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(71) Applicant: **Cooper Industries Inc.**
1001 Fannin, Suite 4000
Houston
Texas 77002 (US)

(72) Inventor: **Thornburrow, Edward Thomas**
116 Potternewton Lane
Leeds
West Yorkshire
LS7 3DR (GB)

Inventor: **Ashley, Robert**
4 Christie Way
Kettering
Northamptonshire (GB)

(74) Representative: **Jackson, Peter Arthur**
GILL JENNINGS & EVERY
Broadgate House
7 Eldon Street
London EC2M 7LH (GB)

(54) Downhole safety valve.

(57) A downhole safety valve for retrofitting to a well comprises an annular member (4) to be built into the wellhead, a closure valve (28) to be set in a tubing string (27) just below the wellhead, and a piston (15) reciprocatable in the annular member and having a depending rigid tubular stinger (26) for operating the valve.

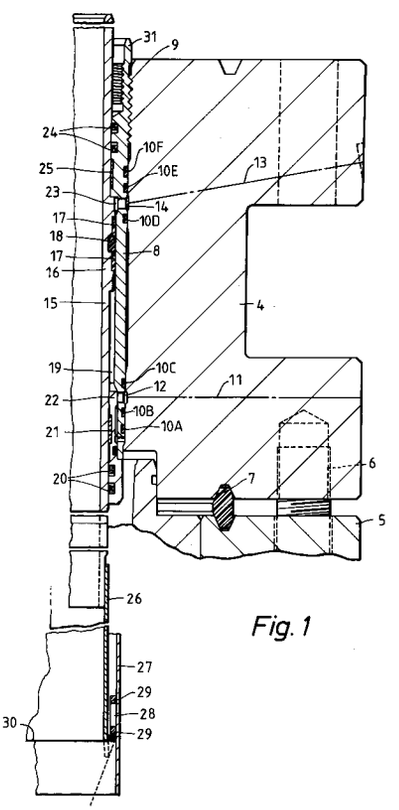

Fig. 1

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Wells in gas and oil fields are usually built with downhole safety valves, sometimes referred to as sub-surface safety valves, which close to contain the well pressure in emergency situations. Such valves may be constructed as flapper or ball valves and are usually held open against normal well pressure by hydraulic pressure applied down from the surface through a control line. Such control lines are vulnerable and liable to damage which can result in complicated and lengthy workover situations.

The present invention is concerned with the retrofitting of a well with a downhole safety valve. Conventionally this has involved installing at the wellhead an intermediate flange and a piggy back hanger either to give the facility of installing a control line or to create an annulus down which control fluid can be pumped to supply pressure to a downhole safety valve. However, these solutions involve the killing of the well and pulling of the completion in order to install the valve, and still result in the need to provide for the feeding of control fluid down the well to operate the valve.

The inventors have now appreciated that the above problems can be overcome by setting a downhole closure valve a short distance, say between 2 and 15, preferably between 3 and 10 and most preferably substantially 5 metres below the wellhead, and to operate the valve by means of a piston in the wellhead which is coupled directly and mechanically to the valve by a stinger, preferably rigid with the piston.

Accordingly, in accordance with the present invention, a downhole valve assembly for a well comprises a closure valve which is, or is arranged to be, secured within tubing in a completed well; an annular member which is, or is arranged to be, built into a wellhead; a piston which is axially slidable within the annular member; means for displacing the piston axially within the annular member; and a stinger depending from the piston down to the valve to operate the valve upon axial movement of the piston.

The piston may be subjected to a variety of forces to provide the valve control. Thus the displacement means may comprise at least one fluid space to which fluid under pressure can be applied through a gallery in the annular member to urge the piston in a respective axial direction. The fluid under pressure applied to one fluid space may then be arranged to hold the piston and stinger against the action of a spring in a position in which the valve is held open; the spring providing a fail safe closing of the valve upon reduction in the fluid pressure.

The fluid pressure might be provided by a hand pump and the pressure locked in within an integral needle valve. However, when a more permanent reliable pressure source is required, this could be provided by an hydraulic accumulator. For security purposes it is proposed that the accumulator be secured within the annular member behind a tamper proof cover.

In an alternative arrangement, one fluid under pressure applied to one fluid space is arranged to hold the piston and stinger against the action of normal well pressure applied to another fluid space, in a position in which the valve is held open. The piston and stinger being arranged to be moved by the well pressure applied to the second fluid space upon reduction of the first fluid pressure, to cause closing of the valve.

The invention also includes a method of retrofitting a completed well with a downhole safety valve, without pulling the completion, the method comprising plugging the tubing to seal the well, fitting the wellhead with an additional annular member such as a flange or spool, unplugging the tubing, running in and securing a downhole pressure valve within the tubing, and running into the annular member a piston having a depending stinger which reaches down to the valve assembly, the piston being axially movable relatively to the annular member to operate the valve via the stinger.

The advantage of the new system is that the means of actuating the valve, whether it be applied hydraulic pressure, well bore pressure, or spring force, or a combination of combination of these, is located at the surface, say 5 metres above the valve installed in the existing tubing. This removes the need for pressure lines in the tubing or casing annulus which is a source of problem and failure.

Three examples of valve assemblies constructed in accordance with the present invention are partially illustrated in half axial section in respective ones of the three figures of the accompanying drawings.

In the arrangement shown in figure 1, a spool 4 is shown built into a wellhead, to another part 5 of which it is bolted by a ring of bolts with the usual interposed seal 7.

The inner periphery of the spool 4 is prepared to receive a piston hanger 8 which is screwed into the spool at 9 and sealed to the spool by six annular seals 10A, 10B, 10C, 10D, 10E and 10F. Between the seals 10A and 10B a gallery 11 extending radially through the spool leads into an annular groove 12. A similar gallery 13 leads radially through the spool to an annular groove 14 between the seals 10D and 10E.

Slidable within the piston hanger 8 is a tubular piston 15 having an outer radial projection 16 forming an annular piston head provided with plastic bearings 17 and a seal 18, which slide against a cylindrical outer portion of the piston hanger 8. Below the piston head 16 and between the piston

and piston hanger is provided a fluid space 19, the lower end of which is closed by seals 20 carried by the lower portion of the piston hanger and sliding against a cylindrical external surface of the piston. The piston hanger also carries a plastic bearing 21 against which the same cylindrical portion of the piston slides. The annular groove 12 communcates with the fluid space 19 through radial ports 22.

Above the piston head 16 is a second fluid space 23, shown axially much shorter than the space 19 only because the piston is shown in its uppermost position. The upper end of the space 23 is sealed by seals 24 which, together with a further plastic bearing at 25, are carried by the upper portion of the piston hanger and slide against an external cylindrical surface at the top of the piston.

Screwed to the bottom of the piston is a tubular stinger 26, which may be of 2 inch diameter and approximately 5 metres long. This extends into the 3 inch tubing 27 and terminates adjacent to a safety valve unit 28, which is sealed within the tubing by packers 29. In this case the valve is shown as a flapper valve having a closure flap 30 which, under the action of a small torsion spring and well pressure from below tends to pivot upwardly to the horizontal position shown in full lines in figure 1 in which it abuts against an annular seating to close the passsageway through the tubing. At this time the piston 15 is in its illustrated raised position so that the lower end of the stinger 26 does not interfere with the flap. The piston is held in this raised position by hydraulic pressure applied through the line 11. When the valve is to be opened, the line 11 is vented and hydraulic pressure is applied through the line 13 to force the piston and hence the stinger 26 downwardly so that the lower end of the stinger engages and forces the flap 30 downwards to the dotted line position. A piston stroke of about 3 inches is sufficient for this purpose.

The conversion of a well by the fitting of such a safety valve may typically involve the following steps. First, a blow out preventer (BOP) stack is fitted on top of the existing tree and a back pressure valve (BPV) is set in the existing $3\frac{1}{2}$ inch tubing hanger. After testing the tree is lifted and the new spool 4 is fitted. Thereafter the tree is remade-up and all the connections are tested. The BOP stack is reinstalled and the BPV pulled. The flapper valve unit 28 can the be installed by wireline through the BOP at a known and required depth by setting the packers 29. Two inch nominal tubing to form the stinger 26 is then cut to the required length and fitted to the piston 15 which is assembled with its hanger 8. These are then run into the wellhead under pressure control and the hanger rotated by the engagement of dogs of the running tool with slots 31 at its upper end so that the screw connection 9 is made with the spool. The running tool is then withdrawn and the BOP stack removed.

The arrangement shown in figure 2 utilises a spool 4A which will be built into the wellhead. The spool is prepared to locate therein a screwed in piston hanger 8A. A piston 15A having concentric cylindrical upper portions 32 and 33 is sealed to external cylindrical portions of the spool, against which it slides, by means of seals 34 and 35. The piston is also sealed to cylindrical portions of the piston hanger 8A against which it slides, by means of seals 36 and 37. A helically coiled compression spring 38 is located between the spool 4A and piston 15A and urges the piston upwardly to the illustrated position. The spring may be overcome to lower the piston by fluid pressure contained within an hydraulic accumulator 39 and fed to a fluid space 40 between the piston and piston hanger via a gallery 41 in the spool and a gallery 42 in the piston hanger.

In use a stinger will be connected at a wireline set latch groove 26A to, and extend down through, the bottom of the piston 15A for operating a valve such as the flapper valve unit shown in figure 1. Otherwise installation and operation of the valve are analogous to the figure 1 example. The accumulator 39 is shown mounted within a cavity portion 43 of the spool the cavity being closed by an armoured glass cover 44 secured by tamper proof bolts 45. It is envisaged that, within the cavity 43, there would also be provided necessary valving and pressure gauges, visible through the window 44. The cavity could also form a fluid reservoir or dunk tank if the applied pressure is to be relieved in case of emergency, for example upon fusion of a fusible pipe.

The arrangement shown in figure 3 is similar in many respects in that shown in figure 1. Thus a spool 4B as screwed into it a piston hanger 8B. A piston 15B slides upwardly and downwardly relatively to complementary cylindrical surfaces of the piston hanger 8B and spool 4B by means of plastic bearings 46 carried by the piston hanger and 47 carried by a radially outwardly enlarged annular piston head 48 of the piston. A fluid space 49 provided above the piston head 48 is sealed by seals 50, 51 and 52. A gallery 53 through the spool 4B opens into the fluid space 49.

A second fluid space 54 is provided below the piston head 48 between the spool 4B and piston, and communicates with the interior of the piston and hence downhole through a ring of radial ports 55. The lower end of the piston is provided with a screw thread 56 for connection of the stinger 26.

Installation and operation of the figure 3 example are analogous to the previous examples except that in this case the piston 15B will be forced

downwardly to hold open the flapper valve when sufficiently high pressure is applied through the gallery 53 to the fluid space 49 to overcome the upward force provided by the well pressure acting in the fluid space 54 on the underside of the piston head 48. The valve will then close if the gallery 53 is vented or if there is an excessively high surge in well pressure.

Claims

1. A downhole valve assembly for a well, the assembly comprising a closure valve (28) which is, or is arranged to be, secured within tubing (27) in a completed well; an annular member (4) which is, or is arranged to be, built into a wellhead; a piston (15) which is axially slidable within the annular member; means (22,23,38,40;49,54) for displacing the piston axially within the annular member; and a stinger (26) depending from the piston down to the valve to operate the valve upon axial movement of the piston.

2. An assembly according to claim 1, wherein the displacement means comprises at least one fluid space (22,23;40;49,54) to which fluid under pressure can be applied through a gallery (11,13;41;53) in the annular member (4) to urge the piston (15) in a respective axial direction.

3. An assembly according to claim 2, wherein fluid under pressure applied to one fluid space (40) is arranged to hold the piston (15A) and stinger (26) against the action of a spring (38) in a position in which the valve (28) is held open; the spring providing a fail safe closing of the valve upon reduction in the fluid pressure.

4. An assembly according to claim 3, wherein the fluid pressure is provided by an accumulator (39) secured within the annular member (4A) behind a tamper proof cover (44).

5. An assembly according to claim 3, wherein one fluid under pressure applied to one fluid space (49) is arranged to hold the piston (15B) and stinger against the action of well pressure applied to another fluid space (54), in a position in which the valve is held open; the piston and stinger being arranged to be moved by the well pressure applied to the second fluid space, upon reduction of the first fluid pressure, to cause closing of the valve.

6. An assembly according to any one of the preceding claims, in which the stinger (26) is a tube rigid with the piston (15).

7. An assembly according to any one of the preceding claims, in which the stinger is between 3 and 10 metres long.

8. A method of retrofitting a completed well with a downhole safety valve, without pulling the completion, the method comprising plugging the tubing (27) to seal the well, fitting the wellhead with an additional annular member (4), unplugging the tubing, running in and securing a downhole pressure valve (28) within the tubing, and running into the annular member a piston (15) having a depending stinger (26) which reaches down to the valve assembly, the piston being axially movable relatively to the annular member to operate the valve via the stinger.

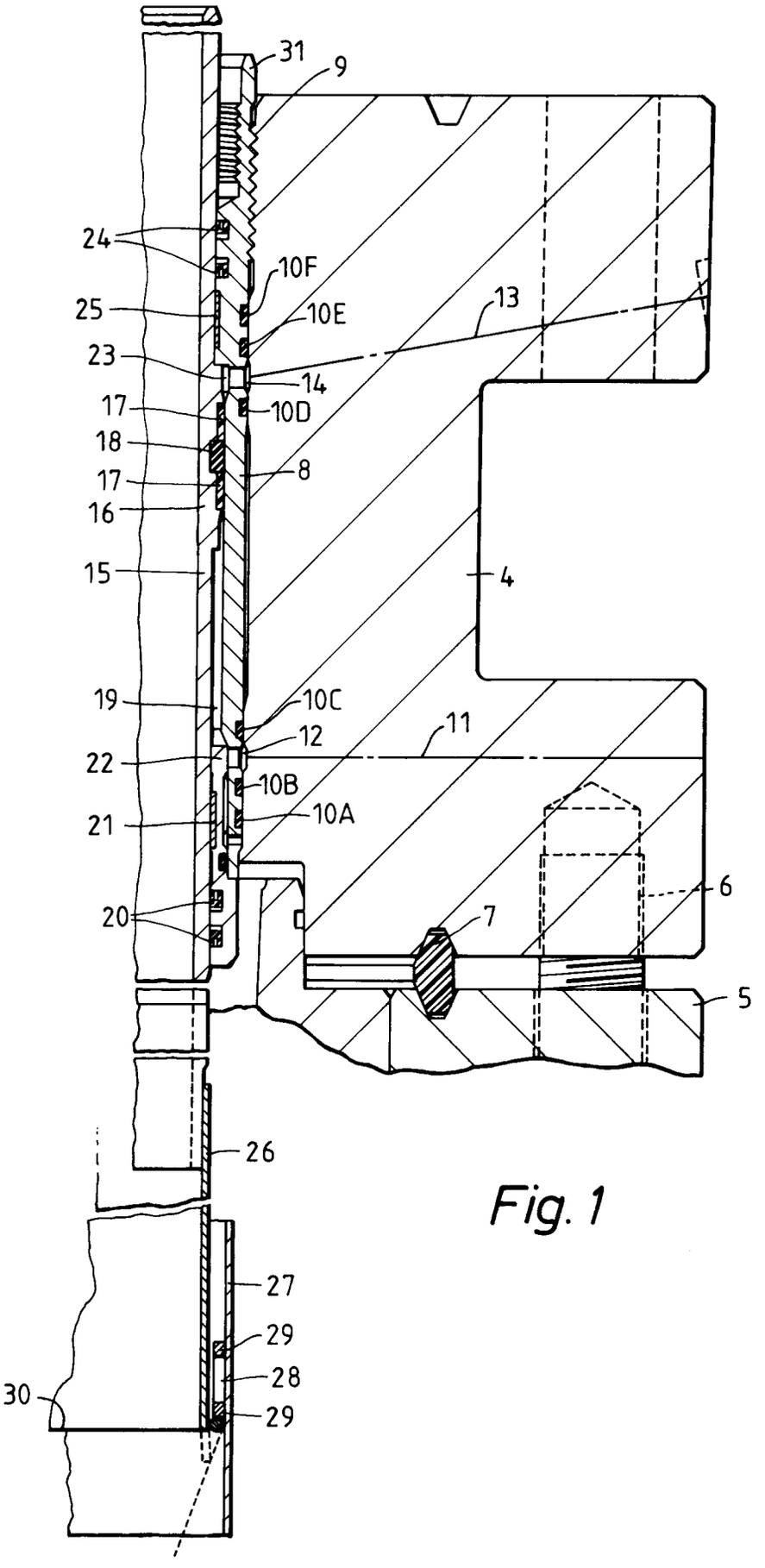
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Fig. 1

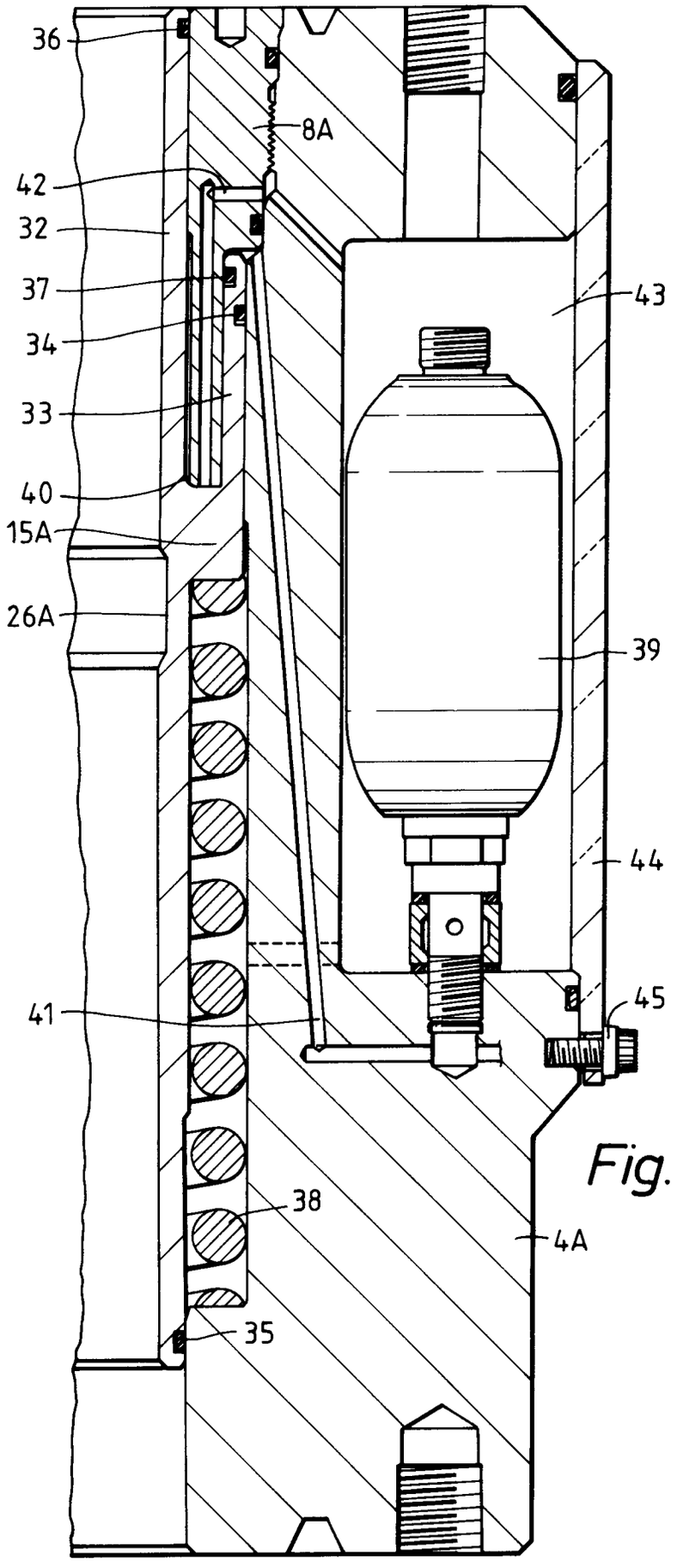
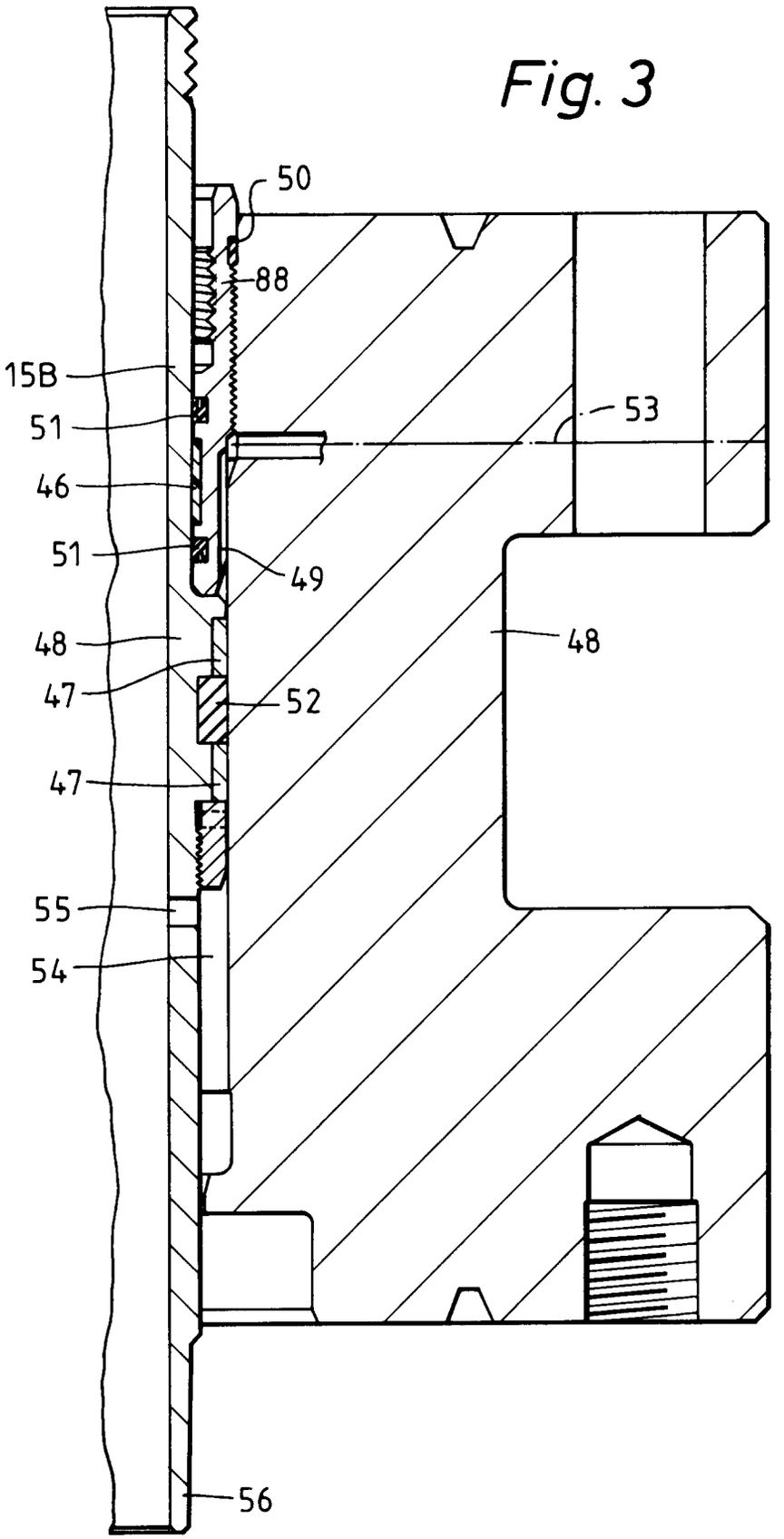


Fig. 2

Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 5446

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US-A-4 161 219 (PRINGLE) * the whole document * ---	1-3,6,8	E21B34/14 E21B34/10 E21B34/02
A	US-A-5 165 480 (WAGONER) * figures 1-5 * ---	1-3,8	
A	US-A-4 4I5 027 (RUSELL) * abstract * ---	4	
A	US-A-4 319 639 (MOTT) * abstract * ---	1	
A	US-A-5 203 410 (COBB) ---		
A	GB-A-2 129 848 (RUSELL) ---		
A	US-A-4 807 700 (WILKINS) ---		
A	GB-A-2 208 301 (HEINONEN) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 December 1993	Fonseca Fernandez,H

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