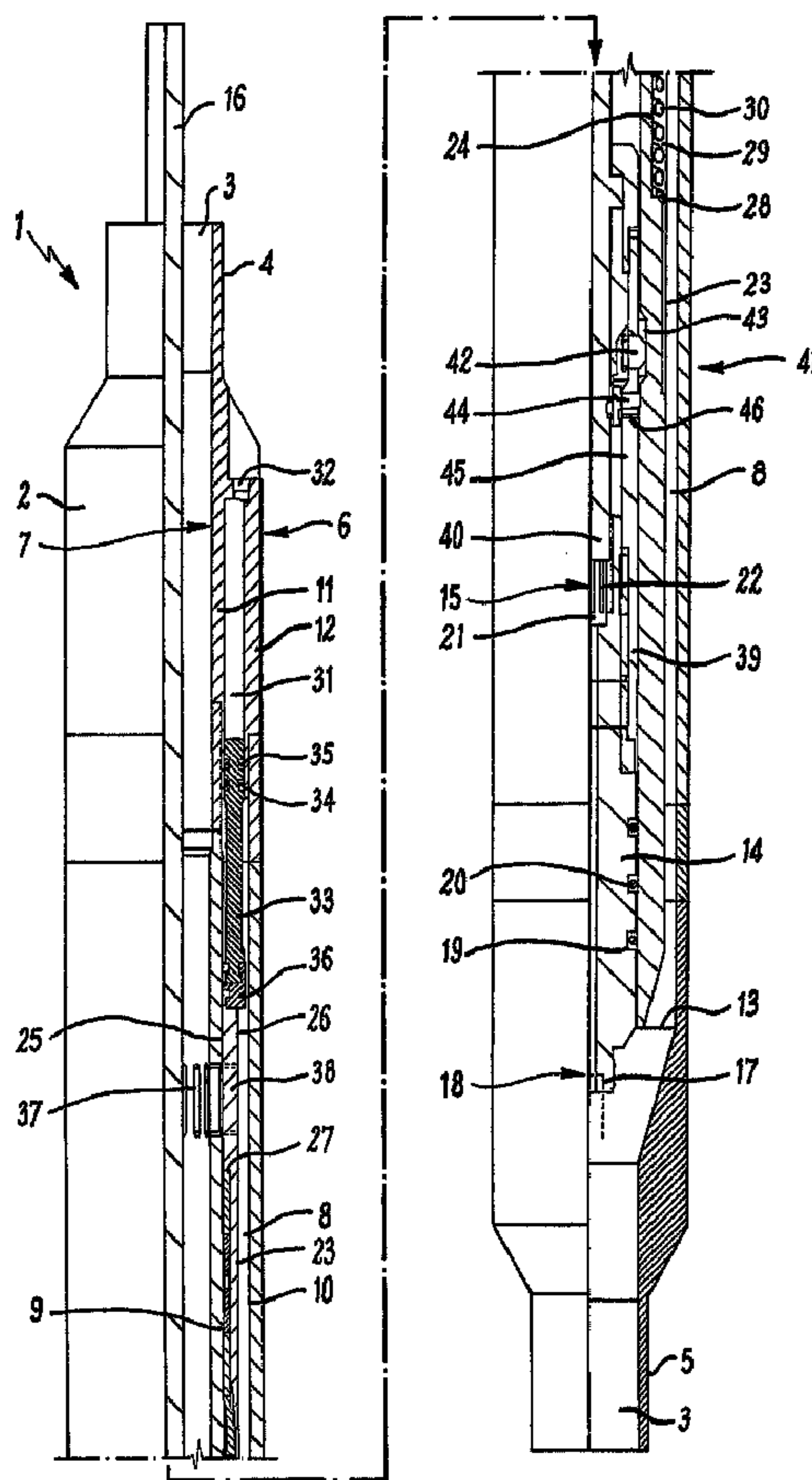




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(57) **Abrégé/Abstract:**

There is disclosed a safety valve for use in well bore operations, for example, in cooperation with a progressive cavity pump or rod pump. In one embodiment of the invention, a safety valve (1) disclosed which is designed for use with upper and lower conduits

(57) Abrégé(suite)/Abstract(continued):

in the form of upper and lower pump rod strings (16, 18) located in wellbore production tubing (50). The safety valve comprises a housing (2) having a longitudinal bore (3) extending therethrough; a coupling member (14) for coupling the upper rod string to the lower rod string, the coupling member sealably mounted within the longitudinal bore; an annular flow passage (8) bypassing the coupling member; and valve means comprising a valve sleeve (23) located in the annular flow passage. In use, the valve sleeve is utilised to control flow of fluid through the flow passage bypassing the coupling member.

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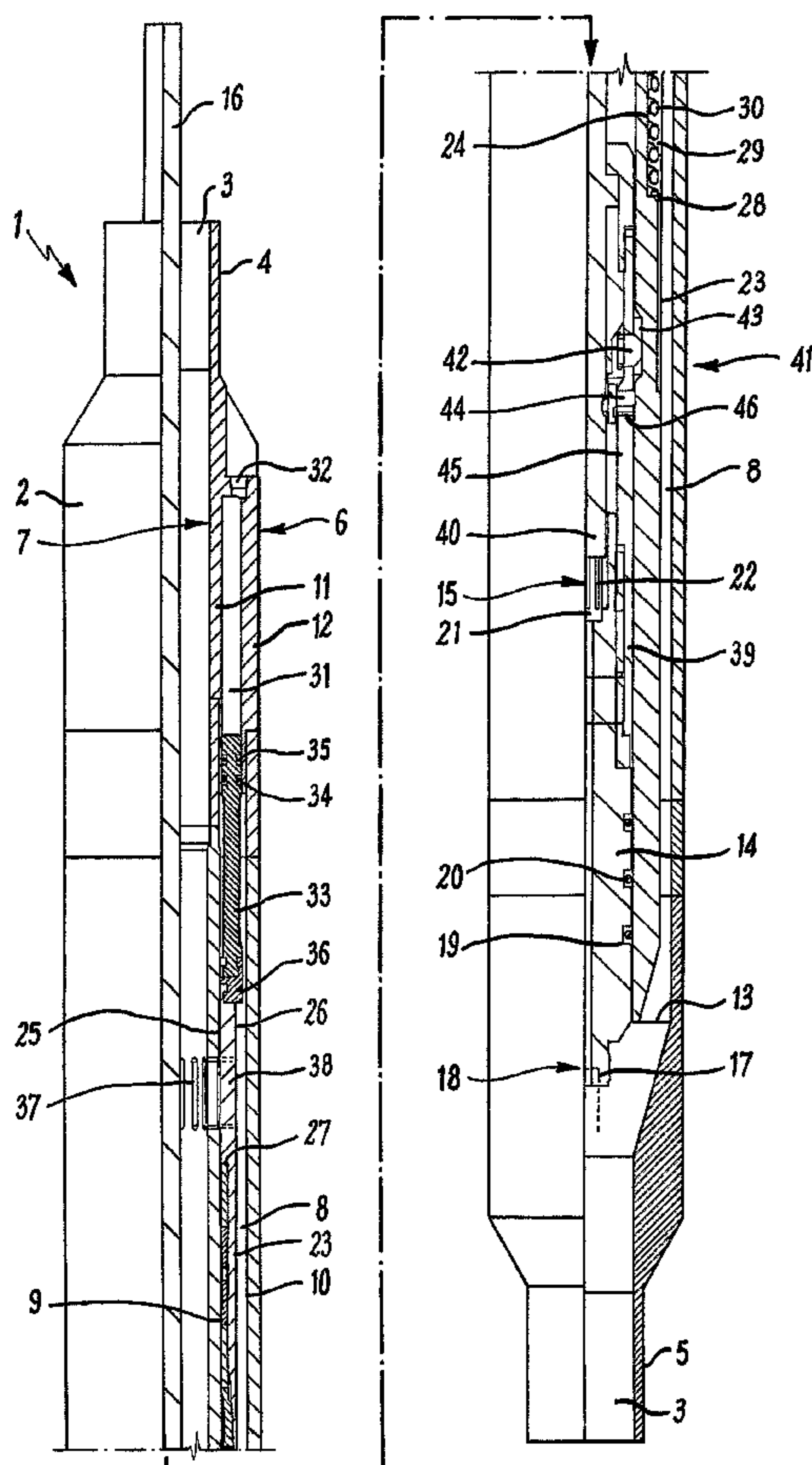
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(54) Title: SAFETY VALVE



(57) Abstract: There is disclosed a safety valve for use in well bore operations, for example, in cooperation with a progressive cavity pump or rod pump. In one embodiment of the invention, a safety valve (1) disclosed which is designed for use with upper and lower conduits in the form of upper and lower pump rod strings (16, 18) located in wellbore production tubing (50). The safety valve comprises a housing (2) having a longitudinal bore (3) extending therethrough; a coupling member (14) for coupling the upper rod string to the lower rod string, the coupling member sealably mounted within the longitudinal bore; an annular flow passage (8) bypassing the coupling member; and valve means comprising a valve sleeve (23) located in the annular flow passage. In use, the valve sleeve is utilised to control flow of fluid through the flow passage by-passing the coupling member.

WO 2006/048629 A1

WO 2006/048629 A1



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1 **Safety Valve**

2

3 The present invention relates to a safety valve for use
4 in well bore operations. In particular, but not
5 exclusively, the present invention relates to a safety
6 valve for use in wellbore production tubing, for example,
7 in cooperation with a progressive cavity pump or rod pump.

8

9 In the field of oil and gas drilling and well production,
10 safety valves are commonly used in producing wells to
11 prevent and contain accidents. For example, if downhole
12 pressure exceeds a certain level, it is often a matter of
13 urgency to shut in the well to prevent blowout and/or
14 damage to equipment.

15

16 Less than a quarter of producing oil wells flow
17 naturally. Therefore it is necessary to employ some
18 means of artificial lift, for example a pump of some
19 description. Such artificial lift means are also
20 employed in subsea operations and in difficult locations
21 in order to boost production.

22

1 Progressive cavity pumps (PCP) are generally employed in
2 low flowrate applications where there is not enough lift
3 to cause problems. Progressive cavity pumps are flexible
4 and reliable, and in general resistant to abrasive
5 solids. In comparison to some other pumping methods the
6 PCP produces an almost fluctuation-free flow out of a
7 well. PCPs are also durable and less prone to damage
8 than, for example, ESP pumps.

9

10 However, in subsea drilling and the majority of offshore
11 operations there is a strict requirement for failsafe
12 safety systems to be employed. These failsafe systems
13 are often safety valves that can be closed automatically
14 in the event of a problem.

15

16 A typical safety valve employed in the art is a flapper
17 valve. This kind of valve is biased closed in general by
18 a spring which forces the flapper upwards against a
19 sealing surface. Typically an actuation means such as a
20 rod or a sleeve is provided, and is controlled by a
21 hydraulic line from surface which, when actuated, moves
22 the flapper to an open position. Removal of pressure
23 will cause the flapper to close again.

24

25 This kind of safety valve is useful for shutting in a
26 well when there is a problem occurring downhole.
27 However, such flapper valves are unsuitable for
28 progressive cavity pumps, where a conduit in the form of
29 a rod string is required to pass through the bore of the
30 system down to the PCP rotor. The PCP is typically
31 located below what would be the location of a failsafe
32 valve.

33

1 One solution in the art is to use a rod string with a
2 modified end which pushes open the flapper valve and
3 continues moving downwards to mate with the PCP rotor or
4 a further rod string connected to the PCP rotor. Should a
5 problem occur downhole the rod can be pulled,
6 disengaging from the rotor and, once clear of the
7 flapper, the safety valve can be closed. However, as
8 discussed above, it is clear that should a problem occur
9 at the surface and the rod cannot be pulled then the
10 valve will remain open.

11

12 There is little provision for failsafe valves that allow
13 PCPs or rod pumps to be driven therethrough, while
14 maintaining a valve that can be actuated regardless of
15 whether the problem is downhole or at the surface.
16 Furthermore there is little provision for failsafe valves
17 that allow the valve to be opened or closed irrespective
18 of whether the rod is inserted or retracted, or
19 conversely that allow PCPs to be driven therethrough
20 regardless of whether the valve is open or closed.

21

22 CA2244593, for example, describes a rotary pump coupling
23 device that is used for flushing dual rotary screw pumps.

24

25 US4066128 describes a well flow control apparatus
26 comprising, inter alia, an improved mandrel for
27 supporting a flow control device along a flow conductor
28 in a well bore.

29

30 GB2362907 describes a downhole pump and valve assembly
31 that is made up of two mechanically independent
32 components, the downhole portion contains a primary valve

1 and secondary valve, and the uphole portion has a pump.
2
3 These problems and disadvantages apply equally in
4 relation to use of safety valves with other downhole
5 equipment such as drill strings, artificial lift
6 equipment such as gas lift pipes, and electrical/fibre-
7 optic/hydraulic penetrators. For example, a rotary drill
8 string suffers from similar disadvantages in terms of an
9 inability of prior safety valves to facilitate drive
10 transfer through the valve whilst maintaining the ability
11 to quickly close the valve. In the case of gas lift
12 pipes and penetrators, whilst it is not necessary in
13 these cases to transfer drive through the valve, the

1 problem of requiring the gas lift/penetrator string to be
2 pulled to close the safety valve remains.

3

4 It is an object of at least one embodiment of the present
5 invention to provide a safety valve that obviates OR
6 mitigates at least one limitation of the prior art.

7

8 According to a first aspect of the present invention,
9 there is provided a safety valve for use with upper and
10 lower conduits located in wellbore production tubing, the
11 safety valve comprising:

12 a housing having a longitudinal bore extending
13 therethrough;

14 a coupling member for coupling the upper conduit to
15 the lower conduit; and

16 valve means operable between a first condition
17 permitting fluid flow between the upper and lower
18 conduits and a second condition in which such flow is
19 blocked;

20 wherein the coupling member is sealably mounted
21 within the longitudinal bore;

22 wherein an annular flow passage is provided which
23 bypasses the coupling member; and

24 wherein the valve means is located in the annular
25 flow passage.

26

27 Preferably, the upper conduit is an upper tubing string
28 and the lower conduit is a lower tubing string. The
29 tubing strings may provide a mechanical support and/or
30 may define a fluid flow path to enable a downhole
31 operation to be conducted.

1
2 The coupling member may serve for fluidly coupling the
3 upper conduit to the lower conduit, to permit fluid flow
4 therebetween. This may facilitate use of the safety valve
5 with gas lift tubing or pipe comprised of upper and lower
6 conduits in the form of upper and lower tubing strings,
7 where an upper gas lift tubing section is to be coupled
8 to a lower gas lift tubing section. This may

1 enable injection of gas into the production tubing below
2 the valve (in an artificial, gas-lift procedure), whereby
3 recovery of well fluids is stimulated, the well fluids
4 flowing through the annular flow passage into the
5 production tubing above the valve and to surface.

6
7 The coupling member may be adapted to be connected to one
8 of the upper and lower conduits, and the housing may be
9 adapted to be connected to the other one of the upper and
10 lower conduits. Accordingly, by sealingly mounting the
11 coupling member in the housing bore, the upper and lower
12 tubing strings may be fluidly coupled, and the connecting
13 member may therefore serve for indirectly connecting the
14 upper and lower tubing strings together.

15
16 Alternatively, the coupling member may serve for
17 connecting the upper and lower conduits together, and may
18 therefore serve for directly connecting the conduits.

19
20 The coupling member may comprise a tubing section, pipe,
21 sub or the like which may serve for coupling the upper
22 and lower conduits and may therefore be adapted to form
23 part of a completed conduit extending through the valves.

24
25 The coupling member may take the form of a penetrator
26 body, the penetrator body serving for coupling the upper
27 and lower conduits which may be upper and lower
28 penetrator conduits. The upper and lower penetrator
29 conduits may comprise or take the form of tubes, pipes,
30 wires and/or cables and may be electrical, fibre-optic
31 and/or hydraulic tubes, pipes, wires or cables and may
32 serve for providing power and/or control signals to
33 downhole equipment, particularly pumps such as electrical

1 submersible pumps (ESPs). Accordingly, when the upper
2 and lower conduits are coupled, supply of power and/or
3 control signs to downhole equipment may be facilitated.
4 Additionally, by sealably mounting the penetrator body in
5 the housing bore, return flow of fluid (such as well
6 fluids lifted by the pump) may be directed along the flow
7 passage whilst the body provides connection between the
8 upper and lower penetrator conduits.

9
10 Preferably however, the coupling member takes the form of
11 a motion transferring member arranged to provide a means
12 to provide motion from the upper conduit to the lower
13 conduit. The safety valve may be for use with upper and
14 lower conduits in the form of upper and lower tubing
15 strings, which may be upper and lower rod strings of a
16 pump. Alternatively, the safety valve may be for use
17 with upper and lower conduits in the form of upper and
18 lower tubing strings which may be respective sections of
19 a drill string, or any other downhole tubing of a type
20 where motion is to be transferred through the safety
21 valve.

1

2

3

4 The annular flow path and valve means therein provides a
5 fluid path which can be opened and closed to regulate
6 flow in a production string. The motion transferring
7 member provides a means of transferring motion from above
8 the safety valve to below the safety valve without
9 compromising the effectiveness of the valve means.

10

11 Most preferably and advantageously the valve means is an
12 annular valve. Annular valves are well known in the art
13 and are very effective in shutting off producing wells.
14 Such a valve would allow the motion transferring member
15 to move within the housing whether the valve was open or
16 closed.

17

18 Preferably the coupling/motion transferring member
19 comprises a hollow, substantially cylindrical body.
20 Preferably the motion transferring member forms a
21 sealtight fit within the longitudinal bore.

22

23 Preferably the annular flow passage divides a substantial
24 portion of the housing into an outer cylindrical housing
25 and an inner cylindrical housing.

26

27 The annular cavity allows the fluid to bypass the
28 coupling/motion transferring member, and the annular
29 valve located therein opens or closes to allow or prevent
30 fluid flow up the production tubing.

31

32 Preferably the annular valve comprises a hollow
33 cylindrical valve sleeve surrounding a hollow cylindrical

1 valve body. Preferably the cylindrical valve body is an
2 integral part of the inner cylindrical housing.
3 Preferably the valve sleeve is movable along the valve
4 body. Preferably the valve sleeve has one or more valve
5 sleeve apertures. Preferably the valve body has one or
6 more valve body apertures. The valve is open when the
7 valve sleeve moves to a position where the sleeve
8 apertures align with the valve body apertures.
9
10 Most preferably the annular valve has an actuation means
11 which displaces the valve sleeve of the annular valve.
12 This actuation means therefore controls the opening and
13 closing of the valve, allowing and preventing fluid flow
14 within the tubing.
15
16 Preferably the actuation means for the annular safety
17 valve is a rod piston. Preferably the rod piston is
18 located in a longitudinally extending rod piston cavity.
19 Preferably the rod piston is axially moveable within the
20 rod piston cavity. Preferably movement of the rod piston
21 is effected by means of hydraulic fluid pressure within
22 the rod piston cavity.
23
24 Preferably the rod piston is biased with a spring. In
25 this way the piston, and hence the valve can be biased to
26 be default open or default closed.
27
28 Preferably the rod piston cavity is in fluid
29 communication with a hydraulic control line port located
30 at an outer surface of the substantially cylindrical
31 housing. Preferably the hydraulic control line port
32 connects to a control line. Preferably the control line
33 extends to the top of the wellbore. This will allow the

1 annular valve to be opened or closed from the surface by
2 controlling hydraulic fluid pressure in the control line.

3

4 Optionally there is an intermediary stage between the
5 hydraulic control line port and the control line.

6 Preferably the intermediary stage is a component of a
7 downhole fixture located in the wellbore. In particular
8 embodiments, the safety valve may be adapted to be
9 located in an existing downhole valve. Accordingly, the
10 downhole fixture may be a sub-surface safety valve (SSSV)
11 and may be locked open. The SSSV may take the form of a
12 tubing retrievable surface controlled safety valve
13 (TRSCSV). In this way, the control line of an existing,
14 already installed, downhole component can be employed to
15 actuate the safety valve of the present invention. In
16 these embodiments, the safety valve of the invention may
17 be adapted to engage within a main bore of the existing
18 valve, which may be locked open by the safety valve or
19 using the existing valve control equipment.

20

21 Preferably the movement of the motion transferring member
22 is restricted to rotational motion. This facilitates the
23 transfer of rotational motion from an upper rod string to
24 a lower rod string, allowing for example a progressive
25 cavity pump to be driven from the surface, or transfer of
26 motion between upper and lower drill strings or other
27 rotatable tubing strings.

28

29 Alternatively the movement of the motion transferring
30 member is restricted to axial motion. This alternative
31 allows the transfer of an axial reciprocation of the
32 upper rod string to the lower rod string, allowing for
33 example a rod pump to be driven from the surface.

1 Preferably sealing means are provided between the
2 coupling/motion transferring member and the housing.
3 This ensures that any fluid flow is either prevented or
4 directed through the annular flow passage, depending on
5 whether the annular valve is closed or open,
6 respectively.

7
8 The sealing means maybe a plurality of circumferentially
9 extending seals. The circumferentially extending seals
10 maybe located within circumferentially extending recesses
11 on an outer surface of the coupling/motion transferring
12 member. Alternatively the circumferentially extending
13 seals are located within circumferentially extending
14 recesses on an inner surface of the longitudinal bore.

15
16 Preferably a bearing means is provided between the
17 coupling/motion transferring member and the substantially
18 cylindrical housing. This bearing means reduces friction
19 between the motion transferring member and the housing.

20
21 The valve may comprise means for connecting the
22 coupling/motion, transferring member to the upper conduit
23 which may comprise a female receptacle integral to the
24 coupling/motion transferring member and a male insert
25 provided on or adapted to be coupled to the upper
26 conduit.

27
28 The male insert may comprise a spline shaft, and the
29 female receptacle may comprise a spline sleeve into which
30 the spline shaft forms an interference fit. The spline
31 shaft and spline sleeve mate to form a connection capable
32 of transferring rotational motion.

1 Preferably the male insert further comprises a locking
2 mechanism. The locking mechanism is to hold the spline
3 shaft within the spline sleeve and prevent unwanted
4 retraction of the upper conduit.

5
6 The locking mechanism may comprise a key. The female
7 receptacle may comprise a recess with which the key can
8 communicate. As the upper conduit with the male insert
9 is lowered into the safety valve, the key locates within
10 the recess and prevents the upper conduit from being
11 forced upwards.

12
13 Preferably the male insert further comprises a non-
14 rotating mandrel. Preferably the locking mechanism is an
15 integral part of the non-rotating mandrel. Most
16 preferably and advantageously the upper conduit is free
17 to rotate within the non-rotating mandrel. This means
18 that the locking mechanism does not rotate, and only the
19 upper conduit rotates, making the locking mechanism more
20 effective.

21
22 Preferably the male insert further comprises a no-go key.
23 Most preferably the no-go key is fixed in location on the
24 non-rotating mandrel. Preferably the female receptacle
25 further comprises a shoulder with which the no-go key
26 communicates. The no-go key and the shoulder contact to
27 stop the upper conduit travelling too far downwards.

28
29 The valve may comprise means for connecting the
30 coupling/motion transferring member to the lower conduit,
31 which may comprise a female receptacle integral to the
32 coupling/motion transferring member and a male insert

1 provided on or adapted to be coupled to the top end of
2 the lower conduit.

3

4 Optionally the lower conduit is a lower rod string and
5 may be a PCP rotor.

6

7 Preferably the top end and the bottom end of the housing
8 are adapted for connection to production tubing.

9

10 Optionally, the means of connecting the coupling/motion
11 transferring member to the lower conduit further
12 comprises a torque reducing means. A PCP rotor in
13 rotation often results in a transfer of torque to the rod
14 string driving the rotation. This creates a backlash
15 rotation wherein the rod string moves in a circular path
16 within the bore. A torque reducing means would reduce
17 the transfer of this torque into the safety valve.

18

19 Whilst the above aspects of the invention have been
20 defined in relation to a safety valve for use with tubing
21 strings located in wellbore production tubing, it will be
22 understood that the safety valve may be utilised in any
23 desired, suitable downhole tubing such as casing, liner
24 or the like. Equally, it will be understood that the
25 safety valve may be for use with any suitable upper and
26 lower tubing strings. The safety valve may also have
27 uses in other types of tubing such as pipelines.

28

29 Further features of the present invention are defined in
30 the claims.

1 The present invention will now be described, by way of
2 example only, with reference to the accompanying
3 drawings, in which:

4

5 Figure 1 is a part cross-sectional view a safety
6 valve in accordance with an embodiment of the
7 present invention;

8

9 Figure 2 is a schematic view of the safety valve of
10 Figure 1 shown in use, disposed within a wellbore;

11

12 Figures 3A to 3C are longitudinal sectional views,
13 from top to bottom, of a safety valve in accordance
14 with an alternative embodiment of the present
15 invention;

16

17 Figures 4A to 4C are longitudinal sectional views,
18 from top to bottom, of a safety valve in accordance
19 with a further alternative embodiment of the present
20 invention;

21

22 Figure 5 is a schematic view of the safety valve of
23 Figures 4A to 4C shown in use, disposed within a
24 wellbore; and

25

26 Figure 6 is a view of a penetrator for use with a
27 safety valve in accordance with a yet further
28 alternative embodiment of the present invention.

29

30 With reference to Figure 1, there is presented a safety
31 valve 1 that functions to selectively open and close a
32 well production as described in detail below. The safety
33 valve 1 comprises a cylindrical housing 2, with a central

1 bore 3 running there through, and having a top 4 and a
2 bottom end 5. The outer diameter of the housing 2
3 defines a housing outer surface 6, and the central bore 3
4 defines an inner diameter of the housing 6 and a housing
5 inner surface 7. The top 4 and bottom 5 ends of the
6 safety valve 1 are adapted for connection to a production
7 string (not shown).

8
9 Between the housing outer surface 6 and the housing inner
10 surface 7 is located an annular passageway 8, distinct
11 from the central bore 3. The inner diameter of the
12 annular passageway 8 is larger than the inner housing
13 diameter and the outer diameter of the annular passageway
14 8 is less than the housing outer diameter. The annular
15 passageway 8 thus defines an inner annular surface 9 and
16 an outer annular surface 10, and splits the housing 2
17 into an inner housing 11 and an outer housing 12.

18
19 The central bore 3 widens towards the bottom end 5 of the
20 housing 2, and the annular passageway 8 extends downwards
21 and is open to fluid communication at the bottom end 5 of
22 the safety valve 1 via an annular aperture 13 thus
23 formed. The top end of the annular passageway 8 is
24 closed to fluid communication.

25
26 Disposed near the bottom end 5 of the safety valve 1 is a
27 rotary section 14. The rotary section 14 is situated
28 within the central bore 3, with a top end 15 adapted for
29 connection to an upper rod string 16, and a lower end 17
30 adapted for connection to a lower rod string 18. The
31 rotary section 14 provides a transfer of torque from the
32 upper rod string 16 to the lower rod string 18 without
33 compromising the safety valve 1. The rotary section 14

1 is free to rotate within the central bore 3, with no
2 transfer of rotational motion to the rest of the safety
3 valve 1.

4

5 The rotary section 14 has three circumferentially
6 extending recesses 19 on the outer surface, within which
7 are located rotary seals 20, maintaining a seal between
8 the bottom end 5 of the safety valve 1 and the central
9 bore 3 above the rotary section 14. Additionally, the
10 top end 15 of the rotary section 14 comprises a mating
11 sleeve 21 adapted to receive a spline shaft 22. The
12 spline shaft 22 and the mating sleeve 21 form an
13 interference fit capable of transferring torque.

14

15 Within the annular passageway 8 is located a valve sleeve
16 23. A longitudinally and circumferentially extending
17 annular recess 24 on the inner annular surface 9 provides
18 a means of locating the valve sleeve 23 within the
19 annular passageway 8. The recess 24 and the valve sleeve
20 23 are sized to allow the valve sleeve 23 to reciprocate
21 axially within the annular passageway 8.

22

23 The valve sleeve 23 has an inner valve sleeve surface 25
24 and an outer valve sleeve surface 26. The inner valve
25 sleeve surface 25 forms a valve sleeve shoulder 27;
26 likewise an annular recess shoulder 28 is formed in the
27 annular recess 24 on the inner annular surface 9, located
28 beneath the valve sleeve shoulder 27. The valve sleeve
29 shoulder 27 and the annular recess shoulder 28 define a
30 spring cavity 29. The spring cavity 29 contains a spring
31 30 in compression. The lower end of the spring 30 pushes
32 against the annular recess shoulder 28 and the upper end
33 of the spring 30 pushes against the valve sleeve shoulder

1 27 and biases the valve sleeve 23 in an upwards
2 direction.

3
4 Within the housing 2 is further located a cylindrical,
5 longitudinally extending piston cavity 31, distinct from
6 and parallel to the central bore 3, extending from the
7 top end of the annular passageway 8 in an upwards
8 direction to the housing outer surface 6. Where the
9 piston cavity 31 meets the housing outer surface 6 is
10 located a piston cavity port 32, which provides fluid
11 communication between an external fluid source (not
12 shown) and the piston cavity 31.

13
14 The piston cavity 31 contains a rod piston 33, axially
15 movable therein. The rod piston 33 is cylindrical, with
16 two circumferential recesses 34 at a top end. Within
17 these circumferential recesses 34 are located sealing
18 rings 35 which form a seal between the rod piston 33 and
19 the piston cavity 31. At a bottom end of the rod piston
20 33 is a connector 36 that joins the rod piston 33 to a
21 top end of the valve sleeve 23, such that axial
22 reciprocation of the rod piston 33 results in axial
23 reciprocation of the valve sleeve 23.

24
25 The fluid pressure in the piston cavity 31 governs the
26 axial reciprocation of the rod piston 33. By increasing
27 the pressure of the fluid in the piston cavity 31 the
28 upwards biasing force of the spring 30 can be overcome to
29 move the piston 33 and the valve sleeve 23 downwards.

30
31 There are a number of circumferentially distributed
32 housing ports 37 in the inner housing 11 allowing
33 communication between the central bore 3 and the annular

1 passageway 8. The valve sleeve 23 also has a number of
2 circumferentially distributed sleeve ports 38, situated
3 to coincide with the housing ports 37 when the rod piston
4 33 and valve sleeve 23 are moved fully downwards.
5 Therefore, by controlling the fluid pressure in the
6 piston cavity 31, the ports 37,38 can be aligned and
7 misaligned. The default position, with low piston cavity
8 31 fluid pressure, is closed, requiring an increase in
9 fluid pressure to align the ports 37,38.

10

11 When the ports 37,38 are aligned, fluid passage is
12 permitted between the bottom end 5 of the safety valve 1,
13 which is in communication with downhole gas or oil (not
14 shown), through the valve sleeve ports 38 and the inner
15 housing ports 37, into the central bore 3 and up to the
16 top end 4 of the safety valve 1. This corresponds to an
17 operating position in which the well is open to
18 production. Conversely, moving the valve sleeve 23 to
19 take the inner housing ports 37 and the valve sleeve
20 ports 38 out of alignment corresponds to an operating
21 position in which the well is shut in.

22

23 Transfer of rotational motion from the upper rod string
24 16 to a lower rod string 18 is possible regardless of the
25 operating position of the safety valve 1. Rotational
26 motion is assisted by a bearing 39 which reduced the
27 friction between the inner housing 11 and the rotary
28 section 14.

29

30 The upper rod string 16 has a modified lower end 40,
31 adapted for connection to the rotary section 14 of the
32 safety valve 1. The lower end 40 of the upper rod string
33 16 forms a spline shaft 22, for inserting in the mating

1 sleeve 21 of the rotary section 14. When inserted, a
2 locking mechanism 41 holds the upper rod string 16 in
3 place.

4
5 The locking mechanism 41 consists of a key 42 which is
6 integral to the lower end 40 of the upper rod string 16.
7 The key 42 locates within a landing nipple 43, which is
8 integral to the inner housing 11 and part of the central
9 bore 3. Additionally, the lower end 40 of the upper rod
10 string 16 comprises a no-go key 44 and the inner housing
11 11 comprises a latch body 45 which defines a shoulder 46
12 at its upper end. When the upper rod string 16 is
13 lowered through the central bore 3, the no-go key 44
14 comes to rest on the shoulder 46, preventing additional
15 downwards motion. Any additional downwards motion might
16 damage the rotary section 14, which by this point is
17 connected to the upper rod string 16 by virtue of the
18 mating sleeve 21 and the spline shaft 22.

19
20 Figure 2 shows a schematic representation of the safety
21 valve 1 disposed within a producing wellbore 47,
22 particularly a rig 48 wellbore 47. The wellbore 47
23 comprises a casing 49, within which a production tubing
24 50 is set in place with a packer 51. The bottom end 52
25 of the production tubing 50, beneath the packer 51, is in
26 fluid communication with formation fluids 53; namely gas
27 and oil.

28
29 Located near a top end of the wellbore 47 is positioned
30 the safety valve 1 of the present invention. The safety
31 valve 1 is connected at the top 4 and bottom 5 ends to
32 the production tubing 50. When open, the annular flow
33 path 54 bypasses the rotary section 14 within the safety

1 valve 1, facilitating flow of formation fluids from the
2 bottom 52 of the production tubing 50 to the surface 55.
3 The rotary section 14 is located therein to permit
4 transfer of rotational motion from above the safety valve
5 1 to below the safety valve 1, with no adverse effects on
6 the operation of the valve 1.

7

8 A control panel 56 governs the fluid pressure supplied to
9 the safety valve 1 via the control line 57 and the piston
10 cavity port 32. When well production is in progress, the
11 fluid pressure is high to align the inner housing ports
12 (not shown) and the valve sleeve ports (not shown) and
13 permit fluid flow there through. If a problem is
14 detected, or a fault occurs, the control panel 56 will
15 reduce the fluid pressure such that the inner housing
16 ports (not shown) and the valve sleeve ports (not shown)
17 are out of alignment and the well 47 is shut in.

18

19 The production wellbore 47 illustrated uses a progressive
20 cavity pump 58 to enhance lift of the formation fluids
21 53. The progressive cavity pump 58, as is known in the
22 art, comprises a PCP stator 59 and a PCP rotor 60. The
23 PCP rotor 60 is single helical in shape, and the stator
24 59 is double helical in shape. Rotation of the rotor 60
25 within the stator 59 results in a progressing cavity
26 which creates an upwards flow of fluid.

27

28 Rotation of the rotor 60 is effected from the surface 55
29 via an upper rod string 16. At the surface 55 the upper
30 rod string 16 is rotated by a top drive 61 such as is
31 used to turn drill stems.

32

1 The upper rod string 16 is attached to the upper end 15
2 of the rotary section 14 located within the safety valve
3 1, and the lower rod string 18 is attached to the lower
4 end 17 of the rotary section 14 within the safety valve
5 1. Therefore when the top drive 61 drives the rotation
6 of the upper rod string 16, the lower rod string 18
7 rotates due to the transfer of rotational motion through
8 the safety valve 1. The lower rod string 18 rotation
9 will result in rotation of the PCP rotor 60 and create an
10 upwards flow of formation fluid 53. Meanwhile the safety
11 valve 1 may be closed and re-opened as and when required.
12

13 One advantage of the current system is that it allows
14 progressive cavity pumps to be deployed in subsea
15 operations, particularly in operations where the safety
16 regulator insists that a failsafe barrier is provided.
17 This could be in offshore wells such as in the North Sea
18 or Gulf of Mexico, or indeed land wells where there is
19 such a requirement. Failsafe devices are prerequisites
20 of subsea operations; in the event of a problem occurring
21 the production needs to be shut in to prevent formation
22 fluids from polluting the sea.

23
24 Current safety valves such as the flap and ball type
25 require retraction of the pump or production string to
26 close the valve. If a problem occurs downhole this is
27 generally possible, however if the problem occurs at the
28 surface, sometimes the string cannot be pulled. This
29 makes such systems problematic.

30
31 The advantage of the present invention is that the valve
32 is controlled separately from the string and as such can

1 be opened or closed whether a fault is downhole or at the
2 surface.

3

4 The transfer of rotational motion through the valve also
5 allows PCP pumps to be used in such systems, which was
6 not permissible before due to concerns over safety.

7

8 Furthermore, the use of an annular type valve means that
9 the well can be shut in even at high rates.

10

11 By allowing for the capability to have an intermediary
12 stage to transfer hydraulic pressure from the control
13 line to the hydraulic control line port, it is possible
14 to run the safety valve of the present invention into an
15 existing downhole component comprising the intermediary
16 stage. This allows the present invention to also take
17 advantage of existing control lines rather than requiring
18 a dedicated control line in every application, as will
19 now be described.

20

21 Accordingly, turning now to Figures 3A to 3C, there is
22 shown sequentially from top to bottom a longitudinal
23 sectional view of a safety valve in accordance with an
24 alternative embodiment of the present invention, the
25 safety valve indicated generally by reference numeral
26 100. An upper end of the safety valve is thus shown in
27 Figure 3A and a lower end in Figure 3C. Like components
28 of the safety valve 100 with the valve 1 of Figures 1 and
29 2 share the same reference numerals, incremented by 100.
30 Only the substantial differences between the valve 100
31 and the valve 1 will be described herein in detail.

32

33 The valve 100 is shown latched into an existing sub-
34 surface safety valve (SSSV) 62. The SSSV 62 has a valve

1 housing 64 which is coupled to production tubing in a
2 wellbore (not shown), in a similar fashion to the housing
3 2 of the valve 1. In the illustrated embodiment, the
4 SSSV 62, which typically includes a flapper valve (also
5 not shown), has failed and is no longer able to operate
6 adequately to shut-off flow through the wellbore. The
7 safety valve 100 has been run into the production tubing
8 on an upper conduit in the form of an upper pump rod
9 string 116, and is coupled at a lower end to a lower
10 conduit in the form of a lower pump rod string 118. The
11 lower rod string 118 is coupled to and drives a rotor of
12 a pump (not shown), such as the pump 58 shown in Figure
13 2. Prior to running of the valve 100, the SSSV flapper
14 is locked open, and the valve 100 is then run and latched
15 into the SSSV housing 64, as shown in the Figures. In
16 this fashion, existing control equipment of the SSSV 62
17 may be utilised to actuate the safety valve 100, as will
18 be described below.

19

20 The valve 100 includes a valve sleeve 123 having a number
21 of sleeve ports 138, and an inner housing 111 having a
22 number of ports 137. The sleeve 123 is coupled to a rod
23 piston 133, which is in fluid communication with a fluid
24 inlet 66 of the SSSV valve housing 64. Reciprocation of
25 the rod piston 133, and thus axial alignment of the
26 sleeve ports 138 and the inner housing ports 137, is
27 controlled by an existing control line (not shown) which
28 is in fluid communication with the inlet 66 of the SSSV
29 housing 64, in a similar fashion to that described above
30 in relation to the valve 1. When the ports are aligned,
31 fluid flows up an annulus defined between the production
32 tubing and the external surface 126 of the valve sleeve
33 123, through the ports 138 and 137, along a central bore

1 103 of the valve 100, into an annulus 103' defined
2 between the SSSV housing 64, and into the production
3 tubing above the valve.

4

5 The valve 100 includes a rotary section 114 in the form
6 of a connecting rod, which connects the upper rod string
7 116 to the lower rod string 118, and permits transfer of
8 a rotary drive force to the pump. The connecting rod 114
9 extends through the SSSV valve housing 64 and through a
10 housing 102 of the valve 100, and includes a splined
11 portion 122 which mates with a splined sleeve 121 on the
12 upper rod string 116.

13

14 The valve 100 is latched into the SSSV valve housing 64
15 by a proprietary locking mechanism 68, such as that
16 commercially available from the Applicant, which
17 restrains the main valve housing 102 against further
18 axial movement relative to the SSSV housing 64. During
19 run-in, the valve 100 is supported on a shoulder 70 of a
20 body 72 provided at a lower end of the connecting rod
21 114, and the valve 100 includes a lower sub 74 carrying a
22 collet 76 which engages around the connecting rod 114.
23 When the valve 100 has been located within the SSSV
24 housing 64, further downward movement of the housing 102
25 is then prevented by virtue of a no-go shoulder in the
26 SSSV housing. At this point, a fluted running sub 84
27 restrains a spring loaded mandrel 86 in a position where
28 locking keys or dogs 78 of the mechanism 68 are
29 de-supported, and the mechanism is thus disengaged.
30 Additional force then applied to the connecting rod 114
31 causes a shoulder 82 on the rod 114 to snap through the
32 collet 76. The connecting rod 114 travels a short
33 distance further downhole until the fluted running sub 84

1 on the connecting rod releases the mandrel 86, which
2 moves down to support the keys 78, which engage in a
3 recess 80. The valve 100 is then located in the SSSV 62.
4 In use, the fluted running sub 84 permits fluid flow up
5 the production tubing between flutes on the sub. The
6 valve 100 includes appropriate rotary/axial seal units
7 119 at a lower end, which provide a seal between the
8 rotating connecting rod 114 and the valve housing 102,
9 and the valve 100 is now fully latched into the SSSV 62
10 and ready for use.

11

12 It will therefore be understood that the valve 100,
13 whilst being of similar structure to the valve 1, is
14 operated utilising existing downhole equipment provided
15 for operating the now-defunct SSSV 62. This avoids a
16 requirement to carry out an expensive recovery and
17 replacement of the SSSV 62, and thus minimises downtime.

18

19 Turning now to Figures 4A to 4C, there is shown
20 sequentially from top to bottom a longitudinal sectional
21 view of a safety valve in accordance with a further
22 alternative embodiment of the present invention, the
23 safety valve indicated generally by reference numeral
24 200. An upper end of the safety valve is thus shown in
25 Figure 4A and a lower end in Figure 4C. Like components
26 of the safety valve 200 with the valve 1 of Figures 1 and
27 2 share the same reference numerals incremented by 200,
28 and with the valve 100 of Figures 3A to 3C, share the
29 same reference numerals incremented by 100 or 200, as
30 appropriate. Only the substantial differences will be
31 described herein in detail.

32

1 The valve 200 is essentially of similar structure to the
2 valve 100, save that the valve 200 is shown in use with
3 gas lift tubing 88 in an artificial lift procedure, which
4 is illustrated in the schematic view of Figure 5. In the
5 gas lift procedure, gas is injected into a region 90 of
6 the production tubing 250 (where well fluids enter the
7 production tubing), to reduce the hydrostatic pressure of
8 the column of fluid in the production tubing in the
9 region 90. The resulting reduction in bottomhole
10 pressure allows well fluids to enter the wellbore 247 at
11 a higher flow rate, thereby stimulating production.

12

13 The valve 200 includes a coupling member in the form of a
14 stab-in body 292, which is designed to stab-into a lower
15 sub 274 of the valve 200, and carries appropriate seals
16 for sealing the body 292 in the sub 274. The body 292 is
17 threadably connected to a lower end of an upper conduit
18 in the form of an upper gas lift tubing string 216, which
19 forms part of the gas lift tubing 88. A lower conduit in
20 the form of a lower gas lift tubing string 218 is
21 threadably coupled to the lower sub 274, and the stab-in
22 body thereby serves for fluidly coupling the upper and
23 lower gas lift tubing strings 216 and 218.

24

25 The valve 200 is shown latched into an existing SSSV
26 housing 264, in a similar fashion to the valve 100 of
27 Figures 3A to 3C, and is thus run and latched using a
28 locking mechanism 268 similar to the mechanism 68 of the
29 valve 100. Additionally, a proprietary crossover packer
30 94 is provided above the upper gas lift string 216, which
31 serves both to locate and restrain the gas lift pipe 88
32 within the valve housing 102, and to control flow of

1 injected gas to the region 90 and produced well fluids to
2 surface.

3

4 In more detail, the crossover packer 94 includes flow
5 paths (not shown) which extend between the annulus in the
6 area 96 and the gas lift pipe 88, and separate flow paths
7 which extend between the annulus in the area 98 and a
8 well fluid return tubing 63. Gas to be injected is
9 directed along an annulus 65 defined between the
10 production tubing 250 and the return tubing 63, flows
11 through the packer 94 along the injection flow paths into
12 the gas lift pipe 88, passes through the valve 200 and is
13 injected into the production tubing 250 in the region 90
14 through flow ports 67. The stimulated, produced well
15 fluids flow up an annulus defined between the production
16 tubing 250 and an external surface 226 of a valve sleeve
17 223, through aligned ports 238 and 237, along a central
18 bore 203 of the valve 200 and into the region 98, as
19 indicated by the arrows in Figure 5. The well fluids then
20 flow through the crossover packer 94 return flow paths
21 and into the return tubing 63 and thus to surface.

22

23 In this embodiment of the invention, there is no rotation
24 of the gas lift pipe 88 and thus it is not necessary to
25 transfer rotation between the upper and lower gas lift
26 strings 216 and 218. Whilst the above embodiment has
27 been described in relation to a gas lift pipe located
28 within an existing SSSV 262, it will be understood that
29 the valve 200 may be of like structure to that of the
30 valve 1 of Figures 1 and 2 and thus designed as a primary
31 valve, rather than a remedial valve to be located in
32 existing valve structures.

33

1 The valve 200 may be employed with other types of non-
2 rotary tubing or other strings. For example, turning to
3 Figure 6, there is shown an alternative string in the
4 form of a penetrator string 388. Like components of the
5 penetrator string 388 with the gas lift string 88 of
6 Figures 4A to 4C share the same reference numerals,
7 incremented by 300. The penetrator string 388 provides
8 power for downhole equipment, such as an electrical
9 submersible pump (ESP - not shown), used to stimulate
10 well fluid flow. Additionally or alternatively, the
11 penetrator string 388 can provide appropriate control
12 signals for controlling the operation of downhole
13 equipment such as the ESP, as will now be described.

14

15 The penetrator string 388 includes a stab-in body 392
16 which is designed to stab in and seal within the valve
17 200 lower sub 274, in a similar fashion to the body 292
18 on the gas string 88. The stab-in body 392 provides
19 connection between upper conduits in the form of upper
20 penetrator lines 316a, 316b and 316c and lower conduits
21 in the form of lower penetrator lines 318a, 318b and
22 318c. The penetrator lines may comprise electrical power
23 or control lines, fibre-optic control lines, hydraulic
24 power or control lines or any desired combination
25 thereof. Indeed, it will be understood that any desired
26 or suitable number of penetrator lines may be provided
27 for carrying out a desired downhole function.

28

29 In the illustrated embodiment, the upper penetrator lines
30 316 are coupled and sealed to the stab-in body 392 by a
31 bushing (not shown) which is located in an axial bore
32 (also not shown) that extends through the body 392. The
33 lower penetrator lines 318 extend up through the bore and

1 mate with the upper lines 316, to provide appropriate
2 mechanical, electrical and/or fluid connection between
3 the lines 316 and 318. This permits the desired downhole
4 function to be carried out. The lines 316, 318 may be
5 sealed using a suitable sealing compound if desired or
6 required.

7

8 In the illustrated embodiment, the penetrator lines 316
9 are suspended within the well from surface, and the lower
10 lines 318 suspended from the body 392. However, in an
11 alternative arrangement, the penetrator lines 316 may be
12 piggy-backed on an upper tubing string (not shown) and
13 the lower penetrator lines (not shown) on a lower tubing
14 string (not shown), which support the lines and permit
15 further downhole functions, such as conveying fluids.
16 Indeed, the connected tubing strings may provide a gas
17 lift function similar to that described above. The stab-
18 in body 392 may thus also provide connection between the
19 upper and lower tubing strings, although the body 392 may
20 be an annular member mounted on an external surface of
21 the tubing string formed by connection of the upper and
22 lower tubings.

23

24 In use, the penetrator string 388 is made up at surface
25 and the body 392 is stabbed-into the valve lower sub 274,
26 sealing the body 392 to the valve 200. The penetrator
27 string 388 is also coupled to the downhole equipment
28 whose operation is to be controlled/powered through the
29 string 388, such as the ESP. The valve 200 and
30 associated equipment is then run and located within an
31 existing SSSV, as described above. However, as is the
32 case with the gas lift string 88, the valve 200 may be of
33 like structure to that of the valve 1 of Figures 1 and 2

1 and thus designed as a primary valve, rather than a
2 safety valve for location within existing valve
3 structures. Following location downhole, power and
4 control signals may be provided to operate the ESP
5 through the connected penetrator lines 316, 318.

6
7 Further modifications and improvements may be added
8 without departing from the scope of the invention herein
9 described. For example, the rotary section of the
10 embodiment described may be replaced with an axially
11 movable member to allow the safety valve to be used with
12 a rod pump.

13
14 The safety valve may be for use with any desired
15 downhole/wellbore tubing, and a section of the downhole
16 tubing itself may form the coupling member and may be
17 adapted to be sealably mounted in the housing bore. Thus
18 the coupling member may form part of a completed conduit
19 string extending through the valve.

CLAIMS

1. A safety valve for use with upper and lower conduits located in wellbore production tubing, the safety valve comprising:
 - a housing having a longitudinal bore extending therethrough;
 - a coupling member for coupling the upper conduit to the lower conduit; and
 - valve means operable between a first condition permitting fluid flow between the upper and lower conduits and a second condition in which such flow is blocked;
 - wherein the coupling member is sealably mounted within the longitudinal bore;
 - wherein an annular flow passage is provided which bypasses the coupling member; and
 - wherein the valve means is located in the annular flow passage.
2. A safety valve as claimed in claim 1, for use with an upper conduit in the form of an upper tubing string and a lower conduit in the form of a lower tubing string.
3. A safety valve as claimed in either of claims 1 or 2, wherein the coupling member serves for fluidly coupling the upper conduit to the lower conduit, to permit fluid flow therebetween.
4. A safety valve as claimed in any one of claims 1 to 3, for use with gas lift tubing comprised of upper and lower conduits in the form of upper and lower tubing strings, where an upper gas lift tubing string is coupled to a lower gas lift tubing string by the coupling member.
5. A safety valve as claimed in any one of claims 1 to 4, wherein the coupling member is adapted to be connected to one of

the upper and lower conduits, and wherein the housing is adapted to be connected to the other one of the upper and lower conduits.

6. A safety valve as claimed in any one of claims 1 to 4, wherein the coupling member is adapted for directly connecting the upper and lower conduits together.

7. A safety valve as claimed in any one of claims 1 to 6, wherein the coupling member comprises a tubing section.

8. A safety valve as claimed in claim 7, wherein the coupling member is adapted to form part of a completed conduit extending through the valve.

9. A safety valve as claimed in any one of claims 1 to 3, or 6 to 8, for use with a penetrator, wherein the coupling member takes the form of a penetrator body, the penetrator body adapted for coupling the upper and lower conduits in the form of upper and lower penetrator conduits.

10. A safety valve as claimed in claim 9, wherein the upper and lower penetrator conduits take the form of conduits selected from the group comprising tubes, pipes, wires and cables.

11. A safety valve as claimed in any one of claims 1 to 3, or 6 to 8, wherein the coupling member takes the form of a motion transferring member arranged to provide a means to transfer motion from the upper conduit to the lower conduit.

12. A safety valve as claimed in claim 11, wherein the safety valve is for use with upper and lower conduits in the form of upper and lower rod strings of a pump.

13. A safety valve as claimed in claim 11, wherein the safety valve is for use with upper and lower conduits in the form of upper and lower sections of a drill string.

14. A safety valve as claimed in any one of claims 1 to 13, wherein the annular flow path and valve means therein provides a fluid path which can be opened and closed to regulate flow in a production string.

15. A safety valve as claimed in any one of claims 1 to 14, wherein the valve means comprises an annular valve.

16. A safety valve as claimed in any one of claims 1 to 15, wherein the coupling member comprises a hollow, substantially cylindrical body.

17. A safety valve as claimed in any one of claims 1 to 16, wherein the housing comprises an outer hollow cylindrical housing portion and an inner hollow cylindrical housing portion with the annular flow passage provided therebetween.

18. A safety valve as claimed in claim 15, or either of claims 16 or 17 when dependent on claim 15, wherein the annular valve is adapted to be opened to selectively permit fluid flow up the annular passage and into the production tubing, bypassing the coupling member.

19. A safety valve as claimed in claim 15 or any one of claims 16 to 18 when dependent on claim 15, wherein the annular valve comprises a hollow cylindrical valve sleeve surrounding a hollow cylindrical valve body.

20. A safety valve as claimed in claim 19, wherein the cylindrical valve body is an integral part of the inner cylindrical housing.

21. A safety valve as claimed in claim 19 or 20, wherein the valve sleeve is movable along the valve body.

22. A safety valve as claimed in any one of claims 19 to 21, wherein the valve sleeve has at least one valve sleeve aperture, and the valve body has at least one valve body aperture, and wherein the valve is open when the valve sleeve is in a position where the sleeve apertures are aligned with the valve body apertures.

23. A safety valve as claimed in any one of claims 19 to 22, wherein the annular valve has an actuation means which displaces the valve sleeve of the annular valve.

24. A safety valve as claimed in claim 23, wherein the actuation means for the annular valve is a rod piston.

25. A safety valve as claimed in claim 24, wherein the rod piston is located in a longitudinally extending rod piston cavity and is axially moveable therein.

26. A safety valve as claimed in claim 25, wherein movement of the rod piston is effected by means of hydraulic fluid pressure within the rod piston cavity.

27. A safety valve as claimed in any one of claims 24 to 26, wherein the rod piston is spring biased to a default position where the valve means is closed.

28. A safety valve as claimed in any one of claims 25 to 27, wherein the rod piston cavity is in fluid communication with a hydraulic control line port located in the valve housing.

29. A safety valve as claimed in claim 28, wherein there is an intermediary stage between the hydraulic control line port and a

control line of the safety valve.

30. A safety valve as claimed in claim 29, wherein the intermediary stage is a component of a downhole fixture located in the wellbore.

31. A safety valve as claimed in any one of claims 1 to 30, wherein the safety valve is adapted to be located in an existing downhole valve.

32. A safety valve as claimed in claim 31, wherein the existing downhole valve is a sub-surface safety valve (SSSV) and is locked open.

33. A safety valve as claimed in claim 32, wherein the SSSV is a tubing retrievable surface controlled safety valve (TRSCSV).

34. A safety valve as claimed in claim 31, wherein the existing valve is adapted to be locked open and wherein the safety valve is adapted to engage within a main bore of the existing downhole valve.

35. A safety valve as claimed in claim 11 or any one of claims 12 to 34 when dependent on claim 11, wherein movement of the motion transferring member is restricted to rotational motion.

36. A safety valve as claimed in claim 11 or any one of claims 12 to 34 when dependent on claim 11, wherein movement of the motion transferring member is restricted to axial motion.

37. A safety valve as claimed in claim 36, wherein the safety valve is for use with upper and lower rod strings of a rod pump.

38. A safety valve as claimed in any one of claims 1 to 37,

wherein sealing means are provided between the coupling member and the housing.

39. A safety valve as claimed in any one of claims 1 to 38, comprising a female receptacle for connecting the coupling member to the upper conduit, the female receptacle integral to one of the coupling member and the upper conduit, and a male insert on the other one of the coupling member and the upper conduit.

40. A safety valve as claimed in claim 39, wherein the male insert comprises a splined shaft, and the female receptacle comprises a splined sleeve into which the splined shaft forms an interference fit capable of transferring rotational motion.

41. A safety valve as claimed claim 39 or 40, wherein the male insert further comprises a locking mechanism for holding the splined shaft within the splined sleeve, to selectively prevent retraction of the upper conduit from the valve housing.

42. A safety valve as claimed in claim 41, wherein the locking mechanism comprises a key, and the female receptacle comprises a recess with which the key can communicate such that as the male insert is engaged with the female receptacle, the key locates within the recess and prevents the upper conduit from being forced upwards.

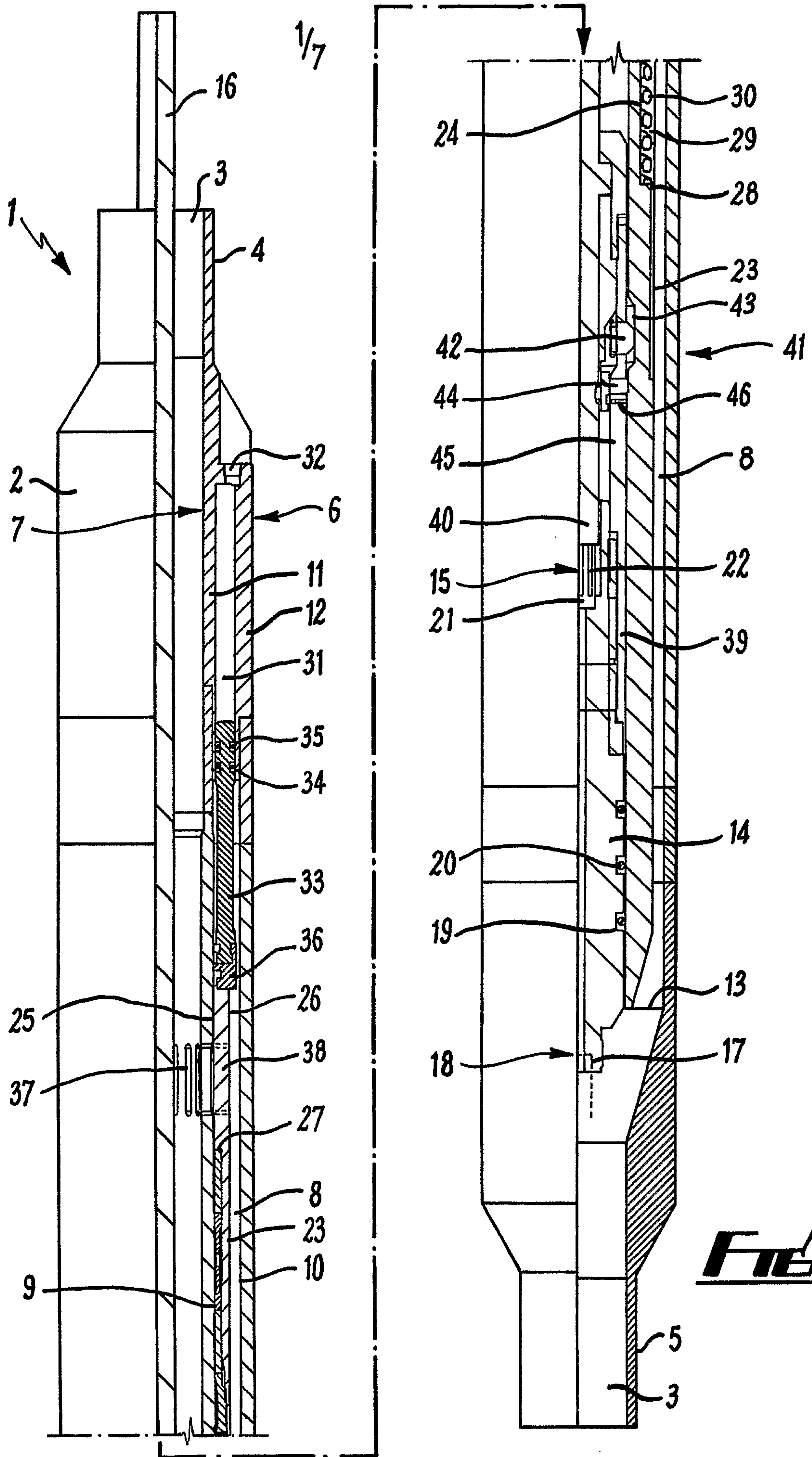
43. A safety valve as claimed in claim 41 or 42, wherein the male insert further comprises a non-rotating mandrel, and wherein the locking mechanism is an integral part of the non-rotating mandrel.

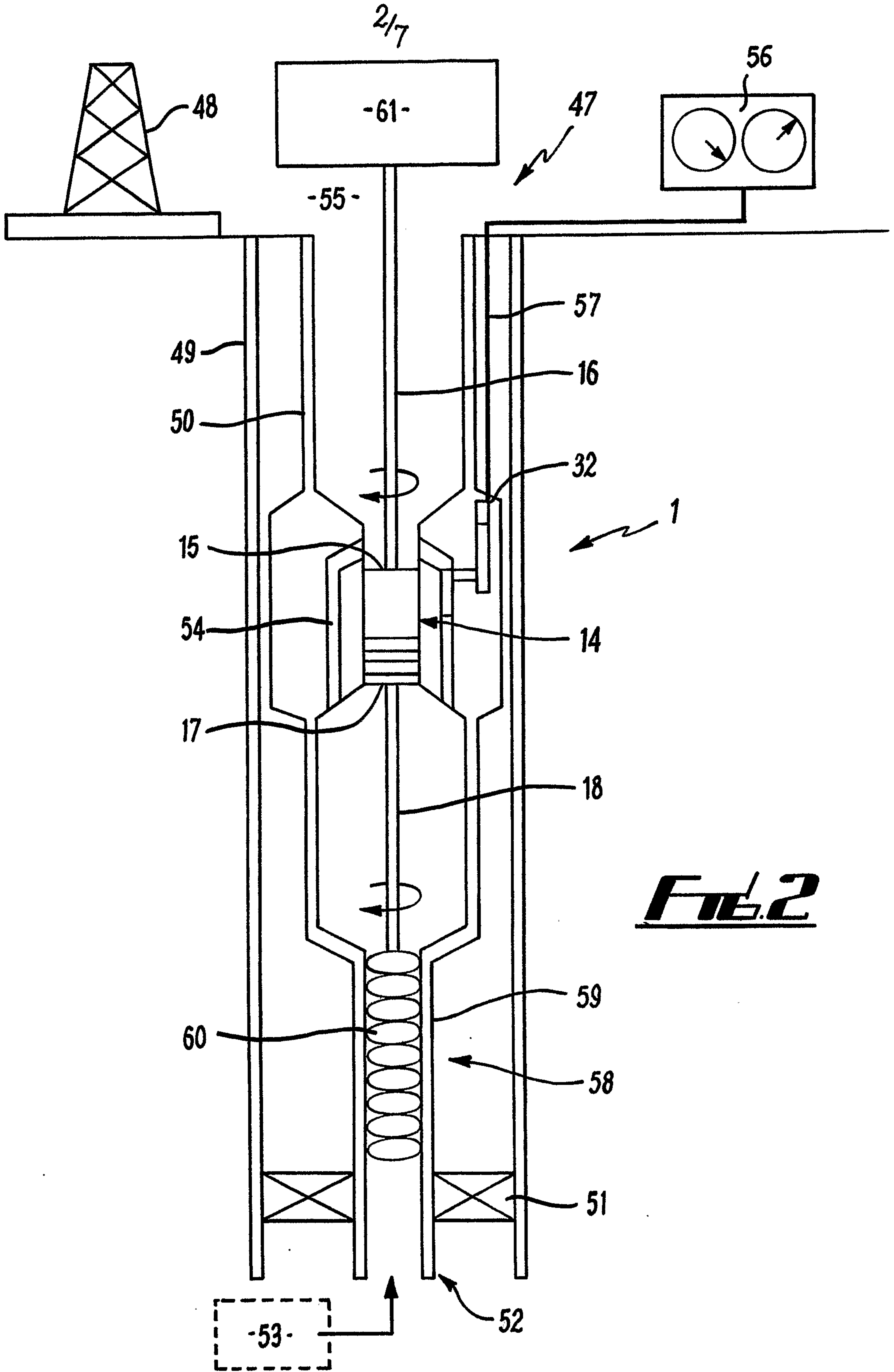
44. A safety valve as claimed in claim 43, wherein the upper conduit is free to rotate within the non-rotating mandrel.

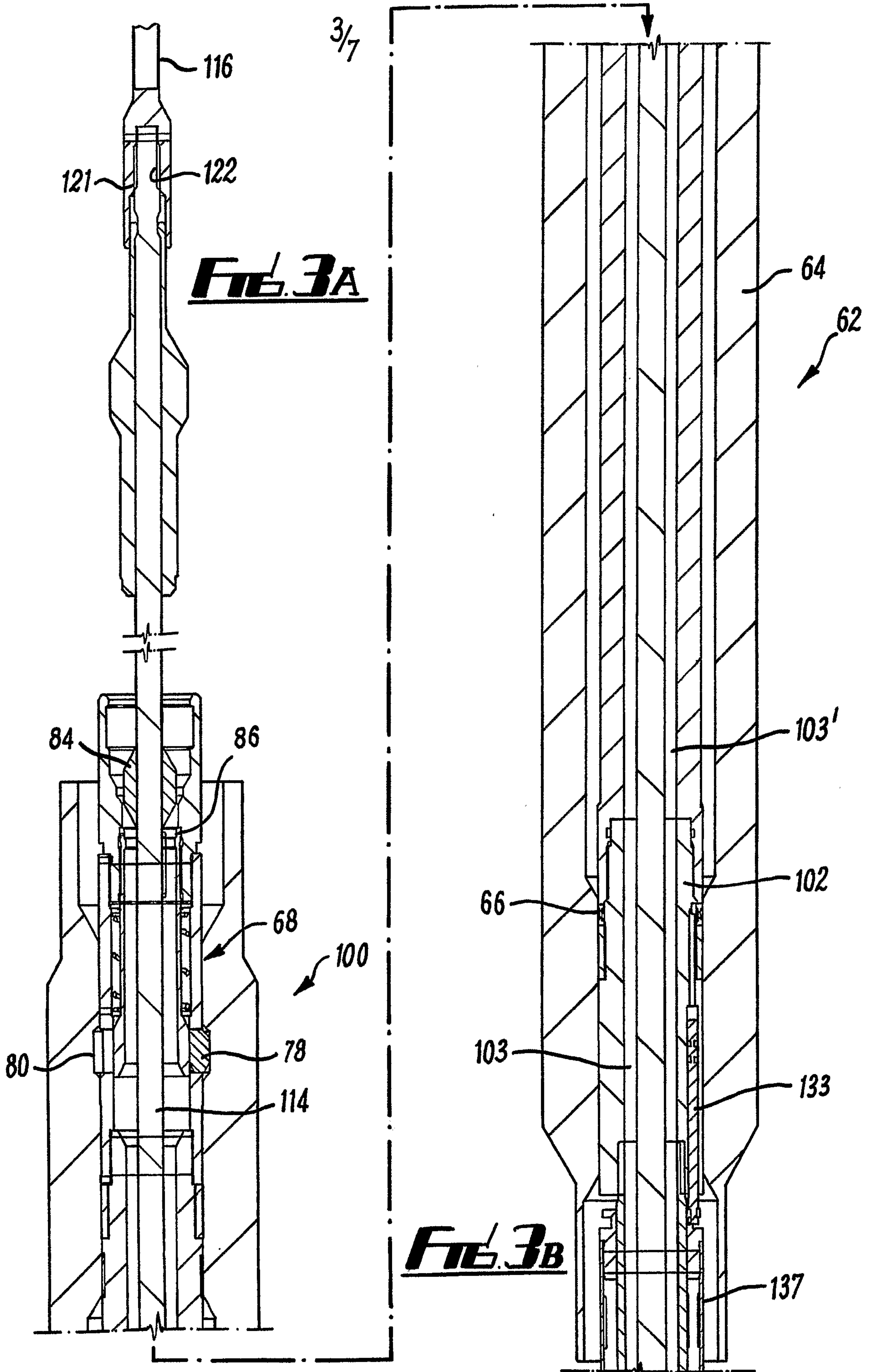
45. A safety valve as claimed in any one of claims 39 to 44,

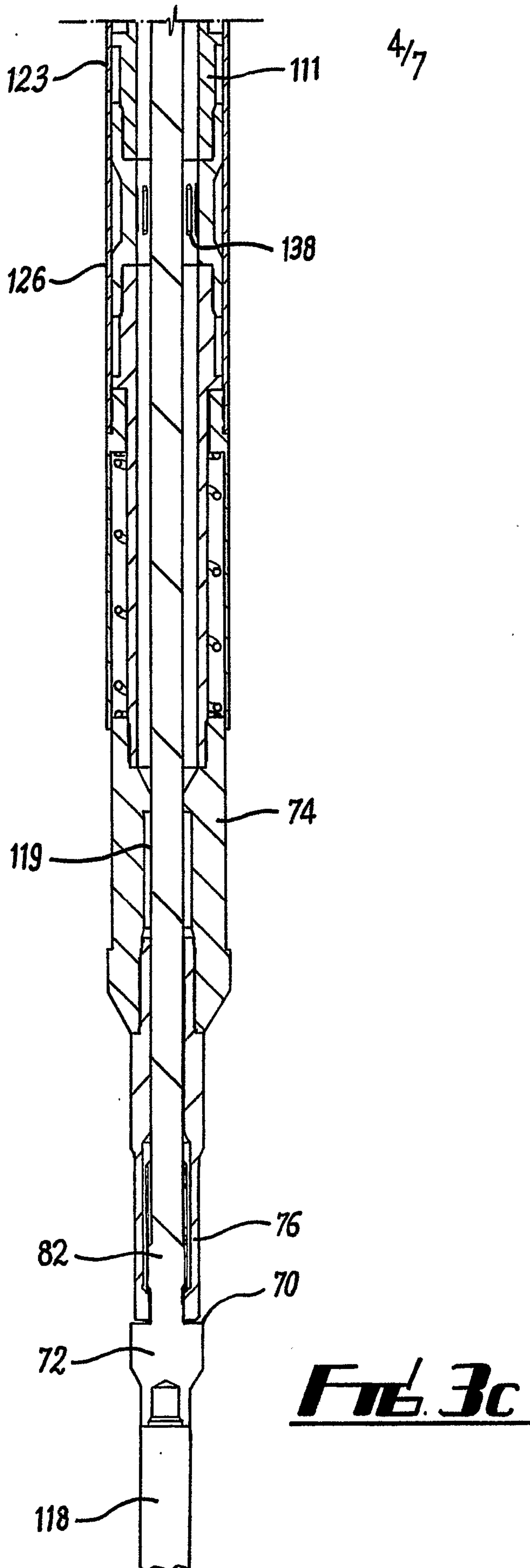
wherein the male insert further comprises a no-go key and the female receptacle further comprises a shoulder with which the no-go key communicates to prevent further downward travel of the upper conduit.

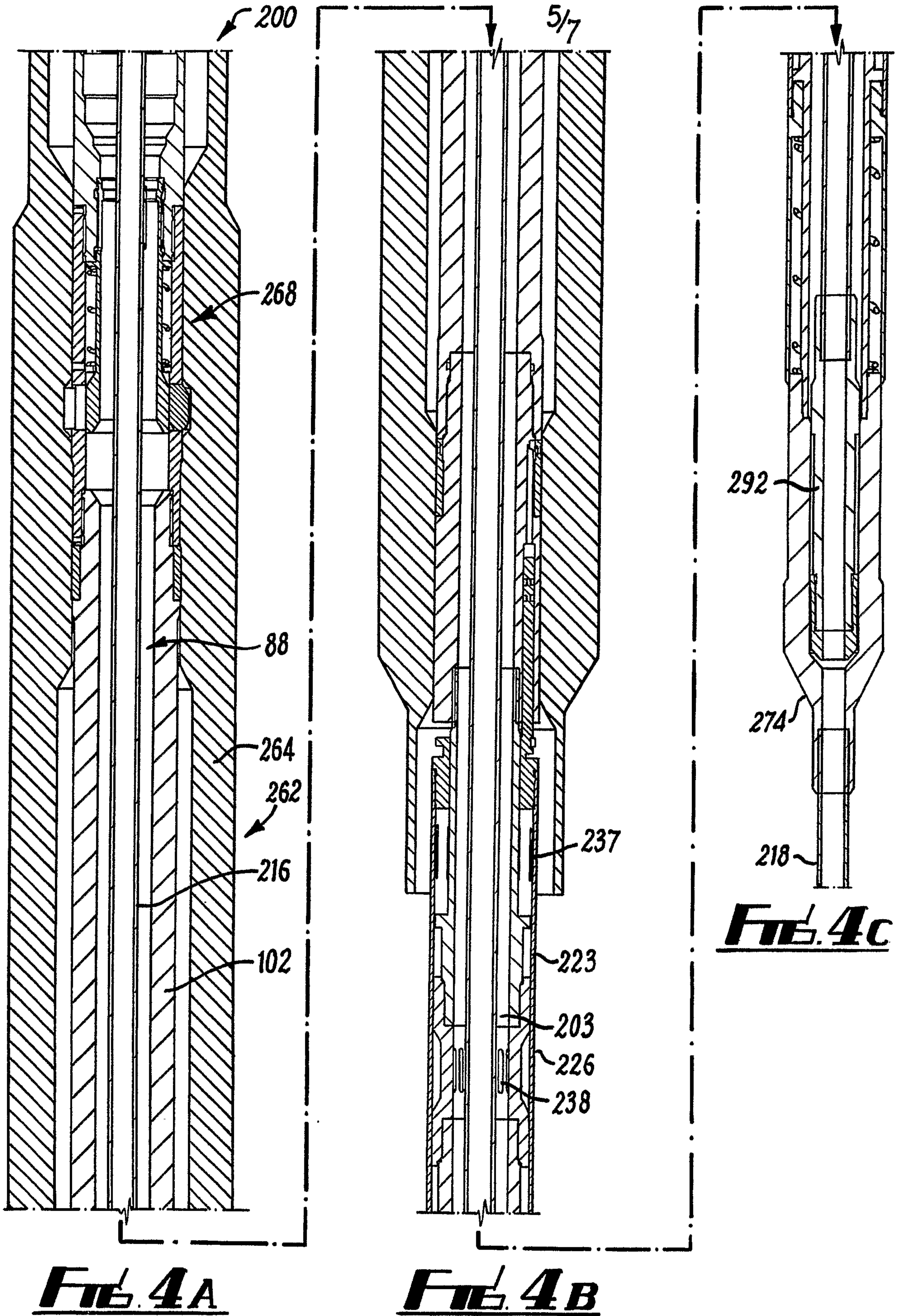
46. A safety valve as claimed in any one of claims 39 to 45, wherein the means of connecting the coupling member to the lower conduit further comprises a torque reducing means for reducing transfer of backlash torque into the safety valve.











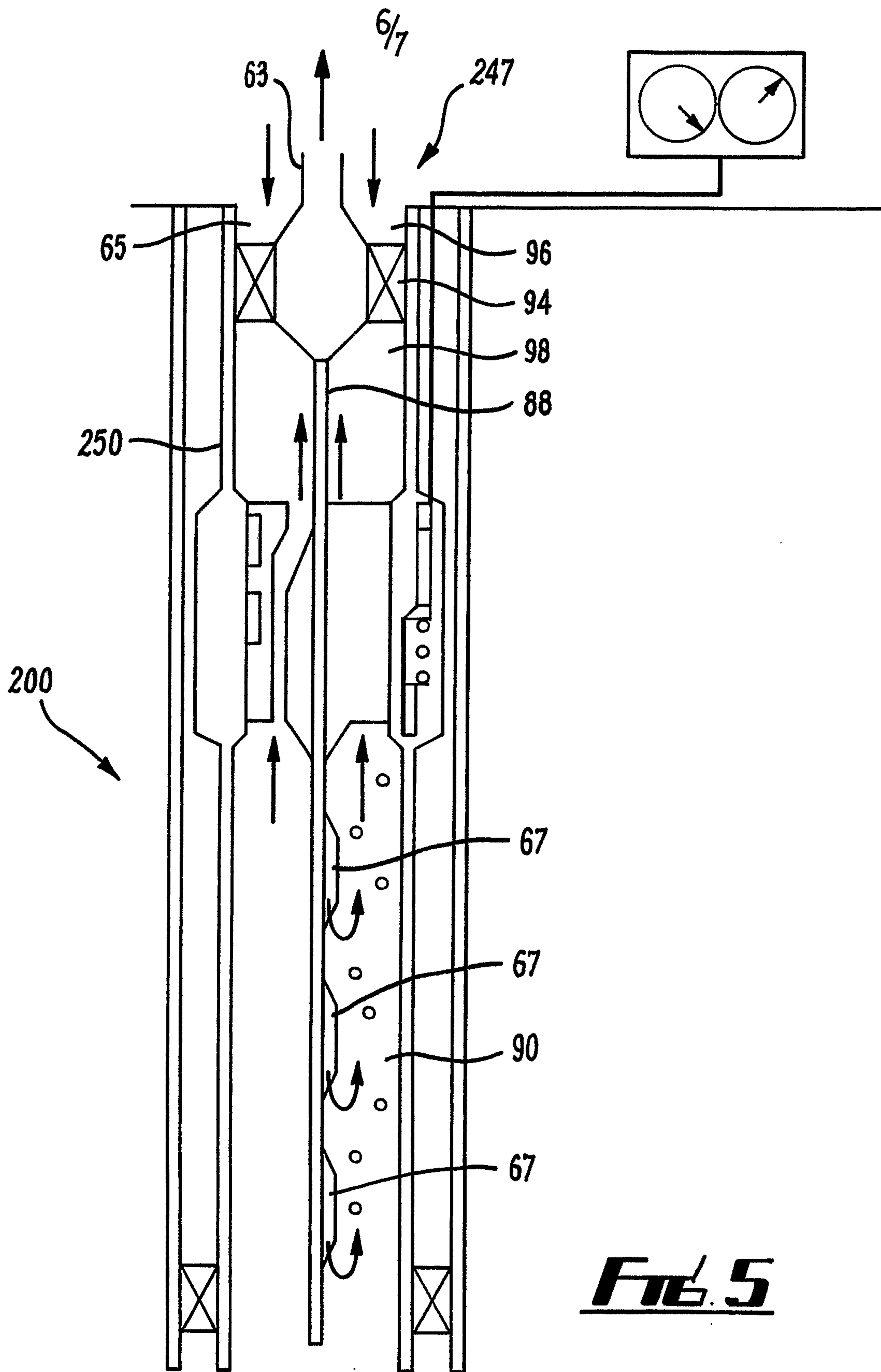


FIG. 5

