

1 "Recovery of production fluids from an oil or gas
2 well"

3

4 The present invention relates to the recovery of
5 production fluids from an oil or gas well having a
6 christmas tree.

7

8 Christmas trees are well known in the art of oil and
9 gas wells, and generally comprise an assembly of
10 pipes, valves and fittings installed in a wellhead
11 after completion of drilling and installation of the
12 production tubing to control the flow of oil and gas
13 from the well. Subsea christmas trees typically have
14 at least two bores one of which communicates with the
15 production tubing (the production bore), and the
16 other of which communicates with the annulus (the
17 annulus bore). The annulus bore and production bore
18 are typically side by side, but various different
19 designs of christmas tree have different

1 configurations (ie concentric bores, side by side
2 bores, and more than two bores etc).

3
4 Typical designs of christmas tree have a side outlet
5 to the production bore closed by a production wing
6 valve for removal of production fluids from the
7 production bore. The top of the production bore and
8 the top of the annulus bore are usually capped by a
9 christmas tree cap which typically seals off the
10 various bores in the christmas tree, and provides
11 hydraulic channels for operation of the various
12 valves in the christmas tree by means of intervention
13 equipment, or remotely from an offshore installation.

14
15 In low pressure wells, it is generally desirable to
16 boost the pressure of the production fluids flowing
17 through the production bore, and this is typically
18 done by installing a pump or similar apparatus after
19 the production wing valve in a pipeline or similar
20 leading from the side outlet of the christmas tree.
21 However, installing such a pump in an active well is
22 a difficult operation, for which production must
23 cease for some time until the pipeline is cut, the
24 pump installed, and the pipeline resealed and tested
25 for integrity.

26
27 A further alternative is to pressure boost the
28 production fluids by installing a pump from a rig,
29 but this requires a well intervention from the rig,
30 which can be even more expensive than breaking the
31 subsea or seabed pipework.

1
2 According to the present invention there is provided
3 a method of recovering production fluids from a well
4 having a tree, the tree having a first flowpath
5 having an outlet, and a second flowpath, the method
6 comprising diverting fluids from a first portion of
7 the first flowpath to the second flowpath, and
8 diverting the fluids from the second flowpath back
9 to a second portion of the first flowpath, and
10 thereafter recovering fluids from the outlet of the
11 first flowpath.

12
13 Preferably the first flowpath is a production bore,
14 and the first portion of it is typically a lower
15 part near to the wellhead. The second portion of
16 the first flowpath is typically an upper portion of
17 the bore adjacent a branch outlet, although the
18 second portion can be in the branch or outlet of the
19 first flowpath.

20
21 The diversion of fluids from the first flowpath
22 allows the treatment of the fluids (eg with
23 chemicals) or pressure boosting for more efficient
24 recovery before re-entry into the first flowpath.

25
26 Optionally the second flowpath is an annulus bore,
27 or a conduit inserted into the first flowpath.
28 Other types of bore may optionally be used for the
29 second flowpath instead of an annulus bore.

30
31 Typically the flow diversion from the first flowpath
32 to the second flowpath is achieved by a cap on the

1 tree. Optionally, the cap contains a pump or
2 treatment apparatus, but this can preferably be
3 provided separately, or in another part of the
4 apparatus, and in most embodiments, flow will be
5 diverted via the cap to the pump etc and returned to
6 the cap by way of tubing. A connection typically in
7 the form of a conduit is typically provided to
8 transfer fluids between the first and second
9 flowpaths.

10

11 The invention also provides a flow diverter assembly
12 for a tree, the flow diverter assembly comprising
13 flow diverter means to divert fluids from a first
14 portion of the first flowpath having an outlet to a
15 second flowpath, and means to divert fluids from the
16 second flowpath back to a second portion of the
17 first flowpath for recovery therefrom via the outlet
18 of the first flowpath, wherein the first portion of
19 the first flowpath, the second flowpath and the
20 second portion of the first flowpath form a conduit
21 for continuous passage of fluid.

22

23 Typically, the diverter assembly can be formed from
24 high grade steels or other metals, using eg
25 resilient or inflatable sealing means as required.

26

27 The assembly may include outlets for the first and
28 second flowpaths, for diversion of the fluids to a
29 pump or treatment assembly.

30

31 The assembly preferably comprises a conduit capable
32 of insertion into the first flowpath the assembly

4a

1 having sealing means capable of sealing the conduit
2 against the wall of the production bore. The
3 conduit
4
5

1 may provide a flow diverter through its central bore
2 which typically leads to a christmas tree cap and the
3 pump mentioned previously. The seal effected between
4 the conduit and the first flowpath prevents fluid
5 from the first flowpath entering the annulus between
6 the conduit and the production bore except as
7 described hereinafter. After passing through a
8 typical booster pump, squeeze or scale chemical
9 treatment apparatus, the fluid is diverted into the
10 second flowpath and from there to a crossover back to
11 the first flowpath and first flowpath outlet.
12

13 The assembly and method are typically suited for
14 subsea production wells in normal mode or during well
15 testing, but can also be used in subsea water
16 injection wells, land based oil production injection
17 wells, and geothermal wells.
18

19 The pump can be powered by high pressure water or by
20 electricity which can be supplied direct from a fixed
21 or floating offshore installation, or from a tethered
22 buoy arrangement, or by high pressure gas from a
23 local source.
24

25 The cap preferably seals within christmas tree bores
26 above the upper master valve. Seals between the cap
27 and bores of the tree are optionally O-ring,
28 inflatable, or preferably metal-to-metal seals. The
29 cap can be retro-fitted very cost effectively with no
30 disruption to existing pipework and minimal impact on
31 control systems already in place.

1

2 The typical design of the flow diverters within the
3 cap can vary with the design of tree, the number,
4 size, and configuration of the diverter channels
5 being matched with the production and annulus bores,
6 and others as the case may be. This provides a way
7 to isolate the pump from the production bore if
8 needed, and also provides a bypass loop.

9

10 The cap is typically capable of retro-fitting to
11 existing tree caps, and many include equivalent
12 hydraulic fluid conduits for control of tree valves,
13 and which match and co-operate with the conduits or
14 other control elements of the tree to which the cap
15 is being fitted.

16

17 In most preferred embodiments, the cap has outlets
18 for production and annulus flow paths for diversion
19 of fluids away from the cap.

20

21 The invention also provides a tree having flow
22 diverter means to divert production fluids from a
23 production bore via a second flowpath to remote
24 apparatus for treatment, and to return the fluids to
25 the tree for recovery from the tree outlet. The
26 treatment apparatus typically comprises a pump or
27 chemical treatment apparatus.

28

29 The invention also provides a tree having a flow
30 diverter assembly, the assembly comprising a flow
31 diverter means to divert fluids from a first portion
32 of a first flowpath having an outlet to a second

6a

1 flowpath, and means to divert fluids from the second
2 flowpath back to a second portion of the first
3 flowpath for recovery therefrom via the outlet of
4 the first flowpath, wherein the first portion of the
5 first flowpath, the second flowpath and the second
6 portion of the first flowpath form a conduit for
7 continuous passage of fluid.

8
9 Embodiments of the invention will now be described
10 by way of example and with reference to the
11 accompanying drawings in which:-

12
13 Fig. 1 is a side sectional view of a typical
14 production tree;

15 Fig. 2 is a side view of the Fig. 1 tree with a
16 diverter cap in place;

17 Fig. 3 is a view of the Fig. 1 tree with a
18 second embodiment of a cap in place;

19
20

Fig. 3b is a view of the Fig. 1 tree with a third embodiment of a cap in place; Fig. 4a is a view of the Fig. 1 tree with a fourth embodiment of a cap in place; and Fig. 4b is a side view of the Fig. 1 tree with a fifth embodiment of a cap in place.

Referring now to the drawings, a typical production tree on an offshore oil or gas wellhead comprises a production bore 1 leading from production tubing (not shown) and carrying production fluids from a perforated region of the production casing in a reservoir (not shown). An annulus bore 2 leads to the annulus between the casing and the production tubing and a christmas tree cap 4 which seals off the production and annulus bores 1, 2, and provides a number of hydraulic control channels 3 by which a remote platform or intervention vessel can communicate with and operate the valves in the christmas tree. The cap 4 is removable from the christmas tree in order to expose the production and annulus bores in the event that intervention is required and tools need to be inserted into the production or annulus bores 1, 2.

The flow of fluids through the production and annulus bores is governed by various valves shown in the typical tree of Fig. 1. The production bore 1 has a branch 10 which is closed by a production wing valve (PWV) 12. A production swab valve (PSV) 15 closes the production bore 1 above the branch 10 and PWV 12.

1 Two lower valves UPMV 17 and LPMV 18 (which is
2 optional) close the production bore 1 below the
3 branch 10 and PWV 12. Between UPMV 17 and PSV 15, a
4 crossover port (XOV) 20 is provided in the production
5 bore 1 which connects to a the crossover port (XOV)
6 21 in annulus bore 2.

7
8 The annulus bore is closed by an annulus master valve
9 (AMV) 25 below an annulus outlet 28 controlled by an
10 annulus wing valve (AWV) 29, itself below crossover
11 port 21. The crossover port 21 is closed by
12 crossover valve 30. An annulus swab valve 32 located
13 above the crossover port 21 closes the upper end of
14 the annulus bore 2.

15
16 All valves in the tree are typically hydraulically
17 controlled (with the exception of LPMV 18 which may
18 be mechanically controlled) by means of hydraulic
19 control channels 3 passing through the cap 4 and the
20 body of the tool or via hoses as required, in
21 response to signals generated from the surface or
22 from an intervention vessel.

23
24 When production fluids are to be recovered from the
25 production bore 1, LPMV 18 and UPMV 17 are opened,
26 PSV 15 is closed, and PWV 12 is opened to open the
27 branch 10 which leads to the pipeline (not shown).
28 PSV 15 and ASV 32 are only opened if intervention is
29 required.

30

1 Referring now to Fig. 2, a wellhead cap 40 has a
2 hollow conduit 42 with metal, inflatable or resilient
3 seals 43 at its lower end which can seal the outside
4 of the conduit 42 against the inside walls of the
5 production bore 1, diverting production fluids
6 flowing up the production bore 1 in the direction of
7 arrow 101 into the hollow bore of the conduit 42 and
8 from there to the cap 40. The bore of conduit 42 can
9 be closed by a cap service valve (CSV) 45 which is
10 normally open but can close off an outlet 44 of the
11 hollow bore of the conduit 42. Outlet 44 leads via
12 tubing (not shown) to a wellhead booster pump or
13 chemical treatment etc to be applied to the
14 production fluids flowing from the bore of the
15 conduit 42. The booster pump and chemical treatment
16 apparatus is not shown in this embodiment. After
17 application of pressure from the booster pump or
18 chemical treatment as appropriate, the production
19 fluids are returned via tubing to the production
20 inlet 46 of the cap 40 which leads via cap flowline
21 valve (CFV) 48 to the annulus between the conduit 42
22 and the production bore 1. Production fluids flowing
23 into the inlet 46 and through valve 48 flow down the
24 annulus 49 through open PSV 15 and diverted by seals
25 43 out through branch 10 since PWV 12 is open.
26 Production fluids can thereby be recovered via this
27 diversion. The conduit bore and the inlet 46 can
28 also have an optional crossover valve (COV)
29 designated 50, and a tree cap adapter 51 in order to
30 adapt the flow diverter channels in the tree cap 40
31 to a particular design of tree head. Control

1 channels 3 are mated with a cap controlling adapter 5
2 in order to allow continuity of electrical or
3 hydraulic control functions from surface or an
4 intervention vessel.

5
6 This embodiment therefore provides a fluid diverter
7 for use with a wellhead tree comprising a thin walled
8 diverter conduit and a seal stack element connected
9 to a modified christmas tree cap, sealing inside the
10 production bore of the christmas tree typically above
11 the hydraulic master valve, diverting flow through
12 the diverter conduit and the top of the christmas
13 tree cap and tree cap valves to typically a pressure
14 boosting device or chemical treatment apparatus, with
15 the return flow routed via the tree cap to the
16 annular space between the diverter conduit and the
17 existing tree bore through the wing valve to the
18 flowline.

19
20 Referring to Fig. 3a, a further embodiment of a cap
21 40a has a large diameter conduit 42a extending
22 through the open PSV 15 and terminating in the
23 production bore 1 having seal stack 43a below the
24 branch 10, and a further seal stack 43b sealing the
25 bore of the conduit 42a to the inside of the
26 production bore 1 above the branch 10, leaving an
27 annulus between the conduit 42a and bore 1. Seals
28 43a and 43b are disposed on an area of the conduit
29 42a with reduced diameter in the region of the branch
30 10. Seals 43a and 43b are also disposed on either
31 side of the crossover port 20 communicating via

1 channel 21c to the crossover port 21 of the annulus
2 bore 2. In the cap 40a, the conduit 42a is closed by
3 cap service valve (CSV) 60 which is normally open to
4 allow flow of production fluids from the production
5 bore 1 via the central bore of the conduit 42 through
6 the outlet 61 to the pump or chemical treatment
7 apparatus. The treated or pressurised production
8 fluid is returned from the pump or treatment
9 apparatus to inlet 62 in the annulus bore 2 which is
10 controlled by cap flowline valve (CFV) 63. Annulus
11 swab valve 32 is normally held open, annulus master
12 valve 25 and annulus wing valve 29 are normally
13 closed, and crossover valve 30 is normally open to
14 allow production fluids to pass through crossover
15 channel 21c into crossover port 20 between the seals
16 43a and 43b in the production bore 1, and thereafter
17 through the open PWV 12 into the bore 10 for recovery
18 to the pipeline. A crossover valve 65 is provided
19 between the conduit bore 42a and the annular bore 2
20 in order to bypass the pump or treatment apparatus if
21 desired. Normally the crossover valve 65 is
22 maintained closed.

23
24 This embodiment maintains a fairly wide bore for more
25 efficient recovery of fluids at relatively high
26 pressure, thereby reducing pressure drops across the
27 apparatus.

28
29 This embodiment therefore provides a fluid diverter
30 for use with a wellhead tree comprising a thin walled
31 diverter with two seal stack elements, connected to a

1 tree cap, which straddles the crossover valve outlet
2 and flowline outlet (which are approximately in the
3 same horizontal plane), diverting flow through the
4 centre of the diverter conduit and the top of the
5 tree cap to pressure boosting or chemical treatment
6 apparatus etc, with the return flow routed via the
7 tree cap and annulus bore (or annulus flow path in
8 concentric trees) and the crossover loop and
9 crossover outlet, to the annular space between the
10 straddle and the existing xmas tree bore through the
11 wing valve to the flowline.

12
13 Fig. 3b shows a simplified version of a similar
14 embodiment, in which the conduit 42a is replaced by a
15 production bore straddle 70 having seals 73a and 73b
16 having the same position and function as seals 43a
17 and 43b described with reference to the Fig. 3a
18 embodiment. In the Fig. 3b embodiment, production
19 fluids passing through open LPMV 18 and UPMV 17 are
20 diverted through the straddle 70, and through open
21 PSV 11 and outlet 61a. From there, the production
22 fluids are treated or pressurised as the case may be
23 and returned to inlet 62a where they are diverted as
24 previously described through channel 21c and
25 crossover port 20 into the annulus between the
26 straddle 70 and the production bore 1, from where
27 they can pass through the open valve PWV 12 into the
28 branch 10 for recovery to a pipeline.

29
30 This embodiment therefore provides a fluid diverter
31 for use with a wellhead tree which is not connected

1 to the tree cap by a thin walled conduit, but is
2 anchored in the tree bore, and which allows full bore
3 flow above the "straddle" portion, but routes flow
4 through the crossover and will allow a swab valve
5 (PSV) to function normally.

6
7 The Fig. 4a embodiment has a different design of cap
8 40c with a wide bore conduit 42c extending down the
9 production bore 1 as previously described. The
10 conduit 42c substantially fills the production bore
11 1, and at its distal end seals the production bore at
12 83 just above the crossover port 20, and below the
13 branch 10. The PSV 15 is, as before, maintained open
14 by the conduit 42c, and perforations 84 at the lower
15 end of the conduit are provided in the vicinity of
16 the branch 10. In the Fig. 4a embodiment, LPMV 18
17 and UPMV 17 are held open and production fluids in
18 the production bore 1 are diverted by the seal 83
19 through the XOY port 20 and channel 21c into the XOY
20 port 21 of the annulus bore 2. XOY valve 30 into the
21 annulus bore is open, AMV 25 is closed as is AWV 29.
22 ASV 32 is opened and production fluids passing
23 through the crossover into the annulus bore 2 are
24 diverted up through the annulus bore 2, through the
25 open service valve (CSV) 63a through the chemical
26 treatment or pump as required and back into the inlet
27 62b of the production bore 1. Cap flowline valve
28 (CFV) 60a is open allowing the production fluids to
29 flow into the bore of the conduit 42c and out of the
30 apertures 84, through open PWV 12 and into the branch
31 10 for recovery to the pipeline. Crossover valve 65b

1 is provided between the production bore 1 and annulus
2 bore 2 in order to bypass the chemical treatment or
3 pump as required.

4
5 This embodiment therefore provides a fluid diverter
6 for use with a wellhead tree comprising a thin walled
7 conduit connected to a tree cap, with one seal stack
8 element, which is plugged at the bottom, sealing in
9 the production bore above the hydraulic master valve
10 and crossover outlet (where the crossover outlet is
11 below the horizontal plane of the flowline outlet),
12 diverting flow through the crossover outlet and
13 annulus bore (or annulus flow path in concentric
14 trees) through the top of the tree cap to a treatment
15 or booster with the return flow routed via the tree
16 cap through the bore of the conduit 42, exiting
17 therefrom through perforations 84 near the plugged
18 end, and passing through the annular space between
19 the perforated end of the conduit and the existing
20 tree bore to the production flowline.

21
22 Referring now to Fig. 4b, a modified embodiment
23 dispenses with the conduit 42c of the Fig. 4a
24 embodiment, and simply provides a seal 83a above the
25 XOV port 20 and below the branch 10. LPMV 18 and
26 UPMV 17 are opened, and the seal 83a diverts
27 production fluids in the production bore 1 through
28 the crossover port 20, crossover channel 21c,
29 crossover valve 30 and crossover port 21 into the
30 annulus bore 2. AMV 25 and AWV 29 are closed, ASV 32
31 is opened allowing production fluids to flow up the

1 annulus bore 2 through outlet 61b to the chemical
2 treatment apparatus or to the pump (or both) as
3 required, and is returned to the inlet 62b of the
4 production tubing 1 where it flows down through open
5 PSV 15, and is diverted by seal 83a into branch 10
6 and through open PWV 12 into the pipeline for
7 recovery.

8
9 This embodiment provides a fluid diverter for use
10 with a wellhead tree which is not connected to the
11 tree cap by a thin walled conduit, but is anchored in
12 the tree bore and which routes the flow through the
13 crossover and allows full bore flow for the return
14 flow, and will allow the swab valve to function
15 normally.

16
17 Embodiments of the invention can be retrofitted to
18 many different existing designs of wellhead tree, by
19 simply matching the positions and shapes of the
20 hydraulic control channels 3 in the cap, and
21 providing flow diverting channels or connected to the
22 cap which are matched in position (and preferably
23 size) to the production, annulus and other bores in
24 the tree. Therefore, the invention is not limited to
25 the embodiments specifically described herein, but
26 modifications and improvements can be made without
27 departing from its scope.

1 Claims

2

3 1. A method of recovering production fluids from a
4 well having a tree, the tree having a first flowpath
5 having an outlet, and a second flowpath, the method
6 comprising diverting fluids from a first portion of
7 the first flowpath to the second flowpath, and
8 diverting the fluids from the second flowpath back
9 to a second portion of the first flowpath, and
10 thereafter recovering fluids from the outlet of the
11 first flowpath.

12

13 2. A method as claimed in claim 1 wherein the
14 first flowpath is a production bore.

15

16 3. A method as claimed in any preceding claim
17 wherein the second flowpath is an annulus bore.

18

19 4. A method as claimed in claim 1 or claim 2,
20 wherein the fluids are diverted from the first
21 flowpath through a conduit disposed in the first
22 flowpath, and wherein the fluids are returned via
23 the annulus between the conduit and the first
24 flowpath.

25

26 5. A method as claimed in claim 4, wherein the
27 bore of the conduit provides the second flowpath.

28

29 6. A method as claimed in claim 4 or claim 5,
30 wherein the conduit is sealed to the first flowpath
31 across an outlet of the flowpath.

32

1 7. A method as claimed in any preceding claim,
2 wherein the first portion of the first flowpath is a
3 lower part of the first flowpath proximate to the
4 wellhead.

5

6 8. A method as claimed in any preceding claim,
7 wherein the fluids are returned to the first
8 flowpath at an upper portion of the first flowpath.

9

10 9. A method as claimed in any preceding claim,
11 wherein the fluids are diverted via a cap connected
12 to the tree.

13

14 10. A method as claimed in claim 9, wherein the
15 fluids are diverted via the cap from the second
16 flowpath to the second portion of the first
17 flowpath.

18

19 11. A method as claimed in claim 9, wherein the
20 fluids are diverted via the cap from the second
21 portion of the first flowpath to the second
22 flowpath.

23

24 12. A method as claimed in any one of claims 9 to
25 11, wherein a pump or treatment apparatus is
26 provided in the cap.

27

28 13. A method as claimed in any preceding claim,
29 wherein a pump or chemical treatment apparatus is
30 connected between the first and second flowpaths.

31

1 14. A method as claimed in any preceding claim
2 wherein the fluids are diverted through a crossover
3 conduit between the first flowpath and the second
4 flowpath.

5
6 15. A flow diverter assembly for a tree, the
7 assembly comprising a flow diverter means to divert
8 fluids from a first portion of a first flowpath
9 having an outlet to a second flowpath, and means to
10 divert fluids from the second flowpath back to a
11 second portion of the first flowpath for recovery
12 therefrom via the outlet of the first flowpath,
13 wherein the first portion of the first flowpath, the
14 second flowpath and the second portion of the first
15 flowpath form a conduit for continuous passage of
16 fluid.

17
18 16. An assembly as claimed in claim 15 comprising a
19 tree cap housing the flow diverter means.

20
21 17. An assembly as claimed in either of claims 15
22 or 16, including outlets for the first and second
23 flowpaths to divert the production fluids to a pump
24 or treatment assembly.

25
26 18. An assembly as claimed in any of claims 15 to
27 17, comprising a conduit for placement within the
28 first or second flowpaths.

29
30 19. An assembly as claimed in claim 18, having
31 sealing means capable of sealing between the conduit
32 and the wall of the flowpath to prevent fluid from

1 the flowpath entering the annulus between the
2 conduit and the flowpath.

3

4 20. An assembly as claimed in claim 18 or claim 19,
5 wherein the conduit provides at least one further
6 flowpath for diverting the fluid.

7

8 21. An assembly as claimed in any of claims 15 to
9 20, wherein the cap has fluid conduits for control
10 of tree valves, which conduits match and co-operate
11 with the conduits or other control elements of the
12 tree to which the cap is connected.

13

14 22. An assembly as claimed in any of claims 15 to
15 21, wherein the first flowpath comprises a
16 production bore.

17

18 23. An assembly as claimed in any of claims 15 to
19 22, wherein the second flowpath comprises an annulus
20 bore.

21

22 24. An assembly as claimed in any of claims 15 to
23 23, wherein the flow diverter means is adapted to
24 divert production fluids from a production bore via
25 a flowpath to remote apparatus for treatment and to
26 return the fluids to the tree for recovery from the
27 tree outlet.

28

29 25. A tree having flow diverter means to divert
30 production fluids from a production bore via a
31 second flowpath to remote apparatus for treatment,

1 and to return the fluids to the tree for recovery
2 from the tree outlet.

3

4 26. A tree as claimed in claim 25, wherein the
5 treatment apparatus comprises a pump or chemical
6 treatment apparatus.

7

8 27. A tree having a flow diverter assembly, the
9 assembly comprising a flow diverter means to divert
10 fluids from a first portion of a first flowpath
11 having an outlet to a second flowpath, and means to
12 divert fluids from the second flowpath back to a
13 second portion of the first flowpath for recovery
14 therefrom via the outlet of the first flowpath,
15 wherein the first portion of the first flowpath, the
16 second flowpath and the second portion of the first
17 flowpath form a conduit for continuous passage of
18 fluid.

19