July 18, 1967 M. R. JONES 3,331,437

WELLHEAD ASSEMBLY

Filed Jan. 6, 1965 3 Sheets-Sheet 1

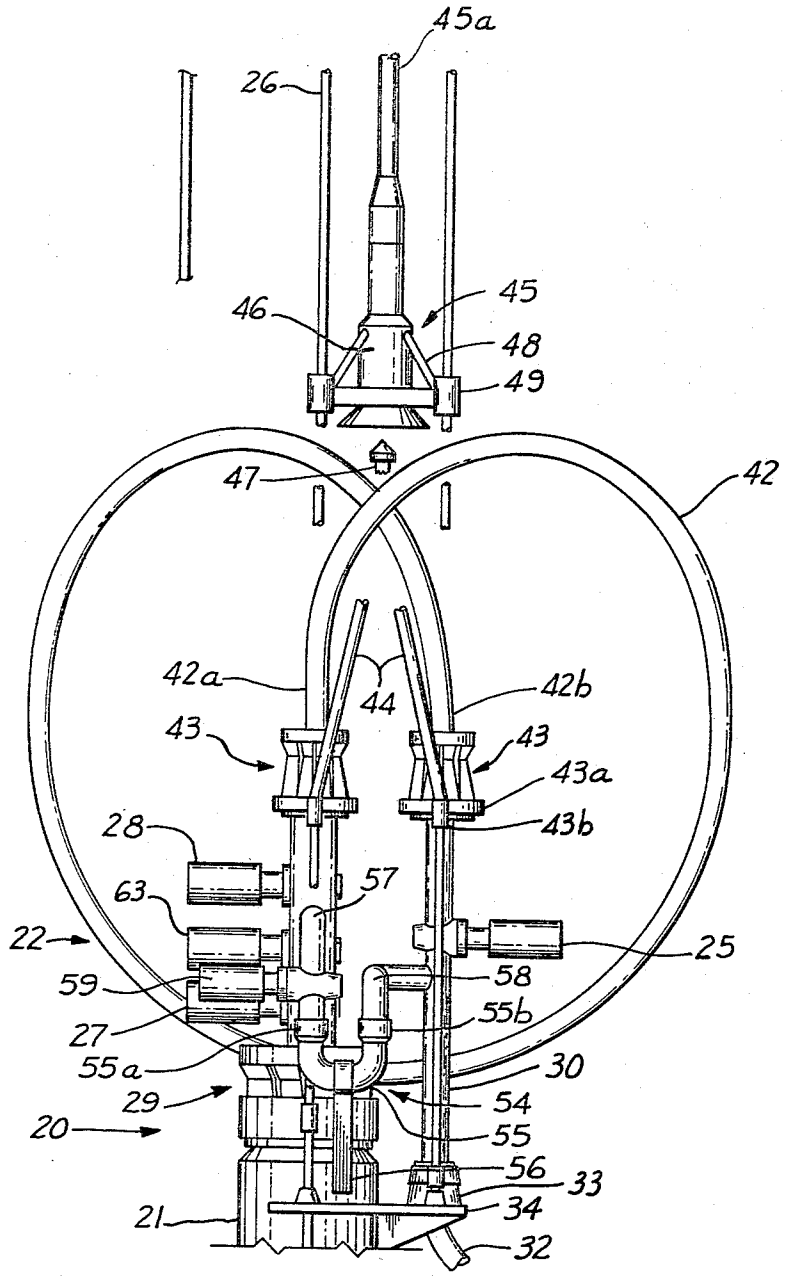

Fig-1

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WELLHEAD ASSEMBLY

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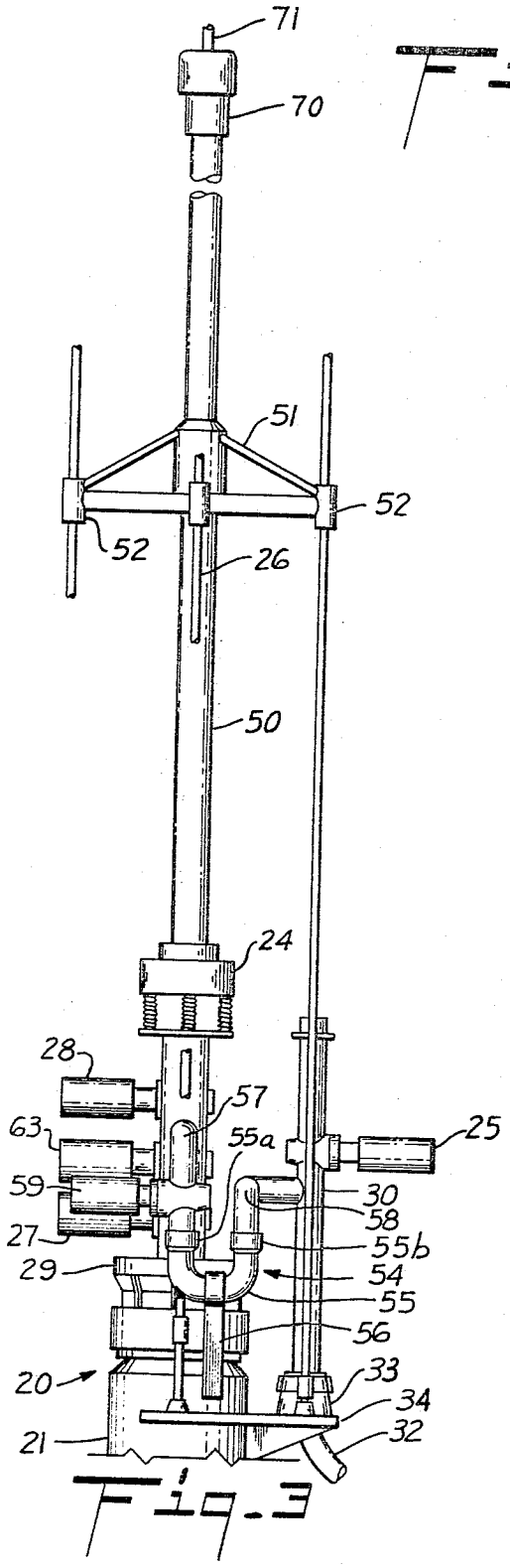

Fig. 3

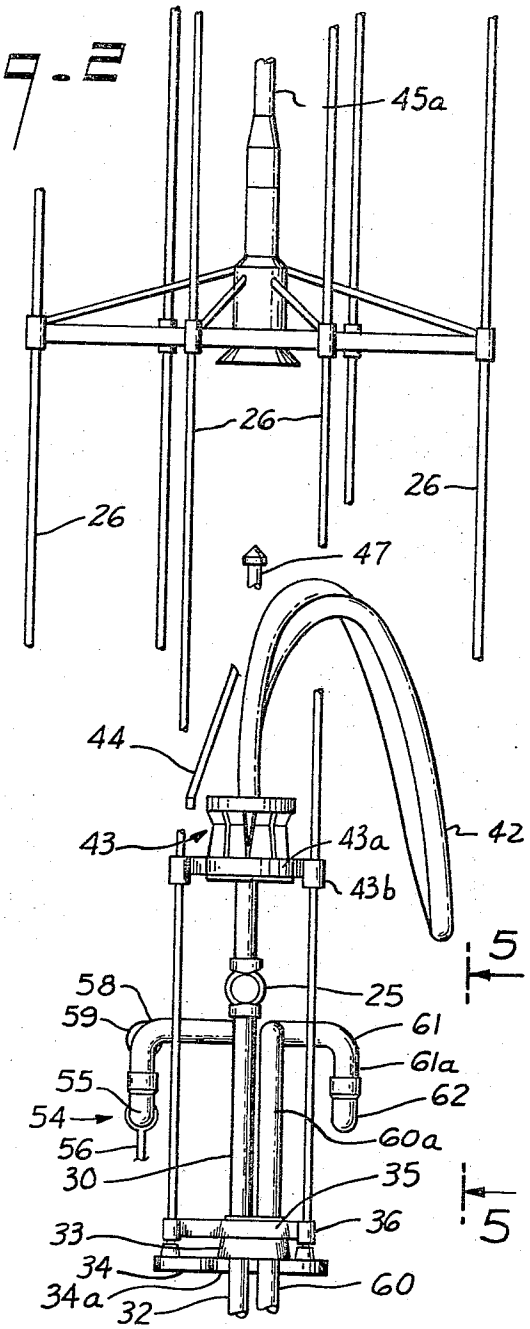

Fig. 2

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WELLHEAD ASSEMBLY

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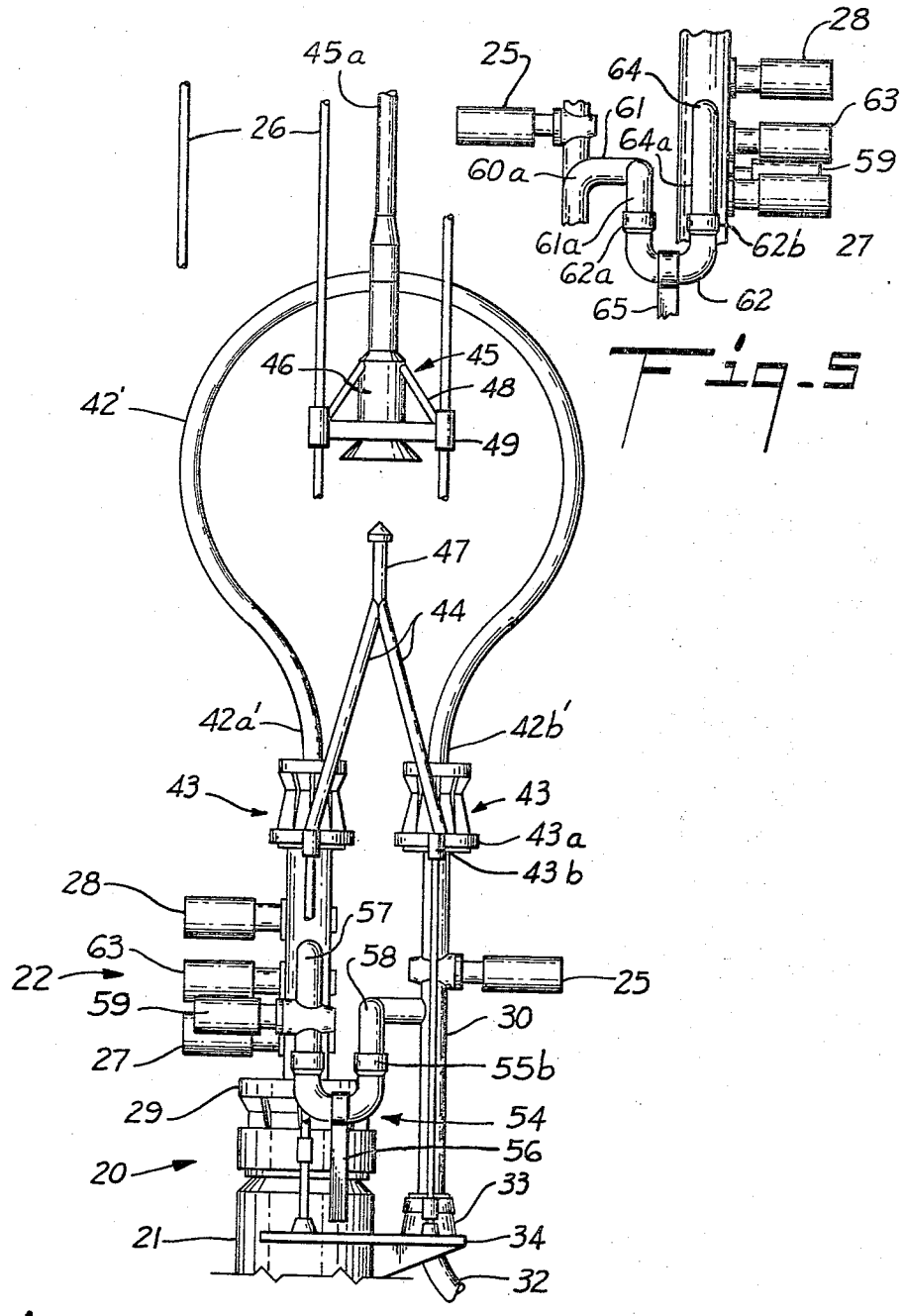

Fig. 5

Fig. 4

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WELLHEAD ASSEMBLY

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ABSTRACT OF THE DISCLOSURE

The embodiment disclosed is a Christmas tree with a valved vertical flow passageway therethrough, a valved flow line end adjacent the Christmas tree, a curved flow line loop of a radius great enough to permit passage of tools between the flow line and the flow passageway, remotely actuable connectors joining the ends of the loop to the ends of the Christmas tree and flow line and a bypass between the Christmas tree and flow line to provide for flow therebetween when said loop is removed to permit vertical access to the tree passageway.

This invention relates to an improved wellhead assembly for wells which are not readily accessible such as those located underwater.

One method of completing underwater wells is to locate the wellhead equipment adjacent the bottom of the water and to produce the well through flow lines that run along the bottom from the well to the vicinity of a production facility where the well fluid is collected. Many well maintenance operations can be conducted by pumping tools into and out of the well through the flow lines connected thereto. To allow this type of maintenance work to be done, the underwater flow lines are kept free of any sharp turns or bends and, at the wellhead itself, gently curve from the horizontal into vertical alignment with the vertical bore in the Christmas tree that provides access to the well.

From time to time, certain operations may be performed in the well, which cannot be done by well tools pumped through the flow line. Normally, these operations are performed from a surface vessel from which tools are run vertically into the well through the vertical bore in the Christmas tree. Therefore, the wellhead should be arranged to allow these latter operations, as well as to allow tools to be pumped into the well through its flow line.

Several wellhead constructions have been proposed to meet these requirements. In one, the vertical bore of the tree is provided with a laterally curving flow wing for connection to a flow line. This allows tools to be both run from the surface and pumped through the flow line into the bore of the tree. With this arrangement, however, a deflector is located in the bore when pumping well tools through the flow line to prevent the tools from following their natural course and continuing vertically in the bore past the opening to the flow wing when they are traveling out of the well.

In another design which has been proposed, a downwardly facing U-tube is releasably connected to the upper end of the bore in the Christmas tree and an adjacent upwardly facing end of the flow line. This provides the gently curving connection between the flow line and the Christmas tree through which well tools can be pumped. This connection, however, must be removed to allow vertical access to the well through the bore in the tree.

In the first proposed solution, the deflectors normally require apparatus for orienting them and for releasably locking them in place. Further, they usually require special equipment to remove them when, for example, it is

desired to have vertical access to the well through the bore in the tree. All of this apparatus is subject to mechanical failure, particularly after it has been in a well for a long period of time.

With the other arrangement, when the U-tube is removed to provide vertical access to the well through the bore in the tree, production of the well through its flow line is interrupted. This is an undesirable result as frequently it is desired to continue producing the well while performing certain operations, such as swabbing, with tools run vertically into the well. Further, it is often desirable to check the production of a well after performing a maintenance operation before replacing the U-tube as it may be necessary to perform other operations to obtain the desired or expected production rate. In addition, this removable U-tube arrangement required the end of the flow line to be spaced from the vertical bore in the Christmas tree to which it was connected by the U-tube a distance equal to at least twice the minimum radius of curvature required for the passage of the flow line tools to be pumped therethrough. This requirement increased substantially the size and cost of the wellhead structures and the guide structures required to move the U-tube into and out of position.

Therefore, it is an object of this invention to provide a wellhead assembly, which similarly to the first mentioned construction, allows the well to continue to flow through its flow line while simultaneously allowing vertical access thereto, but which, similarly to the second mentioned construction does not require the installation of a deflector to guide well tools pumped into and out of the well through its flow line.

It is another object of this invention to provide a removable connector for connecting the Christmas tree of an underwater wellhead assembly to a flow line which allows the end of the flow line to be positioned as close as desired to the Christmas tree, and, preferably, which requires only a minimum of vertical space.

These and other objects, advantages and features of the invention will be apparent to those skilled in the art from a consideration of this specification and attached drawings.

The invention will now be described in connection with the embodiment illustrated in the attached drawings in which:

FIGURE 1 is a view, in elevation, of an embodiment of a wellhead assembly constructed in accordance with this invention, and showing the flow line connected to the Christmas tree by a curved connector to allow the passage of well tools therebetween and a second connector or bypass line to allow production of the well through the flow line when the curved connector is removed;

FIGURE 2 is a side view of the wellhead assembly shown in FIGURE 1, showing the end of the flow line, a side view of the curved connector used to connect the flow line to the Christmas tree for the passage of well tools, the second connector, and a service line positioned parallel to the flow line and connected to the tree to provide a line to cooperate with the flow line and allow fluid to be circulated into and out of the flow line when pumping tools into and out of the well;

FIGURE 3 is a view similar to FIGURE 1 but showing a riser pipe connected to the Christmas tree to allow tools to be run from the surface of the water vertically into the bore of the tree while the tree is connected to the flow line by the bypass line;

FIGURE 4 is a view similar to FIGURE 1 showing an alternate shape for the curved connector for connecting the end of the flow line to the bore of the Christmas tree; and

FIGURE 5 is a view taken along line 5—5 of FIGURE 2 showing how the service line is connected into the Christmas tree.

As shown in FIGURE 1, wellhead **20** includes casing head or base **21** and Christmas tree **22**. The Christmas tree includes a vertical production bore (not shown) which extends through the tree through which fluid and well tools can pass into and out of the well. Master valve **27** and swabbing valve **28** are provided to control the flow of fluid through this bore. A string of tubing (not shown) normally extends downwardly through the well casing and is connected to the production bore in the tree to provide a conduit through which the well fluid can flow to the surface.

Usually, Christmas tree **22** is releasably attached to casing head **21** to allow it to be removed when desired. Various ways can be provided to releasably attach the tree. In the embodiment shown, collet type releasable connection **29** is used of the type described in U.S. Patent No. 3,096,999. The tree is guided into position on the wellhead by means of guide lines **26** and other guide lines (not shown) as are required, in the manner well known in the art.

Located to one side of tree **22** and extending vertically parallel thereto is end **30** of flow line **32**. As best seen in FIGURE 2, end **30** of flow line **32** is supported by an enlarged support head **33**, which is attached thereto, and which rests on outwardly extending flow line supporting flange **34** that is attached to and supported by casing head **21**. The flow line and support head are retrievable. They are guided into position on the flange by guide lines attached to the flange on each side of slot **34***a* through which the flow line extends. Guide structure including collar **35** and sleeves **36**, which are slidably mounted on the guide lines, guide the end of the flow line and the support head into and out of position on the support flange. The collar is attached to the support head.

In the embodiment shown in the drawings, the production bore of tree **22** and end **30** of flow line **32** are fluidly connected to allow well tools to be pumped through the flow line into the production bore by means of connector **42**. The connector has its end **42***a* releasably connected to the upper end of tree **22** in alignment with the production bore therein and its other end **42***b* releasably connected to and in alignment with the upper end **30** of flow line **32**. Connector **42** preferably has a radius of curvature such that all well tools designed for pumping into and out of the well can freely pass through it from the flow line to the Christmas tree and back again. Obviously, in order to accommodate the well tools to be pumped through this connector, its radius of curvature should be relatively large. For example, it is generally considered that a minimum radius of five feet is required to allow the passage of most well tools in use today through tubing having a nominal diameter of two inches. A radius of five feet would mean that the end of flow line **32** would have to be a minimum of ten feet from tree **22** where a simple U-shaped connector tube of two inch tubing is used.

In accordance with one aspect of this invention, the connector which connects the tree to the end of the flow line is so shaped that the end of the flow line can be positioned as close to the tree as desired. Thus, as shown in FIGURE 1, connector **42** departs from the aforementioned simple U-shape and curves laterally upward from the tree with the desired radius of curvature and continues curving without inflection until it reaches the end of the flow line. This causes the connector to extend laterally to each side of the vertical axis of both the tree and the flow line and to be somewhat "pretzel" shaped.

An alternate shape for the connector is shown in FIGURE 4. In this embodiment end portions **42***a'* and **42***b'* of connector **42'** curve laterally upward from the tree and the end of the flow line and diverge outwardly from each other. Then when opposite portions of the connector are

spaced apart sufficiently to maintain the desired radius of curvature, the curvature of the connector changes causing its opposite portions to curve laterally toward each other thus forming the "light bulb" shaped connector shown in FIGURE 4.

Each end of connector **42** carries means for connecting and disconnecting the connector to the tree and flow line. Any suitable type of connecting means desired could be used for this purpose, although, preferably, it can be operated remotely to allow the connector to be connected and disconnected from the surface of the water. In the embodiment shown, the same type of connector means is used here that is used to connect tree **22** to casing head **21**.

Connector **42** is lowered into place by means of carrier **44** which is raised and lowered by running tool **45**. The running tool is normally carried by pipe string **45***a* and includes a head **46** which can be releasably connected to fishing neck **47** on carrier **44**. The tool is guided vertically by framework **48** which has laterally extending members connected to a plurality of sleeves **49** that slide along guide lines **26**. Thus, the running tool can be led back into engagement with fishing neck **47** when it is desired to retrieve the connector. The connector is oriented with respect to the tree and the end of the flow line as it is being lowered into position, by collars **43***a* that are connected to connecting means **43** and to sleeves **43***b* that slide on the guide lines.

As shown in FIGURE 1, with connector **42** in place, well fluids can flow out of the well through the bore in tree **22**, connector **42**, and flow line **32** to a production facility remote therefrom. Further, well tools can be pumped from this remote facility through flow line **32** into the bore of tree **22**, and down into the well to perform their intended service. When it is desired to perform some operation which requires vertical access to the well, connector **42** is removed by running tool **45** to open the bore of tree **22** to receive tools lowered from the surface. Usually before the connections between the connector and the tree and flow line have been released, valve **28** and valve **25**, located adjacent the end of flow line **32**, are closed. The valves usually are arranged to be operated by controls located remote from the wellhead such as the remote production facility.

After the connector has been removed, vertical access riser pipe **50** is lowered and releasably attached to the upper end of tree **22** in the manner shown in FIGURE 3 by remotely operable latch **24**. Here again any suitable latch can be used for this purpose such as the one shown in the aforementioned patent adapted for operation by pressure fluid.

The vertical access riser pipe **50**, provided with the desired equipment, such as remotely operated wire line stuffing box **70**, is guided into engagement by frame **51** which has a plurality of sleeves **52** which slide along guide lines **26** in the same manner as did frame **48** used to run and retrieve the connector. When vertical access pipe **50** with stuffing box **70** is in position and connected to tree **22**, valves **27** and **28** can be opened and tools run vertically into and out of the well on wire line **71** in the conventional manner.

As explained above, while performing some of the operations through the riser pipe, it is desirable to produce the well through the flow line. In accordance with this invention, this is accomplished by a connector or bypass line **54** comprising an upwardly facing U-shaped tube **55** attached to casing-head **21** by bracket **56**. Two elbow connections **57** and **58** are attached at right angles to the tree and flow line, respectively, and have downwardly extending portions which are received within enlarged socket portions **55***a* and **55***b* of U-tube **55**. The ends of the elbows are provided with appropriate seals (not shown) which engage the inside surface of these sockets to provide a seal therebetween. This arrangement allows both the flow line and Christmas tree to be removed

vertically and reinstalled into position independently of each other and independent of the U-shaped tube **55**. Elbow **57** is provided with valve **59** to control the flow of fluids through the bypass passageway.

Thus, with the wellhead assembly of this invention, when vertical access to the well is desired, connector **42** can be removed, and yet fluid communication can be maintained between the flow line and the Christmas tree through bypass connector **54**. Swabbing valve **28** and wire line stuffing box **70** combine to provide for flow control in the riser during the conducting of operations through the vertical riser without interferring with flow through the bypass.

When connector **42** is in place valve **59** can be left open or closed as desired. When well tools are being pumped into and out of the hole, however, it should be closed; otherwise, the tools may stall in the loops in the connector, if the fluid pushing them is allowed to crossover between the flow line and the tree through the bypass line. Also, when running well tools through this wellhead assembly, the well tool should be arranged with seals spaced sufficiently far apart to bridge the intersection of the bypass line and the flow line and the bypass line and the tree, otherwise, the tool may stall at these points.

To allow well tools to be pumped into and out of the well, service line **60** (FIG. 2) is provided for connection to the tree **22** to permit fluid communication between the surface and the tubing string at a point below the depth to which the tools are to be pumped. This allows fluid to circulate through the flow line, the tree, the well tubing, and back to the surface through the service line when the tools are being pumped into position in the well tubing. Then by reversing this circulation, tools can be returned to their starting point. Fluid communication is established between the service line and the well tubing below the depth of the tools in any convenient manner.

Service line **60** is connected to the tree in a manner similar by bypass line **54**. As shown in FIG. 5, its end **60***a* is provided with an elbow connection **61** that has a downwardly extending portion **61***a*. Another elbow connection **64** (FIG. 5) has one end connected into the tree and one end **64***a* extending downwardly generally parallel to end **61***a* of elbow **61** and U-shaped connector tube **62** is positioned to receive these downwardly extending portions in sockets **62***a* and **62***b* provided on each end thereof. Connector tube **62** is mounted on the wellhead by a bracket **65**. With this arrangement service line **60** doesn't interfere with the retrieving of tree **22**. The service line is attached to support head **33** in the same manner as flow line **32** and supported by the head and flange **34**. Slot **34***a* in the flange is large enough to accommodate both lines. This allows the service line to be run and retrieved with the flow line.

Appropriate seals, of course, are carried by the downwardly extending end portions of the elbows to engage the sockets of U-tube **62** and prevent fluid from escaping from the service line through these connections.

Valve **63** in the tree serves as a master valve for the service line. If desired, a valve may be located in the service line to prevent fluid from entering or escaping therefrom when the tree is removed from the casing head.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus and structure.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. An underwater wellhead assembly, comprising an underwater wellhead, including a base and a Christmas tree mounted on the base, having a vertical bore through which well fluid can flow from the well and through which well tools can be introduced into the well for various operations including but not limited to swabbing to induce flow, a flow line having one end near the Christmas tree for conducting fluids away from the Christmas tree to a location remote therefrom, a gently curving connector having one end connected to the end of the flow line near the Christmas tree and one end releasably connected to the vertical bore of the Christmas tree to allow fluid to flow from the Christmas trree to the flow line and well tools to be pumped in and out of the well through the flow line and Christmas tree, and means, including a bypass line having its opposite ends connected into the sides of the flow line and the bore of the Christmas tree, respectively, to allow fluid to flow therebetween when the connector is disconnected from the Christmas tree to allow operations such as swabbing from directly above the wellhead.

2. Underwater wellhead apparatus, comprising a Christmas tree having a vertically extending bore through which well fluid can flow from a well and well tools can pass into a well, a flow line having an end located near the Christmas tree, said end extending upwardly parallel to the bore in the Christmas tree, a gently curving first connector, having its opposite ends releasably connected to the Christmas tree and the end of the flow line, to conduct well fluid from the bore of the Christmas tree to the flow line and through which well tools can be pumped from the flow line into the bore of the Christmas tree, and a second connector, extending between the bore of the Christmas tree and the flow line and connected into the sides thereof to allow well fluid to flow therebetween when the first connector tube is removed.

3. Wellhead apparatus of the character defined in claim **2** in which the first connector tube extends laterally beyond at least one of the vertical centerlines of the vertical bore of the Christmas tree and the vertical end of the flow line to allow the end of the flow line to be spaced from the bore of the Christmas tree a distance less than twice the minimum desired radius of curvature of the first connector.

4. In an underwater wellhead assembly, including an underwater Christmas tree releasably attached to a casing head for supporting casing extending into a well, said tree having a vertically extending bore through which well fluid can flow from the well and well tools can enter the well, a flow line for carrying well fluid from the well to a remote location having one end positioned near the tree and parallel to the bore therein, a connector curved with a radius of curvature sufficient to allow well tools to be pumped therethrough from the flow line to the bore of the Christmas tree, means for remotely connecting and disconnecting the opposite ends of the connector to the bore of the Christmas tree and the end of the flow line to allow the connector to be removed when it is desired to run well tools vertically from the surface of the water into the well through the bore of the tree, and a bypass line, to provide fluid communication between the bore of the tree and the flow line when the connector is removed, having its opposite ends connected into the sides of the bore of the tree and the flow line below their ends with the longitudinal axis of the bypass line at the connections intersecting the longitudinal axes of the bore of the tree and the flow line at an angle to allow well tools to pass the ends of the bypass line without being deflected.

5. The wellhead assembly of claim **4** in which the bypass line includes a U-shaped tube mounted on the casing head and two connections having horizontal ends connected into the sides of the flow line and flow tube and

downwardly extending ends for releasably engaging the ends of the U-shaped tube.

6. Wellhead apparatus, comprising an underwater wellhead including a base and a Christmas tree removably mounted on the base having a vertical bore through which well fluid can flow from the well and well tools can enter the well, a flow line having an end near the wellhead which extends substantially parallel to the bore in the tree, and a curved connector having opposite ends for connection to the bore of the tree and the end of the flow line, respectively, to provide fluid communication therebetween, the connector curving adjacent its ends until it extends laterally on opposite sides of the vertical axes of the tree and the end of the flow line to allow the ends of the connector to be spaced apart a distance less than twice the minimum desired radius of curvature while allowing the connector to have at least the minimum desired radius of curvature.

7. Wellhead apparatus of the character defined in claim 6 in which the connector curves without inflection throughout its length.

8. Wellhead apparatus of the character defined in claim 6 in which the portions of the connector adjacent the ends diverge upwardly.

9. An underwater wellhead assembly, comprising, a casing head for supporting casing extending into a well, a Christmas tree having a vertically extending bore through which well fluid can flow from the well and well tools can enter the well, means operable from a remote location for releasably connecting the tree to the casing head, a flow line for carrying fluid from the well to a remote location having one end positioned near the tree and parallel to the bore therein, a connector curved with a radius of curvature sufficient for tools to be pumped therethrough from the flow line into the bore of the Christmas tree, means operable from a remote location

for connecting and disconnecting the opposite ends of the connector to the bore of the Christmas tree and the end of the flow line to allow the connector to be removed when it is desired to run well tools vertically from the surface of the water into the well through the bore of the tree, and a bypass line to provide fluid communication between the bore of the tree and the flow line when the connector is removed, including a first elbow connection having one end connected into the side of the tree and one end extending downwardly parallel to the bore of the tree, a second elbow connection having one end connected into the side of the flow line and one end extending downwardly parallel to the end of the flow line, a U-shaped member connected to the casing head and positioned for one end to sealingly engage the downwardly extending end of the first elbow and the other end to sealingly engage the downwardly extending end of the second elbow connection to provide fluid communication between the bore of the tree and the flow line when the connection is removed, and valve means for controlling the flow of fluid through the bypass line.

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