# CIRCULATION CONTROL VALVE AND ASSOCIATED METHOD

## TECHNICAL FIELD

The present invention relates generally to equipment utilized and operations performed in conjunction with a subterranean well and, in an embodiment described herein, more particularly provides a circulation control valve and associated method.

## BACKGROUND

It is frequently beneficial to be able to selectively permit and prevent circulation flow through a sidewall of a tubular string in a well. For example, at the conclusion of a cementing operation, in which the tubular string has been cemented in the well, it is sometimes desirable to circulate cement out of a portion of an annulus exterior to the tubular string. As another example, in staged cementing operations it may be desirable to flow cement through sidewall openings in a tubular string. Numerous other examples exist, as well.

Although circulation control valves for these purposes have been used in the past, they have not been entirely satisfactory in their performance. For example, one circulation control valve includes multiple rupture disks

which are ruptured by internal pressure in order to provide fluid communication through the rupture disks between the annulus and the interior of the valve. However, if all of the rupture disks do not rupture (which will frequently be the case if rupturing of the first disks relieves the internal pressure), then the flow area between the annulus and the interior of the valve will be substantially reduced.

Therefore, it may be seen that improvements are needed in the art of circulation control valves and associated methods.

## SUMMARY

In the present specification, a circulation control valve is provided which solves at least one problem in the art. One example is described below in which valve devices are used to control opening and closing of a valve, but flow between the interior and exterior of the valve does not pass through the valve devices. Another example is described below in which pressure differentials between a pressurized internal chamber of a valve and the interior and/or exterior of the valve are used to control opening and closing of the valve.

In one aspect, a circulation control valve for use in a subterranean well is provided. The valve includes at least one opening for providing fluid communication between an interior longitudinal flow passage and an exterior of the valve. The valve also includes first and second valve devices. Fluid communication is provided through each of the first and second valve devices in response to application of a respective one of first and second pressure differentials applied across the corresponding valve device. Fluid communication through the opening is permitted in response to application of the first pressure differential

to the first valve device, and fluid communication through the opening is prevented in response to application of the second pressure differential to the second valve device.

In another aspect, a circulation control valve is provided which includes at least one opening for providing fluid communication between an exterior of the valve and an interior longitudinal flow passage extending through the valve, a generally tubular closure device circumscribing the interior flow passage, and an internal chamber for containing pressurized fluid. The closure device displaces in a first direction in response to application of a first pressure differential between the interior flow passage and the internal chamber to thereby permit fluid communication through the opening. The closure device displaces in a second direction opposite to the first direction in response to release of a second pressure differential between the interior flow passage and the internal chamber to thereby prevent fluid communication through the opening.

In yet another aspect, a method of controlling circulation flow between an interior flow passage of a tubular string and an annulus external to the tubular string in a subterranean well is provided. The method includes the steps of: interconnecting a valve in the tubular string, the valve including at least one opening for providing fluid communication between the interior flow passage and the annulus; applying an increased pressure to the interior flow passage while fluid communication through the opening between the interior flow passage and the annulus is prevented, thereby permitting fluid communication through the opening between the interior flow passage and the annulus; and then applying another increased pressure to the interior flow passage while fluid communication through the opening between the interior flow passage and the annulus is

permitted, thereby preventing fluid communication through the opening between the interior flow passage and the annulus.

These and other features, advantages, benefits and objects will become apparent to one of ordinary skill in the art upon careful consideration of the detailed description of representative embodiments of the invention hereinbelow and the accompanying drawings, in which similar elements are indicated in the various figures using the same reference numbers.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic partially cross-sectional view of a well system and associated method embodying principles of the present invention;

FIGS. 2A-D are enlarged scale cross-sectional views of successive axial sections of a circulation control valve which may be used in the well system and method of FIG. 1, the valve being depicted in a run-in closed configuration;

FIGS. 3A-D are cross-sectional views of successive axial sections of the valve of FIGS. 2A-D, the valve being depicted in an open circulating configuration;

FIGS. 4A-D are cross-sectional views of successive axial sections of the valve of FIGS. 2A-D, the valve being depicted in a subsequent closed configuration;

FIGS. 5A-D are cross-sectional views of successive axial sections of the valve of FIGS. 2A-D, the valve being depicted in another closed configuration;

FIG. 6 is a further enlarged scale elevational view of a displacement limiting device of the valve of FIGS. 2A-D;

FIGS. 7A-D are cross-sectional views of successive axial sections of an alternate circulation control valve which may be used in the well system and method of FIG. 1, the valve being depicted in a run-in closed configuration;

FIGS. 8A-D are cross-sectional views of successive axial sections of the valve of FIGS. 7A-D, the valve being depicted in an open circulating configuration; and

FIGS. 9A-D are cross-sectional views of successive axial sections of the valve of FIGS. 7A-D, the valve being depicted in a subsequent closed configuration.

**DETAILED DESCRIPTION**

It is to be understood that the various embodiments of the present invention described herein may be utilized in various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of the present invention. The embodiments are described merely as examples of useful applications of the principles of the invention, which is not limited to any specific details of these embodiments.

In the following description of the representative embodiments of the invention, directional terms, such as "above", "below", "upper", "lower", etc., are used for convenience in referring to the accompanying drawings. In general, "above", "upper", "upward" and similar terms refer to a direction toward the earth's surface along a wellbore, and "below", "lower", "downward" and similar terms refer to a direction away from the earth's surface along the wellbore.

Representatively illustrated in FIG. 1 is a well system and associated method 10 which embody principles of the

present invention. In the well system 10, a tubular string 12 is installed in a wellbore 14, thereby forming an annulus 16 exterior to the tubular string. The wellbore 14 could be lined with casing or liner, in which case the annulus 16 may be formed between the tubular string 12 and the casing or liner.

The tubular string 12 could be a production tubing string which is cemented in the wellbore 14 to form what is known to those skilled in the art as a "cemented completion." This term describes a well completion in which production tubing is cemented in an otherwise uncased wellbore. However, it should be clearly understood that the present invention is not limited in any way to use in cemented completions, or to any other details of the well system 10 or method described herein.

If the tubular string 12 is cemented in the wellbore 14, it may be desirable to circulate cement out of an upper portion of the annulus 16. For this purpose, a circulation control valve 18 is provided in the well system 10.

Near the conclusion of the cementing operation, openings 20 in the valve 18 are opened to permit circulation flow between the annulus 16 and an interior flow passage 22 of the tubular string 12. After circulation flow is no longer desired, the openings 20 in the valve 18 are closed.

Referring additionally now to FIGS. 2A-D, the valve 18 is representatively illustrated at an enlarged scale and in greater detail. The valve 18 may be used in the well system 10 and associated method as described above, but the valve may alternatively be used in other systems and methods in keeping with the principles of the invention.

As depicted in FIGS. 2A-D, the valve 18 is in a run-in closed configuration in which flow through the openings 20

between the flow passage 22 and the annulus 16 is prevented. When used in a cemented completion, this configuration of the valve 18 would be used when the tubular string 12 is installed in the wellbore 14, and when cement is flowed into the annulus 16. When used in a staged cementing operation, the valve 18 may be open when cement is flowed into the annulus 16.

A generally tubular closure device 24 in the form of a sleeve is reciprocably displaceable within an outer housing assembly 26 of the valve 18 in order to selectively permit and prevent fluid flow through the openings 20. The closure device 24 carries flexible or resilient seals 28 thereon for sealing across the openings 20, but in an important feature of the embodiment of FIGS. 2A-D, a metal-to-metal seal 30 is also provided to ensure against leakage in the event that the other seals 28 fail.

Furthermore, another internal sleeve 36 and additional seals 32 are provided, so that the openings 20 can be sealed off positively. The sleeve 36 can be displaced from within the flow passage 22, for example, using a conventional shifting tool engaged with an internal shifting profile 34 in the sleeve. The sleeve 36 is depicted in its closed position in FIGS. 5A-D.

The metal-to-metal seal 30 is enhanced by operation of a sealing device 40 which includes an arrangement of pistons 38, 42 and a biasing device 44. In an important feature of the sealing device 40, at least one of the pistons 38, 42 applies a biasing force to the metal-to-metal seal 30 whether pressure in the flow passage 22 is greater than pressure in the annulus 16, or pressure in the annulus is greater than pressure in the flow passage.

This feature of the sealing device 40 is due to a unique configuration of differential piston areas on the pistons 38, 42. As will be appreciated by those skilled in the art from a consideration of the arrangement of the pistons 38, 42 as depicted in FIG. 2B, when pressure in the flow passage 22 is greater than pressure in the annulus 16, the pistons will be biased downwardly as viewed in the drawing, thereby applying a downwardly biasing force to the metal-to-metal seal 30.

When pressure in the annulus 16 is greater than pressure in the flow passage 22, the piston 38 will be biased upwardly as viewed in the drawing, but the piston 42 will be biased downwardly, thereby again applying a downwardly biasing force to the metal-to-metal seal 30. Thus, no matter the direction of the pressure differential between the flow passage 22 and the annulus 16, the metal-to-metal seal 30 between the piston 42 and the closure device 24 is always enhanced by the sealing device 40.

The biasing device 44 is used to exert an initial biasing force to the metal-to-metal seal 30. A snap ring 46 installed in the housing assembly 26 limits upward displacement of the closure device 24 and limits downward displacement of the pistons 38, 40.

The closure device 24 is biased upwardly by means of a pressurized internal chamber 48. The chamber 48 could, for example, contain nitrogen or another inert gas at a pressure exceeding any hydrostatic pressure expected to be experienced at the valve 18 in the wellbore 14. Other compressible fluids, such as silicone, etc., could be used in the chamber 48, if desired.

The seals 28, 32 on the lower end of the closure device 24 close off an upper end of the chamber 48. The upper end

of the closure device 24 is exposed to pressure in the flow passage 22. Thus, if pressure in the flow passage 22 is increased sufficiently, so that it is greater than the pressure in the chamber 48, the closure device 24 will be biased to displace downwardly.

Displacement of the closure device 24 relative to the housing assembly 26 is limited by means of a displacement limiting device 54. The device 54 includes one or more pin or lug(s) 50 secured to the housing assembly 26, and a sleeve 56 rotationally attached to the closure device 24, with the sleeve having one or more profile(s) 52 formed thereon for engagement by the lug.

Referring additionally now to FIGS. 3A-D, the valve 18 is representatively illustrated in a configuration in which pressure in the flow passage 22 has been increased to a level greater than the pressure in the chamber 48. As a result, the closure device 24 has displaced downwardly relative to the housing assembly 26, and fluid flow through the openings 20 is now permitted.

Subsequent release of the increased pressure in the flow passage 22 allows the lug 50 in the housing assembly 26 to engage a recessed portion 52a of the profile 52. This functions to secure the closure device 24 in its open position, without the need to maintain the increased pressure in the flow passage 22.

An enlarged scale view of the sleeve 56 and profile 52 thereon is representatively illustrated in FIG. 6. In this view it may be seen that the lug 50 can displace relative to the profile 52 between several portions 52a-f of the profile.

Initially, in the run-in configuration of FIGS. 2A-D, the lug 50 is engaged in a generally straight longitudinally

extending profile portion 52b. When pressure in the flow passage 22 has been increased so that it is greater than pressure in the chamber 48, the lug 50 will be engaged in profile portion 52d (with the valve 18 being open). Subsequent release of the increased pressure in the flow passage 22 will cause the lug 50 to engage profile portion 52a, thereby maintaining the valve 18 in its open configuration.

Another application of increased pressure to the flow passage 22 greater than pressure in the chamber 48 will cause the lug 50 to engage profile portion 52e (with the valve 18 still being open). Subsequent release of the increased pressure in the flow passage 22 will cause the lug 50 to engage profile portion 52c, with the closure device 24 correspondingly displacing to its closed position (as depicted in FIGS. 4A-D).

Further increases and decreases in pressure in the flow passage 22 will not result in further opening and closing of the valve 18. Instead, the lug 50 will move back and forth between profile portions 52c & f. This is beneficial in cemented completions, in which further circulation through the valve 18 is not desired. However, further openings and closings of the valve 18 could be provided, for example, by making the profile 52 continuous about the sleeve 56 in the manner of a conventional continuous J-slot, if desired.

Referring additionally now to FIGS. 4A-D, the valve 18 is representatively illustrated after the second application of increased pressure to the flow passage 22, and then release of the increased pressure as described above. The valve 18 is now in a closed configuration, in which fluid communication between the flow passage 22 and annulus 16 via the openings 20 is prevented by the closure device 24.

Note that the lug 50 is now engaged with the profile portion 52f as depicted in FIG. 4B. This demonstrates that further increases in pressure in the flow passage 22 do not cause the valve 18 to open, since the device 54 limits further downward displacement of the closure device 24.

However, it will be readily appreciated that the profile 52 could be otherwise configured, for example, as a continuous J-slot type profile, to allow multiple openings and closings of the valve 18. Thus, the closure device 24 can be repeatedly displaced upward and downward to close and open the valve 18 in response to multiple applications and releases of pressure in the flow passage 22, if the profile 52 is appropriately configured.

Referring additionally now to FIGS. 5A-D, the valve 18 is representatively illustrated in a closed configuration in which the internal sleeve 36 has been displaced upwardly, so that it now blocks flow through the openings 20 between the annulus 16 and flow passage 22. Displacement of the sleeve 36 may be accomplished by any of a variety of means, but preferably a conventional wireline or tubing conveyed shifting tool is used.

The sleeve 36 may be displaced as a contingency operation, in the event that one or more of the seals 28, 32 leak, or the closure device 24 is otherwise not operable to prevent fluid communication between the flow passage 22 and the annulus 16 via the openings 20. Seal bores 58 and a latching profile 60 may also (or alternatively) be provided for installation of a conventional packoff sleeve, if desired.

Referring additionally now to FIGS. 7A-D, an alternate configuration of the circulation control valve 18 is representatively illustrated. The configuration of FIGS.

7A-D is similar in many respects to the configuration described above, most notably in that both configurations open in response to application of a pressure increase to the flow passage 22, and then close following application of a subsequent pressure increase to the flow passage.

However, the configuration of FIGS. 7A-D utilizes valve devices 62, 64 to control displacement of the closure device 24. The valve devices 62, 64 could be, for example, conventional rupture disks, shear pinned shuttle valves or any other type of valve devices which open in response to application of a certain pressure differential. The valve devices 62, 64 are selected to isolate respective internal chambers 66, 68 from well pressure until corresponding predetermined differential pressures are applied across the valve devices, at which point the devices open and permit fluid communication therethrough.

A radially enlarged piston 70 on the closure device 24 is exposed to the chamber 66 on its upper side, and a lower side of the piston is exposed to another chamber 72. Another radially enlarged piston 74 on a sleeve 78 positioned below the closure device 24 is exposed to the chamber 68 on its lower side, and an upper side of the piston is exposed to another chamber 76.

All of the chambers 66, 68, 72, 76 initially preferably contain a compressible fluid (such as air) at a relatively low pressure (such as atmospheric pressure). However, other fluids (such as inert gases, silicone fluid, etc.) and other pressures may be used, if desired.

The closure device 24 is initially maintained in its closed position by one or more shear pins 80. However, when pressure in the flow passage 22 is increased to achieve a predetermined pressure differential (from the flow passage

to the chamber 66), the valve device 62 will open and admit the well pressure into the chamber 66. The resulting pressure differential across the piston 70 (between the chambers 66, 72) will cause a downwardly directed biasing force to be exerted on the closure device 24, thereby shearing the shear pins 80 and downwardly displacing the closure device.

Referring additionally now to FIGS. 8A-D, the valve 18 is representatively illustrated after the closure device 24 has displaced downwardly following opening of the valve device 62. Fluid communication between the flow passage 22 and the annulus 16 via the openings 20 is now permitted.

When it is desired to close the valve 18, pressure in the flow passage 22 and annulus 16 may be increased to a predetermined pressure differential (from the annulus to the chamber 68) to open the valve device 64. Note that the valve device 64 is physically exposed to the annulus 16, rather than to the flow passage 22, and so the valve device is not in fluid communication with the flow passage until the closure device 24 is displaced downwardly to open the valve 18. As a result, it is not necessary for the predetermined pressure differential used for opening the valve device 64 to be greater than the predetermined pressure differential used for opening the valve device 62.

When the valve device 64 opens, well pressure will be admitted into the chamber 68, and the resulting pressure differential (between the chambers 68, 76) across the piston 74 will cause an upwardly directed biasing force to be exerted on the sleeve 78. The sleeve 78 will displace upwardly and contact the closure device 24. Since the piston 74 has a greater differential piston area than that of the piston 70, the upwardly directed biasing force due to

the pressure differential across the piston 74 will exceed the downwardly directed biasing force due to the pressure differential across the piston 70, and the closure device 24 will displace upwardly as a result.

Referring additionally now to FIGS. 9A-D, the valve 18 is representatively illustrated after the closure device 24 has displaced upwardly following opening of the valve device 64. The closure device 24 again prevents fluid communication between the flow passage 22 and the annulus 16 via the openings 20.

A snap ring 82 carried on the sleeve 78 now engages an internal profile 84 formed in the housing assembly 26 to prevent subsequent downward displacement of the closure device 24. Note that an internal sleeve 36 and/or latching profile 60 and seal bores 58 may be provided for ensuring that the openings 20 can be sealed off as a contingency measure, or as a matter of course when operation of the valve 18 is no longer needed.

However, in the alternate configuration of FIGS. 7A-9D, the closure device 24 is itself provided with a shifting profile 86 to allow the closure device to be displaced to its closed position from the interior of the flow passage 22 (such as, using a conventional shifting tool), in the event that the closure device cannot be otherwise displaced upwardly (such as, due to seal leakage or valve device malfunction, etc.).

It may now be fully appreciated that the above description of the circulation control valve 18 configurations provides significant improvements in the art. The valve 18 is capable of reliably and conveniently providing a large flow area for circulation between the flow passage 22 and the annulus 16, and is further capable of

reliably and conveniently preventing fluid communication between the flow passage and annulus when desired.

In particular, the above description provides a circulation control valve 18 for use in a subterranean well, with the valve including at least one opening 20 for providing fluid communication between an interior longitudinal flow passage 22 and an exterior of the valve (annulus 16). Fluid communication is provided through each of first and second valve devices 62, 64 in response to application of a respective one of first and second pressure differentials applied across the corresponding valve device. Fluid communication through the opening 20 is permitted in response to application of the first pressure differential to the first valve device 62, and fluid communication through the opening 20 is prevented in response to application of the second pressure differential to the second valve device 64.

The first pressure differential may be between pressure in the interior flow passage 22 and pressure in a first internal chamber 66 of the valve 18. The second pressure differential may be between pressure on the exterior of the valve 18 and pressure in a second internal chamber 68 of the valve.

The second valve device 64 may be exposed to pressure in the interior flow passage 22 only when fluid communication is permitted through the opening 20.

A closure device 24 of the valve 18 may be displaced in a first direction in response to application of the first pressure differential to the first valve device 62, and the closure device 24 may be displaced in a second direction opposite to the first direction in response to application

of the second pressure differential to the second valve device 64.

The closure device 24 may comprise an internal sleeve which circumscribes the interior flow passage 22.

Also provided by the above description is a circulation control valve 18 which includes at least one opening 20 for providing fluid communication between an exterior of the valve (annulus 16) and an interior longitudinal flow passage 22 extending through the valve, a generally tubular closure device 24 circumscribing the interior flow passage 22, and an internal chamber 48 for containing pressurized fluid. The closure device 24 displaces in a first direction in response to application of a first pressure differential between the interior flow passage 22 and the internal chamber 48 to thereby permit fluid communication through the opening 20, and the closure device displaces in a second direction opposite to the first direction in response to release of a second pressure differential between the interior flow passage 22 and the internal chamber 48 to thereby prevent fluid communication through the opening 20.

The valve 18 may also include a displacement limiting device 54 which, in response to displacement of the closure device 24 in the first direction, secures the closure device in a position in which fluid communication through the opening 20 is permitted. The displacement limiting device 54 may permit displacement of the closure device 24 in the second direction in response to application and then release of the second pressure differential.

The valve 18 may also include a sealing device 40 which prevents fluid communication through the opening 20 in cooperation with the closure device 24, the sealing device including a piston arrangement 38, 42 which applies a

biasing force to a metal-to-metal seal 30. The piston arrangement 38, 42 may apply the biasing force to the metal-to-metal seal 30 in response to pressure in the interior flow passage 22 being greater than pressure on the exterior of the valve 18, and in response to pressure in the interior flow passage being less than pressure on the exterior of the valve.

The valve 18 may also include an internal sleeve 36 which is displaceable from an interior of the valve to selectively permit and prevent fluid communication through the opening 20 between the interior flow passage 22 and the exterior of the valve, when fluid communication through the opening is not prevented by the closure device 24.

A method of controlling circulation flow between an interior flow passage 22 of a tubular string 12 and an annulus 16 external to the tubular string in a subterranean well is also provided. The method includes the steps of: interconnecting a valve 18 in the tubular string 12, the valve including at least one opening 20 for providing fluid communication between the interior flow passage 22 and the annulus 16; applying a first increased pressure to the interior flow passage 22 while fluid communication through the opening 20 between the interior flow passage and the annulus 16 is prevented, thereby permitting fluid communication through the opening 20 between the interior flow passage 22 and the annulus 16; and then applying a second increased pressure to the interior flow passage 22 while fluid communication through the opening 20 between the interior flow passage and the annulus 16 is permitted, thereby preventing fluid communication through the opening between the interior flow passage and the annulus.

The step of applying the first increased pressure may also include selectively admitting the first increased pressure to a first internal chamber 66 of the valve 18, thereby causing a closure device 24 of the valve to displace in a first direction to permit fluid communication through the opening 20. The step of applying the second increased pressure may also include selectively admitting the second increased pressure to a second internal chamber 68 of the valve 18, thereby causing the closure device 24 to displace in a second direction opposite to the first direction to prevent fluid communication through the opening 20.

The step of applying the second increased pressure may also include applying the second increased pressure to the annulus 16.

Each of the increased pressure applying steps may also include displacing an internal generally tubular closure device 24 of the valve 18.

The method may also include the step of displacing an internal sleeve 36 from an interior of the valve 18 to selectively permit and prevent fluid communication through the opening 20 between the interior flow passage 22 and the annulus 16.

The method may also include the step of applying a biasing force from a piston arrangement 38, 42 of a sealing device 40 to a metal-to-metal seal 30 which selectively prevents fluid communication through the opening 20, and wherein the piston arrangement applies the biasing force to the metal-to-metal seal in response to pressure in the interior flow passage 22 being greater than pressure in the annulus 16, and in response to pressure in the interior flow passage being less than pressure in the annulus.

The step of applying the first increased pressure may also include displacing a closure device 24 of the valve 18 in a first direction, and the step of applying the second increased pressure may also include then releasing the second increased pressure, thereby displacing the closure device 24 in a second direction opposite to the first direction.

Of course, a person skilled in the art would, upon a careful consideration of the above description of representative embodiments of the invention, readily appreciate that many modifications, additions, substitutions, deletions, and other changes may be made to these specific embodiments, and such changes are within the scope of the principles of the present invention. Accordingly, the foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the present invention being limited solely by the appended claims and their equivalents.

Claims

1. A method of controlling circulation flow between an interior flow passage of a tubular string and an annulus external to the tubular string in a subterranean well, the method comprising the steps of:

interconnecting a valve in the tubular string, the valve including at least one opening;

applying a first increased pressure to the interior flow passage while fluid communication through the opening between the interior flow passage and the annulus is prevented and while the interior flow passage through the valve is unobstructed, thereby permitting fluid communication through the opening between the interior flow passage and the annulus prior to release of the first increased pressure;

and then applying a second increased pressure to the interior flow passage while fluid communication through the opening between the interior flow passage and the annulus is permitted and while the interior flow passage through the valve remains unobstructed, thereby preventing fluid communication through the opening between the interior flow passage and the annulus.

2. The method of claim 1, wherein the step of applying the first increased pressure further comprises selectively admitting the first increased pressure to a first internal chamber of the valve, thereby causing a closure device of the valve to displace in a first direction to permit fluid communication through the opening.

3. The method of claim 2, wherein the step of applying the second increased pressure further comprises selectively admitting the second increased pressure to a second internal chamber of the valve, thereby causing the closure device to displace in a second direction opposite to the first direction to prevent fluid communication through the opening.

4. The method of claim 1, wherein the step of applying the second increased pressure further comprises applying the second increased pressure to the annulus.

5. The method of claim 1, wherein each of the increased pressure applying steps further comprises displacing an internal generally tubular closure device of the valve.

6. The method of claim 1, further comprising the step of displacing an internal sleeve from within an interior of the valve to selectively permit and prevent fluid communication through the opening between the interior flow passage and the annulus.

7. The method of claim 1, further comprising the step of applying a biasing force from a piston arrangement of a sealing device to a metal-to-metal seal which selectively prevents fluid communication through the at least one opening, and wherein the piston arrangement applies the biasing force to the metal-to-metal seal in response to pressure in the interior flow passage being greater than pressure in the annulus, and in response to pressure in the interior flow passage being less than pressure in the annulus.

8. The method of claim 1, wherein the step of applying the first increased pressure further comprises displacing a closure device of the valve in a first direction, and wherein the step of applying the second increased pressure further comprises then releasing the second increased pressure, thereby displacing the closure device in a second direction opposite to the first direction.

9. A method of controlling circulation flow between an interior flow passage of a tubular string and an annulus external to the tubular string in a subterranean well, the method comprising the steps of:

interconnecting a valve in the tubular string, the valve including at least one opening which provides fluid communication between the interior flow passage and the annulus, and the valve including an internal generally tubular closure member which selectively permits and prevents fluid communication through the opening;

applying a first increased pressure to the interior flow passage, while fluid communication between the interior flow

passage and the annulus is prevented, thereby permitting fluid communication through the opening prior to release of the first increased pressure; and

then applying a second increased pressure to the interior flow passage, while fluid communication between the interior flow passage and the annulus is permitted, thereby preventing fluid communication through the opening.

10. The method of claim 9, wherein the step of applying the first increased pressure further comprises selectively admitting the first increased pressure to a first internal chamber of the valve, thereby causing the closure member to displace in a first direction to permit fluid communication between the interior flow passage and the annulus through the opening.

11. The method of claim 10, wherein the step of applying the second increased pressure further comprises selectively admitting the second increased pressure to a second internal chamber of the valve, thereby causing the closure member to displace in a second direction opposite to the first direction and preventing fluid communication between the interior flow passage and the annulus through the opening.

12. The method of claim 9, wherein the step of applying the second increased pressure further comprises applying the second increased pressure to the annulus.

13. The method of claim 9, further comprising the step of rotationally displacing an internal sleeve within an interior of the valve, thereby selectively permitting and preventing fluid communication between the interior flow passage and the annulus through the opening.

14. The method of claim 9, further comprising the step of applying a biasing force from a piston arrangement of a sealing device to a metal-to-metal seal which selectively prevents fluid communication through the opening, and wherein the piston arrangement applies the biasing force to the metal-to-metal seal in response to pressure in the interior flow passage being greater than pressure in the annulus, and in response to pressure in the interior flow passage being less than pressure in the annulus.

15. The method of claim 9, wherein the step of applying the first increased pressure further comprises displacing the closure member of the valve in a first direction, and wherein the step of applying the second increased pressure further comprises then releasing the second increased pressure, thereby displacing the closure member in a second direction opposite to the first direction.