

Fluid Flow Devices

Related Applications

[0001] This application claims the benefit of United States Provisional Patent Application Serial No. 60/706,846 filed August 9, 2005, for FLUID FLOW DEVICES, the entire disclosure of which is fully incorporated herein by reference.

Background of the Invention

[0002] A variety of known fluid flow devices include first and second metal components disposed on opposite sides of a third metal component to press against the third metal component to form a seal. Examples of such known fluid flow devices are disclosed in US Patent Number 4,552,389 entitled "Fluid Coupling," US Patent Number 6,685,234 entitled "Fluid Fitting With Torque Suppression Arrangement," US Patent Number 4,687,017 entitled "Inverted Bellows Valve," US Patent Number 6,189,861 entitled "Diaphragm Valve," and US Patent Number 4,684,106 entitled "Valve," the entire disclosures of which are fully incorporated herein by reference.

Summary

[0003] The disclosure is directed broadly to fluid flow devices with one or more metal components that are at least partially hardened for forming a seal with another portion of the device that is softer than the hardened portion. An example of one such fluid flow device includes first and second metal components assembled on opposite sides of a third metal component. A load is applied by the first and second metal components to the third metal component. A hardened engaging portion is included on at least one of the metal components. The hardened engaging portion engages and plastically deforms the metal component it is pressed against to form a seal. In one embodiment, the hardened engaging portion indents into and plastically deforms the metal component it is pressed against to form a seal, while in another embodiment, the hardened engaging portion compresses and

plastically deforms a projecting portion or corner of the metal component it is pressed against. In another embodiment, the fluid flow device is a fluid coupling, a diaphragm valve, or a bellows valve.

[0004] Another inventive aspect disclosed in this application relates to hardening a portion of a fluid flow device for forming a seal with another portion of the device that is softer than the hardened portion. In one embodiment, a diffusion based surface treatment, such as for example, low temperature carburization, is used to produce a hardened surface without the formation of carbide precipitates. In this disclosure, reference to producing a hardened surface “without formation of carbide precipitates” means that the amount of carbide precipitates formed, if any, is too small to adversely affect the corrosion resistance of the hardened portion.

[0005] Further advantages and benefits will become apparent to those skilled in the art after considering the following description and appended claims in conjunction with the accompanying drawings.

Brief Description of the Drawings

[0006] In the accompanying drawings, which are incorporated in and constitute a part of the specification, embodiments of the invention are illustrated, which, together with a general description of the invention given above, and the detailed description given below, serve to exemplify embodiments of the invention

[0007] Figure 1 is a schematic illustration of a portion of a fluid flow device;

[0008] Figure 2 is a schematic illustration of a seal area of a fluid flow device;

[0009] Figure 3 is a schematic illustration of a seal area of a fluid flow device;

[0010] Figure 4 is a schematic illustration of a seal area of a fluid flow device;

[0011] Figure 5 is a schematic illustration of a seal area of a fluid flow device;

[0012] Figure 6 is a schematic illustration of a seal area of a fluid flow device;

[0013] Figure 7 is a schematic illustration of a seal area of a fluid flow device;

[0014] Figure 8 is a sectional view of a fitting;

[0015] Figure 9 is a sectional view of a seal area of a bellows valve;

[0016] Figure 10 is a sectional view of a seal area of a diaphragm valve; and

[0017] Figure 11 is a sectional view of a seal area of a diaphragm valve.

Detailed Description

[0018] The present application is directed broadly to fluid flow devices with metal to metal seals. The fluid flow device includes a first metal component having a hardened engaging surface or portion and a second metal component that is softer than the hardened portion. The second metal component is assembled with the first component such that the hardened surface engages and plastically deforms the second metal component to provide a metal to metal seal.

[0019] A fluid flow device in which at least a portion of one of the components that forms a metal to metal seal is hardened, may have certain advantages as compared to fluid flow devices that form metal to metal seals between two unhardened metal components. For example, hardening one or both of the metal components may allow for greater versatility in the materials used in a fluid flow device. In addition, hardening at least a portion of one of the components that forms a metal to metal seal may result in a seal that has a lower leak rate. Furthermore, hardening a surface that by low temperature carburization, or other hardening process, may increase the corrosion resistance of the surface, which may be advantageous in certain applications.

[0020] While the exemplary embodiments described herein are presented in the context of fluid flow devices, such as for example, a bellows valve, a diaphragm valve, and a fluid coupling, those skilled in the art will readily appreciate that the present invention may be configured in other ways. The fluid flow device may take a wide variety of different forms. In this application a fluid flow device refers to any device that fluid flows through. Examples of fluid flow devices include, but are not limited to valves, fittings, couplings, meters, and pumps. These examples and the disclosed exemplary embodiments are intended to illustrate the broad application of the invention and provide no limitation on the present invention.

[0021] While various inventive aspects, concepts and features of the inventions may be described and illustrated herein as embodied in combination in the exemplary embodiments, these various aspects, concepts and features may be used in many alternative embodiments, either individually or in various combinations and sub-combinations thereof. Unless expressly excluded herein all such combinations and sub-combinations are intended to be within the scope of the present inventions. Still further, while various alternative embodiments as to the various aspects, concepts and features of the inventions--such as alternative materials, structures, configurations, methods, circuits, devices and components, software, hardware, control logic, alternatives as to form, fit and function, and so on--may be described herein, such descriptions are not intended to be a complete or exhaustive list of available alternative embodiments, whether presently known or later developed. Those skilled in the art may readily adopt one or more of the inventive aspects, concepts or features into additional embodiments and uses within the scope of the present inventions even if such embodiments are not expressly disclosed herein. Additionally, even though some features, concepts or aspects of the inventions may be described herein as being a preferred arrangement or method, such description is not intended to suggest that such feature is required or necessary unless expressly so stated. Still further, exemplary or representative values and ranges may be included to assist in understanding the present disclosure, however, such values and ranges are not to be construed in a limiting sense and are intended to be critical values or ranges only if so expressly stated. Moreover, while various aspects, features and concepts may be expressly identified herein as being inventive or forming part of an invention, such identification is not intended to be exclusive, but rather there may be inventive aspects, concepts and features that are fully described herein without being expressly identified as such or as part of a specific invention, the inventions instead being set forth in the appended claims. Descriptions of exemplary methods or processes are not limited to inclusion of all steps as being required in all cases, nor is the order that the steps are presented to be construed as required or necessary unless expressly so stated.

[0022] In this disclosure, reference to carburizing stainless steel “without formation of carbide precipitates” means that the amount of carbide precipitates formed, if any, is too small to adversely affect the corrosion resistance of the stainless steel.

[0023] Figure 1 schematically illustrates an example of a fluid flow device 12. The fluid flow device 12 includes a metal seal component 14, and first and second metal clamping

components 16, 18. The clamping components 16, 18 are assembled on opposite sides of the seal component 14. The clamping components 16, 18 are pressed together as indicated by arrows 20, 22. Load is applied by the first and second clamping components 16, 18 to the seal component 14. Referring to Figures 2-7, one or more hardened engaging portions 10 are included on the seal component 14, the first clamping component 16, and/or the second clamping component 18. The hardened engaging portion 10 engages and plastically deforms the metal seal component 14, or one of the metal clamping components 16, 18 to form a seal. In the Figures 2-7, the hardened engaging portions 10 are illustrated as a portion extending or projecting from at least one of the seal component or clamping components to indent into the component it is being pressed against. The engaging portion, however, may be a hardened portion or surface that engages a non-hardened extending or projecting portion to compress and plastically deform the extending or projecting portion to form a seal without indenting into it.

[0024] The seal component 14 and the clamping components 16, 18 may take a variety of different forms in fluid flow devices 12. Examples of seal components include, but are not limited to, diaphragms used in diaphragm valves, bellows used in bellows valves, bellows supports used in bellows valves, and gaskets used in fittings. Examples of clamping components 16, 18 include, but are not limited to, valve bodies, such as diaphragm valve bodies and bellows valve bodies, and fitting gland members. The hardened engaging portion may take a variety of different forms. In an exemplary embodiment, the hardened engaging portion 10 is an annular, axially extending projection that is hardened by a diffusion based surface treatment. The hardened engaging portion may be formed by hardening the entire component that includes the hardened engaging portion or may be formed by hardening only a portion of the component that forms the hardened engaging portion. The hardened engaging portion is harder than the metal fluid flow device component that it engages in an exemplary embodiment. For example, stainless steel hardened by a low temperature carburization process may have a typical hardness of about 900-1100 Vickers, though higher hardness values, such as about 1400 Vickers have been achieved. Unannealed stainless steel, meanwhile, may have a hardness of about 250-350 Vickers and annealed stainless steel may have a hardness of about 125-175 Vickers. The actual hardness difference between the hardened engaging portion and the component is selectable by user.

[0025] The seal component 14 and the clamping components 16, 18 may be made from a wide variety of different metals. Examples include iron, copper, nickel, titanium, magnesium, manganese, alloys of these metals and any other metal or alloy known to be useful in making valves, valve components and other fluid flow devices. In one embodiment, the particular component or components which define hardened engaging portion 10 is made from a metal or metal alloy which has been case hardened by low temperature carburization or other hardening process to not only increase surface hardness but also preferably, although not necessarily, to increase corrosion resistance.

[0026] Low temperature carburization ("LTC") of stainless steel has been described in a number of publications including U.S. Patent No. 5,792,282, EPO 0787817, Japanese Patent Document 9-14019 (Kokai 9-268364), U.S. Patent No. 6,165,597 and U.S. Patent No. 6,547,888, the disclosures of which are fully incorporated herein by reference. In this technology, a workpiece is contacted with a carbon-containing gas at an elevated temperature less than 1000°F (538°C). As a result, high concentrations of elemental carbon diffuse into the workpiece surfaces without formation of carbide precipitates. The result is that surface hardness and corrosion resistance of the workpiece are significantly enhanced.

[0027] In low temperature carburization, atomic carbon diffuses interstitially into the workpiece surfaces, i.e., carbon atoms travel through the spaces between the metal atoms. Because the processing temperature is low, these carbon atoms form a solid solution with the metal atoms of the workpiece surfaces. They do not react with these metal atoms to form other compounds. Low temperature carburization is therefore different from normal carburization carried out at higher temperatures in which the carbon atoms react to form carbide precipitates, i.e., specific metal compounds such as $M_{23}C_6$ (e.g., $Cr_{23}C_6$ or chromium carbide), M_5C_2 and the like, arranged in the form of discrete phases separate and apart from the metal matrix in which they are contained.

[0028] Other processes are known for altering the surface characteristics of a metal workpiece. That is, other processes are known in which the hardness, corrosion resistance and/or other surface characteristic of a metal workpiece may be altered by interstitial diffusion of atoms into the workpiece surfaces to form solid solutions with the metal atoms therein without formation of new compounds in separate phases. Examples include nitriding of iron, chromium and/or nickel based alloys, carbo-nitriding of iron, chromium and/or nickel

based alloys, and nitriding of titanium-based alloys, to name a few. For convenience, all of these processes will be referred to collectively as “diffusion based surface treatments.” All such diffusion-based surface treatments can be applied using the technology of this disclosure.

[0029] In the technology of this disclosure, the hardened engaging portion 10 may be formed by making one or more components, or a portion of the components, from a metal or alloy that will case or surface harden in response to a diffusion-based surface hardening treatment. The component, or the portion of the component, may then be subjected to this hardening treatment. For example, if the hardened engaging portion 10 is formed in the clamping component 16 by low temperature carburization, then the entire clamping component 16 or just the portion to be hardened may be made from a metal or alloy that exhibits a hardening response to this particular diffusion process.

[0030] Metals and alloys which exhibit a hardening response to the diffusion-based surface treatments are known. For example, the materials which will exhibit a hardening response to low temperature carburization are described in the above-noted US Patent No. 5,792,282, U.S. Patent No. 6,093,303, U.S. Patent No. 6,547,888, EPO 0787817 and Japanese Patent Document 9-14019 (Kokai 9-268364), the disclosures of which are fully incorporated herein by reference. Examples include, but are not limited to: steels containing 5 to 50, preferably 10 to 40, wt.% Ni; alloys that contain 10 to 40 wt.% Ni and 10 to 35 wt.% Cr; stainless steels, such as AISI 300 and 400 series steels, including AISI 316, 316L, 317, 317L and 304 stainless steels; alloy 600; alloy 625; alloy 825; alloy C-276; alloy C-22 and alloy 20 Cb, to name a few.

[0031] In the same way, the materials that will exhibit a hardening response to the other diffusion-based surface treatments mentioned above are also known.

[0032] Figures 2-7 illustrate examples of configurations of the seal component 14, clamping members 16, 18, and hardened engaging portion 10. In each example illustrated by Figures 2-7, the seal component 14 is clamped between the clamping members 16, 18. In the example illustrated by Figure 2, the hardened engaging portion 10 is included on the seal component 14. The hardened engaging portion 10 engages and plastically deforms one of the clamping components 16 to form a seal.

[0033] In the example illustrated by Figure 3, the hardened engaging portion 10 is included on one of the clamping components 18. The hardened engaging portion 10 engages and plastically deforms the seal component 14 to form a seal.

[0034] In the example illustrated by Figure 4, a first hardened engaging portion 10 is formed on a first side 23 of the seal component and a second hardened engaging portion 10 is formed on a second side 24 of the seal component. The hardened engaging portions 10 on the first and second sides 23, 24 of the sealing component engage and plastically deform the clamping components 16, 18 to form seals.

[0035] In the example illustrated by Figure 5, a first hardened engaging portion 10 is formed on the first clamping component 16 and a second hardened engaging portion 10 is formed on the second clamping component 18. The hardened engaging portions 10 defined by the first and second clamping components engage and plastically deform the first and second sides 23, 24 of the sealing component 16, 18 to form seals.

[0036] In the example illustrated by Figure 6, first and second hardened engaging portions 10 are formed on the seal component 14. The hardened engaging portions 10 defined by the seal component engage and plastically deform one of the clamping components 16, 18 to form first and second seals.

[0037] In the example illustrated by Figure 7, first and second hardened engaging portions 10 are formed on one of the clamping components 16, 18. The hardened engaging portions 10 defined by the clamping component engage and plastically deform the seal component 14 to form first and second seals.

[0038] In accordance with this disclosure, it has been found that hardening at least a portion of one of the components that forms a metal to metal seal has advantages when compared to fluid flow device seals between two unhardened metal components. For example, hardening of one or both of the metal components allows for greater versatility in the materials that can be used in a fluid flow device. For example, if a fluid flow device 12 includes unhardened clamping components that are made from stainless steel, the sealing component may be made from a softer material, such as annealed stainless steel or nickel, to provide a hardness differential between the clamping components and the sealing component. Annealed stainless steel can be more difficult in some cases to work with than non-annealed stainless

steel, and nickel is more susceptible to corrosion in harsh environments than stainless steel. When the clamping components 16, 18 include hardened engaging portions 10, the seal component 14 may be made from harder materials, such as stainless steel, and still have enough of a hardness differential to form a good seal. For example, the clamping components 16, 18 may be made from stainless steel and processed to form one or more hardened engaging portions 10 and the seal component may be made from stainless steel, such as 316 stainless steel. The hardness differential between the hardened engaging portion 10 and the stainless steel facilitates a seal between hardened engaging portion 10 and the seal component. According to another example, the clamping components may be made from stainless steel and the seal component may include a hardened engaging portion or portions.

[0039] The differential hardness of the hardened engaging portion 10 and a stainless steel component is greater than the differential hardness between non-annealed stainless steel and annealed stainless steel or nickel. As a result, a seal that has a lower leak rate may be formed if a hardened engaging portion 10 is included. For example, a seal formed between a stainless steel surface and a hardened engaging portion 10 that is hardened using a low temperature carburization process may seal light gasses even more effectively than a seal formed between stainless steel and nickel, because the differential hardness is greater. Examples of light gasses include hydrogen and helium. A seal formed between a stainless steel surface and a hardened engaging portion 10 that is hardened using a low temperature carburization process can be effective to contain light gasses at pressures greater than 1000 psi, and even greater than 5000 psi, with a leak rate of less than 1 std cc/hr.

[0040] Figures 8-11 illustrate examples of fluid flow devices 12 that may include hardened engaging portions. U.S. Patent Nos. 3,521,910 and 6,685,234 (herein “the ‘234 patent”) disclose coupling assemblies that include a pair of glands having ends that seal on opposite faces of a seal member. U.S. Patent Nos. 3,521,910 and 6,685,234 are incorporated herein by reference in their entirety. Figure 8 illustrates the coupling 30 shown in Figure 1 of the ‘234 patent modified to include hardened engaging portions 10. The coupling 30 includes first and second glands 32, 34 or coupling members and a seal member 36 or gasket. The glands have sealing faces 38, 40 that are brought into sealing engagement with end faces 42, 44 of the seal member 36. Each sealing face preferably includes a circumferential continuous bead 46 that extends axially outward for engaging the seal member 36. Each bead 46 is hardened to form a hardened engaging portion 10. A pair of coupling nuts 50 may be threadably engaged or

otherwise joined for urging the glands into sealing engagement with the seal member 36. Further details of the of the coupling can be obtained by referencing the '234 patent. In one exemplary embodiment, the sealing member 36 and the glands 32, 34 are made from stainless steel and the beads 46 are hardened using a low temperature carburization process. The beads 46 indent into and plastically deform the metal washer to form a seal. In one embodiment, the hardened beads 46 are provided on the sealing member 36 rather than the glands and the glands are not hardened. In another embodiment, the surface, or contact portion thereof, of the glands or sealing member that contacts the beads 46 is hardened and the beads are not hardened. Thus, the hardened surface compresses and plastically deforms the beads 46 to form a seal.

[0041] U.S. Patent No. 4,687,017 (herein "the '017 patent") discloses a bellows valve. U.S. Patent No. 4,687,017 is incorporated herein by reference in its entirety. Figure 9 illustrates the seal arrangement of the bellows valve shown in Figure 3 of the '017 patent modified to include a hardened engaging portion 10. The bellows valve 60 includes a valve body 62, a bonnet 64, and a closing member 66 with an attached bellows 68. The valve bonnet 64 extends outwardly from the valve body 62 and is held thereon by a retaining member 67. In an exemplary embodiment, the valve body 62, the bonnet 64, the closing member 66, and the bellows 68 are constructed of stainless steel. In an exemplary embodiment, the bellows 68 is pleated or folded for accommodating selective axial movement. The closing member 66 includes an enlarged diameter flange 70 that is designed to overlay or close the valve chamber open end 72. More particularly, the enlarged diameter flange is adapted to sealingly engage the valve body 62 adjacent the chamber open end 72.

[0042] The sealing engagement between flange 70 and the valve body 52 at the open end 72 is provided through use of a bead seal arrangement. Preferably, a continuous rounded or arcuate annular bead 74 is provided on the lower surface of the enlarged diameter flange 70. In an exemplary embodiment, the closing member 66 is made from stainless steel and the bead 74 is hardened by a process, such as low temperature carburization, to form a hardened engaging portion 10. The bead 74 may be designed for mating engagement with a generally planar shoulder 76 formed on the valve body 62 in circumferential surrounding relation to the valve chamber open end 72. The hardened bead 74 indents into and plastically deforms the planar shoulder 76 to provide a fluid tight seal around the open end of the valve chamber. Pressurized fluid, such as light gas, is thereby confined in the valve chamber and leakage

therefrom is inhibited. As will be appreciated, the orientation of the bead seal can be reversed, i.e., by placing an arcuate bead on the valve body and having an associated planar surface on the closing member. In another embodiment, the planar surface that contacts the bead, whether on the valve body or the closing member, may be hardened and the bead may not be hardened. Thus, the surface may compress and plastically deform the bead to form a seal. Further details of the valve shown in Figure 9 can be obtained by referencing the '017 patent.

[0043] U.S. Patent No. 6,189,861 (herein "the '861 patent") discloses a diaphragm valve. U.S. Patent No. 6,189,861 is incorporated herein by reference in its entirety. Figure 10 illustrates the seal arrangement of the diaphragm valve shown in Figure 5B of the '861 patent modified to include one or more hardened engaging portions 10. The diaphragm valve 80 includes a valve body 82, a diaphragm arrangement 84, and a bonnet 86. The diaphragm arrangement may comprise a single diaphragm or may include multiple diaphragms as illustrated by Figure 10. The valve body 82 includes a circumferential raised flange or collar 90.

[0044] Figure 10 shows of the relationship between the flange or collar 90, the diaphragm arrangement 84, and the lower clamping edge portion of the bonnet 86. The diaphragm 84 is shown in position on the top planar surface 90a of the collar 90. The diaphragm 84 may be provided with a convex center section and a generally planar, radially extending peripheral edge section 84a. The bonnet 86 may have a contoured lower peripheral surface that includes a flat 86a that is surrounded by a cylindrical wall 86b that terminates in a corner 86c. In one exemplary embodiment, the flat 86a, the wall 86b, and/or the corner 86c of the bonnet are hardened. When the bonnet 86 is driven into clamping engagement as shown in Figure 10, the flat 86a clamps the top surface of the diaphragm assembly 84 as shown. The corner 86c deflects and bends the outer peripheral portion of the diaphragm 84 downwardly creating a high sealing pressure over the corner 92 of the collar 90. In an exemplary embodiment, the corner 92 may be hardened to form a hardened engaging portion 10. In another exemplary embodiment, the valve body 82 and the bonnet 86 are made from stainless steel and the corner 92 is hardened using a low temperature carburization process. In another embodiment, the diaphragm is hardened and the valve body 82 and the bonnet 86 are not hardened so that the diaphragm plastically deforms the valve body and/or the bonnet 86 to form a seal.

[0045] The clamping sequence is as follows. When the bonnet is driven into initial clamping engagement, the corner 86c deflects and bends the outer peripheral portion 84a of the diaphragm downward and over the corner 92 of the collar 90. The flat 86a then begins clamping the top surface of the diaphragm 84 against the top planar surface 90a of the collar 90. In an exemplary embodiment, the collar 90 is hardened and is substantially harder than the diaphragm 84, which may be made from Elgiloy, 316 stainless steel, and Inconel 750, for example. The corner 86c continues acting on the diaphragm 84 peripheral portion 84a, thus bending and crimping the diaphragm 84 around the corner 92. The force applied during this make-up procedure is sufficient to plastically deform or yield the diaphragm 84 against the hardened corner 92 to create a primary body seal there between. Further details of the valve shown in Figure 10 can be obtained by referencing the '861 patent.

[0046] U.S. Patent No. 4,684,106 (herein "the '106 patent") discloses a diaphragm valve. U.S. Patent No. 4,684,106 is incorporated herein by reference in its entirety. Figure 11 illustrates the seal arrangement of the diaphragm valve shown in Figure 2 of the '106 patent modified to include one or more hardened engaging portions 10. The diaphragm valve 100 may include a metal valve body 102, a metal diaphragm 104, and a bonnet 106. Figure 11 shows an enlarged peripheral edge portion of the body 102 and the bonnet 106 having the diaphragm 104 axially clamped therebetween. The valve body 102 and the bonnet 106 may have spaced-apart opposite flat and parallel circumferential areas 116, 118 between which an inner or primary circumferential area of the diaphragm 104 may be axially clamped over an inner circumferential area. Tightening of a bonnet nut (not shown) moves the clamping surfaces 116, 118 toward one another for squeezing the diaphragm 104 therebetween.

[0047] The valve body 102 and the bonnet 106 may also include secondary flat and parallel clamping surfaces 120, 122 spaced axially and radially from the primary clamping surfaces 116, 118. The primary surfaces 116, 118 may be separated from the secondary surfaces 120, 122 by relatively sharp corners 124, 126 across which the diaphragm 104 is bent axially. In an exemplary embodiment, the corners 124, 126 are hardened and plastically deform the softer metal diaphragm to form a seal. The axial spacing between corners 124, 126 are less than the normal axial thickness of the diaphragm 104 and less than the axial spacing between the clamping surfaces 116, 118. As a result, the corners 124, 126 provide excellent seals against the opposite face surfaces of the diaphragm 104. An outer circumferential flange 130 extends axially from the secondary clamping surface 120 on the body 102 for protecting the

inner or primary clamping surface 116 against knicks and other damage during processing and assembly of the valve. The axial projection of the flange 130 may be substantially greater than the axial spacing between the primary and the secondary surfaces 116,120. Directly opposite from the protective flange 130, the bonnet member 106 may be provided with an enlarged recess 134 for receiving a terminal end portion 136 of the diaphragm 104 in a free and unclamped condition. Secondary corners, generally indicated as 142,144, may be axially spaced from one another a distance substantially less than the axial spacing between the corners 124,126 so that the outer end portion 136 of the diaphragm 104 is axially deformed to a greater degree than the axial deformation thereof between the corners 124,126. In an exemplary embodiment, the corners 124, 126, 142, 144 are hardened to form hardened engaging portions 10. The corners 124, 126, 142, 144 are harder than the diaphragm and plastically deform the diaphragm to provide primary and secondary seals. In another embodiment, the diaphragm 104 is hardened and the corners 124, 126, 142, 144 are not hardened so that the diaphragm plastically deforms the corners to form a seal.

[0048] The invention has been described with reference to the preferred embodiments. Modification and alterations will occur to others upon a reading and understanding of this specification. It is intended to include all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

Claims

1. A fluid coupling, comprising:

a generally annular, metal sealing gasket;

first and second metal coupling components; the metal coupling components assembled on opposite sides of the metal sealing gasket such that a load is applied by the metal coupling components to the metal sealing gasket; and

a generally annular, hardened sealing bead included on at least one of the metal sealing gasket, the first metal coupling component and second metal coupling component that indents into and plastically deforms at least one of the metal sealing gasket, the first metal coupling component and second metal coupling component to form a seal therebetween.
2. The fluid coupling of claim 1 wherein fluid flowing through the fluid coupling contacts the first and second metal coupling components and the metal sealing gasket.
3. The fluid coupling of claim 1 wherein the hardened sealing bead is included on the first metal coupling component and wherein the hardened sealing bead indents into the metal sealing gasket to form the seal.
4. The fluid coupling of claim 3 wherein the hardened sealing bead is hardened using a low temperature carburization process to produce a hardened surface without formation of carbide precipitates.
5. The fluid coupling of claim 1 wherein the hardened sealing bead is included on the metal sealing gasket and wherein the hardened sealing bead indents into the first metal coupling component to form the seal.
6. The fluid coupling of claim 5 wherein the hardened annular sealing bead is hardened using a low temperature carburization process to produce a hardened surface without formation of carbide precipitates.
7. The fluid coupling of claim 1 further comprising a second generally annular, hardened sealing bead; wherein the first and second metal coupling components have opposed radial end faces that include the hardened sealing beads extending axially therefrom toward each other; and wherein the hardened sealing beads indent into and plastically deform opposite face areas of the gasket to form seals.

8. The fluid coupling of claim 1 wherein the metal sealing gasket is made from non-annealed stainless steel.
9. The fluid coupling of claim 1 wherein the metal coupling components and the metal sealing gasket are made from stainless steel.
10. The fluid coupling of claim 1 wherein the metal coupling components and the metal sealing gasket are made from stainless steel and the hardened sealing bead is hardened using a diffusion based surface treatment process.
11. The fluid coupling of claim 10 wherein the diffusion based surface treatment process is a low temperature carburization process to produce a hardened surface without formation of carbide precipitates.
12. The fluid coupling of claim 1 wherein the seal is effective to contain light gasses at pressures greater than 1000 psi with a leak rate at or below 1 std. cc/hr.
13. The fluid coupling of claim 1 wherein the seal is effective to contain light gasses at pressures greater than 5000 psi with a leak rate at or below 1 std. cc/hr.
14. A bellows valve, comprising:
 - a metal valve body having inlet and outlet passages and a valve seat disposed between the inlet and outlet passages;
 - a valve stem received by the valve body; the valve stem adapted for selective sealing engagement with the valve seat;
 - a bellows having a first end and a second end, the first end being sealingly connected to the valve stem;
 - a metal closing member adapted to receive the valve stem therethrough, the metal closing member being sealingly connected to the second end of the bellows;
 - a bonnet member, wherein the bonnet member and the metal valve body are assembled on opposite sides of the metal closing member such that a load is applied by the valve body and the bonnet member to the closing member; and
 - a generally circumferentially continuous, hardened bead extending axially outward from one of the valve body and the closing member that indents into and plastically deforms a generally planar surface located on the other of the valve body and the closing member to form a seal therebetween.

15. The bellows valve of claim 14 wherein the hardened bead is located on the metal closing member and indents into the valve body to form the seal.
16. The bellows valve of claim 14 wherein the hardened bead is located on the valve body and indents into the metal closing member to form the seal.
17. The bellows valve of claim 14 wherein the hardened bead is hardened using a low temperature carburization process to produce a hardened surface without formation of carbide precipitates.
18. The bellows valve of claim 14 wherein the hardened bead is made from stainless steel and is hardened using a diffusion based surface treatment process.
19. The bellows valve of claim 14 wherein the bonnet, the valve body, the closing member, and the bellows are made from stainless steel.
20. The bellows valve of claim 14 wherein the seal is effective to contain light gasses at pressures greater than 1000 psi with a leak rate at or below 1 std. cc/hr.
21. The bellows valve of claim 14 wherein the seal is effective to contain light gasses at pressures greater than 5000 psi with a leak rate at or below 1 std. cc/hr.
22. A diaphragm valve, comprising:
 - a valve body and a bonnet member,
 - a metal diaphragm arrangement including one or more diaphragms, wherein the bonnet member and the valve body are assembled on opposite sides of the metal diaphragm arrangement such that a load is applied by the bonnet member and the valve body to the metal diaphragm arrangement; and
 - a hardened engaging portion included on at least one of the metal diaphragm arrangement, the bonnet member, and the valve body near a respective outer periphery thereof; the hardened engaging portion engages and plastically deforms at least one of the metal diaphragm arrangement, the bonnet member, and the valve body to form a seal therebetween.
23. The diaphragm valve of claim 22 wherein the metal diaphragm comprises a plurality of diaphragms in a stacked arrangement.
24. The diaphragm valve of claim 22 wherein the hardened engaging portion comprises an annular edge of the bonnet that engages the diaphragm arrangement.

25. The diaphragm valve of claim 22 wherein the valve body and the bonnet member each includes a generally flat surface near a respective outer periphery thereof; at least one of the generally flat surfaces being adjacent an outer corner thereof; the diaphragm assembly being clamped between the generally flat portions; the diaphragm assembly having an outer peripheral portion adjacent the generally flat surfaces that bends over and seals at the corner.
26. The diaphragm valve of claim 25 wherein the hardened engaging portion comprises the corner.
27. The diaphragm valve of claim 22 wherein the hardened engaging portion is hardened using a low temperature carburization process to produce a hardened surface without formation of carbide precipitates.
28. The diaphragm valve of claim 22 wherein the bonnet, the valve body, and the diaphragm arrangement are made from stainless steel.
29. The diaphragm valve of claim 22 wherein the hardened engaging portion is made from stainless steel and is hardened using a diffusion based surface treatment process.