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(54) **CHECK VALVE WITH IMPROVED SEALING MEMBER**

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F16K 15/06 (2006.01)
F16K 15/02 (2006.01)

(52) **U.S. Cl.**
CPC ***F16K 15/06*** (2013.01); ***F16K 15/023*** (2013.01); *Y10T 137/7915* (2015.04)

(58) **Field of Classification Search**
CPC F16K 15/021; F16K 15/023; F16K 15/08; F16K 15/141; F16K 1/44; Y10T 137/7866;
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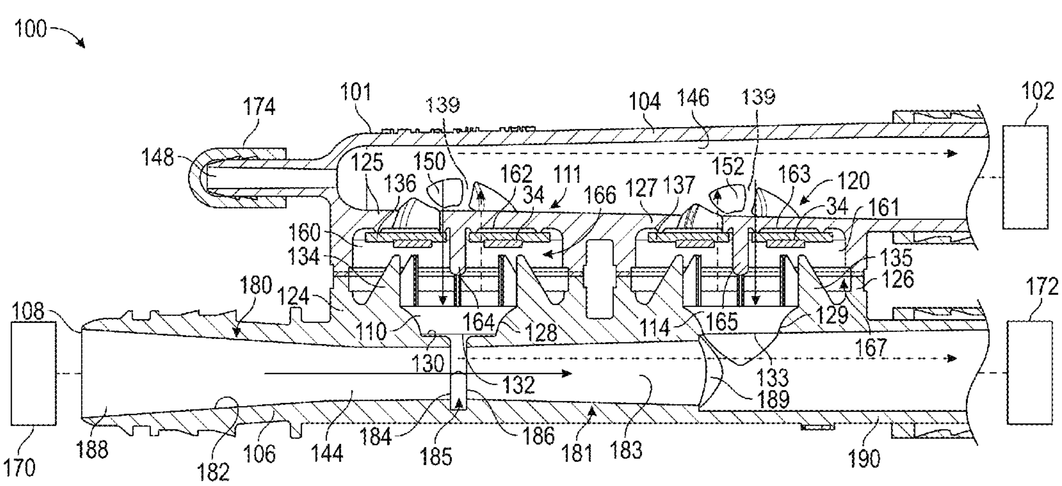
(57) **ABSTRACT**

Check valves are disclosed, including check valve included in an aspirator, that includes a housing defining an internal cavity having a first port and a second port both in fluid communication therewith, and a sealing member within the cavity. The sealing member is translatable between a closed position against a first seat within the internal cavity of the housing and an open position against a second seat within the internal cavity of the housing. The sealing member has a sealing material positioned for sealing engagement with the first seat when the sealing member is in the closed position and a reinforcing member positioned for engagement with the second seat when the sealing member is in the open position.

20 Claims, 5 Drawing Sheets



(58) **Field of Classification Search**
CPC Y10T 137/137; Y10T 137/7862; Y10T 137/7896; Y10T 137/7918; Y10T 137/7919; Y10T 137/7913; Y10T 137/7916
USPC 137/533.27
See application file for complete search history.

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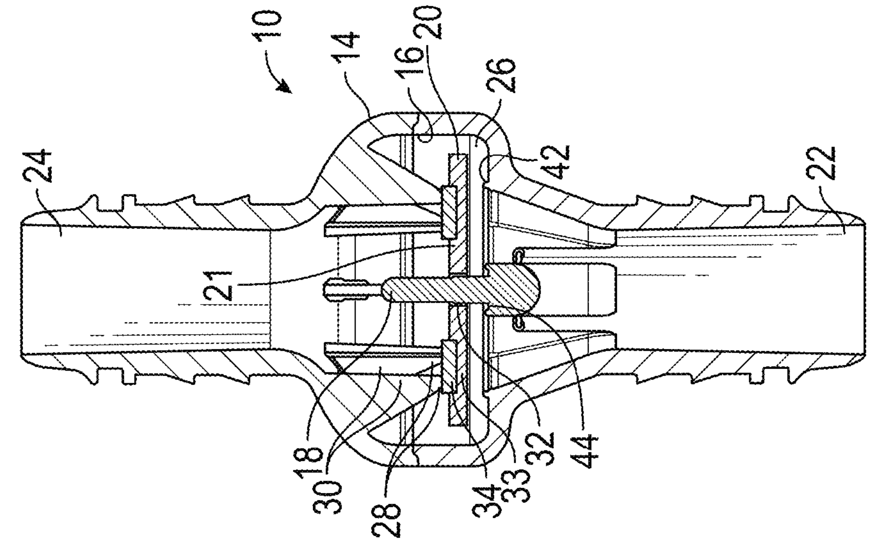


FIG. 2

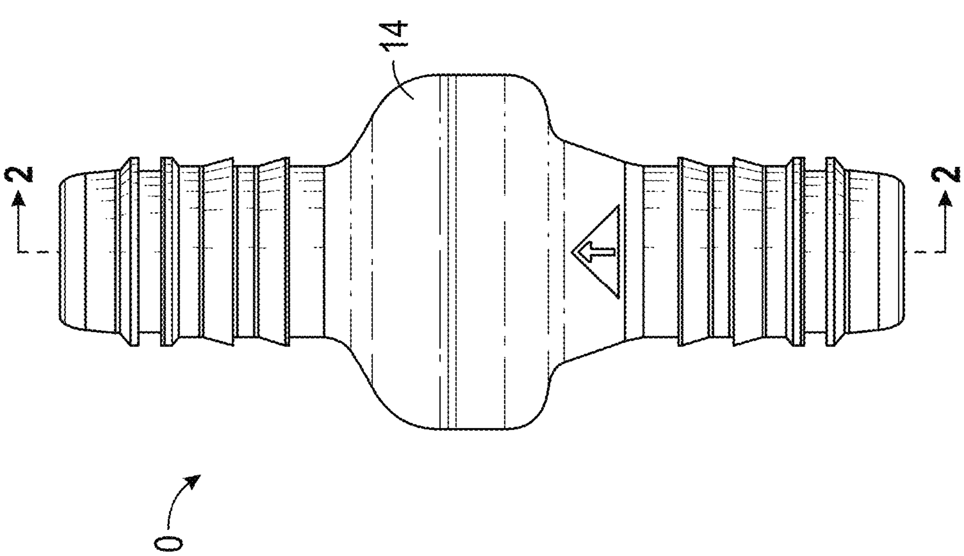


FIG. 1

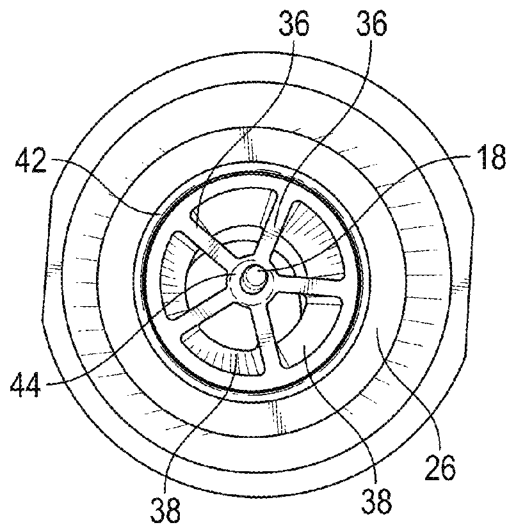


FIG. 3A

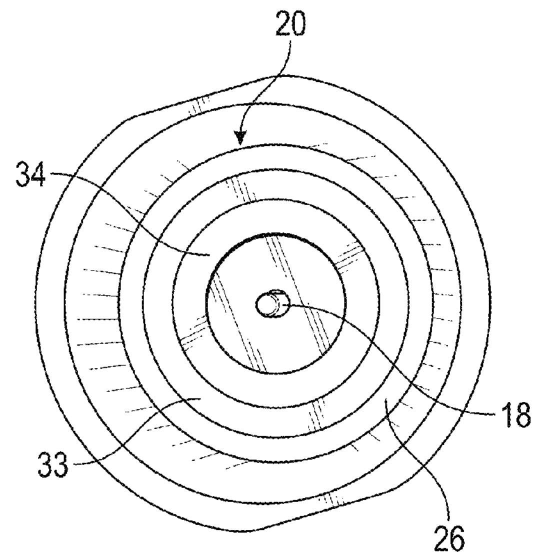


FIG. 3B

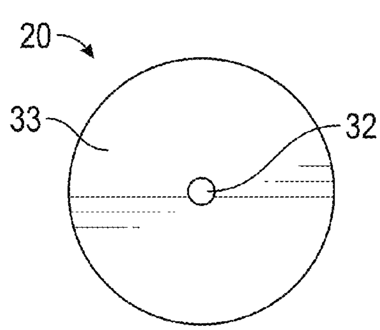


FIG. 3C

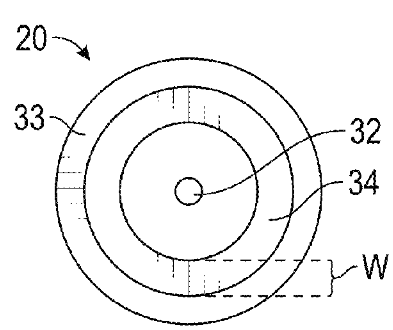


FIG. 3D

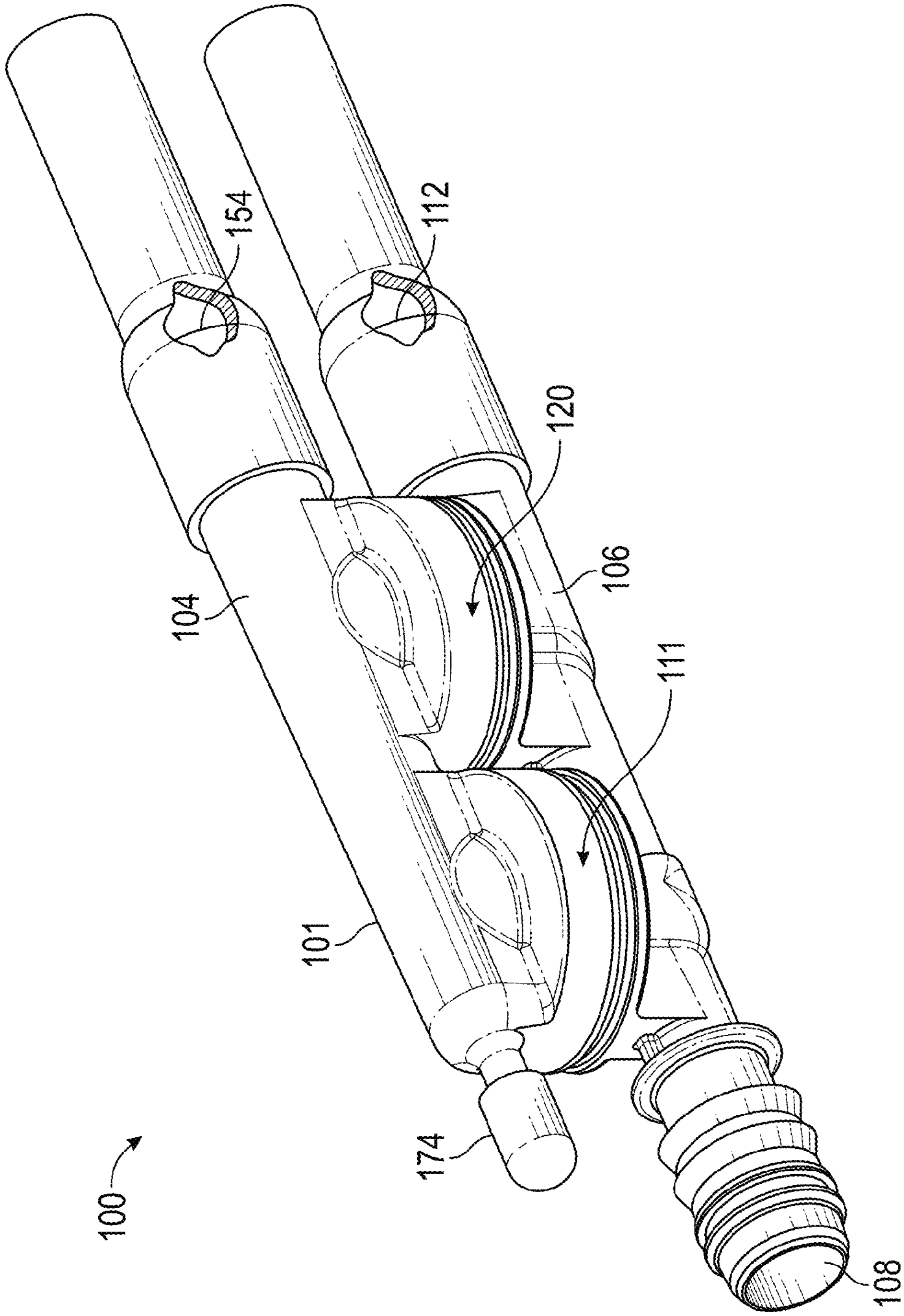
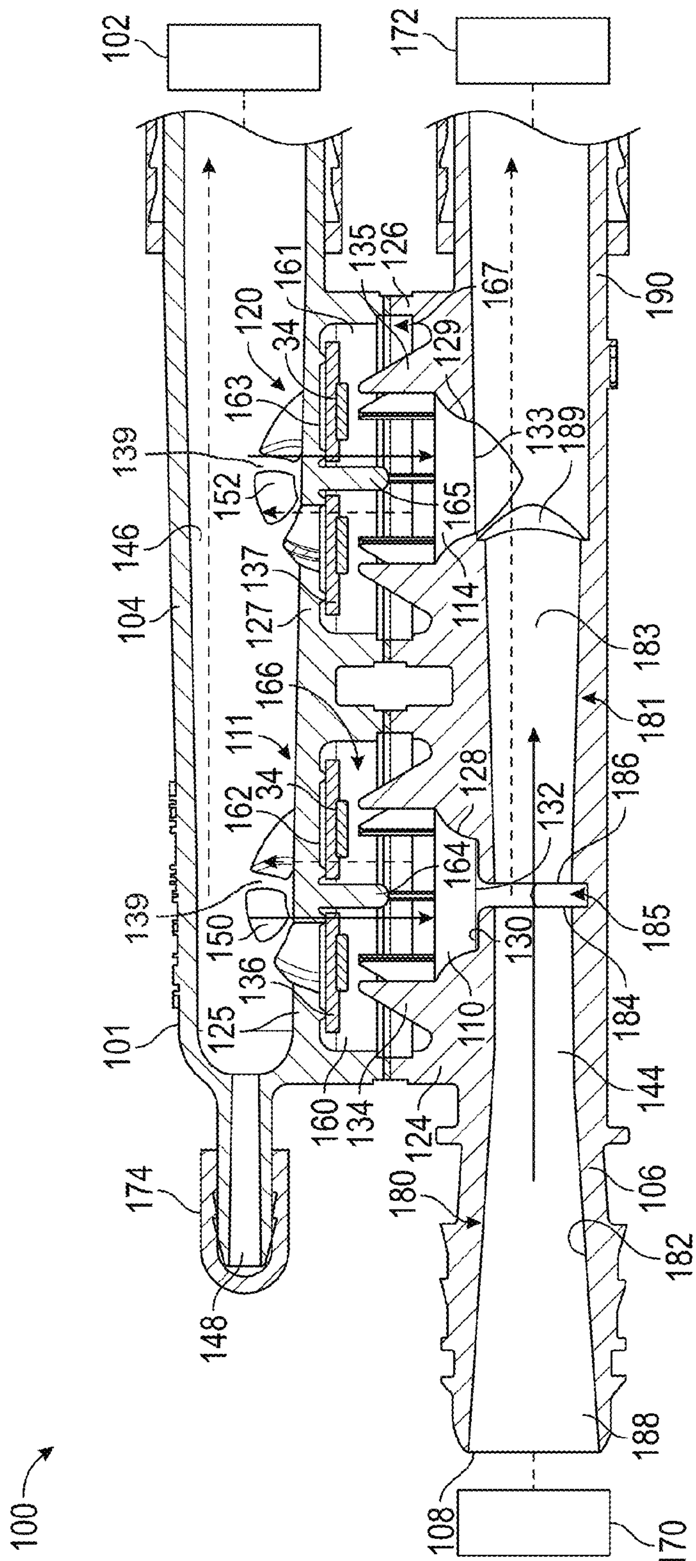


FIG. 4


102
172
135
126
161
120
167
190
34
129
163
133
189
139
152
165
146
137
114
104
127
183
166
181
111
128
34
186
162
132
164
139
185
150
130
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125
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134
124
174
180
106
182
148
188
100
108
170

FIG. 5

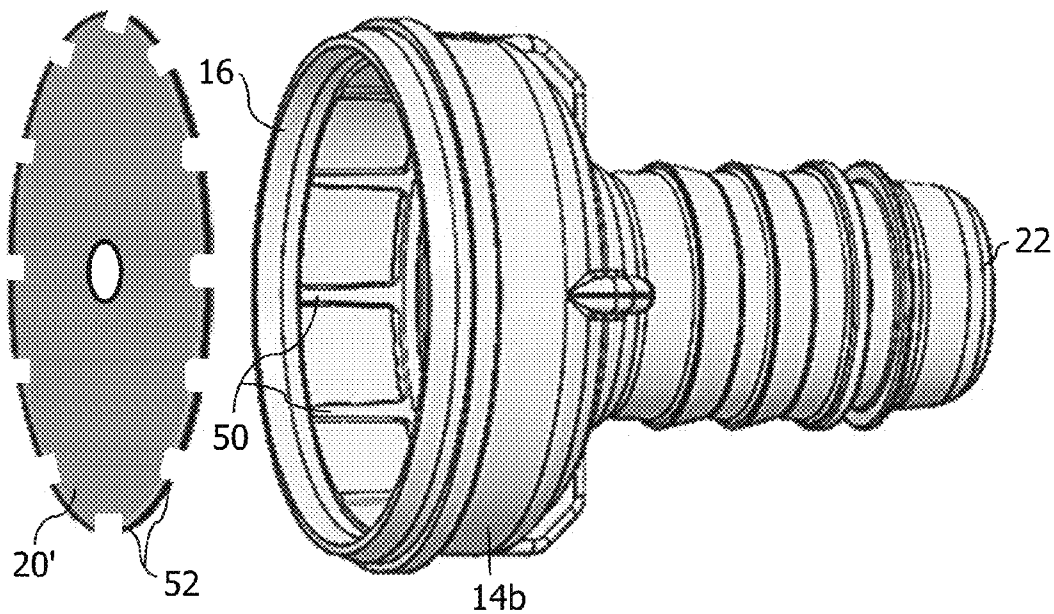

FIG. 6

CHECK VALVE WITH IMPROVED SEALING MEMBER

RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 61/929,264, filed Jan. 20, 2014, the entirety of which is incorporated herein by reference.

TECHNICAL FIELD

This application relates to check valves for use in engine systems such as internal combustion engines, more particularly to check valves having an improved sealing member.

BACKGROUND

Engines, for example vehicle engines, have included aspirators and/or check valves for a long time. Typically, the aspirators are used to generate a vacuum that is lower than engine manifold vacuum by inducing some of the engine air to travel through a venturi. The aspirators may include check valves therein or the system may include separate check valves. When the check valves are separate, they are typically included downstream between the source of the vacuum and the device using the vacuum.

In engines that have a brake boost system, conditions exist that may make it difficult for a check valve to seal effectively. This is undesirable, and new check valves are needed to provide more efficient sealing.

SUMMARY

In one aspect, check valve units are disclosed that are connectable into a fluid communication system, for example those systems in an internal combustion engine. In one embodiment, the check valve includes a housing defining an internal cavity having a first port and a second port both in fluid communication therewith, and a sealing member within the cavity. The sealing member is translatable between a closed position against a first seat within the internal cavity of the housing and an open position against a second seat within the internal cavity of the housing. The sealing member has a sealing material positioned for sealing engagement with the first seat when the sealing member is in the closed position and a reinforcing member positioned for engagement with the second seat when the sealing member is in the open position. The second seat may be a plurality of radially spaced apart fingers extending into the internal cavity. The first seat may include a first annular seal bead surrounding an opening defined by the housing for fluid communication between the internal cavity and the first port. The sealing member seals in the closed position under a change in pressure of about 1.0 kPag to about 6.0 kPag.

In one embodiment, the reinforcing member is mounted on the exterior surface of the sealing material or is encased within the sealing material. In another embodiment, the sealing material is over-molded onto a portion of the reinforcing member. When assembled, the reinforcing material of the sealing member is positioned above, but radially inward relative to the position of the first annular seal bead. In one embodiment, with such a positioned reinforcing material, the first seat may also include a second annular seal bead disposed radially inward of the first annular seal bead. Here, the reinforcing material is positioned above both the first and second annular seal beads and is further radially outward relative to the position of the second annular seal bead.

In one aspect, the width of the reinforcing member is proportional to the dimensions of the portion of the second seat that engages the sealing member. When the reinforcing member is a ring of material, the width is the difference between the inner diameter and the outer diameter of the ring of material.

In one embodiment, the housing includes a pin and the sealing member may include a bore therethrough. Once the check valve is assembled, the pin of the housing is received in the bore of the sealing member for translation of the sealing member along the pin.

In another embodiment, the housing may include one or more guides positioned about the periphery of the sealing member, and the sealing member may include fluting in its periphery that aligns with one or more guides.

In another aspect, aspirators are disclosed that include check valves therein that have the sealing member with a reinforcing member as described herein. The use of the word "aspirator" is not intended to be construed in a limiting manner and includes devices with a Venturi gap that operates with atmospheric pressure as the motive flow or operates with greater than atmospheric spheric pressure, for example, boosted air from a turbocharge, as the motive flow. The check valve may be positioned within the aspirator to control fluid flow through a suction port aligned with a Venturi gap. In one embodiment, the aspirator includes a second check valve controlling fluid flow through a bypass downstream from the Venturi gap. The second check valve may also have a sealing member with a reinforcing member as described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front perspective view of a check valve.

FIG. **2** is a longitudinal, cross-sectional view of the check valve of FIG. **1**.

FIG. **3**A is a top plan view of the check valve without the sealing member.

FIG. **3**B is a top plan view of the check valve with the sealing member positioned in the cavity.

FIG. **3**C is a bottom plan view of the sealing member.

FIG. **3**D is a top plan view of the sealing member.

FIG. **4** is a side, perspective view of one embodiment of an aspirator having the improved sealing member.

FIG. **5** is a side, longitudinal cross-sectional plan view of the aspirator of FIG. **4**.

FIG. **6** is a front perspective view of one embodiment of a section of the housing and the sealing member in an un-assembled state.

DETAILED DESCRIPTION

The following detailed description will illustrate the general principles of the invention, examples of which are additionally illustrated in the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements.

As used herein, "fluid" means any liquid, suspension, colloid, gas, plasma, or combinations thereof.

FIGS. **1-2** disclose a check valve **10** that includes a housing **14** defining an internal cavity **16** having a pin **18** therein upon which is seated a sealing member **20** and defining a first port **22** in fluid communication with the internal cavity **16** and a second fluid port **24** in fluid communication with the internal cavity **16**. The housing **14** may be a multiple piece housing with pieces connected together with a fluid-tight seal. The internal cavity **16** typically has larger dimensions than the first port **22** and the second port **24**. In the illustrated embodiment, the first port **22** and the second port **24** are positioned opposite one another to define a generally linear flow path through the check valve **10**, when the sealing member **20** is not present, but is not limited to this configuration. In another embodiment, the first and fluid ports may be positioned relative to one another at an angle of less than 180 degrees. The portion of the housing **14** defining the internal cavity **16** includes an internal first seat **26** upon which the sealing member **20** seats when the check valve is "closed" and a second seat **28** upon which the sealing member seats when the check valve is "open." In FIG. **2**, the second seat **28** is a plurality of radially spaced fingers **30** extending into the internal cavity **16** from an interior surface of the internal cavity **16** that is more proximate the second port **24**.

A top view looking into the internal cavity **16** is shown in FIG. **3**A. Here, the pin **18** is seen centrally positioned within the internal cavity **16** and a plurality of arms **36** are extending radially outward from the pin **18** to subdivide the flow path leading into the internal cavity into a plurality of conduits **38** to direct the fluid flow around the periphery of the sealing member **20** when the check valve **10** is in an open position. In FIG. **3**B, the sealing member **20** has been placed onto the pin within the internal cavity **16** of FIG. **3**A. As seen, the reinforcing member **34** is facing upward toward the viewer, which will be toward the second port **24** in a fully assembled check valve **10**.

The sealing member **20** is reinforced for improved performance, in particular in a brake boost system within an engine. The sealing member **20** as seen in FIGS. **3**B to **3**D includes a sealing material **33** and a reinforcing member **34**. The illustrated embodiment has a generally central bore **32** to receive pin **18**, but is not limited thereto. In another embodiment shown in FIG. **6**, one or more guides **50** may be positioned about the periphery of the sealing member **20'** in the cavity, defined in part by housing section **14***b*, and the sealing member **20'** may or may not include fluting **52** that receives the guides **50**. As shown in FIGS. **2**, and **3**B, the reinforcing member **34** may be mounted on the exterior surface **21** of the sealing member **20** that faces the second seat **28**, or in other embodiments may be over-molded at least partially by the sealing material **33** or encased within the sealing material **33**. In one embodiment, the reinforcing member **34** is or includes metal having a rigidity enabling the sealing member **20** to withstand extruding when a high change in pressure is experienced. As used herein, "metal" is used generically to represent all materials that may be pure metal, metal alloys, metal composites, and combinations thereof having a suitable rigidity. In another embodiment, the reinforcing member **34** may be carbon fiber or plastics such as nylon or acetyl with or without fill (typically 30% by volume) such as glass, mineral, and the like.

The reinforcing member **34** may be a ring of material, such as those described above. The ring has an inner diameter and an outer diameter. As used herein, the width W (FIG. **3**D) of the ring is the difference between the inner diameter and the outer diameter. The width W of the ring is proportional to the second seat **28** to provide stability to the sealing member **20** when in the open position. In check valve **10**, the width is generally about 1 mm to about 10 mm. In another embodiment, the width of the check vale is about 2 mm to about 4 mm. The ring of reinforcing material also has a thickness. The thickness may be about 0.05 mm to about 1.00 mm, but in another embodiment may be 0.02 mm to about 0.5 mm. Typically, reinforcing material **34** is within the outer seal bead **42** and outer sealing material **33**, but is not limited thereto. Also, the reinforcing material **34** is typically outside of the inner seal bead **44** and outside of the hole **32** in the sealing material **33**, if a hole exists, but is not limited thereto. Note that there may or may not be an inner guide pin **18** and therefore no need for a center hole **32** on the sealing material **33**. It is preferred that the second seat **28** lines up somewhere within the width W of the reinforced material **34**.

The check valve **10** in one embodiment is for inclusion in a brake boost system and seals at very low change in pressure, for example a change in pressure of about 1.0 kPag to 6.0 kPag or more specifically about 2.4 kPag to about 4.4 kPag, but can withstand high changes in pressure such as a change in pressure of about 500 kPag to about 2,500 kPag or more specifically about 1,000 kPag to about 1,800 kPag. Additionally, the addition of the reinforcing member **34** improves the leak rate of the check valve. The leak rate is about 0.2 cc/min to about 2 cc/min, or more specifically about 0.3 cc/min to about 0.7 cc/min.

FIG. **4** is an external view of an aspirator-check valve assembly, generally identified by reference number **100**, for use in an engine, for example, in a vehicle's engine. The engine may be an internal combustion engine that includes a device requiring a vacuum. Check valves are normally employed in an internal combustion engine in the air flow line between the engine block and the air intake port at the full mixing port, normally a carburetor or fuel injection port. The engine and all its components and/or subsystems are not shown in the figures, with the exception of a few boxes included to represent specific components of the engine as identified herein, and it is understood that the engine components and/or subsystems may include any common to the internal combustion engines.

Referring to FIGS. **4** and **5**, the aspirator-check valve assembly **100** is connectable to a device requiring a vacuum **102** and creates vacuum for said device **102** by the flow of air through a passageway **144**, extending generally the length of a portion of the aspirator-check valve assembly, designed to create the Venturi effect. The aspirator-check valve assembly **100** includes housing **101**, which as illustrated is formed of an upper housing portion **104** and a lower housing portion **106**. The designations of upper and lower portions are relative to the drawings as oriented on the page, for descriptive purposes, and are not limited to the illustrated orientation when utilized in an engine system. Preferably, upper housing portion **104** is joined to lower housing portion **106** by sonic welding, heating, or other conventional methods for forming an airtight seal therebetween.

Still referring to FIGS. **4** and **5**, the lower housing portion **106** defines passageway **144** which includes a plurality of ports, some of which are connectable to components or subsystems of the engine. The ports include: (1) a motive port **108**, which supplies clean air from the engine intake air cleaner **170**, typically obtained upstream of the throttle of the engine; (2) a suction port **110**, which can connect via the check valve **111** to a device requiring vacuum **102**; (3) a discharge port **112**, which is connected to an engine intake manifold **172** downstream of the throttle of the engine; and, optionally, (4) a bypass port **114**. Check valve **111** is preferably arranged to prevent fluid from flowing from the suction port **110** to the application device **102**. In one embodiment, the device requiring vacuum **102** is a vehicle brake boost device. The bypass port **114** may be connected to the device requiring vacuum **102** and, optionally, may include a check valve **120** in the fluid flow path therebetween. Check valve **120** is preferably arranged to prevent fluid from flowing from the bypass port **114** to the application device **102**.

As shown in FIG. **5**, lower housing portion **106** includes lower valve seats **124**, **126**. Each lower valve seat **124**, **126** is defined by a continuous outer wall **128**, **129**, and, optionally, a bottom wall such as wall **130** in lower valve seat **124**. A bore **132**, **133** is defined in each lower valve seat **124**, **126** to allow for air flow communication with air passageway **144**. Each lower valve seat **124**, **126** includes a plurality of radially spaced fingers **134**, **135** extending upwardly from an upper surface thereof. The radially spaced fingers **134**, **135** serve to support a seal member **136**, **137**.

Referring again to FIGS. **4** and **5**, the upper housing portion **104** is configured for mating to or with the lower housing portion **106** to form the check valves **111**, **120**, if both are present. Upper housing portion **104** defines passageway **146** extending the length thereof and defines a plurality of ports, some of which are connectable to components or subsystems of the engine. The ports include: (1) a first port **148** that may be capped with cap **174** or may be connected to a component or subsystem of the engine; (2) a second port **150** in fluid communication with the suction port **110** in the lower housing portion **106**, and between which the seal member **136** is disposed; (3) a third port **152** in fluid communication with the bypass port **114** in the lower housing portion **106**, and between which the seal member **137** is disposed; and (4) a fourth port **154** which may function as an inlet connecting the aspirator-check valve assembly to a device requiring vacuum **102**.

As shown in FIG. **5**, the upper housing portion **104** includes upper valve seats **125**, **127**. Each upper valve seat **125**, **127** is defined by continuous outer wall **160**, **161** and bottom wall **162**, **163**. Both upper valve seats **125**, **127** may include a pin **164**, **165** extending downwardly from the bottom walls **162**, **163**, respectively, toward the lower housing portion **106**. The pins **164**, **165** function as a guide for translation of the sealing members **136**, **137** within the cavities **166**, **167** defined by the mated upper valve seat **125** with the lower valve seat **124** and defined by the mated upper valve seat **127** with the lower valve seat **126**.

Each sealing member **136**, **137** may be a reinforced sealing member as described above that includes the reinforcing member **34**. As illustrated, each sealing member **136**, **137** includes a bore therethrough sized and positioned therein for receipt of the pin **164**,**165** within its respective cavity **166**, **167**.

Referring again to FIG. **5**, the passageway **144** in the lower housing portion **106** has an inner diameter along a central longitudinal axis that includes a first tapering portion **182** (also referred to herein as the motive cone) in the motive section **180** of the lower housing portion **106** coupled to a second tapering portion **183** (also referred to herein as the discharge cone) in the discharge section **181** of the lower housing portion **106**. Here, the first tapering portion **182** and the second tapering portion **183** are aligned end to end (outlet end **184** of the motive section **180** to inlet end **186** of the discharge section **181**). The inlet ends **188**, **186** and the outlet ends **184**, **189** may be any circular shape, ellipse shape, or some other polygonal form and the gradually, continuously tapering inner dimensions extending therefrom may define, but are not limited to, a hyperboloid or a cone. Some example configurations for the outlet end **184** of the motive section **180** and inlet end **186** of the discharge section **181** are presented in FIGS. **4-6** of co-pending U.S. Patent Application No. 61/833,746, filed Jun. 11, 2013, incorporated by reference herein in its entirety. As seen in FIG. **5**, a Venturi gap **185** is defined between the outlet end **184** of the motive section **180** and the inlet end **186** of the discharge section **181**.

As seen in FIG. **5**, the first tapering portion **182** terminates at a fluid junction with suction port **110**, which is in fluid communication therewith, and at this junction the second tapering portion **183** begins and extends away from the first tapering portion **182**. The second tapering portion **183** is also in fluid communication with the suction port **110**. The second tapering portion **183** then forms a junction with the bypass port **114** proximate the outlet end **189** of the second tapering portion and is in fluid communication therewith. The first and second tapering portions **182**,**183** typically share the central longitudinal axis of the lower housing portion **106**.

Still referring to FIG. **5**, the inner diameter of the second tapering portion **183** tapers gradually, continuously from a smaller diameter inlet end **186** to a larger diameter outlet end **189**. This inner diameter may be any circular shape, ellipse shape, or some other polygonal form, including but not limited to a hyperboloid or a cone. The optional bypass port **114** may intersect the discharge section **190** as described above to be in fluid communication with the second tapering section **183**. The bypass port **114** may intersect the second tapering section **183** adjacent to, but downstream of the outlet end **189**. The lower housing portion **106** may thereafter, i.e., downstream of this intersection of the bypass port, continue with a cylindrically uniform inner diameter until it terminates at the discharge port **112**. Each of the respective ports **108**, **110**, **112**, and **114** may include a connector feature on the outer surface thereof for connecting the passageway **144** to hoses or other features in the engine.

When the aspirator-check valve assembly **100** is connected into an engine system, for example as illustrated in FIG. **5**, the check valves **111** and **120** function as follows. As the engine operates, the intake manifold **172** draws air in motive port **180**, through passageway **144**, and out the discharge port **112**. This creates a partial vacuum in the check valves **111**, **120** and passageway **146** to draw seals **136**, **137** downward against the plurality of fingers **134**, **135**. Due to the spacing of fingers **134**, **135**, free fluid flow from passageway **144** to passageway **146** is allowed. The partial vacuum created by the operation of the engine serves in the vacuum assistance of at least the operation of the device requiring vacuum **102**.

The air flow system in the typical internal combustion engine operates on the principle that as the engine operates, a partial vacuum is created which pulls air through the air intake port of the carburetor or fuel injector to aid in proper fuel combustion. This vacuum has been found to be useful in supplementing vacuum assist subsystems in the vehicle, particularly brakes, automatic transmissions and most recently, air conditioners. Aspirator-check valve assemblies such as assembly **100** may provide a connection between the main airway and the subsystem and serve to inhibit back pressure from the subsystem from disturbing airflow through the main airway.

The check valves disclosed herein, with the inclusion of the reinforcing member, have several advantages over other check valves. One advantage is that the check valve, in particular the sealing member, seals at low changes in pressure, but can withstand high changes in pressure (for example, an engine backfire). Other advantages include a reduction in the leak rate when the sealing member is in a closed position, the material that the sealing member is made of is prevented from "extruding" through, into, or around the radially spaced arms **36**, **139**, and results in low flow restrictions through the check valve.

Although the invention is shown and described with respect to certain embodiments, modifications will occur to those skilled in the art upon reading and understanding the specification, and the present invention includes all such modifications.

What is claimed is:

1. A check valve comprising:

a housing defining an internal cavity having a first port and a second port both in fluid communication therewith; and

a sealing member within the cavity, wherein the sealing member is a generally flat disc translatable between a closed position against a first seat within the internal cavity of the housing and an open position against a second seat within the internal cavity of the housing;

wherein the sealing member comprises a sealing material positioned for sealing engagement with the first seat when the sealing member is in the closed position and a reinforcing member positioned for engagement with the second seat when the sealing member is in the open position;

wherein, in the open position, fluid communication with the second port is through the second seat;

wherein the first seat includes a first annular seal bead surrounding an opening defined by the housing for fluid communication between the internal cavity and the first port, and a second seal bead disposed radially inward of the first annular seal bead and separated therefrom by the opening defined by the housing for fluid communication between the internal cavity and the first port; and

wherein the reinforcing member comprises a material different than the sealing material of the sealing member.

2. The check valve of claim **1**, wherein the housing includes a pin, the sealing member includes a bore therethrough, and the pin of the housing is received in the bore of the sealing member for translation of the sealing member along the pin.

3. The check valve of claim **1**, wherein the second seat is a plurality of radially spaced apart fingers extending into the internal cavity.

4. The check valve of claim **1**, wherein the reinforcing member is mounted on the exterior surface of the sealing material or is encased within the sealing material.

5. The check valve of claim **1**, wherein the sealing material is over-molded onto a portion of the reinforcing member.

6. The check valve of claim **1**, wherein the reinforcing member is a ring of material having a width of about 2 mm to about 4 mm, the width being the difference between the inner diameter and the outer diameter of the ring of material.

7. The check valve of claim **1**, wherein the sealing member seals in the closed position under a change in pressure of about 1.0 kPag to about 6.0 kPag.

8. The check valve of claim **1**, wherein the check valve is incorporated into an aspirator.

9. An aspirator comprising:

a check valve according to claim **1** controlling fluid flow through a bypass port downstream from a Venturi gap.

10. The check valve of claim **1**, further comprising one or more guides positioned about the periphery of the sealing member.

11. The check valve of claim **10**, wherein the sealing member includes fluting in its periphery that align with the one or more guides.

12. The check valve of claim **1**, wherein the reinforcing material member of the sealing member is positioned at least partially radially inward relative to the position of the first annular seal bead.

13. The check valve of claim **12**, wherein the reinforcing member of the sealing member is positioned radially outward relative to the position of the second annular seal bead.

14. An aspirator comprising:

a check valve according to claim **1** controlling fluid flow through a suction port aligned with a Venturi gap.

15. The aspirator of claim **14**, further comprising a second check valve according to claim **1** controlling fluid flow through a bypass downstream from the Venturi gap.

16. A check valve comprising:

a housing defining an internal cavity having a first port and a second port both in fluid communication therewith; and

a sealing member within the cavity, wherein the sealing member is a generally flat disc translatable between a closed position against a first seat within the internal cavity of the housing and an open position against a second seat within the internal cavity of the housing;

wherein the sealing member comprises a sealing material positioned for sealing engagement with the first seat when the sealing member is in the closed position and a reinforcing member positioned for engagement with the second seat when the sealing member is in the open position;

wherein the second seat is a plurality of radially spaced apart fingers extending into the internal cavity;

wherein the first seat includes a first annular seal bead surrounding an opening defined by the housing for fluid communication between the internal cavity and the first port, and a second seal bead disposed radially inward of the first annular seal bead and separated therefrom by the opening defined by the housing for fluid communication between the internal cavity and the first port; and

wherein the reinforcing member comprises a material different than the sealing material of the sealing member.

17. The check valve of claim **16**, wherein the reinforcing member is mounted on the exterior surface of the sealing material or is encased within the sealing material.

18. The check valve of claim **16**, wherein the sealing material is over-molded onto a portion of the reinforcing member.

19. The check valve of claim **16**, wherein the reinforcing member is a ring of material having a width of about 2 mm to about 4 mm, the width being the difference between the inner diameter and the outer diameter of the ring of material.

20. The check valve of claim **16**, wherein the sealing member seals in the closed position under a change in pressure of about 1.0 kPag to about 6.0 kPag.

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