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(54) Title: NOZZLE CHECK VALVE

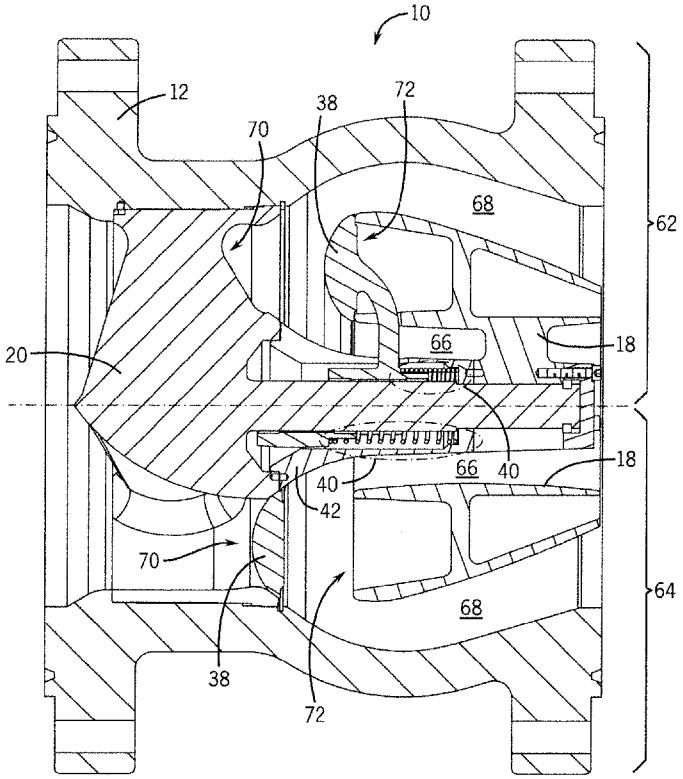

FIG. 6

(57) Abstract: The disclosed embodiments include check valves (10) capable of improved dynamic performance (e.g., closing and opening times). The check valves (10) may include an annular disc (38) having an opening (59). The annular disc (38) may be lightweight and present a reduced surface area to the flow, thus increasing the closure speed of the check valve (10) as well as the opening speed of the check valve (10). Other components, such as a spacer (42) component, may be reconfigured to modify the check valve (10) for increased performance in a variety of applications, including low flow volume, medium flow volume, and high flow volume applications.

WO 2012/005791 A1

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NOZZLE CHECK VALVE

BACKGROUND

[0001] This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present invention, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

[0002] Check valves are capable of protecting mechanical equipment by preventing the reversal of flow through a conduit. That is, the check valve is capable of allowing the passage of a fluid (i.e., liquid or gas) in one direction through the conduit (e.g., forward flow) and stopping the flow of the fluid through the conduit in the opposite direction (e.g., backward flow). Unfortunately, certain check valves may have a slow response time, which reduces performance or reliability of the system. Furthermore, the check valve may be subject to fatigue or failure due to repeated cycling and slamming of a moving element on a stationary element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Various features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying figures in which like characters represent like parts throughout the figures, wherein:

[0004] FIG. 1 is an exploded perspective view of a nozzle check valve, a flange valve body, and a weldable valve body, in accordance with one embodiment of the disclosure;

[0005] FIG. 2 is a perspective frontal view of a nozzle check valve, including a nozzle, in accordance with one embodiment of the disclosure;

[0006] FIG. 3 is an exploded perspective side-view of components of a nozzle check valve, in accordance with one embodiment of the disclosure;

[0007] FIG. 4 is an exploded perspective rear view of a nozzle check valve, including a diffuser, in accordance with one embodiment of the disclosure;

[0008] FIG. 5 is an exploded perspective frontal view of an annular disc and a spacer, in accordance with one embodiment of the disclosure; and

[0009] FIG. 6 is a cross-sectional side view of an embodiment of a nozzle check valve.

[0010] Parts List

10	check valve
12	flanged end valve body
14	weld end valve body
16	valve body
18	diffuser
20	nozzle
22	axial forward direction
24	backward direction
26	dome-shape center
28	three airfoils
30	bore
32	section
34	section
36	shaft
38	annular disk
40	coil spring
42	spacer
44	section
46	section
48	locking assembly
50	bolt
52	locking cap
54	annular ring
56	bore
58	radial arm
59	opening
60	three slots

62 upper half
64 lower half
66 **flow passage**
68 **flow passage**
70 valve seat
72 **valve seat**

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0011] One or more specific embodiments of the present invention will be described below. These described embodiments are only exemplary of the present invention. Additionally, in an effort to provide a concise description of these exemplary embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[001 2] When introducing elements of various embodiments of the present invention, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements. Moreover, the use of "top," "bottom," "above," "below," and variations of these terms is made for convenience, but does not require any particular orientation of the components.

[0013] The disclosed embodiments include a nozzle check valve having an annular or toroidal disc (e.g., circular disc with a hollow center) capable of improving valve closure time, reducing disc weight, decreasing valve opening and closing times, and increasing a volume of flow through the valve body.

Additionally, the disclosed embodiments enables for the modular reconfiguration of **valve** components, such as **a** spacer, that renders the **valve** suitable for **a** variety of operating conditions and environments, including subsea environments. Accordingly, the valve may be delivered as a kit, including multiple components suitable for reconfiguring the valve for different applications, such as different flow applications, e.g., low flow applications, medium flow applications, and high flow applications.

[0014] Additionally, the valve may be used with piping of different sizes (e.g., between 10 in. to 20 in., 15 in. to 45 in., 35 in. to 80 in., 10 in. to 80 in. diameters) and may be used in any orientation (e.g., horizontal orientation, vertical orientation, angled orientation). Further, the nozzle check valve includes features capable of improving valve inspection and valve maintenance by enabling easy access to the valve components through the use of a removable locking mechanism. Additionally, the modular design of the check valve enables for the separation of the valve components from the valve body, which enables the valve body to be separately manufactured using techniques such as forging.

[001 5] FIG. 1 is an exploded perspective view of embodiments of a nozzle check valve 10, **a** flanged end valve body 12, and a weld end valve body 14. In the illustrated embodiment, the nozzle check valve 10 includes a valve body 16, which may be selectively replaced with one of the bodies 12 or 14. That is, the internal components of the check valve 10 may be used in any one of the valve bodies 12, 14, and 16. Indeed, all of the valve 10 components, such as a diffuser 18, may be used interchangeably used with valve bodies 12, 14, and 16. In the figure, the diffuser 18 of the check valve 10 is shown through the rear of the valve body 16. Further, the valve 10 components may be manufactured separately from the valve bodies 12, 14, and 16 used with any number of valve bodies for improved flexibility. Such modular flexibility enables the valve 10 to be configured for a wide variety of applications. For example, the valve 10 components may be configured for a certain type of flow, including low flow applications, medium flow applications, and high flow applications, as described in more detail below.

[0016] Because of the ability to manufacture the valve body separate from the nozzle 20 and other valve 10 components, the valve body may be manufactured by using forging techniques. Forging allows an increase in strength of the valve bodies 12, 14 and 16 due to, for example, grain hardening. In other embodiments, the valve bodies 12-16 may be manufactured, by using computer numerically controlled (CNC) techniques, casting techniques, milling techniques, and so forth. The valve bodies 12-16 may be coated with an internal and/or external layer of an oxidation and corrosion resistant material such as inconel® (e.g., austenitic nickel-chromium-based superalloy) available from Special Metals Corporation of New Hartford, New York, U.S.A. Other corrosion resistant materials may include stainless steel, titanium, and forth. Such coating provides enhanced component life in corrosive environments such as subsea environments. Further, the cost of manufacturing the valve bodies 12, 14 and 16 is reduced because the valve bodies may be manufactured out of a less costly material such as steel, brass, cast iron, aluminum, and so forth, and then coated with a more expensive material suitable for preventing corrosion and oxidation. Accordingly, the valve bodies 12, 14 and 16 may be manufactured and coated for certain properties, such as corrosion prevention and then the remainder of the valve 10 components may be inserted into a specific valve body.

[0017] In certain applications, such as applications specifying quick removal and replacement of a valve, the flanged end valve body 12 may be used. The flanged end valve body 12 enables easy installation and removal of the valve 10 from a conduit such as a flanged pipe. The valve 10 may be installed, for example, by using gaskets and a plurality of nuts and bolts suitable for securing the flange end valve body 12 to the conduit. In other applications, such as subsea manifold applications, it may be desirable to fixedly couple the valve 10 to the conduit by using welds. Welding the valve 10 to the conduit may reduce weight, create stronger connections, and define a substantially leak-proof passage. Accordingly, the weld end valve body 14 may be used to provide a fixed connection. The weld end valve body 14 is capable of withstanding the heat generated during welding and may be capable of meeting ISO 14313

(pipeline valves) and ISO 14723 (subsea pipeline valves) specifications. Indeed, all of the valve bodies 12, 14, and 16 may be capable of meeting a variety of valve-related ISO, ANSI, API, ASME, and/or NACE specifications, including subsea specifications. Further, it is to be understood that other valve bodies may be used, including valve bodies that combine flanged ends, weld ends, and/or hub ends. That is, the valve body may include a flange end at one end of the valve body and a hub end at the opposite end.

[0018] FIG. 2 depicts a perspective view of the front end of the nozzle check valve 10, including a nozzle 20. The figure is illustrative of the ability of the nozzle check valve 10 to enable a flow in an axial forward direction 22 (i.e., forward flow) and to prevent a flow in a backward direction 24 (i.e., backward flow). The forward flow 22 may be driven, for example, by a pump, a compressor, or any other device capable of creating a movement of a fluid through the nozzle 20. In one embodiment, the nozzle 20 includes a dome-shape center 26 with three airfoils 28 attached to a barrel 30. In certain embodiments, the nozzle 20 is manufactured as one part, that is, the dome-shape center 26, the airfoils 28, and the barrel 30 may all be forged, cast and/or milled out of the same billet so as to result in the nozzle 20 having no welds, rivets, or other fasteners. Accordingly, the dome-shape center 26 and airfoils 28 are capable of defining a smooth flow path through the inside walls of the barrel 30 that may exhibit a substantially low pressure drop as the fluid passes through the nozzle 20 and into the remainder of the valve body 16. Indeed, the nozzle 20 may improve the forward fluid flow through the check valve 10. It is to be understood that in other embodiments, the nozzle 20 may include more or less airfoils 28, and may be manufactured as separate parts that may then be welded together. As mentioned above, the nozzle 20 may also be a component that may be manufactured separate from the valve body 16. Indeed, all or substantially all other valve 10 components may be components manufactured separate from the valve body 16, as described in more detail with respect to FIG. 3 below.

[0019] FIG. 3 illustrates an exploded perspective side view of an embodiment of the nozzle check valve 10 including a plurality of valve 10 components. In the

illustrated embodiment, the valve body 16 includes a section 32 and a section 34. The section 32 has a smaller interior diameter than an interior diameter of the section 34. The interior inner diameter and length of the section 32 is suitable for allowing the insertion of the barrel 30 of the nozzle 20 inside of the section 32. Once positioned inside the valve body 16, the nozzle 20 may be secured by using any number of fastener features such as an interference fit, lock rings, bolts, screws, welds, pins, or a combination thereof. In certain embodiments, the design of the valve body may include mechanical stop features aiding in the fastening of the nozzle 20 to the valve body 16. For example, the nozzle 20 may encounter a protrusion in the valve body 16 that prevents axial movement of the nozzle 20 with respect to the valve body 16. Such a mechanical stop feature may be located downstream of the forward flow, thus aiding in the retention of the nozzle 20, even during high forward flow conditions. A similar mechanical stop feature may be located upstream of the forward flow, thus aiding in the retention of the nozzle during high reverse flow conditions. In the illustrated embodiment, the nozzle 20 includes a shaft 36 concentrically or co-axially positioned in the approximate axial center of the nozzle 20, at the rear of the nozzle 20. Accordingly, the shaft 36 protrudes from the rear of the nozzle 20 and into the section 34 of the valve body 16 when the nozzle 20 is positioned inside of the section 32.

[0020] The shaft 36 may be suitable for concentrically and/or co-axially positioning other valve 10 components, such as an annular or toroidal disc 38, a coil spring 40, and a spacer 42, inside of the valve body 16. Accordingly, a section 44 of the shaft 36 may be of a length and an outer diameter adequate for accommodating the toroidal disc 38, coil spring 40, and spacer 42 as the aforementioned components are "slid" axially onto the section 44 of the shaft 36. A remainder section 46 of the shaft 36 may be of a length and an outer diameter adequate for insertion into the diffuser 18. Additionally, the diffuser 18 may include a length and an outer diameter suitable for inserting the diffuser 18 into the section 34 of the valve body 16. Once the valve 10 components have been positioned inside the valve body 16, a locking assembly 48 may then be used to

securely couple the shaft 36 to the diffuser 18 and valve body 16, locking all valve components securely in place. Such a modular valve 10 design allows for the straightforward reconfiguration and/or replacement of substantially all of the valve 10 components.

[0021] The check valve 10 may be delivered as a kit so as to be reconfigured in the field. That is, the check valve 10 may include surplus components, such as multiple spacers 42 of different sizes and shapes, that allow an operator to reconfigure the valve in the field to better accommodate different operational environments and specifications. Indeed, the locking assembly 48 may be removed in the field so as to allow access to the inside of the valve 10, as described in more detail below with respect to FIG. 4

[0022) FIG. 4 is illustrative of an embodiment of the locking assembly 48 that may be useful in providing easy access to the valve 10 components. In the depicted embodiment, the locking assembly 48 includes three bolts 50 and a locking cap 52. It is to be understood that in other embodiments, more or less bolts may be used. The bolts 50 may be of any type, including torx bolts, security torx bolts, hex bolts, Robertson bolts, and so forth, capable of securing the locking cap 52 to the diffuser 18. Accordingly, the diffuser 18 may include threaded openings 53 adequate for engaging the bolts 50 and securing the bolts 50 in place. In certain embodiments, the rear end of the shaft 36 may also include a retaining ring 55 suitable securing the nozzle 20 to the diffuser 18. In other embodiments, the shaft 36 may be secured to the diffuser by using any number of fasteners, such as retaining pins, bolts, screws, or a combination thereof. Further, the bolts, including the bolts 50 used to secure the locking cap 52, are not structural bolts. That is, the bolts are not used to structurally secure the valve 10, and thus, are capable of withstanding vibration, thermal changes, and so forth. Such abilities, among others, allow the valve 10 to be substantially maintenance-free.

[0023] A field technician or engineer may use tools such as a hex wrench to remove the bolts 50, uncouple the locking cap 52, remove the retaining ring 55,

and subsequently remove the diffuser 18. The removal of the diffuser 18 allows access to the valve 10 components, as illustrated. Accordingly, components such as the spacer 42, the disc 38, and so on, may be removed and replaced so as to reconfigure the valve 10 to meet specific operational parameters such as flow rate, pressure drop, and/or other parameters. Indeed, components such as the disc 38 and the spacer 42 may include features capable of providing for an improved fluid flow volume, fast closing times, and low pressure drops. Additionally, the diffuser 18 includes a shape, for example, an airfoil shape, that optimizes the fluid flow through the valve body. Such as a shape may be designed to minimize or eliminate recirculation zones that result in reduced fluid flows and/or pressure buildups.

[0024] FIG. 5 is an exploded perspective frontal view of an embodiment of the annular disc 38 and the spacer 42 capable of improved fluid flow volume, fast closing times, and low pressure drops. In the depicted embodiment, the annular disc 38 includes a toroidal ring 54 that is co-axially or concentrically coupled to a barrel 56 through the use of three radial arms 58. The front side of the toroidal ring 54 is curved, as depicted in FIG. 6, while the rear side of the toroidal ring 54 may be flat. It is to be understood that in other embodiments, more or less radial arms 58 may also be used to support the barrel 56. The toroidal ring 54 defines an opening 59 (e.g., three sections defining an annular opening) through the center of the disc 38. The opening 59 in the center of the disc 38 may be of a diameter 57 sized between approximately 10%-20%, 15%-50%, 40%-90% of the outer diameter 61 of the disc 38.

[0025] The opening 59 is configured to improve fluid flow through the valve 10. That is, the annular disc 38 allows at least two flows, a first flow is capable of passing through the annular opening 59 of the annular disc 38, and a second flow is capable of passing around the circumference of the annular disc 38, as depicted in more detail in FIG. 6. Further, the curved surface on the front face of the toroidal ring 54 allows for a smoother flow both through the annular opening 59 as well as around the circumference of the annular disc 38. Accordingly, the annular disc 38 is capable of a much improved flow volume because of an

increase in internal flow volume due to using a plurality of flow passages as well as a design that decreases resistance to the fluid flow.

[0026] As further illustrated in FIG. 5, an embodiment of the spacer 42 is exploded from the annular disc 38. In the illustrated embodiment, the spacer 42 includes three slots 60. Each of the slots 60 is suitable for allowing the insertion of a radial arm 58 of the annular disc 38. That is, the barrel 56 of the annular disc 38 may be inserted into approximately the center of the spacer 42 such that the radial arms 58 are inserted into the slots 60. Once the radial arms 58 are positioned in the slots 60, the annular disc 38 may be secured from rotating in a circumferential direction (i.e., "anti-rotation"). However, the slots 60 allow the annular disc 38 to move in an axial direction inwardly towards the rear of the spacer 42 and outwardly away from the rear of the spacer 42 and towards the front of the spacer 42. Such axial movement relative to the valve body 12, 14, 16 is capable of opening or closing the valve 10, as described in more detail below with respect to FIG. 6.

[0027] The spacer 42 may be replaced, for example, to accommodate different types of flow conditions. Indeed, the spacer 42 may be replaced in the field with a spacer 42 having a body that is shaped differently, for example, by having a smaller or larger outer body diameter, and/or smaller or larger body length. Additionally, the spacer 42 may be replaced with a spacer 42 having slots 60 shorter or longer in length, allowing for easy reconfiguration of the length of travel of the annular disc 38. As an example, for lower flow volume applications, increasing the outer diameter of the spacer 42 may result in more of the fluid flow impacting the toroidal ring 54, causing a faster opening of the valve 10. In another example, for heavy flow applications, decreasing the outer diameter of the spacer 42 may allow for a faster flow through the annular disc 38. Accordingly, a plurality of spacers 42 may be delivered as part of a valve 10 kit. The field technician may thus quickly reconfigure the valve 10 for specific application by replacing components, such as the spacer 42, more suitable to the specific application. For example, a first spacer 42 may be designed for low to medium flow volumes, a second spacer 42 may be designed for medium to high

flow volumes, a third spacer 42 may be designed for low flow volumes, a fourth spacer 42 may be designed for medium flow volumes, and a fifth spacer 42 may be designed for high flow volumes.

[0028] FIG. 6, is a cross-sectional view of an embodiment of the check valve 10. In the depicted embodiment, the upper half 62 of the figure illustrates the check valve 10 in an open position, while, for comparison purposes, the lower half 64 of the figure illustrates the check valve 10 in a closed position. As mentioned above, the check valve 10 is capable of an improved flow and a reduced pressure loss. That is, the check valve 10 is able to allow for a substantially greater flow volume while minimizing any pressure or hydraulic loss experienced as the flow passes through the check valve 10. Indeed, in certain embodiments, the pressure loss coefficient (i.e., K value) may be less than approximately 0.5. Indeed, features such as a plurality of flow passages 66, 68 may result in an improved fluid flow and a reduced pressure loss coefficient.

[0029] In one embodiment, the first flow passage 66 is an annular or toroidal flow passage having the spacer 42 in the approximate center of the flow passage 66 with the outer walls of the spacer 42 defining the inner circumference of the flow passage 66. The outer circumference of the flow passage 66 may then be defined by the inner walls of the diffuser 18. In this embodiment, the second annular flow passage 68 is concentrically or co-axially positioned to surround the first flow passage 66. The inner circumference of the second annular flow passage 68 may be defined by the outside walls of the diffuser 18, and the outer circumference of the second annular flow passage 68 may be defined by the inner walls of the flanged valve body 12. By combining the use of a plurality of flow passages 66 and 68, the check valve 10 may substantially increase the amount of fluid flow through the check valve 10 while simultaneously reducing the pressure loss experienced because the fluid flow may be capable of an improved flow volume and lower flow speed.

[0030] The annular disc 38 is capable of a quick dynamic response in both the opening and the closing of the flow passages 66, 68. A quick dynamic response

(i.e., fast opening and fast closing action) may allow the check valve 10 to prevent a set of conditions know as "slam." If a valve does not close rapidly to prevent backward flow, an undesirable high pressure surge know as "hammer" may form on sudden shut-off of the valve, which may then "slam" the valve's disc against a valve seat 70. The check valve 10 includes several features that allow for a no-slam performance. For example, the annular disc 38 is lightweight at least partially due to the reduction of mass accomplished by having an open center portion 59, as shown in FIG. 5. Indeed, weight savings of 50% or more may be possible with the annular disc 38 design. Accordingly, the reduction in mass allows the annular disc 38 to move more quickly in both opening and closing modalities. The annular disc 38 may be manufactured out of stainless steel, titanium, aluminum, austenitic nickel-chromium-based superalloys, and so forth.

[0031] Further, the distance between the open and closed positions of the annular disc 38 may be less than approximately 2, 5, 10, 50, 100 millimeters. Such small closure distances improve the closure speed because the annular disc 38 may not have to move very far from a completely open position to a completely closed position, and vice versa. Additionally, the closure speed in any orientation (e.g., horizontal orientation, vertical orientation, angled orientation) may be improved by the use of the spring 40. The spring 40, as illustrated, is in a compressive state when the check valve 10 is in an open position (e.g., during forward flow). Accordingly, when the forward flow stops, the spring aids the movement of the annular disc 38 by propelling the annular disc 38 into the valve seat 70, thus closing the check valve 10. The check valve 10 may also include other features such as low-friction bearings (e.g., bearings with low friction coating) that may decrease friction of moving components, even further increasing the no-slam capabilities of the check valve 10. Indeed, the combined effect of such features is to virtually eliminate hammers and slams.

[0032] Likewise, the speed of the opening of the check valve 10 may be considerably improved by the use of the features disclosed herein. During forward flow, the forward flowing fluid impinges upon the annular disc 38. The

pressure of the flowing fluid against the annular disc 38 is sufficient to overcome the compressive force exerted by the spring 40. Accordingly, the annular disc 38 may be pushed by the forward flow away form the seat 70 to an open valve position. The fluid may then flow around the outside circumference of the annular disc 38 (i.e., through flow passage 68), and also through the center portion of the annular disc 38 (i.e., through flow passage 66). The annular disc 38 may be moved by a sufficient force of the forward fluid flow until it becomes seated at a valve seat 72 in a fully open position. As mentioned above, the annular disc 38 is lightweight, which allows less fluid pressure to move the annular disc 38. Additionally, the annular disc 38 may be stabilized by the radial arms 58 positioned inside the spacer slots 60. Accordingly, the pressure exerted by the forward flow is directed more towards moving the annular disc 38 axially and not towards "spinning" the annular disc 38. In other words, the annular disc 38 may translate (i.e., move axially without rotation) between open and closed positions.

[0033] While the invention may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the following appended claims.

CLAIMS

1. A nozzle check valve (10) comprising:

a valve body (12, 14, 16);

a nozzle (20) coupled to an interior of the valve body (12, 14, 16);

an annular disc (38) disposed in the interior of the valve body (12, 14, 16); and

a first fluid passage (66) in fluid communication with the annular disc (38), wherein the annular disc (38) is configured to move in an axial direction without rotation relative to the valve body (12, 14, 16) to open and close the first fluid passage (66).

2. The nozzle check valve (10) of claim 1, comprising a second fluid passage (68) in fluid communication with the annular disc (38), wherein the annular disc (38) is configured to move in an axial direction without rotation relative to the valve body (12, 14, 16) to open or close the second fluid passage (68).

3. The nozzle check valve (10) of claim 1, wherein the valve body (12, 14, 16) is removable from the nozzle (20).

4. The nozzle check valve (10) of claim 3, wherein the valve body (12, 14, 16) comprises a forging, a casting, a computer numerical control (CNC), a milling, or a combination thereof.

5. The nozzle check valve (10) of claim 1, wherein the annular disc (38) comprises a disc portion (54), a central opening (59) disposed in the disc portion (54), a barrel (56) disposed in the central opening (59), and a plurality of radial arms (58) extending between the disc portion (54) and the barrel (56).

6. The nozzle check valve (10) of claim 1, comprising a spacer (42) coupled to the annular disc (38) via an anti-rotation feature (58, 60).

7. The nozzle check valve (10) of claim 1, comprising a diffuser (18) coupled to the valve body (12, 14, 16), wherein the diffuser (18) is removable from the valve body (12, 14, 16).

8. The nozzle check valve (10) of claim 7, comprising a locking assembly (48) capable of coupling with the diffuser (18) to secure access to valve (10) components inside of the diffuser (10) and valve body (12, 14, 16).

9. A check valve (10) kit comprising:

a valve body (12, 14, 16) comprising a first fluid flow passage (66) and a second fluid flow passage (68) co-axial to the first fluid flow passage (66); and

an annular disc (38) positioned internally in the valve body (12, 14, 16), wherein the annular disc (38) is capable of opening and closing both the first (66) and the second (68) fluid flow passages.

10. The check valve (10) kit of claim 9, wherein the annular disc (38) comprises a center opening (59) having a diameter (57) at least greater than 10% the outer diameter (61) of the annular disc (38).

11. The check valve (10) kit of claim 9, wherein the annular disc (38) approximately simultaneously opens both the first (66) and second (68) fluid flow passages and approximately simultaneously closes both the first (66) and second (68) fluid flow passages.

12. The check valve (10) kit of claim 9, wherein the valve body (12, 14, 16) comprises a corrosion-resistant coating.

13. The check valve (10) kit of claim 12, wherein the corrosion-resistant coating comprises a austenitic nickel-chromium-based superalloy, a stainless steel, a titanium, or a combination thereof.

14. The check valve (10) kit of claim 9, comprising a first spacer (42) configured to couple with the annular disc (38) with a first anti-rotation feature (58, 60), wherein the first spacer (42) has a first flow volume configuration.

15. The check valve (10) kit of claim 14, comprising a second spacer (42) configured to couple with the annular disc (38) with a second anti-rotation feature (58, 60), wherein the second spacer (42) has a second flow volume configuration.

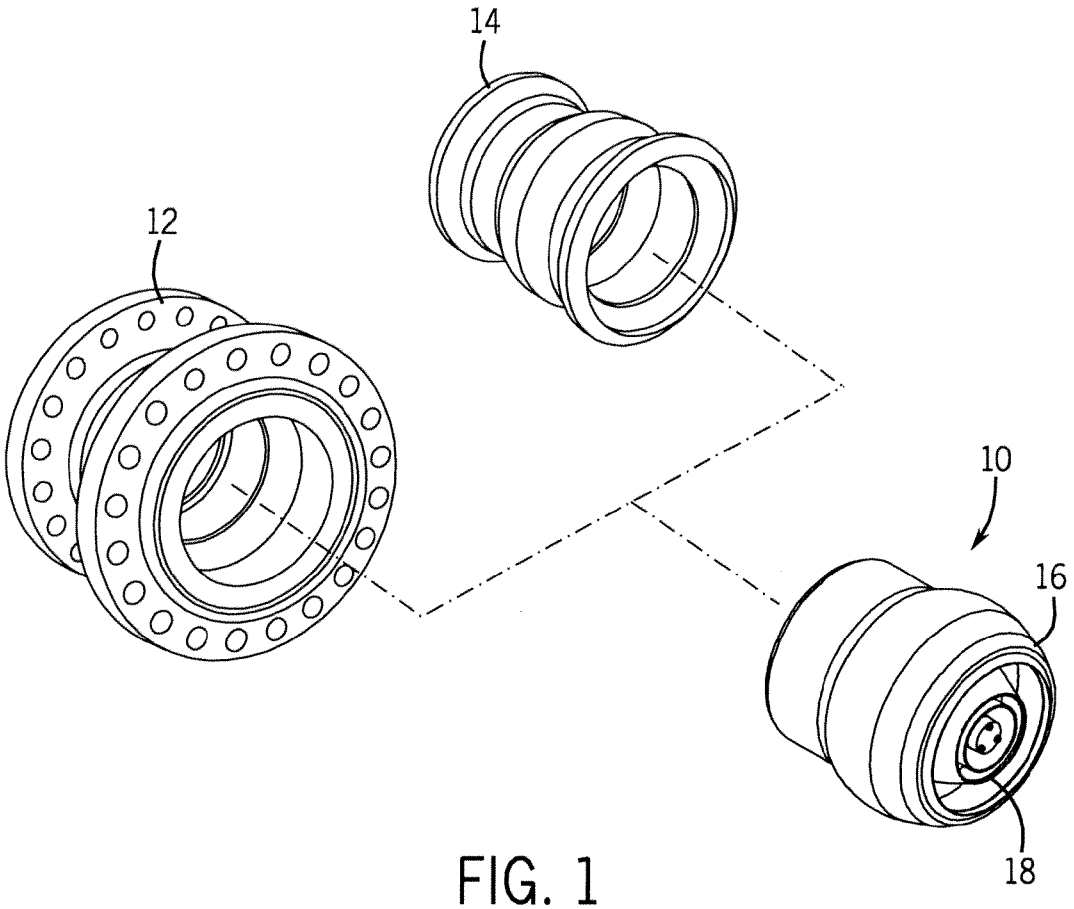

FIG. 1

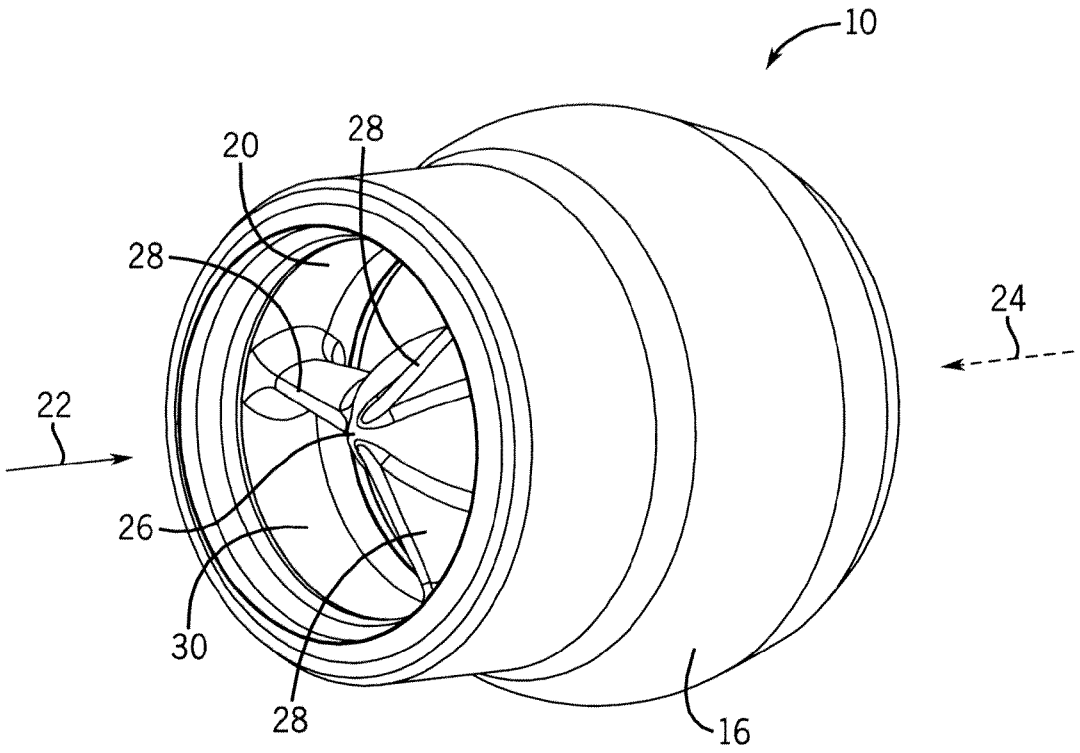

FIG. 2

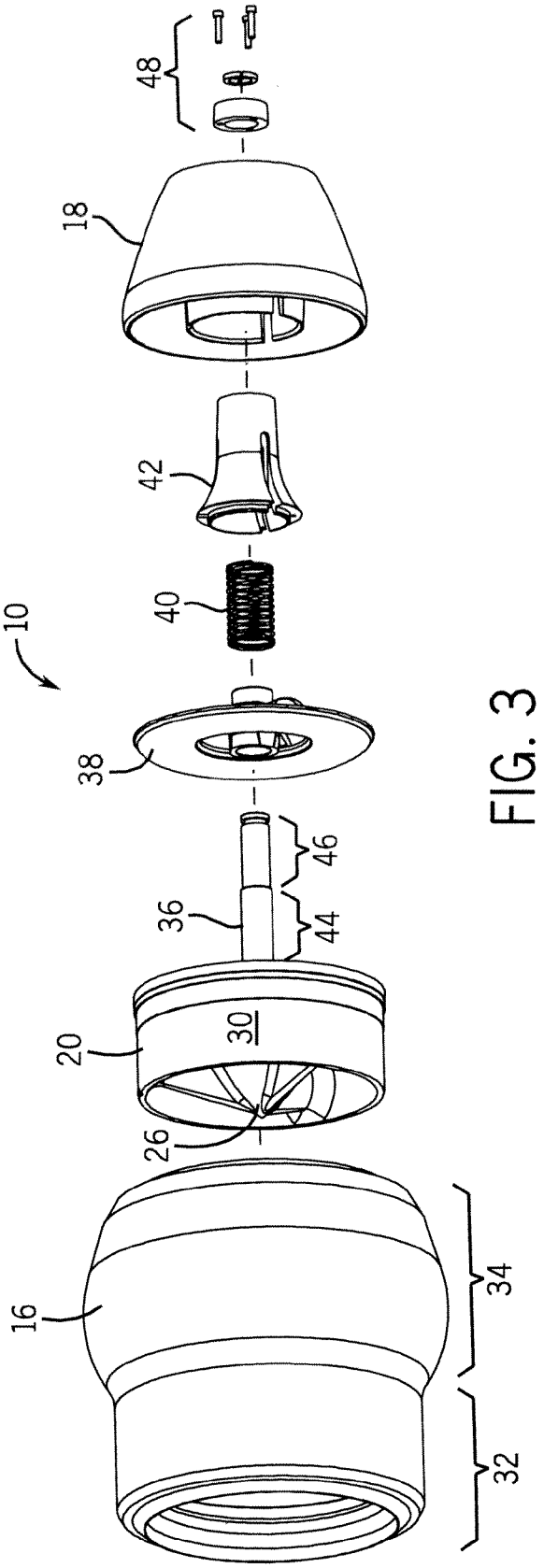

FIG. 3

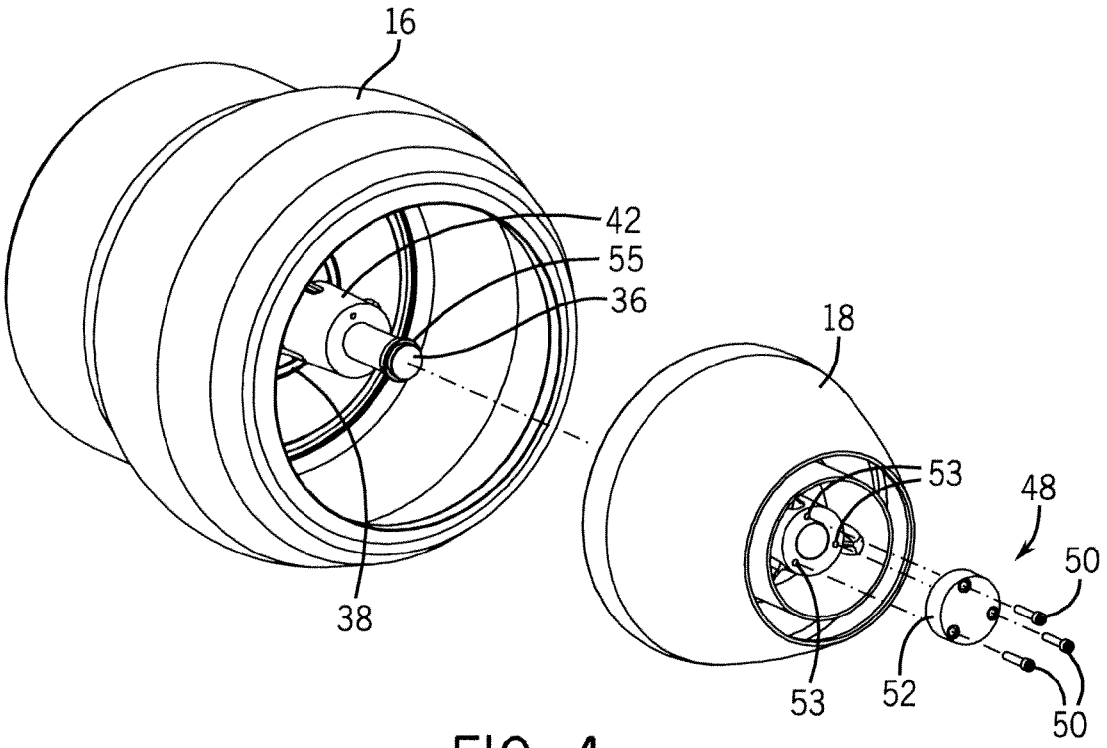

FIG. 4

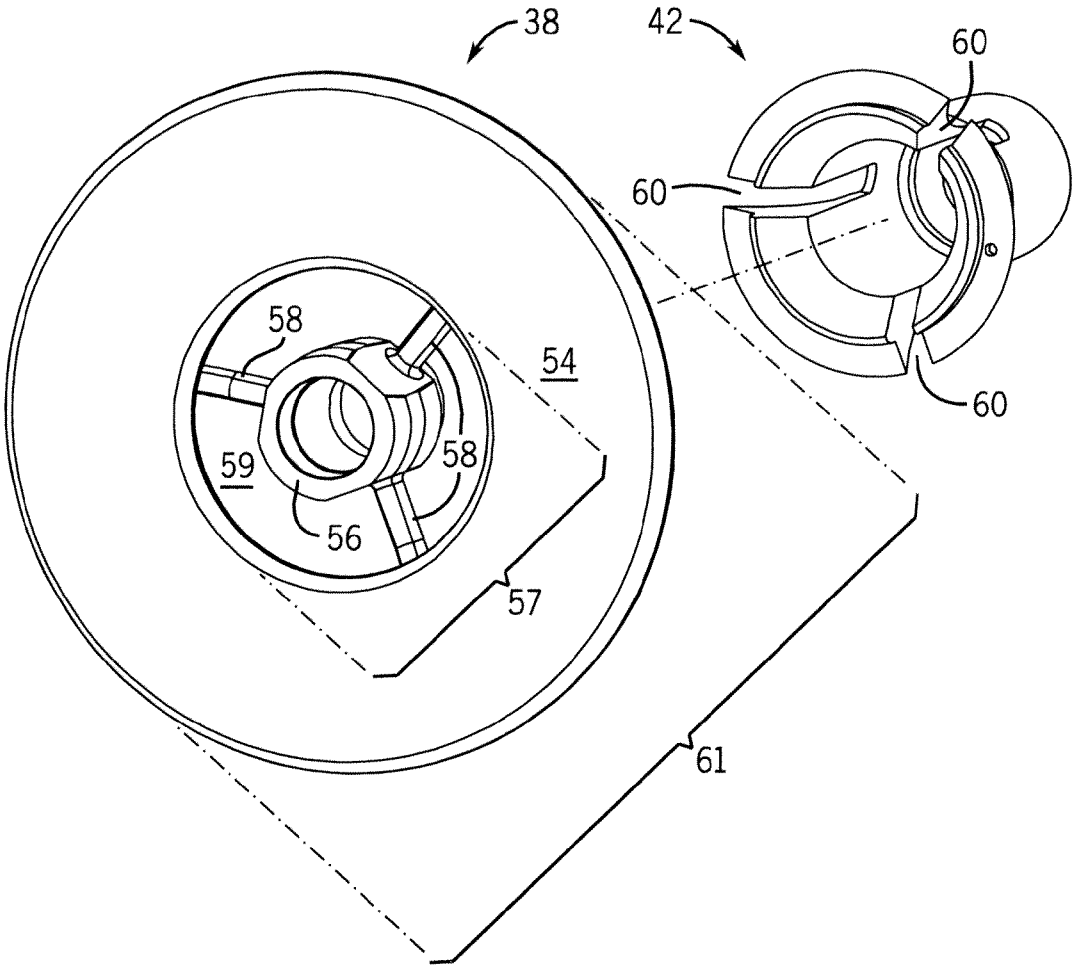

FIG. 5

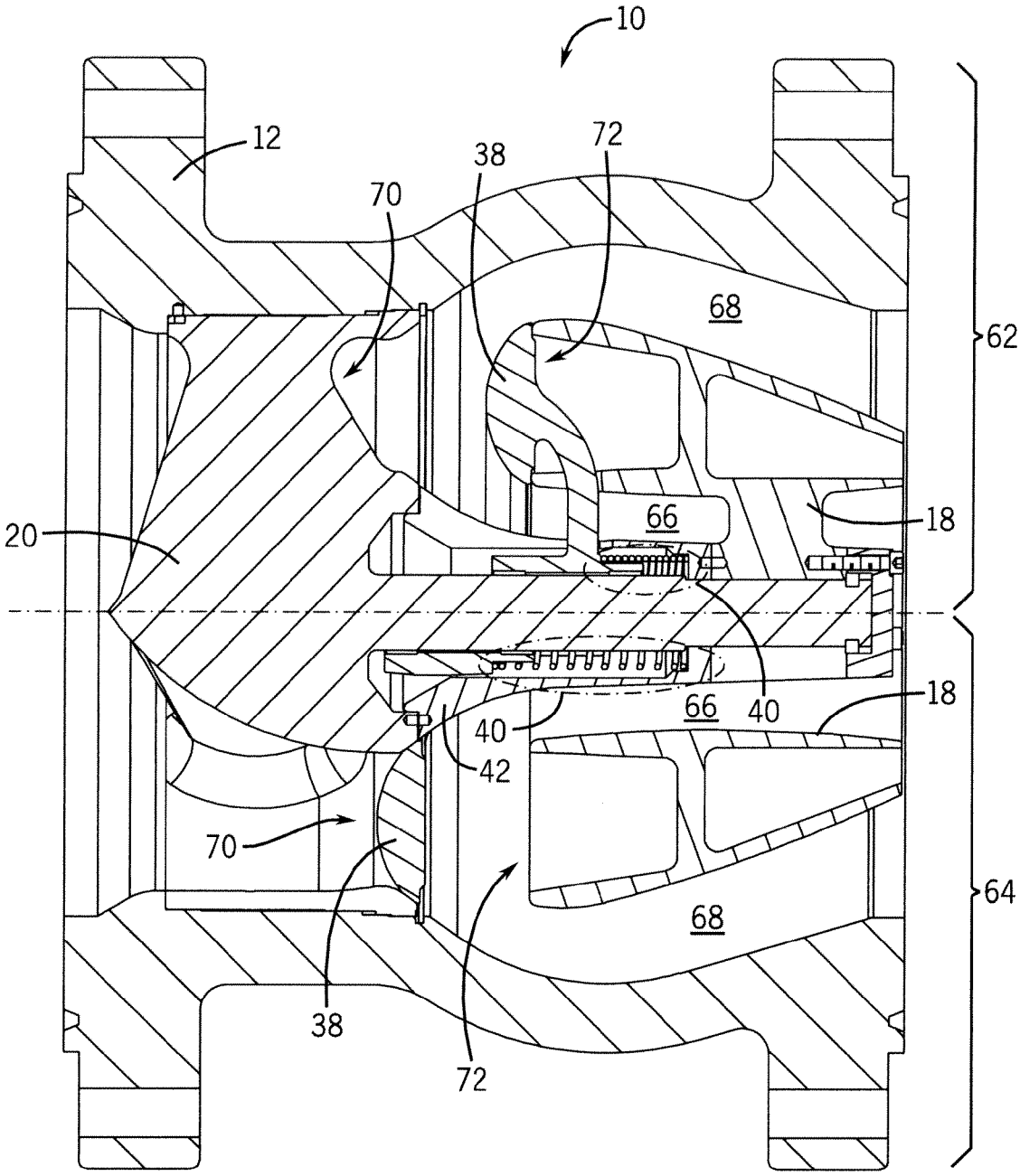

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/033128

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16K15/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2005 009989 B3 (ERHARD GMBH & CO KG [DE]) 1 June 2006 (2006-06-01) figures 1,3	1-8
X	US 4 437 492 A (TAYLOR JULIAN S [US]) 20 March 1984 (1984-03-20) figures 1-12	1-8
X	US 6 443 183 Bl (R00RDA 0ENE [CA]) 3 September 2002 (2002-09-03) figures 1-5	1-8
X	US 4 766 929 A (YAINDL CHARLES [US]) 30 August 1988 (1988-08-30) figure 1	1-15
X	DE 202 00 792 Ul (N0REVA GMBH [DE]) 4 April 2002 (2002-04-04) figure 1	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" documentwhich may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2011	10/06/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bilo, Eric

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/033128

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

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

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

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

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

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

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

see additional sheet

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

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

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

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

Remark on Protest

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

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

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-8

   A nozzle check valve comprising a valve body, a nozzle a first fluid passage and an annular disc configured to move without rotation.

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2. claims: 9-15

   A check valve kit comprising a valve body and an annular disc capable of opening and closing a first and second fluid passage.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2011/033128

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102005009989 B3	01-06-2006	NONE	
US 4437492 A	20-03-1984	NONE	
us 6443183 Bl	03-09-2002	CA 2350053 Al US 2002189688 Al	07-12-2001 19-12-2002
us 4766929 A	30-08-1988	NONE	
DE 20200792 Ul	04-04-2002	AT 295498 T EP 1329658 Al	15-05-2005 23-07-2003