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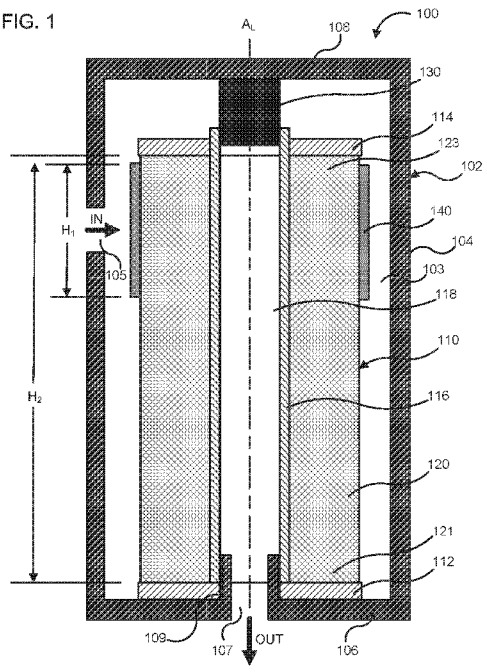
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FIG. 1



(57) Abstract: A filter assembly comprises a filter housing defining an internal volume. A filter element is positioned within the internal volume. The filter element comprises a filter media comprising a plurality of pleats. The plurality of pleats define a plurality of pleat tips. A barrier is positioned around at least a portion of the filter media. At least a portion of the plurality of pleat tips contact a barrier inner surface of the barrier and are bonded thereto so as to secure the respective pleats.

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FILTER ELEMENT WITH BARRIER

Technical Field

[0001] The present disclosure relates generally to filters for use with internal combustion engine systems.

Background

[0002] Internal combustion engines generally use various fluids during operation. For example, fuel (e.g., diesel, gasoline, natural gas, etc.) is used to run the engine. Air may be mixed with the fuel to produce an air-fuel mixture, which is then used by the engine to run under stoichiometric or lean conditions. Furthermore, one or more lubricants may be provided to the engine to lubricate various parts of the engine (e.g., piston cylinder, crank shaft, bearings, gears, valves, cams, etc.). These fluids may become contaminated with particulate matter (e.g., carbon, dust, metal particles, etc.) which may damage the various parts of the engine if not removed from the fluid.

[0003] To remove such particulate matter or other contaminants, the fluid is generally passed through a filter element (e.g., a fuel filter, a lubricant filter, an air filter, etc.) structured to remove the contaminants from the fluid, prior to delivering the fluid to the internal combustion engine. The filter element is typically positioned within a housing. In some filter assemblies, the lubricant may be inserted into the housing such that it impinges directly on a filter media included in the filter element, which may not be desirable.

Summary

[0004] Embodiments described herein relate generally to systems and methods for filtering a fluid, for example air, fuel, air-fuel mixture or a lubricant, and in particular to a filter element that comprises a barrier positioned around a portion of a filter media of the filter element.

[0005] In a first set of embodiments, a filter assembly comprises a filter housing defining an internal volume. A filter element is positioned within the internal volume. The filter element

comprises a filter media comprising a plurality of pleats. The plurality of pleats define a plurality of pleat tips. A barrier is positioned around at least a portion of the filter media. At least a portion of the plurality of pleat tips contacts and are bonded to a barrier inner surface of the barrier so as to secure the at least a portion plurality of pleats in a fixed positioned.

[0006] In another set of embodiments, a filter element comprises a filter media comprising a plurality of pleats. The plurality of pleats define a plurality of pleat tips. A barrier is positioned around at least a portion of the filter media. At least a portion of the plurality of pleat tips contacts and are bonded to a barrier inner surface of the barrier so as to secure the at least a portion of the plurality of pleats in a fixed position. A first end cap is positioned on a first end of the filter media. A second end cap is positioned on a second end of the filter media opposite the first end.

[0007] In yet another set of embodiments, a method comprises providing a filter media comprising a plurality of pleats. The plurality of pleats define a plurality of pleat tips. A first end cap is coupled to a filter media first end of the filter media. A second end cap is coupled to a filter media second end of the filter media, which is opposite the filter media first end. A barrier is positioned around at least a portion of the filter media such that each of the plurality of pleat tips contact a barrier inner surface of the barrier. At least a portion of the plurality of pleat tips are bonded to the barrier inner surface of the barrier so as to secure the at least a portion of the plurality of pleats in a fixed position.

[0008] In still another set of embodiments, a method for using a filter element comprises providing a filter element. The filter element comprises a filter media comprising a plurality of pleats. The plurality of pleats define a plurality of pleat tips. The filter element also comprises a barrier positioned around at least a portion of the filter media. At least a portion of the plurality of pleat tips contact, and are bonded to a barrier inner surface of the barrier so as to secure the at least a portion of the plurality of pleats in a fixed position. The filter element is positioned in an internal volume of a filter housing such that the barrier is in a flow path of the fluid inlet of the filter housing. The method further comprises flowing a fluid into the internal volume via the fluid inlet such that the fluid flow impinges on a barrier outer surface of the barrier of the filter element, the barrier outer surface opposite the barrier inner surface.

[0009] It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent) are contemplated as being part of the subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the subject matter disclosed herein.

Brief Description of Drawings

[0010] The foregoing and other features of the present disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several implementations in accordance with the disclosure and are therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings.

[0011] FIG. 1 is a schematic illustration of a filter assembly, according to an embodiment.

[0012] FIG. 2 is a side view of a filter element, according to another embodiment.

[0013] FIG. 3 is a top perspective view of the filter element of FIG. 2.

[0014] FIG. 4A is a front view of a portion of a filter media and a barrier positioned thereon, which can be included in the filter assembly of FIGS. 1 or 2; and FIG. 4B is a side cross-section view of the filter media of FIG. 4A taken along the line X-X shown in FIG. 4A.

[0015] FIG. 5 is a schematic flow diagram of a method for fabricating a filter element.

[0016] FIG. 6 is a schematic flow diagram of a method for using a filter element in a filter assembly.

[0017] Reference is made to the accompanying drawings throughout the following detailed description. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative implementations described in the detailed description, drawings, and claims are not meant to be limiting. Other implementations may be utilized, and other changes may be made, without departing from the spirit or scope of the

subject matter presented here. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the figures, can be arranged, substituted, combined, and designed in a wide variety of different configurations, all of which are explicitly contemplated and made part of this disclosure.

Detailed Description of Various Embodiments

[0018] Embodiments described herein relate generally to systems and methods for filtering a fluid, for example, air, fuel, air-fuel mixture or a lubricant, and in particular to a filter element that comprises a barrier positioned around a portion of a filter media of the filter element.

[0019] Internal combustion engines generally use various fluids during operation. For example, fuel (e.g., diesel, gasoline, natural gas, etc.) is used to run the engine. Air may be mixed with the fuel to produce an air-fuel mixture, which is then used by the engine to run under stoichiometric or lean conditions. Furthermore, one or more lubricants may be provided to the engine to lubricate various parts of the engine (e.g., piston cylinder, crank shaft, bearings, gears, valves, cams, etc.). These fluids may become contaminated with particulate matter (e.g., carbon, dust, metal particles, etc.) which may damage the various parts of the engine if not removed from the fluid.

[0020] To remove such particulate matter, or otherwise contaminants, the fluid is generally passed through a filter element (e.g., a fuel filter, a lubricant filter, an air filter, etc.) structured to remove the particulate matter from the fluid, prior to delivering the fluid. Some filter assemblies include a housing within which the filter element is positioned. In some filter assemblies, the lubricant may be inserted into the housing such that it impinges directly on a filter media included in the filter element, which may not be desirable. Furthermore, the filter media may include a plurality of pleats defining a plurality of pleat tips which may be susceptible to damage during insertion of the filter element into a filter housing or during operation.

[0021] Embodiments described herein provide for a filter element that comprises a barrier positioned around at least a portion of a filter media of the filter element. Such embodiments may provide benefits including, for example: (1) preventing a fluid (e.g., air, fuel, air-fuel

mixture or lubricant) inserted into a filter housing containing the filter element from directly impinging on the filter media of the filter element; (2) preventing damage, distortion or disturbance of location of the plurality of pleats; and (3) extending life of the filter element, thereby reducing maintenance costs.

[0022] FIG. 1 is a schematic illustration of a filter assembly 100 according to an embodiment. The filter assembly 100 may be used to filter a gas (e.g., air) or another fluid provided to an engine. The filter assembly 100 comprises a filter housing 102, a filter element 110, and optionally, a center tube 116.

[0023] The filter housing 102 defines an internal volume 103 within which the filter element 110 is positioned. The filter housing 102 may be formed from a strong and rigid material, for example plastics (e.g., polypropylene, high density polyethylene, polyvinyl chloride, etc.), metals (e.g., aluminum, stainless steel, etc.), polymers (e.g., reinforced rubber, silicone) or any other suitable material. In particular embodiments, the filter housing 102 may comprise a cylindrical housing having generally a circular cross-section. In other embodiments, the filter housing 102 may have any suitable cross-sectional shape, for example racetrack, oval, rectangular, polygonal, etc.

[0024] In some embodiments, the filter housing 102 comprises a monolithic structure. In other embodiments, the filter housing 102 comprises a sidewall 104. A base 106 is positioned at a sidewall first end of the sidewall 104 and coupled thereto. A cover 108 is positioned on a sidewall second end of the sidewall 104 opposite the sidewall first end. The cover 108 may be removably coupled to the sidewall 104.

[0025] For example, cover 108 may comprise threads defined on outer surface thereof and structured to engage mating threads defined on an inner surface of the sidewall 104, proximal to the sidewall first end, so as to allow removable coupling thereto. In other embodiments, the cover 108 may be snap fit, friction fit, screwed, bolted, or coupled to the sidewall first end using any other suitable removable coupling mechanism. The cover 108 is removable from the filter housing 102 so as to allow insertion and/or removal of the filter element 110 from the internal

volume 103. The cover 108 may be formed from any suitable material, for example, metal, plastics, polymers, elastomers, rubber, reinforced rubber, etc.

[0026] The sidewall 104 defines a fluid inlet 105 structured to receive a fluid (e.g., air, fuel, air-fuel mixture or a lubricant). The fluid inlet 105 is positioned such that the fluid entering the internal volume 103 impinges on a barrier 140 included on the filter element 110 (described below in detail) positioned within the internal volume 103. A fluid outlet 107 is defined in the base 106 of the filter housing 102. The fluid outlet 107 is structured to allow the fluid filtered through the filter element 110 to exit the filter housing 102.

[0027] In particular embodiments, the filter housing 102 may also comprise an inlet flange 109 extending from a rim of the fluid outlet 107 into the internal volume 103. The inlet flange 109 may be structured to receive a center tube first end of the center tube 116 therearound. The inlet flange 109 may serve as an alignment feature and/or a securing feature so as to allow proper positioning of the filter element 110 within the internal volume 103.

[0028] The filter media 120 is positioned along a longitudinal axis A_L of the filter assembly 100. The filter media 120 comprises a porous material having a predetermined pore size and is configured to filter particulate matter from the lubricant (e.g., engine oil) flowing therethrough. The filter media 120 may be positioned around the center tube 116. In particular embodiments, the center tube 116 may be included in the filter element 110, for example, the filter media 120 may be wound around the center tube 116 such that the center tube 116 is removable from the internal volume 103 with the filter element 110. In other embodiments, the filter media 120 may be removable from the center tube 116. For example, the center tube 116 may be integrated with the filter housing 102, or positioned separately in the filter housing 102 from the filter media 120.

[0029] In some embodiments, the filter media 120 may be caged. For example, the filter element 110 may also comprise a porous rigid structure (e.g., a wire mesh) positioned around the filter media 120, and structured to prevent damage to the filter media 120 during insertion and/or removal of the filter element 110 from the internal volume 103.

[0030] In particular embodiments, the filter media 120 may comprise a pleated filter media comprising a plurality of pleats. For example, FIG. 4A shows a portion of a filter media 320 which can be used as the filter media 120 of the filter element 110. The filter media 320 comprises a plurality of pleats 322. The plurality of pleats define a plurality of pleat tips 324. The plurality of pleats 322 may provide reinforcement to the filter media (e.g., by increasing a rigidity thereof) and/or increase a surface area of the filter media 320 so as to enhance a filtering efficiency thereof.

[0031] As described previously, the filter media 120 may be positioned around the center tube 116. The center tube 116 defines a center tube channel 118 in fluid communication with the fluid outlet 107. In particular embodiments, the center tube 116 may include slots or openings to allow the filtered fluid to flow through the filter media 120 into the center tube channel 118. The center tube channel 118 is in fluid communication with the fluid outlet 107 so as to allow the fluid being filtered through the filter media 120 and entering the center tube channel 118 to exit the filter housing 102 via the fluid outlet 107.

[0032] A first end cap 112 is coupled to a filter media first end 121 of the filter media 120 proximal to the fluid outlet 107. The first end cap 112 may include a first end cap opening structured to receive the center tube first end of the center tube 116. A second end cap 114 is coupled to a filter media second end 123 of the filter media 120 opposite the filter media first end 121. The second end cap 114 may define a second end cap opening structured to receive a center tube second end of the center tube 116 opposite the center tube first end. The first end cap 112 and the second end cap 114 may be formed from any suitable material, for example plastics, metals, rubber, reinforced rubber, polymers etc.

[0033] The first end cap 112 and the second end cap 114 may have a cross-section generally corresponding to the cross-section of the filter housing 102. In other embodiments, the cross-section of the first end cap 112 and the second end cap 114 may be smaller than the cross-section of the filter housing 102. The second end cap 114 may protect the second end of the filter media 120 as the filter element 110 is inserted into the internal volume 103 and/or maintain a shape (e.g., a cylindrical shape) of the filter media 120 so as to facilitate insertion of the filter element 110 into the internal volume 103. In particular embodiments, the first end cap

112 and the second end cap 114 may be fixedly coupled to the filter media first end 121 and the filter media second end 123, respectively via an adhesive.

[0034] In some embodiments, the filter assembly 100 may also comprise a bypass valve 130. The bypass valve 130 may comprise a one way valve (e.g., a check valve, a spring loaded valve, etc.) configured to selectively open so as to allow at least a portion of a fluid (e.g., a fuel or a lubricant) to bypass the filter media 120, and enter the center tube channel 118. For example, the filter media 120 may get contaminated over a period of extensive use which may prevent the fluid from passing through the filter media 120. This may cause excessive pressure to build up inside the internal volume 103, which may damage the filter element 110 and/or the filter housing 102. In such instances, the bypass valve 130 may open to allow the fluid to bypass the filter media 120 and flow directly into the center tube channel 118, thereby prevent excessive pressure from building up or releasing the pressure. A portion of the bypass valve 130 may be positioned in the center tube second end. In particular embodiments, the cover 108 may comprise a receptacle or any other feature structured to receive at least a portion of the bypass valve 130.

[0035] A barrier 140 is positioned around at least a portion of the filter media 120. For example, as shown in FIG. 1, the barrier 140 is positioned proximal to the filter media second end 123 of the filter media 120. Furthermore, at least a portion of the plurality of pleat tips defined by the plurality of pleats of the filter media 120 may contact a barrier inner surface of the barrier 140, and be bonded thereto so as to secure the plurality of pleats in a fixed location. For example, the barrier 140 may have a barrier inner circumference corresponding to an filter media outer circumference of the filter media 120 such that when the barrier 140 is positioned around at least the portion of the filter media 120, the barrier inner surface contacts the plurality of pleat tips. In particular embodiments, each of the plurality of pleat tips is bonded to the barrier inner surface. In other embodiments, only a portion of the plurality of pleat tips may be bonded to the barrier inner surface. For example, every other pleat tip of the plurality of pleat tips may be bonded to the barrier inner surface.

[0036] For example, as shown in FIG. 4A, a barrier 340 is positioned around the filter media 320. FIG. 4B shows a side-cross of the filter media 320 of FIG. 4A taken along the line

X-X in FIG. 4A. The barrier 340 may be substantially similar to the barrier 140. As shown in FIG. 4B, the barrier 340 comprises a barrier inner surface 342 facing the filter media 320, and a barrier outer surface 344 opposite the barrier inner surface 342.

[0037] At least a portion of the plurality of pleat tips 324 (e.g., all of the plurality of pleat tips 324) contacts the barrier inner surface 342 and are bonded thereto, so as to secure the plurality of pleats 322 in fixed position relative to each other and/or the barrier 340. In some embodiments, at least the portion of the plurality of pleat tips 324 may be thermally bonded to the barrier inner surface 342. In other embodiments, at least the portion of the plurality of pleat tips 324 may be bonded to the barrier inner surface 342 via an adhesive. In particular embodiments, a plurality of slots (not shown) may be defined on the barrier inner surface 342. At least the portion of the plurality of pleat tips 324 may be positioned within a corresponding slot, which may facilitate bonding of the plurality of pleats to the barrier 340 and/or securing of the plurality of pleats 322 in the fixed location.

[0038] In particular embodiments, an adhesive or a thermally activated material may be applied the barrier inner surface 342 of the barrier 340 (or the barrier 140) before the barrier 340 is secured to the plurality of pleat tips 324. For example, the adhesive may comprise a self-curing or reactive adhesive, or have a melting point lower than a melting point of each of the barrier 340 and the filter media 320. The barrier 340 may be bonded to the filter media 320 in a flat configuration. The filter media 320 is molded, rolled or folded and secured to itself to form a cylindrical structure (e.g., folded around the center tube 116).

[0039] Referring again to FIG. 1, the barrier 140 is positioned proximal to the fluid inlet 105 such that the stream of fluid (e.g., air, fuel, air-fuel mixture or lubricant) entering the internal volume impinges on a barrier outer surface (e.g., the barrier outer surface 344) of the barrier 140. Expanding further, the filter media 120 is formed from a first material, and the barrier 140 is formed from a second material stronger than the first material. Suitable second materials can include but are not limited to metals (e.g., aluminum foil, aluminum tube, thin aluminum wrap, stainless steel, steel coated with corrosion inhibitor, alloys, etc.), composites (e.g., molded plastic nylon, vinyl, etc.), cellulose (e.g., coated heavy weight paper, cardboard, card stock, etc.), synthetic non-woven wrap (e.g., KOLON®), any other suitable material or a

combination thereof. The stream of fluid entering the internal volume 103 via the fluid inlet 105 impinges on the barrier 140 instead of the filter media 120. The stronger material of the barrier 140 may therefore, also prevents the fluid stream directly impinging thereon, which may be undesirable. For example, direct impingement of the fluid on the filter media 120 may distort (e.g., bend) the plurality of pleats from their original location, which may cause the pleat tips to bunch or cluster together, thereby reducing an effective surface area of the filter media 120 used for filtering the fluid.

[0040] As shown in FIG. 1, the filter media 120 has a first axial length H_1, and the barrier 140 has a second axial length H_2. In some embodiments, the second axial length H_2 is less than the first axial length H_1. For example, the second axial length H_2 may be less than half of the first axial length H_1. In other embodiments, the second axial length H_2 may be substantially the same as the first axial length H_1, so that the barrier 140 covers substantially all of the filter media 120. In such embodiments, at least a portion of the barrier 140 may be porous or have slots or openings defined therein so as to allow the fluid to be communicated therethrough to the filter media 120.

[0041] In still other embodiments, the barrier 140 may comprise a first barrier positioned around a first portion of the filter media 120 (e.g., proximal to the filter media second end 123). The filter element 110 may also comprise a second barrier positioned on a second portion of the filter media 120 different from the first portion. The second barrier can be formed from the same material as the first barrier or different therefrom. In such embodiments, at least a portion of the plurality of pleat tips (e.g., the plurality of pleat tips 324) may also be bonded to a second barrier inner surface of the second barrier (e.g., thermally bonded or via an adhesive) so as to further secure the plurality of pleats (e.g., the plurality of pleats 322).

[0042] In particular embodiments, the barrier 140 may be formed from a highly porous material (e.g., a wire mesh or cage) structured to allow the fluid to flow therethrough towards the filter media 120. In such embodiments, a barrier portion of the barrier 140 may be formed of a stronger and/or less permeable material. The barrier portion may be positioned proximal to the fluid inlet 105 such that the fluid flowing into the internal volume 108 impinges on the barrier portion. The barrier portion may be monolithically formed with the barrier 140, or the

barrier portion may be coupled to the barrier 140 (e.g., include a plate welded or adhered to the a barrier outer surface of the barrier 140). In such embodiments, the barrier portion may also serve as an alignment feature to be located proximal to the fluid inlet 105. In other embodiments, alignment features (e.g., the tabs 219) may be defined on the first end cap 112 and/or the second end cap. The alignment features may be structured to engage with mating alignment features provided in the filter housing 102, so as to allow proper alignment of the barrier portion relative to the fluid inlet 105. Having a porous barrier with only a barrier portion made of a stronger and less permeable material may reduce parasitic pressure drop in the fluid flowing therethrough into the filter media 120.

[0043] FIG. 2 is a side view of a filter element 210 according to another embodiment, and FIG. 3 is a top perspective view thereof. The filter element 210 comprises a filter media 220, a first end cap 212, a second end cap 214 and a center tube 216.

[0044] The filter media 220 is positioned around the center tube 216 and structured to filter a fluid flowing therethrough. In particular embodiments, the filter media 220 may comprise a plurality of pleats defining a plurality of pleat tips, as described before herein with respect to the filter media 320. The filter media 22 may be substantially similar to the filter media 120, 320 or any other filter media described herein.

[0045] The first end cap 212 is positioned on a filter media first end 221 of the filter media 220. The first end cap 212 defines a first end cap opening structured to receive a center tube first end of a center tube 216 therethrough. The first end cap 212 may be substantially similar to the first end cap 112 and, therefore not described in further detail herein.

[0046] The second end cap 214 is positioned on a filter media second end 223 opposite the filter media first end 221. The second end cap 214 defines a second end cap opening 215. A plurality of tabs 219 may be positioned radially around a periphery of the second end cap 214 at predetermined locations. The plurality of tabs 219 may be structured and positioned so as to allow proper alignment of the filter element 210 during insertion into a filter housing (e.g., the filter housing 102). For example, the plurality of tabs 219 may be sized to contact an inner surface of a sidewall of the filter housing during insertion into an internal volume thereof. In

other embodiments, the plurality of tabs 219 may be structured to engage mating slots defined in the filter housing so as to facilitate alignment of the filter element 210 within the filter housing.

[0047] The filter media 220 is positioned around the center tube 216. The center tube 216 defines a plurality of pores to allow a fluid (e.g., a fuel or lubricant) filtered through the filter media 220 to enter a center tube channel of the center tube 216 and exit the filter element 210. The center tube 216 may be substantially similar to the center tube 116 and, therefore not described in further detail herein.

[0048] A barrier 240 is positioned around a portion of the filter media 220, proximal to the filter media second end 223. At least a portion of the plurality of pleat tips of plurality of pleat of the filter media 220 contact a barrier inner surface of the barrier 240 and are bonded thereto, for example thermally bonded or via an adhesive. The barrier 240 may be substantially similar in structure and function to the barrier 140 described previously, and therefore not described in further detail herein.

[0049] FIG. 5 is a schematic flow diagram of an example method 400 for forming a filter element, for example the filter element 110, 210 or 310. The method 400 comprises providing a filter media comprising a plurality of pleats that define a plurality of pleat tips, at 402. For example, the filter media comprises the filter media 120, 220, 320 or any other filter media described herein, that includes a plurality of pleats (e.g., the plurality of pleats 322) defining a plurality of pleat tips (e.g., the plurality of pleat tips 324).

[0050] In particular embodiments, the filter media may be positioned around a center tube, at 404. For example, the filter media 120, 220, 320 may be positioned around the center tube 116, 216. A first end cap is coupled to a filter media first end of the filter media, at 406. For example, the first end cap 112, 212 is coupled to the filter media first end 121, 221 of the filter media 120, 220, 320. A second end cap is coupled to a filter media second end of the filter media, at 408. For example, the second end cap 114, 214 is coupled to the filter media second end 123, 223 of the filter media 120, 220, 320. For example, the first end cap and the second cap may be thermally bonded to the filter media or coupled thereto via an adhesive.

[0051] A barrier is positioned around at least a portion of the filter media, at 410. For example, the barrier 140, 240, 340 is positioned around the filter media 120, 220, 320 such that at least a portion of the plurality of pleat tips (e.g., the plurality of pleat tips 324) of the filter media (e.g., the filter media 320) contact a barrier inner surface (e.g., the barrier inner surface 342) of the barrier (e.g., the barrier 340). At least the portion of the plurality of pleat tips are bonded to the barrier inner surface of the barrier, at 412 so as to secure the plurality of pleats in a fixed position.

[0052] For example, the at least a portion of the plurality of pleats tips 324 are bonded to the barrier inner surface 342 of the barrier 340 so as to secure the plurality of pleats 322 in a fixed position relative to each other and/or the barrier 340. In some embodiments, at least the portion of the plurality of pleat tips (e.g., the plurality of pleat tips 324) are thermally bonded to the barrier inner surface (e.g., the barrier inner surface 342). In other embodiments, at least the portion of the plurality of pleat tips (e.g., the plurality of pleat tips 324) are bonded to the barrier inner surface (e.g., the barrier inner surface 342) via an adhesive. Furthermore, the filter media (e.g., the filter media 120, 220, 320) is formed from a first material, and the barrier (e.g., the barrier 140, 240, 340) is formed from a second material which is stronger than the first material.

[0053] FIG. 6 is a schematic flow diagram of an example method 500 for using a filter element with a filter assembly (e.g., the filter assembly 100), which comprises a filter housing (e.g., the filter housing 102, 202) defining a fluid inlet therein (e.g., the fluid inlet 105). The method comprises providing a filter element, at 502. The filter element comprises a filter media (e.g., the filter media 120, 220, 320) comprising a plurality of pleats (e.g., the plurality of pleats 322) defining a plurality of pleat tips (e.g., the pleat tips 324). A barrier (e.g., the barrier 140, 240, 340) positioned around at least a portion of the filter media. At least a portion of the plurality of pleat tips contact, and are bonded to a barrier inner surface of the barrier so as to secure the at least a portion of the plurality of pleats in a fixed position.

[0054] In particular embodiments, the he filter assembly may also comprise a cover (e.g., the cover 108) removably coupled to the filter housing. In such embodiments, the method 500 may comprise uncoupling the cover of the filter housing, at 504. For example, the cover 108 is uncoupled and removed from the filter housing 102 so as to allow a user to access the internal

volume 103 of the filter housing 102. A used filter may be removed from the filter housing, at 506.

[0055] The filter element is positioned in the internal volume of the filter housing, at 508. The filter element is positioned such that the barrier of the filter element is positioned in a flow path of a fluid inlet of the filter housing. For example, the filter element 110 is positioned within the internal volume 103 of the filter housing 102 such that the barrier 140 proximal to the filter media second end 123 thereof is in the flow path of the fluid inlet 105 defined on the sidewall 104 of the filter housing 102. In particular embodiments, the cover may be coupled to the filter housing, at 510 so as to secure the filter element within the filter housing. For example, the cover 108 is coupled to the filter housing 102 so as to secure the filter element 110 within the internal volume 103 thereof.

[0056] The method 500 further comprises flowing the fluid into the internal volume via the fluid inlet, at 512. For example the fluid (e.g., air, fuel, air-fuel mixture, or lubricant) is inserted through the fluid inlet 105 into the internal volume 103. The fluid flow impinges on a barrier outer surface of the barrier, which is opposite the barrier inner surface. For example, the fluid may be inserted into through the fluid inlet 105 at sufficient pressure so as to form fluid jet streaming towards the filter element 110. Since the barrier 140 is positioned in the flow path of the fluid inlet 105, the fluid (e.g., fuel or lubricant) entering the internal volume 103 via the fluid inlet 105 impinges upon the barrier outer surface of the barrier 140 instead of directly on the filter media 120. This may protect the filter media 120, as previously described in detail herein.

[0057] The fluid flows at least one of through the barrier, around the barrier, and/or under the barrier towards the filter media. For example, the barrier 140, 240, 340 may be formed from a porous material or have pores or otherwise openings defined therein, which allow the fluid to flow therethrough towards the filter media 120, 220, 320. Moreover, the fluid may also flow around and/or under the barrier 140, 240, 340 so as to reach the filter media 120, 220, 320. The fluid flows through the filter media, at 516. For example, the fluid flows through the filter media 120, 220, 320 and is, thereby filtered.

[0058] It should be noted that the term "example" as used herein to describe various embodiments is intended to indicate that such embodiments are possible examples, representations, and/or illustrations of possible embodiments (and such term is not intended to connote that such embodiments are necessarily extraordinary or superlative examples).

[0059] The terms "coupled," "connected," and the like as used herein mean the joining of two members directly or indirectly to one another. Such joining may be stationary (e.g., permanent) or moveable (e.g., removable or releasable). Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate members being attached to one another.

[0060] It is important to note that the construction and arrangement of the various exemplary embodiments are illustrative only. Although only a few embodiments have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter described herein. Other substitutions, modifications, changes and omissions may also be made in the design, operating conditions and arrangement of the various exemplary embodiments without departing from the scope of the embodiments described herein.

[0061] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any embodiment or of what may be claimed, but rather as descriptions of features specific to particular implementations of particular embodiments. Certain features described in this specification in the context of separate implementations can also be implemented in combination in a single implementation. Conversely, various features described in the context of a single implementation can also be implemented in multiple implementations separately or in any suitable subcombination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be

excised from the combination, and the claimed combination may be directed to a subcombination or variation of a subcombination.

WHAT IS CLAIMED IS:

1. A filter assembly, comprising:

a filter housing defining an internal volume;

a filter element positioned within the internal volume, the filter element comprising:

a filter media comprising a plurality of pleats, the plurality of pleats defining a plurality of pleat tips; and

a barrier positioned around at least a portion of the filter media, at least a portion of the plurality of pleat tips contacting and bonded to a barrier inner surface of the barrier so as to secure the at least a portion of the plurality of pleats in a fixed position.

2. The filter assembly of clam 1, wherein the filter housing further comprises:

a sidewall, a fluid inlet defined on the sidewall and structured to allow a stream of a fluid to enter the internal volume,

wherein the barrier is positioned proximal to the fluid inlet such that the stream of the fluid entering the internal volume impinges on a barrier outer surface of the barrier, the barrier outer surface opposite the barrier inner surface.

3. The filter assembly of claim 1, wherein each of the plurality of pleat tips is thermally bonded to the barrier inner surface.

4. The filter assembly of claim 1, wherein each of the plurality of pleat tips is bonded to the barrier inner surface via an adhesive.

5. The filter assembly of claim 1, wherein the filter media is formed from a first material, and wherein the barrier is formed from a second material, the second material stronger than the first material.

6. The filter assembly of claim 1, wherein the filter media has a first axial length, and wherein the barrier has a second axial length, the second axial length less than the first axial length.

7. The filter assembly of claim 6, wherein the second axial length is less than half of the first axial length.

8. The filter assembly of claim 2, wherein the filter housing further comprises a base and a cover positioned opposite the base, the cover coupled to the sidewall, and wherein the filter media comprises a filter media first end positioned proximal to the base, and a filter media second end positioned proximal to the cover, the barrier positioned proximal to the filter media second end.

9. A filter element comprising:

a filter media comprising a plurality of pleats, the plurality of pleats defining a plurality of pleat tips;

a barrier positioned around at least a portion of the filter media, at least a portion of the plurality of pleat tips contacting and bonded to a barrier inner surface of the barrier so as to secure the at least a portion of the plurality of pleats in a fixed position;

a first end cap positioned on a first end of the filter media; and

a second end cap positioned on a second end of the filter media opposite the first end.

10. The filter element of claim 9, further comprising:

a center tube, the filter media positioned around the center tube;

11. The filter element of claim 9, wherein each of the plurality of pleat tips is thermally bonded to the barrier inner surface.

12. The filter element of claim 9, wherein each of the plurality of pleat tips is bonded to the barrier inner surface via an adhesive.

13. The filter element of claim 9, wherein the filter media is formed from a first material, and the barrier is formed from a second material, the second material stronger than the first material.

14. The filter element of claim 9, wherein the filter media has a first axial length, and the barrier has a second axial length, the second axial length less than the first axial length.

15. A method, comprising:

providing a filter media comprising a plurality of pleats, the plurality of pleats defining a plurality of pleat tips;

coupling a first end cap to a filter media first end of the filter media;

coupling a second end cap to a filter media second end of the filter media, the filter media second end opposite the filter media first end;

positioning a barrier around at least a portion of the filter media such that each of the plurality of pleat tips contact a barrier inner surface of the barrier; and

bonding at least a portion of the plurality of pleat tips to the barrier inner surface of the barrier so as to secure the at least a portion of the plurality of pleats in a fixed position.

16. The method of claim 15, wherein each of the plurality of pleat tips is thermally bonded to the barrier inner surface.

17. The method of claim 15, wherein each of the plurality of pleat tips is coupled to the barrier inner surface via an adhesive.

18. The method of claim 15, wherein the filter media is formed from a first material and the barrier is formed from a second material, the second material stronger than the first material.

19. A method for using a filter element, the method comprising:

providing a filter element, the filter element comprising:

a filter media comprising a plurality of pleats, the plurality of pleats defining a plurality of pleat tips, and

a barrier positioned around at least a portion of the filter media, at least a portion of the plurality of pleat tips contacting and bonded to a barrier inner surface of the barrier so as to secure the at least a portion of the plurality of pleats in a fixed position;

positioning the filter element in an internal volume of a filter housing such that the barrier is in a flow path of the fluid inlet of the filter housing; and

flowing a fluid into the internal volume via the fluid inlet, the fluid flow impinging on a barrier outer surface of the barrier of the filter element, the barrier outer surface opposite the barrier inner surface.

20. The method of claim 19, wherein the fluid flows via at least one of through the barrier, around the barrier, and under the barrier towards the filter media so as to be filtered through the filtered media.

FIG. 1

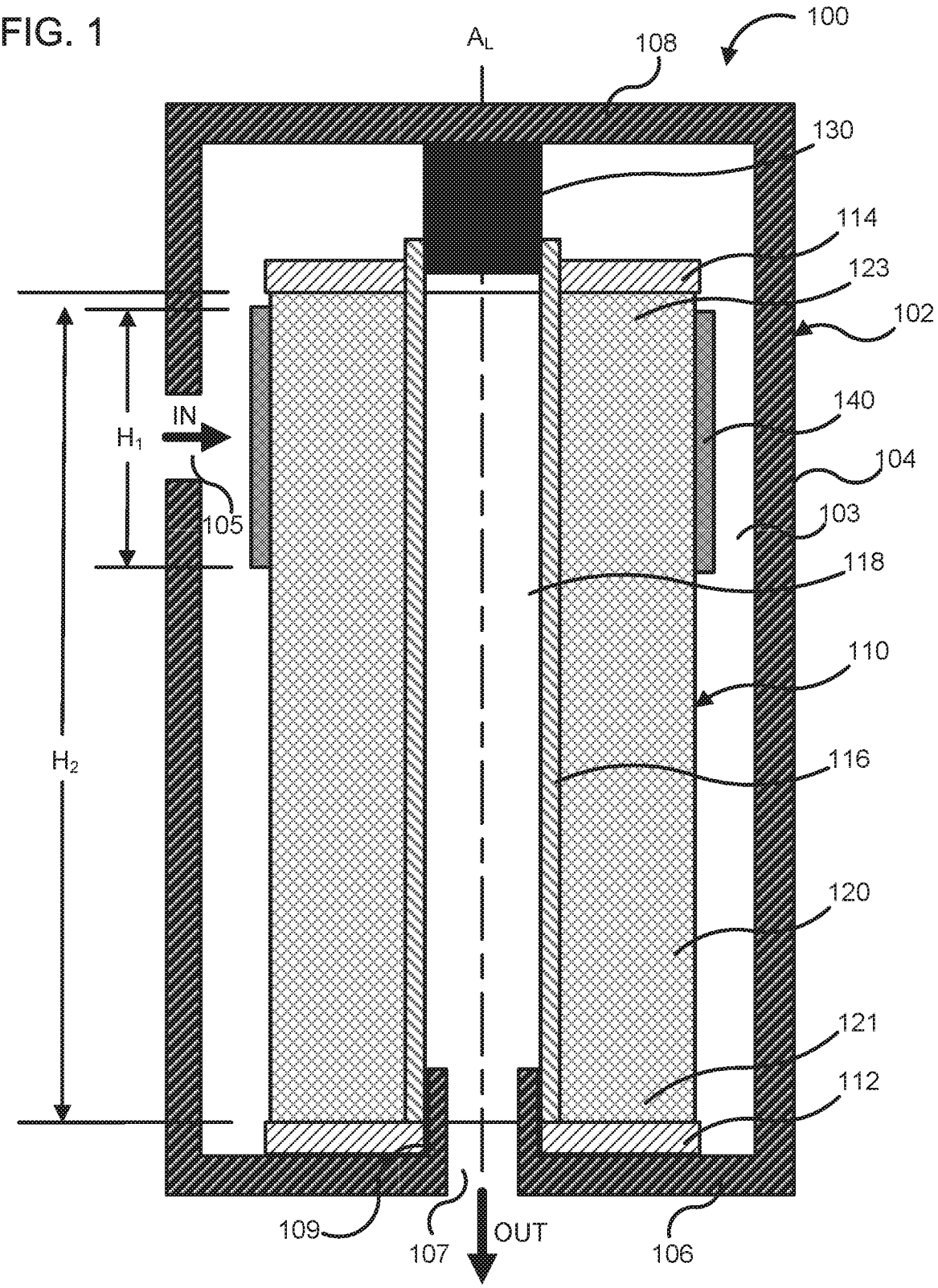

100
A_L
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130
114
123
102
140
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121
112
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H_1
105
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109
107
OUT
106

FIG. 2

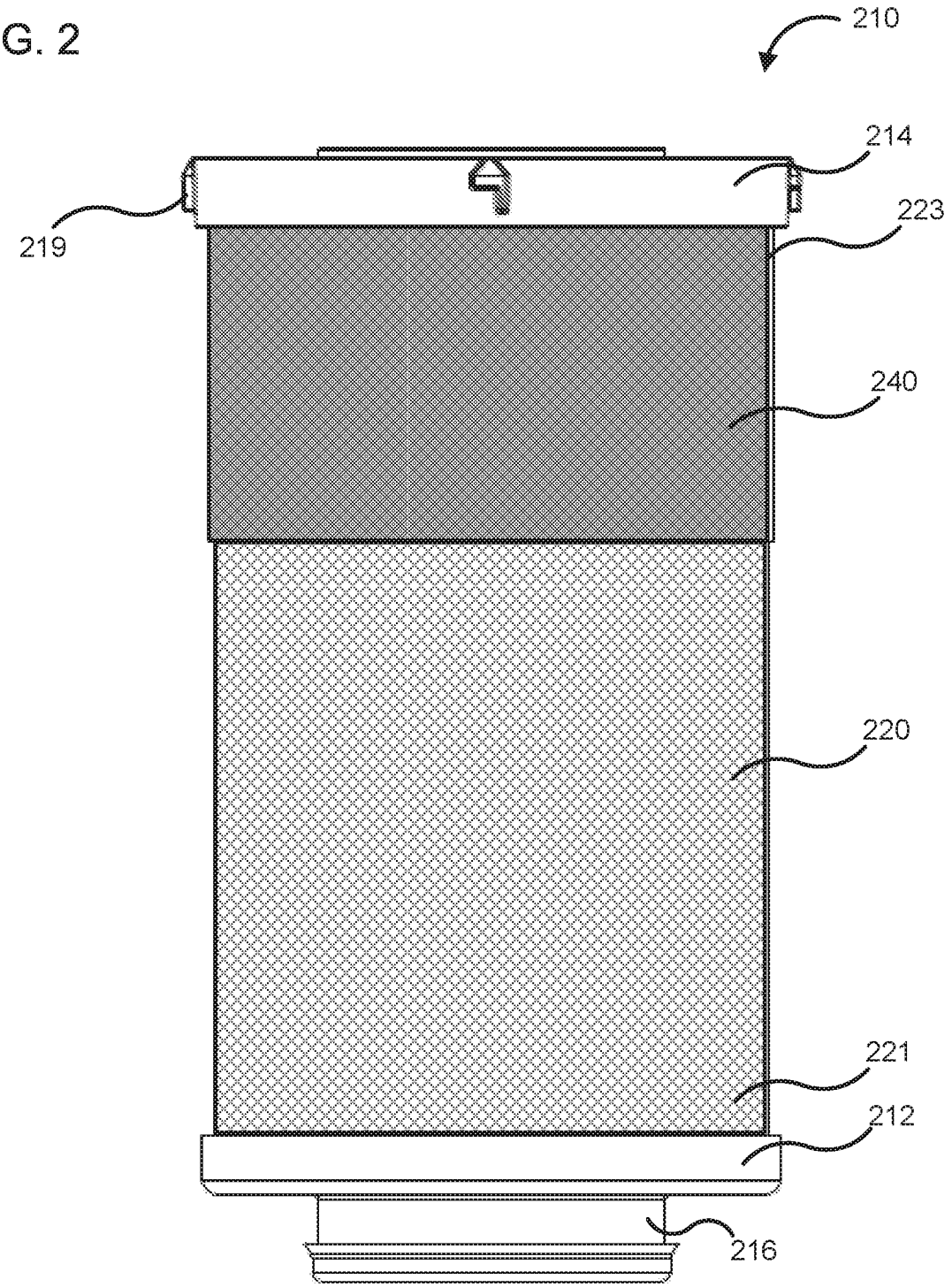


FIG. 3

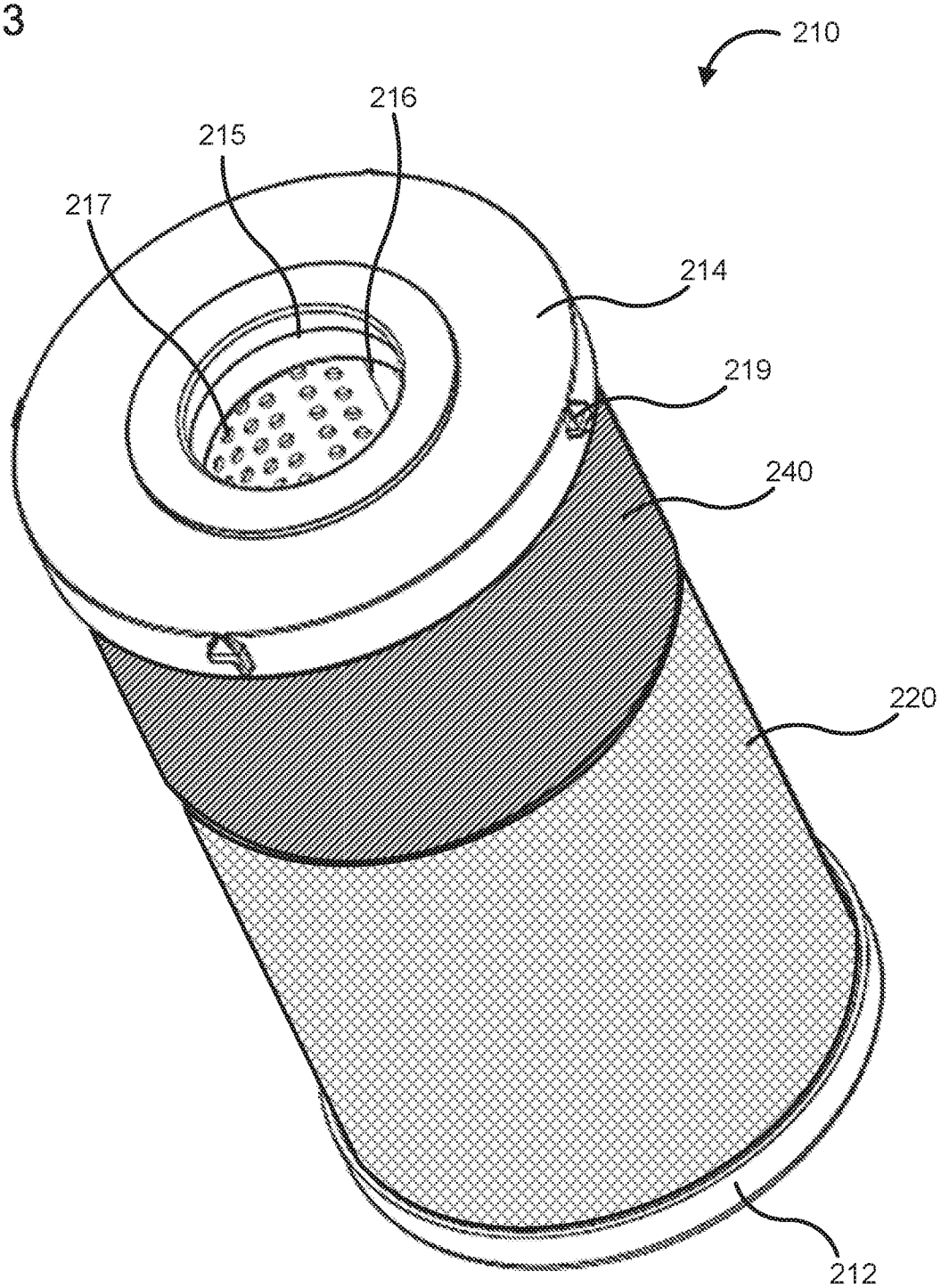


FIG. 4A

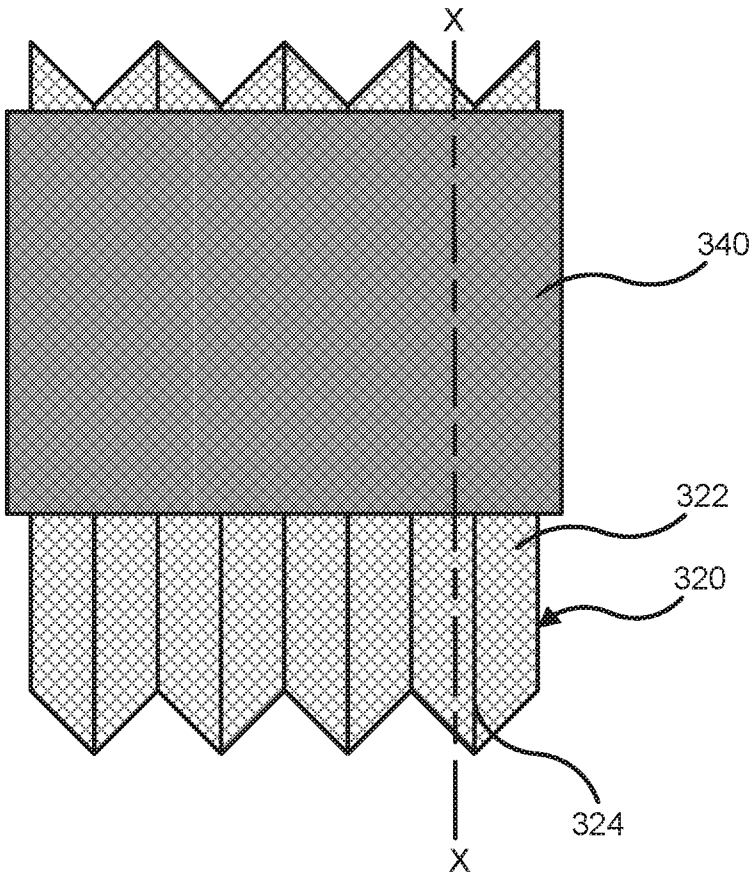


FIG. 4B

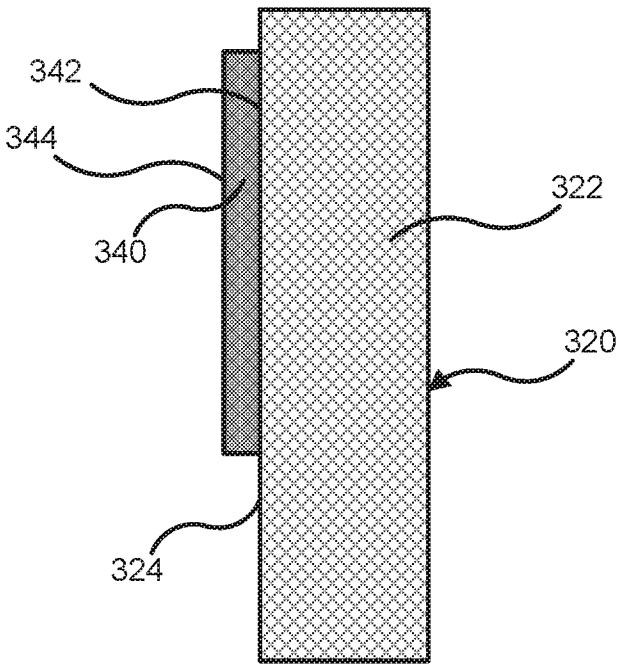


FIG. 5

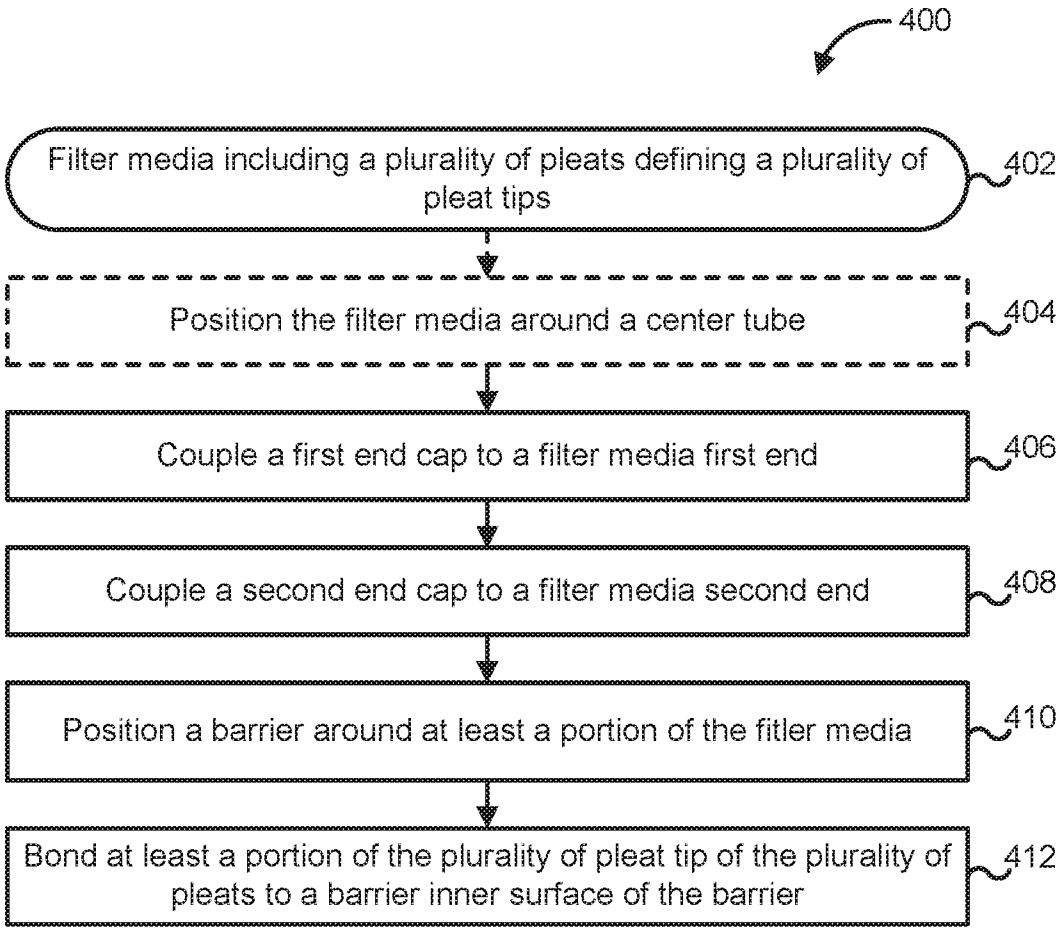
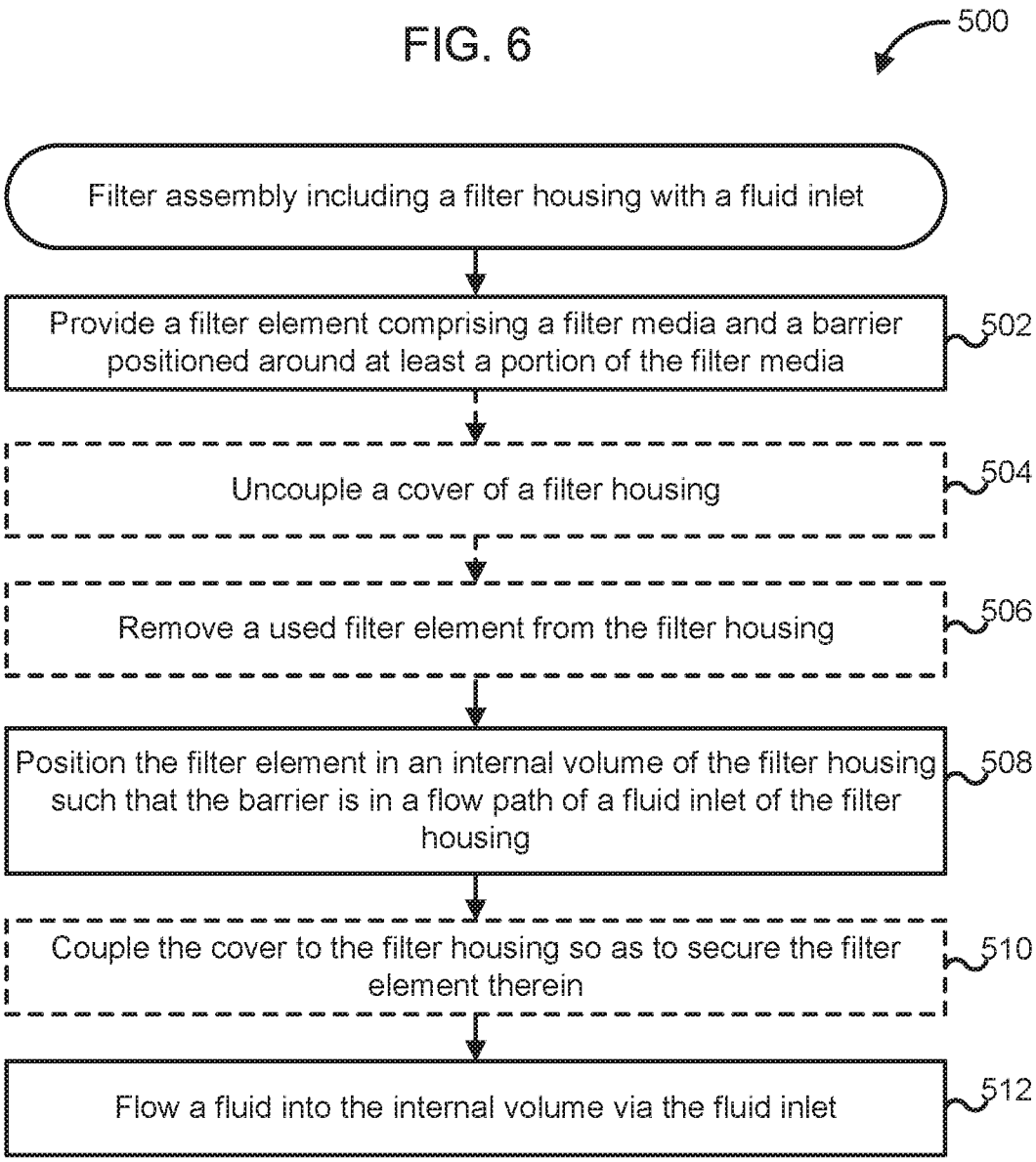

400
Filter media including a plurality of pleats defining a plurality of pleat tips
402
Position the filter media around a center tube
404
Couple a first end cap to a filter media first end
406
Couple a second end cap to a filter media second end
408
Position a barrier around at least a portion of the fitler media
410
Bond at least a portion of the plurality of pleat tip of the plurality of pleats to a barrier inner surface of the barrier
412

FIG. 6


500
Filter assembly including a filter housing with a fluid inlet
Provide a filter element comprising a filter media and a barrier positioned around at least a portion of the filter media
502
Uncouple a cover of a filter housing
504
Remove a used filter element from the filter housing
506
Position the filter element in an internal volume of the filter housing such that the barrier is in a flow path of a fluid inlet of the filter housing
508
Couple the cover to the filter housing so as to secure the filter element therein
510
Flow a fluid into the internal volume via the fluid inlet
512

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US17/64665

A. CLASSIFICATION OF SUBJECT MATTER

IPC - B01D 27/06, 27/07, 29/11, 29/21, 46/02, 46/52 (2018.01)

CPC - B01D 27/06, 27/07, 29/11, 29/114, 29/21, 46/02, 46/52, 46/521

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)
See Search History document

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,149,700 A (MORGAN, JS et al) 21 November 2000; figures 1-2, 4, 7; column 2, lines 26-28, 46-67; column 3, lines 12-51; column 4, lines 17-22, 43-51	1-20
Y	US 6,334,881 B1 (GIANNETTA, R et al) 01 January 2002; column 2, lines 55-61; column 3, lines 28-35, 57-63; column 4, lines 41-46; column 8, line 64 – column 9, line 10	1-20
Y	US 2012/0223006 A1 (SANN, N et al) 06 September 2012; figure 1; paragraph [0022]	6-7, 14
A	US 2004/0255783 A1 (GRAHAM, KM et al) 23 December 2004; entire document	1-20
A	US 5,814,219 A (FRIEDMANN, FA et al) 29 September 1998; entire document	1-20
A	US 2010/0192529 A1 (SCHUSTER, H-M) 05 August 2010; entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"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
18 January 2018 (18.01.2018)	16 FEB 2018
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)