Aug. 9, 1949. C. HANSEN 2,478,628

TESTING CASING HEADS

Filed Jan. 27, 1947 3 Sheets-Sheet 1

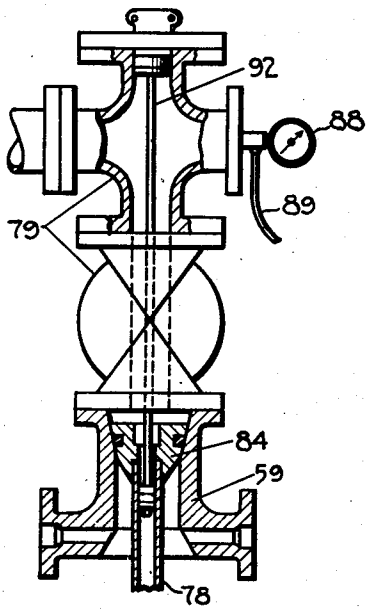

Fig. 7

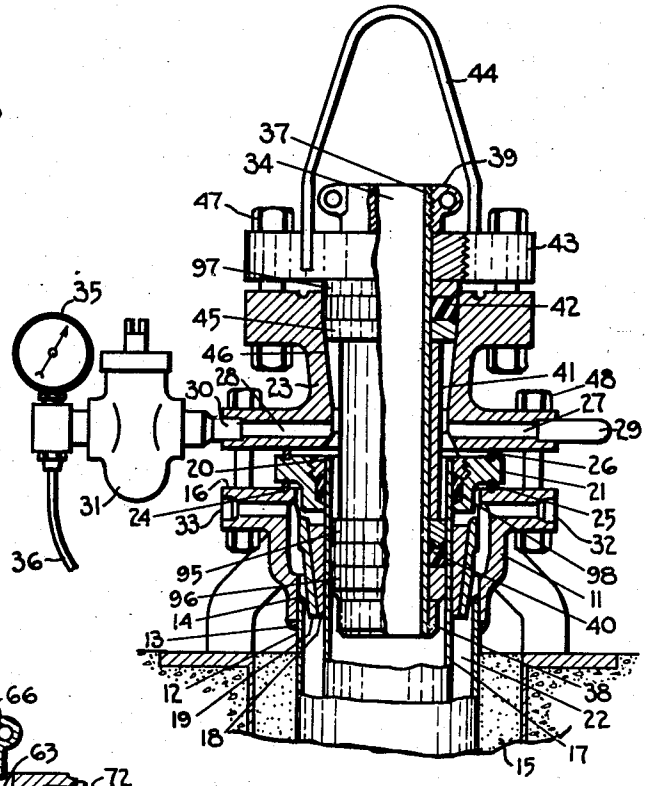

Fig. 1

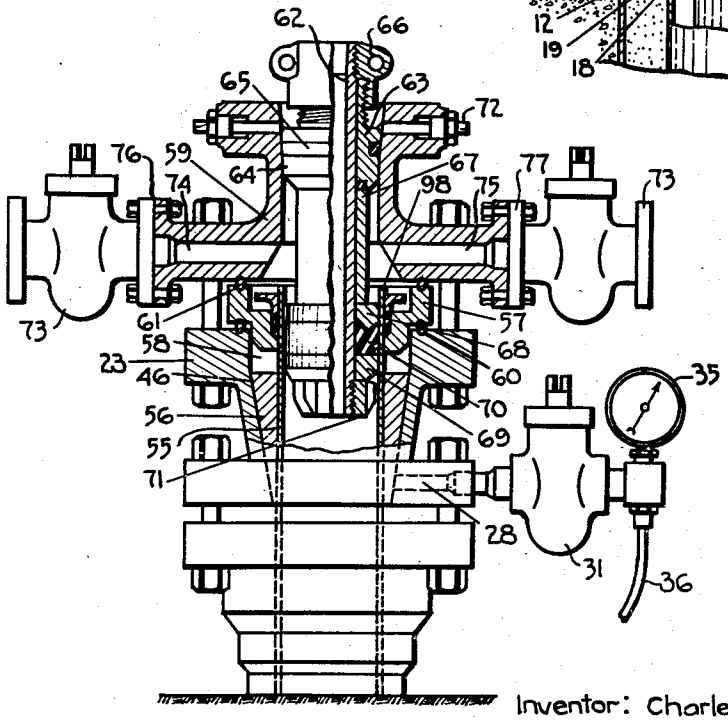

Fig. 2

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TESTING CASING HEADS

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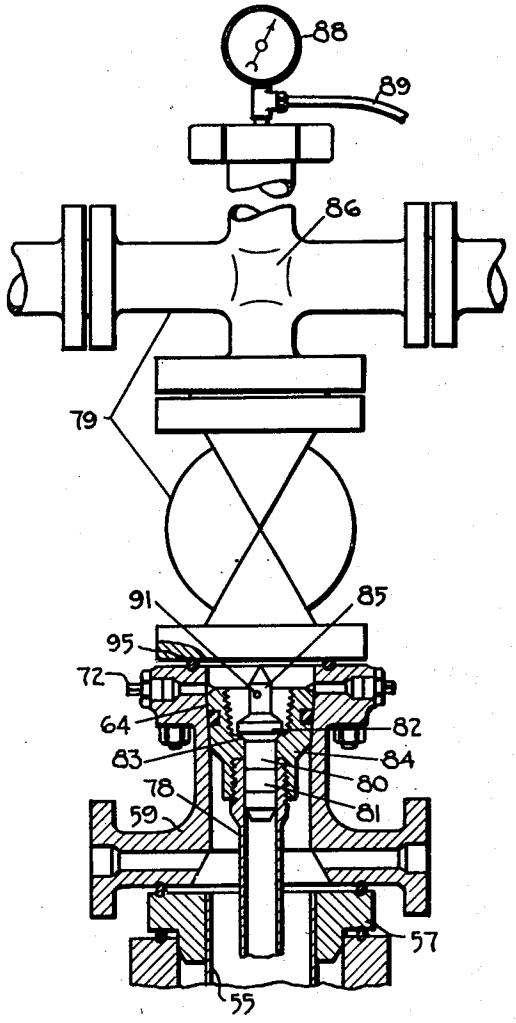

Fig. 3

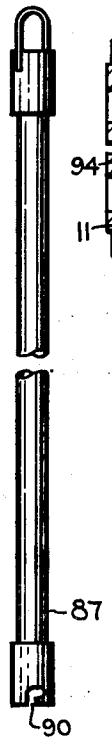

Fig. 4

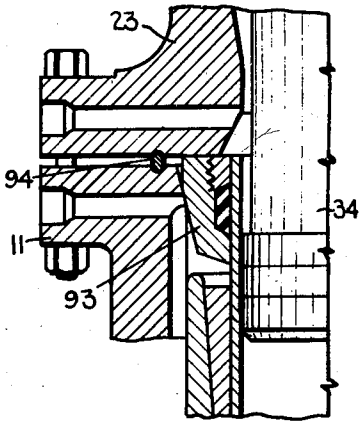

Fig. 5

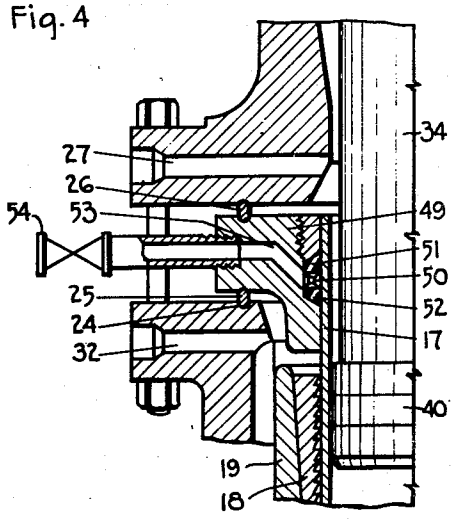

Fig. 6

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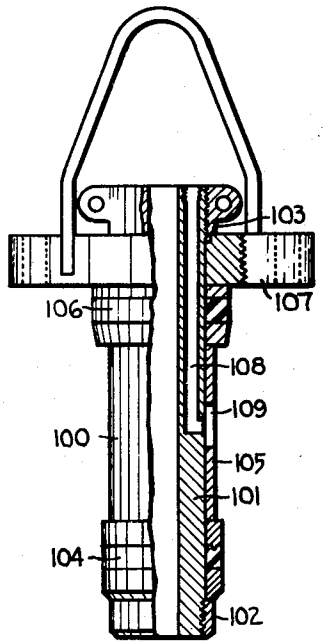

Fig. 8

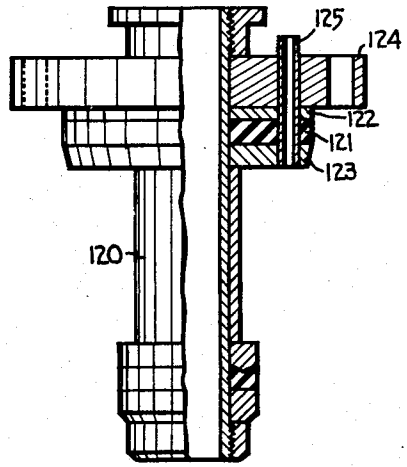

Fig. 10

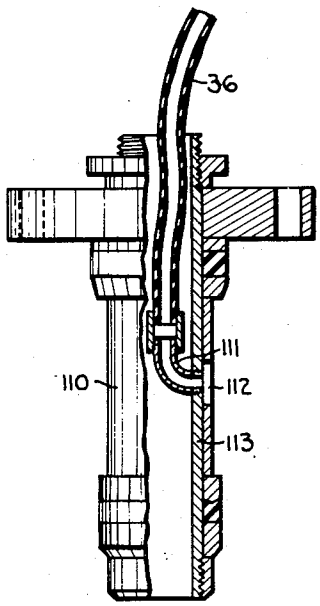

Fig. 9

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UNITED STATES PATENT OFFICE

2,478,628

TESTING CASING HEADS

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Application January 27, 1947, Serial No. 724,644

2 Claims. (Cl. 73—46)

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This invention relates to well casing heads and pertains more particularly to a method for testing the seals between the fittings of a casing head assembly as it is being installed on the well before the well is brought into production.

As a well is completed a set of high pressure fittings is attached to the upper ends of the various strings of casing which extend into the well. When the well is completed these fittings comprise the casing head assembly including that part which is commonly known as the "Christmas tree." Although considerable care is exercised in connecting the various fittings and although each component part of the assembly is always previously tested to a pressure in excess of the rated working pressure, there is no assurance until the well actually produces that the assembled fittings installed on the well head will withstand the working pressures without leaking.

In this connection, it is not uncommon for leaks to develop in the casing head assembly at the packing, sealing rings, screw threads and/or other connections which are made up or assembled at the well. Such leaks, however, are not usually discovered until after the well had been allowed to produce. Such leaks are not only hazardous but have caused the loss of numerous wells. Even though the leak can be repaired after the well has been brought in, it is often necessary to again set up the drilling machinery and to kill the well before the repairs can be made. This procedure involves considerable expense and may result in damaging the well's production.

It is therefore the primary object of this invention to provide a method for testing a casing head assembly for leaks as it is being installed on the well.

Another object of the present invention is to provide an apparatus adapted to be positioned at various locations within the assembly and to seal off the various test areas.

A further object of this invention is to provide a simple, inexpensive testing apparatus of sturdy construction which can be easily and quickly installed or removed from the casing head and which is capable of withstanding the high testing pressures.

A still further object is to provide a method whereby various parts of the casing head assembly may be tested after they have been installed at the well.

These and other objects of this invention will be understood from the following detailed description of the method and the preferred embodiments of the apparatus of the present invention as shown in the accompanying drawings wherein:

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Figs. 1, 2, 3 and 7 are diagrammatic views, partly in cross-section, of the present testing apparatus positioned in different parts of the casing head assembly.

Fig. 4 is a view of a retrieving tool used to remove part of the testing apparatus from the casing head.

Figs. 5 and 6 are diagrammatic views partly in cross-section of packing elements forming part of casing head structures tested according to the present method.

Figures 8, 9 and 10 are modified forms of the testing mandrel.

In describing the present invention, reference is made to the attached drawings which show a typical well multi-string installation such as employed in high pressure wells requiring three strings of casing. It is to be understood that modifications or alterations can be made in the testing method and apparatus of this invention to permit adaptation to systems and types of well control installation other than that shown.

In setting up the component parts of this assembly at the well, installation of the entire well head assembly is not completed at one time, but is made progressively as the drilling of the well advances. In Fig. 1, for example, the lowermost casing head base unit 11 is attached to the upper end of the large (for example, 13⅜") outer casing 12 at the time said casing is run and cemented in the well as shown at 15. The attachment of the casing 12 to the base unit 11 is generally made by welding as shown at 13 and 14. After attachment of the base unit 11, continued drilling through the large casing 12 may be accomplished in a manner well known in the art by flanging to the upper flange face 16 of the base unit 11, a drilling riser (not shown) comprising blow-out preventer equipment, flow outlets, etc.

When the well is in condition to receive a smaller size (for example, 9⅝") casing 17, the latter is usually run through the drilling riser and cemented in the well. Afterwards, the drilling riser is removed from the well, permitting the insertion of slips 18 and a spider 19 in the base unit 11 for supporting the casing 17. The casing 17 is then cut off at its upper end, at a point 20 as shown, and an annular fluid-tight means such as the packing assembly 21, containing packing 98, is installed which seals off the annulus 22 between the casings 12 and 17 at the surface of the well. A casing spool is then flanged

to the base unit 11, for example by means of bolts 48, as illustrated, which retain the packing assembly 21 in place. The upper flange face of the base unit 11, the lower flange face of the casing spool 23 and both sides of the flange of the packing element or assembly 21 are all equipped with annular grooves, as shown at 24, which are adapted to receive annular fluid-tight means such as sealing rings 25 and 26 which are preferably metallic sealing rings. The casing spool 23 is provided with threaded outlets such as 27 and 28, one of said outlets being adapted to receive a bull plug 29 and the other a nipple 30 of a high pressure valve 31 as will be described hereinbelow. The base unit 11 is also provided with similar threaded outlets 32 and 33 adapted to receive the testing equipment but normally plugged shut. All parts which have been described as being installed on the well thus far, except the drilling riser, are permanent, being retained in assembly during the production life of the well.

It should be particularly noted that all of the connections made at the well in assembling the forenamed parts are susceptible to leakage. It is therefore highly desirable to test these vulnerable points of possible leakage at the time of installation and before drilling operations are resumed. This object can be accomplished by employing the means and method of the present invention.

The testing apparatus used in making this test is shown in Fig. 1. The equipment comprises a tubular testing mandrel 34, a gage 35, and a conduit such for example as a flexible hose 36 to which is connected a conventional hydraulic pump (not shown). The testing mandrel 34 is utilized in this invention to seal off certain sections or points of the casing head assembly to be tested and to prevent the longer mud-filled inner casings from being subjected to the test pressures. The inner casing is usually considerably longer than any of the outer casings and is usually subjected to greater pressures due to the greater static head of the drilling fluid within the casing. To expose this casing to an additional test pressure might cause a rupture in said casing.

As can be seen in Fig. 1 the testing mandrel 34 comprises an assemblage of parts which are related and function in the following manner. The testing mandrel 34 is provided with an inner sleeve 37 having its lower end threaded to receive the shoulder stop nut 38 and its upper end threaded to receive the adjustment nut 39. Slidably mounted on the outside of the sleeve 37 above the stop nut 38 is a cylindrical lower packing element 40 and its glands or abutments 95 and 96, a spacer sleeve 41, an upper packing element 42 and its glands 45 and 97, and a companion flange 43. These elements are held in place on the sleeve by the adjustment nut 39. A becket 44 is attached to the companion flange 43 to facilitate the handling of the testing plug or mandrel 34 when inserting it or removing it from the well control assembly.

In installing the test mandrel 34, the becket 44 is secured to a catline and the mandrel, with the packing adjustment nut 39 in the unloosened position, is lowered into place, as shown in Fig. 1, until the mandrel is supported by the lower ring gland 45, of upper packing element 42, in the tapered bore 46 of the casing spool 23. Following the seating of the testing mandrel 34 in the well control assembly, flange bolts and nuts 47 are installed and tightened. The adjustment nut 39 is then tightened by rotation, which causes the upper and lower packings, 42 and 40 respectively, to be compressed into sealing engagement with the bore 46 of the casing spool 23 and the bore of the casing 17 respectively.

The pressure gage 35 is then connected, as shown in Fig. 1, to the high pressure valve 31 and a flexible hydraulic hose 36 is installed to apply the pressure of a hydraulic pump to the outlet 28 of the casing spool 23, while the other outlet 27 is closed by a bull plug 29. Hydraulic pressure is then applied through the side outlet 28 to the interior of the well control hook-up. This pressure, which is confined between the packing elements 40 and 42 of the test mandrel 34, is thus applied to the sealing ring 26, the packing assembly 21 and the threaded connections of the side outlets 27 and 28 to test their ability to hold pressure.

A falling pressure as denoted by the readings of the pressure gage 35 indicates the presence of any leak. Repairs can then be made to the casing head before any more of it is assembled. The packing assembly 21 and the sealing ring 25 may be tested for leaks before or after installation of the testing mandrel 34. The high pressure valve 31 is for this purpose transferred from outlet 28 to outlet 32 in the base unit 11 while the other outlet 33 is closed by means of a plug identical with plug 29. Hydraulic pressure is then applied as described above through the side outlet 32 to the annulus between the casings 12 and 17 which is closed at the upper end by the packing assembly 21 and the sealing ring 25 and at the lower end by liquid standing in the well. This pressure is applied to the packing assembly 21, the metallic sealing ring 25 and the threaded connections of the casing outlet vents 32 and 33, thus testing these seals for possible leaks.

When considerable trouble is encountered with the seal formed by the packing in the packing element 21, it has been found advantageous to employ a packing element 49, such as shown in Fig. 6, having a lantern ring 50 located between rings of packing 51 and 52 which form the seal against the casing 17. A conduit 53 leads from the lantern ring to the outside of the packing element, said conduit being normally closed by a valve 54. Thus when pressure is applied through outlets 27 or 32 in order to test metallic sealing ring 26 or 25, the packing assembly 49 may first be tested by opening the valve 54 and noting any drop in test pressure by the gage. Any testing fluid leaking past the packing 51 or 52 will have access to the outside through the lantern ring 50, conduit 53 and the open valve 54. After the packing assembly has been tested for leaks the valve 54 is closed while the sealing rings are tested. Should leaks occur at any of the forementioned points or at other places, repairs can be made and the assembly retested before reflanging the drilling riser for further drilling.

If the test is satisfactory, the testing mandrel 34 is removed after first loosening the adjustment nut 39 by rotation. The gage 35 and the flexible hose 36 are also removed. The drilling riser (not shown) is then flanged to the upper end of the casing spool 23 for continued drilling and for running and landing a smaller inner casing 55.

After the smaller (for example 7") casing 55 has been run and cemented in the well and the drilling riser has been removed, the casing 55 is suspended, or supported by slips 56. The casing 55 is then cut off, as shown at point 98 and the

packing assembly 57, similar to the packing assembly 21, is placed and packed off around the casing 55 thus closing the annulus 58 between said casing and the bore 46 of the casing spool 23. The tubing-head spool 59 is then flanged in place above packing assembly 57 after the sealing rings 60 and 61, similar to rings 25 and 26, have been placed in the annular grooves of the flange faces, as shown. These parts are also part of the permanent installation and inasmuch as they are exposed to the full pressure of the well, they must likewise be tested before the well is brought into production.

To test the lower sealing ring 60 and the packing assembly 57 for leaks, pressure is applied as before through the conduit 28. Other points besides the lower sealing ring 60 and the packing assembly 57 will also be subjected to this test pressure, but since they have previously been tested, any drop of pressure indicated by gage 35 can be due only to failure of the elements 60 or 57. If desired, a lower test pressure may be applied in this and subsequent tests as the remaining seals usually do not encounter the abnormal high pressures that are sometimes present before the inner string of casing is landed.

To test the upper sealing ring 61 a testing mandrel is provided which may be identical or similar to the one previously described, or may have certain modifications in order to adapt it for use with the component parts of a particular head structure being tested. For example, the testing mandrel 62 may have slidably mounted thereon a plug 63 provided with packing 65 which seats in the upper tapered bore 64 of the tubing-head spool 59. Longitudinal adjustment is provided between the mandrel 62 and the plug 63 by means of a right and left-hand threaded inter-connecting nut 66. A sleeve 67 is slidably carried by the mandrel 62 to engage the lower face of the plug 63 and also the upper end of the packing gland 68. The upper gland 68 and the lower gland 69, as well as the packing 70 are all arranged to slide on the mandrel 62 and are of such peripheral measurement as to closely fit the bore of the casing 55. A nut 71 is threaded to the lower end of the mandrel to retain the parts slidably mounted thereon.

The testing mandrel 62, in assembly, is lowered into the well control hook-up, to the position as shown in Fig. 2, and is retained therein by the hold-down screws 72, the latter being a part of the tubing-head spool 59. The lower packing 70 is expanded and sealed off inside the casing 55 by rotational adjustment of the nut 66. When thus installed, the hydraulic pump, together with the gage 35, is connected to one of the two side outlet valves 73 in the same manner as has previously been described for testing the installation of the larger casing 17. Hydraulic pressure is thus applied through either side outlet 74 or 75 to the interior of the well control hook-up between the test mandrel packings 65 and 70. This pressure tests the effectiveness of the seals at such vulnerable points as the upper sealing ring 61, the packing assembly 57 and the flange connections 76 and 77, before subjecting them to well pressure.

Referring to Fig. 3, after effecting the test described above, the drilling riser is mounted on the upper flange face of the tubing-head spool 59, drilling operations are completed and the well is tubed. After the tubing 78 has been run and landed and the drilling riser removed, the "Christmas tree," as diagrammatically represented in general by numeral 79, is installed, preparatory to bringing the well into production. The installation of the "Christmas tree" usually necessitates the assembly of several sub-assemblies, as it is difficult or impossible to transport and install a relatively large and complicated "Christmas tree" in one complete unit. The connections which fasten these sub-assemblies, and particularly the connection between the tubing-head spool and the "Christmas tree," are sealed by gaskets, sealing rings or other fluid-tight means, and are susceptible to leakage if improperly installed.

The present invention also provides a method and apparatus for testing the effectiveness of all such last-mentioned connections before the well is brought into production. The testing mandrel for making this test may in this case be modified to a form such as a plug 80 shown in Fig. 3. The lower end of the plug 80 is provided with a packing 81, preferably of a rubber-like material, which seals off the tubing 78 at its upper end. An enlarged shoulder 82 is formed on the plug 80 so as to engage the shoulder bore 83 of the tubing suspension plug 84, the latter being attached to the upper end of the tubing 78 and seated in the tapered bore 64 of the tubing-head spool 59 to support the tubing 78 and to pack it off inside the tubing-head spool. A fishing neck 85 provided with radial pins 91 extends upward from the enlarged shoulder portion 82 of the plug 80 to facilitate its removal following the completion of the test.

The test plug 80, at the operator's discretion, may be positioned in the upper end of the tubing 78 before the "Christmas tree" 79 is installed, or may be passed down through the central stem 86 of the tree by means of a retrieving tool 87 (Fig. 4) following the installation of the tree.

Whatever method is selected, the test plug 80 is positioned, as shown in Fig. 3, and a gage 88 and a flexible hose 89 are connected at any convenient point on the tree 79. The hydraulic pump (not shown) is then connected to the free end of the flexible hose 89 and the entire tree 79, as well as the tubing suspension plug 84 and the sealing ring 95, is subjected to a test pressure before the actual well pressure is introduced. Repairs, as needed, can be made before bringing the well into production.

Following the final operation of testing, the test plug 80 is removed by means of the retrieving tool 87, the lower end of which is provided with slots 90. The retrieving tool is lowered in through the tree 79 and is caused to engage the pins 91 of the test plug 80 with the slots 90 to remove the test plug 80 from the tubing 78. After replacing the top flange through which the retrieving tool was removed, the assembly is in condition to permit the well to be brought into production with the assurance that all connections are pressure-tight.

Although the use of three different types of test mandrels or plugs 34, 62 and 80 is shown in the method of testing hereinabove described, it is to be understood that this is done only for the purpose of showing the adaptability of this method to the use of different types of testing equipment. It can readily be appreciated that the test plug 80, that is used when testing the "Christmas tree," can be replaced as shown in Fig. 7 by an elongated test mandrel 92 similar to the test mandrel 34. Likewise, a test mandrel of the type designated by 62 could be replaced

by one similar to test mandrel **34** which in turn could be replaced by a test plug.

It is also realized that many different variations of the testing method are possible depending upon the equipment being used and tested in assembling the well head control system. For example, the method of testing could be shortened and simplified considerably if a flangeless packing assembly **93**, as shown in Fig. 5, is used instead of the flanged type packing assemblies **21** and **57** previously described. Use of this type of assembly having no flange would eliminate one sealing ring and would leave only one ring **94** to be tested for each packing assembly used. Many types of packing can be used in both the packing assemblies and packing elements of the test mandrels. In the latter case however a resilient material, such, for example, as rubber or rubberlike material is the preferred form.

Since some types of casing head assemblies do not have the necessary outlets (**27**, **32** and **74**) by which the test pressure may be applied to the seals and packing being tested, a modified form of the testing mandrel **34** may be used, such as one shown in Figs. 8, 9 or 10. These testing mandrels all possess a means by which the hose **36** from the hydraulic pump (not shown) may be attached directly to the mandrel so that the test pressure is applied through the mandrel to the test zone between the packing elements.

As can be seen in Fig. 8, the testing mandrel **100** is provided with an inner sleeve **101** having its lower end threaded to receive the shoulder stop nut **102** and its upper end threaded to receive the adjustment nut **103**. Slidably mounted on the outside of the sleeve **101** above the stop nut **102** is a lower packing element **104**, a spacer sleeve **105**, an upper packing element **106** and a companion flange **107**. A fluid passageway **108** is formed longitudinally in the wall of said inner sleeve **101** so that its lower end communicates with an aperture **109** in the spacer sleeve **105**. The upper end of the fluid passageway **108** is adapted to receive the test gage **35** and hydraulic pump hose **36** (shown in Fig. 1). Fluid pressure applied by the pump will pass down the fluid passageway **108** and out the aperture **109** in the spacer sleeve **105**.

The testing mandrel **110**, shown in Fig. 9, makes use of a short nipple or elbow **111** attached to the inside of the sleeve **113**. To one end of the elbow **111** is attached the hydraulic pump hose **36** while the other end of the elbow communicates with an aperture **112** in the sleeve **113**. Another testing mandrel **120** is shown in Fig. 10. In this embodiment of the present invention the hydraulic pump hose may be attached to a small pipe or tube passing through the upper packing element **121**, its glands **122** and **123**, and the companion flange **125**.

I claim as my invention:

1. Apparatus for testing for leakage of a well installation of the type having a flanged tubular string extending into the well and a flanged tubular well head fitting connected to said string at the surface by means comprising a seal ring between the flanged portions of said tubular string and well fitting, said seal ring having a diameter greater than the inside diameter of said tubular string, said apparatus comprising a test mandrel insertable into said tubular well head fitting and depending into said tubular string, an upper packer carried by said mandrel adapted to seal off said tubular well head fitting above said seal ring, a lower packer carried by said mandrel adapted to seal off said tubular string below said seal ring, fluid passage means extending through said well head fitting for applying fluid pressure to the space defined by said two packers within said tubular well head fitting and string, whereby said pressure is applied to the connection formed by said seal ring, and indicating means for registering a decrease of said pressure due to leakage from said space.

2. Apparatus for testing for leakage of a well installation of the type having a flanged tubular string extending into the well and a flanged tubular well head fitting attached to said string at the surface by a connection element between the flanged portions of said tubular string and well fitting, said apparatus comprising a test mandrel insertable into said tubular well head fitting and depending into said tubular string, an upper packer carried by said mandrel adapted to seal off said tubular well head fitting above said connection element, a lower packer carried by said mandrel adapted to seal off said tubular string below said connection element, fluid passage means extending through said well head fitting for applying fluid pressure to the space defined by said two packers within said tubular well head fitting and string, whereby said pressure is applied to said connection element, and indicating means for registering a decrease of said pressure due to leakage from said space.

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