

Description

The present invention relates to a circulation valve for use in wells comprising an actuator. This valve, when closed, has to be urged to the closed position and when open has to be urged to the open position. Known circulation valves require two biasing arrangements, one arrangement for biasing to the closed position and the other for biasing to the open position.

In the testing of wells it is frequently desirable to be able to selectively produce the well through the tubing and to circulate fluid between the casing-tubing annulus and the tubing in the area above the packer. Desirably this is done with a circulating valve provided in the tubing.

An aim of the present invention is to provide a circulation valve with an actuator in which when the actuator is in one position, a resilient means in compression urges the actuator toward said one position and when the actuator is in the other position, such as valve open position, the resilient means urges the actuator toward such open position.

Another aim is to provide a slide valve with a shutter to protect seals and an actuator which forms part of the valve and which resiliently urges the valve to closed position when the valve is closed and to open position when the valve is opened and in which movement of the valve between open and closed position operates the shutter. Preferably this latter valve will include means for returning it to the closed position after it is been opened.

According to the present invention there is provided a valve for circulating fluid between the tubing and the casing-tubing annulus in wells, comprising a housing having a flow path therethrough, with a movable valve member arranged to control the flow through said flow path, and an actuator arranged to control movement of said valve member between open and closed positions, characterised by first and second escapement means which are co-operable with said housing and and actuator and which confine resilient means in compression, said first escapement means being selectively operable to limit movement of one end of the resilient means relative to the housing or the actuator, and said second escapement means being selectively operable to limit movement of the other end of the resilient means relative to the housing or the actuator, said first and second escapement means alternately securing opposite ends of the resilient means to said housing and actuator in response to movement of the actuator, whereby when the valve is closed, the resilient means urges the valve member to the closed position and when the valve is open, the resilient means urges the valve member to the open position, and by third escapement means cooperable with the housing and actuator, said third escapement means in one position securing a shutter

associated with the valve member, to the actuator and in another position securing the shutter to the housing.

Preferably the valve has a pressure responsive surface for use in moving the actuator in one direction to open the valve and an internal annular recess is provided in the actuator, which can combine with a positioning tool to enable the actuator to be moved in the other direction to close the valve.

Further, in a preferred embodiment of the present invention, the resilient means is a coiled spring and each said escapement means is formed by movable lugs and recesses in the housing and actuator.

Preferably, the actuator has a tubular shape and forms part of said movable valve member, said tubular actuator being located in said housing for axial reciprocation of spaced apart resilient seals carried by the actuator. One of these seals is in engagement with the wall of a bore in the housing in all positions of the actuator, and has a smaller effective area for fluid than the other of the seals. This other seal engages said bore in one position and is disengaged from the housing in another position to control flow through the ports.

Concerning the third escapement means, this preferably changes from said other position to said one position at approximately the same time that the first and second escapement means alternate the attachment of the ends of the resilient means to the housing and actuator.

The present invention will now be further described by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a schematic illustration of a well test installation employing a circulating valve designed in accordance with the present invention;

Figures 2, 3 and 5 are schematic illustrations of the operation of an actuator of the present invention showing in Figure 2 the valve in closed position, in Figure 3 the actuator of the valve moved in a transition position in which the several escapement means are released from the housing or actuator as shown in Figure 2 preparatory to engaging the other of the actuator and housing, and in Figure 4 the valve in a fully open position;

Figure 5 is a view in elevation of a positioning tool for re-closing the valve once it has been opened; and

Figure 6 is a view in section through a preferred form of circulating valve constructed according to the present invention.

Referring first to Figure 1, there is shown a well having a casing 10 and standard surface equipment 11 at the top of the well. The casing and well are shown to be perforated at 12 into the formation to be tested.

Within the well there is an assembly made up of packer 14, foot sleeve 15, landing nipple 16, and transducer fitting 17 which are preferably run into the well and located in place in a pre-

liminary operation as by conventional wireline techniques.

The test or production tubing 18 is shown to have a circulating valve 19 therein in accordance with this invention and a cushion valve 21 and seal unit 13 with the tail-pipe of the seal unit shown in sealing engagement with the packer 14. During running of the tubing 18 the cushion valve may be utilized to support a column of fluid in the tubing which is released by opening of the cushion valve when the string engages the packer 14.

The packer 14 seals off the producing formation and the foot sleeve 15 is provided with a suitable control mechanism to control the flow through the foot sleeve and into the tubing. The landing nipple and transducer fitting provide for locating a transducer such as a pressure sensing device within the fitting to sense the pressure in the casing and below the packer. With this assembly static pressure in the formation below the packer as well as build-up pressure can be recorded or transmitted to the surface through a suitable electric line and flow can be provided through the foot sleeve to test the flow characteristics of the well.

During testing operation the circulating valve 19 is normally closed. Conditions may arise, however, when it is desirable or imperative to provide for circulation between the casing-tubing annulus and the tubing.

In accordance with this invention the circulating valve 19 is one which may be quickly and readily opened to provide for such circulation.

The actuator was developed to form a part of the circulating valve 19 and its operation and construction will be explained in conjunction with its use as a part of a circulating valve.

Referring first to Figure 6 wherein a preferred form of circulating valve according to the invention is shown, the circulating valve has a housing made up of an upper sub 22 and a lower sub 23 joined together by a suitable sleeve-like housing member 24. At its lower end the housing is provided with a plurality of circumferentially arranged ports 25 to permit flow through the housing.

A tubular actuator 26 is reciprocal within the housing and has at its upper and lower extremity, seals 27 and 28. The upper seal 27 seals with the bore 22a through the upper sub 22 and the lower seal 28 is a sealing engagement with the counterbore 23a within the lower sub 23. With the actuator in the closed position as shown in Figure 6, the two seals 27 and 28 prevent flow through the ports 25 and maintain the integrity of the tubing in which the circulating valve is placed.

It is apparent from Figure 6 that the preferred form of valve is a sleeve valve in which the lower end of the actuator 26 which carries the seal 28 is a sleeve valve member which when raised uncovers the ports 25 and permits fluid communication between the interior and the exterior of the housing.

The outer diameter of the seal 28 is greater than the outer diameter of the seal 27 and thus an increase in pressure within the circulating valve is effective on the difference between these two areas to urge the actuator tube 26 toward a valve open position.

A resilient means in the form of spring 29 is held in compression between an upper escapement assembly 31 and an intermediate escapement assembly 32. Alternative resilient means can of course be substituted. Spring 29 is always in compression and when the valve is in the closed position shown in Figure 6, the spring 29 urges the valve to a closed position. When the valve is in an open position, the spring 29 urges the valve member towards the open position. This operation is described later.

The upper escapement assembly 31 includes a lug carrier 33 having radial holes 34 at circumferentially spaced points thereabout in which lugs 35 are carried. The lugs 35 co-operate with an upper housing groove 36 and an upper actuator groove 37 in the housing and actuator, respectively.

In like manner the intermediate escapement assembly 32 includes a lug carrier 38 having radial holes 39 therethrough in which lugs 41 are carried. The lugs 41 alternately co-operate with a groove 42 in the housing 24 and groove 43 in the actuator 26. A lower escapement assembly indicated at 44 is provided for controlling a shutter. This latter escapement includes a lug carrier 45, the lower portion 45a of which forms the said shutter. Circumferentially spaced holes 46 receive the lugs 47. The lugs 47 co-operate with the groove 48 in the housing and the groove 49 in the actuator 26.

A plurality of upper and lower threaded holes 51 and 52, respectively, are provided in the housing. These holes are provided in circumferentially spaced points and receive lock studs (not shown) to lock the spring system in compression during assembly of the valve. Suitable studs introduced through the holes 51 bear against the upper end of the lug carrier 33 and hold it in position with the lugs 35 in the grooves 36. Then a suitable tool is introduced into the housing 19 and spring 29 compressed until the lug carrier 38 is above the holes 52 and studs are run into the holes 52 to bear against the bottom of the lug carrier 38 and hold the spring in compression. The shutter lug carrier 45 with the lugs 47 can then be dropped into the housing and the actuator inserted into the housing from the bottom and thereof and moved to a position in which the valve is open and the grooves 37, 43 and 49 are positioned underneath the three sets of lugs. If the valve actuator has not previously been provided with seals 27 and 28, these seals 27 and 28 can be located in place at this time. Thereafter, the upper and lower subs 22 and 23 are threaded to the sleeve housing 24 to complete the assembly. Removal of the supporting bolts from the holes 52 will permit the actuator to move

downwardly under the force of spring 29 to position all of the parts in the position shown in Figure 6. At this time the bolts may be removed from the holes 51 and the valve is ready for use.

Reference is made to Figures 2, 3 and 4 to show the operation of the valve. In Figure 2 the valve is schematically shown in its closed position with the lugs 35 of the upper escapement assembly 31 engaged in the grooves 36 in the housing and the lugs 41 of the intermediate escapement assembly 32 engaged in the grooves 43 in the actuator. As the spring 29 is in compression, the actuator is urged downwardly relative to the housing to hold the valve in a closed position. In this position the lugs 47 and the shutter escapement 44 are engaged with the housing to hold the shutter in the down position, as viewed in the drawings.

The intermediate position of the actuator is shown in Figure 3. The application of pressure internally of the valve acts on the differential between the two seals 27, 28 and moves the actuator in an upward direction. It will be noted that in the Figure 3 position the shutter is still in place over the ports 25 but the actuator has moved up to a position in which the lower seal assembly 28 is above the lower end of the shutter. This protects the seal assembly as it moves out of the lower sub 23 to prevent damage to the seal by pressure flowing between the lower end of the shutter and the upper end of the lower sub 23. As the shutter is still in a closed position it will act as a rough seal to limit flow through the ports 25 and permit the elevated pressure to be maintained within the valve.

It will be noted that the width of the various lugs is substantially less than the width dimension of the various grooves with which they cooperate. Thus the spring 29 will tend to urge the lugs of the upper and intermediate escapement assemblies 31 and 32 away from each other. As the actuator 26 continues its upward movement it urges the dogs 41 of the intermediate escapement assembly 32 outwardly and the spring 29 seats these dogs in groove 42 in the housing. At about the same time the groove 37 moves slightly above the groove 36 of the upper escapement assembly and force the lugs 35 into the grooves 37 on the actuator. At this time the spring force is applied in a direction to urge the actuator upwardly as viewed in the drawing to augment the high pressure in the tubing and drive the valve to a fully open position.

The fully open position is shown in Figure 3 and it will be noted that the lugs 35 of the upper escapement assembly 31 are in the groove 37 in the actuator and the lugs of the intermediate escapement assembly 32 are in the groove 42 in the housing.

As the upper and intermediate escapement assemblies are making their transition between the housing and actuator the lower escapement assembly controlling the shutter 45a like-

wise makes a transition in which the lug 47 are moved out of the groove 48 in the housing and moved into the grooves 49 in the actuator as shown in Figure 4. When this occurs the lower escapement assembly is latched to the actuator and moved up with the actuator to move the shutter 45a into an out of the way position to fully expose the ports 25 and provide a full open flow through the ports 25.

While the operation of the several escapement assemblies has been explained as happening substantially simultaneously it will be apparent that this is not necessary and the escapements could transfer the lugs between the housing and actuator in sequential operation.

After the reason for allowing flow through the circulating valve has been corrected, the circulating valve may be closed, if desired. For this purpose a conventional positioning tool indicated generally at 53 and having a lug profile which is a mirror image of the profile indicated generally at 54 within the actuator 26, is utilized. The positioning tool is a conventional piece of equipment known as the type B Otis Positioning Tool. See *The Composite Catalog of Oil Field Services and Equipment* for the years 1974—1975, page 3968. The positioning tool will be located in the bore in the actuator, preferably with the conventional pump down piston thereabove, and will latch into the profile 54 within the actuator 26. The tubing will then be pressurised to shift the actuator downwardly returning the tool to the position shown in Figure 2.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims.

Claims

1. A valve for circulating fluid between the tubing and the casing-tubing annulus in wells, comprising a housing (24) having a flow path therethrough, with a movable valve member (26, 28) arranged to control the flow through said flow path, and an actuator (26) arranged to control movement of said valve member (26, 28) between open and closed positions, characterised by first and second escapement means (31, 32) which are co-operable with said housing (24) and actuator (26), and which confine resilient means (29) in compression, said first escapement means (31) being selectively operable to limit movement of one end of the resilient means (29) relative to the housing (24) or the actuator (26), and said second escapement means (32) being selectively operable to limit movement of the other end of the resilient means (29) relative to the housing (24) or the actuator (26), said first and second escapement means (31, 32), alternately securing

downwardly under the force of spring 29 to position all of the parts in the position shown in Figure 6. At this time the bolts may be removed from the holes 51 and the valve is ready for use.

Reference is made to Figures 2, 3 and 4 to show the operation of the valve. In Figure 2 the valve is schematically shown in its closed position with the lugs 35 of the upper escapement assembly 31 engaged in the grooves 36 in the housing and the lugs 41 of the intermediate escapement assembly 32 engaged in the grooves 43 in the actuator. As the spring 29 is in compression, the actuator is urged downwardly relative to the housing to hold the valve in a closed position. In this position the lugs 47 and the shutter escapement 44 are engaged with the housing to hold the shutter in the down position, as viewed in the drawings.

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opposite ends of the resilient means (29) to said housing (24) and actuator (26) in response to movement of the actuator (26), whereby when the valve is closed, the resilient means (29) urges the valve member (26, 28) to the closed position and when the valve is open, the resilient means (29) urges the valve member (26, 28) to the open position, and by third escapement means (44) cooperable with the housing (24) and actuator (26), said third escapement means (44) in one position securing a shutter (45a) associated with the valve member (26, 28), to the actuator (26) and in another position securing the shutter (45a) to the housing (24).

2. Valve as claimed in claim 1, characterised by a pressure responsive surface for moving said actuator (26) in one direction to open the valve and an internal annular recess (54) in said actuator, which in combination with a positioning tool which engages in said recess, is used for moving the actuator in said other direction to close the valve.

3. Valve as claimed in claim 1 or 2, characterised in that said resilient means is a coiled spring (29).

4. Valve as claimed in any one of claims 1 to 3, characterised in that each escapement means (31, 32, 44) is formed by movable lugs (35, 41, 47) and recesses (36, 37, 42, 43, 48, 49) in the housing (24) and actuator (26).

5. Valve as claimed in claim 1, characterised in that said actuator (26) has a tubular shape and forms part of said movable valve member, said tubular actuator (26) being located in said housing (24) for axial reciprocation of spaced apart resilient seals (27, 28) being carried by the actuator (26), one of said seals (27) being in engagement with a bore in said housing (24) in all positions of the actuator (26) and having a smaller effective area for fluid than the other of the seals (28) to thus provide a pressure responsive area, said other of said seals (28) engaging said bore in one position and being disengaged from the housing (24) in another position to control flow through ports (25).

6. Valve as claimed in claim 5, in which said third escapement means (44) changes from said other position to said one position at approximately the same time that the first and second escapement means (31, 32) alternate the securing of the ends of the resilient means (29) to the housing (24) and actuator (26).

Revendications

1. Soupape pour la circulation de fluide entre le tube et l'anneau cuvelage-tube dans les puits, comprenant une enveloppe (24) traversée par une voie de passage de fluide, avec un obturateur mobile (26, 28) agencé pour commander le passage de fluide par cette voie, et un organe de mise en action, ou actionneur (26) agencé pour commander le mouvement de cet obturateur (26,

28) entre des positions d'ouverture et de fermeture, caractérisée par un premier et un deuxième moyens d'échappement (31, 32) qui coopèrent avec l'enveloppe (24) et l'actionneur (26) et retiennent entre eux un moyen élastique (29) en compression, le premier moyen d'échappement (31) étant manoeuvrable sélectivement pour limiter le mouvement d'une extrémité du moyen élastique (29) par rapport à l'enveloppe (24) ou à l'actionneur (26) et le deuxième moyen d'échappement (32) étant manoeuvrable sélectivement pour limiter le mouvement de l'autre extrémité du moyen élastique (29) par rapport à l'enveloppe (24) ou à l'actionneur (26), le premier et le deuxième moyens d'échappement (31, 32) assujettissant alternativement les extrémités opposées du moyen élastique (29) à l'enveloppe (24) et à l'actionneur (26) à la suite du mouvement de l'actionneur (26), de sorte que lorsque la soupape est fermée, le moyen élastique (29) rappelle l'obturateur (26, 28) en position de fermeture, et lorsque la soupape est ouverte, le moyen élastique (29) rappelle l'obturateur (26, 28), en position d'ouverture, et par un troisième moyen d'échappement (44) qui coopère avec l'enveloppe (24) et l'actionneur (26) et, dans une position, assujettit à l'actionneur (26) un volet (45a) associé à l'obturateur (26, 28), et dans une autre position, assujettit ce volet (45a) à l'enveloppe (24).

2. Soupape selon la revendication 1, caractérisée par une surface sur laquelle agit la pression pour le déplacement de l'actionneur (26) dans un sens pour l'ouverture de la soupape et un évidement annulaire (54) prévu à l'intérieur de l'actionneur qui, en association avec un outil de positionnement qui s'y engage, sert à déplacer l'actionneur dans l'autre sens pour la fermeture de la soupape.

3. Soupape selon l'une des revendications 1 et 2, caractérisée par le fait que le moyen élastique est un ressort hélicoïdal (29).

4. Soupape selon l'une des revendications 1 à 3, caractérisée par le fait que chaque moyen d'échappement (31, 32, 44) est formé par des pattes mobiles (35, 41, 47) et des évidements (36, 37, 42, 43, 48, 49) prévus dans l'enveloppe (24) et l'actionneur (26).

5. Soupape selon la revendication 1, caractérisée par le fait que l'actionneur (26) est tubulaire et fait partie de l'obturateur mobile, ce actionneur tubulaire (26) étant placé dans l'enveloppe (24) pour un mouvement de va-et-vient axial de joints d'étanchéité élastiques espacés (27, 28) portés par l'actionneur (26), l'un (27) de ces joints étant engagé avec un alésage de l'enveloppe (24) dans toutes les positions de l'actionneur (26) et ayant une plus petite surface d'action du fluide que l'autre (28) de ces joints pour fournir une surface d'action de la pression, et l'autre (28) de ces joints étant engagé avec l'alésage dans une position et dégagé de l'enveloppe (24) dans une autre position pour commander le passage de fluide par



les orifices (25).

6. Soupape selon la revendication 5, dans laquelle le troisième moyen d'échappement (44) passe de son autre position à sa première position à peu près en même temps que le premier et le deuxième moyens d'échappement (31, 32) font alterner l'assujettissement des extrémités du moyen élastique (29) à l'enveloppe (24) et à l'actionneur (26).

Patentansprüche

1. Ventil für den Fluidumlauf zwischen dem Rohrstrang und dem Mantel-Rohrstrang-Ringraum in Bohrlöchern mit einem Gehäuse (24), durch welches ein Strömungsweg hindurchgeht und das ein bewegliches Ventilelement (26, 28) aufweist, das zur Steuerung des Stroms durch den Strömungsweg angeordnet ist, und mit einer Betätigungseinrichtung (26), die für die Steuerung der Bewegung des Ventilelements (26, 28) zwischen Offen- und Schließstellungen angeordnet ist, gekennzeichnet durch eine erste und eine zweite Schalteinrichtung (31, 32), die mit dem Gehäuse (24) und der Betätigungseinrichtung (26) zusammenwirken können und die eine in Kompression befindliche elastische Einrichtung (29) begrenzen, wobei die erste Schalteinrichtung (31) selektiv betätigbar ist, um die Bewegung eines Endes der elastischen Einrichtung (29) relativ zum Gehäuse (24) oder zur Betätigungseinrichtung (26) zu begrenzen, während die zweite Schalteinrichtung (32) selektiv betätigbar ist, um die Bewegung des anderen Endes der elastischen Einrichtung (29) relativ zum Gehäuse (24) oder zur Betätigungseinrichtung (26) zu begrenzen, wobei die erste und die zweite Schalteinrichtung (31, 32) abwechselnd die gegenüberliegenden Enden der elastischen Einrichtung (29) um Gehäuse (24) und an der Betätigungseinrichtung (26) ansprechend auf die Bewegung der Betätigungseinrichtung (26) festlegen, wodurch, wenn das Ventil geschlossen ist, die elastische Einrichtung (29) das Ventilelement (26, 28) in die Schließstellung und wenn das Ventil offen ist, die elastische Einrichtung (29) das Ventilelement (26, 28) in die Offenstellung drückt, und durch eine dritte Schalteinrichtung (44), die mit dem Gehäuse (24) und der Betätigungseinrichtung (26) zusammenwirken kann und in einer Stellung einen

dem Ventilelement (26, 28) zugeordneten Verschluss (45a) an der Betätigungseinrichtung (26) festlegt, während sie in der anderen Stellung den Verschluss (45a) am Gehäuse (24) festlegt.

2. Ventil nach Anspruch 1, gekennzeichnet durch eine auf Druck ansprechende Oberfläche zur Bewegung der Betätigungseinrichtung (26) in eine Richtung zum Öffnen des Ventils und durch eine innere Ringaussparung (54) in der Betätigungseinrichtung, die in Kombination mit einem Positionierwerkzeug, welches in die Aussparung eingreift, dazu verwendet wird, die Betätigungseinrichtung in die andere Richtung zum Schließen des Ventils zu bewegen.

3. Ventil nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die elastische Einrichtung eine Schraubenfeder (29) ist.

4. Ventil nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß jede Schalteinrichtung (31, 32, 44) von beweglichen Ansätzen (35, 41, 37) und Aussparungen (36, 37, 42, 43, 48, 49) im Gehäuse (24) und der Betätigungseinrichtung (26) gebildet wird.

5. Ventil nach Anspruch 1, dadurch gekennzeichnet, daß die Betätigungseinrichtung (26) eine rohrförmige Gestalt hat und einen Teil des beweglichen Ventilelements bildet, wobei die rohrförmige Betätigungseinrichtung (26) in dem Gehäuse (24) für eine axiale Hin- und Herbewegung von im Abstand angeordneten elastischen Dichtungen (27, 28) angeordnet ist, die von der Betätigungseinrichtung (26) getragen werden, wobei eine der Dichtungen (27) in Eingriff mit einer Bohrung im Gehäuse (24) in allen Stellungen der Betätigungseinrichtung (26) steht und eine kleinere für das Fluid wirksame Fläche als die andere Abdichtung (28) aufweist, um so eine auf Druck ansprechende Fläche zu schaffen, während die andere Dichtung (28) an der Bohrung in einer Stellung angreift und die Eingriffstellung am Gehäuse (24) in der anderen Position zur Steuerung des Stroms durch Öffnungen (25) gelöst wird.

6. Ventil nach Anspruch 5, bei welchem die dritte Schalteinrichtung (44) von der anderen Stellung in die eine Stellung annähernd zur gleichen Zeit umschaltet, zu der die erste und die zweite Schalteinrichtung (31, 32) die Festlegung der Enden der elastischen Einrichtung (29) am Gehäuse (24) und an der Betätigungseinrichtung (26) ändern.



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