

June 10, 1969

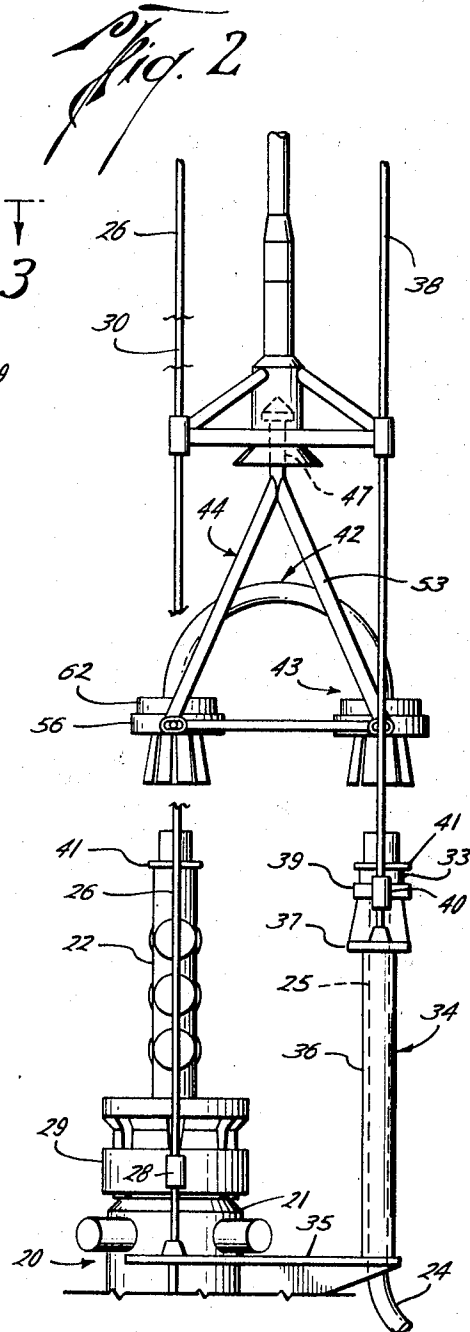
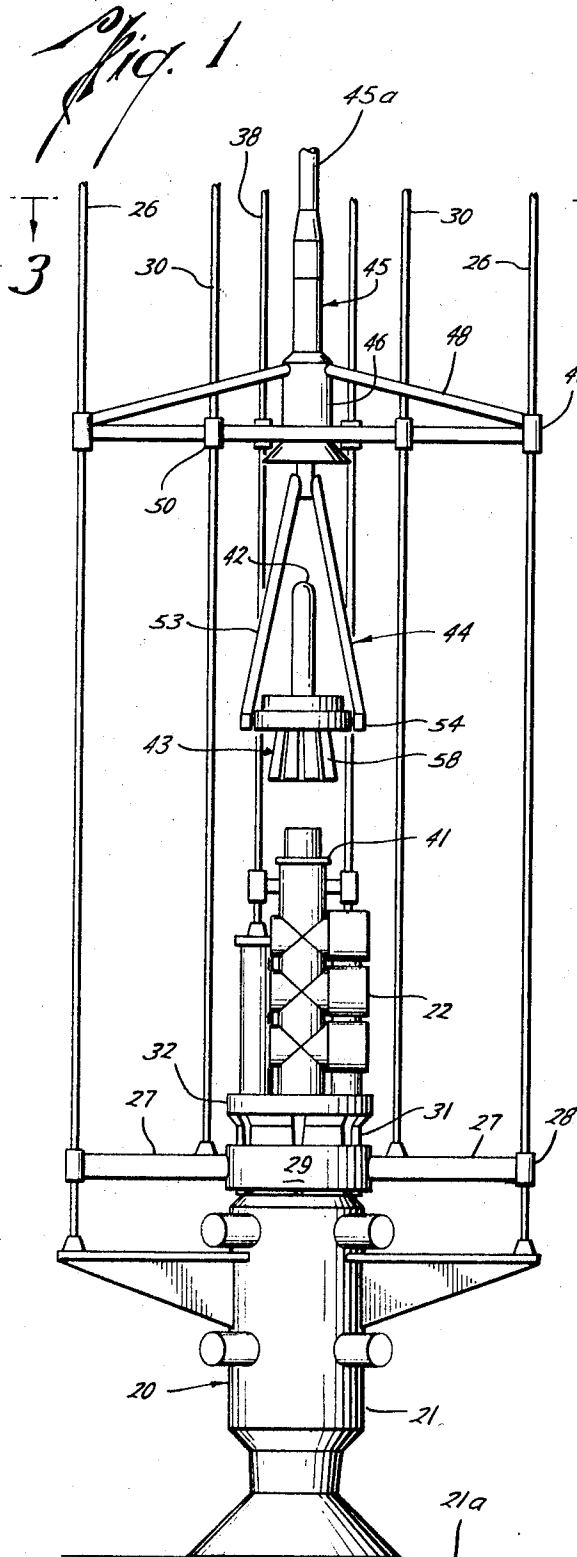
A. G. AHLSTONE

3,448,799

WELL COMPLETION APPARATUS

Filed Aug. 9, 1961

Sheet 1 of 4



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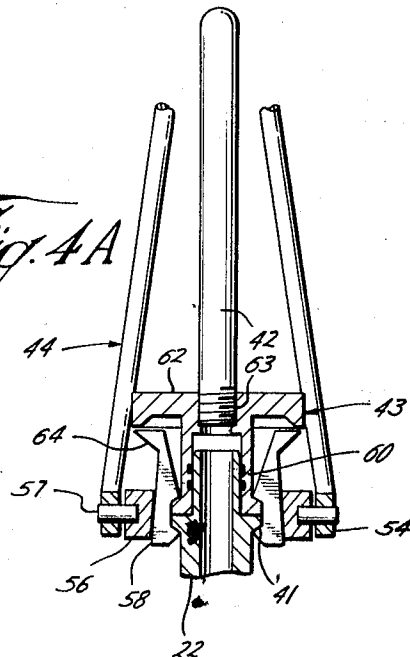
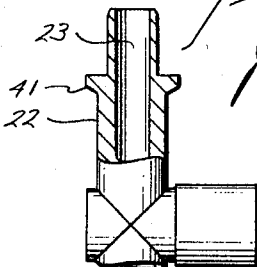
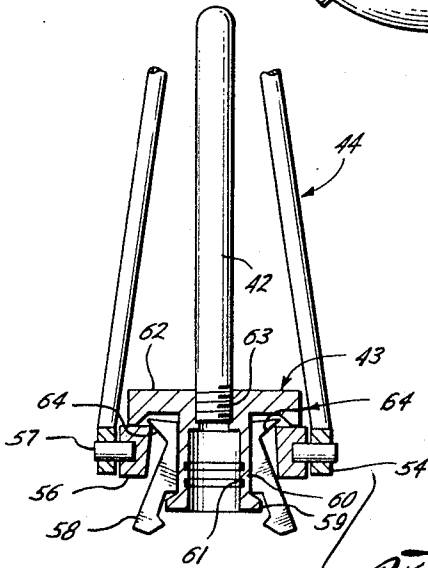
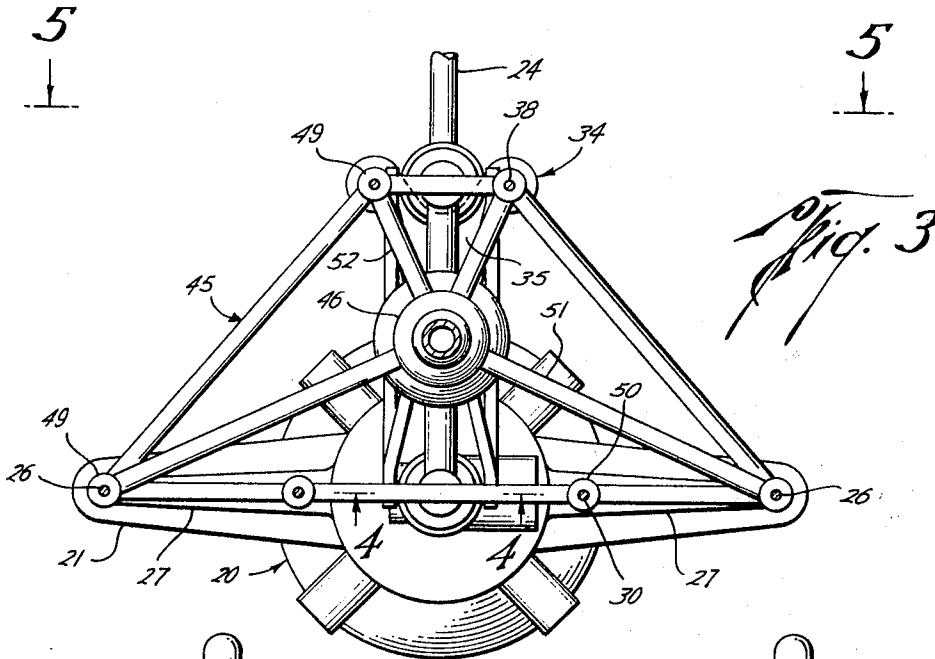
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Fig. 5

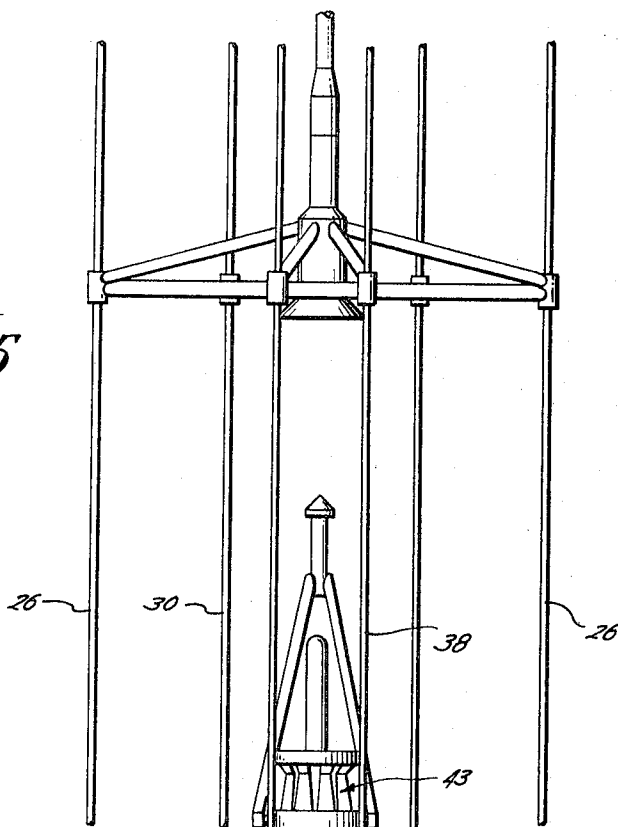
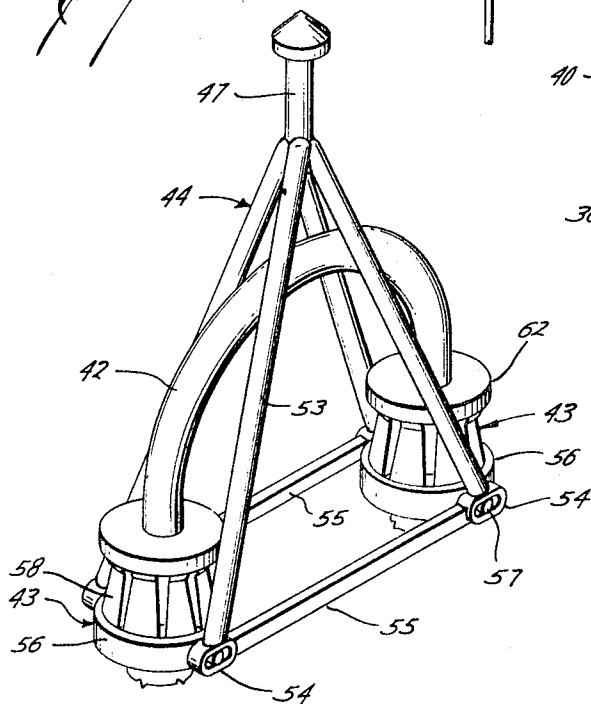


Fig. 6



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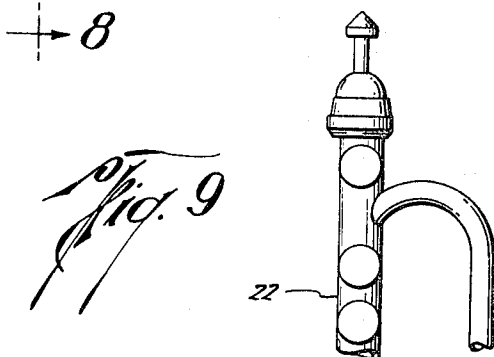
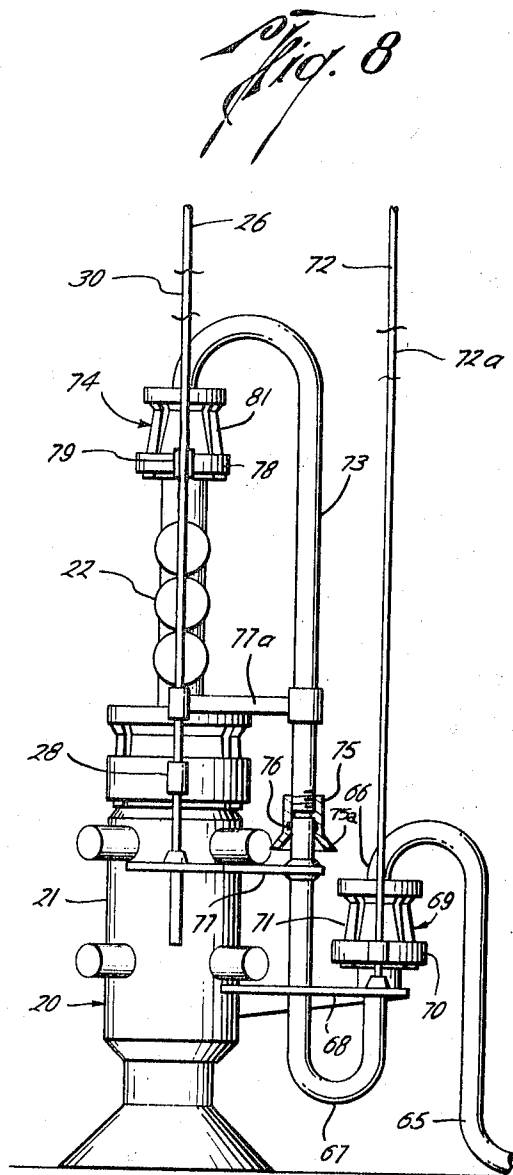
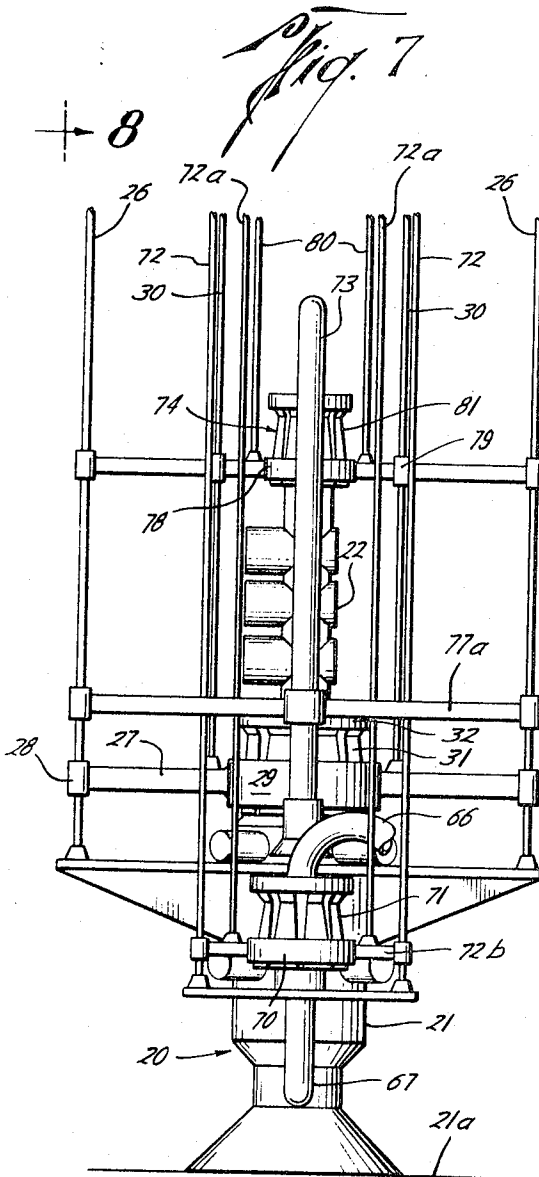
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Sheet 4 of 4



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3,448,799

WELL COMPLETION APPARATUS

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Int. Cl. E21b 33/02, 43/01

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3 Claims

This invention relates to apparatus for use in completing a well at an underwater level or other inaccessible location. More particularly, it relates to apparatus for connecting the Christmas tree and flowline of such a well for fluid communication therebetween.

In the completion of a well of this type, a base including means for suspending the well casing may first be anchored at the underwater level and the Christmas tree removably installed thereabove, as described, for example, in a copending application, Ser. No. 81,142, filed Jan. 6, 1961, now Patent No. 3,137,348 and assigned to the assignee of the present application. The connection of the flowline to this tree must be of such a nature that either may be installed and subsequently removed or replaced independently of the other. That is, the Christmas tree may require repairs which can only be made above the water. Also, the flowline is especially susceptible to corrosion which may require that it be replaced.

The invention is particularly useful in the completion of wells at such depths that the use of divers in making and breaking these connections is impractical or impossible. Furthermore, the lateral separation of the tree and flowline necessary to permit their independent removal and replacement presents a very real problem insofar as remotely actuated connections are concerned. This is particularly true of simple gravity operated connecting mechanisms, such as those shown in a copending application, Ser. No. 746,997, filed July 7, 1958, and assigned to the assignee of the present application, and now issued as U.S. Patent No. 3,096,999.

It is an object of this invention to provide simple yet effective apparatus for so completing such a well, and particularly for connecting the Christmas tree and flowline for manipulation independently of one another.

Another object is to provide such apparatus in which the necessary connections may be made solely in response to vertical reciprocation of the various parts.

A further object is to provide such apparatus which may be gravity operated and require no connections other than lift and guide lines with the completion equipment above water level.

A more particular object is to provide such apparatus in which the connection between the tree and flowline may be made with the remotely actuated and gravity operated mechanism shown in the aforementioned copending application, Ser. No. 746,997.

These and other objects are accomplished, in accordance with the illustrated embodiments of the invention, by well completion apparatus which comprises a wellhead including a base anchored at an underwater level and a Christmas tree removably mounted on the base in an upright position, and a flowline having one end near the wellhead which extends substantially parallel to the Christmas tree. The tree and end of the flowline are fluidly communicated with one another by means including a U-tube releasably connectable to each. This connection and the release of same is accomplished by remotely actuated means which, in the illustrated embodiments of the invention, is operable merely in response to relative vertical reciprocation of said U-type and each of the Christmas tree and end of the flowline. In this manner, either the Christmas tree or flowline may be removed or replaced separately of the other upon disconnection from the aforesaid U-tube.

In one embodiment of the invention, the end of the flowline is mounted in an upright position on the wellhead base and the U-tube is reciprocated in an inverted position to make or release the connection between it and the Christmas tree and end of the flowline. Thus, the tree and flowline may be installed on the base in any desired order, prior to installation of the U-tube, and independently removed or replaced upon removal of such tube.

In other embodiments of the invention, the U-tube is mounted on the base with its opposite ends in an upright position, and the Christmas tree and the end of the flowline are independently connected or disconnected with respect thereto and in any desired order upon vertical reciprocation of each. For this purpose, there is a tubular part connecting with the flow passage through the tree and extending downwardly therefrom to removably connect with one upright end of the U-tube.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a view of the front of the first-mentioned embodiment of the invention during lowering of the U-tube for connection with the upper end of the Christmas tree and upright end of the flowline;

FIG. 2 is a view of a side of the apparatus of FIG. 1;

FIG. 3 is a top plan view of the apparatus of FIG. 1, as seen along broken line 3—3 thereof;

FIG. 4 is an enlarged sectional view of the upper end of the Christmas tree and one end of the U-tube, as seen in FIG. 1 as said tube is being lowered onto the tree;

FIG. 4A is a view similar to FIG. 4, but wherein the U-tube has been connected with the upper end of the Christmas tree;

FIG. 5 is a rear view of part of the apparatus of FIG. 1, as seen along broken line 5—5 of FIG. 3, with the U-tube connected to the upper end of the flowline;

FIG. 6 is an enlarged perspective view of the U-tube and the means on the opposite ends thereof connecting it to the Christmas tree and upright end of the flowline, as shown in FIGS. 4A and 5;

FIG. 7 is a rear view of apparatus constructed in accordance with one form of the second-mentioned embodiments of the invention, with the Christmas tree and end of the flowline connected with the upright U-tube mounted on the wellhead base;

FIG. 8 is a view of the apparatus of FIG. 7, as seen along broken line 8—8 thereof, with the flowline turned 90°; and

FIG. 9 is a side view of part of another form of apparatus constructed in accordance with the second-mentioned embodiment.

With reference now to the details of the above-described drawings, and particularly the embodiment of the invention shown in FIGS. 1 to 6, an underwater wellhead 20 includes a base 21 having casing suspension means anchored at a subsurface level 21a and a Christmas tree 22 removably mounted on the base in an upright position. A flow passage 23 through the Christmas tree extends downwardly through the tree and base for connection with a well casing communicating at its lower end with the production zone. As previously mentioned, the details of this wellhead, and particularly the means for suspending the casing, may correspond to those shown and described in copending application Ser. No. 81,142.

A flowline 24 with which this Christmas tree flow passage is to be fluidly connected extends from any remote location to its open end 25 adjacent the wellhead. As previously mentioned, and in accordance with the present invention, this end 25 of the flowway extends vertically upright and substantially parallel to the upright Christmas tree. Upon connection of the tree and flowline in the manner to be described, well fluid may be flowed upwardly

from the production zone and through the flowline to a remote gathering system.

As described in copending application, Ser. No. 81,142, the wellhead base has been lowered into position by means of lines 26 connected to opposite sides thereof and extending to above the water level for connection with suitable hoisting equipment. The Christmas tree 22 has been lowered onto the upper end of the base, guided by means of radially extending arms 27 having sleeves 28 slidable downwardly over the lines 26. These arms 27 are connected to a collar or sleeve 29 which is movable between a position to support the Christmas tree as it is raised and lowered and another position (FIGS. 1, 2 and 4) to connect the tree to the wellhead base 21. For this purpose, the collar 29 and its arms 27 are suspended from guide lines 30 which, similarly to the lines 26, extend upwardly to the water level. As more fully described in both of the aforementioned copending applications, when the tree is landed on the base 21, the guide lines 30 may be lowered further to permit the collar to move downwardly from a flange 32 on the tree into a position in which it forces dogs 31 into locking position with respect to the base 21. Conversely, as the lines 30 are raised to move the collar 29 upwardly, the dogs are released and the collar engages with the flange 32 for raising the tree to the water level.

An enlarged neck 33 (FIG. 2) on the upper end 25 of the flowline is removably mounted on the upper end of a pedestal 34 which, in turn, is mounted on an outwardly extending flange 35 of the wellhead base 21 to dispose the ends of the tree and flowline to be connected at substantially the same level. As best shown in FIG. 5, this pedestal 34 includes a pair of columns 36 extending upwardly from the flange for connection with a cross plate 37. A pair of guide lines 38 are connected at their lower ends to the cross plate 37 for extension upwardly to water level, and a collar 39 about the neck 33 of the flowline has sleeves 40 which are slidable over the lines 38 for guiding the end of the flowline into and out of mounted position on the pedestal 34. The plate 37 as well as the flange 35 are recessed inwardly toward the wellhead so that the flowline 24 extends freely therethrough.

As previously mentioned, the tree and flowline may be lowered into the position shown and then removed or replaced independently of the other and in any desired order. The upper end of each has an annular flange 41 thereabout for connection with the ends of an inverted U-tube 42 as the latter is lowered into place. As shown in FIGS. 1, 2 and 4, each lower end of the U-tube 42 carries means 43 for connecting and disconnecting it with respect to both the Christmas tree and upper end of the flowline merely upon vertical reciprocation of such U-tube with respect thereto. More particularly, this means corresponds substantially to that shown and described in copending application, Ser. No. 746,997, so that, as will be described below, such connection and disconnection may be without the use of hydraulic lines or other apparatus especially susceptible to damage.

The U-tube 42 is lowered into place on the wellhead and the flowline by means of a carrier 44 which is raised and lowered by means of a running tool 45. This tool is suspended from a line 45a and has a head 46 connected to the upper end of a fishing neck 47 on the upper end of carrier 44 by remotely releasable means such as those commonly used in oil well practice. A framework 48 connected about the head has a series of sleeves 49 for moving over the lines 26 and 38 for the wellhead and flowline, respectively, and additional sleeves 50 which receive and slide over the guide lines 30. As best shown in FIG. 3, the framework 45 is reinforced by lateral bracing 51 and 52 extending radially outwardly from the head 46.

As shown in FIG. 6, the carrier 44 has legs 53 which extend downwardly from the fishing neck 47 for connection with slotted lugs 54 on opposite ends of lateral bracing members 55. These lugs, and thus the carrier 44, are releasably connected to collars 56 of each connector 43

by means of pins 57 on each collar which extend through the slots in the lugs.

As best shown in FIGS. 4 and 4A, each collar 56 surrounds a plurality of circumferentially spaced apart locking dogs 58 carried on an outwardly extending flange 59 on a centrally disposed tubular member 60 which is adapted to fit over the upper end of the Christmas tree 22. More particularly, the lower end of the flange 59 is adapted to abut with the upper end of the Christmas tree flange 41, and sealing rings 61 are carried within the tubular member 60 for sealing with respect to the outside of the Christmas tree received therein. There is an outwardly extending annular flange 62 on the upper end of tubular member 60 and threadedly connected at 63 to the lower end of the U-tube 42. As shown in FIG. 4, this flange 62 rests upon the top side of the collar 56 and the inner upper edge of the collar 56 bears against a top flange 64 on the locking dogs 58 to hold them in a releasing position, as the U-tube and carrier 44 therefor are raised and lowered.

However, upon landing of the flange 59 upon the flange 41 and further lowering of running tool 45, the carrier 44 and thus the collar 56 are free to move further downwardly to the position shown in FIG. 4A. This downward movement of the collar relative to the locking dogs 58 cams them into a locking position over the flange 41, as shown in FIG. 4A. Obviously, upon raising of the carrier 44, the collar 56 will also be raised to cam the locking dogs outwardly to releasing position, as shown in FIG. 4. Since the flange 62 is then supported on the top side of the collar 56, further upward movement of the carrier 44 will raise the U-tube 42 with it.

In practice, after the carrier 44 has been lowered to connect the U-tube 42 with the Christmas tree and end 25 of the flowline, as shown in FIG. 6, the running tool 45 is disconnected from the carrier and withdrawn therefrom. To remove or replace either or both of the Christmas tree 22 and flowline 24, the running tool 45 need only be lowered to connect with the fishing neck 47 in any suitable manner. The carrier may then be raised to disconnect the U-tube from both the Christmas tree and flowline and raise them to above water level. At this time, the Christmas tree may be released from the base 21 and raised to water level upon raising of the guide lines 30, or the flowline 24 may be gripped by any suitable tool and raised along the guide lines 38 for replacement. Obviously, a substitute flowline may be lowered into mounted position upon the pedestal 34 by means of the same guide lines 38.

With reference now to the form of the invention shown in FIGS. 7 and 8, an underwater wellhead 20 includes a base 21 anchored at a subsurface level 21a and a Christmas tree 22 removably connected to the base in an upright position, all as shown and described in connection with FIGS. 1 to 6. In fact, it is contemplated that the Christmas tree may be raised and lowered and connected and disconnected with respect to the base 21 in the manner previously described, and identical reference characters are used when this is true.

The apparatus of FIGS. 7 and 8 differs from that shown in FIGS. 1 to 6 in that the flowline 65 has an end 66 near the wellhead which extends vertically downwardly, rather than upwardly, as in the case of the end 25 of the flowline 24. Also, the U-tube 67 for connecting the upper end of the Christmas tree with the upper end 66 of the flowline is mounted in an upright position on the base 21, and particularly upon an outwardly extending flange 68 thereon. Thus, in this embodiment, each of the Christmas tree and flowline may not only be installed and removed or replaced independently of one another, but also without prior removal of the U-tube 67.

For this purpose, the downwardly extending end 66 of the flowline 65 carries a connector 69 constructed similarly to the connector 43 previously described for landing upon and then locking the flowline to the upper right-

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hand end of the U-tube 67. As in the case of the connector 43, the connector 69 has a collar 70 surrounding a plurality of circumferentially spaced apart locking dogs 71 and movable over guide lines 72 anchored to the base flange 68 and extending upwardly to water level. This collar may be raised and lowered by additional lines 72a connected at their lower ends to arms 72b on the collar and extending upwardly to water level. As in the case of the ones previously described, the collar 70 may be lowered on the lines 72a to land the connector 69 on the end of the U-tube and then permitted to move further downwardly to lock the flowline end 66 to the U-tube. Conversely, the lines 72a may be raised to lift the collar 70 from locking position and then lift the end of the flowline from connection to the U-tube for replacement, as may be desired.

There is a tubular member 73 releasably connected by connector 74 to the upper end of the Christmas tree 22 and turned downwardly for removable connection at its lower end 75 to the upright left-hand end of the U-tube 67. As best shown in FIG. 8, the lower end 75 of this tubular member has a socket with an O-ring 76 or other sealing member which fits closely over the upper end of the U-tube 67 as such tubular member is lowered into place by means of the connector 74. Preferably, the left-hand upper end of the U-tube 67 and lower right-hand end of tubular member 73 are more fixedly located by means of a flange 77 extending outwardly from the side of the base 21 above the flange 68, and a lateral brace 77a slidable over guide lines 26. Alignment is also facilitated by a flared skirt 75a beneath the lower end 75 of said tubular member.

The connector 74 on the tubular member 73 may be constructed similarly to the connectors 43 and 69 previously described. Thus, it comprises a collar 78 having sleeves 79 guidably slidable over lines 30 extending upwardly to the water level. Furthermore, the collar 78 surrounds and is vertically reciprocable with respect to circumferentially spaced apart locking dogs 81 which are adapted to be connected and disconnected to a flange on the upper end of the Christmas tree, such as the one shown at 41 in FIGS. 1, 2, 4 and 4A. Thus, the tubular member may be lowered onto or raised from connection with the upper end of the Christmas tree by the raising or lowering of the lines 80. The flowline 65 is, of course, raised and lowered with respect to connected position on the U-tube 67 regardless of the manner in which the Christmas tree and tubular member 73 are manipulated.

The form of the apparatus shown in FIG. 9 differs from that shown in FIGS. 7 and 8 only in that a tubular member 82 for connecting the Christmas tree 22 to the left-hand upper end of U-tube 67 is fixed to the Christmas tree and extends outwardly from the side thereof. More particularly, the upper end of tubular member 82 is, similarly to the tubular member 73, curved to a substantial semi-circle so as to tangentially join with the flow passage through the upper end of the Christmas tree. In all embodiments of the invention, the U-tube and the flowline are curved on radii which enable the passage of various well tools through the flowline and wellhead, which might otherwise not be possible in the case of more abrupt connections between the parts in question. This is also true, of course, of the tubular members 73 and 82 of the embodiments shown in FIGS. 7 to 9.

It is also apparent that other types of remotely actuated

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connectors may be used in the place of the gravity operated connectors above described. Such other connectors could, for example, be fluid operated by means of hydraulic lines extending to the water level.

This invention further contemplates that the wellhead may have two passages therethrough for connection with dual flowlines by means of a pair of U-tubes, all for purposes well known in the art. However, since this involves no more than a duplication of what is shown in the drawings, it need not be described.

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.

It will be understood that certain features and sub-combinations 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 possible 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. Well completion apparatus, comprising an underwater wellhead including a base and a Christmas tree removably mounted on the base and having an outlet, a U-tube, means supporting the U-tube with its opposite ends facing upwardly and substantially parallel to and laterally offset from the Christmas tree, means connecting the outlet from the Christmas tree with one end of the U-tube to provide fluid communication between said Christmas tree and the U-tube, a flowline, means for lowering one end of the flowline into alignment with the other end of the U-tube, and means for releasably connecting the one end of the flowline to said other end of the U-tube when they are so aligned.

2. Well completion apparatus of the character defined in claim 1, wherein the outlet from the Christmas tree is at its upper end, and the means for connecting said outlet to one end of the U-tube comprises a tubular member having a U-bend therein, and means are provided for lowering the tubular member beneath the water level to connect its opposite ends with the upper end of the tree and said one end of the U-tube.

3. Well completion apparatus of the character defined in claim 1, wherein the outlet from the Christmas tree is in the side thereof, and there is a tubular member having a U-bend therein extending laterally outwardly from the outlet and downwardly parallel to the tree for releasable connection with the one end of the U-tube.

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U.S. Cl. X.R.

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