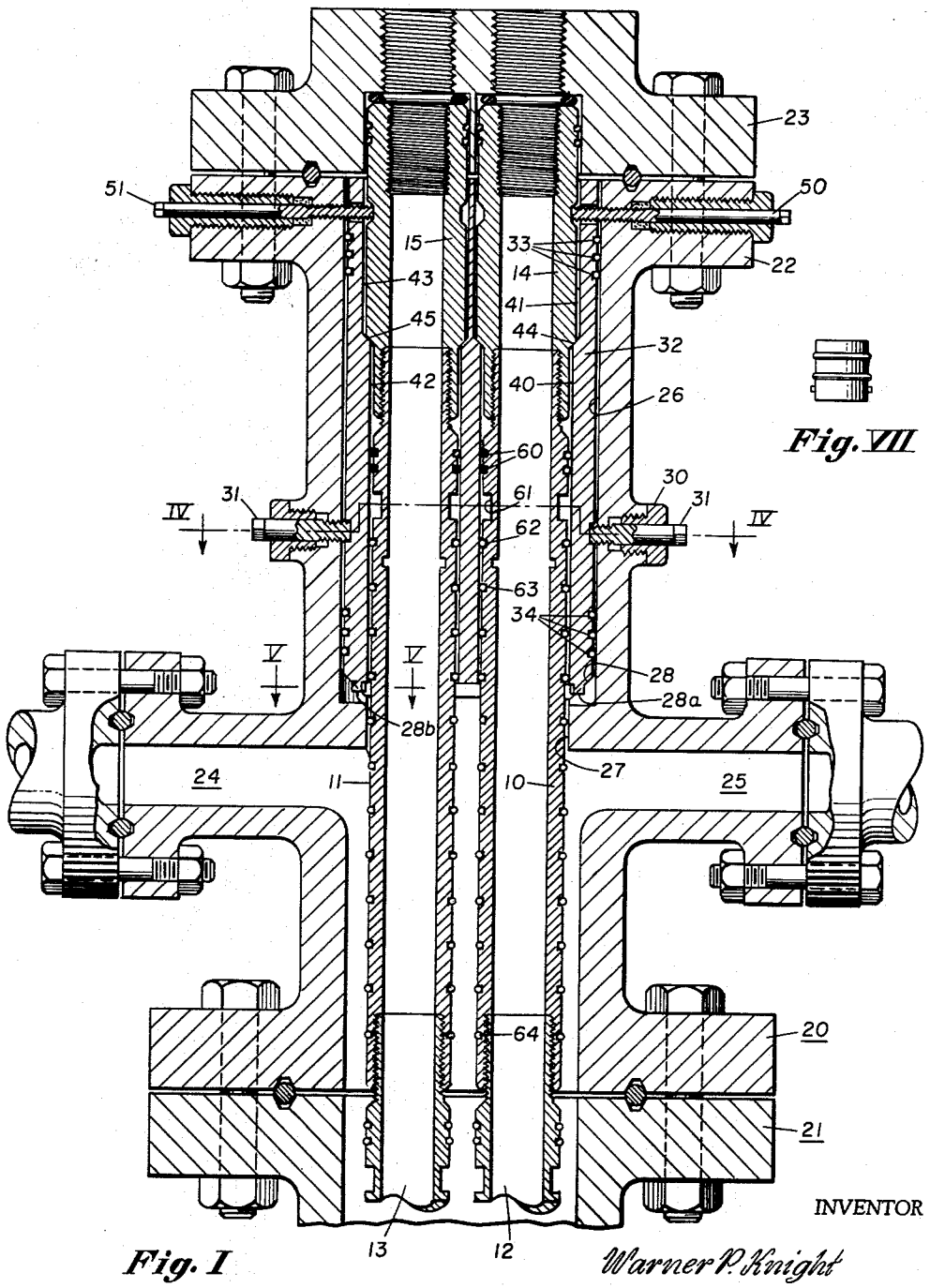


Fig. I

Fig. VII

INVENTOR

Warner P. Knight

BY

Wm. T. Wofford

ATTORNEY

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SYSTEM AND METHOD FOR RUNNING AND HANGING TUBING IN A WELL

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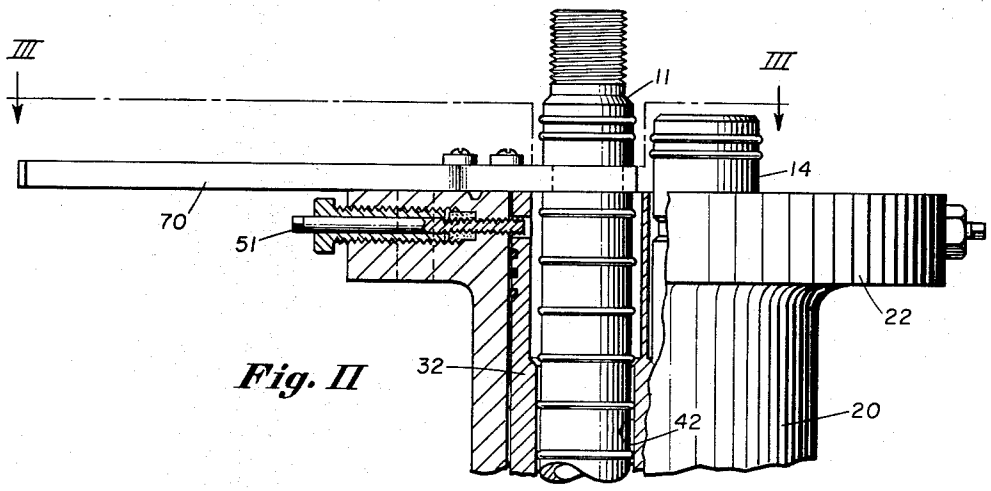


Fig. II

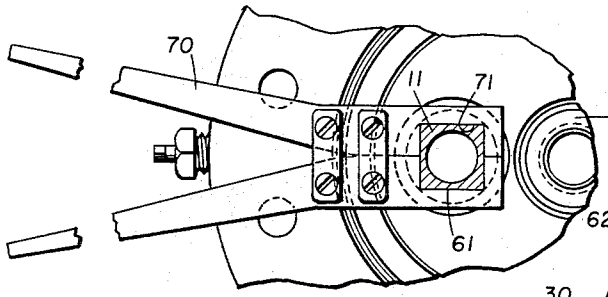


Fig. III

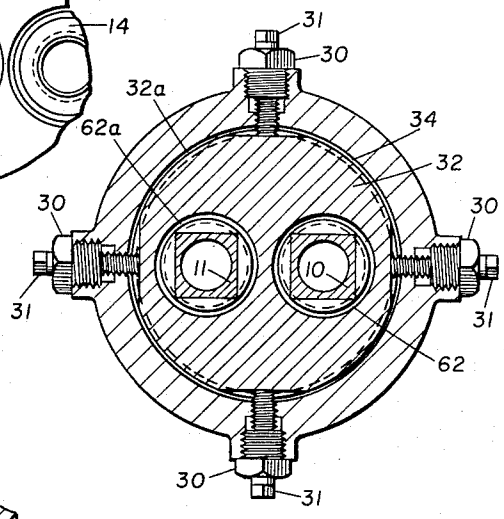


Fig. IV

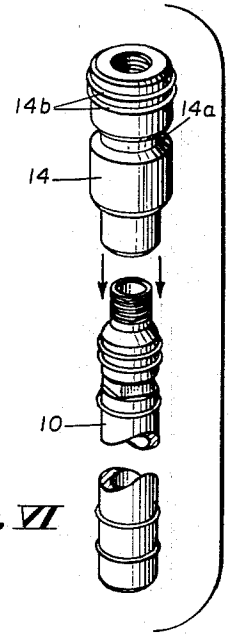


Fig. VI

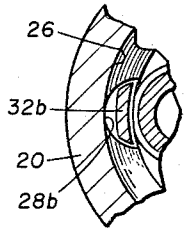


Fig. V

INVENTOR

Warner P. Knight

BY

Wm. T. Wofford

ATTORNEY

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3,248,130

SYSTEM AND METHOD FOR RUNNING AND HANGING TUBING IN A WELL

Warner P. Knight, Rte. 9, Box 236, Fort Worth, Tex.

Filed Apr. 2, 1965, Ser. No. 463,414
1 Claim. (Cl. 285—27)

This application is a continuation-in-part of copending application, Serial No. 86,892, filed February 3, 1961, now abandoned.

This invention relates to a method and system for running tubing into a well and for suspending this tubing under tension in a sealed relationship in a tubing head so as to permit raising or lowering of the tubing relative to the tubing head while maintaining a well under control.

In a more specific aspect, the invention is particularly useful for installing a plurality of strings of tubing in a given well. Dual completions and other multiple completions involving more than two strings of tubing in a well have been found highly desirable in order to provide separate communication to each of a plurality of different producing zones. Multiple strings of tubing are installed in a well with packers sealing the annulus between the tubing strings and the casing in the well in order to maintain separately the production from each of the producing zones.

By way of example, where two strings of tubing are employed for producing two vertically spaced zones, general practice is to set a first packer above the lower of the zones and then to run a second packer into the well on the first string of tubing. Thereafter a second string of tubing is run into the well and connected into the second packer. Production through the first string of tubing is from a zone below the first packer, and production through the second string of tubing is from a zone between the first or lower packer and the second or upper packer.

In such installations, it has been found desirable to maintain all tubing strings in tension, that is, stretched in a manner similar to an elastic band. Difficulty has been encountered with existing equipment in setting dual or multiple tubing strings in tension not only because they may not be manipulated while the well is under pressure, but because in the initial installation it is often found necessary to cut and thread the upper end of tubing at the tubing head so that tubing hangers may be suited with the proper tension on the tubing. Particular difficulty is encountered installing tubing in wells which are under pressure.

It is an object of the present invention to provide a system and method for hanging tubing in a well which permits operation with the well under positive control at all times during the installation, and which permits ready adjustment of well head equipment after initial installation while maintaining the well under control.

More particularly in accordance with the present invention, well head equipment is provided for a tubing installation which includes a tubing head having an opening extending therethrough with an intermedaite element adapted to be supported and sealed in the tubing head and having a plurality of openings therethrough. A tubing hanger in each opening is cooperable with the intermediate element and to be supported by the intermediate element. At least one nipple connected to the bottom of each tubing hanger supports a section of tubing extending into the well. Provision is made for maintaining a pressure seal between the nipple exterior and the interior of the intermediate element below each tubing hanger.

In a more specific aspect, the invention relates to a system for installing and maintaining a string of tubing in a well under tension while maintaining the well under control, and includes a tubing head having a reentrant bore therethrough with a first upfacing shoulder therein. A sealing bowl seats on said upfacing shoulder. Means carried by the sealing bowl engages the wall of the reentrant bore to maintain a pressure tight seal therebetween. The sealing bowl has at least one reentrant aperture extending therethrough with an intermediate upfacing shoulder. A tubing hanger in the sealing bowl aperture is seated on the intermediate upfacing shoulder. At least one nipple is provided to interconnect the bottom of the hanger and tubing extending into the well with the nipple extending through the sealing bowl. Sealing means carried by the nipple is adapted to engage the walls of the aperture to maintain a pressure-tight seal therebetween and to permit movement through the sealing bowl of the nipple for manipulation of the tubing string while maintaining well control.

For a more complete understanding of the present invention and for further objects and advantages thereof, reference may now be had to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a cross sectional elevational view of a tubing installation in accordance with the present invention;

FIG. 2 is a fragmentary cross sectional elevational view showing a special sealing nipple being run into a well through a sealing bowl;

FIG. 3 is a fragmentary top plan view taken along the lines III—III of FIG. 2;

FIG. 4 is a cross sectional view taken along the line IV—IV of FIG. 1;

FIG. 5 is a fragmentary cross sectional view taken along the line V—V of FIG. 1;

FIG. 6 is a perspective exploded view of one of the tubing hangers and one of the sealing nipples provided in accordance with the present invention; and

FIG. 7 is a schematic elevational view of a back pressure valve which may be used in connection with the invention.

Referring now to FIG. 1, a pair of nipples **10** and **11**, each having a substantially cylindrical exterior surface and a longitudinal bore, are connected at the lower ends thereof to like nipples **12** and **13** which in turn are connected to additional similar nipples (not shown) at the lower ends thereof and thence to support a pair of strings of tubing (not shown). The bores extending through the respective sets of nipples provide for separate flow of production from two zones penetrated by the well in which said tubing is installed.

The nipples **10** and **11** are supported at the upper ends thereof by tubing hangers **14** and **15**, respectively. The manner in which the nipples **10–13** function with associated elements to permit raising and lowering of tubing hangers **14** and **15** to install tubing under tenison is a significant contribution to the petroleum producing art.

As illustrated in FIG. 1, a tubing head **20** is affixed to the casing head **21** by bolts coupling the upper radial flange on the casing head **21** and the lower radial flange on the tubing head **20**. Tubing head **20** is provided with an upper radial flange **22** to which there is connected upon the completion of the installation, a flanged coupling element **23** which accommodates connections to production control equipment commonly known as a Christmas tree.

The tubing head **20** is provided with a pair of lateral ports **24** and **25** which communicate with the annular zone in the well. The upper section of the tubing head **20** is provided with an enlarged bore **26** of substantially greater diameter than the bore **27** of the lower intermediate portion of the tubing head. The bores **26** and **27** may thus be understood to form a reentrant opening

extending through the tubing head with an upfacing sloping shoulder **28**. The tubing head is provided with a plurality of bushings, such as bushing **30**, through which set screws **31** extend. Screws **31** may extend into the cavity within the tubing head **20**.

An intermediate element hereinafter referred to as a sealing bowl **32** is adapted to be inserted into bore **26** in the upper portion of the tubing head **20**. The diameter of the sealing bowl **32** is slightly less than the diameter of the bore **26** so that it may readily be inserted. The O-rings **33** mounted in grooves in the exterior surface of the sealing bowl **32** near the upper end and the O-rings **34** mounted in grooves on the exterior surface of the sealing bowl **32** near the lower end thereof engage the inner wall of the bore **26** to maintain a pressure-tight seal therein. When the sealing bowl **32** is inserted into the bore **26** to rest upon shoulder **28**, the hold down screws **31** are tightened to engage the exterior surface of the sealing bowl **32** preferably on milled flat areas provided at circumferentially spaced points.

The sealing bowl **32** is provided with a pair of reentrant bores. The right hand bore has a lower section **40** constituting a cylindrical inner surface of diameter smaller than the diameter of the upper section **41**. Similarly, the left hand bore has a lower section **42** constituting a cylindrical inner surface of diameter smaller than the diameter of the upper section **43**. Lower sections **40** and **42** are both of sufficient diameter to permit tubing strings to be fed therethrough (including the tubing collars). An upfacing shoulder such as shoulder **44** having a sloping face is provided between lower bore **40** and upper bore **41**. In a similar manner, a shoulder **45** having a sloping face is provided between the lower bore **42** and the upper bore **43** in the left hand channel.

Tubing hanger **14** connected to the upper end of nipple **10** is provided with a shoulder which seats on the shoulder **44** in order to provide a positive support for the nipples and tubing extending therebelow. Tubing hanger **15** similarly seats on the shoulder **45**.

The upper end of the sealing bowl **32** is provided with at least one radial port for each bore therethrough in order to permit hold down screws such as screws **50** and **51** to extend through the walls of the sealing bowl **32** near the upper end into engagement with the exterior surface of tubing hangers **14** and **15**, respectively. Hangers **14** and **15** are provided with circumferential grooves into which the hold down screws **50** and **51** extend.

As above stated, the cylindrical inner surfaces or bores **40** and **42** are of sufficient size to permit the free movement of the tubing and tubing collars therethrough and are larger than the diameter of the nipples **10–13**. However, each of the nipples is provided with a plurality of O-rings, the latter being spaced along the length of each such nipple and so dimensioned as to provide a pressure-tight seal between the nipple and the cylindrical inner surfaces **40** and **42**.

More particularly, a pair of O-rings **60** carried in grooves around the upper end of the nipple **10** contact the inner wall of the bore **40**. Immediately below the O-rings **60** there is provided a milled zone **61**, preferably providing four flat surfaces in the periphery of the nipple **10**. Below the zone **61** there are provided additional O-rings such as rings **62**, **63** and **64**. O-rings or packing elements are sized for sealing engagement with the respective cylindrical inner surfaces **40** and **42** and **62–64** are provided in number sufficient to permit the tubing hanger **14** and nipples **10** and **12** to be raised in the well while maintaining at all times a positive pressure seal between at least one nipple below a tubing hanger **14** and the wall of the bore **40** through which the nipples pass.

For example, as shown in the fragmentary sectional view of FIG. 2, tubing hanger **15** of FIG. 1 has been raised relative to the upper flange **22** of the tubing head

20 and removed. The nipple **11** is shown extending slightly above the surface of flange **22** and supported by a special wrench-like tool **70** sometimes herein called a "hanging tool" which rests upon the upper surface of the flange **22** and which engages the flats in the zone **61** of FIG. 1. In this case, a seal between the nipple **11** and the bore **42** is maintained by the O-rings carried by the lower portion of the nipple **11**. With the nipple **11** in the position shown in FIG. 2, additional nipples may be secured thereto to permit the tubing string to be lowered to even greater depths. Alternatively, the nipple may be further elevated in the well to apply further tension on the tubing.

The use of the hanging tool **70** for supporting the nipple **11** is best shown in FIG. 3. The tool has a rectangular opening **71** which in dimensions corresponds with the cross section of the nipple **11** at the milled zone **61**. It is understood that the hanging tool **70** could take any convenient form that would be compatible with its function, and also, the milled zone **61** could take any convenient form that would provide a suitable means on the outer periphery of each nipple intermediate the ends thereof to accommodate the hanging tool.

FIG. 4 illustrates a sectional view taken along the line IV—IV of FIG. 1 more clearly to show the cross sectional configuration of the nipples **10** and **11** together with the flat zones on the surface of the sealing bowl **32** provided to receive the hold down screws **31**. It will be seen that the annulus **32*a*** between the sealing bowl **32** and bore **26** is sealed by the O-ring **34** while the annulus between the nipple **10** and the bore **40** is sealed by the O-ring **62**. In a similar manner the annulus between the nipple **11** and the bore **42** is sealed by O-ring **62*a***.

FIG. 5 illustrates structure for positioning the sealing bowl **32** in the bore **26**. In this regard reference should first be had to orienting depressions **28*a*** and **28*b*** shown in FIG. 1, milled in diametrically opposed portions of the shoulder **28*a***. The depressions **28*a*** and **28*b*** are adapted to mate with projections formed on the lower end of the sealing bowl **32**. More particularly the sealing bowl **32** has two diametrically opposed projections extending below the surface of the beveled shoulder **28**. In FIG. 5, one projection **32*b*** is illustrated positioned in depression **28*b***. When the sealing bowl is inserted into the bore **26**, it is rotated until the projections, such as projection **32*b***, register with the depressions, such as the depression **28*b***. When this is accomplished, the hold down screws **31** are in alignment with the flat zones on the exterior surface of the sealing bowl **32** and at the same time the hold down screws **51** are in alignment with the radially extending holes in the upper end of the sealing bowl **32**.

FIG. 6 illustrates an exploded view showing the tubing hanger **14** and the upper nipple **10**. The tubing hanger **14** has the radial groove **14*a*** into which the hold down screw **51** of FIG. 1 extends. The upper end of the tubing hanger **14** is provided with a pair of sealing rings **14*b*** which serve to maintain a seal between the tubing hanger and the Christmas tree structure **23** (FIG. 1).

In operation, a dual completion may be carried out as follows:

(a) Upon completion of drilling operation and the setting and cementing of casing, the well is drilled in and a blow-out preventer is installed on the upper flange **22** of the tubing head **20**. The tubing head **20** is then fastened to the casing head **21**.

(b) The well casing is then perforated at two zones of interest and a first packer set at a selected depth between the perforated zones.

(c) A first string of tubing is introduced into the well through the blow-out preventer.

(d) A second packer is mounted on the first string of tubing and lowered below the tubing head.

(e) The sealing bowl **32** is installed in the tubing head through the blow-out preventer, over the first string of tubing, and the hold down screws **31** are tightened to maintain the tubing bowl in a fixed position in the tubing head **20** with the projections, such as projection **32***b*, in the depressions, such as **28***b*, FIG. 5.

(f) The first tubing string is then lowered to locate the second or upper packer above the upper set of perforations and to couple the lower end of the tubing into the first or lower packer.

(g) Nipples, such as nipples **10** and **12**, are connected to the upper end of the first string of tubing along with a tubing hanger **14**. The latter is then lowered into the sealing bowl **32**.

(h) The second string of tubing is then lowered through the bore **42** by way of the blow-out preventer until the bottom end of the second string of tubing "touches" the upper packer. The second string is then raised and nipples **11** and **13** are installed in the second string thereof along with an intermediate length of tubing, if necessary. The tubing hanger **15** is added and is seated in the bore **43** with the lower end adjacent to the upper packer.

(i) Tubing hangers **14** and **15** are locked in place by the hold down screws **50** and **51**.

(j) At this point the blow-out preventer may be removed since the sealing bowl is locked in position by hold down screws **31**, the tubing hangers **14** and **15** are locked in position by hold down screws **50** and **51**, and the head of the well is sealed by O-rings **33** and **34** between the sealing bowl **32** and the tubing head **20** and by O-rings on each of the nipples.

When necessary, back pressure valves such as shown in FIG. 7 may be installed in one of the nipples **10–13** or may be installed in the tubing strings near the lower ends thereof to close the tubing channels.

(k) The tubing hangers **14** and **15** are raised and while in raised position such as illustrated in FIG. 2 are removed so that additional nipples may be added to each of the strings of tubing to permit the lowering of the first string sufficient to lock said first string in the lower packer and to permit the first string to be raised to set the upper packer and to place the first string in tension. The desired tension may stretch the tubing in some cases as much as 50 inches so that nipples sufficient in number to accommodate the setting of the upper packer and tensioning the first tubing string will be necessary. Similarly, nipples sufficient in number are installed on the second string to permit it to be stabbed into and secured to the upper packer for production from the zone between the lower and upper packers. The second string of tubing must also be tensioned, nipples in number sufficient to permit the tensioning operation being included.

(l) The tubing strings are raised successively by applying tension thereto to pull one or several of the nipples **10–13** on each string above the tubing head flange **22**.

(m) When sufficient tension has been registered on a first of the string of tubing, hanging tool **70** is fixed to the flat surfaces on the nipple positioned immediately above the top of the flange **22**.

(n) The first string of tubing is lowered so that the wrench or hanging tools **70** take the weight of the string and the tensile force therein while the nipples above the flange **22** are removed and replaced by a tubing hanger.

(o) The strings of tubing are raised slightly to permit removal of the hanging tools **70** and the tubing hanger is lowered into the sealing bowl.

(p) Steps (m) and (o) are repeated for the second string.

(q) The Christmas tree structure **23** is added for producing through the strings of tubing, and back pressure valves are removed from the tubing or nipples.

It will be understood that the foregoing operations permit the reworking of the tubing strings while maintaining the well under control. Greater or less tension can be set into the tubing strings by merely raising the tubing hanger out of the sealing bowl and adding or removing nipples as desired. In each case, however, the nipples employed maintain a pressure-tight seal between the exterior of the nipples and the interior of the sealing bowl **32**.

It will be clear from the foregoing that the minimum effective increment that the tubing string may be lengthened or shortened is the length of one nipple. This is also the distance between the hanging tool accommodating means on adjacent nipples. Further, the minimum effective length for a nipple is the length of the intermediate element cylindrical inner surface. There must always be at least one nipple below each tubing hanger. The minimum spacing between adjacent packing elements, whether on one nipple or on adjacent nipples, must not exceed the length of an intermediate element cylindrical inner surface.

The term "packing element" as used herein is intended to encompass a sealing element such as an O-ring as well as any suitable sealing element means well known to those skilled in the art that will accomplish the requisite pressure seal. The packing elements could also make up a solid longitudinally extending seal on each nipple of length exceeding that of the intermediate element inner cylindrical surface, if that were desired.

While the foregoing has dealt specifically with a dual completion system, it is to be understood that features of the invention may be employed for hanging as many strings of tubing as can be accommodated by the casing in a tubing head in the manner above described by use of a sealing bowl with additional channels extending therethrough.

Components discussed and not illustrated, but used as adjuncts to hanging plural strings of tubing in carrying out the present method are well known in the art. The blowout preventer, packers, back pressure valves, and other conventional apparatus used in connection with the invention may all be of any suitable make or type as will be readily understood by those familiar with the petroleum production art.

Applicant has, however, devised a new system and a new method for the handling and manipulation of multiple completion well head equipment. The tubing head with a reentrant bore therethrough is of size sufficient to admit as many strings of tubing as desired. The intermediate sealing bowl element is adapted to be supported and sealed in the tubing head and is provided with as many openings therethrough as tubing strings to be placed in the well. A tubing hanger is provided in each opening in the sealing bowl and cooperates with means in the sealing bowl for supporting the hanger. At least one nipple is connected to the bottom of each tubing hanger and is adapted to support a section of tubing in each string in the well. Pressure seal means are provided to seal the annulus between the sealing bowl and the tubing head and between the nipples and the channels through the sealing bowl.

It will be seen that the invention relates not only to construction of the well head equipment, but also to a new method of hanging tubing in a well involving operations extending into the hole itself and particularly the cooperation between the well head equipment and the packers in the well.

In carrying out the method of the present invention to set a pair of tubing strings through the bore of a well head below which a first packer is installed, the steps set forth above will be followed. One of the tubing strings carrying a second packer is inserted through the bore of the tubing head. The bore of the tubing head is then stopped except for two passages therethrough, the first of which is an annular passage concentric with the first string of tubing and the second of which is a cylindrical passage parallel to the first annular passage for introduction of a second string of tubing.

The first string of tubing is then lowered until the second packer is at a predetermined depth. The second string of tubing is then introduced through the cylindrical passage until the lower end thereof is adjacent the top of the second packer. There are then established slidable annular seals in the first annular passage, and also in a second annular passage between the second string of tubing and the cylindrical passage through which it extends. The strings of tubing, the second packer and the first packer are then interconnected below the well head and coupled to the wall of the well while maintaining the annular seals in the tubing head. Tension is then applied to stretch the strings of tubing while maintaining the annular seals. The tubing strings are then hung in the well head while maintaining tension on the strings of tubing through the annular seals. Thus at all times the well pressure is sealed by the O-rings or packing elements carried by the sealing bowl and by the nipple-formed tubing sections.

Having described the invention in connection with certain embodiments thereof, it is to be understood that further modifications may now suggest themselves to those skilled in the art, and it is intended to cover such modifications as fall within the scope of the appended claim.

I claim:

Well head equipment for tubing installation which comprises:

(a) a tubing head having a bore therethrough;

(b) an intermediate element supported and sealed in said tubing head and having a plurality of axial openings therethrough;

(c) a tubing hanger in each said opening;

(d) cooperable means in said intermediate element for supporting each said hanger;

(e) at least one nipple connected to the bottom of each said hanger and supporting a section of said tubing extending into said well;

(f) each said opening of said intermediate element having a cylindrical inner surface below said hanger of diameter such as to make a slidable fit with said respective nipple;

(g) each said nipple having a substantially cylindrical exterior surface and annular packing elements disposed at spaced intervals along its length and sized for sealing engagement with said inner surface;

(h) the length of each said nipple being at least the length of said inner surface, and the spacing of any two adjacent packing elements not exceeding the length of said inner surface;

(i) and means on the outer periphery of each said nipple intermediate the ends thereof to accommodate a hanging tool;

(j) whereby nipples may be moved longitudinally through the intermediate element to manipulate a tubing string while maintaining well control.

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CARL W. TOMLIN, *Primary Examiner.*

D. W. AROLA *Assistant Examiner.*