The invention relates to a barrier valve for creating a fluid tight barrier in a well during the installation of completion equipment. The barrier valve includes a housing having a longitudinal direction for being installed in a tubular string. A hinged curved, substantially circular valve flapper is disposed in the housing. The valve flapper has a normally closed position for forming a fluid tight barrier between the inlet side of the housing and the outlet side of the housing. The valve flapper is configured for forming a fluid tight barrier in two directions, i.e. both in an upstream direction and in a downstream direction. A pressure actuated valve flapper actuator is configured for bringing the valve flapper from the closed position to an open position after a predetermined number of pressure increases. Also described is a method for opening a fluid tight barrier valve in a well, as well as a tubular part having a zigzag recess.
A barrier valve for use in a well completion, a tubular part with a zigzag recess and a method for opening the barrier valve

The present invention relates to a normally closed barrier valve used for creating a fluid tight barrier in a wellbore, either during the installation of completion equipment or as a barrier during production.

In the completion of oil and gas recovery wells, several components are involved in carrying out the installation of the completion equipment. It is often necessary to be able to apply hydraulic pressure in order to operate and install the completion equipment. To be able to apply hydraulic pressure, it is necessary that the completion string is provided with a fluid tight barrier or plug for maintaining the pressure in the string. For such a plug to function as a barrier for the wellbore pressure, the barrier must be able to resist pressure from both sides. Several methods exist for creating such a barrier. A common method involves a ceramic or glass plug that is punctured after the completion equipment has been set. Several challenges and elements of uncertainty are associated with the use of such plugs, such as premature puncturing or problems with puncturing the plug, for example. Additionally, a separate running tool must be inserted to puncture the plug.

As explained above, the function of the barrier valve is to be pressure-tight from both sides. Another prior art barrier valve design includes a ball valve. A ball takes up a lot of space and hence requires a significant increase of the wall thickness of the wellbore pipes. In many wells, there is a requirement of thinner wall thicknesses. This makes it difficult to implement a ball valve arrangement while at the same time pressure requirements are upheld.

Still another prior art design comprises downhole valves including a curved circular flapper having an internal curve in order to abut against the inside of a valve housing when the valve is in an open position. The valve is rotatably mounted in a flapper housing. When the valve is closed, the flapper seals against a sealing surface of an upper and a lower tubular element, respectively, so that a sealing
surface is present on each side of the flapper. The valve can be actuated by a latching means extending in a longitudinal direction with respect to the valve.

The present invention relates to a normally closed barrier valve for creating a fluid tight barrier in a well during installation of completion equipment. The barrier valve includes a housing having a longitudinal direction for being installed on a pipe string. The housing includes an inlet side having an inlet and an outlet side having an outlet, comprising a hinged curved, substantially circular valve flapper in the housing. The barrier valve has a normally closed position and, in the closed position, forms a fluid tight barrier between the inlet side of the housing and the outlet side of the housing. The valve flapper is rotatably supported in one axially floating valve seat for sealing engagement between the valve flapper and the axially floating valve seat when the valve flapper is in the closed position. A locking tubular is axially displaceable in the longitudinal direction of the housing and includes a front rim abutting against a circumference of the valve flapper when the valve flapper (1) is in the closed position. Locking fingers are associated with the locking tubular and extends into a locking groove in the housing when the valve flapper is in the closed position. A pressure actuated valve flapper actuator is provided for actuating an axially displaceable piston section in a longitudinal direction of the housing after a predetermined number of pressure increases. An axially displaceable release sleeve for urging the locking fingers out of the locking groove of the housing is connected to the piston section, whereby axial displacement of the piston section displaces the axially displaceable release sleeve and urges the locking fingers out of the locking groove of the housing and the valve flapper opens, and whereby the floating valve seat is arranged for sealing in both the upstream and downstream directions in that the valve flapper is configured for being pushed against the floating valve seat when pressure is applied from the downstream side and the floating valve seat is configured for being pushed towards the downstream side against the locking tubular when pressure is applied from the upstream side.

The present invention relates to a valve arrangement including a curved flapper that is able to resist pressure from both sides. The valve flapper is curved in order
to fit into the tubular shape in an open position, allowing the overall wall thickness to be reduced.

The valve is a hydraulically operated valve installed in the string. The operational principle of the valve is that when hydraulic pressure is applied in the string, a piston moves in an axial direction. The piston is returned to a starting position by means of a stored/biasing force, e.g. from a spring. The valve flapper is rotatably supported in an axially floating valve seat for sealing engagement between the valve flapper and the axially floating valve seat when the valve flapper is in a closed position.

An axially, with respect to the longitudinal direction of the housing, displaceable locking tubular has a front rim abutting against a circumference around the valve flapper when the valve flapper is in the closed position. Locking fingers associated with the locking tubular extends into a locking groove in the housing when the valve flapper is in the closed position. An axially displaceable transfer sleeve is connected to a piston section. The axially displaceable release sleeve for urging the locking fingers out of the locking groove in the housing is connected to a piston section, which is in turn connected to an axially displaceable transfer sleeve. The floating valve seat is arranged for sealing in both the upstream and downstream directions in that the valve flapper is configured for being pushed against the floating valve seat when pressure is applied from the downstream side, and the floating valve seat is configured for being pushed towards the downstream side against the locking tubular when pressure is applied from the upstream side. The piston is in turn linked to a zigzag recess extending in a direction along the circumference, transversally of the piston, through a pin. The pin, which moves within the zigzag recess, limits the axial movement of the piston. The zigzag recess may be formed along the circumference of a dedicated ring or sleeve shaped zigzag recessed locking tubular rotatably mounted on the outside of the piston. The zigzag recessed locking tubular is prevented from axial movement relative to the piston by suitable locking rings. In other words, the zigzag recess extends transversally to the longitudinal direction of the piston. When the piston has moved a sufficient distance in an axial direction, the pin is carried further on
within the zigzag recess when the piston returns to the starting position. The
zigzag recess is designed, after a given number of "zigzag patterns", to have an
exit that causes, when the piston has been moved a given number of times, the
pin to be brought to the exit, which in turn allows the piston to travel a greater
distance in an axial direction. When the piston travels longer in the axial direction
than the limitation imposed by the zigzag recess, the piston applies a force on the
valve mechanism which in turn opens the curved valve flapper. The piston
includes a lower locking tubular that holds the valve flapper in an open position.
Such arrangements that include a locking tubular holding a flapper in an open
position are currently commonly used in oil well safety valves.

The curved flapper design of the downhole barrier valve with a floating piston and
a flapper lock allows the valve to resist pressure from both the upper and lower
sides of the valve flapper even though a sealing surface is only present on one
side of the valve flapper.

The piston moves in an axial direction when hydraulic force is applied in the string.
The biasing or stored force and movement of the piston unlocks and opens the
valve. The movement of the piston is controlled by the pin carried within the
circumferential zigzag recess in the piston or in the zigzag recessed locking
tubular. The nature of the zigzag recess allows the number of pressure
applications before the valve opens to be determined through the number of
zigzag recesses.

The zigzag recess can be configured with a given number of zigzag repetitions
that limits the axial movement of the piston in that the pin is carried within the
zigzag recess. The number of zigzag repetitions controls the number of pressure
applications before the pin is carried to the exit of the zigzag recess that releases
the piston to travel further in an axial direction to thereby unlock the valve
mechanism.

The curved valve flapper that seals the valve is supported by a floating valve seat
on one side and a flapper lock on the other side. The flapper lock prevents the

valve flapper from opening. The valve flapper is hinged onto and seals against the floating valve seat, thus providing the sealing function. When pressure is applied to the valve from the underside, the valve flapper is pushed against the valve seat of the pressure to seal the valve. When pressure is applied to the valve from the top side, the floating valve seat with the valve flapper is driven towards the flapper lock by the pressure, which prevents the valve flapper from opening and makes sure the valve flapper seals against the valve seat.

The locking tubular that prevents the valve flapper from opening when pressure is applied to the valve from the top side is retained by a locking function. This locking function is unlocked by the axial movement of the piston when the pin exits from the zigzag recess and travels in an axial direction.

The housing of the barrier valve includes an inlet side having an inlet and an outlet side having an outlet. The hinged and curved, substantially circular valve flapper is disposed in the housing.

The repeating zigzag recess includes a number of repetitions that corresponds to the predetermined number of pressure increases, as well as an exit. The pin extending into the zigzag recess is fixedly connected to the housing. In this manner, a piston section may urge the zigzag recessed tubular part in a first direction on a pressure increase in the housing, and a biasing element may urge the zigzag recessed tubular part in a second direction when the pressure in the housing is released. A release element opens the valve flapper after the pin has been carried out the exit of the zigzag recessed tubular part and allows displacement of the piston to release the valve flapper.

The normally closed barrier valve may further include an axially, with respect to the longitudinal direction of the housing, displaceable locking tubular having a front rim that abuts against a circumference around the valve flapper when the valve flapper is in the closed position in order to maintain the valve flapper in the closed position. However, no sealing surface exists between the front rim of the axially displaceable locking tubular and the circumference of the valve flapper.
Alternatively, the valve flapper actuator may include an electric actuator element connected to an electronic circuit associated with a pressure sensor, with the electronic circuit being configured for signalling the electric actuator element when the predetermined number of pressure increases is reached.

The electric actuator element may be an electrically operated valve connected to a reservoir of pressurized fluid, and the pressure from the reservoir of pressurized fluid can be applied to a piston for moving the piston and opening the valve flapper.

Locking fingers extending into a locking groove in the housing when the valve flapper is in the closed position may be connected with the locking tubular, and an axially displaceable transfer sleeve may be connected to the piston section. The axially displaceable release sleeve is able to urge the locking fingers out of the locking groove of the housing, and is connected to the piston section.

In an open position, the valve flapper may rest against the housing, and the axially displaceable transfer sleeve may extend on the inner side of the valve flapper so that the axially displaceable transfer sleeve covers the valve flapper and forms a substantially continuous, smooth flow path through the barrier valve.

The floating valve seat may be configured for sealing both in the upstream and downstream directions in that the valve flapper is pushed against the floating valve seat when pressure is applied from the right, and when pressure is applied from the left, the floating seat is pushed to the right towards the locking tubular that prevents the valve flapper from opening.

The invention further includes a zigzag recessed tubular part for a release mechanism for opening a flapper of a barrier valve after a number of pressure increases in the barrier valve. The zigzag recessed tubular includes a tubular element having an external and an internal circumference and having at least one
zigzag recess running along the external circumference of the tubular element, or along the periphery of the zigzag recessed tubular part.

The zigzag recessed tubular part may include two zigzag recesses having two respective exits extending out from the tubular element.

The invention also includes a method for opening a fluid tight barrier valve in a well during installation of completion equipment.

The method comprises the steps of:

- providing a fluid tight barrier valve comprising a housing having a longitudinal direction in a tubular string, the housing comprising an inlet side having an inlet and an outlet side having an outlet, a hinged curved, substantially circular valve flapper in the housing having a normally closed position for forming a fluid tight barrier between the inlet side of the housing and the outlet side of the housing, the valve flapper being rotatably mounted to and being configured for sealing against a floating valve seat and for forming a fluid tight barrier in two directions, and a pressure actuated valve flapper actuator, the valve flapper actuator being configured for bringing the valve flapper from the closed position to an open position after a predetermined number of pressure increases and for applying the predetermined number of pressure increases in order to bring the valve flapper from the closed position to the open position. The method further comprises pressure actuating a pressure actuated valve flapper actuator for actuating an axially displaceable piston section in a longitudinal direction of the housing after a predetermined number of pressure increases, providing an axially displaceable release sleeve, carrying the locking fingers out of the locking groove in the housing via the axially displaceable release sleeve connected to the piston section, and opening the valve flapper.

Brief description of the accompanying drawings:

Fig 1. is a general system view of a barrier valve according to the invention showing a quarter section of the barrier valve in a closed position;
Fig 2. is a cross-section of the barrier valve as shown in Fig. 1 in the closed position;

Fig 3. shows one of the components of the barrier valve provided with zigzag recesses; and

Fig 4. is a cross-section of the barrier valve as shown in Figs. 1 and 2 in an opened position;

The invention will now be explained in more detail with reference to an exemplary embodiment and with reference to the drawings, in which:

The following description is made in relation to Figs. 1, 2, and 4, which show the same barrier valve but of which Figs. 1 and 2 show the valve in a closed position whereas Fig. 4 shows the valve in an open position after a number of pressure cycles have opened the valve. Similar reference numbers refer to similar elements, and the figure references refer to all three Figs. By "the valve" is meant the barrier valve of the invention. Moreover, the references "right" and "left" are used merely in order to explain the accompanying drawings, and are of course not associated with a real configuration. The right side of the drawings is considered the downstream side and the left side is considered the upstream side. Of course, this does not exclude the possibility that fluid may flow in the opposite direction in some cases.

The barrier valve according to an embodiment of the invention includes a housing 30, 31 formed by an upstream housing section 30 and a downstream housing section 31. The housing 30, 31 has an inlet 32 and an outlet 33. The inlet and outlet are provided with proper connectors for being connected, for example, to tubular strings, typically pin and box connectors. The barrier valve further includes a flapper 1 hinged to a floating valve seat 2. Valve flapper 1 is held in a closed position by a locking tubular 3, which is in turn held in position by locking fingers 4. Locking tubular 3, held in position by locking fingers 4, forms a flapper lock retaining valve flapper 1 in the closed position. Fingers 4 engages a locking groove 14 in the downstream housing section 31 to prevent locking tubular 3 from moving towards the right/downstream, so that locking tubular 3 holds valve flapper
1 in the closed position hence forming the flapper lock. The floating seat 2 includes a first seal 22 (Figs. 2, 4) that seals against a release sleeve 13. Release sleeve 13 also seals against an insert sleeve 23 by way of a second seal 24 having the same sealing diameter as the first seal 22. Release sleeve 13 is hence pressure balanced and will only be actuated by an applied force. Insert sleeve 23 together with the first seal 22, second seal 24, and a third seal 25 forms, together with valve flapper 1 and valve seat 2, a seal through the valve. Also, the floating valve seat 2 is connected to a biasing spring 28 for holding valve flapper 1 in abutment against locking tubular 3, as well as a spacer pin 29 abutting against insert sleeve 23 in order to minimize the movement of the floating seat 2. Spacer pin 29 passes through release sleeve 13 so that release sleeve 13 is free to move towards the right.

Locking tubular 3 holds valve flapper 1 in such a manner that valve flapper 1 is pushed against the floating valve seat 2 when the pressure on the left side of valve flapper 1 is higher than the pressure on the right side of the valve flapper. When the pressure on the left side of valve flapper 1 is lower than the pressure on the right side of the valve flapper, valve flapper 1 seals against the floating valve seat 2 in that the pressure forces valve flapper 1 against the valve seat 2.

A biasing element, in this example shown as a nitrogen reservoir, uses nitrogen pressure for providing a pre-tensioning, and is located in the left part of the valve. The valve includes a piston section 6 to which, when hydraulic pressure is applied, an axial force is applied so that piston section 6 moves towards the left (upstream) against the biasing element because a sealing diameter 34 that is larger than a sealing diameter 35 exerts a piston force from the left on piston 6 from the nitrogen reservoir 5. The same sealing diameters 34 and 35 result in a piston force from the right when internal pressure is applied, and move the piston towards the left when a pressure higher than the pressure in nitrogen reservoir 5 is applied.

When piston section 6 is moved towards the left, a pin 7 is forced through a first recess 8 (cf. Fig. 3, which shows a zigzag recessed tubular part 9). The zigzag recessed locking tubular 9, including a first recess 8, a recess end 11 of the zigzag
recess, and a next recess 12, is shown in Fig. 3. Recess 8 runs in the circumferential direction of the zigzag recessed locking tubular 9, transversally to the longitudinal direction of the valve. The pin 7 in the first recess 8 limits the axial movement of piston section 6. When a force is exerted on piston section 6, pin 7 travels in the first recess 8 and forces the zigzag recessed locking tubular 9 to rotate due to the configuration of the recess. Pin 7 limits the movement of piston section 6 in that the pin stops in a recess end 11 of the zigzag recess, and travels on to the next recess 12 when the hydraulic pressure is released and a stored dynamic force urges piston section 6 back. After a number of pressure applications that corresponds to a number of zigzag recesses 8, pin 7 is carried towards the exit 10. Piston section 6 is then free to move in an axial direction and will then, due to the biasing element, carry piston section 6 further towards the right.

When piston section 6 is moved towards the right, a force is transferred to release sleeve 13, via a transfer sleeve 15, and pushes down locking fingers 4, which is released from a locking groove 14, which releases locking tubular 3 and in turn prevents flapper 1 from opening. The force transferred between piston section 6 and transfer sleeve 15 is transferred via a split ring 16, located in a first groove 18, after a given distance is carried into a second groove 17 to thereby release transfer sleeve 15 from piston section 6. Piston section 6 thus continues the axial movement and forces flapper 1 open, which in turn forces locking tubular 3 towards the right. Piston section 6 forces flapper 1 to turn 90 degrees to a fully open position and piston section 6 goes to rest against locking tubular 3 as shown in Fig. 4. Piston section 6 is locked in position in that a split ring 20 is carried in locking groove 21. Locking tubular 3 is held in an open position in that a split ring 26 is locked in a third groove 27. With that, the valve is permanently set in an open position.

In Fig. 3, the zigzag recessed locking tubular 9 is shown in greater detail. As mentioned, the zigzag recess is arranged for guiding the pin 7 (Figs. 1, 2, and 4). Zigzag recessed locking tubular 9 includes a zigzag recess having a number of turns with one recess end 11 for each turn. The number of recesses, or "turns", is
determined by the number of pressure increases it is desired to be able to carry out, as discussed above. The pin stops in a recess end 11 of the zigzag recess and is carried on to a next recess 12 when the hydraulic pressure is released and the pretension from the nitrogen reservoir exerts a force that urges piston section 6 back. After a number of pressure applications corresponding to a number of zigzag recesses 8, pin 7 travels towards exit 10.

In an alternative arrangement, with no zigzag fitting 9, the valve flapper actuator may include an electronic arrangement replacing the zigzag arrangement. An electronic arrangement may comprise a pressure sensor that detects pressure applications, a programmable electronics package that can be pre-programmed with respect to a desired number of pressure cycles before the valve is to open, and a valve that opens and releases a pre-charged nitrogen pressure. The nitrogen pressure applies a pressure to piston 6 so that the valve opens in the same manner as described above.
CLAIMS

1. A normally closed barrier valve for creating a fluid tight barrier in a well during installation of completion equipment, including a housing (30) having a longitudinal direction for being installed in a tubular string, the housing (30) including an inlet side having an inlet and an outlet side having an outlet, and a hinged, curved, substantially circular valve flapper (1) with a normally closed position in the housing, which in the closed position forms a fluid tight barrier between the inlet side of the housing (30) and the outlet side of the housing; the valve flapper (1) being rotatably supported in one axially floating valve seat (2) and is sealingly engaged between the valve flapper (1) and the axially floating valve seat (2) when the valve flapper is in a closed position; an axially, with respect to the longitudinal direction of the housing (30, 31), displaceable locking tubular (3) having a front rim abutting against a circumference of the valve flapper (1) when the valve flapper (1) is in the closed position; locking fingers (4), connected to the locking tubular (3), extending into a locking groove (14) in the housing (30) when the valve flapper (1) is in the closed position; a pressure actuated valve flapper actuator for actuating an axially displaceable piston section (6) in a longitudinal direction of the housing after a predetermined number of pressure increases; an axially displaceable release sleeve (13) for leading the locking fingers (4) out of the locking groove (14) in the housing (31), connected to the piston section (6), whereby axial displacement of the piston section displaces the axially displaceable release sleeve (13) and carries the locking fingers (4) out of the locking groove (14) in the housing (31) and the valve flapper 1 opens, and whereby the floating valve seat (2) is configured for sealing both in the upstream and downstream directions in that the valve flapper (1) is configured for being pushed against the floating valve seat (2) when pressure is applied from the downstream side, and the floating valve seat (2) is configured for being pushed towards the downstream side against the locking tubular (3) when pressure is applied from the upstream side.
2. The barrier valve of claim 1, wherein the pressure actuated valve flapper actuator comprises a zigzag recessed tubular part (9) including at least one zigzag recess having a repeating zigzag pattern with a number of repetitions corresponding to the predetermined number of pressure increases, and an exit (10);
a pin (7) fixedly connected to the housing (30) and extending into the zigzag recess;
the piston section (6) is configured for urging the zigzag recessed tubular part (9) in a first direction on a pressure increase in the housing;
a biasing element urging the zigzag recessed tubular part (9) in a second direction when the pressure in the housing (30) is released;
the axially displaceable release sleeve (13) being configured for opening the valve flapper (1) after the pin (7) has been carried out of the exit (10) of the zigzag recessed tubular part (9).

3. The barrier valve of claim 1,
wherein the valve flapper actuator comprises an electric actuator element connected to an electronic circuit associated with a pressure sensor, the electronic circuit being configured for signalling the electric actuator element when the predetermined number of pressure increases is reached.

4. The barrier valve of claim 3,
wherein the electric actuator element is an electrically controlled valve connected to a reservoir (5) of pressurized fluid, with the pressure from the reservoir (5) of pressurized fluid being applied to the piston (6) for moving the piston and opening the valve flapper (1).

5. The barrier valve of any one of the previous claims, wherein:
in an open position, the valve flapper (1) goes to rest against the housing (31); and
the axially displaceable transfer sleeve (15) runs on the inside of the valve flapper (1) in such a manner that the axially displaceable piston section (6) covers the valve flapper (1) and forms a substantially continuous smooth flow path through the barrier valve.
6. A zigzag recessed tubular part (9) of a release mechanism for opening a flapper (1) of a barrier valve after a number of pressure increases in the barrier valve, including a tubular element having an internal circumference and an external circumference, the zigzag recess comprising a repeating zigzag pattern with a number of repetitions corresponding to the number of pressure increases to which the barrier valve may be subject before the barrier valve is opened; each repetition of the zigzag pattern comprising a recess end (11); and wherein the zigzag recess is terminated in an exit (10) leading out of the tubular element, characterized in that:

   the at least one zigzag recess extends along the external circumference of the tubular element.

7. The zigzag recessed tubular part (9) of claim 6, wherein the tubular element comprises two zigzag recesses each having a respective exit (10) leading out of the tubular element.

8. A method for opening a fluid tight barrier valve in a well during the installation of completion equipment, comprising the steps of:

   providing a fluid tight barrier valve comprising a housing (30) having a longitudinal direction in a tubular string, the housing (30) comprising an inlet side having an inlet and an outlet side having an outlet, a hinged curved, substantially circular valve flapper (1) rotatably supported in a floating valve seat in the housing, having a normally closed position for forming a fluid tight barrier between the inlet side of the housing (30) and the outlet side of the housing, the valve flapper being configured for forming a fluid tight barrier in two directions;

   pressure actuating a pressure actuated valve flapper actuator for actuating an axially displaceable piston section (6) in a longitudinal direction of the housing after a predetermined number of pressure increases;

   providing an axially displaceable release sleeve (13);
carrying locking fingers (4) of the release sleeve (13) out of the locking groove (14) in the housing (31) by way of the axially displaceable release sleeve (13) connected to the piston section (6); and opening the valve flapper (1).
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
E21B 34/10 (2006.01), E21B 34/12 (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B, F16K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
DK, NO, SE, FI: Classes as above.

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPDOC, WPI, FULLTEXT: ENGLISH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<td>X</td>
<td>US 6328109 B1 (PRINGLE, RONALD E. ET AL.) 2001.12.11 Column 10 line 8-57 and figure 4.</td>
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<td>A</td>
<td>Column 6 line 17-38, column 11 line 25-55 and figures 2a and 2b.</td>
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<td>A</td>
<td>US 4393930 A (ROSS RICHARD J. ET AL.) 1983.03.18 Column 5 line 32 - column 6 line 7 and figures 3 and 4.</td>
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☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance
  "E" earlier application or patent but published on or after the international filing date
  "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  "O" document referring to an oral disclosure, use, exhibition or other means
  "P" document published prior to the international filing date but later than the priority date claimed
  "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  "&" document member of the same patent family

Date of the actual completion of the international search: 19/1/2013
Date of mailing of the international search report: 22/1/2013

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Form PCT/ISA/210 (second sheet) (July 2009)
**INTERNATIONAL SEARCH REPORT**

**Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. **O** Claims Nos.:
   - because they relate to subject matter not required to be searched by this Authority, namely:

2. **☐** Claims Nos.:
   - because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. **☐** Claims Nos.:
   - because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1: Claims 1-5 and 8 are directed to a barrier valve with a flapper assembly.
2: Claims 6 and 7 are directed to an index mechanism.

The reason for which the inventions are not so linked as to form a single inventive concept, as required by Rule 13.1 of PCT, are as follows:

*(see extra sheet)*

1. **☐** As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. **☒** As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. **☐** As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. **O** No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- **☐** The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

- **☐** The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

- **D** No protest accompanied the payment of additional search fees.
INTERNATIONAL SEARCH REPORT
Information on patent family members

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Form PCT/ISA/210 (patent family annex) (July 2009)
Continuation of Box No. III:

1: Claims 1-5 and 8 are directed to a barrier valve with a flapper assembly providing a fluid tight barrier in both directions of a well in the closed position. Claim 1 describes a barrier valve with flapper in the closed position. The valve assembly comprises a floating valve seat and locking fingers for securing the fluid tight seal.

2: Claims 6 and 7 are directed to an index mechanism and the features of said mechanism. The mechanism is intended for opening a flapper valve after a number of pressure increases.

In conclusion, the groups of claims are not linked by common or corresponding special technical features and define two different inventions not linked by a general inventive concept. The application, hence does not meet the requirement of unity of invention as defined in Rules 13.1 and 13.2 of PCT.