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Float Valve Apparatus Having Metal-to-Metal Seals and Method for Using Same

Abstract

A float valve assembly has a moveable dart member biased in a normally-closed position in a housing. A baffle strainer member can be operationally attached to the housing using mating thread in order to provide a metal-to-metal fluid pressure seal between the baffle strainer member and the housing. External threads on the baffle strainer member can also mate with internal threads in a central through bore of a tubular carrier sub in order to provide a metal-to-metal fluid pressure seal between the baffle strainer member and the carrier sub.

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Background/Summary

CROSS REFERENCES TO RELATED APPLICATION [0001] THIS APPLICATION IS A CONTINUATION OF U.S. patent application Ser. No. 18/650,826, FILED Apr. 30, 2024, CURRENTLY PENDING, AND CLAIMS PRIORITY OF U.S. DESIGN patent application Ser. No. 29/891,173, FILED May 2, 2023 (NOW ISSUED AS U.S. patent D1,062,998) AND U.S. PROVISIONAL PATENT APPLICATION Ser. No. 63/518,612, FILED Aug. 10, 2023, ALL INCORPORATED HEREIN BY REFERENCE.

STATEMENTS AS TO THE RIGHTS TO THE INVENTION MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT
[0002] NONE
BACKGROUND OF THE INVENTION
1. Field of the Invention
[0003] The present invention pertains to an improved float sub for use in connection with oil and gas drilling operations including, without limitation, in vertical, horizontal and/or directional well bores. More particularly still, the present invention pertains to a float sub including at least one float valve assembly that does not comprise or utilize sealing elements constructed of rubber or synthetic elastomeric materials.
2. Description of Related Art
[0004] During the drilling of oil and/or gas wells, drilling rigs and associated equipment can be used to manipulate and move tubular goods (including, without limitation, drill pipe, casing and/or other tubulars) into and out of wellbores that extend into subterranean strata. For example, drill bits and/or other down hole equipment are typically conveyed into a wellbore and maneuvered within said wellbore using a tubular work string made up of a plurality of individual sections of drill pipe (frequently called “joints”). The individual joints are joined in end-to-end relationship at said drilling rig and installed in a wellbore until a pipe string (known as a “drill string”) is formed having a desired length.
[0005] Various fluids, commonly referred to as drilling mud and/or drilling fluids, are often pumped into a through-bore of said pipe string during well drilling and/or completion operations. The drilling mud typically exits at least one port or outlet near the distal end of the pipe string; the fluid is then circulated back to the earth's surface through the annular space formed between the exterior of the drill string and the interior of the surrounding wellbore. In certain circumstances, such drilling fluid can be “reverse” circulated. In such cases, the fluid flows from said annular space, through said at least one port or outlet (in the opposite direction from the example described above), and into the central through-bore of the pipe string.
[0006] Float subs have been used in connection with certain oil and gas drilling operations. Generally, float subs comprise a housing having at least one check or “float” valve disposed within said housing. Typically, a float sub comprising at least one spring biased check valve is positioned a predetermined distance (for example, one or two pipe sections or “joints”) above the bottom or distal end of the drill string. Such float (check) valves typically remain in a normally-closed position.
[0007] When sufficient force acts on said check valve—typically via fluid pressure of drilling mud, cement or other fluid pumped down the inner bore of the drill string—said check valve opens, permitting pumped fluid to flow through said open check valve and out flow port(s) near the distal end of the drill string. Importantly, float valves prevent fluid flow in the opposite direction (that is, from the bottom of the drill string upward) through the central bore of the drill string. As such, float valves prevent drilling mud present in a wellbore from entering the drill string while said drill string is being lowered into said wellbore. Put another way, the float valve allows the drill string to

“float” during its descent into a well. During cementing operations, when cement is pumped down the central through-bore of the drill string and out the distal end of the drill string, float valve(s) also prevent unwanted backflow of cement into the central bore of the pipe string.
[0008] Fluid flow through a float valve is controlled by forces acting on a biased sealing member movably positioned within a float valve body. At least one spring biases said valve sealing member in a closed and sealed relationship against a seat on the interior surface of the float valve body. When a predetermined force (acting in the direction of the lower or distal end of the drill string) overcomes said biasing force, said valve sealing member will at least partially open and permit fluid to flow through said valve. It is to be understood that a float valve constitutes a restriction to flow within the inner bore of a drill string. This restriction can impact the functionality of the drilling operation and can create wear on those parts of the float valve exposed to fluid flow.
[0009] Conventional float valves utilize fluid pressure seals (such as O-rings and bushings) constructed of rubber or—more commonly in current operations—synthetic elastomeric materials. These conventional fluid pressure seal members work well in “normal” conditions. However, over time, many significant improvements have been made to drilling operations and capabilities; as such, long-reach lateral and horizontal wells are currently being drilled in ever-more challenging environments. As a result, many float valves are exposed to extremely high temperatures, high pressures and/or exotic drilling muds and additives. In many cases, such rubber and synthetic elastomeric materials suffer from poor performance—if not outright catastrophic failure—in such challenging high-temperature and/or high-pressure environments.
[0010] Those skilled in the art would recognize that failure of a float valve can have significant adverse consequences on drilling operations. Any failed equipment in a drill string typically requires that the drill string be removed from a well bore, the failed equipment be repaired or replaced, and the entire assembly be re-installed in the well bore. This typically interferes with ongoing drilling operations and leads to additional costs. In extreme cases, a failing float valve can result in highly unsafe conditions, potentially causing death, personal injury and/or catastrophic damage to property.
[0011] Thus, there is a need for a float sub having at least one float valve that does not utilize fluid pressure seals (such as O-rings and bushings) constructed of rubber or synthetic elastomeric materials. The improved float valve should comprise metal-to-metal seals within said float sub, thereby making the float valve(s) less likely to fail, even in challenging environments having extremely high temperatures, high pressures and/or damaging drilling muds and additives.

SUMMARY OF THE INVENTION

[0012] The present invention comprises a method and apparatus for controlling downhole pressure in a drill string. In a preferred embodiment, the present invention comprises a plurality of float valve assemblies that can be beneficially arranged in a desired configuration. In one common arrangement, said float valve assemblies of the present invention can be arranged in a combination of at least two stacked float valve assemblies, comprising first (upper) and second (lower) float valve assemblies installed within a central flow bore of at least one tubular carrier member.
[0013] Each float valve assembly comprises an interchangeable float assembly body apparatus which, in turn, generally comprises a housing with center brace, a sealing dart and a shaped dart shaft movably received within a dart shaft guide. A heavy-duty spring biases said sealing dart in a closed position as detailed more fully herein. Said housing can be investment cast in a single unit comprising center brace unit and dart shaft guide. Further, said sealing dart, when in a normally-closed position, can cooperate with an opposing seat surface to form an internal metal-to-metal seal.
[0014] Each housing can be machined or otherwise manufactured with a thread having desired dimensions (such as, for example, 3.5 12P UN V) to form a housing threaded seal. Moreover, each such housing can be heat treated in the presence of carbon monoxide to carburize the surface for additional hardness and wear resistance; said heat treatment can beneficially result in a hardness

rating of at least 55 Rockwell.
[0015] In one embodiment, a baffle sealing apparatus can be operationally attached to a float assembly (typically, an upper float valve assembly) body apparatus. Said baffle sealing apparatus can be machined or otherwise manufactured with a thread that matches the thread of said housing (such as, for example, 3.5 12P UN V) of said float assembly body apparatus. Further, said baffle sealing apparatus can also be machined or otherwise manufactured with an external thread (such as with a 4.00 12P UN V or 10P STUB ACME thread pattern) to mate with matching threads on the inner threaded sealing area of the metal tubular carrier. Said threaded baffle sealing unit can incorporate a baffle strainer comprising a plurality of arranged openings of varying sizes to trap and/or filter out foreign objects that can damage and/or render the float assembly inoperative.
[0016] In one embodiment, a seal housing is operationally attached to a float assembly (typically, a lower float valve assembly) housing and contains a plurality of precision seal channels that are configured to contain synthetic multi seals. Said synthetic multi seals can comprise rigid temperature and pressure resistant materials such as, for example, solid PTFE (Teflon), Polyether Ether Ketone (PEEK) and Para-Aramid (KEVLAR). Said synthetic multi seals can be molded or machined to closely fit within the precision seal channels of said seal housing and can be relieved on a 16-degree bias to facilitate installation. Said bias relief can be beneficially installed in a staggered arrangement to maintain positive seal.
[0017] The present invention, and particularly the aforementioned metal-to-metal seals formed therein provide an especially important mechanism, particularly when used in connection with managed pressure drilling (MPD) technique(s) employed during the drilling of horizontal well lateral sections. The MPD drilling technique is a method for maintaining pressure on the anulus of a well bore to maintain the integrity of said well bore walls while adding drill pipe to a drill string (making a connection) or removing a section of drill pipe from the drill string (tripping out of the hole). During such operations it is imperative that downhole float valve assemblies remain intact in order to prevent uncontrolled backflow of drilling fluids in the drill string.
[0018] It is the standard procedure many operators of drilling rigs to utilize multiple conventional float valves with synthetic elastomeric polymers with seals of different material makeup. With excessive down hole temperatures (frequently approaching 400+ F), increasing pump pressures for drilling fluids used to remove hole cuttings to the surface, and back pressure from MPD operations, conventional “synthetic rubber” seals prematurely fail from excessive heat, wear, and chemical degradation from oil base mud additives and carbon dioxide (CO2), hydrogen sulfide (H2S), and methane gases from the well bore. The metal-to-metal seals formed by the float valve assemblies and the tubular carrier of the present invention forms an impervious fluid pressure seal.

Description

BRIEF DESCRIPTION OF THE ANNOTATED DRAWINGS/FIGURES
[0019] The foregoing summary, as well as any detailed description of the preferred embodiments, is better understood when read in conjunction with the drawings and figures contained herein. For the purpose of illustrating the invention, the drawings and figures show certain preferred embodiments. It is understood, however, that the invention is not limited to the specific methods and devices disclosed in such drawings or figures.
[0020] Further, the drawings constitute a part of this specification and include exemplary embodiments of the invention. It is to be understood that in some instances, various aspects of the invention may be shown exaggerated or enlarged to facilitate an understanding of the invention. Therefore, the drawings may not be to scale.
[0021] FIG. **1** depicts a side view of a float valve body assembly of the present invention.
[0022] FIG. **2** depicts a side sectional view of a float valve body assembly of the present invention.

[0023] FIG. **3** depicts a side view of a float valve assembly of the present invention with an upper baffle sealing member installed.
[0024] FIG. **4** depicts an end view of said upper threaded baffle sealing member of said float valve assembly of the present invention.
[0025] FIG. **5** depicts a side perspective view of said float valve assembly of the present invention with said upper baffle sealing member installed.
[0026] FIG. **6** depicts a side sectional view of said float valve assembly of the present invention with said upper baffle sealing member installed.
[0027] FIG. **7** depicts a side view of a float valve assembly of the present invention with a seal assembly (but no external sealing members) installed.
[0028] FIG. **8** depicts a side view of a float valve assembly of the present invention with a seal assembly and external sealing members installed.
[0029] FIG. **9** depicts a side view of an external sealing member of the present invention.
[0030] FIG. **10** depicts a top view of an external sealing member of the present invention.
[0031] FIG. **11** depicts a side sectional view of a float sub housing of the present invention.
[0032] FIG. **12** depicts a side sectional view of a float sub of the present invention with first and second float valves installed.
[0033] FIG. **13** depicts a side sectional view of the float sub, configured as depicted in FIG. **10**, installed downhole within a subterranean wellbore.
[0034] FIG. **14** depicts a side view of a second embodiment adapter member of the present invention.
[0035] FIG. **15** depicts an end view of said second embodiment adapter member of the present invention.
[0036] FIG. **16** depicts a side sectional view of said second embodiment adapter member of the present invention along line A-A of FIG. **14**.
[0037] FIG. **17** depicts a side perspective view of said second embodiment adapter member of the present invention.
[0038] FIG. **18** depicts a side sectional view of a float sub with first and second float valves, as well as said second embodiment adapter member, installed.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

[0039] Before describing various embodiments of the present disclosure in further detail by way of exemplary description, examples, and results, it is to be understood that the apparatus and methods of the present disclosure are not limited in application to the details of specific embodiments and examples as set forth in the following description. The description provided herein is intended for purposes of illustration only and is not intended to be construed in a limiting sense. As such, the language used herein is intended to be given the broadest possible scope and meaning, and the embodiments and examples are meant to be exemplary, not exhaustive. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description only and should not be regarded as limiting unless otherwise indicated as so. Moreover, in the following detailed description, numerous specific details are set forth in order to provide a more thorough understanding of the present disclosure.
[0040] It will be apparent to a person having ordinary skill in the art that the present disclosure may be practiced without these specific details. In other instances, features which are well known to persons of ordinary skill in the art have not been described in detail to avoid unnecessary complication of the description. It is intended that all alternatives, substitutions, modifications, and equivalents apparent to those having ordinary skill in the art are included within the scope of the present disclosure. Thus, while the apparatus and methods of the present disclosure have been described in terms of particular embodiments, it will be apparent to those of skill in the art that variations may be applied to the apparatus and methods and the steps or in the sequence of steps of the methods described herein without departing from the concept, spirit, and scope of the inventive

concepts.
[0041] In a preferred embodiment, the present invention comprises a float valve system for controlling pressure in a drill string comprising some combination of first (upper) and second (lower) float valve assemblies, as described more fully herein. FIG. **1** depicts a side view of a float valve body assembly **100** of the present invention. Said float valve body assembly **100** generally comprises substantially cylindrical housing **102** having at least one side opening defining window **131** that permits easy access to central bore **132** of said housing member **102**.
[0042] Center brace member **114** and dart shaft guide **108** are disposed in said central bore **132** of housing member **102**. Shaped dart shaft **109** is movably disposed within said dart shaft guide **108**; in a preferred embodiment, said shaped dart shaft **109** has three sides defining a triangular cross section. Bias spring **103** is generally disposed between center brace **114** and spring shield **104** in in said central bore **132** of housing member **102**; in the embodiment depicted in FIG. **1**, said bias spring **103** comprises a coil spring, with dart shaft **109** disposed through the central opening along the longitudinal axis of said bias spring **103**. Sealing dart **106** extends beyond upper end surface **107** of housing member **102** and is biased by bias spring **103**.
[0043] FIG. **2** depicts a side sectional view of a float valve body assembly **102** of the present invention. Said housing member **102** has a substantially cylindrical shape having at least one window **131** opening into central bore **132** of said housing member **102**. Center brace member **114** and dart shaft guide **108** are disposed in said central bore **132** of housing member **102**. Shaped dart shaft **109** is movably disposed within through bore **108***a* of said dart shaft guide **108**. Bias spring **103** is disposed between center brace **114** and spring shield **104**, while dart shaft **109** is disposed through the central longitudinal opening of said coil bias spring **103**.
[0044] Female threads **112** are disposed on the inner surface of said lower housing **102**. Although other thread configurations can be used without departing from the scope of the present invention, said female threads **112** can comprise 3.5 12P UN V threads. Dart shaft **109** having triangular cross section is moveably disposed within central bore **108***a* of dart shaft guide **108**, while sealing dart **106** extends beyond upper end surface **107** of housing member **102** and is acted upon by bias spring **103**.
[0045] FIG. **3** depicts a side view of a float valve assembly **100** of the present invention with an upper baffle sealing member **120** installed. Said float valve assembly **100** generally comprises cylindrical housing **102** having central bore **132**. Center brace member **114** and dart shaft guide **108** are disposed in said central bore **132**. Shaped dart shaft **109** is movably disposed within said dart shaft guide **108**; in a preferred embodiment, said shaped dart shaft **109** has three sides defining a triangular cross section. Bias spring **103** is generally disposed between center brace **114** and spring shield **104**. Threaded baffle strainer member **120** having external threads **117** is operationally attached to housing **102**.
[0046] Said housing member **102** can be investment cast in a single unit comprising center brace member **114** and dart shaft guide **108**. Threaded baffle strainer member **120** disposed near the upper end **107** of said housing **102** can be machined with an external connection thread **117** having desired dimensions (such as, for example, 3.5 12P UN V). Said housing **102** can also be beneficially heat treated in the presence of carbon monoxide to carburize the surface of said housing **102** for additional hardness and wear resistance; said heat treatment can beneficially result in a hardness rating of at least 55 Rockwell.
[0047] FIG. **4** depicts an end view of a threaded baffle strainer member **120** of said float valve assembly **100** of the present invention. Said threaded baffle strainer member **120** can comprise a plurality of openings **128** of varying shapes, sizes and orientations that extend through said baffle strainer **120**. When installed on said float valve assembly **100**, said openings **128** of said baffle strainer **120** act to trap and/or filter out foreign objects that can damage and/or render said first or upper float assembly **100** (and, more specifically, components within central bore **132**) inoperative. External connection threads **117** can be disposed along the outer surface of said threaded baffle

strainer member **120**.
[0048] FIG. **5** depicts a side perspective view of said float valve assembly **100** of the present invention. Said float valve assembly **100** generally comprises housing member **102** having a substantially cylindrical shape. Side openings define windows **131** that permit easy access to central bore **132** of said housing member **102**. Center brace member **114** and dart shaft guide **108** are disposed in said central bore **132** of housing member **102**.
[0049] Shaped dart shaft **109** is movably disposed within central bore **108***a* of said dart shaft guide **108**; in a preferred embodiment, said shaped dart shaft guide **109** has three sides defining a triangular cross section. Bias spring **103** is generally disposed between center brace **114** and spring shield **104**, while threaded baffle strainer member **120** is operationally attached to housing **102**. Threaded baffle strainer member **120** has a plurality of concentric openings **128**, while external connection threads **117** are disposed along the outer surface of said threaded baffle strainer member **120**.
[0050] FIG. **6** depicts a side sectional view of float valve assembly **100** of the present invention. Referring to FIG. **6**, said housing member **102** can have a substantially cylindrical shape having side openings defining windows **131** into central bore **132** of said housing member **102**. Center brace member **114** and dart shaft guide **108** are disposed in said central bore **132** of housing member **102**. Shaped dart shaft **109** is movably disposed within through bore **108***a* of said dart shaft guide **108**; in the embodiment depicted in FIG. **6**, said shaped dart shaft **109** has three sides defining a triangular cross section. Bias spring **103** is generally disposed between center brace **114** and spring shield **104**.
[0051] Threaded baffle strainer member **120** is operationally attached to housing **102** at upper end **107** thereof. In a preferred embodiment depicted in FIG. **6**, said threaded baffle strainer member **120** comprises lower extension member **121** having external male threads **110**. Said external threads **110** can engage and mate with opposing female threads **112** disposed on the inner surface of lower housing **102**, thereby forming a metal-to-metal fluid pressure seal between said threaded baffle strainer member **120** and housing **102**. Threaded baffle strainer member **120** can comprise a plurality of openings **128** that extend through said baffle strainer member **120**, while external connection threads **117** are disposed along the outer surface of said threaded baffle strainer member **120**.
[0052] Said external male threads **110** can be machined with a matching thread (such as, for example, 3.5 12P UN V) to mate with opposing female threads **112** disposed on the inner surface of lower housing **102** to form a metal-to-metal fluid pressure seal. Additionally, said external connection threads **117** along the outer surface of baffle strainer member **120** can be machined (such as with a 4.00 12P UN V or 10P STUB ACME thread pattern) to mate with a matching thread pattern along an inner threaded sealing area of a tubular carrier to form another metal-to-metal fluid pressure seal described more fully herein.
[0053] Triangular dart shaft **109** is moveably disposed within central bore **108***a* of dart shaft guide **108**. Sealing dart **106** is biased in a normally closed position by bias spring **103**; in this closed position, tapered external sealing surface **105** of said sealing dart **106** engages with and forms an internal metal-to-metal seal against opposing tapered internal sealing surface **101** of threaded baffle strainer member **120** and, more specifically, extension **121** thereof.
[0054] FIG. **7** depicts a side view of a float valve assembly **100** of the present invention with a seal assembly **140** (but no external sealing members) installed. Said float valve assembly **100** generally comprises a housing **102** having center brace member **114** and dart shaft guide **108**. Said housing member **102** has a substantially cylindrical shape having at least one side opening defining window **131** that permits easy access to central bore **132** of said housing member **102**. Shaped dart shaft **109** is movably disposed within said dart shaft guide **108**, while bias spring **103** is disposed on center brace **114**.
[0055] Seal housing **140** is operationally attached to housing member **102**; in a preferred

embodiment, said seal housing **140** is operationally attached to housing member **102** at upper end **107** thereof. Said seal housing **140** comprises a plurality (4 in the example depicted) of precision seal channels **141** that extend around the circumference of said upper seal housing **140** and are oriented substantially parallel to each other (and perpendicular to the longitudinal axis of housing member **102**. Said precision seal channels **141** are configured to receive seal members. It is to be observed that more or less than four (4) precision seal channels **141** can be employed without departing from the scope of the present invention.

[0056] FIG. **8** depicts a side view of a float valve assembly **100** of the present invention with a seal housing **140** and external sealing members **142** installed. Seal housing **140** is operationally attached to housing **102** at upper end **107** thereof. Although not visible in FIG. **8**, it is to observed that seal housing **140** can comprise external threads **110** that can engage and mate with opposing female threads **112** disposed on the inner surface of lower housing **102** (visible in FIG. **6**), thereby forming a metal-to-metal fluid pressure seal between said seal housing **140** and housing **102**. A plurality of precision seal members **142** are received within parallel seal channels **141** (depicted in FIG. **5**) around the circumference of said upper seal housing **140**.

[0057] FIG. **9** depicts a side view of an external sealing member **142** of the present invention, while FIG. **10** depicts a top view of an external sealing member **142**. In a preferred embodiment, said synthetic multi precision seal members **142** can be constructed from rigid temperature and pressure resistant materials such as, for example, Solid PTFE (marketed under the brand name Teflon"), Polyether Ether Ketone (PEEK) and Para-Aramid (marketed under the brand name "KEVLAR"). Said synthetic multi seal members **142** can be molded or machined to fit the precision seal channels **141** (best shown in FIG. **5**) and can be relieved on a 16-degree bias relief **145** to facilitate installation. Said bias relief **145** is beneficially arranged in a staggered orientation in order to maintain positive seal.

[0058] As previously noted, the present invention, and particularly the aforementioned metal-to-metal seals, comprise an especially important mechanism used in the MANAGED PRESSURE DRILLING (MPD) technique used in connection with drilling of horizontal well lateral sections. As previously noted, the MPD technique involves applying fluid pressure on the anulus of a well bore to maintain the integrity of well bore walls while adding drill pipe to drill string (making a connection) or removing a joint of drill pipe or stand from the drill string (tripping out of the hole). During such operations it is imperative that downhole float valve(s) maintain a fluid pressure seal in order to prevent uncontrolled backflow of drilling fluids from the annulus through the drill string by the downhole pressure being created by the MPD operation.

[0059] FIG. **11** depicts a side sectional view of a float carrier sub **200** of the present invention (with no float valve assemblies installed). Said tubular float carrier sub **200** comprises a metal tubular body member **201** of predetermined outside diameter (OD) and length, with a box end (female) threaded connection **202** and pin end (male) threaded connection **203**. Tubular body member **201** has a centered through bore **204** extending from said box connection **202** to said pin connection **203**; said through bore **204** includes precision bore section **205** to accommodate float valve assemblies, as more fully set forth herein, as well as band **209** along its internal diameter. Relief groove **206**, inner threaded receiver **207** and repair allowance **208** are machined to predetermined specifications.

[0060] FIG. **12** depicts a side sectional view of a float carrier sub **200** of the present invention with first (lower) float valve assembly **400** and second (upper) float valve assembly **300** installed. In the embodiment depicted in FIG. **12**, it is to be observed that first (lower) float valve assembly **400** is configured in accordance with the float valve assembly depicted in FIG. **8**, while said second (upper) float valve assembly **300** is configured in accordance with the float valve assembly depicted in FIG. **3**.

[0061] Still referring to FIG. **12**, said float carrier sub **200** generally comprises a first (lower) float valve assembly **400** that is inserted into precision bore **205** of float carrier sub **200** until seated. A

second (upper) float assembly **300** is then lowered into said precision bore **205** of float carrier sub **200** until threads of inner threaded receiver **207** engage with external threads **117** (of baffle strainer member). Torques forces can be applied to said second (upper) float valve assembly **300** (ideally manually) to predetermined torque values. Said float carrier sub **200** (together with float valve assemblies **300** and **400**) can be installed at a predetermined location within a drill string, such as depicted in FIG. **13**.

[0062] FIG. **13** depicts a side sectional view of float carrier sub **200**, configured as depicted in FIG. **12**, installed downhole within a subterranean wellbore **500**. Said float carrier sub **200** (as well as included float valve assemblies **300** and **400**) can be conveyed to a desired depth within said subterranean wellbore **500** using tubular work string **510**.

[0063] Drilling rig operators typically utilize multiple conventional float valves with synthetic elastomeric polymers with seals of different material makeup. With excessive down hole temperatures (frequently approaching 400+ F), increasing pump pressures for drilling fluids used to remove hole cuttings to the surface, and back pressure from MPD operations, conventional "synthetic rubber" seals prematurely fail from excessive heat, wear, and chemical degradation from oil base mud additives and CO2, H2S, methane and/or other gases from the well bore.

[0064] However, it is imperative that downhole float valve(s) remain intact to prevent uncontrolled backflow of drilling fluids being forced into the central flow bore of the drill string by the downhole pressure, particularly those created by the MPD operations. The metal-to-metal seal formed by second (upper) float valve assembly **300** and float carrier sub **200** forms metal-to-metal fluid pressure seal that is impervious to fluid flow. As such, fluid will not flow around float valve assemblies **300** and **400**—that is, between the exterior of said float valve assemblies and the internal surface of bore **205** of float carrier sub **200**. Further, a metal-to-metal seal prevents fluid from flowing through the interface between threaded baffle strainer member **120** and housing **102**. Additionally, a fluid first (lower) float valve assembly **400** can utilize a plurality of solid synthetic seals (typically 4) disposed in stacked arrangement to further assist in control of back pressure.

[0065] FIG. **14** depicts a side view of a second embodiment adapter member **150** of the present invention, while FIG. **15** depicts an end view of said second embodiment adapter member **150**. FIG. **16** depicts a side sectional view of said second embodiment adapter member **150** along line A-A of FIG. **14**, while FIG. **17** depicts a side perspective view of said second embodiment adapter member **150**. Referring to FIG. **14** through **18**, second embodiment adapter member **150** generally comprises central cylindrical body section **151**, lower external threads **152**, upper extension **153** (having tapered inner surface **155**) and central through bore **154**. Said external threads **152** can engage and mate with opposing female threads **112** disposed on the inner surface of a lower housing **102** (depicted, for example, in FIG. **2**), thereby forming a metal-to-metal fluid pressure seal between said second embodiment adapter member **150** and a housing **102**.

[0066] FIG. **18** depicts a side sectional view of a float sub with first (lower) float valve assembly **500** and second (upper) float valve assembly **300**; said second embodiment adapter member **150** is installed as part of first (lower) float valve assembly **500**. Said float carrier sub **200** generally comprises a first (lower) float valve assembly **500** that is inserted into precision bore **205** of float carrier sub **200** until seated. A second (upper) float assembly **300** is then lowered into said precision bore **205** of float carrier sub **200** until threads of inner threaded receiver **207** engage with external threads **117** (of baffle strainer member). Said float carrier sub **200** (together with float valve assemblies **300** and **500**) can be installed at a predetermined location within a drill string.

[0067] In operation, as depicted in FIG. **13**, float carrier sub **200** (as well as included float valve assemblies **300** and **400**) can be conveyed to a desired depth within a subterranean wellbore using tubular drill string or casing string. Said float carrier sub can be positioned a predetermined distance (for example, one or two pipe joints) above the bottom or distal end of the drill string or casing string.

[0068] Referring to FIG. **6**, sealing dart **106** of float valve assembly **300** is biased in a normally

closed position by bias spring **103**; in this closed position, tapered external sealing surface **105** of said sealing dart **106** engages with and forms an internal metal-to-metal seal against opposing tapered internal sealing surface **101** of threaded baffle strainer member **120** and, more specifically, extension **121** thereof.

[0069] When sufficient predetermined force acts on said sealing dart **106**—typically via fluid pressure of drilling mud, cement or other fluid pumped down the inner bore of the drill string—said bias spring **103** partially compresses, forcing said sealing surface **105** of sealing dart **106** to separate from sealing surface **101** and form an opening. Pumped fluid can flow through said opening; however, sealing dart **106** cooperates with sealing surface **101** to prevent fluid flow in the opposite direction. Referring to FIG. **12**, said float valve assembly **300** is received within precision bore **205** of float carrier sub **200** until threads of inner threaded receiver **207** engage with external threads **117** (of baffle strainer member), thereby forming a metal-to-metal fluid pressure seal between said float valve assembly **300** and carrier sub **200**.

[0070] The subject matter of the present invention is described with specificity herein to meet statutory requirements. However, the description itself is not intended to necessarily limit the scope of claims. Rather, the claimed subject matter might be embodied in other ways to include different steps or combinations of steps similar to the ones described in this document, in conjunction with other present or future technologies. Although the terms “step” and/or “block” or “module” etc. might be used herein to connote different components of methods or systems employed, the terms should not be interpreted as implying any particular order among or between various steps herein disclosed unless and except when the order of individual steps is explicitly described.

[0071] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided. One skilled in the relevant art will recognize, however, that the technology may be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

Claims

1. A float valve assembly comprising: a) a tubular sub member configured to be conveyed into a wellbore in a tubular string, said tubular sub member having a central through bore and internal connection threads disposed within said central through bore; b) a first float valve disposed within said central through bore of said tubular sub member, wherein said first float valve comprises external threads configured to engage in mating relationship with said internal connection threads of said tubular sub member; and c) a second float valve disposed within said central through bore of said tubular sub member, wherein said second float valve comprises at least one seal member disposed along an external surface of said second float valve, and wherein said at least one seal member is configured to form a fluid pressure seal against an inner surface of said tubular sub member.

2. The float valve assembly of claim 1, wherein said internal threads of said tubular sub member and said external threads of said first float valve cooperate to form a fluid pressure seal.

3. The float valve assembly of claim 1, wherein said at least one seal member comprises a plurality of seal members oriented in perpendicular relationship to the longitudinal axis of said central through bore of said tubular sub member.

4. The float valve assembly of claim 1, wherein said first float valve assembly comprises: a) a housing defining an inner space, a flow port and a seat disposed around said flow port; b) a dart member comprising a dart shaft and a dart head; and c) a spring configured to bias said dart head against said seat and form a metal-to-metal fluid pressure seal across said flow port, wherein said dart head is configured to be at least partially displaced from said seat when a predetermined fluid

pressure acts on said dart head and opposes said bias force applied by said spring.
5. The float valve assembly of claim 4, wherein said dart head is substantially conical.
6. The float valve assembly of claim 4, wherein said seat is substantially circular.
7. The float valve assembly of claim 4, wherein said dart shaft has three sides.
8. The float valve assembly of claim 4, further comprising a baffle strainer member operationally attached to said housing, wherein said baffle strainer member is configured to filter out solid materials from passing through said flow port.
9. The float valve assembly of claim 4, further comprising at least one adapter member disposed between said first float valve and said second float valve.
10. A float valve assembly comprising: a) a tubular sub member configured to be conveyed into a wellbore in a tubular string, said tubular sub member having a central through bore and internal connection threads disposed within said central through bore; and b) a first float valve disposed within said central through bore of said tubular sub member, wherein said first float valve comprises external threads configured to engage in mating relationship with said internal connection threads of said tubular sub member, wherein said internal threads of said tubular sub member, and wherein said internal threads of said tubular sub member and said external threads of said first float valve cooperate to form a fluid pressure seal.
11. The float valve assembly of claim 10, further comprising a second float valve disposed within said central through bore of said tubular sub member, wherein said second float valve comprises at least one seal member disposed along an external surface of said second float valve, and wherein said at least one seal member is configured to form a fluid pressure seal against an inner surface of said tubular sub member.
12. The float valve assembly of claim 11, wherein said at least one seal member comprises a plurality of seal members oriented in perpendicular relationship to the longitudinal axis of said central through bore of said tubular sub member.
13. The float valve assembly of claim 10, wherein said first float valve assembly comprises: a) a housing defining an inner space, a flow port and a seat disposed around said flow port; b) a dart member comprising a dart shaft and a dart head; and c) a spring configured to bias said dart head against said seat and form a metal-to-metal fluid pressure seal across said flow port, wherein said dart head is configured to be at least partially displaced from said seat when a predetermined fluid pressure acts on said dart head and opposes said bias force applied by said spring.
14. The float valve assembly of claim 13, wherein said dart head is substantially conical.
15. The float valve assembly of claim 13, wherein said seat is substantially circular.
16. The float valve assembly of claim 13, wherein said dart shaft has three sides.
17. The float valve assembly of claim 13, further comprising a baffle strainer member operationally attached to said housing, wherein said baffle strainer member is configured to filter out solid materials from passing through said flow port.
18. The float valve assembly of claim 13, further comprising at least one adapter member disposed between said first float valve and said second float valve.